AN EXPERIMENTAL AND NUMERICAL STUDY OF THE THERMAL PERFORMANCE OF A BRIDGE DECK DE-ICING SYSTEM

By

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Completion of this thesis has been education all the way. Not just the academic type, but also the personal development that came along with it. When I started out, little did I know what a thesis entails. I found out soon enough. Even though I may have felt frustrated at many times during its course, now at the end of it all, I feel a sense of achievement and I believe I have learned a lot.

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NOMENCLATURE

A = Area (ft^2)

A_f = Free area (ft^2)

A_t = Total area (ft^2)

A_r = Free area ratio

B = Offset factor

C = Snow melting performance class

C_p = Specific heat (Btu/lb/°F)

D = Diameter of tube (ft)

E_{calib} = Flowmeter calibration error (%)

E_{temp} = Error in temperature measurement (°F)

E_{gpm} = Error in calculating mass flow rate in gpm (%)

E_{Cp}= Error in calculating the specific heat.(%)

$E_{\dot{m}}$ = Error in calculating mass flow rate in lb/hr (%)

E_{ρ} = Error due to difference in density due to inexact GS-4 quantity mixed with water. (%)

$E_{\Delta T}$ = Error in determining temperature drop (%)

H = Heaviside unit function

h_c = Forced coefficient convection (Btu/hr-ft^2°F)

h_f = Enthalpy of fusion for water (143.5 Btu/lb)

h_{fg} = Heat of evaporation at the film temperature (Btu/lb)

K = Thermal conductivity of the material (Btu/hr/ft/°F)

M : Multiplier factor used to conform calibrated temperature to the boiling point.

$\dot{m}$ = Mass flow rate of the fluid (lb/hr)

$N_{y,z}$ = Number of nodes in the Y or Z direction

$\boldsymbol{P}$ = Composite node property

p_{av} = Vapor pressure of moist air (in. of mercury)

p_a = atmospheric pressure (in. Hg)

p_i = property of material i

p_w = water vapor partial pressure, (psia)

p_{ws} = saturated water vapor pressure, (psia)

$Q_{input\ flux}$ = Input heat flux (Btu/hr/ft^2)

q_{top} = Heat input from top node (Btu/hr)

q_{bottom} = Heat input from bottom node (Btu/hr)

q_{right} = Heat input from right node (Btu/hr)

q_{left} = Heat input from left node (Btu/hr)

q_{front} = Heat input from front node (Btu/hr)

q_{back} = Heat input from back node (Btu/hr)

q = Heat input from adjacent node (Btu/hr)

q_s = Sensible heat transferred to the snow (Btu/hr/ft^2)

q_m = Heat of fusion (Btu/hr/ft^2)

q_e = Heat of evaporation (Btu/hr/ft^2)

q_h = Heat transfer by convection and radiation (Btu/hr/ft^2)

q_r = Radiant heat loss (Btu/hr/ft^2)

q_c = Convective heat loss (Btu/hr/ft^2)

R = Resistance to account for insulation and air leaks (Btu/hr/ft^2/°F)$^{-1}$

SF = Maximum recorded snowfall in 24 hours (in. of snow)

S = Heat output from unit area of heater per unit time

$S_{y,z}$ = Slab dimension in the Y or Z direction (ft.)

Srad = Incident solar flux (Btu/hr-ft^2)

T_{top} = Temperature of top surface of the slab(°F)

T_{bottom}= Temperature of bottom surface of the slab(°F)

T_{avg} = Average top slab temperature (°F)

$\boldsymbol{T}_a$ = Thermocouple readings above pipes (°F)

$\boldsymbol{T}_b$ = Thermocouple readings between pipes(°F)

$\boldsymbol{T}_{above}$ = Average top slab temperature for locations directly above pipes (°F)

$\boldsymbol{T}_{between}$ = Average top slab temperature for locations between pipes (°F)

$\boldsymbol{T}_{i/t}$ = Temperature of the ith node at time t (°F)

T_{air} = Air temperature (°K)

$T_{ambient}$ = Ambient temperature (°F)

$Ta_{rankine}$ = Air temperature (°R)

$T_{i,j,k}$ = Node temperature (°F)

T_{adj} = Temperature of adjacent node (°F)

$T_{dewpoint}$ = Dew point temperature (°K)

$T_{i,j,k}$ = Node temperature (°R)

T_{sky} = Sky temperature (°K)

$t_{dewpoint}$ = Dew point temperature (°F)

t = Time (hr)

t_a = Air temperature (°F)

t_p = Surface temperature(°F)

t_m = Mean outdoor temperature during freezing (°F)

t_f = Water film temperature (°F), usually taken as 33°F

t_b = Design air temperature at 97.5% frequency level (°F)

V = Wind speed (mph)

V_i = Volume of the node i (ft^3)

Vf_i = Volume fraction of material i

X = depth of node from top surface (ft)

X_{max} = maximum depth from top surface (ft)

Symbols

α = maximum thermal diffusivity

ρ = Density (lb/ft^3)

Ω = Density of snow (lb/ft^3)

ϕ = relative humidity (%)

σ = 0.714 e -08, Stefan constant (Btu/hr-ft^2 R^4)

ΔT = Temperature difference (°F)

Δt = time step (hr.)

