✓ SOLAR ENERGY SCHOOL HEATING AUGMENTATION
EXPERIMENT

✓ Sections I, II, and III

MASTER

Date Published—January 3, 1977

Work Performed Under Contract No. EY-76-C-02-2586

InterTechnology Corporation
Warrenton, Virginia

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
Division of Solar Energy

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

This report has been printed directly from copy supplied by the originating organization. Although the copy supplied may not in part or whole meet the standards for acceptable reproducible copy, it has been used for reproduction to expedite distribution and availability of the information being reported.

Available from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22161

Price: Paper Copy \$7.75 (domestic)
\$10.25 (foreign)
Microfiche \$3.00 (domestic)
\$4.50 (foreign)

SOLAR ENERGY SCHOOL HEATING
AUGMENTATION EXPERIMENT

SECTION I ✓

OPERATION AND PERFORMANCE OF THE
FAUQUIER HIGH SCHOOL SOLAR HEATING SYSTEM

ITC REPORT NO. 281076

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

3 January 1977

Submitted to the Energy Research and Development
Administration in Partial Fulfillment of Contract
EY-76-C-02-2586

InterTechnology Corporation
100 Main Street
Warrenton, Virginia 22186

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
I. Introduction and Summary	1
II. Solar Heating System	2
A. Description of System	2
B. Modifications to the System	5
1. Controls	5
2. Piping	7
III. Operational History and Maintenance	7
A. The 1974-75 Heating Season	7
B. The 1975-76 Heating Season	9
C. Maintenance	10
1. Collectors	10
2. Controls	12
3. Pumps	14
4. Storage Tanks	15
5. Classroom Heat Distribution System	15
IV. Operational Data	16
A. Collector	16
1. Performance of the Collector Array	16
2. Performance of Individual Collectors	23
3. Selective Coating	24
4. Absorber	31
B. Insolation Data	33
<u>Appendix</u>	
A. Control System Specifications	
B. Analysis of Corroded Absorber Plates	
C. Insolation Data	

I. Introduction and Summary

On January 22, 1974, InterTechnology Corporation (ITC) received a contract from the National Science Foundation (Contract NSF-C868) to design, construct and operate a solar heating system located at the Fauquier County High School. ITC was one of four contractors chosen to install solar heating systems at schools in various regions of the country. One of the primary goals of this program was to acquire data on the systems and to demonstrate their operation before the 1973-74 heating season was over.

ITC designed the system, installed it and brought it into operation on March 19, 1974, less than sixty days after authority to proceed had been given. The solar system, which includes 2415 square feet of collector, has provided nearly all of the heating requirements for five modular classrooms with a total of 4100 square feet of floor area. Details of the design, construction and initial operation of the system are found in the first report of this project.*

The present report covers the operation, maintenance and modifications to the system over the 1974-75 and 1975-76 heating seasons. The major findings and conclusions of this report are:

- the solar system has shown the capability of providing essentially 100% of the heating requirements of the five classrooms it serves.
- the drain-down method of freeze protection has functioned well with no damage to the system occurring as a result of freezing.
- the corrosion inhibitor has worked well with the aluminum absorber plates with no failures arising from internal corrosion.

*"Solar Energy School Heating Augmentation Experiment",; December 4, 1974; NSF-RA-N-74-019, Government Printing Office #038-000-00204.

- the selective coating appears to have degraded in terms of its solar absorptance and this has led to some loss in collector thermal performance.
- a control system has been developed and installed to allow the system to operate automatically in its most efficient mode.
- the rubber hose connections have failed repeatedly due to the high temperatures attained by the collector under no-flow conditions.
- vandalism has been practically non-existent in spite of the readily accessible location of the solar collector.
- interest in the solar heating system has been high and the system has been viewed by a large number of visitors from all parts of the United States as well as throughout the world.

II. Solar Heating System

A. Description of the System

The Fauquier High School Solar Heating System utilizes a solar collector array of 2415 square feet active area. The collectors are mounted in a single plane which is tilted at a 53° angle from the horizontal. The latitude of Warrenton, Virginia is 38.6°. Details of the collector construction are given in Table II-1.

Thermal storage is provided by water stored in two concrete tanks, each of 5500 gallon capacity. The tanks are insulated with 4" of polyurethane and have a temperature loss of 1°F per day at a temperature of 140°F. Piping to the tanks is arranged so they can be used separately for maximum efficiency.

The site piping layout which shows the location of the collectors, storage tanks, and modular classrooms is given in Figure II-1.

TABLE II-1
F.H.S. SOLAR COLLECTOR PARAMETERS

Number of collectors	- 105
Collector area	- $23 \text{ ft}^2 \times 105 = 2415 \text{ ft}^2$
Glazing	- two layers of double strength glass
Absorber plate	- aluminum "Roll-Bond"
Coating	- Alcoa 655 process $\alpha = 0.93$ (nominal values) $\epsilon = 0.35$
Back insulation	- 3" foil-faced fiberglass
Flow configuration	- series - parallel, 3 collectors in series, 35 rows in parallel
Piping	- 2" steel pipe
Collector flow	- 47 g.p.m. (approximately 10 lbs/hr-ft^2)
Coolant	- treated water
Thermal storage	- 10,000 gal. water in two tanks

A drain-down mode is used to provide freeze protection for the collectors. No anti-freeze is used in the system. There are no heat exchangers in the system except for the classrooms where two water-air convectors are used for space heating. The convectors are equipped with a two speed fan and are sized to provide the heating requirements of the classrooms with 100°F water storage temperatures. Back-up heating is provided with the electric resistance heaters originally installed in the classrooms. One classroom has, in addition, an oil heater.

B. Modifications to the System

1. Controls

Following the 1974-75 heating season, a design for a new control system was initiated. The control system which was originally installed had never performed adequately in an automatic mode. Much of the time the system had to be operated manually. It was decided that to build a new control system using more reliable components would be more desirable than to attempt to fix the old controls.

The specifications for the new control system are included in the present report as Appendix A. The basic function of the control system is to operate the collector and provide heat to the classrooms in the most economical manner. Collection of solar energy is initiated whenever the temperature of the collector plates exceeds that of the storage tanks. The cooler of the storage tanks is selected for thermal storage in order to maximize the amount of solar energy collected.

The classrooms can be provided with heat from either of the two storage tanks. The most general mode of operation in the daytime is to heat the classrooms

from the hotter tank while the other tank is collecting solar energy. The main circulation pump will be shut down whenever the collector outlet temperature is less than or equal to 3°F above the inlet temperature. In order to prevent rapid cycling due to intermittent clouds, a time delay of six minutes occurs before the system actually shuts down. After the system shuts down, the water in the collector and pipes automatically drains back into the tank from which it was pumped.

In each classroom there are two thermostats marked "day" and "night". The day thermostat controls the classroom demand from 7 A.M. to 3 P.M.; the night thermostat is in control the rest of the time. The day and night thermostat settings are typically 70°F and 50°F respectively. A crystal controlled clock is built into the control system to signal the switchover between day and night modes. The clock is battery powered in the event of a power outage.

To conserve energy on weekends or on school holidays, the classrooms are maintained at the night thermostat setting. This is accomplished without manual intervention by the use of programming switches on the front of the control panel. These switches allow the school calendar to be entered into the control system's memory for a period of up to 16 days.

The control system has functioned well since it was installed and the "bugs" were worked out of it. The electronics used in the control system can be considered as state-of-the-art with PROMs (Programable Read Only Memories) and other large scale integrated circuits being extensively employed. This poses the problem that a very highly skilled technician is necessary to fix it, if the need arises. The contractor for the control system has quoted a daily rate of \$184 for maintenance work with a half-day minimum charge.

2. Piping

Some relatively minor changes were made in the piping and valve layout in the pumphouse. These changes were made to allow more simplified modes of operation. The present piping configuration is shown in Figure II-1.

In January of 1976, problems were noted with the start-up of the collector following a very cold night (0°F). The collector flow-rate was erratic, indicating a blockage. Upon further examination it was discovered that the combination flowmeter-balancing valve was retaining enough moisture so that the piston type flow indicator was freezing tight and preventing flow. It was decided to remove all 35 flowmeters to prevent the reoccurrence of this problem. The removal of the flowmeters also meant that the balancing valves for each row were removed. The effect of this on collector performance is discussed in Section IV-A-1.

III. Operational History and Maintenance

A. The 1974-75 Heating Season

Because of the previously mentioned problems with the original control system, most of the operation of the system was carried out manually. The correct system operating modes were set up in the morning and then reset in the late afternoon.

The solar system was able to meet the heating requirements of the five classrooms except for a day in December when local flooding caused the system to be shut down. A low concrete block wall was then constructed to divert groundwater from the pumphouse and storage tanks.

Figure II-2
Plumbing Schematic and Temperature Control Points

On one day in February the tank temperature fell to 82°F which was too low to provide adequate heat to the classrooms. This low tank temperature was due to a string of four sunless days and was also due in part to the fact that only one storage tank was in operation because of a failure of one of the storage tank pumps.

Following the 74-75 heating season, the tanks were cooled down (by running the collector at night) and then were emptied and resealed.

B. The 1975-76 Heating Season

During the summer of 1975, experiments were undertaken to determine the thermal efficiency of various collector types (single glazed, double glazed, etc.). Data collection was somewhat hampered by the continuing malfunction of the data logger. Also during this period the final specifications for the new control system were being completed.

Because of the slow delivery of components for the control system, installation of the controls did not begin until late fall. Until the control system became fully operational, most of the heating requirement was met by the conventional electric resistance heaters. From the time in mid-January when most of the problems were ironed out of the new system, the solar system was able to meet the heating demand.

Problems with hose leaks continued as they had in the past. At one time in the late winter, there were eight rows closed off because of leaks. This represents approximately one-fourth of the collector area. The weather (insolation) was sufficiently good at this time so the loss in capacity was not important.

C. Maintenance

1. Collector Maintenance

The majority of the maintenance work performed on the system has been on the solar collectors. Collector components that have required maintenance are the hose connections, the absorber plate and the glazing.

The glazing has required maintenance only to replace those panes of glass which have cracked. Most of the cracked panes have been on the inside of the two glazing layers. This breakage has been ascribed to thermal expansion and to improper glazing techniques used on some of the collector boxes (the boxes glazed on site). Only six panes have been damaged due to this cause. The number of outside panes broken has also been small. In only one instance was a pane believed to have been broken by vandalism. This is remarkable considering the proximity of the collectors to the gym and the athletic fields. The replacement of broken panes involves removing the caulking compound and lifting off the remaining pieces. This process is best accomplished on warm days when the caulk is soft enough for easy removal. To replace an inner pane, the outer pane must be removed separately since the double glazing is composed of two separate layers of glass rather than as a sealed unit as is found on sliding patio doors and other types of insulated glazing.

The glazing has functioned satisfactorily in preventing moisture from entering the collector box. There has been some condensation which has appeared between the glazing layers after a rain. Most of the condensation that is present is due to leaks in the rubber hose connectors. The condensation clears as the absorber plate and glazing warm up.

Because of the rainfall and snow that occurs in the Warrenton area during the winter, the amount of dust that accumulates on the surface of the glazing is

negligible. From examinations of collector boxes which have been opened, we have noticed very little dust on the surface of the absorber plate. This observation is significant because the accumulation of dust on the absorptive coating will lower its solar absorptance and, in the case of selective coatings, will increase its emittance.

The absorber plate itself has required no maintenance except for the replacement of two panels. These panels developed leaks due to corrosion. The corrosion originated from the outside of the absorber plate and is believed to be due to water from hose leaks. Further discussion of this topic is found in Section IV.

Hose connectors have been the primary area of maintenance on the solar collector. The original hoses were automobile heater hoses. The normal operating temperatures of the solar collector (140-150°F) are actually lower than those encountered in automotive coolant systems. However, problems arise due to the high dry-plate or stagnation temperatures which the collector reaches during the summer. The maximum dry-plate temperature that has been recorded is 350°F. On any reasonably sunny day in the summer, the collector plate will warm up to 280°F-320°F and remain at that temperature for three to four hours.

These high temperatures have caused the rubber compound of the hoses to "dry out" or vulcanize. Eventually the hose becomes so brittle that the expansion and contraction of the absorber plate will crack it. In some cases, a leak occurs where the hose is clamped to the absorber plate nipple. These leaks are due to loss of clamping force as the rubber hose sets and hardens under the hose clamp.

There are a total of 140 hose connectors in the F.H.S. collector array. Of these connectors, 70 are between collectors and 70 are between collectors and the inlet and outlet manifolds (there are 35 rows with 3 collectors in series in each row).

Almost all problems with hoses have been with the 70 that make the series connection between collectors. In all, a total of 34 hoses have been replaced. The replacement hoses have been made with a higher temperature rubber compound.

On the first row of collectors a metal swage type of coupling was tried between collectors. Also, a teflon bellows was used to connect the top collector to the outlet manifold. All these connectors have performed well with no problems. In order to use the metal connectors, the collector boxes had to be separated by 4-5 inches. The labor involved in modifying the entire collector array in this fashion would be similar to that involved in replacing the collectors entirely.

Hose replacement is very time consuming because some of the glazing must be removed. The collector boxes are butted up to one another and the hose clamps are located inside the collector boxes. Four panes of glass must be removed to replace one hose. Because of the difficulties in removing the glazing, there has been almost a 50% breakage rate. It takes two men approximately four hours to replace one hose.

2. Controls

From the time the new control system was installed in the winter of 1975-76, very little maintenance has been required. The main problems have come from control elements such as valves and temperature sensors. The temperature sensors are linear thermistors and are encapsulated in stainless steel tubes. A thermistor is located in each storage tank, in the supply and return lines to the collector, and on a collector absorber plate.

After the control system became operational, it was noticed that solar collection was initiated at a fairly late time (approximately 10:30 to 11:00 A.M.) on clear

mornings. This start-up lag was caused by abnormally low temperature readings of the absorber plate due to the location of the thermistor sensor near the edge of the plate. When the sensor was moved to a position in the upper middle of the plate, the system came on earlier in the morning and more energy was collected.

Soon after the problem with the late turn-on time was solved, the collector row in which the temperature sensor was located developed a leak at a hose connection. The row was then valved off until the leak could be repaired. In the meantime, the control system operated normally since the function of the collector thermistor is only to turn the system on and thus it is not necessary that the collector have fluid flow. The temperature sensor will, however, be subject to stagnation or dry plate temperatures every day. On a routine check of the system, the collector temperature was found to read 0°C, corresponding to a very high thermistor resistance. Upon removal of the thermistor, one lead was found to have come loose. The probable cause of failure was believed due to the thermal expansion and contraction of the lead. The lead was reconnected and the sensor has operated properly since that time.

The control valves have on a few occasions failed to actuate properly. Since there is no feedback from the valve position microswitches to the control system (except for indicator lights), the system will continue to operate. The main problem has been with the valves on the return side of the storage tanks. These valves, when they are slow to operate or stick, can allow water to be transferred from one tank to another. The tanks will not overflow since they are not kept completely full, and the tanks can not be lowered below the immersed level of the storage tank pumps. If a mis-balance of levels between the tanks occurs, it is necessary to manually rebalance them. If there were an interconnecting pipe between the storage tanks, no problems would occur. Because of the construction of the tank, however, it is not feasible to add this feature.

On a number of cold mornings the classrooms were not receiving heat due to a blown circuit breaker on the 115V. line to the classroom circulation pumps and convactor fans. It was determined that on these mornings all of the classrooms would demand heat upon switching from night mode to day mode at 7:00 A.M. The resulting surge from the simultaneous starting of all the motors caused the breaker to trip. When the breaker was replaced with one of a slightly higher rating, the system functioned normally.

3. Pumps

In order to provide a net positive suction head for the main collector circulation pump, it was necessary to use an immersion type of pump in each storage tank. The original pumps, manufactured by the Beckett Company were rated for continuous operation in water up to 200°F. However, both pumps failed due to electrical shorts in the pump motor. The cause of the shorts was due to water leakage into the sealed motor assembly. It was decided to switch to a sump pump with the motor out of the water and connected to the impeller by a long shaft.

The sump pump used (Teel Model TE) does not have a sufficiently long shaft for the pump inlet to be located more than a few feet below the water line. Since the tank becomes mixed after a short period of pumping, little efficiency is lost by pumping from the top of the tank. Since the sump pumps were installed they have operated satisfactorily with no problems.

The classroom circulation pumps have operated with no maintenance since their installation.

The main collector circulation pump (Bell and Gossett Model 1522, 1 h.p.) has also operated with no problems except for some shaft slippage due to the loosening of the set screw for the shaft key. The set screw was re-tightened and a thread locking compound was used to prevent further loosening.

It should be noted that a drain-down system such as used for the F.H.S. collector requires a pump with sufficient head to deliver water to the top of the collector array. For the F.H.S. system the static head is much larger than the friction head. Thus, if the pump had been sized only on the basis of the friction head at the desired flow rate, it may not have produced enough pressure to raise the water to the level of the collector.

4. Storage Tanks

The two 5500 gallon water storage tanks were adapted for storage purposes from concrete transformer vaults. Initially both tanks leaked. When the tanks were drained and re-sealed, there was still some leakage which appeared at the higher tank temperatures and would diminish as the tank cooled. This indicated that the problems were due to thermal expansion of the concrete walls.

In the spring of 1975, after the heating season was over the tanks were cooled and drained. Cooling was accomplished by operating the collector at night. The tanks were then re-coated, sealed and re-filled. Since that time, there has been little loss of water except when there were leaks in the collector that were not immediately discovered. Some water is lost from evaporation. This evaporation also constitutes a heat loss from storage.

5. Classroom Heat Distribution System

The heat distribution system is composed of two convectors (Young Model CH85) along with a circulating pump and solenoid valve for each of the five classrooms. The purpose of the solenoid valve is to prevent hot water from entering the convector except when there is a demand for heat. This part of the system has operated maintenance free except for one solenoid valve which required the replacement of a leaky seal.

IV. System Performance and Operational Data

A. Collector Performance

1. Performance of the Collector Array

A comparison has been made between the spring 1974 and spring 1976 performance of the collector array. From an examination of the efficiency of the collectors under a variety of conditions, it is possible to draw conclusions about the performance of individual components of the system. In cases where changes in more than one component can produce the same observed change in system performance, it is necessary to examine individual properties of materials. For example, a decrease in either the glazing transmittance or the solar absorptance of the collector coating can produce the same overall loss of efficiency.

Efficiency comparisons should be made under as like conditions as possible. Otherwise, it is possible for external parameters (wind, ambient temperature, insolation) to mask any real changes in system efficiency. The accuracy of the instrumentation used to record system data is also important if small changes in absolute performance are to be determined. For the comparisons of system performance reported here, data were taken only on "clear" days and under moderate wind conditions (5 to 15 m.p.h.). The equipment used to measure the system performance was identical to that used in 1974 with the exception of the collector flowmeter which was changed from a mechanical type with a visual readout to a strain-gauge type of flowmeter with an electrical output that could be recorded on the data-logger.

The method used for taking the data was similar to that recommended by the National Bureau of Standards in their interim report NBSIR 74-635. In this method, data is taken for 15 minute periods under conditions of steady and high insolation (200 Btu/hr-ft^2 minimum) and with a constant inlet temperature.

The latter requirement of constant inlet temperature can only be approximated. Under conditions of high insolation and no load, energy is delivered to the storage tank resulting in an increasing collector inlet temperature. This will have the same effect on collector performance for both time periods under consideration and in any event is expected to be small.

The instantaneous collector efficiency, η , is defined as:

$$\eta = \frac{\dot{m} C_p (T_{in} - T_{out})}{Q_i}$$

where

$\dot{m}$ = flow rate through the collector, lbs/hr-ft²-of-collector

C_p = specific heat of water, Btu/lb-°F

T_{in} = inlet water temperature, °F

T_{out} = outlet water temperature, °F

Q_i = total (direct plus diffuse) insolation on plane of collector, Btu/hr-ft².

For the purposes of calculating $\dot{m}$, the collector area was computed as 23 ft² per collector. This is the active area of the absorber plate. The inlet and outlet temperatures were measured at the pump house so the losses of several hundred feet of pipe are included in the overall performance.

The most useful way of correlating the data is by use of the Hottel-Whillier-Bliss model of flat plate solar collector performance. In this model the collector efficiency is given by:

$$\eta = F_R [\alpha_T - U_L (T_{in} - T_{amb})/Q_i]$$

- F_R - collector heat removal efficiency factor
- α - solar absorptance of the coating
- τ - solar transmittance of the glazing
- U_L - collector heat loss coefficient, $\text{Btu/hr-ft}^2\text{-}^\circ\text{F}$
- Q_i - insolation on plane of the collector, Btu/hr-ft^2
- T_{in} - inlet temperature to the collector array, $^\circ\text{F}$
- T_{amb} - ambient temperature, $^\circ\text{F}$

For most flat-plate collectors, a plot of η vs. $(T_{in}-T_{amb})/Q_i$ will result in a straight line. The intercept of the line with the η axis will give $F_R\alpha\tau$. The slope of the line gives F_RU_L .

The data from the spring 1976 efficiency tests are presented in Figure IV-1 along with data taken from the final report covering the installation and initial operation of the system (NSF-RA-N-74-019). From this figure it appears that the system efficiency has decreased by approximately 10%. From the trend of the data, it appears that a reduction in $F_R\alpha\tau$ is responsible for most of the change.

The known properties of glass would tend to rule out a change in the transmittance of the glazing due to changes in its material properties. There are, however two external factors, dirt and condensation, which can effect a change in the glazing transmittance. Previous studies have shown that the effects of dirt are small (1%-2%) as long as there has been some precipitation to keep it clean. Visual inspection of the glass did not reveal any significant accumulation of dirt either on the outside or inside of the glazing. Thus, it is probable that there would be very little difference in the transmittance reduction due to dirt between 1974 and 1976. The number of panels showing moisture condensation was low and thus could not make a significant reduction in overall transmittance.

Figure IV-1: Performance Comparison Between Spring 1974 and Spring 1976

From the visual appearance of the collector array, it would appear that a reduction in coating absorptance would be the major factor in loss of performance. A large variation in the darkness of the absorber plate is quite evident. Some of the panels are a light gray color, while others have a chocolate brown appearance. None of the panels look black. However, over half of the energy contained in the solar spectrum is at wavelengths to which the human eye is not sensitive. It is thus quite difficult to make even a qualitative estimation of solar absorptivity by visual techniques. To obtain a quantitative measure of solar absorptance, a reflectometer was purchased. The results of tests made on various coatings are presented in a following section.

It should be noted that the panels were not of a uniform color when originally installed. From examinations of color photographs taken in the spring of 1974, it has been determined that the relative appearance of the panels has not changed. The panels that appear to be light in color now were also relatively lighter in color two years ago.

The second possibility that must be considered as a possible cause of lower efficiency is a reduction in the collector heat removal efficiency, F_R . The factor, F_R , depends on the flow rate through the collector, its heat loss coefficient and the construction of the absorber plate (spacing of flow tubes, thickness and thermal conductivity of the plate). In an array of identical collectors, the value of F_R will depend upon the flow distribution.

The F.H.S. collector has 35 vertical rows, each row being composed of 3 collectors plumbed in series. The rows are plumbed in parallel and are fed by 2" headers running the length of the array. Normally, to ensure balanced flow, a reverse return piping arrangement is used with the inlet and outlet being on diagonally opposite corners. In the F.H.S. system, flowmeters were installed on

each row so the rows could be individually balanced. With the use of this method of flow balancing, reverse return piping was not necessary. An unbalanced piping arrangement was instead used with the inlet and outlet to the collector array being on the same side.

When the flowmeters were removed because of the freezing problems discussed earlier, the system became unbalanced. It was determined that collector rows furthest from the inlet and outlet were receiving very little flow. This was indicated by high outlet temperatures as determined with a surface temperature probe. The effect of this is to cause some of the collector rows to operate at higher average plate temperatures than others and thus at lower efficiency. The collectors on the end closest to the inlet will have a higher flow rate than before and an increase in efficiency. Due to the exponential variation of F_R with flowrate, this increase in efficiency will not compensate for the loss in efficiency due to a corresponding drop in flow.

In Figure IV-2 the calculated variation of F_R with flow is shown. The nominal flowrate for the collector array is 47 g.p.m., corresponding to a flow of 9.8 lbs/hr-ft^2 of collector area. In calculating the curve a collector loss coefficient, U_L , of $0.6 \text{ Btu/hr-ft}^2\text{-}^\circ\text{F}$ was used. From the curve it is seen that a drop in flow to 3 lbs/hr-ft^2 will lead to a drop in F_R and thus in efficiency. A doubling or tripling of the flow from the nominal value results in little gain in efficiency.

The data in Figure IV-1 do not cover a wide enough range of the collector fluid parameter, $(T_{in} - T_{amb})/Q_i$, to obtain an accurate value of the slope of the data or $F_R U_L$. There does appear to be no significant change in the slope and thus little change in U_L (assuming that F_R has not changed greatly). The collector heat loss coefficient is not expected to change unless the emittance, ϵ , of the selective coating changes or unless there are other factors such as wet insulation behind the absorber plate. Because the selective coating is not highly

Figure IV-2: Variation of F_R with Collector Flow Rate

selective ($\alpha/\epsilon \approx 2.5$, $\epsilon \approx 0.3-0.35$) a double glazed configuration was used for the collector. With a double glazed collector, small changes in ϵ (10-15%) will not produce large changes in U_L . Such changes are best determined by testing the emittance properties of the coating itself.

The conclusions drawn from the comparison of 1974 and 1976 solar collector performances are:

- there has been a real decrease in performance of 10% to 15% when operating under normal values of insolation, inlet temperature and ambient temperature.
- the loss in efficiency is probably due to a number of factors, the most likely being a decrease in the solar absorptance of the coating and a decrease in F_R due to flow imbalances.
- collector performance testing is useful for revealing the long-term changes in the properties of materials used in collector construction.

2. Performance of Individual Collectors

The performance of a number of individual collectors was measured during the spring and summer of 1975. The method used to determine collector efficiency was the same as that described in the preceding section. In addition to the efficiency measurements, data were acquired on the dry plate (stagnation) temperatures attained by the collectors.

The dry plate temperature is useful as an indicator of collector efficiency, and also as an aid in determining the conditions to which the materials in the

collector will be exposed. From the variation of dry plate temperature with insolation (as when a cloud obscures the sun), an estimate of the thermal capacitance can be obtained. The efficiency plots are given in Figures IV-3 and IV-4. The variation of dry plate temperature, insolation and ambient temperature is shown in Figures IV-5 through IV-7. The raw data used to derive these figures as well as additional data are given in Appendix D, contained in a separate volume.

The efficiency of the individual ITC collector is seen to be very similar to that of the collector array. The plots of dry plate temperature show that the collectors spend an appreciable part of the day at temperatures around 300°F. The thermal capacitance of the collectors is sufficient to smooth out the very rapid fluctuations caused by clouds.

3. Selective Coating

The selective coating used on the absorber plates of the F.H.S. collector was applied by the Alcoa Technical Center, New Kensington, Pennsylvania. The commercial designation of the coating is the Alcoa 655 process. The absorber plates that were coated were manufactured by the "Roll-Bond" process using type 1100 (commercially pure) aluminum. Aluminum absorber plates were chosen because of their cost and because they could be delivered in time to meet the construction schedule.

While the exact nature of the 655 process remains proprietary to Alcoa, some details are known. The coating is produced by the action of a weak alkaline solution which contains borates and silicates. The overall processing time is approximately one hour. A number of plates can be processed simultaneously. The coating thickness is less than one micron, and it is composed mainly of aluminum oxide. Typical values of α and ϵ are 0.93 and 0.35.

Figure IV-3
Comparison of 1-Tedlar and ITC Collectors

Figure IV-4
Comparison of 2-Tedlar and ITC Collectors

Eastern Daylight Saving Time
 Figure IV-5
 Dry Plate Temperature for 1-Kalwall Cover and ITC Collector at 13° for
 July 26, 1975.

Figure IV-6
Dry plate temperature data for the ITC and single Tedlar collectors for 14 June 1975.

Figure IV-7
Dry plate temperature data for the ITC and double Tedlar collectors for 23 June 1975

The F.H.S. system represents the first large scale use of the Alcoa coating. It is of interest to study the effects of over two years of exposure of the coating to a wide variety of operating conditions including many hours of dry plate (or stagnation) temperatures. While the 655 coating does not have the best optical properties of the selective coatings available today, it is still the least expensive selective coating that can be applied to aluminum absorber plates.

Unfortunately, no α and ϵ measurements exist for the absorber plates as they were installed in the F.H.S. collector. Therefore, a before and after comparison cannot be made. Overall collector efficiency comparisons can be made, however, and these were discussed in a previous section. Since the efficiency comparisons indicated a possible decrease in solar absorptance, it was felt that a measure of the absorptance of some panels would be useful.

Measurements were made of the absorptance of two samples taken from plates removed after approximately one year of service. The visual appearance of these samples was light brown and gray respectively. A reflectometer purchased from the Willey Corporation was used to make the measurements. This instrument (called the "Alpha-Meter") utilizes a slide projector for a light source and a silicon cell for a photo-detector. Because of the spectral characteristics of the light source and the silicon cell, the instrument will give a true solar absorptance only for those coatings which have a uniform absorption over the entire solar spectrum. For the samples that were measured, the error in the absorptance is estimated at $\pm 3\%$.

The absorptances of other coatings were also determined and these measurements are shown in Table IV-1 along with those of the F.H.S. samples.

Approximately one third of the collector plates of the F.H.S. system have visual appearances similar to those of F.H.S. samples #1 and #2. If the rest of the collector array is assumed to have an average absorptance of 0.90, then the weighed absorptance for the collector array is:

$$\text{Absorptance of array} \approx 2/3 \times 0.90 + 1/3 \times 0.75 = 0.85$$

The average absorptance of the lighter colored panels has been taken to be 0.75 based on the measurements in Table IV-1.

An average loss of absorptance of 5% would agree with results obtained by Alcoa on samples subjected to temperatures of 300°F or higher. The F.H.S. collector plates will reach temperatures in excess of 300°F on any warm, sunny day with no fluid flow. Because of no demand for heat, the collectors run dry all summer. It thus appears that after two summers the coating absorptance has degraded to the point of causing a measurable decrease in performance. From data reported by Alcoa, the emittance of the coating does not appreciably change and may even improve after heat treatment. This agrees with our finding of little change in the collector heat loss coefficient.

4. Absorber Plates

The absorber plates used for the Fauquier High School collector were manufactured by the Olin Brass Corporation, East Alton, Illinois. The panels were made of type 1100 aluminum by the "Roll-Bond" process. The flow pattern used for the plates is considered proprietary to ITC. A chemical formulation based on sodium chromate is used in the storage tank water to inhibit corrosion in the system.

The long-term reliability of aluminum collector panels in solar systems is not well known. Such information is needed in view of the very favorable cost/performance advantages of using aluminum. The F.H.S. system is a good example of

TABLE IV-1
ABSORPTANCE MEASUREMENTS

<u>Sample</u>	<u>Absorptance</u>	<u>Comments</u>
F.H.S. #1	0.77	Light brown appearance
F.H.S. #2	0.72	Light grey appearance
Alcoa 655	0.94	F.H.S. panel reprocessed by Alcoa
Copper Oxide	0.88	Sample furnished by Enthone, Inc.
"Solarchrome"	0.95	Black chrome sample furnished by Corillum, Inc.
3M-Black Velvet	0.98	Non-selective paint
Krylon Ultra-Flat Black	0.97	Non-selective paint

a multi-metal solar system with aluminum, steel, copper and brass in contact with the water transfer fluid. To prevent galvanic corrosion, dielectric couplings are used where dissimilar metals are joined.

In two instances absorber plates have failed due to corrosive attack. The dates of failure were October 31, 1974 and March 5, 1976. The failures occurred near the inlet of the middle collector in Rows 16 and 4 respectively. The Row 16 failure consisted of a small hole at the point just above where the inlet nipple is welded to the absorber plate. The Row 4 failure was in the inlet nipple itself. Both plates were removed and the failed sections sent to Olin Brass for analysis.

The reports from Olin are included as Appendix B. For both reports the conclusion was that the corrosion originated from the exterior of the absorber plate. No corrosion products were found on the inside of the plates. Since both rows had been leaking prior to the failures, it is suspected that the presence of water in the bottom of the collector box caused the corrosion to start.

From an examination of the water flow passages in other sections of the two plates, it appears that no corrosion is taking place and that the inhibitor has produced a smooth film on the aluminum.

B. Insolation Data

1. Description of Data Collection System

When the F.H.S. system was installed, two pyranometers were purchased and mounted horizontally and at the 53° tilt angle of the collector array. The pyranometers were obtained from the Hy-Cal Engineering Company (Model P-8405).

In 1975 four additional pyranometers of the same Model as above were purchased and mounted at various tilt angles. This brought the number of pyranometer angles to six. These are: 0° (horizontal), 16° , 28° , 40° , 53° , and 62° . Data from the pyranometers were accumulated on a Tracor multi-point recorder. The recorder plots were integrated by hand using a planimeter. The integrated areas were converted to engineering units using the pyranometer calibrations furnished by the manufacturer.

In Appendix C, insolation data are presented for the months of February 1975 through mid-April 1976. In some cases data are not available due to equipment malfunction or snow covering the pyranometers. There are no data for the month of September 1975. The data are presented as daily totals for the six angles and as hour-by-hour values for the 53° tilt angle of the collector.

In the summer of 1976 the accuracy of some of the pyranometers was checked against a recently purchased Eppley Model PSP. Both the Hy-Cal pyranometers tested read low in comparison with the Eppley. The Hy-Cal pyranometers (0° and 53°) were consistent with each other to within 3%. In comparison with the Eppley they were about 15% low.

The Hy-Cal pyranometer used at 0° was taken to the Smithsonian Radiation Laboratory where it was checked against their standard (also an Eppley PSP). It was found to read low by 13% in agreement with the ITC measurements. The deviation between the Hy-Cal and Eppley pyranometer readings is not constant but depends on the sun angle, ratio of direct to diffuse insolation and ambient temperature. There may also be variations due to wind speed since the Hy-Cal P-8405 has a single glass dome while the Eppley has a double dome. Since the exact cause of the Hy-Cal calibration discrepancy has not been determined, the insolation data in Appendix C are presented "as is" with no correction factor applied.

Appendix A

Control System Specifications

ITC SPECIFICATION SCS-1001-010575

SOLAR CONTROL SYSTEM

REVISED 23 JULY 1975

- 1.0 Scope - This specification is intended to provide the performance requirements for the design, fabrication, assembly, installation and testing of an electronic controller which is capable of performing the various functions necessary in the operation of the Fauquier High School Solar Heating System. The requirements are described below in both prose and tabular form, either one being sufficient for constructing the other.
- 2.0 Background
- 2.1 The system consists of a solar collector array, thermal storage and heating capacity for five detached classrooms at the Fauquier High School in Warrenton, Virginia. Thermal storage for the system is accomplished via two 5,500 gallon tanks of water. Operation of the system is keyed to the relative temperatures of the collector, storage tanks and classrooms. Continuous monitoring of these temperature relationships permits several modes of operation in which the water is selectively routed through the system by activating various pumps and valves.
- 2.2 Recent modification of plumbing configuration to allow for greater flexibility of operation requires that a new controller be procured, since the old controller is incompatible with the new system. Also, it is desired that the new controller demonstrate a higher degree of reliability than the old system. Accordingly, the primary design emphasis should be placed on operational performance, reliability and maintainability, in that order.

3.0 Description

- 3.1 A detailed description and schematic diagram of the old system are contained in ITC Report No. 090974, dated 4 December 1974, Solar Energy School Heating Augmentation Experiment, Design Construction and Initial Operation. The modified plumbing configuration and temperature control points are schematically represented in Figure 1.
- 3.2 The controller will be capable of monitoring a number of input temperatures and differences in temperature from temperature control points. Based on these inputs, the controller will logically determine which combination of electromechanical devices (pumps, valves, etc.) should be activated. The system will be capable of fully automatic operation unless overridden by manual control. The manual control mode will provide the means for individually activating any valve or pump via the System Status Display Board which contains status lamps and toggle switches for each controllable device, arranged in a manner that depicts the system configuration schematically.

4.0 System Requirements.

- 4.1 General -The general requirements for daytime and nighttime controller operation are summarized in this section. For this section "daytime" and "nighttime" are defined as follows: "daytime" is defined as the period of time beginning one hour before the normal school starting time and ending at school closing time during any school day. All other times are considered to be "nighttime", including weekends and holidays.

4.2 Operation.

- 4.2.1 The general principles governing the decisional logic are as follows:
- 4.2.1.1 For most efficient collection, the cooler tank is circulated to the collector;
- 4.2.1.2 For quickest space heating during "daytime" operation when the room is occupied, the warmer tank circulates to space;

- 4.2.1.3 During "nighttime" when the room is not occupied the lower grade heat in the lower temperature tank is consumed which prepares that tank for more efficient collection during "daytime".
- 4.2.1.4 These general principles apply as long as at least one tank is above a threshold temperature for effective space heating, which threshold is higher for the "daytime" than for the "nighttime" mode. When both tanks are at temperatures less than this threshold, the warmer tank is circulated to the collector on demand, and only then is a space demand responded to. These thresholds are set at 21°C (70°F) and 38°C (100°F), for "night" and "day", respectively.
- 4.2.2 Three simultaneous conditions trigger collector demand for water circulation.
- 4.2.2.1 No water is circulated to the collector from a tank with temperature above an upper limit at which it is no longer necessary to collect heat. Thus, to respond to collector demand at least one tank must have temperature below this limit, which is set at 82°C (180°F).
- 4.2.2.2 Since there is little benefit in circulating cooler water through a warmer collector when that temperature difference is due only to ambient temperature (for instance on a warm day with low insolation), it is necessary to discriminate for insolation heating of the collector. This threshold insolation query can be implemented by requiring collector temperature to be greater than ambient, by a certain amount. (The exact temperature difference in deciding to initiate flow would be set optimally by comparison, through the energies involved, to the temperature difference between tank outlet and return). In view of the small increase in heat collection to be gained, this temperature difference $\Delta 1$ is set at 22°C (40°F).
- 4.2.2.3 The third simultaneous test for initiating flow is the relative temperature difference $\Delta 2$ between the collector and the supply tank, which is the cooler tank except where both tanks are below threshold. **For circula-**

tion, the collector must be the hotter by an amount variable between 6°C (10°F) and 28°C (50°F) in increments of 6°C (10°F).

4.2.3 After collector flow is initiated by these conditions, it is halted when:

4.2.3.1 Both tank temperatures are above 82°C (180°F) or,

4.2.3.2 The temperature increase between the tank outlet and return approaches some small value of marginal benefit. This is set at $\Delta 3 = 1.0^{\circ}\text{C}$ (2°F) to 5°C (9°F) in adjustable increments of 1.0°C (2°F). A 0.6°C (1°F) rise with system flow corresponds to storing at a rate of approximately 4 Btu/sec or 4 kw, and this flow is driven by 1.5 hp or 1 kW. The total tradeoff might occur below 0.3°C (0.5°F). Thus, a control range of 0.1 to 1°C in 0.1°C steps would appear more proper, but circuitry and cost constraints obviate such tight limits. The extra heat that might be collected is in any case a small part of the whole.

4.2.4 Three characteristic time intervals arise in determining desired response to changes in the operating conditions envisioned above.

4.2.4.1 When the space thermostat is activated and demands heat, it shall be supplied immediately. ($\Delta\tau_1 = 0^m$).

4.2.4.2 Collector demand shall be responded to within a longer time interval on determination of some stability of the condition. For the system to accommodate dynamic operation characteristics such as intermittent cloud cover and temperature equilibration of piping with circulating water, it is required that the collector not be involved in a mode change until all input parameters to collector demand have remained static for a specified interval of time. This time interval shall be easily changed in 5 minute increments from an interval of 5 minutes to an interval of 60 minutes. If any inconsistency arises in four evenly spaced samples in the interval, then the period for change verification shall be restarted as of the time of that inconsistency. ($\Delta\tau_2 = 5 \rightarrow 60^m$).

- 4.2.4.3 The third characteristic time involves the decision to switch tanks when supplying either space or collector because of change of their temperatures. Since their rate of temperature change is typically 10°C per 10 hours, and because the difference in efficiency of space heating or of heat collection is insignificant over a water temperature interval of a few degrees, it is not necessary to change often between tanks. Because tank temperature changes slowly and because temperatures are rounded to 10°C for logic decisions, there is an intrinsic delay of perhaps one hour in switching tanks. Thus, an additional delay of 0 to 3 hours in 1 hour increments shall be incorporated, ($\Delta\tau_3 = 0 \rightarrow 3^h$).
- 4.2.5 An important additional requirement is that when the collector demand ceases, the circulating water shall drain back into the tank from which it came. This will automatically happen if the logic of Table I is implemented, including the "no change" entries, except for V3 and V4 during transitions from states A to S and B to P respectively. As indicated in the table, these require a temporary value of 1 during the period required for drainage. This transient valve position does not interfere with continuing response to space demand, but it is necessary that the drain period be shorter than the verification period $\Delta\tau_2$ for collector turn-on given in section 4.2.4.2. This drainage period $\Delta\tau_4$ shall range from 5 to 9 minutes in one minute increments, ($\Delta\tau_4 = 5 \rightarrow 9^m$). The temperature limits and time delays given in the above paragraphs are summarized in Table III.
- 4.2.6 Provision shall be incorporated for manually bypassing either of the storage tanks by selector switch so that either tank may be in effect "removed from the system". The method of system operation in this single tank mode shall be essentially the same as the requirements outlined above.
- 4.2.7 It is desired that the controller be designed to minimize any non-essential electromechanical cycling and to also minimize power requirements.

- 4.2.8 These general statements of operating principles are realized by the logic circuit properties indicated in Tables I and II. The temperature differences $\Delta 1$ and $\Delta 2$ of Table II have been set at above 22°C (40°F) and at 6°C (10°F) to 28°C (50°F), respectively.
- 4.3 Electrical
- 4.3.1 In order to provide the maximum degree of reliability, the controller will be of all solid-state design using plug-in components or modules wherever possible.
- 4.3.2 Use of electromechanical components such as relays is discouraged. Specific test points and self-test features shall be provided to the greatest extent practicable to facilitate testing and maintenance. Switching of AC voltages shall be done using solid-state relays employing synchronous/zero voltage turn-on that are capable of handling AC loads presented by the existing pumps and valves. It should be noted that once voltage has been applied to a motorized valve, this voltage must be maintained (latched) until the valve has completed its cycle.
- 4.3.3 It is desired that all numerical displays and indicators, as provided, be solid-state devices, e.g. light-emitting diodes (LED's). Provision shall be made for simultaneously illuminating all indicators as an independent "lamp test" mode.
- 4.3.4 In the event of a power failure, the system shall restore itself automatically to the previous operating mode when power is re-applied. The controller will not require any specific sequence of events in applying/removing power from the system.
- 4.3.5 The proposed controller shall utilize a time-of-day clock. It shall be provided with a numerical readout device, and be capable of being easily reset. Battery operation shall also be provided to power the clock during power outages.

- 4.3.6 To ensure that circulating water does not freeze in the collector, due to any unexpected condition an independent temperature sensor and thermostatic control will interrupt power to P3 and to VS10 whenever collector temperature drops below 40°F.
- 4.4 Mechanical
- 4.4.1 The controller will be constructed to provide ease of maintenance, accessibility and replacement of all modules and parts. All controls will be marked and located in such manner that the control position can be readily identified. It is desired that the controller be mounted within a standard, wall-mounted type, NEMA-12 enclosure. All exposed metal parts that are subject to rusting will be finished with some type of protective coating.
- 4.5 Display Board Interface (DELETED)
- 4.5.1 All valve and pump control signal outputs from the controller shall be compatible with the existing display board, which will be revised to reflect the modified plumbing schematic of Figure 1.
- DELETED 4.5.2 In addition, in the "Manual" mode of system operation, all valves and pumps shall be individually controllable from the existing switches and indicator lamps in the modified display board.
- DELETED 4.5.2 In addition, in the "Manual" mode of system operation, all valves and pumps shall be individually controllable from the existing switches and indicator lamps in the modified display board.
- 4.6 Environmental
- 4.6.1 The controller will be required to operate satisfactorily over an ambient temperature range of 0°F to 160°F at level of relative humidity up to 95%.
- 4.7 Documentation
- 4.7.1 The supplier will furnish, as a minimum, a system manual which includes detailed operating instructions for the controller, a description of the various modes of operation, maintenance procedures, logic diagrams, wiring diagrams, and applicable schematics. Also to be included in the manual are a list of materials and part location diagrams. The manual will be delivered at the time of equipment installation. Any changes

7/23/75

to the equipment made necessary as a result of the installation will be furnished by the supplier in the form of revisions of the manual. A complete set of drawings defining the equipment shall be furnished by the seller. The drawings shall meet as a minimum requirement the following industrial standards:

USAS Y 32.16-1968	Reference designations for electric and electronic parts and equipment.
USAS Y14.15-1966	Electrical and electronic diagrams.
USAS Y32.2-1967	Electrical and electronic diagrams, graphic symbols for
USAS Y32.14-1962	Logic diagrams, graphic symbols for

4.8 Installation and Testing

- 4.8.1 The supplier will furnish, no later than 30 days prior to starting the installation, a proposed installation schedule and a list of equipment and/or services required of ITC prior to or during the installation period. The supplier will also furnish at this time a proposed plan for demonstrating compliance with this Definition of Requirements.

5.0 Additional Conditions

- 5.1 To the extent that the detailed system description contained in Tables I and II of this specification fails to be compatible with the operating principles stated in prose form, or in the event that the detailed description fails to be compatible with the constraints of system hardware, resulting in system malfunction, the contractor assumes full responsibility for informing ITC of such inconsistencies prior to contract agreement, and of his intent to modify circuitry to realize the system generally described.

The technical considerations stated in the Roburn Corporation letter to InterTechnology Corporation dated July 17, 1975 constitute a part of this specification. This letter is furnished as an appendix.

7/23/75

6.0 Acceptance

- 6.1 Prior to starting equipment fabrication, the supplier will furnish to ITC the details of his design approach, which may include such things as a sketch of the proposed control panel layout, logic diagrams and flow diagrams, for final approval.

TABLE 1. Properties of automatic control system. A d or n in the mode output denotes 1 during "day" or "night", respectively, and 0, otherwise. An x denotes "no change", and xo denotes "no change" during "day" and "closed" during "night", etc... For V3 and V4 transients, see par. 4.2.5.

Inputs		Mode Outputs		Mode Output Properties	
Case Number	Variable and Function				
0	g = 1 if T1 > T2	A	if=1 T1->coll.->space	V1	Open = 1
1	o = 1 if T1 > threshold	B	if=1 T2->coll.->space	V2	"
2	t = 1 if T2 > threshold	C	if=1 T1->coll.	V3	"
3	c = 1 if Collector demand	D	if=1 T2->coll.	V4	"
4	s = 1 if Space demand	E	if=1 T1->space	V5	"
5		F	if=1 T2->space	V6	"
6		G	if=1 T1->Coll., T2->space	V7	"
7		H	if=1 T1->space, T2->coll.	V8	"
8		I	if=1 Exit	V9	"
9		J	if=1 Manual heat control	V10	VS Power on = shut = 1
10				P1	Power on = 1
11				P2	"
12				P3	"
13				PR	Room Pump "
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					
27					
28					
29					
30					
31					

Table II, Definition of function c, the collector demand variable

Case Number	Inputs				collector demand if = 1
	Variable and Function	if T1 and T2 > 82°C	if TC - TA > ΔT or if P3 = 1	if TC - cool tank > ΔT2 of if P3 = 1	if TR - T0 > ΔT3
0		0	0	0	0
1		0	0	0	1
2		0	0	1	0
3		0	0	1	1
4		0	1	0	0
5		0	1	0	1
6		0	1	1	0
7		0	1	1	1
8		1	0	0	0
9		1	0	0	1
10		1	0	1	0
11		1	0	1	1
12		1	1	0	0
13		1	1	0	1
14		1	1	1	0
15		1	1	1	1

12/1/75

TABLE III

<u>Spec Paragraph</u>	<u>Symbol</u>	<u>Condition</u>
<u>To Start Collector</u>		
4.2.2.1	T1	Tank 1 Less than 82°C (180°F)
4.2.2.1	T2	Tank 2 Less than 82°C (180°F)
4.2.2.2	$\Delta 1$	$(TC-TA)^* > 22^\circ C (40^\circ F)$
4.2.2.3	$\Delta 2$	One tank > threshold $(TC-T_{\text{cooler tank}}) > \begin{cases} 6^\circ C \rightarrow 30^\circ C \\ \text{in } 6^\circ \text{ steps} \end{cases}$ Both tanks < threshold $(TC-T_{\text{warmer tank}}) > \begin{cases} 10^\circ F \rightarrow 54^\circ F \\ \text{in } 11^\circ \text{ steps} \end{cases}$
<u>To Stop Collector</u>		
4.2.3.1	T1	Tank 1 Greater than 82°C (180°F)
4.2.3.1	and T2	Tank 2 Greater than 82°C (180°F)
4.2.3.2	$\Delta 3$	$(TR-T_O)^* \leq 0.6^\circ C \rightarrow 3^\circ C$ in 0.60 steps) $(1.0^\circ F \rightarrow 5^\circ F$ in 1.00 steps)
<u>Mode Criteria</u>		
4.2.1.4	T1	Tank 1 Greater than 21°C "night" (70°F)
4.2.1.4	T1	Tank 1 Greater than 38°C "day" (100°F)
4.2.1.4	T2	Tank 2 Greater than 21°C "night" (70°F)
4.2.1.4	T2	Tank 2 Greater than 38°C "day" (100°F)
<u>Time Intervals</u>		
4.2.4.1	$\Delta \tau 1$	Space demand = 0 ^m
4.2.4.2	$\Delta \tau 2$	Collector Status change 5 ^m → 60 ^m in 5 ^m steps.
4.2.4.3	$\Delta \tau 3$	Tank Switching 0 ^h → 3 ^h in 1 ^h steps.
4.2.5	$\Delta \tau 4$	Collector drain hold period 5 ^m → 9 ^m in 1 ^m steps.
*TC	Collector Dry-Plate Temperature	
TA	Ambient Temperature	
TR	Return Temperature (to tanks)	
TO	Outlet Temperature (from tanks)	

7/23/75

ROBURN CORPORATION

3432 BROOKWOOD DRIVE
FAIRFAX, VIRGINIA 22030

July 17, 1975

Mr. Norris L. Beard
Director of Marketing
InterTechnology Corporation

Sir:

In response to your request for quotation, the ammended specification (draft) of 10 July 1975 and following our discussions with your people, Roburn has arrived at the following quotation.

Specifications:

Temperature Measurement:

0 to 99°C, $\pm 1.5^\circ\text{C}$ error band max for linearity plus tolerance

System clock:

Real time, battery backup, ± 25 parts per million. Clock provides for setting day/night division plus holiday/normal divisions

Temperature Delta:

The following delta sets are provided for system purposes

T1 30°C in 6°C increments

T2 5°C in 1°C steps

T3 22°C fixed

Temperature Set Points:

The following temperature set points are provided for in system operation

T1 = 4.0°C

T2 = 21.0°C

T3 = 38.0°C

T4 = 82.0°C

Time Deltas:

The following time increments are provided for in system operation

- TM-1 0 to 3 hours in 1 hour increments
- TM-2 5 to 60 minutes in 5 minute increments
- TM-3 5 to 9 minutes in 1 minute increments

Temperature Measurement Points:

Temperature shall be measured at the following system points

- Collector-surface mounted unit to one cell (under surface)
- Return-return line unit mounted at entrance to tank area in common line
- Tank-tank 1 and tank 2 mounted internal to each tank on the tank wall 1/3 down from the top

System Logic:

The system shall be configured for each mode of operation according to table 1 and table 11 of the specification. The system programming shall be according to these tables for automatic operation only. If a particular tank is inhibited for a given reason (switch actuated) it's commands shall be diverted to the remaining tank.

Status, Display, Manual Panel:

Internal to the controller is mounted a status, display, manual panel to provide for the following:

- (1) Indicating lamps to show which pumps and valves have been opened or closed
- (2) A digital display to indicate time or temperature as selected:
 - a. Temperature to nearest degree
 - b. Time to the nearest 6 minutes
 - c. Manual control switches to manually energize each valve or pumps and a self test switch to allow for testing of certain critical units in the system

Valve and Pump Controllers:

All valve and pump controllers shall be solid state units derated by a nominal of 50%.

Construction:

The unit shall be all solid state where feasible, except for certain manual switch functions. The digital unit shall be primarily of wire wrap construction using sockets for plug in components. The analog portion shall be p.c. board construction and encapsulated. All long lines shall employ EIA-RS-232C type transmitters and receivers for noise immunity.

All housings shall be of NEMA 3 and NEMA 12 type units and all exposed metal parts shall be appropriately finished for fungus and humidity. All wiring external to the cases shall use the appropriately rated cables per NFPA, volume 5, where required.

Acceptance Test:

Acceptance test shall be performed on ITC/Fauquire High School premises. Temperatures shall be simulated by using resistance boxes and also stimulated by application of heat and cold.

Deliverable Items:

(1) Main Controller:

NEMA 12 case - contains power supplies, logic unit, system clock, status-display-manual panel and temperature time set switches

(2) Temperature Units:

NEMA 3 case - contains analog to digital conversion circuits for temperature sensors

(3) Pump - Valve Units:

NEMA 3 case - contains solid state switches for driving valves and pumps

(4) Cabling:

Necessary cables and connectors to route signals through the system

(5) Drawings:

Engineering sketches and parts lists as required for repair and maintenance

(6) Manual:

Contains descriptions as to theory of system operation and calibration procedures as necessary

(7) Installation:

Two man days of engineering to assist in installation and acceptance test

Scheduling Milestones:

- (1) Third week after ARO design review and subsequent release of all P.O.'s and fabrication drawings
- (2) Sixth week after ARO installation instructions and drawings
- (3) Ninth week after ARO - items 1 thru 6

Note: 3 above is based on parts delivery information acquired during bid preparation

Terms of Payment:

40% on contract initiation

30% at 30 days following design review

30% at final installation and acceptance testing

Cost:

Total cost including latest modification is \$4990.00

This quote is valid for 30 days.

William H. Reading III
President
Roburn Corporation

InterTechnology Corporation

InterTechnology Corporation

WHR/br
c.c. Ted Collins

Appendix B

Analysis of Corroded Absorber Plates

SOMERS THIN STRIP

S. H. Butt, Director
Market Research and Planning
Phone: 258-2770

July 9, 1975

Mr. Norris L. Beard
Director, Marketing
InterTechnology Corporation
Box 340
Warrenton, Virginia 22186

Dear Mr. Beard:

Our Research Laboratory has completed their examination of the failed piece of aluminum ROLL-BOND[®] which you sent to Jack Barton on May 16.

It is our general conclusion that galvanic corrosion occurred from the outside of the panel, probably as the result of the outer surface of the panel being in contact with iron. A projecting nail is a likely suspect. Examination of the inside surface of the panel indicates no sign of interior corrosion. More detail quoted from our Research Laboratory's report follows:

"Figure 1 is a photograph of the section you sent us showing the large hole close to the weld. The diameter of the hole was around 0.25 inches. The metal on the outside of the plate adjacent to the hole had also undergone considerable attack and was covered with corrosion products. This is clearly seen in Figure 2 which shows the hole at a low magnification of 5X. On looking down through the hole, no evidence of corrosion could be seen on the opposite inside surface indicating that attack had been from the outside. This is confirmed by Figure 3 which shows a micrograph of a cross-section of the plate taken at the edge of the hole. Severe attack of the alloy can be seen on the outer surface close to the hole edge. No surface attack has, however, occurred on the inside of the tube.

"Figure 4 shows a scanning electron micrograph of the corrosion product around the hole. Some regions of this tended to charge up during examination, indicating the presence of aluminum oxides which have very low electrical conductivity. Figure 5 shows X-ray energy spectra taken at two different locations on the corrosion product. Naturally Al shows the highest intensity and this is followed by Cr, Si, Ca, Fe, K and a trace of sulfur. X-ray diffraction of the corrosion

product indicated the presence of Boehmite.

"Figure 6a shows a scanning electron micrograph of the internal surface of the tube close to the pit, showing the fine detail of the thin scale present. The scale is mostly smooth but also contains some thicker regions. In addition, some white particles can be seen. Figure 6b shows X-ray energy spectra taken from this area. The aluminum peaks are high and, except for spectrum number 2, fall off the micrograph. This was done intentionally in order to reveal the small peaks corresponding to the other elements. Spectrum number 2 shows that the particle contains Al and Si at similar levels and is, therefore, particulate matter and not an integral part of the scale. The other spectra indicate the presence of Si, Cr, Ca and Fe, together with traces of Ti and Mg which are likely present in the alloy. X-ray diffraction studies revealed the presence of calcite, CaCO_3 , which accounts for the Ca. The Si is present in small particulate matter. The presence of Cr is indicative that a chromate inhibitor was used in the system. Obviously, from the very nature of the defect, leakage must have occurred and this explains the presence of Cr in the corrosion product on the outside of the panel around the hole.

"The most significant finding is the presence of Fe. This tends to support your first theory as to the cause of failure which you related to me during my visit to East Alton. This was that the panel had been resting against a nail head. This would certainly account for the presence of Fe in the corrosion product surrounding the hole. Once a hole had been formed, then one would also expect to see Fe inside the tube close to the hole, as was in fact observed.

"During service, the aluminum adjacent to the nail head was likely acting as a sacrificial anode to protect the nail from corrosion in the cell, Al/water(moisture)/Fe. Once penetration had occurred, the rate of dissolution of the Al would doubtless increase because of the greater availability of water. This theory could also explain why the failure was not detected at an early date. It is highly unlikely that water could have been flowing freely from the hole without it being detected. A likely happening is that the nail head acted as a plug in the hole, thus preventing a high rate of leakage until the diameter of the hole exceeded that of the nail head.

"Apparently some leakage did occur and was responsible for the other small regions on the panel where corrosion had occurred, and which can be seen in Figure 1, because the corrosion product in these areas contain Fe and Cr. These were detected by electron probe microanalysis. Figure 7 shows X-ray energy spectra taken from three such regions. An interesting point here is that chlorine (as chloride) was also detected in the corrosion product in these regions, although it

Mr. Norris L. Beard
InterTechnology Corporation
Warrenton, Virginia 22186

July 9, 1975
Page 3.

was not seen in the corrosion product surrounding the hole. It is possible that the water leached chlorides out of the insulating backing which the panel rested on.

"Close examination of the inside of the collector plate at several locations revealed that no corrosion had occurred during the time it was in service."

As you will note, I am sending a copy of this letter to Dr. Szego for his information. However, the copy going to Dr. Szego does not include the various photographs since we only had one set of these available. If you or Dr. Szego have any question or comment concerning our Laboratory's analysis, please let me know and we will try to respond further.

Very truly yours,

S. H. BUTT, Director
Market Research and Planning

/crc
enc.

cc/Dr. George C. Szego
InterTechnology Corporation
Box 340
Warrenton, Virginia 22186

Figure 1: Section of solar collector plate.

Figure 2: Optical micrograph of hole and corrosion products.

Magnification = 5X

Exterior

Hole

Interior

Figure 3: Cross section of metal adjacent to hole showing attack on the outside. No attack has occurred on the inside wall.

Magnification = 30X

Figure 4: Scanning electron micrograph of corrosion product adjacent to the hole.

Magnification = 50X

Figure 5: X-ray energy spectra of corrosion product.

Figure 6a: Scanning electron micrograph of interior of metal adjacent to the hole.

Magnification = 500X

Figure 6b: X-ray energy spectra of above region obtained from 1. overall region, 2. white particle, 3. thicker ridge-like area, and 4. uniform layer.

Figure 7: X-ray energy spectra of corrosion product taken from small regions of localized corrosion.

Figure 8: Scanning electron micrograph of selective surface.

Magnification = 1,000X

EAST ALTON, ILLINOIS 62024
AREA CODE 618 - 258-2000

FINEWELD[®] TUBE

May 4, 1976

Mr. William S. McEver
Staff Scientist
Intertechnology Corporation
100 Main Street
Warrenton, Virginia 22186

SUBJECT: Roll-Bond[®] Absorber Corrosion Analysis

Dear Mr. McEver:

The results of our investigation are as follows:

1. Corrosion did indeed originate externally. (See Figure 1)
2. The corroded areas all contain chromium which would be expected in view of the fact that a chromate inhibited water was used as the heat transfer fluid. In addition, analysis of the corroded areas indicates the presence of varying amounts of elements normally associated with natural water such as copper, sulfur, chlorides, sodium, potassium, etc.
3. These (water electrolytes) are concentrated as are the corrosion products on the external portions of the connector tube in the areas directly adjacent to the failure.
4. Analysis of the insulation indicates that it had been saturated with water. (See Figure 2)
5. Mode of failure was crevice corrosion. The water saturated insulation/aluminum surface interface provided a natural crevice. The crevice system is driven by a small anode large cathode relationship.

Based on the above analysis, we believe that the waterlogged insulation was the culprit. A likely candidate would be a leaky hose connection.

If we can be of any further assistance, please feel free to give us a call.

Very truly yours,

M. W. Rupp
Market Development Engineer

/ral

FIGURE 1 --
Photograph of Failed
Inlet Connector Tube

FIGURE 2 --
Photograph of "Water-
logged" Insulation

Appendix C

Insolation Data

Average Hourly Insolation on 53° tilted Surface, Btu/hr - ft², February 1975

Date	Time, Hours									
	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700
	Average Flux, Btu/hr - ft ²									
1	0	2	5	7	10	11	14	6	6	1
2										
3	3	21	48	114	219	198	199	215	152	73
4										
5										
6	5	24	47	105	281	198	105	38	10	3
7	14	62	65	105	209	292	286	247	175	91
8	30	94	182	254	269	271	280	253	187	100
9	2	5	13	21	98	21	115	122	169	88
10	30	86	183	242	269	256	226	118	49	21
11	5	23	83	148	206	200	111	66	16	6
12	0	6	5	10	29	21	42	18	16	62
13	7	92	170	149	254	277	283	240	177	92
14	6	30	104	240	287	266	250	211	144	78
15	5	34	43	79	62	53	195	115	45	14
16	8	29	49	36	29	41	27	14	11	9
17	1	3	6	5	8	8	12	9	5	3
18	3	13	20	16	17	13	11	10	7	5
19	13	46	142	231	207	174	113	182	155	82
20	27	99	180	246	213	229	131	240	179	92
21	35	104	186	247	268	271	250	202	161	97
22	33	97	180	251	278	284	278	247	157	90
23	3	11	6	10	29	55	45	68	53	51
24	2	3	15	31	23	14	17	16	16	3
25	36	103	190	237	298	161	291	250	172	41
26	56	130	211	273	297	299	295	261	198	109
27	7	16	29	76	151	140	118	178	180	98
28	15	70	163	150	81	74	88	207	181	98
Total	346	1203	2325	3283	4092	3827	3782	3533	2621	1407
Monthly Average	13.8	48.1	93.0	131.3	163.7	153.1	151.3	141.3	104.8	56.3

Average Hourly Insolation on 53° tilted surface, Btu/hr-ft², March 1975

Date	Time, Hours									
	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700
	Average Flux, Btu/hr-ft ²									
1	33	74	111	50	154	142	253	268	193	33
2	50	114	61	147	211	225	137	59	57	60
3	17	63	97	96	147	143	82	57	91	43
4	43	118	146	253	288	289	282	250	177	93
5	30	106	188	242	276	282	250	190	162	57
6	25	103	207	254	280	279	200	91	148	97
7	12	30	26	30	14	33	28	23	23	25
8	38	77	58	91	107	88	63	161	53	17
9	47	114	196	254	282	280	279	243	171	96
10	6	17	14	18	24	22	15	14	10	4
11	4	11	25	25	42	36	22	22	16	8
12	3	3	4	10	8	11	21	45	14	7
13	9	21	54	106	69	103	70	28	9	3
14	0	1	5	11	13	11	11	6	8	2
27	--	35	72	61	88	90	57	9	19	5
28	0	16	39	175	190	144	135	35	21	0
29	0	0	18	29	55	49	37	24	17	24
30	0	1	4	8	21	39	107	5	13	15
Total	317	904	1325	1860	2269	2266	2049	1530	1202	589
Monthly Average	18.6	50.2	73.6	103.3	126.1	125.9	113.8	85.0	66.8	32.7

Note - Data logger was out of order from the 15th to 26th. The Strip Chart Recorder was installed on the 27th.

Average Hourly Insolation on 53° Tilted Surface, Btu/hr-ft², April 1975

Date	Time, Hours									
	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700
Average Flux, Btu/hr-ft ²										
1	45	112	184	229	259	264	244	204	132	71
2	40	91	154	206	241	259	246	217	154	87
3	28	64	141	189	120	280	121	204	167	95
4	48	110	180	239	266	276	255	215	145	80
5	41	70	148	186	87	122	112	57	85	41
6	43	100	172	224	250	264	249	207	143	74
7	25	64	151	181	136	260	233	185	150	55
8	49	109	178	232	250	265	246	206	135	69
9	48	101	167	218	246	256	194	95	40	9
10	0	19	32	144	211	229	206	191	131	65
11	16	26	10	29	76	79	134	154	107	40
12	0	19	76	154	216	172	226	230	135	85
13	0	26	93	141	181	118	125	155	72	49
14	3	47	100	161	214	224	196	143	79	25
15	0	0	1	9	21	10	10	14	9	0
16	30	93	153	70	98	91	149	195	133	29
17	30	80	125	161	207	206	212	149	130	80
18	0	0	25	60	35	86	35	36	43	9
19	15	15	28	0	1	6	14	19	11	1
20	50	128	186	220	210	236	236	188	130	66
21	30	70	152	216	231	245	229	183	121	64
22	42	39	53	35	40	123	71	28	44	11
23	38	84	138	173	181	194	111	72	32	7
24	7	66	101	133	162	98	55	15	12	0
25	19	64	80	14	13	16	8	12	7	16
26	38	95	156	211	232	238	235	193	130	83
27	39	97	154	201	229	237	227	183	106	61
28	10	63	71	22	6	7	2	0	2	11
29	0	0	1	3	6	5	6	0	3	0
30	0	2	4	3	0	0	12	6	3	1
Total	734	1854	3214	4064	4425	4866	4399	3756	2591	1284
Monthly Avg.	24.5	61.8	107.1	135.5	147.5	162.2	146.6	125.2	86.4	42.8

Total Insolation at Five Different Angles

Date	Flux, Btu/ft ² -day, on surfaces facing south and tilted at					Ideal tilt angle, degrees
	0°	16°	28°	40°	53°	
1	1500	(1814)*	(1976)*	(1930)*	1753	34.4
2	1478	(1679)*	(1777)*	(1795)*	1708	34.0
3	1302	1683	1768	1667	1402	33.6
4	1640	2038	2203	2147	1828	33.2
5	934	1077	1237	1161	955	32.8
6	1604	1940	2113	2064	1729	32.4
7	1402	1593	1686	1703	1458	32.0
8	1671	1919	2094	2039	1747	31.6
9	1431	1579	1723	1639	1385	31.3
10	1206	1378	1512	1442	1246	30.9
11	741	790	887	888	681	30.5
12	1351	1520	1658	1671	1394	30.1
13	1120	1158	1342	1260	1013	29.7
14	1264	1404	1566	1476	1201	29.4
15	150	109	145	138	75	29.0
16	1179	1193	1329	1336	1051	28.6
17	1454	1588	1752	1698	1404	28.3
18	449	414	477	473	330	27.9
19	187	165	212	205	110	27.5
20	1732	1934	2150	2097	1665	27.2
21	1637	1767	1943	1915	1553	26.8
22	668	634	739	710	508	26.5
23	1164	1209	1355	1306	1037	26.1
24	744	765	880	850	649	25.8
25	376	326	396	359	249	25.4
26	1872	1873	2109	2120	1637	25.1
27	1846	1796	2023	2010	1553	24.8
28	327	245	332	278	195	24.5
29	66	55	79	61	24	24.1
30	85	65	86	85	32	23.8
Totals						
	32580	35710	39549	38529	31572	
Monthly Average						
	1086	1190	1318	1284	1052	

Latitude = 38.4° N

Theoretical best tilt angle for the month, assuming that all radiation is beam radiation = 29°

*Estimated values.

Average Hourly Insolation on 53° Tilted Surface, Btu/hr-ft², May 1975
Time, Hours

Date	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
Average Flux, Btu/hr-ft ²											
1	13	23	41	33	34	26	29	25	18	31	0
2	36	100	154	223	233	224	223	186	130	74	17
3	53	93	119	186	212	191	115	68	16	0	0
4	8	43	57	138	199	167	66	170	135	42	22
5	33	65	39	17	66	55	65	46	65	39	17
6	39	88	153	193	225	213	216	171	113	23	0
7	46	98	145	188	210	210	171	115	100	44	12
8	41	93	145	194	217	216	205	167	111	61	15
9	14	42	16	54	150	62	77	128	68	11	3
10	48	53	103	178	172	117	105	101	68	36	15
11	23	12	68	170	207	210	203	147	92	52	0
12	54	28	52	90	147	202	46	0	0	17	6
13	33	91	111	114	166	15	8	81	47	60	18
14	34	84	131	170	192	208	168	148	95	52	12
15	36	59	122	153	144	108	66	16	18	9	0
16	14	23	53	75	119	93	145	141	77	51	12
17	38	14	33	38	26	18	18	21	17	7	0
18	25	41	20	44	55	19	39	70	49	26	0
19	0	14	54	134	149	165	170	104	84	57	14
20	34	80	125	163	194	200	174	105	68	45	13
21	28	78	119	160	180	176	128	56	85	32	0
22	21	57	104	132	153	177	160	81	0	33	13
23	25	74	118	169	196	173	195	90	99	52	9
24	23	83	121	161	173	155	156	133	85	23	4
25	0	5	25	8	0	0	0	6	0	0	0
26	4	11	34	55	29	48	67	62	83	11	2
27	25	76	100	148	191	192	108	4	60	50	11
28	31	83	132	175	197	199	174	139	90	47	1
29	39	79	130	134	127	94	17	53	28	1	0
30	30	38	30	36	167	186	119	120	83	58	16
31	19	51	38	142	104	148	205	99	58	54	11
Total	867	1779	2692	3875	4634	4367	3638	3132	2042	1096	243
Monthly Avg.	27.97	57.39	86.84	125	149.48	140.87	117.35	101.03	65.87	35.35	7.84

Total Insolation, Btu/ft²-day

Date	0°	16°	28°	40°	53°	Ideal tilt angle, degrees
1	370	338	370	383	264	23.50
2	1919	1757	2017	2046	1554	23.19
3	1270	1288	1459	1355	1021	22.88
4	1261	1200	1394	1378	1017	22.58
5	662	525	573	643	495	22.29
6	1741	1735	1932	1907	1448	22.00
7	1805	1603	1934	1909	1352	21.71
8	1902	1788	2018	2011	1478	21.43
9	831	781	885	840	626	21.15
10	1121	1194	1350	1373	1012	20.88
11	1429	1465	1624	1641	1213	20.62
12	829	778	879	870	644	20.36
13	1078	919	1131	1036	757	20.10
14	1808	1514	1773	1764	1303	19.85
15	1030	1035	1033	1020	740	19.61
16	1142	908	1073	1065	803	19.37
17	410	305	387	353	231	19.14
18	606	495	582	578	389	18.19
19	1217	1139	1338	1261	944	18.69
20	1649	1435	1649	1640	1213	18.47
21	1469	1210	1438	1418	1043	18.26
22	1267	1047	1214	1195	931	18.06
23	1655	1397	1695	1660	1212	17.86
24	1610	1323	1563	1548	1126	17.67
25	84	79	77	79	44	17.48
26	633	515	601	616	406	17.30
27	1518	1052	1382	1403	963	17.13
28	2011	1527	1844	1880	1269	16.96
29	1153	911	1118	1078	712	16.80
30	1118	885	1149	1174	882	16.65
31	1185	708	1163	1108	928	16.50
Totals	37889	32856	38645	38232	28020	
Monthly Average	1222	1059	1246	1233	903	20.35

Average Hourly Insolation on 53° Tilted Surface, June 1975

Date	Time, Hours											
	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-
1	1	12	66	66	56	75	16	63	94	44	2	5
2	27	78	126	163	173	172	161	147	104	55	12	3
3	32	74	105	120	73	82	150	146	109	42	12	11
4	32	76	126	140	136	179	182	149	108	64	15	15
5	22	75	112	154	142	151	120	73	61	38	7	7
6	27	78	126	118	139	160	185	52	98	46	0	1
7	26	76	127	158	71	117	64	59	109	59	14	0
8	29	96	123	96	125	161	180	93	98	54	11	0
9	21	71	117	143	183	191	182	145	88	53	9	0
10	27	43	106	79	21	112	69	78	4	36	10	11
11	8	32	64	44	30	24	11	7	14	0	0	0
12 worst	0	0	14	14	11	2	1	10	22	33	14	0
13	33	78	124	167	188	151	137	94	104	67	10	0
14	30	37	73	116	185	191	177	135	85	17	0	1
15 best	19	68	111	158	187	199	191	148	108	59	14	0
16	43	42	12	9	35	83	129	145	95	48	7	15
17	31	70	63	108	138	251	135	106	95	71	12	7
18	32	75	114	100	199	110	67	0	0	0	0	18
19	28	69	113	152	134	184	173	92	92	47	14	7
20	35	54	126	160	171	176	171	141	88	54	8	14
21	27	76	118	151	174	187	172	139	77	49	14	5
22	30	76	122	158	176	180	183	108	83	51	13	4
23	37	80	86	119	136	162	170	137	99	51	9	16
24	35	86	122	154	180	137	176	102	71	78	29	2
25	53	85	122	157	155	168	148	64	30	35	7	57
26	10	17	24	71	27	15	53	24	6	0	0	30
27	18	32	26	37	72	35	30	66	21	0	0	6
28	46	74	116	199	161	135	69	125	112	40	16	56
29	69	104	131	121	161	196	112	63	85	62	39	76
30	36	82	80	91	151	167	161	173	105	64	28	42
Total	864	1916	2895	3523	3605	4018	3775	2884	2265	1316	326	409
Monthly Avg.	29	64	97	117	120	134	126	96	76	44	11	14

Total Insolation at Six Different Angles, Btu/sq ft -day, June 1975

Date	0°	16°	28°	40°	53°	62°	Ideal Tilt Angle
1	757	594	705	707	500	463	16.56
2	1949	1460	1840	1845	1221	1128	16.42
3	1409	1096	1328	1314	956	896	16.30
4	1877	1474	1750	1737	1222	1123	16.18
5	1469	1192	1417	1393	962	985	16.06
6	1545	1305	1549	1490	1030	1004	15.95
7	1538	1122	1160	1413	881	842	15.85
8	1714	1274	1538	1587	1066	924	15.76
9	2000	1408	1795	1834	1203	959	15.67
10	912	(718)*	(836)*	(844)*	594	(581)*	15.59
11	384	(302)*	(352)*	(356)*	234	(245)*	15.51
12	250	(197)*	(230)*	(232)*	121	(160)*	15.46
13	1823	(1436)*	(1672)*	(1688)*	1153	(1162)*	15.39
14	1922	(1514)*	(1763)*	(1780)*	1047	(1225)*	15.33
15	1937	(1525)*	(1776)*	(1793)*	1262	(1234)*	15.28
16	1036	(816)*	(950)*	(959)*	662	(660)*	15.24
17	1526	1183	1457	1435	982	902	15.21
18	1167	838	1032	1051	714	663	15.19
19	1671	1338	1602	1630	1104	1021	15.17
20	1940	1431	1726	1739	1206	1067	15.15
21	2105	1447	1703	1750	1186	1101	15.15
22	1876	1504	1763	1737	1185	1142	15.15
23	1596	1303	1514	1533	1103	1029	15.16
24	1700	1348	1529	1516	1172	1084	15.18
25	1465	1245	1425	1420	1081	1001	15.20
26	386	313	353	348	277	251	15.23
27	477	406	443	454	343	337	15.26
28	1620	1342	1504	1475	1149	1090	15.31
29	1770	1432	1600	1583	1219	1138	15.36
30	1569	1430	1416	1500	1180	1075	15.41
Total							
	43392	34560	39727	40142	28182	26449	
Monthly Average							
	1446	1152	1324	1338	939	882	15.52°

Latitude = 28.4° N

Theoretical best tilt angle for the month, assuming that all radiation is beam radiation = 15.5°

* Estimated values.