Δx, Δy, Δz = grid spacing in the X, Y, Z direction respectively

CHAPTER ONE

INTRODUCTION

1.1 Overview

1.1.1 The problem of bridge icing

Snow, sleet and freezing rain can cause hazardous conditions for unsuspecting or inattentive motorists. Loss of control of the vehicle because of the slick road may lead to dangerous accidents. The formation of ice or frost on bridge decks, while the other part of the road remains ice free is a well known phenomenon and is called preferential icing. Numerous accidents result every year during the winter season due to this. This has led to many countermeasures being developed and new methods being researched at many locations. In a study done in the late 70's, it was estimated that 25,000 accidents occurred annually in the United States alone, due to ice and frost on bridge decks (Blackburn et al., 1978). It is therefore extremely important to prevent this preferential icing effect. In the past various strategies have been employed. The responses may range from using deicing agents or embedded heating elements to high intensity infra red heaters. Some of these methods are in use universally while others have only been tested at certain locations.

1.2 Background and Literature Review

This section lists some of the conventional and non conventional approaches to dealing with road icing and the heat requirements for a system to melt the ice from the surface.

1.2.1 Conventional approach

The application of deicing agents is the conventional method of preventing preferential icing. Materials like salt, sand or other such gritty material can be used for ice removal. Practically any material which is water soluble and can lower the freezing point of water can be used as a deicer. The chemicals commonly in use today are sodium chloride (common salt), calcium chloride, potassium chloride and urea ("Deicing," 1991). These deicers all work in the same fashion. After coming in contact with some moisture, they form a liquid brine. This brine has a lower freezing temperature than water and causes the ice to melt on contact. These deicers spread out under the ice, "undercutting" it, thus breaking the bond between the ice and the road surface. After sufficient loosening, the ice can be easily removed. Deicers differ markedly in their performance. For temperatures below 25 °F, sodium chloride, urea and potassium chloride begin to lose their effectiveness. Calcium chloride on the other hand is effective to temperatures below -20 °F. Heat generated by the friction of the moving traffic is also helpful in increasing the effectiveness of the deicing agents. The shape of the deicer pellets also affects performance.

These deicers however have some undesirable side effects ("Deicing," 1991). Deicer residue that gets tracked into buildings and leaves unsightly marks upon drying. All the chloride salts have a potential for damaging plant life, if used in high concentration. However the major disadvantage of the long term use of these deicers is the corrosive effect they have on metal. Water in which salt is dissolved gets splashed on to cars and parts of the bridge. Corrosion of unpainted iron or unprotected steel can be accelerated if the saline water stays on it for long. In the case of the bridge deck, saline water seeps through small cracks in the concrete to corrode the embedded reinforcing steel inside the concrete. Corrosion of the reinforcing steel can lead to premature deterioration of the bridge deck. Protection strategies (Babaei and Hawkins, 1987) to prevent this deterioration have included the use of denser concrete or latex modified concrete or epoxy coated reinforcing steel. Non-corrosive material like urea can replace the salts. The addition of anti-corrosive materials to salts has also been tested (Fleeg, 1990). These materials form a protective barrier on the metal surface. These alternatives are considerably more expensive and have to be used sparingly. In many cases however money can be wasted if the deicer is distributed early and later found unnecessary (Malloy, 1994). The decision to salt in most cases depends upon local experience and judgment. This decision can be aided by the monitoring of the road surface to predict ice formation.

1.2.2 Prediction of ice formation

Many major airports use runway surface monitoring systems for detecting ice formation. A similar system has been incorporated to combat preferential icing on bridge decks. The system includes a number of small sensors embedded at intervals of the bridge deck ("Deicer," 1994). The deck temperature, condition (wet, dry, freezing), air temperature and other important information is monitored continuously. "Just in time" winter road maintenance is possible with such sensors.

It is observed that the sensors in themselves are not sufficient. They only convey what is happening at the present moment. In some cases this may be too late or salting may take place even though the temperature does not drop below freezing as expected. Also the location of the sensor itself can lead to an error in deicing response if it is located in a cold spot. It can be dangerous if the sensor is in a warm spot and the rest of the road is freezing. A predictive dimension must be added to the sensor information. Various models have been developed to predict formation of ice (Nysten 1980, Thornes 1984, Parmenter and Thornes 1986, Rayer 1987, Stephenson 1988, Thompson 1988, Shao 1990, Kempe 1990, Isaka et al. 1990 and Sass 1992) in different parts of the world. Some of these are available on a commercial basis. These models utilize the input data from the sensors from the site and predict the future road conditions which can be used for making deicing decisions. Typical input parameters measured are the surface temperature, wetness, air temperature, humidity, wind speed, radiation, etc. A thermal mapping (Ponting, 1984) procedure was devised to deal with the geographical differences in the stretch of the road being monitored.