Average Hourly Insolation on 53° Tilted Surface, July 1975

Time, Hours

Date	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800	1800-
	Average Flux, Btu/hr-ft ²											
1 best	74	108	167	189	216	231	194	157	106	52	14	28
2	66	114	158	195	206	194	193	112	98	59	27	51
3	63	103	143	189	207	211	169	146	105	71	30	35
4	45	65	93	66	60	67	53	30	49	81	28	59
5	77	107	149	184	219	199	189	157	93	63	21	57
6	63	80	147	175	207	208	197	160	128	79	26	46
7	44	43	60	44	112	132	67	118	58	39	39	50
8	69	107	130	98	113	151	173	139	105	46	23	68
9	53	102	144	169	166	207	160	41	7	40	41	59
10	59	99	142	166	200	164	187	97	90	14	14	44
11	60	106	121	151	136	59	26	14	39	25	17	50
12	57	63	123	61	92	77	151	142	97	78	37	77
13 worst	22	27	31	38	34	41	40	33	22	26	13	29
14	27	29	35	57	71	76	54	82	42	25	14	43
15	46	54	72	60	56	97	102	86	50	25	6	68
16	17	38	73	170	131	156	96	127	88	26	11	43
17	30	36	37	45	49	97	207	155	139	48	10	40
18	60	103	153	182	226	202	207	129	99	67	42	71
19	91	190	194	204	197	155	182	155	89	50	35	53
20	65	105	148	160	144	40	159	109	41	48	42	54
21	53	111	162	197	193	216	186	164	105	73	40	67
22	67	80	157	200	197	235	215	162	122	70	26	53
23	67	109	126	194	208	221	103	103	91	51	26	58
24	46	95	157	195	216	169	169	146	22	9	3	33
25	55	34	33	45	34	33	57	49	40	38	25	46
26	90	135	183	218	232	216	195	138	92	40	11	56
27	60	109	157	197	223	210	207	164	118	84	34	38
28	39	71	111	155	201	216	211	191	176	122	49	28
29	34	63	108	154	196	218	222	187	134	79	25	29
30	54	89	127	150	166	188	215	148	135	87	36	14
31	49	78	133	179	212	233	216	185	105	98	55	50
Total	1719	2652	3774	4489	4918	4919	4804	3824	2689	1714	819	1507
Monthly Avg.	55	85	122	145	158	158	155	123	86	55	26	48

Total Insolation at Six Different Angles, Btu/sq ft -day, July 1975

	0°	16°	28°	40°	53°	62°	Ideal Tilt Angle
1	2424	1816	2113	2201	1608	1280	15.48
2	2329	1696	2150	2146	1473	1374	15.55
3	2101	1672	1940	2019	1472	1364	15.63
4	966	771	920	872	696	636	15.71
5	2234	1688	1953	2066	1515	1348	15.80
6	2204	1746	1960	2006	1515	1383	15.90
7	1102	864	1263	995	1144	730	16.01
8	1661	1383	1534	1601	1222	1168	16.12
9	1585	1344	1505	1518	1197	1140	16.24
10	1769	1460	1669	1677	1276	847	16.36
11	1177	884	1060	1065	746	775	16.49
12	1455	1206	1323	1391	1054	998	16.63
13	453	385	426	436	355	327	16.77
14	735	635	667	689	556	539	16.92
15	904	794	837	881	720	660	17.08
16	1233	1087	1221	1235	973	919	17.25
17	1174	982	773	1085	893	793	17.42
18	2033	1763	1974	1930	1540	1401	17.59
19	1597	1572	1754	1721	1597	1314	17.77
20	1483	1231	1409	1433	1117	1048	17.96
21	2117	1745	1964	1993	1577	1431	18.16
22	2167	1716	1952	2030	1586	1387	18.36
23	1789	1673	1827	1849	1356	1396	18.57
24	1503	1709	1591	1213	1255	1205	18.78
25	649	565	568	627	488	444	19.00
26	2357	1848	2169	2207	1605	1558	19.22
27	2124	1880	2079	2087	1598	1425	19.45
28	1983	1783	1631	1941	1542	1511	19.69
29	1937	1655	1840	1831	1449	1371	19.93
30	1877	1644	1803	1779	1408	1338	20.18
31	2002	1718	1940	1949	1592	1426	20.43
Total	51126	41585	49928	48473	37783	34536	
Monthly Average	1649	1341	1611	1563	1218	1114	17.49°

Average Hourly Insolation on 53° Tilted Surface, August, 1975
Time, Hours

Date	700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
Average Flux, Btu/hr-ft ²												
1	29	51	102	144	189	216	220	205	159	122	81	44
2	25	68	115	155	189	220	130	186	171	117	73	30
3	32	58	100	153	197	223	236	225	176	131	84	25
4	40	46	69	122	185	192	177	208	152	74	25	14
5	27	59	104	154	176	137	114	193	84	51	12	10
6												
7												
8	13	20	45	104	150	197	218	218	220	188	134	119
9												
10	21	55	84	78	101	164	63	33	58	83	77	43
11	19	50	63	103	165	223	203	193	13	11	44	8
12	18	54	68	122	164	208	221	169	179	111	84	42
13	3	13	57	143	189	206	192	152	171	149	59	21
14	17	35	35	70	71	72	160	181	36	8	28	17
15	25	37	63	105	102	209	201	188	91	13	32	4
16	13	32	108	151	150	184	141	88	31	59	27	22
17	19	18	18	30	98	129	80	132	61	109	59	20
18	7	27	62	154	148	206	214	230	174	160	98	72
19	14	37	81	132	173	219	193	223	208	174	66	47
20	14	42	86	82	151	179	152	155	160	123	53	57
21	1	8	13	35	50	77	92	138	163	136	100	72
22	6	17	65	77	142	91	79	164	177	121	118	74
23	1	9	14	29	45	39	92	69	66	31	17	9
24	7	20	4	86	141	197	228	210	179	11	5	4
25	20	47	61	158	214	152	234	204	168	122	70	21
26	15	42	103	225	203	230	244	230	194	138	85	28
27	18	61	119	173	215	237	242	225	185	121	63	16
28	22	61	109	159	206	228	229	214	169	115	69	14
29	16	54	107	132	211	233	239	177	111	114	53	23
30	14	57	108	156	173	207	161	85	13	30	24	7
31	2	4	7	9	18	24	29	18	12	7	2	1
Total	458	1082	1970	3241	4216	4899	4784	4713	3582	2629	1642	864
Monthly Avg.	16	39	70	116	151	175	171	168	128	94	59	31

Total Insolation at Six Different Angles, Btu/sq. ft.-day,

August, 1975

	0°	16°	28°	40°	53°	62°
1	2030	2120	1673	1666	1562	1765
2	1929	1604	1788	1811	1479	1425
3	2076	1845	2023	2021	1640	1533
4	1582	1414	1557	1580	1304	1203
5	1355	1254	1344	1357	1121	1015
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	2082	1850	2124	2163	1626	1626
9	-	-	-	-	-	-
10	1102	944	1023	1056	860	832
11	1304	1222	1355	1317	1095	1068
12	1632	1567	1792	1704	1440	1305
13	1546	1473	1609	1536	1355	1287
14	880	806	881	872	730	706
15	1229	1119	1259	1266	1070	959
16	1262	1113	1267	1234	1006	1009
17	991	901	984	985	773	745
18	1704	1663	1658	1769	1552	1436
19	1687	1711	1894	1835	1567	1473
20	1482	1344	1524	1498	1254	1141
21	906	964	1086	1057	885	884
22	1226	1171	1254	1281	1131	1053
23	546	457	498	521	421	394
24	1172	1194	1315	1268	1092	1066
25	1570	1564	1707	1682	1471	1402
26	1817	1808	1989	1937	1738	1585
27	1806	1805	1881	1908	1675	1542
28	1676	1694	1870	1840	1595	1482
29	1569	1576	1722	1687	1470	1443
30	1101	1120	1174	1166	1035	998
31	188	160	176	175	133	129
Total	39450	37463	40427	40192	34080	32506
Monthly Average	1409	1338	1433	1434	1217	1161

Average Hourly Insolation on 53° Tilted Surface, October, 1975

Time, Hours

Date	700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
Average Flux, Btu/hr-ft ²												
1												
2												
3												
4												
5												
6												
7												
8	2	31	79	154	221	135	219	71	41	18	7	3
9	0	2	8	14	11	18	17	14	9	8	0	0
10	0	2	14	43	31	35	34	59	37	12	6	0
11	6	13	22	35	86	255	220	178	119	48	5	0
12	6	60	127	200	252	274	287	246	213	136	59	4
13	5	59	122	192	244	261	260	236	214	142	70	7
14	6	52	110	182	235	255	236	186	165	74	33	2
15	3	42	100	168	229	253	249	211	181	127	44	2
16	3	13	26	19	23	40	26	40	29	16	5	0
17	0	4	4	4	5	6	11	9	1	1	0	0
18	0	17	71	175	206	287	280	264	231	161	64	0
19	3	19	24	51	62	111	79	109	160	50	12	0
20	0	48	132	228	265	96	131	129	100	72	32	0
21	13	72	145	229	265	273	287	254	204	124	41	0
22				D A T A	N O T	A V A I L A B L E						
23	12	70	141	210	251	262	259	233	181	107	32	0
24	0	7	10	17	20	24	20	15	17	14	4	0
25	0	11	35	33	35	198	277	225	163	108	18	0
26	0	10	18	25	26	25	21	67	10	10	0	0
27	0	11	21	38	26	42	49	48	46	88	32	0
28	2	25	26	165	246	253	241	206	182	109	11	0
29	6	56	148	211	243	256	120	22	88	32	0	0
30	19	94	173	247	275	288	288	257	195	111	24	0
31	21	89	168	170	235	257	266	271	231	190	78	17
Total	107	807	1724	2810	3492	3904	3877	3350	2817	1758	577	35
Monthly Avg.	5	35	75	122	152	170	169	146	122	76	25	2

↑
DNA
↓

Total Insolation at Six Different Angles, Btu/sq. ft.-day,
October, 1975

	0°	16°	28°	40°	53°	62°
1						
2						
3						
4						
5						
6						
7						
8	824	1035	1074	984	981	992
9	127	111	116	122	101	99
10	325	292	374	348	273	266
11	682	964	966	913	987	923
12	1193	1769	1818	1615	1864	1781
13	1108	1751	1734	1581	1812	1736
14	1011	1486	1497	1328	1536	1489
15	1016	1523	1573	1430	1609	1561
16	327	306	303	314	240
17	58	51	57	64	45	
18	979	1634	1599	1413	1756	
19	528	695	705	672	680	
20	777	1094	1178	1152	1233	
21	1012	1808	1769	1542	1907	
22						
23	877	1658	1625	1451	1758	
24	197	170	185	195	148	
25	674	1039	1014	906	1103	
26	259	218	241	248	212	
27	430	374	444	448	401	
28	821	1355	1318	1214	1466	
29	741	1097	1087	940	1182	
30	999	1826	1794	1593	1971	
31	952	1847	1802	1597	1993	
Total	15890	24103	24273	22074	25258	8847
Monthly Average	691	1048	1055	960	1098	1106

Average Hourly Insolation on 53° Tilted Surface, November, 1975

Time, Hours

Date	700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
Average Flux, Btu/hr-ft ²												
1	0	0	35	191	251	281	256	168	86	43	20	0
2	0	0	106	174	95	90	135	200	182	77	17	0
3	0	0	120	201	208	164	106	240	151	95	13	0
4	0	0	61	174	209	257	263	244	147	106	10	0
5	0	0	91	184	239	259	258	243	137	121	38	0
6	0	0	24	150	168	222	204	232	186	76	25	0
7	0	0	34	109	122	115	89	31	19	15	0	0
8	0	0	82	182	261	267	261	240	174	96	14	0
9	0	0	39	194	241	270	248	233	194	103	108	0
10	0	0	7	23	14	44	128	134	23	5	0	0
11	0	0	36	239	266	268	275	251	206	119	24	0
12	0	0	2	15	8	6	8	6	2	0	0	0
13	0	0	9	13	18	16	18	5	10	16	5	0
14	0	1	6	74	49	222	263	255	228	54	34	0
15	0	0	69	163	233	267	276	236	251	200	113	17
16	0	0	46	134	206	244	281	272	258	204	121	28
17	0	0	63	132	218	265	270	275	253	197	110	18
18	0	7	80	161	241	258	268	262	229	169	77	4
19	0	0	44	129	199	240	263	260	233	188	107	17
20	0	2	65	152	228	255	272	272	240	184	91	9
21	0	0	0	5	10	115	9	172	188	14	0	0
22	0	0	9	33	176	40	38	40	38	52	14	0
23	0	0	8	20	42	61	89	50	31	16	5	0
24	0	0	13	133	138	261	269	274	246	200	73	5
25	0	0	5	12	18	26	42	68	38	13	0	0
26	0	0	4	68	95	121	79	115	128	145	32	0
27	0	0	0	9	12	17	67	44	53	120	9	0
28	0	0	28	107	203	238	267	261	249	195	116	17
29	0	0	16	56	143	207	260	174	159	132	24	0
30	0	0	4	11	19	23	31	25	16	17	7	0
Total	0	10	1106	3248	4330	5119	5293	5282	4355	2972	1207	115
Monthly Avg.	0	0	37	108	144	171	176	176	145	99	40	4

Total Insolation at Six Different Angles, Btu/sq. ft.-day,

November, 1975

	0°	16°	28°	40°	53°	62°
1	809	1381	1374	1255	1331	
2	668	1057	1083	916	1076	
3	710	1168	1153	1037	1298	
4	708	1354	1308	1164	1471	
5	776	1436	1388	1234	1570	
6	645	1186	1158	1006	1287	
7	416	538	516	519	534	
8	715	1439	1390	1214	1577	
9	678	1425	1359	1238	1630	
10	250	354	352	334	378	
11	730	1178	1422	1257	1684	
12	51	44	46	46	47	
13	128	123	134	150	110	
14	640	952	1085	1006	1186	1191
15	779	1636	1588	1370	1825	1857
16	721	1598	1532	1288	1794	1673
17	723	1584	1529	1293	1801	1820
18	688	1530	1438	1236	1756	1718
19	682	1503	1431	1183	1680	1671
20	722	1588	1541	1313	1770	1791
21	306	467	478	437	513	511
22	362	457	447	442	440	456
23	341	325	355	357	322	303
24	653	1411	1355	1170	1612	1603
25	247	247	264	264	222	218
26	419	732	724	680	787	782
27	283	281	315	310	331	318
28	641	1475	1382	1167	1681	1649
29	664	1098	1043	943	1171	1194
30	195	175	201	202	153	158
Total	16350	29742	29411	26031	33037	19011
Monthly Average	545	991	980	868	1101	1118

Average Hourly Insolation on 53° Tilted Surface, December, 1975

Time, Hours

Date	700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
Average Flux, Btu/hr-ft ²												
1	0	0	19	48	288	287	281	242	181	76	0	0
2	0	0	10	131	229	268	216	256	237	179	76	0
3	0	0	11	34	204	271	288	210	187	181	92	9
4	0	0	11	83	220	246	260	257	225	156	63	0
5	0	0	48	128	207	233	256	253	236	171	60	4
6	0	0	14	39	197	205	146	105	87	39	3	0
7	0	0	4	8	18	47	66	40	22	8	0	0
8	0	0	0	7	6	11	11	11	8	3	0	0
9	0	0	1	5	9	9	7	8	5	0	0	0
10	0	0	11	57	207	248	254	110	70	63	48	0
11	0	0	25	112	197	239	255	243	234	183	109	14
12	0	0	29	111	123	105	38	18	5	0	0	0
13	0	0	6	13	20	32	39	50	180	125	15	0
14	0	0	3	14	26	33	35	42	49	35	12	0
15	0	0	9	28	48	47	63	40	16	13	3	0
16	0	0	18	106	196	200	278	203	127	81	18	0
17	0	0	13	17	218	247	262	231	61	24	3	0
18	0	0	32	158	254	218	58	241	47	56	21	0
19	0	0	21	59	67	235	278	275	248	195	91	0
20	0	0	27	113	200	163	272	267	161	138	57	4
21	0	0	0	8	20	43	31	36	53	21	4	0
22	0	0	50	142	215	242	237	109	161	115	70	0
23	0	0	9	141	228	228	214	197	39	28	19	0
24	0	0	63	153	224	200	170	238	251	187	87	0
25	0	0	7	26	105	69	53	34	24	14	2	0
26	0	0	0	5	34	94	31	24	15	12	3	0
27	0	0	4	20	70	13	11	7	7	6	4	0
28	0	0	0	5	42	35	112	118	141	12	4	0
29	0	0	0	9	18	27	37	91	216	177	72	0
30	0	0	0	0	7	12	9	6	4	2	2	0
31	0	0	0	4	3	7	6	7	2	3	0	0
Total	0	0	445	1784	3900	4314	4274	3969	3299	2303	938	31
Monthly Avg.	0	0	14	58	126	139	138	128	106	74	30	1

Total Insolation at Six Different Angles, Btu/sq. ft.-day,

December, 1975

	0°	16°	28°	40°	53°	62°
1	557	1238	1175	1070	1422	1368
2	678	1434	1354	1129	1602	1615
3	546	1266	1206	1052	1487	1455
4	578	1364	1294	1114	1521	1498
5	564	1394	1327	1108	1596	1646
6	476	790	777	683	835	840
7	217	199	229	231	213	176
8	80	65	81	75	57	60
9	59	57	63	64	44	45
10	496	1025	1012	872	1068	1197
11	502	1385	1293	1063	1611	1620
12	249	426	421	358	429	445
13	295	453	439	388	480	480
14	282	288	306	312	249	260
15	278	287	310	311	267	260
16	545	1113	1111	979	1227	1276
17	500	1039	992	870	1076	1177
18	462	1003	987	955	1085	1181
19	535	1285	1263	1125	1469	1510
20	527	1298	1254	1055	1402	1467
21	272	227	245	252	216	214
22	538	1210	1146	1008	1341	1418
23	465	950	996	810	1103	1195
24	526	1398	1292	1164	1573	1609
25	308	346	378	361	334	354
26	211	236	245	245	218	220
27	128	140	151	125	142	144
28	349	478	486	443	469	482
29	339	620	608	541	647	666
30	53	52	57	61	42	44
31	42	37	43	43	32	33
Total	11657	23103	22541	19867	25257	25955
Monthly Average	376	745	727	641	815	837

Average Hourly Insolation on 53° Tilted Surface, January, 1976

Time, Hours

Date	700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
Average Flux, Btu/hr-ft ²												
1			60	171	246	271	275	274	231	177	69	0
2			0	6	13	24	34	34	37	35	14	0
3												
4												
5												
6												
7			3	5	10	16	15	12	9	0	0	0
8			1	17	41	221	232	206	197	118	16	0
9			69	239	236	275	292	284	260	200	105	6
10			58	151	228	252	260	222	138	139	7	0
11			0	6	9	14	19	17	0	0	0	0
12			52	92	236	258	261	250	213	148	41	0
13			49	130	205	119	68	44	20	2	0	0
14			41	129	223	272	294	290	283	228	136	21
15			61	152	232	273	285	258	120	26	4	0
16			2	6	17	56	58	131	181	165	56	0
17			49	195	257	261	208	123	113	131	83	0
18			57	146	231	262	284	275	247	197	103	7
19			37	122	206	265	278	277	265	221	138	29
20			0	0	6	6	3	4	21	28	6	0
21			0	3	5	7	11	69	29	7	6	0
22			39	135	181	140	297	294	272	218	114	15
23			38	79	135	61	34	104	203	193	130	30
24			14	127	180	244	260	256	206	157	81	7
25			3	10	30	30	39	3	4	0	0	0
26			0	6	9	7	8	2	1	4	2	0
27			0	0	3	2	4	6	5	0	0	0
28			56	143	226	271	293	288	264	202	129	4
29			71	142	183	276	153	12	18	83	14	0
30			6	16	22	65	23	19	17	17	18	0
31			3	6	8	8	12	18	13	7	6	0
Total			769	2234	3378	3956	4000	3772	3367	2703	1278	119
Monthly Avg.			28	83	125	147	148	140	125	100	47	4

Total Insolation at Six Different Angles, Btu/sq. ft.-day,

January, 1976

	0°	16°	28°	40°	53°	62°
1	637	1549	1482	1238	1774	1775
2	259	230	246	256	197	198
3						
4						
5						
6						
7	99	87	101	101	70	71
8	453	1002	916	847	1049	1105
9	654	1702	1628	1417	1966	1970
10	522	1331	1285	1129	1455	1544
11	78	94	101	97	65	74
12	590	1353	1271	1087	1551	1541
13	381	661	629	560	637	702
14	690	1715	1623	1384	1917	1929
15	572	1244	1251	1080	1411	1440
16	342	601	596	542	672	654
17	629	1332	1278	1096	1420	1464
18	707	1659	1555	1352	1809	1880
19	691	1705	1608	1368	1838	1950
20	86	87	105	92	74	74
21	133	129	142	146	137	102
22	719	1531	1478	1287	1705	1726
23	508	981	939	837	1007	1044
24	641	1419	1367	1156	1532	1577
25	143	143	153	161	119	122
26	58	53	64	61	39	37
27	25	24	27	28	20	19
28	795	1702	1645	1424	1876	1879
29	491	946	929	801	952	1010
30	264	231	262	270	203	201
31	106	97	109	114	81	81
Total	11273	23608	22790	19931	25576	26169
Monthly Average	418	874	844	738	947	969

Average Hourly Insolation on 53° Tilted Surface, February, 1976

Date	Time, Hours											
	700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
Average Flux, Btu/hr-ft ²												
1			1	10	15	15	33	18	12	0	0	0
2			99	227	286	309	299	298	248	170	36	0
3			31	40	172	245	260	109	170	142	43	0
4			7	101	291	289	272	245	225	147	219	0
5			23	97	203	104	55	58	46	19	1	0
6			0	0	4	10	13	15	14	9	24	0
7			51	134	225	272	296	289	275	229	158	64
8			54	144	229	275	298	298	260	130	30	24
9		8	78	160	244	277	297	290	262	214	127	28
10			44	125	191	247	243	242	175	99	37	5
11												
12												
13			7	25	53	123	58	120	32	20	7	0
14		4	69	149	235	277	297	295	272	228	148	50
15			7	30	67	145	278	198	172	60	20	0
16			88	198	193	226	118	129	38	36	8	0
17			83	136	260	245	125	241	84	37	4	0
18			17	100	250	174	47	27	8	5	5	0
19			43	123	207	271	298	296	288	249	177	69
20			51	125	210	266	294	289	280	231	161	83
21			26	97	96	85	135	50	169	121	85	44
22			9	7	12	15	35	39	109	83	8	0
23		21	94	179	254	287	302	299	270	215	122	37
24		9	69	144	215	167	155	205	115	86	88	15
25		14	74	142	206	126	152	242	189	157	136	39
26		3	27	44	103	129	93	66	58	57	57	7
27		9	81	160	242	281	290	292	254	146	127	44
28		1	31	64	85	109	155	89	58	48	31	25
29		26	96	173	247	276	287	286	251	183	99	21
Total		95	1260	2934	4795	5245	5185	5025	4334	3121	1958	555
Monthly Avg.		4	454	109	178	194	192	186	161	116	73	21

Total Insolation at Six Different Angles, Btu/sq. ft.-day,

February, 1976

	0°	16°	28°	40°	53°	62°
1	156	132	150	153	104	103
2	849	1852	1802	1605	1972	2018
3	618	1163	1109	1041	1212	1229
4	844	1564	1451	1318	1796	1880
5	492	655	683	640	606	626
6	106	102	114	112	89	86
7	900	1844	1806	1594	1993	2028
8	901	1719	1742	1477	1742	1765
9	931	1805	1763	1577	1985	1979
10	804	1375	1363	1219	1408	1483
11						
12						
13	418	452	496	507	445	434
14	1013	1843	1807	1609	2024	1992
15	595	1002	943	892	977	976
16	736	1000	1056	437	1034	1059
17	797	1213	1226	1152	1215	1242
18	479	632	652	601	633	650
19	1074	1954	1935	1729	2021	2060
20	1069	1834	1834	1636	1990	1949
21	726	969	964	931	908	950
22	315	342	390	395	317	281
23	1164	1991	1953	1784	2080	2042
24	967	1319	1342	1214	1268	1321
25	915	1471	1470	1356	1477	1504
26	641	683	721	719	644	650
27	1147	1797	1846	1466	1926	1842
28	726	736	806	781	696	689
29	1158	1910	1931	1718	1945	1952
Total	20540	33359	33355	30163	34507	34790
Monthly Average	761	1236	1235	1117	1278	1289

Average Hourly Insolation on 53° Tilted Surface, March, 1976

Time, Hours

Date	700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
Average Flux, Btu/hr-ft ²												
1		3	35	78	105	125	78	77	123	130	75	30
2		0	7	13	23	32	21	31	70	151	64	10
3		0	8	17	25	32	27	31	35	24	13	1
4		0	8	19	32	34	54	60	119	120	78	19
5		0	51	127	211	252	273	270	67	41	35	13
6		5	15	15	23	63	52	73	235	165	93	29
7		16	92	168	248	292	292	296	277	210	134	53
8		0	45	108	57	72	102	23	35	43	29	5
9												
10												
11		8	70	144	226	256	271	281	261	199	127	66
12		0	6	12	13	16	20	17	9	9	6	1
13		13	35	125	229	267	187	292	254	56	70	14
14		19	68	130	230	278	294	298	271	219	136	62
15		13	78	153	216	218	309	106	153	122	74	17
16		0	0	2	5	12	12	9	10	14	3	0
17		59	123	199	260	290	262	238	264	143	98	34
18		25	64	122	123	52	44	243	258	197	114	59
19		24	53	54	80	86	147	136	133	66	36	32
20		17	72	133	201	257	279	285	252	197	109	55
21		13	107	78	245	225	53	19	40	174	101	31
22		19	48	75	151	189	171	260	257	187	116	46
23		38	94	162	229	268	279	273	237	174	104	43
24		39	94	165	232	270	277	272	241	170	116	46
25		0	7	32	68	249	180	162	148	29	14	5
26		31	85	150	217	258	268	268	242	188	114	46
27		11	11	24	82	71	26	50	15	2	1	33
28		24	78	156	190	262	284	274	254	201	130	66
29		15	35	44	82	150	131	92	64	62	26	10
30		0	7	8	27	19	23	26	18	13	9	0
31		0	6	9	13	14	13	12	13	9	5	0
Total		392	1402	2522	3843	4609	4429	4474	4355	3315	2030	826
Monthly Avg.		14	48	87	133	159	153	154	150	114	70	28

Total Insolation at Six Different Angles, Btu/sq. ft.-day,

March, 1976

	0°	16°	28°	40°	53°	62°
1	753	870	932	876	859	842
2	412	454	488	481	422	410
3	314	268	315	315	213	226
4	545	581	616	603	543	544
5	1100	1395	1444	1288	1340	1348
6	621	747	781	759	768	723
7	1372	2072	2107	1962	2078	2077
8	585	562	646	623	519	541
9						
10						
11	1368	1903	1930	1786	1909	1868
12	161	146	169	172	109	108
13	1172	1552	1647	1526	1542	1498
14	1436	2042	2073	1976	2005	1986
15	1202	1406	1515	1427	1459	1461
16	82	76	87	85	67	63
17	1533	1988	2162	2063	1970	1947
18	1059	1372	1517	1392	1301	1308
19	878	910	990	977	847	841
20	1423	1926	1990	1864	1857	1831
21	909	1108	1112	1092	1086	1091
22	1306	1551	1666	1569	1519	1436
23	1505	1952	2048	1934	1901	1855
24	1572	2010	2119	1997	1922	1929
25	893	990	979	974	894	869
26	1558	1955	2067	1951	1867	1848
27	394	361	404	408	326	328
28	1587	1966	2103	1976	1919	1840
29	830	781	868	842	711	689
30	200	185	204	200	150	151
31	105	107	110	122	94	89
Total	26875	33239	35080	33240	32197	31747
Monthly Average	927	1146	865	1146	1110	1095

Average Hourly Insolation on 53° Tilted Surface, April, 1976

Time, Hours

Date	700	700-800	800-900	900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
Average Flux, Btu/hr-ft ²												
1	0	58	121	197	157	131	219	102	115	130	26	21
2	0	16	31	37	57	19	60	17	11	15	22	26
3	7	49	110	177	237	271	281	263	233	155	94	28
4	0	10	30	38	12	64	10	37	24	92	47	17
5	31	78	130	180	232	255	271	259	233	177	101	37
6	5	48	106	165	228	258	275	260	234	163	91	33
7	22	51	115	181	251	254	281	255	205	138	80	21
8	0	4	24	66	107	210	257	283	258	155	24	13
9	30	85	148	215	263	272	274	255	193	126	60	8
10												
11												
12												
13	27	76	136	200	240	264	262	244	197	126	66	9
14	10	47	104	154	213	248	258	241	207	141	28	3
15	28	64	124	189	232	221	215	169	142	104	70	30
16	17	38	95	151	202	220	232	222	113	81	57	19
17	22	67	112	164	201	218	213	208	106	101	49	10
18	20	63	114	167	206	227	223	211	166	110	59	9
19												
20												
21												
22												
23												
24												
25												
26												
27												
28												
29												
30												
Total	219	754	1500	2281	2838	3132	3331	3026	2437	1814	874	284
Monthly Avg.	15	50	100	152	189	209	222	202	162	121	58	19

Total Insolation at Six Different Angles, Btu/sq. ft.-day,
April, 1976

	0°	16°	28°	40°	53°	62°
1	1376	1314	1515	1471	1277	1262
2	399	361	388	396	311	292
3	1752	2011	2011	2091	1905	1838
4	448	407	438	459	381	357
5	1821	2099	2260	2198	1984	1931
6	1759	2012	2161	2105	1866	1837
7	1816	1965	2147	2087	1854	1789
8	1441	1486	1657	1604	1401	1317
9	1917	2076	2283	2264	1929	1878
10						
11						
12						
13	1876	2029	2216	2181	1847	1789
14	1700	1766	1971	1935	1654	1587
15	1732	1773	1927	1883	1588	1565
16	1605	1593	1777	1693	1447	1410
17	1579	1573	1765	1708	1471	1308
18	1696	1742	1927	1843	1575	1520
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
Total	22917	24207	26443	25918	22490	21680
Monthly Average	1528	1614	1763	1728	1499	1445

INTERTECHNOLOGY CORPORATION
100 MAIN STREET, WARRENTON, VIRGINIA 22186, U.S.A., TELEPHONE 703-347-7900

ITC Report No. 281076

SOLAR ENERGY SCHOOL HEATING
AUGMENTATION EXPERIMENT

✓
SECTION II
OPERATING MANUAL FOR THE
FAUQUIER HIGH SCHOOL SOLAR HEATING SYSTEM

3 January 1977

EY-76-C-02-2586

Submitted to the Energy Research and Development
Administration in Partial Fulfillment of Contract

Fauquier High School Solar Heating Facility

Operating Manual

TABLE OF CONTENTS

	PAGE
Table of Contents	91
List of Figures	95
List of Tables	96
I. Introduction	97
II. How the System Operates	98
A. Basic Logic	98
B. Methods of Operation	98
C. Temperature Criteria	99
D. Automatic Modes	99
E. Manual Modes	99
F. Conditions for Initiating Collector Flow	101
G. Conditions for Halting Collector Flow	101
H. Conditions for Initiating Classroom Heating	104
I. Time Delays	105
J. Summary of Operating Criteria (Table IV)	106
K. "Tank Disable" Function	106
L. Power Failure	108
M. System Clock	108
N. Automatic Drainage	108
O. Mechanical	108
P. Environmental	108

	PAGE
Q. Reference to Control System Description	108
III. Physical Description of System	110
A. Circulation Piping	110
B. Collector	110
C. Thermal Storage	122
D. Corrosion Inhibitor	124
IV. Operating the System	125
A. Classroom Controls	125
B. Classroom Operation	130
C. Main System Operation	131
D. Emergency Overheating Mode	132
V. Components of the System	134
A. Classroom Components	134
1. Pump	134
2. Solenoid Valve	134
3. Forced-Air Heaters	134
4. Thermostats	134
B. Flow Control Components	135
1. Pumps	135
2. Valves	135
a. Motorized Valves	135

	PAGE
b. Solenoid Valves	136
C. Instrumentation	137
1. Recorded Data	138
List of Instrumentation	138
VI. Maintenance Procedures	141
A. Replacement of Glass	141
B. Replacement of Collector Panel	141
C. Hose Connections	142
VII. Trouble Shooting Manual	143
A. Introduction	143
B. Problem Area	143
1. Problem	143
2. Things to Check	143
3. Solutions	143
VIII. Catalog Section (Maintained at the Collector Site)	144
A. Control System	
B. System Components	
1. Pumps	
a. Pump No. 1	
b. Pump No. 2	

- c. Pump No. 3
 - d. Classroom Pumps
 - e. Utility Pump
- 2. Valves
 - a. Valve Body, V1-V9
 - b. Valve Actuators, V1, V2, V4-V9 incl.
 - c. Valve Actuator, V3
 - d. Valves, Solenoid, VS10, VS11, VS12
 - e. Microswitches for Valve Actuators
- 3. Heaters, Classroom
- 4. Corrosion Inhibitor
- 5. Thermal Storage (Refer to Section III.C.)
- C. Instrumentation
 - 1. Pyranometers
 - 2. Thermostats
 - 3. Flowmeter
 - 4. Wind Gauge
 - 5. Levelometers
 - 6. Data Logger, Doric "Digitrend" 210
 - 7. Strip Chart Recorder, Tracor Westronics M11E
 - 8. Temperature Conversion Chart

LIST OF FIGURES

<u>FIGURE NO.</u>	<u>DESCRIPTION</u>
1	Plumbing Schematic
2	Water Storage Tank and Circulation Piping
3	Underground Lines to Collector and Classrooms
4	Collector Inlet Manifold Connections
5	Collector Outlet Manifold Connections
6	Collector Box Construction
7	Thermal Storage Tank
8	Classroom Controls
9	Schematic of Signal Wires From Classrooms
10	Emergency Overheating Mode
11	Pyranometers
12	Calibration of Temperature Sensors
13	Binary Coded Switch (A25)
14	Hexadecimal Switches (List of 8)
15	Mode Select Computer, PC Board
16	Data Distribution and Storage, PC Board
17	Space Demand Contactors
18	Space Demand Contactor Assembly
19	V3 Feedback Conditioner
20	Boost Transformer for V10 and V12
21	Cabinet Wiring for Digitrend and Recorder
22	Vent Valve (V12) Control Logic

List of Tables

<u>Table No.</u>	<u>Description</u>
I	Automatic Control System Logic
II	Definition of Function c, the collector demand variable
III	Manual Mode Operating Conditions
IV	Summary of Operating Criteria

I. INTRODUCTION

One of the first solar heating systems for a high school in the United States of America is now in operation. The system, funded by the National Science Foundation (NSF) jointly with InterTechnology Corporation, heats five buildings of the Fauquier High School in Warrenton, Virginia.

InterTechnology Corporation has built this experimental system to help the NSF, and later ERDA, to learn whether solar heating plants are an effective means for aiding in the energy problems in this country and as a means toward achieving the national goal of energy independence.

The solar collector system at the Fauquier High School heats water which is circulated to five buildings which under normal circumstances will never again require oil or electricity for heat.

The system provides for the collection of solar energy, its control, distribution and storage without specialized staff or personnel being required by the high school. The solar heating plant has a completely automatic control system engineered and built by ITC. A unique underground storage system provides for up to ten days of heat in the event of prolonged overcast periods. The system first began to operate on the 19th of March 1974, 57 calendar days after its inception on 22 January 1974, including the construction of two substantial buildings and the placing of underground thermal storage reservoirs. The system heated the five separate classroom buildings in their entirety during the 1974-5 school season without auxiliary heat from any other source.

This is a completely automated, self-operated system which serves 100 percent of the space which it was designed to heat. The collector is 126' x 26' and has 105 collector assemblies on it. This is the largest single planar array of which ITC is aware. It has been operating at efficiencies ranging from 53 to 63 percent based upon the measured insolation available versus the output. There are over four gallons of water storage per square foot of collector in two separate tanks located underground. These tanks lose only about 1°F per day at 150°F. They have served for heating the five classrooms, namely about 4,100 square feet total for six days during overcast weather when no solar energy was available and the collector was inoperative. The active area of the collector itself is 2,415 square feet.

The system, though simple to operate on the part of the high school, is quite sophisticated. The control system senses six key temperatures and sets up the operation automatically in eight different modes of system operation, including heating classrooms from thermal storage, heating classrooms directly from the solar collector assembly, heating the rooms and sending heat to one of two storage tanks. In addition, rather than use ethylene glycol to protect the system from freezing, there is an automated "dump" mode in which the liquid in the system is quickly allowed to evacuate the collector and subside into one of the tanks and is below the frost line in about 80 seconds.

II. How the System Operates

A. Basic Logic

The solar heating system is designed with several overriding assumptions which govern its logic. The basic assumptions (which apply for most conditions) are that the hotter tank is used for classroom space heating and the water from the cooler tank is sent to the collector for further heating. This means that the two tanks may both be in operation at the same time.

B. Methods of Operation

1. The valves and pumps can be controlled by three methods:
 - (1) Automatic
 - (2) Manual
 - (3) Test
2. The system will normally operate in the automatic condition. While in the automatic mode, the collector will start up, shut down and drain, depending upon the relative temperatures of the storage tanks, the tank outlet and return, ambient, and the collector. At the same time, the system will pump water to the classrooms on an "as required" basis, subject to the limitations of paragraph II.H, below.
3. The controller is capable of monitoring a number of input temperatures and differences in temperature (listed in the next section) from temperature control points. Based on these inputs, the controller logically determines which combination of electro-mechanical devices (pumps, valves, etc.) should be activated. The system is capable of fully automatic operation unless

overridden by manual control. The manual control mode provides the means for individually activating any valve or pump via the System Status Display Board which contains status lamps and toggle switches for each controllable device, arranged in a manner that depicts the system configuration schematically.

C. Temperature Criteria

The system is controlled by six temperatures which are defined as follows:

- T1 Temperature of Tank 1
- T2 Temperature of Tank 2
- TC Temperature of Collector (Dry-Plate Temperature)
- TO Temperature of Outlet from Tanks 1 and 2
- TR Temperature of Return from collector to tanks
- Ta Ambient Temperatures

D. Automatic Modes

There are eight normal operating modes and four special modes* of operating the system. The mode operations actuate eight pumps, nine motorized valves and eight solenoid valves. The mode operations with the valve position and pump operation are shown in Table 1. Table 2 shows the various conditions which will call for collector operation (input "C" in Table 1).

E. Manual Modes

The eight normal and four special modes can be implemented manually by using the "Manual" function switch of the controller, and then referring to Table III for the status of the proper pumps and valves. (A diagram of the "Emergency Overheating" mode is included for reference as Figure 9 even though this condition is virtually impossible in view of the "automatic drain" feature.)

* For the 4 special modes, see Manual Modes, below, and Table III.

TABLE I
AUTOMATIC CONTROL SYSTEM LOGIC
(for symbols, see Notes below)

Case Number Variable and Function	INPUT CONDITIONS					MODES (SYSTEM ACTION)								VALVE AND PUMP STATUS																
	g = 1 if T1 > T2	o = 1 if T1 > threshold	t = 1 if T2 > threshold	c = 1 if Collector demand	s = 1 if Space demand	1 if=1 T1+coll.+space	2 if=1 T2+coll.+space	3 if=1 T1+collector	4 if=1 T2+collector	5 if=1 T1+space	6 if=1 T2+space	7 if=1 T1+Coll., T2+space	8 if=1 T1+space, T2+coll.	Open = 1	V1	V2	V3	V4	V5	V6	V7	V8	V9	VS	Power on = shut = 1	Power on = 1	"	"	Room Pump "	
1	0	0	0	1	0	0	0	0	1	0	0	0	0	x	c	c	o	x	c	c	c	o	c	o	c	c	o	o	c	c
2	0	0	0	1	1	0	1	0	0	0	0	0	0	c	o	c	c	o	c	c	c	o	o	o	c	o	o	o	o	c
3	0	0	1	0	0	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	c
4	0	0	1	0	1	0	0	0	0	0	1	0	0	c	o	x	o	c	x	o	c	c	c	c	c	o	c	o	c	o
5	0	0	1	1	0	0	0	1	0	0	0	0	0	c	x	o	c	c	o	x	c	c	c	o	o	c	o	c	o	c
6	0	0	1	1	1	0	0	0	0	0	0	1	0	c	o	o	c	c	o	o	c	c	c	o	o	o	o	o	o	o
7	0	1	1	0	1	0	0	0	0	n	0	0	0	o	c	c	x	o	c	c	c	x	c	c	o	o	c	c	o	o
8	0	1	1	0	1	0	0	0	0	d	0	0	0	c	o	x	c	c	x	o	c	c	c	c	c	c	o	c	c	o
9	0	1	1	1	0	0	0	1	0	0	0	0	0	c	x	o	c	c	c	o	x	c	c	o	o	c	o	c	o	c
10	0	1	1	1	1	n	0	0	0	0	0	0	0	o	c	c	c	c	o	c	c	c	o	o	o	o	c	o	o	o
11	0	1	1	1	1	0	0	0	0	0	d	0	0	c	o	o	c	c	o	o	c	c	o	o	o	o	o	o	o	o
12	1	0	0	1	0	0	0	1	0	0	0	0	0	c	x	o	c	c	o	x	c	c	o	o	o	c	o	c	o	c
13	1	0	0	1	1	1	0	0	0	0	0	0	0	o	c	o	c	c	o	c	c	o	o	o	o	c	o	o	o	o
14	1	1	0	0	1	0	0	0	0	1	0	0	0	o	c	o	x	o	c	c	x	c	c	o	o	c	c	o	c	o
15	1	1	0	1	0	0	0	0	1	0	0	0	0	x	c	c	o	x	c	c	o	c	o	o	c	o	o	o	c	c
16	1	1	0	1	1	0	0	0	0	0	0	1	0	o	c	c	o	o	c	c	o	c	o	o	o	o	o	o	o	o
17	1	1	1	0	0	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x	c	c	c	c	c	c	c
18	1	1	1	0	1	0	0	0	0	n	0	0	0	c	o	x	c	c	x	o	c	c	c	c	c	c	o	c	c	o
19	1	1	1	0	1	0	0	0	0	d	0	0	0	o	c	c	x	o	c	c	x	c	c	o	o	c	c	o	c	o
20	1	1	1	1	0	0	0	1	0	0	0	0	0	x	c	c	o	x	c	c	o	c	o	o	c	o	o	c	o	c
21	1	1	1	1	1	o	n	0	0	0	0	0	0	c	o	c	c	c	c	c	o	o	o	o	c	o	o	o	o	c
22	1	1	1	1	1	0	0	0	0	0	0	d	0	o	c	c	o	o	c	c	o	c	o	o	o	o	o	o	o	o

- Notes: 1. A "1" in the INPUT CONDITIONS and MODES columns denotes "true".
A "o" denotes "not true".
2. A "d" or "n" in the MODE (SYSTEM ACTION) columns denotes 1 during "day" or "night", respectively, and o, otherwise.*
3. In the VALVE and PUMP STATUS columns, an "o" means "open" or "on".
A "c" means "closed", and an "x" means "no change from previous status".
4. For V3 and V4 transients, see par. II. I-4.
- *For definitions of "day" and "night" see paragraph II.H-1.

F. Conditions for Initiating Collector Flow

The simultaneous limitations which govern the heat collecting operation of the collector are as follows:

- (1) The collector plate temperature T_C must be greater than the ambient temperature T_A by 22°C (40°F) for collector operation. This difference is designated $\Delta 1$. This, however, does not affect classroom heating if at least one tank is hot enough. (see below). If $\Delta 1$ is exceeded, the cooler tank will be circulated to the collector.
- (2) The water storage temperature (T_1 or T_2) will not exceed 82°C (180°F) in either tank. If the tank temperature reaches this value, the collector will not operate, but classrooms may, of course, be heated.
- (3) Another limitation for initiating flow is the relative temperature difference $\Delta 2$ between the collector and the supply tank, which is the cooler tank except where both tanks are below threshold. For circulation, the collector must be the hotter by an amount $\Delta 2$ adjustable between 6°C (10°F) and 28°C (50°F) in increments of 6°C (10°F).

These conditions as they relate to the temperature criteria of paragraph IIC are listed in Table II.

G. Conditions for Halting Collector Flow

After collector flow is initiated by these conditions, it is halted when:

- (1) both tank temperatures are above 82°C (180°F) or;
- (2) the temperature increase between the tank outlet and return approaches some small value of marginal benefit. This is set at $\Delta 3 = 1.0^\circ\text{C}$ (2°F) to 5°C (9°F) in adjustable increments of 1.0°C (2°F).

These conditions are also given in Table II.

TABLE II

Definition of Input c, the Collector Demand Variable

Case Number	Inputs				
	Variable and Function if T1 and T2 > 82°C	if TC - TA > Δ1 or if P3 = 1	if TC - cool tank > Δ2 or if P3 = 1	if TR - T0 > Δ3 or if P3 = 0	collector demand if = 1
0	0	0	0	0	0
1	0	0	0	1	0
2	0	0	1	0	0
3	0	0	1	1	0
4	0	1	0	0	0
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	0
8	1	0	0	0	0
9	1	0	0	1	0
10	1	0	1	0	0
11	1	0	1	1	0
12	1	1	0	0	0
13	1	1	0	1	0
14	1	1	1	0	0
15	1	1	1	1	1

Notes:

1 = "True" or "On"

0 = "Not True" or "Off"

Δ1 = 22°C (40°F)

Δ2 = Adjustable 6° to 30°C
(10° to 54°F)Δ3 = Adjustable .6° to 3°C
(1.0° to 5°F)

TABLE III
FAUQUIER HIGH SCHOOL SOLAR HEAT EXPERIMENT
MANUAL MODE OPERATING CONDITIONS

MODE NUMBER		MODE DESCRIPTION	SPACE NEEDS RP- (1-5)	SYSTEM PUMPS			CONTROLLED VALVES												"O" - Open "C" - Closed	
				Tk.1	Tk.2	Main														
				P1	P2	P3	V1	V2	V3	V4	V5	V6	V7	V8	V9	VS10 C= pwr. on	VS11	VS12		
NORMAL MODES	1	Tank 1 to collector to space	ON	ON	OFF	ON	O	C	C	C	C	O	C	C	O	C	O	C		
	2	Tank 2 to collector to space	ON	OFF	ON	ON	C	O	C	C	C	C	C	O	O	O	O	C		
	3	Tank 1 to collector	OFF	ON	OFF	ON	C	C	O	C	O	O	C	C	C	C	C	C		
	4	Tank 2 to collector	OFF	OFF	ON	ON	C	C	C	O	C	C	C	O	C	C	C	C		
	5	Tank 1 to space	ON	ON	OFF	OFF	O	C	C	C	O	C	C	C	C	C	O	C		
	6	Tank 2 to space	ON	OFF	ON	OFF	C	O	C	C	C	C	O	C	C	C	O	C		
	7	Tank 1 to collector, Tank 2 to space	ON	ON	ON	ON	C	O	O	C	C	O	O	C	C	C	C	C		
	8	Tank 2 to collector, Tank 1 to space	ON	ON	ON	ON	O	C	C	O	O	C	C	O	C	O	O	C		
SPECIAL MODES	9	Emergency overheating of collector	OFF	ON	ON	ON	O	O	O	O	C	O	C	O	O	C	O	C		
	10	Drain collector to Tank 1	OFF	OFF	OFF	OFF	C	C	O	C	C	O	C	C	C	O	C	O		
	11	Drain collector to Tank 2	OFF	OFF	OFF	OFF	C	C	C	O	C	C	C	C	C	O	C	O		
	12	Water transfer, Tank 1 to Tank 2	OFF	ON	OFF	OFF	C	O	C	C	O	C	C	C	C	C	O	C		
	13	Water transfer, Tank 2 to Tank 1	OFF	OFF	ON	OFF	O	C	C	C	C	C	O	C	C	C	O	C		

VS = Solenoid Valve
VS10, Normally open (power off)
VS11, Normally closed (power off)
VS12, Normally closed (power off)

H. Conditions for Initiating Classroom Heating

1. "Daytime" and "Nighttime"

The general requirements for "daytime" and "nighttime" controller operation are summarized in this section.

"Daytime" and "Nighttime" are defined as follows: "Daytime" is defined as the period of time beginning one hour before the normal school starting time and ending at school closing time during any school day. All other times are considered to be "Nighttime", including weekends and holidays.

2. "Daytime" Heating of Classrooms (between the hours of 7:30 a.m. and 3:30 p.m.).

A tank temperature T_1 or T_2 of at least 38°C (100°F) is required in one of the tanks to activate the classroom heating system. The warmer tank will be circulated to space in "Daytime".

3. "Nighttime" Maintenance Heating (between the hours of 3:30 p.m. and 7:30 a.m.)

A tank temperature T_1 or T_2 of at least 21°C (70°F) is required in one of the tanks to activate the classroom heating system. If both tanks are above that temperature the cooler tank will be circulated to space at "Nighttime".

4. While in the heating modes, if no room requires heat, the tank circulating pump (P_1 or P_2) will shut off. One of these pumps is activated when one or more of the classrooms require heat.

I. Time Delays

Three characteristic time intervals arise in determining desired response to changes in the operating conditions envisioned above.

1. When the space thermostat is activated and demands heat, it is supplied immediately. ($\Delta\tau = 0^m$).
2. Collector demand is responded to within a longer time interval, $\Delta\tau_2$, on determination of some stability of the condition. For the system to accommodate dynamic operation characteristics such as intermittent cloud cover and temperature equilibration of piping with circulating water, it is required that the collector not be involved in a mode change until all input conditions to collector demand have remained static for a specified interval of time. This time interval is easily changed in 5-minute increments from an interval of 5 minutes to an interval of 60 minutes. If any inconsistency arises in four evenly spaced samples in the interval, then the period for change verification is restarted as of the time of that inconsistency. ($\Delta\tau = 5 \rightarrow 60^m$).
3. The third characteristic time, $\Delta\tau_3$, involves the decision to switch tanks when supplying either space or collector because of change of their temperatures. Since their rate of temperature change is typically 10°C per 10 hours, and because the difference in efficiency of space heating or of heat collection is insignificant over a water temperature interval of a few degrees, it is not necessary to change often between tanks. Because tank temperature changes slowly and because temperatures are rounded to 1°C for logic decisions, there is an intrinsic delay of perhaps one hour in switching tanks. Thus, an additional delay of 0 to 3 hours in 1-hour increments has been incorporated, ($\Delta\tau_3 = 0 \rightarrow 3^h$).

4. An additional time delay, $\Delta\tau_4$, is incorporated as part of the requirement that when the collector demand ceases, the circulating water shall drain back into the tank from which it came. This will automatically happen if the logic of Table I is implemented, including the "no change" entries, except for V3 and V4 during transitions from modes 1 to 5 and 2 to 6, respectively. As indicated in the table, these require a temporary value of 1 during the period $\Delta\tau_4$ required for drainage. This transient valve position does not interfere with continuing response to space demand, but it is necessary that the drain period be shorter than the verification period $\Delta\tau_2$ for collector turn-on. This drainage period $\Delta\tau_4$ ranges from 5 to 9 minutes in one-minute increments. ($\Delta\tau_4 = 5 \rightarrow 9^m$).

J. Summary of Criteria (Table IV)

The temperature limits and time delays given in the above paragraphs are summarized in Table IV. (It is planned to set these temperature differences and time delays at their final values after determining their optimum values, during the initial stages of operating the control system.)

K. "Tank Disable" Function

To provide for drainage and repair of either storage tank while the other tank is still in use, provision has been incorporated for manually bypassing either of the tanks by selector switch so that either tank may be in effect "removed from the system". The method of system operation in this "single tank" mode is essentially the same as that given above. The means used to accomplish the switch-out of a tank is to force the system to believe (by introducing false signals from temperature sensors) that the tank is both too hot for collector operation and too cold for classroom supply. (Effectively, in Table I, cases 5 and 6 are switched to Cases 2 and 3, respectively, for Tank 1 switch-out; Cases 15 and 16 are switched to Cases 12 and 13, respectively, for Tank 2 switch-out.)

TABLE IV
SUMMARY OF OPERATING CRITERIA

<u>Symbol</u>	<u>Condition</u>
<u>To Start Collector</u>	
T1	Tank 1 Less than 82°C (180°F)
T2	Tank 2 Less than 82°C (180°F)
$\Delta 1$	$(TC-TA)^* > 22^{\circ}C (40^{\circ}F)$
$\Delta 2$	One tank > threshold $(TC-T_{\text{cooler tank}}) > \begin{cases} 6^{\circ}C \rightarrow 30^{\circ}C \\ \text{in } 6^{\circ} \text{ steps} \end{cases}$
	Both tanks < threshold $(TC-T_{\text{warmer tank}}) > \begin{cases} 10^{\circ}F \rightarrow 54^{\circ}F \\ \text{in } 11^{\circ} \text{ steps} \end{cases}$
<u>To Stop Collector</u>	
T1	Tank 1 Greater than 82°C (180°F)
and T2	Tank 2 Greater than 82°C (180°F)
$\Delta 3$	$(TR-T_0) \geq 0.6^{\circ}C \rightarrow 3^{\circ}C \text{ in } 0.6^{\circ} \text{ steps}$ $(1.0^{\circ}F \rightarrow 5^{\circ}F \text{ in } 1.0^{\circ} \text{ steps})$
<u>Mode Criteria</u>	
T1	Tank 1 Greater than 21°C "night" (70°F)
T1	Tank 1 Greater than 38°C "day" (100°F)
T2	Tank 2 Greater than 21°C "night" (70°F)
T2	Tank 2 Greater than 38°C "day" (100°F)
<u>Time Intervals</u>	
$\Delta \tau 1$	Space demand = 0 ^m
$\Delta \tau 2$	Collector Status change 5 ^m → 60 ^m in 5 ^m steps.
$\Delta \tau 3$	Tank Switching 0 ^h → 3 ^h in 1 ^h steps.
$\Delta \tau 4$	Collector drain hold period 5 ^m → 9 ^m in 1 ^m steps.
*TC	Collector Dry-Plate Temperature
TA	Ambient Temperature
TR	Return Temperature (to tanks)
T0	Outlet Temperature (from tanks)

L. Power Failure

In the event of a power failure, the system restores itself automatically to the previous operating modes when power is re-applied. The controller does not require any specific sequence of events in applying or removing power from the system.

M. System Clock

The controller utilizes a time-of-day clock. It is provided with a numerical readout device, and is capable of being easily reset. Battery operation is also provided to power the clock during power outages.

N. Automatic Drainage

To ensure that circulating water does not freeze in the collector due to any unexpected condition, an independent temperature sensor and thermostatic control interrupts power to P3 and to VS10 whenever collector temperature drops below 40°F.

O. Mechanical

The controller is constructed to provide ease of maintenance, accessibility and replacement of all modules and parts. All controls are marked and located in such a manner that the control position can be readily identified. The controller is mounted within a standard, wall-mounted type, NEMA-12 enclosure. All exposed metal parts that are subject to rusting are finished with a protective coating.

P. Environmental

The controller is designed to operate satisfactorily over an ambient temperature range of 0°F to 160°F at level of relative humidity up to 95%.

Q. Reference to Detailed Control System Description

Appendix I includes detailed operating instructions for the controller, a description of the various modes of operation, maintenance procedures,

logic diagrams, wiring diagrams, and applicable schematics.

Also included in the appendix are a list of materials and part location diagrams.

III. Physical Description of System

A. Circulation Piping

The fluid flow of the system is shown schematically in Figure 1. The flow can also be traced out on the control panel display board as well as in Figure 1. As a double check, the operating modes with the corresponding valve positions are shown in Tables I and III. An isometric view of the storage control and circulation piping is shown in Figure 2. Figure 3 shows underground lines to the collector and classrooms.

B. Collector

1. General

The collector operation consists of pumping water through the collector modules and returning the water to one of the two storage tanks. Two pumps must be activated to operate the collector: one as the submerged pumps (P_1 or P_2) and the collector circulating pump (P_3). The pumps are activated when the temperature of the collector absorber plates is greater than the temperature of the cooler tank. When this condition exists the valves will position themselves to select that tank and the appropriate two pumps are turned on. Other conditions which must be met to start collector operation are given in Table II and paragraph II-F.

2. Collector Valves

Each collector run (3 collectors in series) is equipped with inlet and outlet valves, Figures 4 and 5. Additionally the inlet header manifold is equipped with a drain valve located at the Southeast end of the collector. The return header manifold is equipped with a pressure relief valve located at the Northwest portion of the header manifold. At these two locations are also located automatic vent valves which bleed air from the system during startup. Also located at the Northwest portion of the

Figure 1
Plumbing Schematic and Temperature Control Points

Figure 2
Water Storage Tanks and Circulation Piping

Figure 3
Underground Lines to Collector and Classrooms

Figure 5
Collector Outlet Manifold Connections

return header manifold is a solenoid bleed valve, which when activated, opens to let air into the system to facilitate draining the system. Operation of this valve is accomplished only during the "manual" control mode.

3. Collector Flowmeter

An electronic flowmeter which can be used in the data system is located on the Southwest corner of the header. The output of this flowmeter may be recorded on the Data Logger.

4. Collector Plate

a. Materials

Some of the materials considered for this project were: Aluminum ROLL-BOND, copper tube on copper plate, brass tube on brass plate, iron pipe on iron plate, aluminum tube on aluminum plate, and steel platecoil. Aluminum ROLL-BOND was selected for the following reasons:

- i. The plates could be fabricated and delivered in accordance with schedule, and design requirements.
- ii. The chemical etch selective coating was developed for use with aluminum.
- iii. The cost for preformed ROLL-BOND plates, with integral tubes, was approximately 50% less than the estimated cost for the alternatives listed above.

b. Hydraulics

The straight thru, single pass plate design was made to insure uniform water flow through the plate, and minimum pressure drop. Spacing was determined to provide optimal heat transfer between the plate and the fluid.

c. Flow Patterns

Flow patterns were calculated to yield a pressure drop per plate of 0.3 psig, at a flow of 2 gallons per minute.

d. Selective Coatings

The following coating techniques were evaluated for the ROLL-BOND panels:

i. Anodize

ii. Paint

iii. Chemical etch

The α/ϵ ratio of approximately 3 for the chemical etch coating was superior to that which could be expected with paint and anodized coatings. Panels tested showed excellent resistance to heat and humidity on a protracted basis.

5. Collector Box Construction

a. Materials

Wood was selected as the basic material for the collector box primarily because of availability and delivery schedule. Since boxes made from wood required little or no tooling it was possible to delay the final design of the box until final sizing of other components. The boxes were protected with one coat of primer and two coats of a latex house paint.

b. Insulation

Three inches of Johns-Manville Spin Glass FSK (reinforced foil and paper) type 814 was selected for the bottom of the box. This particular form of fiberglass insulation has suitable structural properties to carry the load of the collector plate. The R

value for type 814 insulation at a mean temperature of 100°F is approximately 13. The side wall structure of the box was designed to support each glazing and reduce edge losses from the collector plate. The estimated R value range for the side walls is between 2 and 3. For construction details of the box see Figure 6.

c. Glazing

Two glazings of double strength, 1/8-inch thick glass with approximately one inch air space between panes were selected. No attempt was made to purchase special quality glass, such as low iron content, etc. The time available for delivery of glass dictated the use of standard commercial grades and sizes. Approximately 33% additional glass pane "lights", were ordered to allow for breakage. The breakage was considerably less than the 33% anticipated. Excess glass panes will be used for routine maintenance. For sizes refer to Figure 5a.

6. Collector Assembly

The solar heating system consists of a 2,540 square foot collector array with a net absorber area of 2,415 square feet, made up of 105 collector modules, 3 modules to a row, in 35 rows.

Three boxes are connected end-to-end to make up a collector run. This provides 69 square feet in a run. Boxes are connected to the lower header by use of 3/4-inch heater hose and a 3/4-inch ball valve. Valves were installed at both ends of the run for ease in maintenance.

The geometry of the collector array is fixed by specifying its tilt angle from horizontal and the azimuthal angle. The ITC Solar Collector Assembly for Fauquier High School, Warrenton is

Note: Use $\frac{1}{8}$ Double Strength Lights

Collector Glazing

Figure 5a

FIGURE 6

Solar Collector Box
(Dimensions Shown in Figure 6 Continued)

INTERTECHNOLOGY CORPORATION
BOX 340
WARRENTON, VIRGINIA 22106
USA

120

FIGURE 6

SOLAR COLLECTOR BOX (CONTINUED)

DIMENSIONS

A = 41 inches
B = 40 1/4 inches
C = 39 1/2 inches
D = 38 1/2 inches
E = 36 1/2 inches
F = 6 inches
G = 5 1/4 inches
H = 3 inches
K = 3 1/4 inches
L = 2 inches
M = 1/4 inch
N = 97 1/2 inches
O = 96 3/4 inches
P = 96 inches
R = 95 inches
S = 93 inches
T = 3/4 inch
U = 1/2 inch
V = 1 inch
W = 3/4 inch
X = 3/8 inch

tilted at 53° to the horizontal and faces south for maximum heat collection during the winter months.

The collector modules have been assembled on a support structure 126 feet by 26 feet. The structure consists of steel pipe and angle iron set in concrete trenches and individual footings.

The structure was designed to withstand winds in excess of 100mph.

C. Thermal Storage

Thermal storage is provided by two 5,500-gallon concrete transformer vaults purchased from the Smith Cattleguard Company of Midland, Virginia. The tank was modified to provide three access holes in the top of the tank--one 30-inch manhole with cover and two 8-inch diameter holes in diametrically opposite corners. Tank 2 has one 8-inch hole and one 12-inch hole. For more details, see Figure 7.

The transformer vault is placed below ground upon a 10-inch slab of concrete after covering the slab with two layers of pentachlorophenol-treated 2 by 12-inch boards and 4 inches of foamglass insulation. The transformer vaults are constructed in four sections as shown in Figure 7. The periphery of the tanks is insulated with 4-inch waterproofed polyurethane from C. E. Thurston & Company. The polyurethane insulation is protected by a layer of pentachlorophenol-treated 2 by 12 inch boards. The 2 by 12's extend above the ground level. The top of the tank is insulated with waterproofed polyurethane and 2 layers of pentachlorophenol-treated 2 by 12-inch boards.

The heating load of the space and the 5-day storage requirements indicated that a storage of 5×10^6 Btu or a tank size of approximately 10,000 gallons was needed to meet this requirement.

Figure 7
Thermal Storage Tank

D. Corrosion Inhibitor

Since there is no antifreeze in the solar heating system, a corrosion inhibitor must be incorporated to prevent corrosion of the aluminum Roll-Band absorber plates. The pH of the water-inhibitor solution must be kept between 8.5 and 10.0 to prevent interaction between the aluminum, iron piping, and brass valves.

A one percent solution of sodium chromate (Na_2CrO_4) provides this protection. It is put into the filled water tanks as C4-38 pellets, or Z7 balls, obtainable from Nalco Chemical Company, Chicago.

Dosage is 2.5 pounds of pellets or balls per 100 gallons, or for 5000 gallons, 125 pounds per tank.

IV. Operating the System

A. Classroom Controls

1. The classroom system is composed of five elements:
 - a. and b. The two thermostats, sense the "night" and "day" room temperatures to activate the system.
 - c. A pump, TACO "Red Baron" #UN110, 115V 60 hz, 1/12 HP, which aids in circulating the water.
 - d. The convector fans in two Cabinet Unit Heaters, Young Model CH-85, each using one 115V, 60 hz, permanent split capacitor motor, 1/6 HP each, which blow air across each of the 2 convectors when the system is activated.
 - e. One solenoid valve, ASCO #8210D4, 115V 60 hz, 6 watts.
(Normally closed, opens on power application.)
 - f. In addition there are 2 one-inch pipe size, manually-operated ball valves in each classroom, one in the inlet and one in the exit line.
2. A schematic of the classroom controls is shown in Figure 8. Figure 9 shows the routing of signal and control wires between classrooms.
3. A general description of the function of these components follows.
 - a. Solenoid Valves
The solenoid valves are installed on the inlet water lines for each classroom. The valves are actuated by the thermostats. The purpose of the valve is to control the flow of heated water into each room.

Figure 8
Classroom Controls
(a) Control Room

Figure 8
Classroom Controls
(b)Classrooms

Figure 9
INTERTECHNOLOGY SOLAR PROJECT

SCHEMATIC OF SIGNAL WIRES
 FROM CLASSROOMS

R&L

3/18/74.

Rev. 1/30/76 E.C.

- } TRENCH
- } 2 AC Cables to each classroom.
- } 2 Signal Pairs to each classroom.
- ROOM THERMOSTATS
- EXISTING JUNCTION BOX

b. Room Pumps

The room pumps (and also the valves and fans) are activated by either the "day" or "night" thermostat as previously indicated. Each room is equipped with a control and overload switch and 3 circuit breakers as shown in Figure 8.

c. Heater Fans

The heater fans are located within the cabinet chassis. Each fan has an overload switch located near the pumps. In or on the cabinet chassis is a switch controlling the fan speed. Each fan has a high and low speed position. The fan speed should normally be in the "low speed" condition.

The fans start operating when the thermostat calls for heat and stop operating when heat is not needed.

4. Additional Elements for Classroom Operation

Two additional elements are in the complete classroom heating system. These items are general and apply to all cases.

a. Main Pumps

The first item is the one of the two main room circulating pumps. These pumps are located one in each of the storage tanks (P_1 and P_2). For room heating one of these pumps must be running. The control system will read the room demands and will start and stop the main pump based upon these demands. That is, if a room requires heat, one of these pumps should be running. If no room requires heat, the main pump should be off, unless the collector is collecting heat.

b. Bypass Solenoid Valve, V-II

The other item is a bypass solenoid valve (V-II) which is located outside, near the northeast corner of room 721. Under normal conditions this valve should remain closed. However,

if manual operation is required, wherein the main room circulating pump (P_1 or P_2) does not automatically turn off (and on) with demand, this valve must be opened.

c. Circuit Breakers

Circuit breakers for the main pumps P_1 , P_2 , and P_3 are located in the control room. Referring to Figure 8, all classrooms are on circuit breaker 10, in this same panel.

B. Classroom Operation

Operation of the classroom system is as follows:

1. The classroom needs heat - trips the thermal switch in the "day" or "night" thermostat. These contacts close on demand. This activates the following (provided the control system limitations of paragraph II-H are met).
 - a. Opens solenoid valve
 - b. Starts room pump
 - c. Starts fan motors on convectors.
2. When the classroom heat needs are met, the mercury switch in the "day" or "night" thermostat closes, which:
 - a. Closes solenoid valve
 - b. Stops room pump
 - c. Stops fan motors on convectors.

C. Main System Operation

Initial Turn-On Procedure

1. Turn Auto-Manual switch down to "Manual".
2. Turn all pumps "off".
3. Turn all valves "off".
4. Turn Tank Disable switch to "Normal" (center position).
5. Turn Power switch "on".
6. Correct battery leaks.
7. Set hour switch (H) to correct hour and nearest tenth hour of the day. Minute switch (M) advances in six minute intervals.
8. Set "Day Set" sequence rocker switches (8 rockers per switch) and push "Load" button.
9. Set "Start Time" switches (4 rockers per switch).
10. Set "Stop Time" switches (4 rockers per switch).
11. Set Temperature Differentials ($\Delta 1$, $\Delta 2$, $\Delta 3$) hexadecimal switches on the Data Distribution and Storage board.
12. Set Time Intervals ($\Delta \tau 2$, $\Delta \tau 3$, $\Delta \tau 4$) hexadecimal switches on the Data Distribution and Storage board.
13. Check TC and T0 on test switch. Verify if mode of operation is compatible with actual temperatures. Wait until longest time interval $\Delta \tau$ set in has run out.
14. Turn Auto-Manual switch up to "Auto". Close doors.
15. System is now in Automatic operation.

D. Emergency Overheating Mode

This could occur if water were left in the collector by accident, for instance if a drain valve or tank inlet valve were closed before the collector could drain completely.

Table III and Figure 10 show the valve and pump positions.

Emergency instructions:

1. Switch to Manual mode.

2. Valves as follows:

V1 OPEN	V7 CLOSED
V2 OPEN	V8 OPEN
V3 OPEN	V9 OPEN
V4 OPEN	V10 CLOSED (power on)
V5 CLOSED	V11 OPEN
V6 OPEN	V12 CLOSED

3. When TR (return temperature) reaches a steady value of 180°F or less, go to normal mode.

Figure 10
Emergency Overheating Mode

V. Components of the System

A. Classroom Components

This section presents a diagram of the four control components in the classrooms: namely, pump, solenoid valve, heaters, and thermostats.

Connection of these components is according to Figure 8.

Catalog information on these components is given in Section VIII.

B. Flow Control Components

1. Pumps

The pumps are operated by a secondary power relay which handles the load for each pump. In this way separate circuit breakers may be utilized to disable the current to a pump if and when the need arises. The room pumps are almost within a closed system in themselves. Each room thermostat causes power to be applied through a solid state relay to its associated solenoid valve, room pump, and motor-blown convector. (See Figure 8.)

- a. Pump #1 (P_1)
Same as P_2 .

- b. Pump #2 (P_2)
Dayton "TEEL" Model 5K954A Sump pump, AC Motor 115V, 8.2 amps, 60 Hz, 1725 RPM, Split phase 1/2 HP, 45-60 GPM, 2" pipe.

- c. Pump #3 (P_3)
Bell & Gossett Series 1522, Model 8S, 220V 1 phase, 3500 RPM, 1 HP, 1 1/2" suction, 1 1/4" discharge.

2. Valves

- a. Motorized Valves

The motorized valves except V3 each contain two motors which turn a gear-driven master shaft with a nylon cam attached. V3 has a single motor. Two microswitches ride the cam. One switch employs its set of contacts for AC control to the

motors. The other switch is used to indicate valve position. Each motorized valve is connected to the system by hard wiring to the access panel. Travel of a valve is initiated by a solid state relay. The relay is latched by a manual or automatic command and through the AC microswitch, power is supplied to the valve drive motor. When the motor causes the valve to reach the open position the cam causes the AC continuity to be broken by the microswitch contacts. For the valve to be returned to the closed position the solid state relay is unlatched, causing the AC to flow through the closed set of contacts on the valve AC microswitch.

- i. Motorized valves Nos. V1 through V9 are identical in their valve bodies. This is the Worcester "Econo-Miser" 2 inch screwed-end ball valve #411T-SE with brass body, ball, and stem, and Teflon seats and seals.

Valves V1, V2, and V4 through V9 inclusive are identical in their actuators. This is the Worcester B73 (originally B35 as shown in catalogue data).

- ii. Valve V3 uses the B73W (originally B35W in catalogue data), which is an explosion-proof actuator with a single motor. The reason for this change for V3 was due to availability only.

b. Solenoid Valves VS-10, VS-11, VS-12

The solenoid valves are straightforward with no feedback for indication. They are controlled by latching solid state relays, and the valves themselves generate the display indication.

Listed below are the solenoid valves used in the system:

<u>Valve No.</u>	<u>ASCO Catalog No.</u>	<u>Description</u>
VS-10 (Drain)	8222 B86	Solenoid valve, ASCO "Red Hat", 1 1/2" pipe size, 110 volt 15.4 watts. Brass body, Teflon seats, <u>Normally open</u> .
VS-11 (Bypass)	8210 D22	Solenoid Valve, ASCO "Red Hat", 1 1/4" pipe size, 110 volt 6.0 watts. Brass body, Teflon seats, <u>Normally closed</u> .
VS-12 (Vent)	8210 D95	Solenoid Valve, ASCO "Red Hat", 3/4" pipe size, 110 volt, 11.0 watts. Brass body, Teflon seats, <u>Normally closed</u> .
Classrooms	8210 D4	Solenoid Valve, ASCO "Red Hat" 1" pipe size, 110 volt, 6.0 watts, Brass body, Teflon seats, <u>Normally closed</u> .

All purchased from Noland Co., Falls Church, Virginia

C. Instrumentation

The instrumentation design for the Fauquier High School Solar Heating Project is based on both the operational and experimental requirements. The design and construction of a full-scale working prototype offer an excellent opportunity to gather data useful to future solar heating plant designs while providing all the heat necessary to meet the heating requirements of the classrooms. Economy dictated the least instrumentation which would meet the test and evaluation requirements of the program. However, a certain amount of instrumentation is required to insure that the system is operating properly. All signal inputs are fed into the Data Logger and/or strip chart recorder. The required inputs are also fed into the automatic control system. The following data is recorded on the Data Logger or strip chart recorder:

1. Recorded Data

	<u>Measurement</u>	<u>Measurement Form</u>
1	Solar radiation, horizontal	Millivolts
2	Solar radiation, 16° to horizontal	Millivolts
3	Solar radiation 28° to horizontal	Millivolts
4	Solar radiation 40° to horizontal	Millivolts
5	Solar radiation 53° to horizontal	Millivolts
6	Solar radiation 62° to horizontal	Millivolts
7	T0 collector inlet water temperature	Degrees C
8	TR collector outlet water temperature	Degrees C
9	TC collector plate temperature	Degrees C
10	TA Ambient temperature	Degrees C
11	T1 storage tank number 1 temperature	Degrees C
12	T2 storage tank number 2 temperature	Degrees C
	(optional) Flow rate of water thru collector	Millivolts

2. A list of Instrumentation follows:

- a. Automatic Control System with Valve/Pump Status Readout Panel and Manual Controls (Roburn Corp.).
- b. 1 Digitrend #DS-210 multi-point Data Logger (Doric Scientific)
- c. 6 Temperature Monitors, listed in section II-C including two, T0 and TR, plugged into Taco Inc. "Guzzinta" fittings in the outlet and inlet piping. (supplied by Roburn Corp.)

- d. 6 Pyranometers Model P-8405, 180° Quartz globe covered (HyCal Labs), at angles listed above, as Recorded Data. See Figure 11.
- e. 1 Wind Speed/Direction Indicator, Maestro 11 (Maximum, Inc.)
- f. 1 Pressure gauge, Model 1010, 4 1/2" diameter, in the outlet of P₃, (Ashcroft)
- g. 1 Flowmeter MkV 2" CS and adapter SGA-100B-1F 6-60 GPM, 2.5V-10VDC adjustable (Ramapo Instrument Company)
- h. 1 Watt-Hour Meter, in Pump House, records only solar energy-related electrical power.
- i. 2 Levelometers (Tank Water Level), Small Model, (Horsey Products, Inc.)
- j. Strip Chart Recorder, Model M11E, 24 channels (Tracor Westronics)

Descriptions of each of these items may be found in the Catalog Section.

Pyranometer Number	Angle from Horizontal	mv/SC*	Calibration SC/mv	SC/sq in chart**
1	0°	5.555	79.56	36.16
2	16°	5.561	79.48	36.13
3	28°	6.154	71.82	32.65
4	40°	5.284	83.65	38.02
5	53°	5.731	77.12	35.05
6	62°	5.820	75.95	34.52

* Solar Constant (SC) = 442 Btu/hr-ft²

** At 2 inches per hour chart speed.

Figure 11
Pyranometers

VI. Maintenance Procedures

A. Replacement of Glass

1. Remove wooden lath covering the edges of glass panes involved in the repair.
2. Uncaulk the upper glazing and grasp the glass with the suction cup handles.
3. Use extreme caution to protect personnel from flying glass in the event of breakage during the removal procedure.
4. Continue with the same procedure for future glazings and save unbroken glass for reuse.
5. Remove all caulking from the glass openings, being careful not to allow glass and foreign material to fall on the collector plate or slip between the collector plate and the glazing.
6. Reassembly would be in reverse order. Insure adequate caulking around the edges of all glazings.

B. Replacement of Collector Panel

1. Turn off the inlet and outlet valves of the affected row.
2. Remove all glazing from the affected box.
3. Remove hoses from both ends of the collector plate.
4. Remove retainer blocks which hold the panel against the insulation below.
5. Lift one end of the panel slightly above the box edge and slide the panel out from under the aluminum cross angles.

6. Replacement is in reverse order.

C. Hose Connections

1. Turn off the inlet and outlet valves of the affected row.
2. Remove old hose by cutting and sliding off residue or cut from the collector pipe.
3. Replace the hose with a similar length on one collector pipe while raising one collector panel.
4. Slip two hose clamps over the hose and attach the hose to the other panel pipe.
5. Tighten the hose clamps, but do not over tighten or cut hose.

VII. Trouble Shooting Manual

A. Introduction

The electro-mechanical system, though sophisticated, is relatively easy to trouble shoot, diagnose, and repair.

B. Problem Areas

1. Problem areas can most often be pinpointed by a careful check of the controller lights, unusual sounds, and visible malfunction.
2. Routine early morning checks are suggested to insure satisfactory heating and operation.
 - a. Check all circuit breakers in the power panel to insure that power is available to all equipment.
 - b. Check the automatic controller for:
 - (1) Automatic-manual operations.
 - (2) Day-night mode.
 - (3) Is tank disable switch correctly positioned?
 - (4) Are room demand lights activated? If so, is a pump running and are valves correctly positioned to service the demand?
 - c. Check the tank levels to insure an adequate level for proper pump operation.
3. When the collector is in operation the pressure gauge should register between 20 and 25 psig. A pressure of less than 20 indicates a valve improperly positioned, a pump not operating properly, or a low level in the associated supply tank. Pressure in excess of 25 psig indicates an improperly positioned valve or a blockage in the return line.

VIII. CATALOG SECTION

(Maintained at the Collector Site)

INTERTECHNOLOGY CORPORATION

100 MAIN STREET, WARRENTON, VIRGINIA 22186, U.S.A., TELEPHONE 703-347-7900

SOLAR ENERGY SCHOOL HEATING AUGMENTATION EXPERIMENT

SECTION III PERFORMANCE DATA

ITC Report No. 281076

3 January 1977

EY-76-C-02-2586

Submitted to the Energy Research and Development
Administration in Partial Fulfillment of Contract

Introduction

This section contains the raw data that was generated in the collector testing program carried out by InterTechnology Corporation at the Fauquier High School Solar Heating Facility. The testing program consisted of collector efficiency measurements as well as temperature measurements of collectors under dry-plate or stagnation conditions.

The collectors tested were constructed similarly to the Fauquier High School solar collectors. The collector boxes were made of wood, with 3" of fiberglass back insulation and 1" of side insulation. The absorber plates were of aluminum roll-bond-36" x 92". In all cases except one, the absorber coating is the Alcoa 655 selective coating. This coating has a nominal solar absorptance of 0.93 and an emittance of 0.35. However, there can be a large variation in absorptance from panel to panel making it necessary to handpick the test panels. The panels were picked to provide approximately equal absorptivity as determined visually. One panel was painted with a flat-black Thiokol paint. The emittance of this panel is estimated as 0.9.

A number of different collector glazings were tested. These included Tedlar (polyvinyl fluoride film), Kalwall (fiberglass reinforced polyester) and water white glass (called dull-finish glass in the data sheets). Both single and double glazings were used.

The efficiency data were taken using a standard ITC collector box as a reference. The collector tilt angle was the same as the main collector - 53°. In the data sheets that follow, the following nomenclature is used:

TIME - Eastern daylight time

FLUX - Incident solar radiation on the plane of the collector, Btu/hr-ft^2

TAMB - Ambient temperature, °F

TIN - Inlet water temperature to the collector, °F

TOUT - Outlet water temperature, °F

EFF - Collector efficiency, %

For the dry-plate or stagnation temperature data, the solar flux and the temperature of the middle of the plate are given.

Table Ia (Ref Fig 1)
Performance Data
1-Tedlar vs ITC Collector

PERFORMANCE DATA FOR JULY 6, 1975

FLOW RATE, ITC COLLECTOR = 9.9 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1157	157	82.0	113.9	123.4	60	113.9	124.5	66	0.436	0.440
1208	194	82.6	114.6	126.3	50	114.8	128.3	68	0.361	0.367

FLOW RATE, ITC COLLECTOR = 9.8 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 9.9 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1219	191	83.8	115.0	127.4	64	115.0	128.5	70	0.364	0.367
1230	194	83.5	116.2	128.0	60	116.4	129.6	67	0.365	0.370
1241	198	82.4	118.4	129.9	57	118.4	131.5	66	0.374	0.378
1252	193	83.3	119.5	131.2	60	119.5	132.6	68	0.384	0.388
1303	201	86.5	120.7	132.8	59	120.9	134.2	66	0.360	0.364
1314	203	83.3	122.0	134.1	59	122.0	135.5	66	0.378	0.382

FLOW RATE, ITC COLLECTOR = 9.9 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1324	197	86.9	122.9	135.3	63	123.1	137.5	72	0.377	0.383
1335	198	87.8	124.4	136.0	59	124.4	137.5	66	0.377	0.381
1345	201	88.7	124.5	136.4	59	124.7	137.9	65	0.368	0.372

FLOW RATE, ITC COLLECTOR = 9.8 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1356	200	89.6	125.1	136.6	57	125.2	138.0	63	0.367	0.371
1406	197	86.7	126.2	137.7	58	126.2	138.4	61	0.393	0.394
1416	194	84.9	129.7	140.5	55	129.9	141.5	59	0.425	0.423
1425	188	89.2	128.5	141.5	68	131.2	142.3	59	0.415	0.424
1435	188	91.8	131.9	142.3	55	132.1	142.9	57	0.411	0.413
1444	179	88.7	133.0	142.5	53	133.2	143.2	56	0.453	0.456
1453	172	89.4	133.7	143.2	55	133.9	143.8	57	0.471	0.473

Table Ib

PERFORMANCE DATA FOR JULY 6, 1975

FLOW RATE, ITC COLLECTOR = 9.9 LB/HOUR SQ. FOOT

FLOW RATE, I-TEDLAR COLLECTOR = 9.9 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			I-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1503	170	87.4	135.0	143.8	52	135.0	144.1	54	0.495	0.496
1512	164	91.4	135.5	144.3	54	135.7	144.9	56	0.493	0.495
1521	157	91.2	135.9	144.1	52	136.0	144.5	53	0.514	0.515
1530	157	91.9	135.9	144.1	52	136.0	144.5	53	0.509	0.511
1541	158	90.7	136.6	144.5	50	136.8	145.2	53	0.518	0.521
1552	83	89.6	137.1	142.7	67	137.3	142.5	63	0.998	0.998
1605	134	91.0	137.9	144.1	47	138.0	144.3	47	0.611	0.612
1617	122	91.6	138.2	144.1	48	138.4	144.5	50	0.670	0.672
1629	120	92.7	138.6	144.0	45	138.7	144.1	45	0.670	0.672
1640	123	91.6	138.9	144.5	45	139.1	144.5	43	0.666	0.666

FLOW RATE, ITC COLLECTOR = 9.8 LB/HOUR SQ. FOOT

FLOW RATE, I-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			I-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1651	104	92.1	139.3	143.2	37	139.5	142.9	32	0.779	0.779
1703	106	93.0	139.1	143.1	37	139.3	142.7	32	0.758	0.757
1714	100	96.6	139.1	142.7	35	139.5	142.5	30	0.761	0.762
1725	82	96.3	139.3	142.0	32	139.5	141.5	24	0.934	0.932

Table Ic

PERFORMANCE DATA FOR JULY 8, 1975

FLOW RATE, ITC COLLECTOR = 9.6 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 9.7 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
920	75	66.7	119.5	122.0	33	119.5	121.8	30		
931	83	67.1	120.2	123.3	36	120.2	123.1	34		
941	90	66.4	120.7	124.5	40	120.9	124.5	39	0.978	0.979
952	96	68.5	121.6	126.0	44	121.6	126.2	46	0.913	0.914
1003	108	69.4	122.0	127.0	45	122.2	127.4	47	0.807	0.809
1014	121	72.3	122.5	128.7	49	122.7	129.4	53	0.704	0.708
1024	133	74.1	123.4	130.3	50	123.6	131.2	55	0.639	0.643
1035	90	73.4	124.4	129.6	56	124.5	129.6	55	0.956	0.957
1046	144	74.5	124.7	132.6	53	124.9	133.5	58	0.601	0.605
1056	157	76.1	125.2	133.7	52	125.4	135.0	59	0.545	0.550

FLOW RATE, ITC COLLECTOR = 9.5 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 9.6 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1107	63	75.7	126.5	130.5	59	126.7	129.6	44		
1118	70	77.4	128.0	131.9	54	128.1	131.2	43		
1129	86	77.5	128.5	133.5	56	128.7	133.2	51	0.998	0.997
1140	147	81.0	128.9	137.1	53	129.0	138.0	59	0.571	0.574
1150	80	77.9	129.9	134.1	49	129.9	133.3	41		
1201	65	77.7	130.3	132.6	34	130.5	131.7	19		
1212	35	73.9	130.3	131.4	30	130.5	129.2	-35		
1223	108	75.7	130.1	132.5	21	130.3	131.5	11	0.811	0.807
1233	80	78.6	130.3	133.0	32	130.5	132.3	22		
1244	51	78.1	130.5	131.4	17	130.5	130.5	0		
1255	82	77.4	130.5	132.6	25	130.6	132.1	17		
1306	130	80.1	130.8	137.1	46	131.0	137.7	50	0.663	0.666

FLOW RATE, ITC COLLECTOR = 9.2 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1316	201	81.9	131.5	141.5	46	131.7	142.2	51	0.432	0.434
1327	187	83.1	131.7	141.5	48	131.9	142.3	55	0.458	0.461
1338	207	83.1	132.5	143.2	48	132.6	144.5	56	0.420	0.423
1348	170	84.2	133.0	141.1	44	133.2	141.1	46	0.500	0.501
1359	127	82.0	134.6	140.9	46	135.0	140.7	45	0.694	0.694

Table Id

PERFORMANCE DATA FOR JULY 8, 1975

FLOW RATE, ITC COLLECTOR = 9.0 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 9.6 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1310	61	81.5	135.3	137.5	32	135.5	136.0	9		
1421	193	83.1	135.1	139.6	21	135.5	139.6	21	0.448	0.448
1432	210	86.0	135.5	144.5	39	135.7	145.6	46	0.410	0.413
1443	198	87.8	136.0	146.1	46	136.2	147.0	53	0.430	0.433
1454	94	86.0	136.6	143.1	62	136.8	142.5	59	0.912	0.910
1504	194	87.6	137.9	146.5	40	138.0	147.2	46	0.447	0.449
1515	181	87.8	138.0	146.9	44	138.2	147.6	50	0.480	0.483
1526	165	88.3	138.7	147.6	48	139.1	147.6	49	0.526	0.527
1537	73	86.4	140.0	144.1	51	140.4	142.5	29		
1548	66	86.4	140.5	144.3	51	140.9	143.2	34		
1558	120	87.6	141.1	146.7	42	141.5	146.7	42	0.738	0.740
1609	139	90.3	141.5	147.4	38	141.6	147.2	39	0.620	0.620
1620	82	88.3	142.0	146.3	48	142.3	145.6	38		

FLOW RATE, ITC COLLECTOR = 8.7 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 9.6 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1631	120	88.9	142.3	147.4	37	142.5	146.5	32	0.731	0.728
1642	108	88.2	142.3	146.9	37	142.5	146.1	32	0.819	0.817
1653	66	87.6	142.5	145.0	33	142.5	143.4	13		
1703	56	87.4	142.3	144.5	34	142.5	143.1	9		
1714	61	85.5	142.2	144.0	26	142.3	142.5	3		
1725	53	88.0	141.8	142.9	18	142.2	141.3	-16		
1730	31	83.7	141.5	141.5	0	141.6	139.8	-56		

Table 1e

PERFORMANCE DATA FOR JULY 9, 1977

FLOW RATE, ITC COLLECTOR = 10.5 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 10.0 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	** ITC COLLECTOR			** 1-TEDLAR COLLECTOR			ITC	
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)	(10)	(11)
940	89	72.5	132.3	135.0	32	132.5	134.6	24	0.687	0.687
950	96	72.3	132.5	135.7	35	132.6	135.7	32	0.644	0.644
1000	102	75.9	132.8	136.6	39	133.0	136.8	37	0.577	0.579
1010	110	75.2	133.2	137.7	43	133.3	137.9	41	0.548	0.549
1020	114	78.3	133.7	138.7	46	133.9	139.1	46	0.508	0.511
1030	115	78.4	134.2	139.6	49	134.4	140.0	49	0.509	0.511
1040	120	77.4	135.0	140.7	50	135.0	141.3	52	0.504	0.506
1050	135	77.4	135.5	141.6	48	135.7	142.0	47	0.453	0.455
1100	145	80.8	136.2	143.2	51	136.4	144.1	53	0.406	0.410
1110	151	80.1	137.0	144.5	52	137.1	145.4	55	0.402	0.405

FLOW RATE, ITC COLLECTOR = 10.0 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 9.9 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	** ITC COLLECTOR			** 1-TEDLAR COLLECTOR			ITC	
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)	(10)	(11)
1120	161	81.0	137.9	145.9	51	138.0	146.9	55	0.378	0.381
1138	162	80.6	138.6	145.2	41	138.7	147.6	54	0.378	0.381
1141	165	82.4	138.7	147.4	52	138.9	147.6	52	0.368	0.369
1142	165	82.6	138.7	147.4	52	138.9	147.8	53	0.366	0.368
1143	164	82.9	138.9	147.4	52	139.1	148.1	54	0.367	0.370
1144	163	84.6	139.1	147.4	51	139.1	148.1	55	0.360	0.362
1145	163	84.4	139.1	147.6	52	139.3	148.1	54	0.362	0.364
1146	164	83.3	139.1	147.6	52	139.3	148.1	54	0.366	0.368
1147	166	82.4	139.1	147.8	52	139.3	148.3	54	0.368	0.370
1148	167	83.8	139.1	147.8	52	139.3	148.3	54	0.357	0.359
1149	165	84.0	139.5	147.8	50	139.6	148.3	52	0.362	0.365
1151	165	85.1	139.6	148.1	51	139.6	148.6	54	0.356	0.358
1152	167	85.3	139.8	148.3	51	139.8	148.8	54	0.352	0.355

FLOW RATE, ITC COLLECTOR = 10.0 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 9.9 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	** ITC COLLECTOR			** 1-TEDLAR COLLECTOR			ITC	
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)	(10)	(11)
1153	167	84.9	139.8	148.5	52	140.0	149.2	54	0.355	0.358
1154	167	84.9	140.0	148.6	52	140.0	149.2	54	0.356	0.358
1155	164	83.5	139.8	148.6	54	140.0	149.4	57	0.370	0.373
1156	136	83.8	140.0	148.6	64	140.2	149.2	66	0.445	0.448
1158	144	85.8	140.2	145.4	36	140.2	144.7	31	0.396	0.394
1159	154	85.6	140.2	147.0	44	140.4	147.2	44	0.377	0.378
1200	158	85.6	140.0	147.4	47	140.4	147.6	45	0.368	0.370
1202	173	87.3	140.5	148.5	46	140.7	149.0	48	0.331	0.333
1204	177	87.3	140.4	149.4	51	140.5	150.1	53	0.326	0.328
1206	164	84.2	141.1	149.5	52	140.9	150.3	57	0.373	0.374
1208	184	89.2	140.9	149.4	46	140.9	150.1	50	0.304	0.306
1210	172	86.5	141.1	149.4	50	141.1	150.1	52	0.343	0.344
1211	176	88.3	141.3	150.1	50	141.3	150.4	52	0.326	0.327

Table If

FLOW RATE, ITC COLLECTOR = 10.0 LB/HOUR SQ. FOOT										
FLOW RATE, 1-TEDLAR COLLECTOR = 9.9 LB/HOUR SQ. FOOT										
** ITC COLLECTOR ** 1-TEDLAR COLLECTOR ITC TEST										
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF	X1, X2	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1213	151	86.2	141.5	149.4	52	141.5	149.5	53	0.392	0.393
1222	70	83.5	142.2	148.6	93	142.2	148.5	90	0.884	0.884
1223	76	83.7	142.3	146.9	59	142.2	145.8	47	0.801	0.794
1224	76	86.4	142.3	146.5	55	142.3	145.2	38	0.763	0.755
1227	103	84.4	142.0	146.5	44	142.0	145.6	35	0.581	0.577
1228	107	86.5	142.2	147.0	45	142.2	146.3	38	0.543	0.540
1230	152	86.7	142.0	149.0	46	142.2	149.2	46	0.387	0.388
1231	129	87.8	142.3	149.0	52	142.5	149.0	50	0.449	0.449
1232	123	88.7	142.5	148.1	46	142.5	147.8	42	0.460	0.459

FLOW RATE, ITC COLLECTOR = 9.6 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 9.9 LB/HOUR SQ. FOOT

** ITC COLLECTOR ** 1-TEDLAR COLLECTOR										
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1235	73	87.1	142.5	146.5	53	142.5	145.6	42	0.786	0.780
1245	196	88.3	143.1	151.9	43	143.2	153.1	50	0.302	0.305
1256	106	88.0	144.0	149.4	49	144.1	148.3	44	0.554	0.552
1307	202	91.6	144.7	154.2	46	144.9	154.8	49	0.286	0.288
1318	201	91.9	145.6	156.0	50	145.8	156.4	53	0.293	0.295
1329	204	91.9	147.0	157.1	48	147.2	157.5	50	0.295	0.296
1340	209	92.1	147.9	158.0	47	148.1	158.0	47	0.291	0.292

FLOW RATE, ITC COLLECTOR = 9.0 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 9.9 LB/HOUR SQ. FOOT

** ITC COLLECTOR ** 1-TEDLAR COLLECTOR										
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1351	185	91.2	148.3	159.6	55	148.3	158.5	55	0.339	0.336
1404	192	92.8	149.7	159.3	45	149.7	159.1	48	0.321	0.321
1412	193	92.7	150.3	160.2	46	150.3	160.0	50	0.324	0.324
1423	123	91.9	152.1	157.5	40	152.1	157.1	41	0.511	0.510
1434	191	90.9	152.8	160.0	34	153.0	160.9	41	0.343	0.346
1445	194	92.7	153.1	161.1	37	153.1	162.1	46	0.438	0.439
1456	147	92.7	154.0	160.9	42	154.0	161.4	50	0.441	0.442
1507	78	90.5	154.9	158.4	39	154.9	157.5	32	0.848	0.842
1518	47	88.3	155.3	156.2	17	155.3	154.4	19	1.435	1.416

FLOW RATE, ITC COLLECTOR = 9.6 LB/HOUR SQ. FOOT
 FLOW RATE, 1-TEDLAR COLLECTOR = 9.3 LB/HOUR SQ. FOOT

** ITC COLLECTOR ** 1-TEDLAR COLLECTOR										
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1527	49	87.6	154.9	155.1	4	154.9	153.7	24	1.376	
1538	45	85.3	154.9	154.4	12	154.9	153.0	41		
1549	30	82.6	154.8	153.1	52	154.8	151.5	100		
1600	17	82.4	154.2	152.1	123	154.2	150.8	187		
1603	10	81.1	154.0	151.5	242	154.0	149.9	384		
1604		80.6	154.0	151.4	306	154.0	149.7	473		

Table IIa (Ref. Fig. 1)
Performance Data
1-Tedlar vs ITC Collector

July 10, 1975

FLOW RATE, ITC COLLECTOR = 10.9 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 10.9 LB/HOUR SQ. FOOT

		** ITC COLLECTOR				** 1-TEDLAR COLLECTOR				ITC TEST	
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		X1, X2	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(10), (11)	
943	63	74.5	144.1	144.7	10	144.3	143.1	22		1.110	1.099
954	102	75.7	144.3	147.6	35	144.3	147.0	29		0.689	0.686
1005	112	78.1	145.0	149.4	42	145.0	149.2	40		0.617	0.616
1015	117	76.8	146.1	151.4	49	146.1	151.4	49		0.615	0.615
1026	121	79.5	147.4	153.3	53	147.6	153.0	49		0.586	0.585
1037	126	78.6	150.6	156.4	50	150.6	156.4	50		0.595	0.595
1047	134	79.7	156.4	162.1	47	156.4	162.1	47		0.594	0.594
1058	140	80.4	163.9	169.5	43	164.1	169.9	45		0.619	0.621

FLOW RATE, ITC COLLECTOR = 9.6 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 9.2 LB/HOUR SQ. FOOT

		** ITC COLLECTOR				** 1-TEDLAR COLLECTOR					
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)			
1109	150	80.1	173.3	176.9	23	173.5	177.6	26		0.633	0.636
1119	155	81.9	178.9	184.5	35	179.1	184.3	31		0.644	0.644
1130	159	82.8	177.8	184.3	39	178.0	184.1	36		0.618	0.618
1141	158	82.9	176.5	181.8	32	176.7	180.3	21		0.609	0.605
1151	176	81.7	175.1	182.7	41	175.1	183.4	44		0.552	0.554
1201	182	85.6	174.8	183.0	44	174.8	183.6	45		0.513	0.514
1210	187	87.1	173.3	180.9	39	173.3	181.2	39		0.481	0.482
1220	190	86.9	173.5	181.9	43	173.5	183.2	47		0.478	0.481
1230	60	84.9	172.9	177.4	72	173.1	176.9	58		1.504	1.502
1240	153	84.0	171.5	180.3	56	171.7	181.6	60		0.601	0.606
1250	204	87.1	171.9	181.4	45	172.0	183.0	50		0.439	0.443
1300	201	86.5	172.4	181.4	43	172.4	182.5	46		0.450	0.453
1310	218	89.6	172.4	182.5	45	172.6	184.3	50		0.403	0.408

FLOW RATE, ITC COLLECTOR = 8.9 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 7.8 LB/HOUR SQ. FOOT

		** ITC COLLECTOR				** 1-TEDLAR COLLECTOR					
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)			
1321	212	89.4	171.5	181.0	40	171.2	181.8	36		0.410	0.413

FLOW RATE, ITC COLLECTOR = 10.7 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 11.0 LB/HOUR SQ. FOOT

		** ITC COLLECTOR				** 1-TEDLAR COLLECTOR					
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)			
1332	197	90.0	172.2	180.5	45	172.4	180.1	43		0.438	0.438
1343	81	88.5	171.1	174.8	48	171.3	172.8	20		1.043	1.032
1354	98	89.8	169.2	171.1	38	169.3	169.5	3		1.033	1.021

Table IIb

FLOW RATE, ITC COLLECTOR = 9.0 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 10.4 LB/HOUR SQ. FOOT

		** ITC COLLECTOR				** 1-TEDLAR COLLECTOR					
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(10)	(11)
1404	77	88.3	168.4	170.2	21	168.6	168.1	7		1.032	
1415	91	89.4	168.1	175.3	72	168.3	174.4	70		0.984	0.9
1426	90	88.9	168.3	172.4	42	168.4	170.6	25		0.985	0.8
1437	203	90.5	168.6	176.5	35	168.8	175.8	36		0.404	0.4
1448	192	90.9	169.2	176.5	35	169.3	175.6	34		0.427	0.4
1458	170	90.3	169.2	174.8	30	169.3	173.5	25		0.481	0.47
1509	139	91.6	168.1	172.6	29	168.3	171.5	24		0.567	0.5
1520	43	85.6	165.9	166.7	4	166.1	163.8	56		1.370	
1531	73	87.1	162.9	163.8	11	163.0	162.0	16		1.045	
1541	158	88.9	161.4	164.3	17	161.6	163.0	10		0.463	0

FLOW RATE, ITC COLLECTOR = 9.7 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 10.3 LB/HOUR SQ. FOOT

		** ITC COLLECTOR				** 1-TEDLAR COLLECTOR					
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(10)	(11)
1552	60	86.7	160.2	161.4	20	160.5	159.4	19		1.235	
1603	119	88.7	158.2	161.8	29	158.4	160.7	20		0.598	0.5
1614	116	90.5	157.8	161.8	33	158.0	160.7	24		0.598	0.5
1625	65	86.7	156.2	157.8	24	156.4	156.0	6		1.082	
1636	67	87.8	154.2	155.5	18	154.4	153.7	11		1.001	

FLOW RATE, ITC COLLECTOR = 9.1 LB/HOUR SQ. FOOT
FLOW RATE, 1-TEDLAR COLLECTOR = 10.4 LB/HOUR SQ. FOOT

		** ITC COLLECTOR				** 1-TEDLAR COLLECTOR					
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(10)	(11)
1646	71	87.3	152.1	153.7	21	152.2	152.2	0		0.924	0.9
1657	59	85.8	150.4	151.5	17	150.6	150.1	10		1.104	
1708	39	85.8	148.8	149.2	9	149.0	147.6	39		1.621	
1719	20	83.7	146.1	145.6	25	146.3	143.8	130			
1730	5	72.0	143.6	142.5	182	144.0	140.4	692			

Table IIIa (Ref. Fig. 1)
Performance Data
1-Tedlar vs ITC Collector

PERFORMANCE DATA FOR JULY 18, 1975

FLOW RATE, ITC COLLECTOR = 9.5 LB/HOUR SQ. FOOT

FLOW RATE, 1-TEDLAR COLLECTOR = 9.6 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
950	86	75.9	94.1	98.6	50	94.1	99.1	56	0.607	0.610
955	122	77.9	96.3	101.5	41	96.5	102.6	48	0.435	0.440
1006	137	79.2	99.7	108.5	61	99.7	109.8	71	0.415	0.419
1017	134	78.6	93.4	98.4	36	93.4	99.1	41	0.367	0.370
1028	137	79.0	105.6	111.4	40	105.8	112.1	45	0.451	0.454
1039	142	81.1	117.9	123.4	37	118.0	124.0	40	0.504	0.507
1049	150	81.0	129.9	135.3	34	129.9	135.5	36	0.556	0.557

FLOW RATE, ITC COLLECTOR = 8.9 LB/HOUR SQ. FOOT

FLOW RATE, 1-TEDLAR COLLECTOR = 9.4 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1100	159	80.2	139.6	145.2	31	139.6	145.2	33	0.593	0.593
1111	170	82.9	149.0	154.4	28	149.0	154.6	31	0.594	0.595
1122	179	82.9	157.6	163.2	28	157.6	163.4	30	0.612	0.613

FLOW RATE, ITC COLLECTOR = 9.5 LB/HOUR SQ. FOOT

FLOW RATE, 1-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1133	196	84.2	165.0	171.9	33	165.2	171.9	33	0.594	0.594
1143	188	82.4	173.1	175.5	12	173.3	173.5	1	0.661	0.656
1154	217	85.6	179.3	186.3	31	179.3	186.1	31	0.596	0.595

FLOW RATE, ITC COLLECTOR = 9.4 LB/HOUR SQ. FOOT

FLOW RATE, 1-TEDLAR COLLECTOR = 9.3 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1204	243	86.2	182.1	189.3	28	182.3	189.5	28	0.542	0.542
1205	120	84.9	185.0	191.8	54	185.2	191.5	49		
1216	126	83.7	189.7	191.1	11	189.9	188.8	8		
1227	235	87.6	192.4	201.0	35	192.6	200.7	32	0.602	0.601
1238	232	87.4	194.9	202.7	31	195.1	201.6	26	0.618	0.616

Table IIb

PERFORMANCE DATA FOR JULY 18, 1975

FLOW RATE, ITC COLLECTOR = 10.9 LB/HOUR SQ. FOOT

FLOW RATE, 1-TEDLAR COLLECTOR = 11.3 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1333	226	86.0	185.0	193.8	43	185.2	192.6	37	0.599	0.597
1354	233	86.2	179.4	187.7	39	179.6	187.5	38	0.556	0.556
1405	77	85.8	180.9	186.8	84	181.0	185.9	71		
1415	252	86.7	178.7	183.8	22	178.9	182.9	18	0.503	0.502
1426	107	86.4	179.1	184.1	51	179.3	182.9	38		

FLOW RATE, ITC COLLECTOR = 10.9 LB/HOUR SQ. FOOT

FLOW RATE, 1-TEDLAR COLLECTOR = 11.1 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1437	221	89.1	174.0	181.4	37	174.2	181.4	36	0.547	0.548
1448	214	88.9	174.8	182.1	38	174.9	181.9	36	0.567	0.567
1459	207	89.8	175.8	182.9	37	176.0	182.9	37	0.588	0.589

LEAST SQUARES? :YES

ITC SLOPE=- 46.2015 ITC INTERCEPT= 65.9198

TEST SLOPE=- 42.4817 TEST INTERCEPT= 60.4618

Table IVa (Ref Fig 2)
Performance Data
2-Tedlar vs ITC Collector

PERFORMANCE DATA FOR JULY 2, 1975

FLOW RATE, ITC COLLECTOR = 9.8 LB/HOUR SQ. FOOT
FLOW RATE, 2-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1140	182	80.6	81.9	97.7	85	82.2	97.3	81	0.226	0.226
1150	188	82.4	82.0	96.5	75	82.0	97.0	78	0.207	0.209
1200	191	81.9	83.1	96.6	70	83.1	98.1	77	0.210	0.214
1205	193	82.4	84.6	97.5	66	84.9	99.0	71	0.211	0.216
1206	193	83.1	85.8	98.6	65	86.4	100.4	71	0.213	0.219
1207	193	82.2	86.4	99.1	67	86.5	101.1	75	0.221	0.226
1210	188	81.3	88.2	101.1	69	88.3	103.1	77	0.241	0.247
1215	188	82.0	93.9	105.8	63	94.1	108.9	77	0.265	0.273
1217	192	82.2	94.1	106.7	66	94.3	108.9	75	0.261	0.268
1219	193	83.1	94.7	107.8	68	94.8	108.1	68	0.260	0.261
1220	194	83.1	94.7	107.4	66	94.8	108.3	69	0.258	0.261
1225	192	81.1	95.9	107.8	62	96.1	109.4	68	0.275	0.279
1230	188	82.4	96.5	108.5	64	96.6	110.1	71	0.277	0.282
1231	188	83.8	96.6	108.5	64	96.6	110.1	71	0.271	0.275
1231	189	84.2	96.5	108.7	65	96.6	110.3	71	0.267	0.271
1232	190	84.0	96.6	108.9	65	96.6	110.5	72	0.267	0.272
1235	189	82.2	97.3	109.9	67	97.5	110.5	68	0.283	0.285
1240	194	84.2	99.0	111.2	63	99.0	111.6	64	0.272	0.273
1245	201	84.7	100.6	112.8	61	100.6	113.0	61	0.269	0.270
1250	198	83.3	103.1	114.6	58	103.1	115.4	61	0.291	0.292
1300	200	84.4	106.0	117.7	59	106.2	118.4	61	0.298	0.300
1310	208	85.3	108.5	121.1	61	108.9	120.9	57	0.296	0.296
1320	209	84.4	111.6	122.4	52	111.6	122.4	51	0.309	0.309
1325	218	84.9	114.1	125.8	48	114.3	125.1	53	0.308	0.307
1330	205	86.9	115.9	128.9	57	115.9	128.1	64	0.329	0.327
1340	201	85.3	118.4	130.8	55	118.4	130.1	62	0.356	0.354
1350	201	85.3	120.9	133.3	55	120.9	132.5	62	0.368	0.366
1400	198	86.0	123.6	135.3	53	123.6	134.6	59	0.381	0.379
1410	184	86.0	126.7	138.0	55	127.0	137.1	59	0.425	0.424

Table IVb

PERFORMANCE DATA FOR JULY 2, 1975

FLOW RATE, ITC COLLECTOR = 8.9 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 10.7 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
		TAMB (3)	TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)		
1420	184	85.1	129.0	140.4	55	129.0	139.3	0.443	0.440
1500	174	85.3	131.9	142.0	52	131.9	141.3	0.480	0.478
1510	166	86.9	135.1	145.0	53	135.3	143.8	0.514	0.511
1520	159	87.3	137.5	146.1	49	137.7	145.4	0.545	0.543
1530	148	86.9	139.6	147.8	49	139.6	147.2	0.600	0.598
1540	142	86.7	141.8	149.0	45	142.0	148.5	0.639	0.638
1550	133	86.9	143.4	150.1	45	143.4	149.4	0.693	0.690
1600	127	86.7	145.4	151.4	40	145.4	150.6	0.736	0.733
1610	117	87.6	147.4	152.4	36	147.4	151.7	0.804	0.801
1620	110	87.3	149.2	153.3	32	149.2	152.4	0.877	0.873
1630	101	87.8	150.8	154.4	30	150.8	153.5	0.958	0.954
1645	92	91.2	153.0	155.3	22	153.1	154.6		
1700	82	91.8	154.8	156.4	17	154.8	155.8		
1710	73	91.6	156.6	157.3	8	156.6	156.6		
1725	66	95.5	158.0	157.8	- 2	158.0	157.3		

Table IVc

PERFORMANCE DATA FOR JULY 3, 1975

FLOW RATE, ITC COLLECTOR = 9.5 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 9.9 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1007	111	82.0	191.5	192.7	11	191.5	192.4	8		
1018	120	82.0	190.2	192.4	17	190.2	192.0	15		
1030	127	82.2	189.1	191.8	20	189.1	191.7	20		
1041	133	83.3	187.4	192.7	39	187.4	191.7	32		
1052	139	83.1	186.8	192.9	42	187.0	191.7	33	1.000	0.996
1104	145	84.7	186.8	192.9	40	186.8	191.8	34	0.946	0.942

PERFORMANCE DATA FOR JULY 3, 1975

FLOW RATE, ITC COLLECTOR = 10.3 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 11.1 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1115	152	83.3	188.1	193.8	39	188.2	194.0	42	0.919	0.920

FLOW RATE, ITC COLLECTOR = 9.6 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1200	185	84.9	194.7	202.7	41	194.9	202.5	40	0.788	0.788
1210	191	85.3	192.9	199.8	34	193.1	199.4	32	0.748	0.748
1222	193	86.0	191.5	197.6	30	191.5	199.1	38	0.729	0.733
1234	202	86.7	190.2	197.4	34	190.2	198.2	38	0.689	0.690
1245	199	86.4	189.5	196.7	35	189.7	197.2	37	0.697	0.699
1255	205	86.9	184.6	194.2	45	184.6	194.4	46	0.656	0.656
1300	201	87.6	181.4	196.0	69	181.4	193.8	60	0.661	0.656
1311	196	86.9	181.2	194.2	63	181.4	193.1	59	0.678	0.676
1334	207	86.9	164.5	175.5	51	164.5	178.4	66	0.557	0.564

Table IVd

PERFORMANCE DATA FOR JULY 3, 1975

FLOW RATE, ITC COLLECTOR = 8.7 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 8.0 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1345	203	88.3	167.0	176.0	39	167.0	178.9	47	0.568	0.575
1357	205	88.9	167.7	176.5	37	167.7	178.9	44	0.562	0.568
1409	79	88.5	168.3	174.6	70	168.3	176.5	84		
1421	202	88.7	170.6	178.4	33	170.6	181.0	41	0.583	0.590
1433	123	86.9	175.1	180.1	36	175.3	181.8	42	0.995	

FLOW RATE, ITC COLLECTOR = 8.7 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 7.9 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1445	190	91.2	178.5	184.6	28	178.7	186.6	33	0.645	0.651
1456	69	87.8	181.0	184.5	43	181.0	185.4	50		
1507	68	88.9	183.6	186.4	37	183.8	187.7	46		
1518	166	88.3	185.7	190.4	25	186.3	190.9	22	0.795	0.798

FLOW RATE, ITC COLLECTOR = 8.7 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 8.2 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1529	161	89.2	188.1	191.7	20	188.2	192.6	22	0.823	0.826
1540	154	90.0	190.6	194.2	20	190.6	194.7	22	0.872	0.873
1551	138	91.9	192.7	195.3	16	193.1	195.6	15	0.971	0.974
1602	100	90.7	192.6	192.9	3	192.7	192.4	- 3		

FLOW RATE, ITC COLLECTOR = 8.8 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 8.0 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1613	123	90.1	190.9	193.1	15	190.9	193.3	15		
1624	110	91.4	189.5	190.9	12	189.5	190.8	9		

Table IVe

PERFORMANCE DATA FOR JULY 21, 1975

FLOW RATE, ITC COLLECTOR = 10.2 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 10.2 LB/HOUR SQ. FOOT

TIME	FLUX	TAMB	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1	TEST X2
			TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1052	150	80.6	106.7	115.4	59	106.9	115.4	58	0.417	0.418
1102	156	82.4	101.1	113.4	80	101.1	113.9	84	0.365	0.367

FLOW RATE, ITC COLLECTOR = 10.4 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 9.9 LB/HOUR SQ. FOOT

TIME	FLUX	TAMB	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1	TEST X2
			TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1139	188	83.3	103.5	114.5	61	103.5	114.8	60	0.306	0.307
1144	191	84.4	105.8	116.1	56	105.8	116.8	57	0.307	0.309
1150	188	83.5	111.4	120.7	52	111.4	121.6	54	0.343	0.346
1155	188	83.7	114.8	124.4	53	114.8	125.4	56	0.361	0.364

FLOW RATE, ITC COLLECTOR = 9.8 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 9.6 LB/HOUR SQ. FOOT

TIME	FLUX	TAMB	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1	TEST X2
			TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1216	206	87.3	133.2	142.5	44	133.3	143.4	47	0.401	0.404
1220	208	88.2	137.1	146.1	42	137.3	147.0	45	0.411	0.413
1225	202	87.8	142.7	150.4	37	142.9	151.4	40	0.449	0.452
1234	216	85.5	151.2	159.6	38	151.2	161.6	47	0.472	0.477

FLOW RATE, ITC COLLECTOR = 9.6 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 9.6 LB/HOUR SQ. FOOT

TIME	FLUX	TAMB	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1	TEST X2
			TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1239	196	86.4	151.2	163.6	61	151.4	165.0	67	0.526	0.530
1245	223	87.6	154.8	164.8	43	154.8	166.5	51	0.468	0.471

Table IVf

FLOW RATE, ITC COLLECTOR = 9.5 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 9.4 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1301	221	87.1	101.9	113.6	50	101.9	114.3	53	0.238	0.239
1311	207	85.8	110.8	121.8	50	111.0	122.2	51	0.303	0.304
1332	228	86.4	132.3	143.2	46	132.5	144.3	49	0.365	0.368
1337	227	88.7	137.5	148.1	45	137.7	149.4	48	0.380	0.383
1342	219	86.7	142.0	152.2	45	142.2	153.3	48	0.422	0.425
1347	224	86.2	145.0	155.3	44	145.2	156.0	45	0.429	0.431

FLOW RATE, ITC COLLECTOR = 9.3 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 9.5 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1352	214	88.3	148.6	158.7	44	148.8	159.1	46	0.456	0.457
1357	219	86.2	151.2	161.6	44	151.4	162.1	47	0.467	0.468
1403	218	86.2	154.6	164.3	42	154.8	165.0	45	0.484	0.486

FLOW RATE, ITC COLLECTOR = 8.9 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 9.4 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1429	108	89.2	167.4	170.6	27	167.5	169.7	19		
1430	102	87.8	167.7	171.7	35	167.9	170.8	27		
1436	211	86.9	168.3	176.0	33	168.4	176.2	34	0.555	0.556
1441	209	88.9	171.5	179.3	33	171.7	179.4	35	0.567	0.568
1446	206	90.3	175.3	183.2	34	175.5	183.2	35	0.587	0.588
1452	191	88.0	178.2	185.2	33	178.5	185.2	33	0.657	0.658
1457	183	88.3	180.7	187.5	33	181.0	187.4	32	0.699	0.700
1503	190	90.7	181.8	189.1	35	181.9	189.1	36	0.668	0.669

FLOW RATE, ITC COLLECTOR = 8.7 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 9.2 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1508	186	90.1	181.0	188.6	36	181.4	188.2	34	0.682	0.682
1513	194	88.7	179.6	188.1	38	179.8	187.7	38	0.654	0.654
1519	182	92.7	179.3	187.4	39	179.4	186.8	37	0.674	0.673
1524	171	93.2	178.7	186.4	40	178.9	185.9	38	0.712	0.711
1529	108	92.8	177.6	184.6	57	177.8	183.6	49		
1535	164	93.2	176.5	184.1	40	176.7	183.2	37	0.729	0.726
1540	161	93.2	175.6	183.0	40	176.0	182.3	36	0.737	0.735
1545	154	94.8	174.9	181.9	40	175.1	181.0	36	0.750	0.747

Table IVg

FLOW RATE, ITC COLLECTOR = 8.7 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 9.2 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1551	151	93.7	174.0	180.7	39	174.2	180.0	35	0.765	0.763
1556	150	92.8	173.1	179.8	39	173.3	178.9	34	0.773	0.770
1601	137	93.7	172.0	178.4	40	172.2	177.4	35	0.827	0.824
1606	136	93.9	171.1	177.4	41	171.3	176.7	37	0.828	0.826
1612	135	93.4	170.2	176.4	40	170.4	175.5	35	0.829	0.827
1617	130	93.6	169.2	174.9	39	169.3	174.2	35	0.853	0.851
1622	125	92.1	168.1	173.7	39	168.3	172.8	33	0.887	0.884
1628	120	92.5	167.0	172.6	41	167.2	171.7	35	0.915	0.912

PERFORMANCE DATA FOR JULY 22, 1975

FLOW RATE, ITC COLLECTOR = 10.4 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 10.2 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
929	89	74.9	95.7	98.6	34	95.7	98.4	31	0.613	0.612
930	59	75.6	96.8	99.7	50	96.6	99.5	50	0.921	0.918
935	66	75.7	101.5	103.1	25	101.5	103.1	25	0.883	0.883
937	65	75.7	103.8	104.9	17	103.8	104.7	14	0.936	0.934
939	71	75.9	106.0	107.2	19	106.2	107.1	13	0.884	0.884
941	76	75.9	108.0	109.2	17	108.0	109.2	17	0.847	0.847
943	80	76.5	109.8	111.4	21	109.8	111.2	18	0.824	0.823
948	60	75.6	109.9	115.7	99	109.8	115.5	98		

FLOW RATE, ITC COLLECTOR = 10.3 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 10.3 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1021	93	78.8	145.6	146.7	12	145.8	147.4	18		
1023	133	79.0	148.1	148.3	1	148.1	148.6	4	0.763	0.764
1057	169	80.4	150.3	156.7	40	150.3	157.1	42	0.622	0.623
1059	169	81.0	151.9	157.8	36	152.1	158.2	37	0.627	0.629
1101	159	82.0	152.6	158.5	39	152.8	153.7	39	0.664	0.665
1103	133	81.0	153.5	158.5	39	153.7	158.5	38	0.807	0.808
1105	161	81.9	154.2	160.0	37	154.2	160.0	37	0.669	0.669
1107	170	81.0	155.1	161.4	38	155.3	162.0	41	0.644	0.646
1109	171	81.5	155.8	162.0	37	155.8	162.3	39	0.639	0.640

Table IVh

FLOW RATE, ITC COLLECTOR = 9.8 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 9.6 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1143	185	83.1	169.7	178.0	44	169.7	178.0	43	0.663	0.663
1145	182	83.1	170.8	178.7	43	170.8	178.5	41	0.679	0.679
1147	187	83.1	171.5	179.4	42	171.5	179.4	41	0.666	0.666
1149	189	82.2	172.6	180.5	41	172.6	180.5	40	0.669	0.669
1151	170	80.2	173.1	180.7	44	173.1	180.5	42	0.758	0.758
1153	194	82.4	173.7	181.6	40	173.8	181.2	37	0.657	0.657
1158	208	81.5	175.3	184.1	42	175.5	183.9	39	0.628	0.628
1202	204	82.0	176.5	184.8	40	176.5	184.8	39	0.642	0.642
1205	203	81.9	177.6	185.9	40	177.8	186.1	39	0.650	0.651
1207	197	82.2	178.0	186.3	41	178.2	186.3	39	0.671	0.671

FLOW RATE, ITC COLLECTOR = 9.8 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1246	229	85.1	114.6	123.6	39	114.5	124.0	41	0.288	0.289
1248	201	83.8	120.0	129.6	47	120.0	129.9	48	0.363	0.363
1256	147	83.1	100.6	108.9	56	100.4	108.3	53	0.366	0.363
1259	204	83.7	105.3	114.5	44	105.3	114.5	44	0.286	0.286
1304	204	83.1	114.8	124.5	47	114.8	124.9	49	0.337	0.338
1320	225	82.9	136.8	146.1	41	136.8	146.1	41	0.402	0.402
1326	231	84.2	144.3	153.5	39	144.3	154.4	43	0.420	0.421
1332	228	84.4	150.8	160.0	40	150.8	160.5	42	0.451	0.453
1352	219	83.8	156.4	165.6	41	156.4	166.1	44	0.498	0.500
1357	226	84.0	171.1	180.7	42	171.3	181.0	42	0.548	0.550
1402	225	85.3	174.2	183.8	42	174.2	183.8	42	0.558	0.558
1407	225	85.3	176.4	185.9	42	176.5	185.9	41	0.570	0.570

FLOW RATE, ITC COLLECTOR = 9.7 LB/HOUR SQ. FOOT
 FLOW RATE, 2-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			2-TEDLAR COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1412	159	83.1	177.3	184.5	44	177.3	183.4	38	0.817	0.813
1418	225	84.9	174.6	185.2	46	174.6	184.6	44	0.566	0.565
1423	226	84.0	174.6	184.5	43	174.6	184.3	42	0.564	0.564
1426	224	85.5	175.1	185.4	45	175.1	185.2	44	0.567	0.567

Table IVi

FLOW RATE, ITC COLLECTOR = 9.9 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 10.2 LB/HOUR SQ. FOOT

TIME FLUX		ITC COLLECTOR				2-TEDLAR COLLECTOR			ITC	TEST
		TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF	X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1516	174	85.5	119.5	129.6	58	119.5	128.9	55	0.410	0.408
1525	171	85.3	98.4	113.0	85	98.4	113.2	89	0.308	0.308
1527	168	85.1	98.6	112.8	84	98.6	112.6	85	0.313	0.312
1529	167	86.7	98.6	112.8	85	98.6	112.5	85	0.306	0.305
1531	166	85.8	98.6	113.0	86	98.6	112.6	87	0.314	0.313
1537	160	85.6	102.6	111.7	57	102.6	111.4	57	0.335	0.334
1542	157	86.2	112.3	120.4	51	112.3	120.0	50	0.395	0.394

FLOW RATE, ITC COLLECTOR = 9.5 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME FLUX		ITC COLLECTOR				2-TEDLAR COLLECTOR			ITC	TEST
		TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF	X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1558	141	85.5	133.0	139.1	41	133.2	138.7	39	0.585	0.585
1604	137	85.8	138.7	144.1	38	138.7	144.0	37	0.642	0.641
1609	132	86.0	143.6	148.5	35	143.8	148.3	33	0.698	0.698
1615	132	85.8	147.9	152.4	32	147.9	152.2	32	0.731	0.730
1617	130	85.8	150.1	154.4	32	150.3	154.2	30	0.760	0.760
1620	127	86.5	152.1	156.2	31	152.1	156.0	31	0.788	0.787
1623	125	86.2	153.9	157.8	30	154.0	157.5	27	0.814	0.813
1626	123	86.4	155.7	159.6	31	155.8	159.1	26	0.842	0.841
1629	120	85.8	157.5	161.1	28	157.6	160.7	25	0.877	0.876

FLOW RATE, ITC COLLECTOR = 8.9 LB/HOUR SQ. FOOT

FLOW RATE, 2-TEDLAR COLLECTOR = 9.6 LB/HOUR SQ. FOOT

TIME FLUX		ITC COLLECTOR				2-TEDLAR COLLECTOR			ITC	TEST
		TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF	X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1707	92	86.4	166.5	167.5	11	166.5	167.0	6		
1710	89	86.0	166.3	167.4	11	166.3	166.6	4		
1712	87	86.9	166.6	167.4	7	166.6	166.8	2		
1714	86	86.7	167.0	167.5	6	167.0	167.0	0		
1716	86	87.3	167.5	167.7	2	167.7	167.4	- 4		
1718	83	87.4	167.9	168.1	2	168.1	167.7	- 4		

ITC SLOPE=- 48.2873 ITC INTERCEPT= 68.1250

TEST SLOPE=- 60.1205 TEST INTERCEPT 75.6774

Table Va (Ref. Fig. 3)
Performance Data
Waffle Absorber vs. ITC Collector

PERFORMANCE DATA FOR JULY 23, 1975

FLOW RATE, ITC COLLECTOR = 11.1 LB/HOUR SQ. FOOT
FLOW RATE, WAFFLE COLLECTOR = 10.1 LB/HOUR SQ. FOOT

TIME FLUX		ITC COLLECTOR				WAFFLE COLLECTOR			ITC	TEST
(1)	(2)	TAMB (3)	TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)	X1 (10)	X2 (11)
1239	218	90.5	134.6	144.1	49	134.8	143.6	41	0.372	0.371

FLOW RATE, ITC COLLECTOR = 10.9 LB/HOUR SQ. FOOT
FLOW RATE, WAFFLE COLLECTOR = 9.9 LB/HOUR SQ. FOOT

TIME FLUX		ITC COLLECTOR				WAFFLE COLLECTOR			ITC	TEST
(1)	(2)	TAMB (3)	TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)	X1 (10)	X2 (11)
1245	220	90.5	138.4	147.6	46	138.6	147.4	40	0.384	0.384
1251	216	90.1	142.3	150.3	40	142.5	150.1	35	0.408	0.408
1257	113	90.1	145.4	151.5	59	145.6	152.1	57	0.802	0.805
1303	222	89.1	147.2	155.1	39	147.2	155.8	39	0.424	0.425
1308	189	90.1	149.7	158.0	48	149.7	156.9	38	0.507	0.504
1315	100	89.6	151.9	159.6	84	151.9	159.8	78	0.979	0.980
1320	226	90.3	153.5	161.4	38	153.7	162.0	36	0.439	0.440
1325	209	90.5	155.5	163.6	42	155.7	163.6	38	0.484	0.484
1330	215	90.5	157.3	165.7	43	157.5	165.6	37	0.479	0.479

FLOW RATE, ITC COLLECTOR = 10.9 LB/HOUR SQ. FOOT
FLOW RATE, WAFFLE COLLECTOR = 10.1 LB/HOUR SQ. FOOT

TIME FLUX		ITC COLLECTOR				WAFFLE COLLECTOR			ITC	TEST
(1)	(2)	TAMB (3)	TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)	X1 (10)	X2 (11)
1421	189	90.7	167.2	174.6	43	167.4	175.5	43	0.594	0.597
1426	171	90.5	167.4	173.7	40	167.4	174.6	42	0.654	0.657

PERFORMANCE DATA FOR JULY 24, 1975

FLOW RATE, ITC COLLECTOR = 11.3 LB/HOUR SQ. FOOT
FLOW RATE, WAFFLE COLLECTOR = 11.6 LB/HOUR SQ. FOOT

TIME FLUX		ITC COLLECTOR				WAFFLE COLLECTOR			ITC	TEST
(1)	(2)	TAMB (3)	TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)	X1 (10)	X2 (11)
1024	118	81.9	102.7	107.1	41	103.7	102.9	- 7	0.465	
1131	161	91.6	137.7	144.5	48	138.0	143.6	40	0.507	0.506
1136	178	90.0	139.6	146.7	45	139.8	146.1	41	0.480	0.479
1141	188	90.3	142.0	149.0	42	142.3	148.3	37	0.464	0.463
1146	191	90.9	143.6	151.4	46	143.6	150.8	44	0.464	0.463
1152	140	91.4	145.2	153.0	62	145.4	152.4	58	0.639	0.638
1157	157	91.4	147.4	153.0	40	147.6	152.8	39	0.580	0.580
1202	197	91.9	148.8	156.4	43	149.0	155.7	39	0.471	0.469
1207	200	91.8	151.0	158.7	44	151.2	158.0	40	0.475	0.473
1212	206	91.0	153.3	161.2	43	153.5	160.5	40	0.478	0.476

Table Vb

FLOW RATE, ITC COLLECTOR = 10.9 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 11.5 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1253	205	92.1	174.6	180.9	34	174.9	180.0	28	0.575	0.574
1255	213	92.7	175.8	181.9	31	176.0	181.0	27	0.555	0.553
1257	212	93.4	176.9	183.2	32	177.3	182.3	27	0.559	0.558
1259	219	93.4	178.2	184.5	31	178.0	183.6	29	0.549	0.546
1301	213	93.0	179.1	185.5	33	179.4	184.8	29	0.569	0.568
1303	218	93.4	180.3	186.6	32	180.9	185.9	27	0.560	0.559
1305	221	92.8	181.6	188.1	32	181.9	187.0	26	0.562	0.560
1307	220	92.7	182.5	189.3	34	183.2	188.2	26	0.571	0.570
1309	225	92.5	182.5	190.0	37	183.0	189.5	33	0.560	0.560
1311	229	93.7	183.2	190.8	36	183.6	190.6	35	0.546	0.547

FLOW RATE, ITC COLLECTOR = 11.1 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 11.3 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1325	231	93.7	104.7	120.7	77	105.3	121.8	81	0.220	0.224
1327	237	94.1	107.8	120.6	60	108.5	120.7	58	0.220	0.222
1329	242	94.3	125.8	126.0	1	126.3	119.1	-34	0.263	
1333	232	94.8	118.2	135.5	83	118.4	138.2	96	0.276	0.282
1335	235	95.9	118.4	132.1	64	118.8	138.9	97	0.261	0.276
1410	232	92.1	140.9	144.5	17	141.5	144.5	15	0.357	0.358
1426	62	92.1	147.2	149.5	42	147.6	149.5	36		
1429	225	93.7	146.9	152.6	28	147.2	150.8	18	0.392	0.389
1431	226	94.7	146.9	155.7	43	147.0	154.6	38	0.392	0.390
1433	232	95.0	147.0	156.0	43	147.4	156.0	42	0.383	0.383

FLOW RATE, ITC COLLECTOR = 11.1 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 11.3 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1435	72	92.3	147.6	153.7	94	148.1	154.4	99		
1437	107	92.8	149.0	151.7	28	149.5	151.7	23	0.841	0.844
1439	219	94.1	149.2	156.0	35	149.7	153.5	20	0.413	0.408
1441	221	94.3	149.2	157.8	43	149.7	156.9	37	0.414	0.413
1443	95	93.4	149.4	156.9	88	149.9	157.5	90	0.965	0.971
1445	81	92.7	150.6	154.0	47	151.0	154.6	50		
1450	89	92.7	150.4	155.1	58	150.8	154.6	48		
1455	93	94.3	150.3	156.4	73	150.8	156.7	72	0.981	0.986
1500	89	93.4	151.5	154.2	34	151.9	154.4	32		
1506	198	95.5	151.0	158.5	42	151.4	157.8	37	0.460	0.459

Table Vc

FLOW RATE, ITC COLLECTOR = 11.1 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 11.3 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1511	95	95.7	152.2	159.4	84	152.8	159.1	74	0.967	0.967
1516	84	94.1	153.9	157.8	53	154.4	158.7	58		
1521	200	96.8	154.2	161.4	40	154.6	161.2	38	0.466	0.466
1527	161	93.4	155.1	159.4	30	155.7	159.1	24	0.596	0.597
1532	176	94.5	155.3	161.6	40	155.7	161.8	39	0.545	0.547
1537	180	96.1	156.2	163.0	42	156.7	162.5	36	0.531	0.531
1543	181	94.3	157.1	162.9	35	157.6	162.9	33	0.541	0.543
1548	166	94.8	157.8	163.8	40	158.4	163.6	35	0.589	0.590

PERFORMANCE DATA FOR JULY 26, 1975

FLOW RATE, ITC COLLECTOR = 10.5 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 10.6 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1048	151	77.9	103.8	110.3	45	104.0	102.0	-14	0.407	
1049	152	77.9	104.5	111.7	50	104.7	105.3	4	0.410	0.389
1051	153	78.6	105.5	113.7	57	105.6	110.8	36	0.411	0.403
1053	156	78.1	105.8	114.5	59	105.8	113.2	50	0.411	0.407
1055	157	78.3	106.0	115.5	64	106.2	114.6	57	0.411	0.409
1057	160	79.5	106.2	115.5	62	106.2	115.5	62	0.396	0.396
1059	159	79.7	106.5	115.7	61	106.5	115.9	63	0.399	0.399
1101	160	79.0	107.2	116.2	59	107.4	116.1	57	0.404	0.404
1103	161	78.8	108.7	117.3	57	109.0	116.1	46	0.411	0.409
1105	164	79.4	110.3	118.6	53	110.5	117.2	43	0.409	0.405
1107	168	79.5	111.2	119.8	54	111.4	118.6	46	0.406	0.403
1109	168	79.0	112.1	120.7	54	112.3	119.8	48	0.414	0.412
1111	168	79.5	112.6	121.5	55	112.8	120.9	51	0.414	0.413

FLOW RATE, ITC COLLECTOR = 10.1 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 10.2 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1145	192	80.1	145.6	153.3	41	145.8	153.0	38	0.529	0.528
1147	192	80.8	146.3	154.0	41	146.3	153.7	39	0.528	0.527
1149	195	80.8	147.2	154.9	40	147.2	154.4	38	0.525	0.523
1151	195	81.3	148.1	155.8	40	148.1	155.1	37	0.528	0.526
1153	195	80.2	148.5	156.9	44	148.5	156.0	40	0.535	0.533
1155	196	80.6	145.6	155.8	53	145.8	157.1	59	0.522	0.525
1157	200	80.4	147.0	155.1	41	147.2	157.1	51	0.514	0.519
1159	200	80.6	149.2	156.6	37	149.2	155.7	33	0.521	0.518
1201	201	79.7	147.6	158.2	53	147.8	156.7	46	0.524	0.521
1203	195	80.8	146.9	156.7	51	147.0	158.2	58	0.528	0.532

Table Vd

FLOW RATE, ITC COLLECTOR = 10.5 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 10.7 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1245	214	82.9	175.3	181.9	33	175.3	181.2	30	0.596	0.594
1255	217	83.3	180.0	186.8	33	180.0	186.3	31	0.609	0.607
1313	217	83.5	183.8	191.5	38	183.9	192.4	42	0.627	0.629
1315	220	83.7	184.3	191.8	36	184.5	191.8	36	0.622	0.622
1317	223	82.9	184.8	192.2	35	185.0	192.2	35	0.618	0.618
1319	222	82.9	185.0	192.7	37	185.2	192.6	36	0.622	0.622
1321	224	81.7	182.3	191.7	44	182.5	193.1	51	0.613	0.617
1323	224	82.8	182.7	190.9	39	182.9	192.6	47	0.607	0.611
1325	224	80.8	183.2	191.3	38	183.4	191.3	38	0.619	0.620
1327	226	85.1	183.4	191.7	39	183.6	191.5	38	0.595	0.595
1329	226	82.4	183.8	192.0	39	183.8	192.0	39	0.608	0.608

FLOW RATE, ITC COLLECTOR = 10.7 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 10.6 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1353	228	84.6	107.6	121.8	67	107.8	124.2	76	0.272	0.278
1409	231	85.6	106.3	122.2	73	106.5	127.8	98	0.262	0.275
1411	225	85.8	106.5	120.0	64	106.5	123.8	82	0.264	0.273
1413	225	85.8	107.1	120.0	62	107.1	121.3	67	0.265	0.268
1415	222	84.0	107.6	120.2	61	107.8	121.5	66	0.279	0.282
1445	216	86.0	143.8	151.5	38	143.8	149.4	28	0.433	0.428
1447	208	86.4	145.2	153.0	40	145.4	151.7	32	0.455	0.452
1455	71	83.7	142.9	144.5	24	142.9	145.9	46		
1459	214	86.0	143.4	151.9	43	143.4	150.8	37	0.439	0.436
1501	207	85.5	143.6	152.2	45	143.8	152.4	44	0.456	0.456
1503	205	86.7	144.0	152.6	45	144.1	152.6	44	0.456	0.456

FLOW RATE, ITC COLLECTOR = 10.7 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 10.6 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1505	208	85.5	145.2	153.1	41	145.6	153.0	38	0.460	0.460
1507	209	87.8	146.7	154.4	40	146.9	153.7	35	0.454	0.452
1509	199	86.7	147.6	154.9	40	147.6	154.2	36	0.486	0.484
1511	197	85.8	148.1	156.0	43	148.1	155.3	39	0.500	0.498
1521	51	83.5	153.0	153.0	0	153.3	154.4	23		
1543	45	84.6	163.6	163.6	0	163.6	163.2	- 9		
1548	154	88.0	164.7	168.8	29	164.8	166.8	14	0.718	0.713
1549	125	88.0	165.0	168.8	33	165.2	167.4	18	0.889	0.884
1551	175	86.2	166.1	169.3	20	166.1	168.3	13	0.648	0.645

Table Ve

FLOW RATE, ITC COLLECTOR = 10.6 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 10.7 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1553	172	87.6	167.5	171.9	27	167.7	169.7	12	0.664	0.659
1555	172	85.5	167.7	172.6	30	167.7	171.9	26	0.679	0.677
1557	170	87.6	168.8	173.3	28	169.0	172.9	25	0.681	0.680
1559	170	86.0	170.6	174.4	24	170.8	173.3	16	0.698	0.695
1601	170	86.2	172.0	175.8	24	172.0	174.2	14	0.706	0.701
1603	168	83.3	173.3	177.3	25	173.3	175.8	16	0.739	0.734
1605	63	84.9	174.2	177.1	48	174.4	176.4	34		

PERFORMANCE DATA FOR JULY 27, 1975

FLOW RATE, ITC COLLECTOR = 10.6 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 10.8 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
919	78	78.6	96.1	99.0	39	96.1	99.0	40	0.654	0.654
921	78	79.2	97.0	99.9	39	97.2	98.8	23	0.658	0.652
923	78	79.4	97.7	100.8	42	97.9	99.9	28	0.669	0.664
925	78	80.4	98.6	101.5	39	98.8	100.8	28	0.663	0.660
927	78	81.1	99.5	102.2	37	99.7	101.5	25	0.663	0.659
929	80	81.1	101.9	103.7	24	102.0	102.2	3	0.668	0.661
931	82	80.1	104.2	105.8	21	104.4	103.5	-12	0.696	
933	85	81.9	106.5	108.0	18	106.5	105.6	-12	0.676	
935	84	81.9	108.5	110.1	21	108.7	107.8	-12	0.709	
937	84	81.5	110.5	112.1	21	110.7	109.8	-12	0.735	
939	86	80.4	112.1	113.9	22	112.3	111.7	-7	0.755	
941	88	81.3	114.5	115.7	15	114.6	113.7	-11	0.751	

FLOW RATE, ITC COLLECTOR = 10.2 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 10.1 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1015	114	84.2	143.1	144.9	16	143.2	143.6	3	0.805	0.800
1017	116	84.9	144.5	146.7	19	144.7	144.9	2	0.801	0.794
1019	117	86.0	145.8	148.1	21	145.9	146.5	5	0.793	0.787
1021	119	86.5	146.5	149.4	25	146.7	148.1	12	0.785	0.780
1023	119	85.6	146.9	150.1	28	147.0	149.4	20	0.800	0.797
1025	118	85.5	147.0	150.4	30	147.0	150.3	28	0.809	0.803
1027	121	85.1	147.2	150.8	31	147.4	150.6	27	0.796	0.796
1029	125	85.1	147.6	151.4	31	147.6	151.0	28	0.772	0.771
1031	126	84.7	147.9	151.9	32	147.9	151.5	29	0.773	0.772
1033	129	85.1	148.1	152.2	33	148.3	151.9	29	0.756	0.755
1035	128	85.1	148.5	152.6	33	148.6	152.4	30	0.760	0.760

Table Vf

FLOW RATE, ITC COLLECTOR = 10.0 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 10.3 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1118	165	87.3	178.9	182.3	21	179.1	181.0	12	0.761	0.758
1119	164	87.8	179.1	182.7	22	179.4	181.6	14	0.765	0.763
1120	162	87.6	180.1	183.9	23	180.3	182.9	16	0.781	0.778
1121	163	87.8	180.3	183.9	22	180.3	182.9	16	0.777	0.774
1123	166	87.1	179.4	184.3	29	179.6	184.1	28	0.764	0.764
1125	172	87.8	179.8	184.5	27	180.0	184.8	29	0.734	0.736
1127	174	88.2	180.1	184.8	27	180.3	184.6	26	0.727	0.727
1129	174	87.6	180.7	185.5	28	180.9	185.0	25	0.732	0.731
1131	176	88.3	181.4	186.1	27	181.4	185.7	25	0.724	0.723
1133	174	87.3	181.9	186.8	28	182.1	186.4	26	0.741	0.740
1135	175	86.9	182.5	187.4	28	182.7	187.0	26	0.744	0.744
1137	177	87.6	183.0	187.9	28	183.2	187.5	25	0.736	0.735
1139	178	88.7	183.4	188.4	28	183.6	188.1	26	0.727	0.726
1141	177	88.7	183.8	189.0	30	183.9	188.6	27	0.732	0.731
1201	195	88.7	101.3	112.6	58	101.5	113.7	65	0.258	0.261
1203	196	89.4	107.2	116.1	45	107.4	112.8	28	0.277	0.269
1205	198	89.2	111.2	120.7	48	111.4	115.7	23	0.297	0.284
1207	199	90.1	114.5	124.2	49	114.5	120.2	30	0.308	0.298
1217	202	88.2	104.9	117.7	63	105.1	121.6	85	0.273	0.284
1219	199	89.1	106.9	118.2	57	106.9	118.2	59	0.279	0.279
1221	203	90.3	112.8	120.7	39	113.0	118.8	29	0.288	0.284
1223	205	90.0	115.4	124.9	47	115.5	120.6	25	0.303	0.293

FLOW RATE, ITC COLLECTOR = 9.8 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 9.9 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1239	203	91.4	139.1	147.9	43	140.0	144.5	22	0.414	0.408
1241	207	90.3	142.2	149.5	35	142.3	146.3	19	0.423	0.416
1243	208	90.7	144.9	152.2	35	145.0	149.2	20	0.433	0.426
1245	209	91.0	145.6	154.4	42	145.8	151.9	29	0.436	0.430
1247	205	90.5	146.9	155.7	42	146.9	154.4	37	0.452	0.449
1249	203	90.5	147.6	156.9	45	147.8	155.7	39	0.461	0.458
1251	206	91.6	150.8	153.2	35	151.0	156.7	28	0.452	0.458
1255	200	89.6	143.6	160.3	82	143.6	160.2	82	0.472	0.471
1257	199	90.5	145.6	153.3	38	145.9	161.2	76	0.456	0.477
1259	203	91.8	151.0	156.6	27	151.2	155.7	22	0.463	0.461
1307	208	90.1	143.6	147.9	21	143.8	148.1	21	0.422	0.423
1309	211	89.4	146.1	153.9	36	146.3	146.5	1	0.439	0.422

Table Vg

FLOW RATE, ITC COLLECTOR = 9.8 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 9.9 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1311	207	90.7	147.8	156.6	42	147.9	152.8	23	0.451	0.443
1355	214	94.1	181.6	188.4	32	181.8	187.4	26	0.576	0.574
1357	214	91.2	182.9	189.7	32	183.0	188.4	25	0.594	0.592
1359	212	94.1	183.9	190.8	32	184.1	189.5	25	0.591	0.588
1401	210	92.5	185.2	191.7	30	185.4	190.6	25	0.610	0.608
1403	211	93.9	186.1	192.6	30	186.3	191.3	24	0.605	0.602
1405	210	93.9	185.5	193.8	39	185.7	192.6	32	0.610	0.607
1407	212	94.5	179.1	192.4	62	179.4	193.6	67	0.582	0.586
1411	207	92.3	179.1	187.0	38	178.2	188.2	48	0.592	0.593
1411	162	92.5	178.5	187.0	52	178.5	188.1	59	0.757	0.761
1411	212	92.8	178.7	186.8	38	178.5	187.9	44	0.576	0.578
1411	212	92.7	178.9	187.0	38	178.7	187.9	43	0.578	0.579
1412	212	93.0	179.1	187.0	37	178.9	187.9	42	0.575	0.577
1412	215	93.2	179.3	187.0	36	179.1	188.1	42	0.568	0.570
1413	216	93.4	179.4	187.4	36	179.3	188.2	41	0.565	0.567

FLOW RATE, ITC COLLECTOR = 10.2 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 10.0 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1450	185	92.7	101.9	108.9	39	101.7	105.3	19	0.241	0.231
1451	187	92.5	104.9	109.9	28	104.9	105.3	2	0.252	0.239
1453	194	95.0	105.1	116.1	58	105.1	107.2	11	0.245	0.222
1457	191	92.1	102.6	114.3	63	102.7	114.5	61	0.253	0.254
1459	189	95.0	102.2	115.2	70	102.4	114.8	66	0.243	0.242
1501	189	95.4	100.8	114.6	75	100.8	115.0	75	0.235	0.236
1503	190	93.4	100.2	113.6	72	100.2	114.6	76	0.240	0.243
1505	154	95.0	100.4	113.0	83	100.4	113.6	85	0.283	0.285
1507	183	93.0	100.4	112.8	70	100.6	113.0	68	0.250	0.251
1509	174	92.3	100.8	112.8	71	100.8	113.0	70	0.267	0.268

FLOW RATE, ITC COLLECTOR = 9.4 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 9.4 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			WAFFLE COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1540	164	94.5	144.0	149.9	34	144.0	149.4	31	0.516	0.514
1541	161	93.9	144.1	150.1	35	144.0	149.4	32	0.531	0.528
1543	161	92.5	145.0	151.0	35	144.9	150.1	30	0.543	0.540
1545	134	92.3	145.8	150.8	35	145.8	150.4	33	0.657	0.656
1547	111	92.7	146.1	150.1	33	145.9	150.1	35	0.787	0.786
1549	168	93.4	146.1	151.2	28	145.9	150.4	25	0.520	0.518
1551	161	94.1	146.7	152.8	36	146.5	152.1	33	0.544	0.541
1553	151	93.7	147.4	153.1	36	147.4	153.0	35	0.588	0.588

Table Vh

FLOW RATE, ITC COLLECTOR = 9.6 LB/HOUR SQ. FOOT
 FLOW RATE, WAFFLE COLLECTOR = 9.9 LB/HOUR SQ. FOOT

		ITC COLLECTOR				WAFFLE COLLECTOR			ITC	TEST
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF	X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1617	124	92.5	171.3	172.8	11	171.1	171.0	- 2	0.897	
1618	123	93.0	172.4	173.7	10	172.4	171.9	- 4	0.913	
1619	123	92.5	172.8	173.8	9	172.6	172.0	- 4	0.921	
1621	122	93.7	172.2	174.8	20	172.0	173.3	10	0.916	0.909
1623	118	92.7	171.5	174.6	25	171.5	174.4	24	0.956	0.955
1625	120	92.7	171.7	174.4	22	171.7	174.6	24	0.937	0.937
1627	120	93.9	171.7	174.6	23	171.5	174.2	22	0.930	0.928
1629	121	92.1	172.6	174.6	16	172.4	174.4	16	0.938	0.936
1631	121	92.8	173.3	175.1	14	173.1	174.4	10	0.939	0.935
1632	120	92.3	173.3	175.3	16	173.5	174.8	11	0.951	0.949
1633	119	91.8	173.3	175.5	17	173.5	174.8	11	0.961	0.959

ITC SLOPE=- 43.29 ITC INTERCEPT= 64.07
 TEST SLOPE=- 40.81 TEST INTERCEPT= 59.38

Table VIa (Ref. Fig. 4)
Dry Plate Data, July 18 & 21, 1975
Waffle Absorber vs ITC Collector

DRY PLATE DATA FOR JULY 18, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
950	136	147	86	76
955	144	157	122	78
1006	161	176	137	79
1017	172	188	134	79
1028	183	201	137	79
1039	195	216	142	81
1049	206	228	150	81
1100	215	239	159	80
1111	224	249	170	83
1122	231	257	179	83
1133	242	270	196	84
1143	242	270	188	82
1154	250	278	217	86
1204	248	276	243	86
1205	245	271	120	85
1216	248	276	126	84
1227	259	288	235	88
1238	258	286	232	88
1333	274	303	226	86
1354	269	296	233	86
1405	267	294	77	86
1415	250	273	252	87
1426	257	282	107	86
1437	244	265	221	89
1448	254	277	214	89
1459	261	285	207	90

DRY PLATE DATA FOR JULY 21, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1052	211	234	150	81
1102	218	242	156	82
1113	226	251	169	82
1118	227	252	169	82
1123	231	256	167	83
1128	234	260	170	83
1133	235	260	182	84
1138	240	266	188	84
1139	244	271	188	83
1144	248	275	191	84
1150	251	279	188	84
1155	254	282	188	84
1201	256	284	193	85
1206	252	280	187	84
1211	256	282	203	86
1216	261	288	206	87
1220	264	292	208	88
1225	268	296	202	88
1234	273	302	216	86
1239	275	304	196	86
1245	278	307	223	88
1301	259	283	221	87
1311	250	273	207	86
1317	260	285	226	86

Table VIb

DRY PLATE DATA FOR JULY 21, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1322	267	293	232	87
1327	271	298	233	87
1332	275	303	228	86
1337	279	306	227	89
1342	282	310	219	87
1347	284	311	224	86
1352	285	312	214	88
1357	286	313	219	86
1403	287	314	218	86
1408	277	302	111	88
1413	269	292	198	88
1429	252	272	108	89
1430	252	272	102	88
1436	253	272	211	87
1441	262	283	209	89
1446	267	289	206	90
1452	268	289	191	88
1457	268	290	183	88
1503	268	290	190	91
1508	267	288	186	90
1513	269	290	194	89
1519	270	291	182	93
1524	270	290	171	93
1529	268	287	108	93
1535	266	285	164	93
1540	264	284	161	93
1545	263	282	154	95
1551	261	279	151	94
1601	258	277	150	93
1606	254	271	136	94
1612	251	268	135	93
1617	249	265	130	94
1622	246	261	125	92
1628	243	258	120	93
1633	239	253	113	92
1638	235	249	91	92
1643	228	241	53	91
1648	216	229	39	89
1653	215	226	117	92
1659	214	225	95	91

Table VIIa (Ref. Fig. 5)
 Dry Plate Data, July 22, 1975
 Waffle Absorber vs ITC Collector,
 53°

DRY PLATE DATA FOR JULY 22, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
919	135	146	59	75
924	136	146	60	75
929	136	147	89	75
930	138	149	59	76
935	140	151	66	76
937	140	152	65	76
939	141	152	71	76
941	142	154	76	76
943	144	155	80	77
948	144	156	60	76
953	144	155	57	76
1021	169	183	93	79
1023	170	185	133	79
1057	209	230	169	81
1059	212	233	169	81
1101	213	235	159	82
1103	214	236	133	81
1105	215	237	161	82
1107	218	240	170	81
1109	219	242	171	82
1143	248	276	185	83
1145	250	277	182	83
1147	251	278	187	83
1149	252	280	189	82
1151	253	281	170	80
1153	254	282	194	82
1158	258	286	205	82
1202	260	289	204	82
1205	261	290	203	82
1207	261	291	197	82
1246	262	289	229	85
1248	266	293	201	84
1256	255	280	147	83
1259	257	282	204	84
1304	264	290	204	83
1306	265	291	177	84
1308	264	291	173	82
1314	268	295	198	85
1320	273	301	225	83
1326	278	306	231	84
1332	281	310	228	84
1337	283	312	219	84
1342	286	314	228	84
1347	288	317	227	83
1352	286	315	171	84
1357	288	317	226	84
1402	291	320	225	85
1407	292	322	225	85

Table VIIb

DRY PLATE DATA FOR JULY 22, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1412	288	317	159	83
1418	289	317	225	85
1423	288	316	226	84
1426	290	317	224	86
1516	280	302	174	86
1519	279	301	175	87
1521	278	300	174	86
1525	277	298	171	85
1527	276	297	168	85
1529	275	297	167	87
1531	275	296	166	86
1537	273	293	160	86
1542	271	291	157	86
1548	269	288	151	86
1553	266	285	146	86
1558	263	281	141	86
1604	259	278	137	86
1609	256	274	132	86
1615	253	270	132	86
1617	252	269	130	86
1620	251	267	127	87
1623	250	265	125	86
1626	248	262	123	86
1629	246	260	120	86
1707	218	226	92	86
1710	215	223	89	86
1712	214	221	87	87
1714	212	219	86	87
1716	210	218	86	87
1718	209	216	83	88

Table VIII
Dry Plate Data, July 23, 1975
1-Kalwal covered vs. ITC
Collector, 13°

DRY PLATE DATA FOR JULY 23, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1139	243	243	183	88
1145	248	247	188	88
1150	251	249	194	88
1156	255	253	198	89
1201	259	258	194	89
1207	262	259	200	88
1212	265	260	210	88
1218	268	264	209	89
1223	268	261	204	89
1228	271	264	218	89
1233	274	268	218	89
1239	276	270	218	91
1245	279	270	220	91
1251	279	271	216	90
1257	276	264	113	90
1303	277	264	222	89
1308	274	259	189	90
1315	275	261	100	90
1320	274	259	226	90
1325	276	262	209	91
1330	276	263	215	91
1336	276	264	184	91
1341	273	256	206	89
1347	274	257	207	90
1352	276	262	230	92
1358	280	267	218	90
1404	281	269	216	91
1409	281	267	205	91
1415	280	265	204	91
1421	280	264	189	91
1426	275	256	171	91

Table IXa (Ref. Fig. 6)
 Dry Plate Data, July 24, 1975
 1-Kalwal covered vs ITC Collector
 13°

DRY PLATE DATA FOR JULY 24, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1017	166	179	30	79
1019	168	181	97	81
1024	179	192	118	82
1100	219	224	99	87
1105	224	228	121	88
1110	226	229	164	89
1115	230	234	167	88
1120	236	238	168	89
1126	240	243	167	91
1131	243	245	161	92
1136	247	249	178	90
1141	251	252	188	90
1146	255	256	191	91
1152	259	259	140	91
1157	258	256	157	91
1207	260	255	197	92
1212	267	262	206	91
1218	269	264	194	91
1223	271	265	207	92
1225	271	265	212	93
1227	272	265	208	92
1253	278	267	205	92
1255	278	267	213	93
1257	279	268	212	93
1259	280	270	219	93
1301	280	271	213	93
1303	281	271	218	93
1305	282	272	221	93
1307	283	273	220	93
1309	284	274	225	93
1311	285	275	229	94
1323	275	258	229	94
1325	278	263	231	94
1327	280	266	237	94
1329	279	265	242	94
1335	282	270	235	96
1337	278	264	83	92
1339	271	252	225	92
1344	270	249	84	93
1349	273	255	238	96
1355	273	256	231	95
1400	267	247	230	93
1405	272	255	225	95
1410	265	247	232	92
1426	261	240	62	92
1429	257	231	225	94
1431	263	239	226	95
1433	267	246	232	95

Table IXb

DRY PLATE DATA FOR JULY 24, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1435	266	246	72	92
1437	259	236	107	93
1439	260	236	219	94
1441	264	243	221	94
1443	266	247	95	93
1445	260	239	81	93
1450	247	218	89	93
1455	250	224	93	94
1500	245	221	89	93
1506	249	225	198	96
1511	258	242	95	96
1516	257	242	84	94
1521	260	243	200	97
1527	255	236	161	93
1532	259	240	176	95
1537	262	244	180	96
1543	265	246	181	94
1548	265	244	166	95
1553	264	239	153	96
1558	257	231	81	94
1604	236	201	12	89
1609	216	174	15	88

Table Xa (Ref. Fig 7)
 Dry Plate Data, July 26, 1975
 1-Kalwal covered vs ITC Collector
 13°

DRY PLATE DATA FOR JULY 26, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1048	222	227	151	78
1049	222	228	152	78
1051	224	229	153	79
1053	225	230	156	78
1055	227	231	157	78
1057	229	233	160	80
1059	230	233	159	80
1101	232	234	160	79
1103	233	236	161	79
1105	234	237	164	79
1107	236	237	168	80
1109	237	239	168	79
1111	238	240	168	80
1145	259	255	192	80
1147	261	255	192	81
1149	262	256	195	81
1151	262	257	195	81
1153	264	258	195	80
1155	264	259	196	81
1157	265	259	200	81
1159	266	260	200	81
1201	267	260	201	80
1203	268	261	195	81
1214	273	266	204	80
1224	276	267	205	82
1234	279	268	212	82
1245	282	270	214	83
1255	286	275	217	83
1313	290	277	217	84
1315	291	277	220	84
1317	291	276	223	83
1319	291	277	222	83
1321	292	278	224	82
1323	293	279	224	83
1325	293	280	224	81
1327	294	281	226	85
1329	295	281	226	82
1331	295	281	225	85
1333	296	280	227	85
1335	296	280	227	85
1337	296	280	229	83
1339	297	281	229	84
1339	296	281	229	85
1341	297	282	232	66
1343	290	272	61	82
1345	282	256	84	82
1347	283	254	243	83
1349	286	260	229	84

Table Xb

DRY PLATE DATA FOR JULY 26, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1349	286	262	237	85
1351	288	264	229	84
1353	289	267	228	85
1355	289	269	233	86
1357	290	272	235	85
1359	291	275	91	84
1401	282	262	73	82
1403	277	252	161	84
1405	280	253	236	84
1407	284	260	234	86
1409	286	265	231	86
1411	287	268	225	86
1413	288	271	225	86
1415	288	272	222	84
1420	290	275	227	86
1445	283	260	216	86
1447	285	262	208	86
1451	276	250	51	83
1453	266	236	49	84
1455	260	225	71	84
1459	268	234	214	86
1501	271	241	207	86
1503	273	246	205	87
1505	275	250	208	86
1507	276	253	209	88
1509	277	255	199	87
1511	278	256	197	86
1521	256	224	51	84
1543	249	217	45	85
1548	246	212	154	88
1549	247	213	125	88
1551	247	213	175	86
1553	250	217	172	88
1555	252	221	172	86
1557	255	225	170	88
1559	256	227	170	86
1601	253	231	170	86
1603	260	234	168	83
1605	259	234	63	85

Table XIa (Ref. Fig 8)
 Dry Plate Data, July 27, 1975
 1-Kalwal covered vs ITC Collector
 13°

DRY PLATE DATA FOR JULY 27, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1035	199	206	128	85
1045	208	213	140	86
1051	212	216	145	86
1120	234	236	162	88
1121	235	236	163	88
1123	236	237	166	87
1125	237	238	172	88
1127	238	238	174	88
1129	239	240	174	88
1131	241	241	176	88
1133	242	241	174	87
1135	242	242	175	87
1137	243	243	177	88
1139	245	244	178	89
1141	246	245	177	89
1201	258	255	195	89
1203	259	256	196	90
1205	260	257	198	89
1207	261	258	199	90
1213	264	260	198	90
1215	265	260	199	90
1217	266	260	202	88
1219	266	261	199	89
1221	268	261	203	90
1223	268	262	205	90
1241	275	267	207	90
1243	275	267	208	91
1245	276	268	209	91
1247	276	268	205	91
1249	277	268	203	91
1251	277	267	206	92
1255	277	267	200	90
1257	277	266	199	91
1259	277	266	203	92
1307	279	267	208	90
1309	279	268	211	90
1311	280	268	207	91
1355	281	268	214	94
1357	281	269	214	91
1359	282	270	212	94
1401	282	271	210	93
1403	283	271	211	94
1405	284	272	210	94
1407	284	273	212	95
1409	283	272	103	94
1411	282	267	207	93
1411	282	267	208	93
1411	281	266	212	93
1411	282	266	212	93
1412	282	266	212	93
1412	283	267	215	93
1413	282	267	216	93

Table XIb
 Dry Plate Data, July 27, 1975
 1-Kalwal covered vs ITC Collector
 53°

ANGLE NOW HAS GONE FROM 13 DEGREES TO 53 DEGREES

DRY PLATE DATA FOR JULY 27, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1453	278	253	194	95
1455	275	250	112	93
1457	273	247	191	92
1459	273	248	189	95
1501	274	250	189	95
1503	274	250	190	93
1505	274	251	154	95
1507	273	249	183	93
1509	273	248	174	92
1540	260	236	164	95
1541	260	236	161	94
1543	260	236	161	93
1545	258	234	134	92
1547	254	230	111	93
1549	252	227	168	93
1551	253	227	161	94
1553	253	229	151	94
1618	243	219	123	93
1619	243	219	123	93
1621	242	217	122	94
1623	240	216	118	93
1625	239	214	120	93
1627	238	212	120	94
1629	237	211	121	92
1631	236	210	121	93
1632	235	209	120	92
1633	235	209	119	92

PERFORMANCE DATA FOR AUGUST 12, 1975

FLOW RATE, ITC COLLECTOR = 10.4 LB/HOUR SQ. FOOT

FLOW RATE, I-KALWALL COLLECTOR = 10.4 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			I-KALWALL COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1151	190	82.2	106.2	114.5	45	106.2	116.4	56	0.317	0.322
1153	188	83.7	107.4	116.1	48	107.6	118.4	60	0.320	0.327
1155	206	83.3	108.5	117.9	47	108.7	120.2	58	0.300	0.306
1157	210	83.1	109.9	120.4	52	109.9	122.0	60	0.306	0.309
1159	206	83.1	109.9	121.6	59	109.9	123.8	70	0.314	0.319
1201	208	82.4	105.1	120.4	77	105.1	121.5	82	0.301	0.303
1203	205	83.7	101.1	115.9	75	101.3	118.0	85	0.273	0.283
1205	209	84.9	101.9	113.9	60	102.0	116.4	72	0.263	0.270
1207	207	84.6	102.2	114.1	60	102.4	117.0	73	0.263	0.275
1209	204	82.8	103.3	114.6	58	103.3	117.5	72	0.235	0.293
1211	205	85.6	104.5	115.4	55	104.7	118.2	69	0.275	0.283
1213	209	85.1	105.5	116.6	56	105.6	119.3	68	0.278	0.285
1215	205	86.0	106.7	117.5	55	106.9	120.2	68	0.284	0.291
1217	201	84.7	109.2	118.8	49	109.4	121.3	62	0.306	0.312
1219	210	84.2	112.1	121.1	45	112.1	123.6	57	0.307	0.313

ITC SLOPE=-227.26 ITC INTERCEPT= 122.49

TEST SLOPE=-294.97 TEST INTERCEPT= 155.53

H1,H2,HH,HN

4.39877 4.48927 1.29471 1.34304

V,Y,W,K

837.65000 1008.90000 15.00000 0.00000

HV,HZ,L1,L2

244.55900 300.62900 0.00000 0.00000

PERFORMANCE DATA FOR AUGUST 12, 1975

FLOW RATE, ITC COLLECTOR = 9.4 LB/HOUR SQ. FOOT

FLOW RATE, 1-KALWALL COLLECTOR = 9.5 LB/HOUR SQ. FOOT

TIME	FLUX	ITC COLLECTOR				1-KALWALL COLLECTOR			ITC X1 (10)	TEST X2 (11)
		TAMB (3)	TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1303	221	85.5	148.8	157.8	38	148.8	160.2	49	0.452	0.457
1321	231	87.4	143.8	154.2	43	143.8	156.4	52	0.406	0.410
1323	227	89.2	144.5	153.0	35	144.5	153.7	38	0.403	0.405
1325	231	87.4	145.0	156.0	45	145.0	157.8	53	0.411	0.415
1327	228	86.7	145.6	156.7	46	145.6	158.4	53	0.423	0.426
1331	235	86.4	147.2	157.6	42	147.2	158.9	47	0.418	0.421
1333	218	85.5	148.3	159.1	47	148.3	160.5	53	0.461	0.464
1335	223	87.3	148.1	159.8	50	148.1	161.1	55	0.444	0.446
1341	240	88.0	143.8	154.9	44	143.8	156.4	50	0.389	0.392
1343	234	86.9	144.0	154.9	44	144.1	156.7	51	0.404	0.409
1345	230	89.1	144.3	156.0	48	144.5	158.0	56	0.405	0.410

ITC SLOPE=- 95.43 ITC INTERCEPT= 83.80

TEST SLOPE=-131.32 TEST INTERCEPT= 106.40

H1,H2,HH,HN

9.01327 9.14353 3.23579 3.32270

V,Y,W,K

1318.55000 1565.70000 26.00000 15.00000

HV,HZ,L1,L2

446.48000 536.54400 0.00000 0.00000

PERFORMANCE DATA FOR AUGUST 13, 1975

FLOW RATE, ITC COLLECTOR = 10.7 LB/HOUR SQ. FOOT
 FLOW RATE, 1-KALWALL COLLECTOR = 10.1 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-KALWALL COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1149	192	89.6	110.8	121.1	57	111.0	122.5	61	0.305	0.309
1151	195	87.3	112.5	123.1	59	112.6	124.7	62	0.321	0.326
1151	195	86.0	113.0	123.6	59	113.0	125.2	63	0.331	0.335
1153	190	86.2	113.7	124.4	60	113.7	126.0	65	0.342	0.346
1155	194	85.3	112.1	125.1	72	112.3	126.5	74	0.337	0.341
1157	197	85.1	109.0	123.1	77	109.0	124.9	81	0.321	0.325

ITC SLOPE=-103.59 ITC INTERCEPT= 88.67
 TEST SLOPE=-133.63 TEST INTERCEPT= 108.08

H1,H2,HH,HN
 10.96950 11.12530 3.87446 3.97847
 V,Y,W,K
 1700.96000 1971.73000 32.00000 26.00000
 HV,HZ,L1,L2
 571.25000 670.79400 0.00000 0.00000

PERFORMANCE DATA FOR AUGUST 13, 1975

FLOW RATE, ITC COLLECTOR = 10.1 LB/HOUR SQ. FOOT

FLOW RATE, 1-KALWALL COLLECTOR = 10.1 LB/HOUR SQ. FOOT

		ITC COLLECTOR				1-KALWALL COLLECTOR				ITC	TEST
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF	X1	X2	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	
1159	199	84.4	106.7	120.4	69	106.7	122.2	78	0.308	0.312	
1201	199	84.9	106.7	119.0	62	106.7	120.7	71	0.301	0.306	
1203	203	85.5	106.9	118.8	59	106.9	120.6	68	0.293	0.298	
1205	206	87.1	107.1	119.1	59	107.1	120.9	68	0.281	0.286	
1207	210	90.3	108.0	119.8	57	108.1	122.0	67	0.265	0.271	
1207	210	90.1	108.1	120.0	57	108.1	122.0	67	0.267	0.271	
1209	213	85.3	111.0	121.1	48	111.0	123.8	61	0.295	0.302	
1211	215	86.5	113.7	123.8	47	113.7	126.5	60	0.299	0.305	
1238	204	88.9	139.3	147.9	43	139.3	150.1	53	0.425	0.430	
1249	214	87.8	145.4	153.9	40	145.4	155.5	47	0.438	0.442	
1251	205	91.2	146.5	154.6	40	146.5	156.6	50	0.446	0.451	
1253	213	91.4	147.6	155.8	39	147.8	158.0	49	0.435	0.440	
1255	211	88.7	148.6	157.1	40	148.8	159.1	49	0.456	0.461	
1257	215	92.3	145.0	158.2	62	145.2	160.0	69	0.425	0.429	
1303	226	92.7	139.8	149.7	44	139.8	151.7	53	0.372	0.376	
1304	228	92.3	143.2	151.4	36	143.2	153.5	45	0.382	0.386	
1305	227	93.0	144.0	152.1	36	144.1	154.0	44	0.384	0.389	
1307	223	92.5	145.6	154.8	41	145.8	156.7	50	0.402	0.407	

ITC SLOPE=-104.95 ITC INTERCEPT= 88.18

TEST SLOPE=-124.58 TEST INTERCEPT= 104.42

H1,H2,H3,H4

17.43980 17.68470 6.28209 6.44997

V,Y,W,X

2578.80000 3017.83000 50.00000 32.00000

HV,HZ,L1,L2

878.57300 1043.10000 0.00000 0.00000

1309	217	91.9	146.1	155.8	45	146.3	157.8	54	0.421	0.425	
1311	218	91.8	146.9	156.6	45	146.9	158.2	53	0.423	0.427	
1313	225	93.0	148.3	157.6	42	148.3	159.4	50	0.409	0.413	

ITC SLOPE=-105.13 ITC INTERCEPT= 88.22

TEST SLOPE=-124.34 TEST INTERCEPT= 104.34

H1,H2,H3,H4

18.69150 18.94920 6.80448 6.96302

V,Y,W,X

2710.75000 3173.68000 53.00000 50.00000

HV,HZ,L1,L2

933.65600 1108.82000 0.00000 0.00000

PERFORMANCE DATA FOR AUGUST 13, 1975

FLOW RATE, ITC COLLECTOR = 10.2 LB/HOUR SQ. FOOT
 FLOW RATE, 1-KALWALL COLLECTOR = 10.4 LB/HOUR SQ. FOOT

TIME	FLUX	ITC COLLECTOR				1-KALWALL COLLECTOR			ITC X1	TEST X2
		TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1457	215	93.9	165.0	172.6	36	165.0	173.3	40	0.497	0.498
1459	193	94.5	165.4	172.4	37	165.4	173.5	44	0.553	0.556
1501	150	93.6	165.9	171.9	40	165.9	172.4	45	0.714	0.716
1503	172	90.0	166.3	170.4	25	166.3	169.9	22	0.643	0.641
1505	210	93.0	165.9	172.4	32	165.9	172.9	35	0.516	0.517
1507	158	93.4	165.9	171.9	39	165.9	172.2	42	0.682	0.683
1508	188	93.9	166.3	171.9	31	166.3	172.4	34	0.572	0.573
1509	184	93.7	166.3	172.2	33	166.3	172.6	36	0.586	0.587
1511	179	92.3	166.3	171.9	32	166.3	172.0	34	0.609	0.609
1513	202	93.7	166.1	172.6	33	166.3	173.3	36	0.532	0.535
1515	201	94.3	166.3	173.1	35	166.5	173.8	38	0.534	0.536
1517	203	94.3	166.6	173.3	34	166.8	174.2	38	0.532	0.534
1533	178	92.7	104.9	116.4	66	104.9	117.2	72	0.281	0.283
1535	186	93.7	105.1	118.0	71	105.1	119.1	79	0.268	0.271
1537	186	94.5	105.3	118.8	74	105.5	119.8	80	0.266	0.270
1540	184	94.5	106.5	119.7	73	106.6	121.1	82	0.276	0.280
1545	174	93.4	107.1	121.3	84	107.1	121.6	87	0.304	0.305
1547	160	95.0	108.0	120.2	78	108.0	122.5	95	0.320	0.327

ITC SLOPE=- 90.50 ITC INTERCEPT= 85.06
 TEST SLOPE=-111.92 TEST INTERCEPT= 101.48

H1,H2,HH,HN
 27.37280 27.66840 11.39310 11.60300
 V,Y,W,K
 3561.59000 4108.23000 71.00000 53.00000
 HV,HZ,L1,L2
 1297.08000 1509.10000 0.00000 0.00000

PERFORMANCE DATA FOR AUGUST 13, 1975

FLOW RATE, ITC COLLECTOR = 10.5 LB/HOUR SQ. FOOT

FLOW RATE, I-KALWALL COLLECTOR = 10.6 LB/HOUR SQ. FOOT

TIME	FLUX	TAMB	ITC COLLECTOR			I-KALWALL COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		
1549	149	93.7	108.9	119.5	75	108.9	121.1	68	0.353	0.359
1551	133	94.1	111.6	117.5	47	111.6	119.0	59	0.396	0.401
1555	107	92.3	111.9	117.7	57	111.9	118.4	64	0.508	0.512
1556	97	91.8	113.2	117.7	49	113.2	118.2	55	0.572	0.575
1559	109	93.4	109.8	119.1	90	109.8	119.3	93	0.486	0.486
1601	76	91.9	108.7	115.2	90	108.7	115.7	98	0.682	0.685
1603	91	92.5	109.0	113.9	57	109.0	114.1	59	0.564	0.565
1605	77	91.6	108.9	113.7	67	109.0	114.1	70	0.671	0.674
1607	68	91.2	107.8	113.0	81	107.8	112.8	79	0.753	0.752
1609	63	91.6	107.8	111.7	66	107.8	111.7	67	0.793	0.793
1611	71	92.3	108.5	111.7	48	108.7	111.6	43	0.705	0.705
1612	85	91.9	108.9	113.0	52	108.9	113.0	52	0.603	0.603

ITC SLOPE=- 28.86 ITC INTERCEPT= 64.26

TEST SLOPE=- 50.16 TEST INTERCEPT= 80.46

H1,H2,HH,HN

34.45600 34.77620 15.78230 16.01650

V,Y,W,K

4339.10000 4933.76000 83.00000 71.00000

HV,HZ,L1,L2

1758.63000 1994.69000 0.00000 0.00000

PERFORMANCE DATA FOR AUGUST 13, 1975

FLOW RATE, ITC COLLECTOR = 10.7 LB/HOUR SQ. FOOT
 FLOW RATE, 1-KALWALL COLLECTOR = 10.4 LB/HOUR SQ. FOOT

TIME	FLUX	TAMB	ITC COLLECTOR			1-KALWALL COLLECTOR			ITC	TEST
			TIN	TOUT	EFF	TIN	TOUT	EFF	X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1635	127	93.6	143.6	146.9	27	143.8	147.4	29	0.653	0.661
1637	127	93.6	143.6	147.0	29	143.6	147.4	31	0.658	0.660
1639	100	91.0	143.6	146.7	33	143.6	147.2	37	0.659	0.661
1641	117	93.0	143.4	146.7	30	143.6	147.0	30	0.719	0.722
1643	108	94.5	143.4	146.5	30	143.4	147.0	35	0.765	0.767
1645	108	94.7	143.6	146.1	25	143.6	146.3	26	0.765	0.766
1647	103	93.6	143.6	146.3	28	143.6	146.5	29	0.809	0.810
1649	68	93.4	143.4	145.8	37	143.6	145.4	27		
1651	52	91.6	143.4	144.9	30	143.4	144.3	18		
1653	38	91.0	143.2	144.0	21	143.2	142.7	-15		
1655	35	90.3	142.7	143.2	17	142.7	141.8	-27		

ITC SLOPE=- 41.55 ITC INTERCEPT= 68.73
 TEST SLOPE=- 60.58 TEST INTERCEPT= 84.17

H1,H2,HH,HN.
 39.68850 40.02220 19.72730 19.98160
 V,Y,W,K
 4541.07000 5151.22000 94.00000 83.00000
 HV,HZ,L1,L2
 1910.07000 2158.40000 4.00000 4.00000

PERFORMANCE DATA FOR AUGUST 15, 1975

FLOW RATE, ITC COLLECTOR = 10.0 LB/HOUR SQ. FOOT

FLOW RATE, 1-KALWALL COLLECTOR = 9.7 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	ITC COLLECTOR				1-KALWALL COLLECTOR				ITC X1 (10)	TEST X2 (11)
		TAMB (3)	TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)			
1553	185	87.4	145.8	153.5	42	145.8	154.6	46	0.510	0.513	
1555	191	86.9	145.6	154.4	46	145.8	155.8	51	0.499	0.503	
1557	166	86.7	146.1	154.2	49	146.1	155.8	57	0.574	0.579	
1559	192	88.5	146.5	154.2	40	146.5	155.5	45	0.488	0.492	
1559	193	88.9	146.5	154.4	41	146.5	155.7	46	0.485	0.488	
1601	178	89.6	146.5	155.5	51	146.5	156.7	56	0.524	0.528	
1603	175	88.7	145.2	154.2	51	145.2	155.7	58	0.531	0.535	
1605	111	90.3	145.2	153.0	70	145.2	153.9	76	0.821	0.826	
1607	175	88.5	145.8	153.0	41	145.8	153.9	45	0.530	0.532	
1609	171	88.2	145.8	153.7	46	145.8	154.9	52	0.548	0.551	
1611	158	87.6	146.1	153.9	37	148.1	154.3	41	0.605	0.608	
1614	114	85.6	151.0	155.8	43	151.0	155.3	41	0.873	0.873	
1630	30	82.9	147.4	143.3	30	147.4	146.5	-29			
1641	31	82.6	143.2	144.3	35	143.2	143.1	-6			
1643	27	81.9	142.3	143.4	41	142.3	142.2	-7			
1645	21	82.2	141.3	142.2	43	141.3	140.7	-25			
1646	18	82.4	140.7	141.6	51	140.7	140.2	-30			

ITC SLOPE=- 35.57 ITC INTERCEPT= 66.25
TEST SLOPE=- 53.38 TEST INTERCEPT= 81.15

H1,H2,HH,HN
46.67640 47.04940 23.97920 24.27780
V,Y,W,K
5096.80000 5765.29000 111.00000 94.00000
HV,HZ,L1,L2
2239.17000 2521.87000 9.00000 9.00000

PERFORMANCE DATA FOR AUGUST 18, 1975

FLOW RATE, ITC COLLECTOR = 10.1 LB/HOUR SQ. FOOT
 FLOW RATE, 1-KALWALL COLLECTOR = 9.9 LB/HOUR SQ. FOOT

TIME	FLUX	ITC COLLECTOR				1-KALWALL COLLECTOR				ITC	TEST
		TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(10)	(11)
1115	152	80.6	139.1	144.1	33	139.1	144.3	34		0.611	0.612
1117	136	80.1	138.7	144.3	41	138.9	144.9	43		0.686	0.689
1119	155	80.6	139.1	144.9	37	139.1	145.8	43		0.603	0.605
1121	186	81.0	140.0	145.0	27	140.0	145.9	32		0.503	0.505
1123	199	81.3	140.5	147.4	35	140.7	149.0	41		0.476	0.481
1125	186	80.6	142.2	149.0	37	142.3	150.8	45		0.522	0.527
1127	203	81.3	143.8	150.1	31	143.8	151.4	37		0.482	0.485
1128	204	81.0	144.7	151.5	34	144.9	153.1	40		0.486	0.490
1129	202	80.2	144.9	151.7	34	144.9	153.3	42		0.495	0.499
1131	135	81.0	146.3	152.6	47	146.3	153.9	56		0.745	0.750
1133	209	81.1	144.9	153.1	40	144.9	154.8	47		0.479	0.483
1135	210	81.3	146.7	154.0	36	146.7	155.8	43		0.482	0.486
1137	215	81.7	146.5	155.3	41	146.5	157.3	50		0.472	0.476
1139	207	81.5	148.1	155.7	37	148.1	157.5	45		0.496	0.500

ITC SLOPE=- 50.81 ITC INTERCEPT= 71.34
 TEST SLOPE=- 70.80 TEST INTERCEPT= 86.60

H1,H2,HH,HN
 60.50150 60.91980 30.44160 30.76410
 V,Y,W,K
 6413.16000 7204.16000 139.00000 125.00000
 HV,HZ,L1,L2
 2768.98000 3097.32000 6.00000 6.00000

PERFORMANCE DATA FOR AUGUST 18, 1975

FLOW RATE, ITC COLLECTOR = 10.1 LB/HOUR SQ. FOOT

FLOW RATE, 1-KALWALL COLLECTOR = 9.8 LB/HOUR SQ. FOOT

TIME	FLUX	ITC COLLECTOR				1-KALWALL COLLECTOR				ITC X1	TEST X2
		TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(10)	(11)
1215	221	82.2	167.9	176.2	38	168.1	177.4	42		0.551	0.554
1223	233	82.4	170.1	177.8	34	170.1	178.5	36		0.530	0.532
1225	227	83.1	170.2	178.7	38	170.2	179.8	41		0.543	0.546
1227	235	82.0	170.8	179.1	36	170.8	180.0	38		0.531	0.533
1229	233	83.3	171.1	179.8	38	171.3	180.5	39		0.533	0.535
1231	234	83.3	171.7	180.5	38	171.7	180.9	39		0.533	0.534
1233	225	82.8	172.0	180.7	39	172.2	181.2	40		0.559	0.561
1235	237	84.0	172.4	181.2	38	172.6	182.3	40		0.527	0.530
1237	244	84.0	172.4	182.3	41	172.6	182.9	41		0.514	0.516
1239	241	83.3	172.2	181.6	39	172.4	182.9	43		0.520	0.523
1241	74	82.2	172.4	178.0	77	172.4	177.4	68			
1243	241	81.7	171.3	180.5	39	171.3	180.7	38		0.525	0.525
1245	152	83.7	171.3	179.4	54	171.5	179.8	54		0.816	0.817
1246	213	84.4	171.5	178.7	34	171.7	178.5	32		0.576	0.576
1247	118	84.4	171.3	178.9	65	171.5	179.1	63			
1249	235	86.5	170.8	180.3	41	171.0	180.7	41		0.515	0.516
1251	90	82.8	171.5	176.4	55	171.7	175.3	40			
1300	255	85.8	171.1	180.5	37	171.3	181.9	41		0.478	0.482
1310	246	84.0	166.6	176.2	39	166.8	176.2	38		0.486	0.487
1321	236	83.1	171.1	176.7	24	171.1	176.0	20		0.521	0.519
1331	104	84.0	173.1	181.9	86	173.3	183.2	94			

ITC SLOPE=- 50.41 ITC INTERCEPT= 70.51

TEST SLOPE=- 71.37 TEST INTERCEPT= 85.84

PERFORMANCE DATA FOR AUGUST 18, 1975

FLOW RATE, ITC COLLECTOR = 9.4 LB/HOUR SQ. FOOT
 FLOW RATE, 1-KALWALL COLLECTOR = 9.0 LB/HOUR SQ. FOOT

		ITC COLLECTOR				1-KALWALL COLLECTOR				ITC	TEST
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(10)	(11)
1415	207	85.1	108.0	125.4	79	108.0	126.0	79		0.308	0.309
1417	124	83.8	112.8	122.2	71	113.0	122.7	71		0.531	0.534
1421	232	84.7	102.9	116.8	56	102.9	118.2	60		0.247	0.250
1423	247	84.9	106.2	118.2	46	106.0	121.5	57		0.240	0.247
1424	178	85.1	110.3	119.8	50	110.3	122.7	63		0.348	0.356
1425	3347	85.1	110.1	119.7	3	110.3	121.1	3		0.019	0.019
1427	153	85.8	108.1	119.1	67	108.1	120.4	72		0.391	0.395
1235	153	85.8	107.6	119.1	71	108.1	120.4	72		0.389	0.395
1429	215	85.3	108.5	116.4	35	108.5	116.8	35		0.276	0.277
1431	189	85.1	110.5	121.5	55	110.7	124.2	65		0.333	0.341

ITC SLOPE=- 41.10 ITC INTERCEPT= 66.15
 TEST SLOPE=- 58.98 TEST INTERCEPT= 79.79

H1,H2,HH,HN
 72.84080 73.32520 36.67830 37.05670
 V,Y,W,K
 7590.70000 8441.20000 170.00000 160.00000
 HV,HZ,L1,L2
 3311.16000 3664.81000 10.00000 10.00000

FLOW RATE, ITC COLLECTOR = 8.9 LB/HOUR SQ. FOOT
 FLOW RATE, 1-KALWALL COLLECTOR = 9.0 LB/HOUR SQ. FOOT

		ITC COLLECTOR				1-KALWALL COLLECTOR				ITC	TEST
TIME	FLUX	TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(10)	(11)
1437	235	86.4	148.6	145.9	-10	148.6	147.8	-4			
1441	104	85.1	142.7	147.0	37	142.7	148.3	49		0.885	0.891
1443	60	84.4	146.5	146.7	3	146.7	146.1	-8			
1445	49	82.8	145.2	147.9	49	145.4	146.5	20			

ITC SLOPE=- 40.28 ITC INTERCEPT= 65.82
 TEST SLOPE=- 56.44 TEST INTERCEPT= 78.75

H1,H2,HH,HN
 73.72610 74.21660 37.46210 37.85130
 V,Y,W,K
 7627.59000 8489.83000 174.00000 170.00000
 HV,HZ,L1,L2
 3343.82000 3708.16000 13.00000 13.00000

PERFORMANCE DATA FOR AUGUST 18, 1975

FLOW RATE, ITC COLLECTOR = 10.9 LB/HOUR SQ. FOOT

FLOW RATE, 1-KALWALL COLLECTOR = 10.9 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-KALWALL COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1511	115	85.1	177.3	180.0	26	177.4	177.1	- 4		
1513	182	86.7	175.6	179.8	25	175.6	178.7	18	0.677	0.674
1513	188	86.4	175.6	180.0	25	175.6	178.9	19	0.659	0.656
1515	185	86.4	174.6	180.1	33	174.6	179.8	31	0.667	0.666
1517	203	87.4	173.8	180.5	36	174.0	180.9	37	0.601	0.603
1519	193	86.5	173.7	180.1	37	173.8	180.3	37	0.633	0.634
1521	173	89.4	173.5	179.4	37	173.7	179.4	36	0.689	0.689
1523	177	90.3	173.3	179.1	36	173.5	179.1	35	0.668	0.668
1523	177	91.0	173.1	179.1	37	173.3	178.9	35	0.663	0.663
1525	174	88.3	172.9	179.1	38	173.1	173.9	36	0.687	0.687

ITC SLOPE=- 42.61 ITC INTERCEPT= 66.62

TEST SLOPE=- 60.74 TEST INTERCEPT= 80.24

H1,H2,HH,HN
79.66820 80.15520 41.39150 41.77580
V,Y,W,K
7930.44000 8772.07000 184.00000 174.00000
HV,HZ,L1,L2
3543.69000 3894.13000 14.00000 14.00000

PERFORMANCE DATA FOR AUGUST 18, 1975

FLOW RATE, ITC COLLECTOR = 10.4 LB/HOUR SQ. FOOT

FLOW RATE, 1-KALWALL COLLECTOR = 10.7 LB/HOUR SQ. FOOT

		ITC COLLECTOR				1-KALWALL COLLECTOR			ITC	TEST
TIME FLUX		TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF	X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1526	159	88.9	172.8	178.9	40	172.8	178.2	37	0.750	0.748
1527	155	89.1	172.6	178.5	40	172.8	178.2	37	0.764	0.764
1529	172	86.9	172.0	178.2	37	172.2	178.2	37	0.701	0.702
1531	63	85.8	171.7	175.1	57	171.9	173.7	31		
1532	158	86.5	171.1	174.8	24	171.1	173.5	16	0.752	0.748
1535	165	86.5	170.2	176.4	38	170.4	175.8	35	0.718	0.717
1537	173	86.0	170.2	174.2	24	170.2	173.3	19	0.682	0.679
1539	181	86.5	169.7	175.8	35	169.7	175.5	34	0.653	0.652

ITC SLOPE=- 43.22 ITC INTERCEPT= 66.82

TEST SLOPE=- 62.85 TEST INTERCEPT= 81.01

H1,H2,HH,HN

84.68830 85.16430 45.00190 45.37020

V,Y,W,K

8168.10000 8986.75000 192.00000 184.00000

HV,HZ,L1,L2

3714.49000 4047.91000 15.00000 15.00000

FLOW RATE, ITC COLLECTOR = 10.2 LB/HOUR SQ. FOOT

FLOW RATE, 1-KALWALL COLLECTOR = 10.2 LB/HOUR SQ. FOOT

		ITC COLLECTOR				1-KALWALL COLLECTOR			ITC	TEST
TIME FLUX		TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF	X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1551	158	85.5	146.5	150.8	28	146.5	150.3	25	0.604	0.602
1555	149	87.1	148.5	154.0	38	148.5	153.7	36	0.645	0.643
1555	149	87.4	148.6	154.2	38	148.8	153.7	34	0.646	0.645
1557	146	85.5	150.3	155.7	38	150.3	154.9	33	0.682	0.679

ITC SLOPE=- 43.58 ITC INTERCEPT= 66.93

TEST SLOPE=- 64.00 TEST INTERCEPT= 81.37

H1,H2,HH,HN

87.26440 87.73380 46.66390 47.02380

V,Y,W,K

8310.43000 9113.14000 196.00000 192.00000

HV,HZ,L1,L2

3806.55000 4129.43000 15.00000 15.00000

PERFORMANCE DATA FOR AUGUST 18, 1975

FLOW RATE, ITC COLLECTOR = 9.2 LB/HOUR SQ. FOOT
 FLOW RATE, 1-KALWALL COLLECTOR = 8.6 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	ITC COLLECTOR				1-KALWALL COLLECTOR				ITC X1 (10)	TEST X2 (11)
		TAMB (3)	TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)			
1605	123	86.5	103.5	114.3	81	103.5	114.8	80	0.442	0.444	
1605	129	86.0	103.8	113.9	72	104.0	114.3	69	0.425	0.427	
1607	132	88.3	106.3	114.6	58	106.3	114.8	55	0.410	0.411	
1609	136	86.9	113.2	118.0	33	113.4	118.2	31	0.447	0.448	

ITC SLOPE=- 44.18 ITC INTERCEPT= 67.49
 TEST SLOPE=- 64.25 TEST INTERCEPT= 81.60

H1,H2,HH,HN
 88.98770 89.46340 47.40730 47.77260
 V,Y,W,K
 8554.20000 9347.24000 200.00000 196.00000
 HV,HZ,L1,L2
 3911.35000 4230.49000 15.00000 15.00000

PERFORMANCE DATA FOR AUGUST 19, 1975

FLOW RATE, ITC COLLECTOR = 9.4 LB/HOUR SQ. FOOT
 FLOW RATE, 1-KALWALL COLLECTOR = 9.3 LB/HOUR SQ. FOOT

TIME	FLUX	TAMB	ITC COLLECTOR			1-KALWALL COLLECTOR			ITC X1	TEST X2
			TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1105	173	79.7	102.6	113.2	57	102.4	114.1	63	0.347	0.350
1107	173	77.0	103.3	114.3	59	103.3	115.2	64	0.368	0.371
1109	184	78.8	103.1	115.0	60	103.1	116.1	65	0.338	0.341
1111	183	80.8	102.4	115.0	65	102.4	116.2	71	0.328	0.331
1113	198	81.9	102.7	115.2	59	102.7	116.6	65	0.299	0.303
1115	188	81.0	103.7	115.4	58	103.5	117.7	70	0.322	0.327
1117	182	81.9	104.2	116.6	64	104.2	117.5	68	0.332	0.335
1119	194	78.1	104.9	116.6	57	104.9	119.0	68	0.334	0.341
1121	198	80.1	105.3	117.2	56	105.1	120.0	70	0.319	0.325
1123	191	80.6	105.5	118.4	64	105.3	119.7	70	0.332	0.335
1125	199	80.2	105.1	117.9	60	104.9	119.3	70	0.318	0.322

ITC SLOPE=- 43.69 ITC INTERCEPT= 70.22
 TEST SLOPE=- 62.27 TEST INTERCEPT= 85.29

H1,H2,HH,HN
 43.32410 43.70090 20.93210 21.21480
 V,Y,W,K
 5199.10000 5893.53000 105.00000 94.00000
 HV,HZ,L1,L2
 2127.58000 2406.43000 4.00000 4.00000

PERFORMANCE DATA FOR AUGUST 19, 1975

FLOW RATE, ITC COLLECTOR = 9.4 LB/HOUR SQ. FOOT

FLOW RATE, 1-KALWALL COLLECTOR = 9.4 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-KALWALL COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1129	206	81.0	140.7	134.2	-30	140.5	135.3	-24		
1131	207	81.5	138.2	146.1	36	138.2	147.6	43	0.449	0.452
1133	210	81.9	139.5	148.1	39	139.3	149.2	45	0.448	0.450
1135	212	82.2	138.0	148.5	46	138.0	149.2	50	0.440	0.442
1137	190	81.3	138.7	148.3	47	138.7	149.0	51	0.496	0.498
1139	202	80.1	139.8	148.1	38	139.6	148.6	42	0.474	0.475
1141	214	81.9	140.0	149.5	42	140.0	150.6	47	0.444	0.447
1143	212	82.0	139.6	151.0	50	139.5	151.0	51	0.450	0.450
1145	213	82.4	140.2	149.9	43	140.2	152.1	53	0.444	0.449
1147	212	81.9	140.5	152.2	52	140.5	151.5	49	0.457	0.455
1149	211	82.9	143.4	154.6	49	143.2	152.1	39	0.464	0.458

ITC SLOPE=- 44.23 ITC INTERCEPT= 69.90

TEST SLOPE=- 63.18 TEST INTERCEPT= 84.79

H1,H2,HH,HN

47.88870 48.27470 23.01830 23.30930

V,Y,W,X

5640.44000 6361.81000 116.00000 105.00000

HV,HZ,L1,L2

2329.17000 2620.59000 5.00000 5.00000

PERFORMANCE DATA FOR AUGUST 19, 1975

FLOW RATE, ITC COLLECTOR = 8.9 LB/HOUR SQ. FOOT

FLOW RATE, 1-KALWALL COLLECTOR = 9.5 LB/HOUR SQ. FOOT

TIME (1)	FLUX (2)	TAMB (3)	ITC COLLECTOR			1-KALWALL COLLECTOR			ITC X1 (10)	TEST X2 (11)
			TIN (4)	TOUT (5)	EFF (6)	TIN (7)	TOUT (8)	EFF (9)		
1153	214	81.1	177.6	177.4	- 1	177.6	177.1	- 2		
1155	213	37.0	180.5	183.6	13	180.5	183.4	13	0.831	0.830
1157	213	82.8	179.8	186.8	29	180.0	186.4	29	0.623	0.623
1159	214	83.1	178.5	187.9	39	178.5	186.3	34	0.619	0.615
1201	218	82.8	177.4	186.4	37	177.3	185.2	34	0.602	0.598
1203	218	80.1	177.6	185.9	34	177.4	185.4	34	0.613	0.611
1205	219	83.3	177.4	186.4	37	177.3	185.0	34	0.597	0.594
1207	219	82.0	177.4	186.6	37	177.4	184.6	31	0.602	0.598
1209	219	84.2	177.3	186.4	37	177.3	185.7	37	0.591	0.590

ITC SLOPE=- 50.25 ITC INTERCEPT= 71.97

TEST SLOPE=- 71.54 TEST INTERCEPT= 87.58

H1,H2,HH,HN

52.96590 53.33240 26.28520 26.55260

V,Y,W,K

5902.89000 6607.02000 125.00000 116.00000

HV,HZ,L1,L2

2491.12000 2771.46000 6.00000 6.00000

PERFORMANCE DATA FOR AUGUST 20, 1975

FLOW RATE, ITC COLLECTOR = 8.2 LB/HOUR SQ. FOOT

FLOW RATE, 2-KALWALL COLLECTOR = 8.1 LB/HOUR SQ. FOOT

TIME	FLUX	TAMB	ITC COLLECTOR			2-KALWALL COLLECTOR			ITC	TEST
			TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1215	192	81.0	147.9	155.3	32	147.9	157.8	42	0.535	0.541
1217	194	80.8	138.9	156.2	73	138.9	157.6	78	0.510	0.514
1219	176	81.0	140.7	151.4	49	140.7	153.7	60	0.551	0.557
1221	174	81.9	144.1	151.2	33	144.1	153.0	41	0.564	0.569
1221	156	81.0	142.7	151.7	47	142.7	153.5	56	0.629	0.635
1223	159	80.1	138.7	151.7	67	138.9	153.3	73	0.610	0.616
1225	165	80.1	138.2	148.5	51	138.2	150.1	58	0.577	0.582
1227	107	78.6	141.3	146.5	40	141.3	147.6	48	0.907	0.912
1229	89	77.7	143.6	146.9	30	143.6	147.2	33		
1231	110	78.6	143.4	147.9	34	143.4	147.9	33	0.902	0.902
1233	178	79.9	143.6	150.3	31	143.6	150.8	33	0.555	0.557
1235	207	80.2	144.0	153.0	36	144.0	154.4	41	0.483	0.487
1237	205	82.6	145.0	154.6	38	145.2	156.2	44	0.485	0.490
1237	205	81.9	145.2	154.6	38	145.2	156.4	44	0.488	0.492

ITC SLOPE=- 12.03 ITC INTERCEPT= 50.85

TEST SLOPE=- 17.95 TEST INTERCEPT= 60.83

H1,H2,HH,HN				
7.79536	7.85260	4.91858	4.98537	
V,Y,W,K				
567.33800	649.84300	14.00000	0.00000	
HV,HZ,L1,L2				
337.26400	388.19000	1.00000	1.00000	

PERFORMANCE DATA FOR AUGUST 20, 1975

FLOW RATE, ITC COLLECTOR = 10.1 LB/HOUR SQ. FOOT

FLOW RATE, 2-KALWALL COLLECTOR = 10.2 LB/HOUR SQ. FOOT

TIME	FLUX	ITC COLLECTOR				2-KALWALL COLLECTOR				ITC	TEST
		TAMB	TIN	TOUT	EFF	TIN	TOUT	EFF		X1	X2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)		(10)	(11)
1407	132	83.5	173.1	174.8	12	173.3	175.3	15		0.927	0.930
1409	144	81.9	171.9	175.8	28	172.0	176.4	31		0.861	0.863
1410	185	83.1	170.6	176.0	29	170.6	177.1	36		0.661	0.664
1411	181	82.9	170.2	176.0	32	170.4	177.3	39		0.674	0.678
1413	163	82.4	170.2	175.3	31	170.2	176.2	37		0.751	0.754
1415	143	83.1	170.2	175.3	36	170.6	176.2	40		0.849	0.854
1417	190	80.8	170.4	176.2	31	170.4	177.3	37		0.656	0.658
1419	197	82.4	170.6	176.9	32	170.8	178.0	37		0.627	0.631
1421	198	83.1	171.1	177.4	32	171.3	178.9	39		0.621	0.625
1423	147	82.2	171.7	177.4	39	171.9	178.7	48		0.845	0.850
1425	154	80.8	171.9	176.4	30	172.2	176.9	31		0.816	0.819
1426	159	81.7	171.9	176.7	31	171.9	177.4	36		0.786	0.788
1427	157	80.4	171.7	177.1	35	171.9	177.6	38		0.802	0.804
1429	176	82.4	171.7	177.4	33	171.9	178.2	37		0.705	0.708
1431	169	82.6	171.9	177.3	32	172.0	178.0	36		0.736	0.739
1433	188	82.6	171.9	178.2	34	172.0	179.1	38		0.663	0.666
1435	157	82.2	172.4	178.2	37	172.4	178.9	42		0.795	0.797

ITC SLOPE= 4.99 ITC INTERCEPT= 32.17
 TEST SLOPE= 4.72 TEST INTERCEPT= 37.66

H1,H2,HH,HV
 20.56890 20.67830 14.65320 14.79840
 V,Y,W,K
 1099.84000 1265.06000 32.00000 15.00000
 HV,HZ,L1,L2
 734.76800 848.59400 1.00000 1.00000

PERFORMANCE DATA FOR AUGUST 20, 1975

FLOW RATE, ITC COLLECTOR = 8.4 LB/HOUR SQ. FOOT
FLOW RATE, 2-KALWALL COLLECTOR = 7.6 LB/HOUR SQ. FOOT

TIME	FLUX	TAMB	ITC COLLECTOR			2-KALWALL COLLECTOR			ITC X1	TEST X2
			TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1517	143	80.1	107.4	110.1	16	107.6	110.3	14	0.424	0.425
1519	160	79.7	107.1	116.8	51	107.1	117.9	52	0.402	0.406

ITC SLOPE= 4.95 ITC INTERCEPT= 32.15
TEST SLOPE= 7.18 TEST INTERCEPT= 35.66

H1,H2,HH,HN
21.39510 21.50910 14.99470 15.14380
V,Y,W,K
1166.85000 1331.07000 34.00000 32.00000
HV,HZ,L1,L2
762.07000 875.65400 1.00000 1.00000

FLOW RATE, ITC COLLECTOR = 8.2 LB/HOUR SQ. FOOT
FLOW RATE, 2-KALWALL COLLECTOR = 7.3 LB/HOUR SQ. FOOT

TIME	FLUX	TAMB	ITC COLLECTOR			2-KALWALL COLLECTOR			ITC X1	TEST X2
			TIN	TOUT	EFF	TIN	TOUT	EFF		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1521	156	79.4	105.3	118.0	67	105.3	119.1	65	0.413	0.416
1523	150	81.3	104.4	116.2	65	104.4	118.6	69	0.407	0.415
1528	145	81.3	101.1	114.3	74	101.1	115.9	74	0.403	0.408
1544	138	82.0	102.0	114.8	76	102.2	117.2	79	0.422	0.431
1605	111	81.9	102.2	112.1	73	102.2	112.3	66	0.517	0.518

ITC SLOPE=- 20.75 ITC INTERCEPT= 52.92
TEST SLOPE=- 15.41 TEST INTERCEPT= 53.94

H1,H2,HH,HN
23.55590 23.69680 15.93770 16.10920
V,Y,W,K
1522.25000 1684.59000 39.00000 34.00000
HV,HZ,L1,L2
915.92400 1029.98000 1.00000 1.00000

DRY PLATE DATA FOR AUGUST 12, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1151	225	238	190	82
1153	227	241	188	84
1155	230	244	206	83
1157	233	248	210	83
1159	236	251	206	83
1201	238	254	208	82
1203	240	256	205	84
1205	242	258	209	85
1207	244	261	207	85
1209	246	262	204	83
1211	248	264	205	86
1213	249	266	209	85
1215	251	267	205	86
1217	253	269	201	85
1219	253	270	210	84
1303	275	292	221	86
1321	279	296	231	88
1323	277	293	227	89
1325	278	294	231	88
1327	279	295	228	87
1331	279	294	235	86
1333	280	296	217	86
1335	280	296	223	87
1341	273	286	240	88
1343	273	287	234	87
1345	275	290	230	89

Thickol A

DRY PLATE DATA FOR AUGUST 13, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1136	238	255	191	87
1149	248	265	192	90
1151	249	266	195	87
1151	250	267	195	86
1153	250	268	190	86
1155	251	269	194	85
1157	252	270	197	85
1159	253	270	199	84
1201	254	271	199	85
1203	255	272	203	86
1205	256	273	206	87
1207	257	274	210	90
1207	257	274	210	90
1209	258	276	213	85
1211	260	277	215	87
1222	264	281	205	90
1238	269	287	204	89
1249	270	287	214	88
1251	270	287	205	91
1253	270	287	213	91
1255	271	288	211	89
1257	272	289	215	92
1303	275	292	226	93
1304	276	293	228	92
1305	276	293	227	93
1307	277	294	223	93
1309	277	294	217	92
1311	277	295	216	92
1313	278	295	225	93
1315	278	296	230	93
1320	280	298	228	93
1336	279	295	207	95
1351	270	282	148	94
1407	265	277	131	92
1423	259	270	188	94
1430	249	265	129	93
1437	250	259	176	93
1452	257	268	73	92
1457	256	265	215	94
1459	258	267	193	95
1501	258	268	150	94
1503	255	264	172	90
1505	256	265	210	93
1507	257	266	158	93
1508	257	266	188	94
1509	257	265	184	94
1511	257	265	179	92
1513	257	266	202	94
1515	259	267	201	94

*Thick 1 H**

DRY PLATE DATA FOR AUGUST 13, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1136	238	255	191	37
1517	260	269	203	94
1524	262	270	164	95
1531	251	258	99	92
1533	249	255	178	93
1535	251	257	186	94
1537	252	259	186	95
1540	254	262	184	95
1545	255	262	174	93
1547	254	262	160	95
1549	253	260	149	94
1551	251	258	133	94
1555	245	251	107	92
1556	243	249	97	92
1557	242	248	104	92
1559	239	244	109	93
1601	236	241	76	92
1603	232	236	91	93
1605	229	233	77	92
1607	225	229	68	91
1609	222	225	63	92
1611	218	221	71	92
1612	217	220	85	92
1627	208	211	119	91
1635	212	215	127	94
1637	213	216	127	94
1639	213	217	100	91
1641	213	216	117	93
1643	213	216	108	95
1645	212	215	108	95
1647	212	214	103	94
1649	211	212	68	93
1651	208	209	52	92
1653	204	205	38	91
1655	199	200	35	90

DRY PLATE DATA FOR AUGUST 18, 1975

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1026	206	193	136	81
1042	219	205	151	82
1057	223	210	150	81
1113	230	216	120	82
1113	230	215	123	81
1115	229	215	152	81
1117	229	215	136	80
1119	230	216	155	81
1121	231	217	186	81
1123	234	220	199	81
1125	239	223	186	81
1127	241	225	203	81
1128	243	227	204	81
1129	244	228	202	80
1131	246	229	135	81
1133	247	230	209	81
1135	250	233	210	81
1137	253	236	215	82
1139	255	238	207	82
1144	260	243	213	83
1215	280	262	221	82
1223	283	265	233	82
1225	284	266	227	83
1227	286	268	235	82

DRY PLATE DATA FOR AUGUST 18, 1975

COMPARATOR = THIOKOL PAINT, BOTH PLATES AT 53 DEG TILT

TIME	ITC, DEG F	COM, DEG F	FLOX, BTU/HR SQ-FT	TAMB, DEG F
1229	287	269	233	83
1231	289	270	234	83
1233	290	271	225	83
1235	291	272	237	84
1237	292	274	244	84
1239	293	275	241	83
1241	291	272	74	82
1243	288	271	241	82
1245	290	272	152	84
1246	288	271	213	84
1247	288	271	118	84
1249	290	273	235	87
1251	287	270	90	83
1310	266	258	246	84
1321	282	268	236	83
1331	293	277	104	84
1342	290	276	233	84
1352	296	281	173	85
1403	293	279	141	85
1413	296	282	221	84
1415	295	280	207	85
1417	292	278	124	84
1419	287	274	157	84
1421	284	273	232	85
1423	287	275	247	85
1424	289	277	173	85
1427	283	271	153	86
1429	277	266	215	85
1431	279	269	189	85
1434	272	263	211	85
1437	277	267	235	86
1439	281	269	194	86
1441	279	267	104	85
1443	271	261	60	84
1445	262	254	49	83
1452	247	241	144	85
1453	247	241	166	85
1455	247	241	67	84
1457	249	238	107	85
1459	244	239	221	86
1501	251	244	237	87
1502	256	249	222	88
1511	251	244	115	85
1513	250	244	182	87
1513	250	244	183	86
1515	252	246	185	86
1517	255	249	203	88
1519	259	252	193	87

DRY PLATE DATA FOR AUGUST 18, 1975

COMPARATOR = THIOKOL PAINT, BOTH PLATES AT 53 DEG TILT

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1521	260	252	173	90
1523	261	253	177	90
1523	261	253	177	91
1525	261	254	174	88
1526	262	254	159	89
1527	262	254	155	89
1529	262	254	172	87
1531	259	252	163	86
1533	254	248	158	87
1534	254	248	173	87
1535	255	249	165	87
1537	254	248	173	86
1539	255	249	181	87
1544	261	254	176	87
1547	262	254	169	86
1549	262	254	161	87
1551	262	254	158	86
1551	262	254	158	86
1555	260	253	149	87
	261	253	72	88
1557	259	252	146	86
1603	255	249	127	88
1605	253	247	123	87
1605	252	244	129	86
1607	251	245	132	88
1609	251	245	136	87

DRY PLATE DATA FOR AUGUST 19, 1975

COMPARATOR = THIOKOL PAINT, BOTH PLATES AT 53 DEG TILT

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1043	218	240	158	81
1047	221	243	151	79
1049	221	244	152	80
1051	221	244	143	80
1053	223	245	149	80
1055	224	246	163	79
1057	225	248	169	80
1059	226	250	164	81
1101	227	251	167	81
1103	228	252	173	81
1105	230	254	173	80
1107	232	256	173	77
1109	233	258	184	79
1114	236	261	183	81
1113	237	263	198	82
1115	239	265	188	81
1117	241	267	182	82
1119	243	269	194	80
1121	244	271	198	80
1125	247	273	199	80
1127	249	276	206	81
1129	251	278	206	81
1131	252	280	207	82
1133	254	282	210	82
1135	255	284	212	82
1137	256	285	190	81
1139	256	285	202	80
1141	257	286	214	82
1143	259	288	211	82
1145	260	290	213	82
1147	262	291	212	82
1149	263	293	211	83
1151	264	294	212	82
1153	265	295	214	81
1155	266	296	213	83
1157	267	297	213	83
1159	268	298	214	84
1201	269	299	216	83
1203	270	300	218	80
1205	270	300	217	83
1207	271	301	219	82
1209	272	302	219	84
1211	272	303	218	82
1213	273	304	220	82
1215	274	305	219	84
1217	275	305	220	81
1219	275	306	223	80
1221	276	307	223	82

DRY PLATE DATA FOR AUGUST 19, 1975

COMPARATOR = THIOKOL PAINT, BOTH PLATES AT 53 DEG TILT

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1225	278	308	224	81
1227	279	309	226	79
1229	279	310	227	82
1231	280	311	224	84
1239	282	314	227	84
1247	285	315	225	83
1249	286	316	228	84
1251	285	315	106	83
1253	278	306	53	81
1255	270	295	60	81
1257	264	286	61	82

DRY PLATE DATA FOR AUGUST 20, 1975

COMPARATOR = THIOKOL PAINT, BOTH PLATES AT 53 DEG TILT

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
901	121	120	51	72
911	129	127	72	72
921	138	135	84	73
932	148	144	90	73
942	158	151	93	73
952	167	159	114	75
1002	165	158	57	73
1013	160	155	63	73
1023	167	160	84	73
1033	172	167	134	75
1043	188	178	144	75
1049	198	186	151	77
1054	204	192	160	77
1104	217	205	159	78
1114	229	215	167	78
1124	237	223	170	60
1124	238	223	171	77
1128	241	226	175	78
1129	241	226	175	78
1130	242	227	176	79
1134	245	230	179	78
1135	246	230	178	79
1136	247	231	177	79
1140	249	233	179	79
1141	249	233	180	79
1142	251	235	185	78
1143	251	235	186	79
1143	252	236	186	61
1145	253	237	184	79
1145	254	238	183	79
1146	254	238	183	79
1146	254	238	183	79
1150	257	241	186	80
1206	264	248	180	81
1215	266	250	192	81
1217	268	252	194	81
1219	269	253	176	81
1221	269	252	174	82
1221	269	252	156	81
1223	268	252	159	80
1225	266	251	165	80
1227	264	249	107	79
1229	259	245	89	78
1231	254	241	110	79
1233	253	241	178	80
1235	256	243	207	80
1237	260	246	205	83

DRY PLATE DATA FOR AUGUST 20, 1975

COMPARATOR = THIOKOL PAINT, BOTH PLATES AT 53 DEG TILT

TIME	ITC, DEG F	COM, DEG F	FLUX, BTU/HR SQ-FT	TAMB, DEG F
1237	260	246	205	82
2	266	252	173	81
1308	263	249	215	84
1323	253	242	97	81
1339	258	247	126	82
1355	247	237	133	81
1407	242	233	55	84
1409	241	232	144	82
1410	242	234	185	83
1411	243	234	181	83
1413	245	236	163	82
1415	246	39	143	83
1417	248	238	190	81
1419	251	240	197	82
1421	253	243	193	85
1423	255	244	147	82
1425	253	242	154	81
1426	253	242	159	82
1427	253	242	157	81
1429	253	243	176	82
1431	254	243	169	83
1433	255	245	185	83
1435	257	246	157	82
1439	255	245	150	82
1441	255	245	162	81
1445	257	247	167	82
1447	257	247	163	82
1449	257	247	164	82
1451	255	244	93	80
1453	250	240	92	82
1455	245	237	107	81
1457	243	236	124	81
1457	243	236	144	82
1512	249	237	161	83
1513	247	238	159	81
1517	247	238	143	80
1519	247	239	160	80
1521	248	239	156	79
1523	248	239	150	81
1528	248	239	145	81
1544	243	236	138	82
1600	230	224	78	81
1605	226	221	111	82
1607	226	220	110	82

DRY PLATE DATA FOR AUGUST 27, 1975

DULL FINISH GLASS=ACOM, TEDLAR OVER GLASS=BCOM, VICE VERSA=CCOM
 THIOKOL PAINT=DCOM, TWO KALWALL=ECOM

TIME	ACOM	BCOM	CCOM	DCOM	ECOM	TITC	FLUX, BTU/ HR SQ-FT	TAMB DEG F
DEG F	-	-	-	-	-	-		
931				155	164	168	115	76
942				171	185	186	120	73
952				183	199	198	123	77
1003				192	209	207	133	77
1013				205	221	211	144	78
1023				212	232	227	150	79
1034				213	243	237	160	79
1042				214	249	244	169	80
1052				216	259	253	180	81
1102				221	268	261	191	79
1113				228	277	269	196	81
1123				235	284	276	202	81
1133				249	290	282	214	81
1144				262	296	288	212	83
1154				274	302	293	218	83
1204				283	307	298	223	83
1206			244	285	308	299	224	82
1217			263	292	312	304	227	83
1227			276	275	316	307	229	83
1238			285	279	320	311	233	83
1239		279	286	282	320	311	235	82
1249		287	292	294	322	314	235	84
1259		295	298	301	324	316	237	84
1307	264	299	301	305	325	318	242	84
1313	277	302	303	308	326	318	245	84
1323	293	306	306	311	326	319	244	84
1333	304	308	308	313	327	319	239	84
1344	313	310	309	314	326	319	237	84
1354	320	311	309	314	325	318	231	85
1405	324	311	309	314	324	318	229	85
1415	327	311	307	313	322	317	228	85
1426	329	309	305	312	319	314	227	85
1436	329	307	303	310	316	312	223	86
1447	329	306	301	308	313	310	220	84
1457	328	304	299	305	309	307	212	84
1508	326	302	297	301	304	302	205	85
1518	324	298	293	296	299	298	195	86
1529	320	294	287	291	294	294	188	84
1539	315	289	282	285	288	289	175	85
1550	310	283	276	279	282	284	165	84
1600	304	277	269	273	275	278	151	86
1611	298	271	263	267	266	271	144	85

DRY PLATE DATA FOR AUGUST 30, 1975

SINGLE KALWALL=COMPARATOR A, TRUTHERM=BCOM, THIOKOL PAINT=CCOM,
GLASS OVER TEDLAR=DCOM, DULL FINISH GLASS=ECOM,
TEDLAR OVER GLASS=FCOM

TIME	ACOM	BCOM	CCOM	DCOM	ECOM	FCOM	TITC	FLUX, BTU/ HR SQ-FT	TAMB
DEG F	-	-	-	-	-	-	-	-	DEG F
1116	230	107	244	265	267	253	255	174	87
1124	238	111	251	271	275	259	262	192	88
1134	248	117	261	282	287	269	272	200	90
1144	246	115	262	281	288	268	271	179	86
1154	244	117	264	280	291	268	273	185	85
1204	244	117	264	278	293	268	272	202	87
1214	254	123	272	286	303	275	280	216	87
1224	259	125	277	292	307	280	283	196	89
1234	261	126	279	293	309	282	284	204	37
1244	265	129	285	298	316	287	290	226	88
1254	274	134	293	305	325	295	296	220	88
1304	254	123	280	291	311	282	282	61	86
1314	237	113	267	275	297	268	270	72	87
1324	259	125	282	290	314	282	284	125	88
1334	224	106	253	259	282	252	255	53	86
1344	197	92	231	231	259	228	234	78	87
1354	226	107	250	251	281	247	250	87	89
1404	241	116	260	262	290	257	259	225	90
1414	230	109	251	258	281	251	251	80	87
1424	230	109	251	257	280	250	250	77	88
1434	218	104	240	242	268	239	240	52	89
1444	199	93	225	226	252	223	225	50	89

DRY PLATE DATA FOR SEPTEMBER 3, 1975

SINGLE KALWALL=COMPARATOR A, TRUTHERM=BCOM, THICKOL PAINT=CCOM,
GLASS OVER TEDLAR=DCOM, DULL FINISH GLASS=ECCOM,
TEDLAR OVER GLASS=FCOM.

TIME	ACOM	BCOM	CCOM	DCOM	ECCOM	FCOM	TITC	FLUX, BTU/ HR SQ-FT	TAMB
DEG F	-	-	-	-	-	-	-	-	DEG F
904			100	125	119	116	125	36	65
914			106	130	125	122	131	70	66
924			121	147	145	142	149	109	66
944			151	180	178	176	180	127	66
954			165	195	194	191	193	135	66
1004	165	32	177	207	207	203	205	149	69
1014	181	52	191	220	221	216	217	161	69
1024	193	70	203	233	234	228	229	170	70
1034	201	84	215	244	246	239	240	175	70
1044	212	94	226	255	253	249	250	191	70
1054	221	101	235	262	267	258	257	185	71
1104	227	106	243	267	275	261	263	210	71
1114	235	111	252	275	285	269	270	219	72
1124	243	115	260	282	294	276	277	226	72
1134	250	118	267	288	301	284	283	230	73
1144	254	118	273	293	303	290	289	234	73
1154	260	121	280	298	315	295	295	238	73
1204	261	123	283	300	317	298	298	242	73
1214	257	123	285	301	319	298	299	224	72
1224	264	126	290	305	325	302	303	249	74
1234	271	130	297	312	332	308	308	243	74
1244	275	132	301	315	336	312	312	249	73
1254	280	134	304	318	340	315	315	250	73
1304	284	136	307	320	343	316	317	257	74
1314	287	139	310	322	345	317	316	263	75
1324	289	141	312	322	347	317	316	265	75
1334	288	141	313	322	347	316	315	260	75
1344	285	139	311	319	345	313	312	249	76
1354	281	137	310	316	344	311	311	246	76
1404	284	137	311	316	344	312	311	242	76
1414	283	137	310	315	343	311	310	223	76
1424	282	136	307	312	340	307	308	245	76
1434	278	135	306	310	337	303	304	199	78
1444	259	126	290	293	320	287	288	183	77
1454	259	127	290	288	318	285	287	240	76
1504	270	131	295	297	327	291	291	230	79
1514	261	126	286	291	318	283	283	168	76
1524	254	123	278	282	311	276	277	158	78
1534	246	119	271	275	306	271	272	171	79
1544	232	112	264	265	295	261	264	146	78
1554	218	104	254	253	284	250	254	165	76
1604	224	106	255	253	284	250	254	149	78
1614	219	105	251	248	278	244	249	146	79
1624	220	105	252	247	277	243	248	135	78
1634	220	105	251	245	275	241	245	134	79
1644	217	103	247	240	270	236	241	117	76
1654	208	100	242	232	262	228	234	107	79
1704	201	96	236	221	255	220	226	99	78
1714	192	92	228	211	246	211	218	90	78
1724	184	97	220	202	236	201	209	81	78