1.2.3 Infrared radiant heating

Infrared heating systems are used extensively for comfort heating, but can be designed specifically for snow melting or to prevent preferential icing on bridge decks (ASHRAE 1987). For the snow melting systems, the emphasis is on horizontal surfaces, while for comfort heating, it is predominantly on the vertical surfaces of the human body. For snow melting systems, a radiation spill may occur at the edges of the horizontal surface being heated as a uniform distribution of heat for the entire slab surface requires an overhead fixture. The radiant output of the infra red lamp will scatter outside the target area. That is considerably more expensive. An alternative is to place fixtures at intermediate positions, which would scatter radiation above the design average value at the center of the slab and below design value towards the edges. This however may lead to snow build up at the edges. An advantage of infra red systems is the fast heating time. as compared to embedded systems. This equipment can be turned on when the snow fall just starts.

1.2.4 Embedded electrical heating elements

Ice melting systems which use electricity as their energy source make use of mineral insulated (MI) cable or a resistance wire assembly embedded in the bridge deck (ASHRAE 1995). The concrete slabs housing these cables have to be designed with expansion contraction joints, reinforcement and drainage to prevent the slab cracking or the crack induced shearing or tensile forces, which may break the heating wire or cable. High cost of electricity make these systems expensive to operate. The large heat capacity of the concrete structure necessitates a long lead time or a high start up power wattage (Brinkman, 1975). An electric deicing system was installed in Louisville Kentucky as conventional methods would have led to traffic congestion (Havens et al., 1979). The system was found to be functional, however installation and operating costs were high.

1.2.5 Use of nuclear waste materials

In a bid to investigate alternative methods of deicing, Dynatherm Corporation built a system making use of nuclear wastes to produce heat. This heat was transferred to the earth below the surface to be heated, by a heat exchange fluid (Brinkman, 1975). The earth proved to be a good storage medium. Heat pipes were used to transport this heat to the surface. The system was successful, however the safety issue due to the use of nuclear waste and its limited availability made it unfeasible. Disposal of nuclear waste also posed a problem for highway authorities. This project however made apparent the potential for using geothermal heat.

1.2.6 Use of hot fluid circulated in embedded pipes

Inslab hydronic heating has been used for building heating purposes and also for deicing surfaces. Hot fluid is circulated in pipes embedded below the surface of the bridge deck to de-ice the surface. The piping may be made out of metal, rubber or thermoplastic. The circulating fluid may be heated by a conventional energy source like fossil fuels or by using an alternative low grade thermal energy source like natural hot springs, geothermal heat or some other constant temperature energy source, like a large water reservoir. The temperature may be "boosted" by one or more heat pumps. Use of geothermal heat is an economically attractive option and is also environmentally friendly.

1.2.7 Prevention of ice formation using geothermal heat

The earth is an unlimited reservoir of heat. It can be used as a heat source or sink as need be. Temperatures a few meters below ground level are essentially constant throughout the year, even when the ambient temperature above the ground varies with the different seasons. Earth can hence be used to either absorb heat or reject it. There have been many systems which make use of this form of geothermal heat.

1.2.7.1 Passive Geothermal Deck Heating Systems

"Heat pipes" are a passive geothermal heating system. Heat pipes were first introduced in 1944, but were not used until 1961. Use of the heat pipe to de-ice bridge decks using geothermal heat was demonstrated by research conducted in Wyoming, Oklahoma, West Virginia, and Japan (Nydahl et al., 1984; Lee et al., 1986).

Heat pipes

A heat pipe is a closed container evacuated of all non-condensable gases, containing a working fluid which transfers heat from a region of higher temperature (earth) to that of lower temperature (bridge deck). The fluid used must be in a two phase equilibrium between these two operating temperatures. For temperatures in the cryogenic zone, nitrogen is used, and for very high temperatures, a metal is used as the working fluid (Brinkman, 1975). A schematic representation of a heat pipe is shown in Fig. 1.1.

Heat is absorbed at the higher temperature end or the evaporator as a heat input which converts the liquid to vapor. At the low temperature or condenser end, the fluid condenses back to a liquid rejecting the latent heat of condensation. In applications, such as bridge deck de-icing, the pipe is oriented so as to allow gravity return of the liquid to the high temperature end. In a gravity free operation, such as outer space applications, a wick using capillary action performs this task.

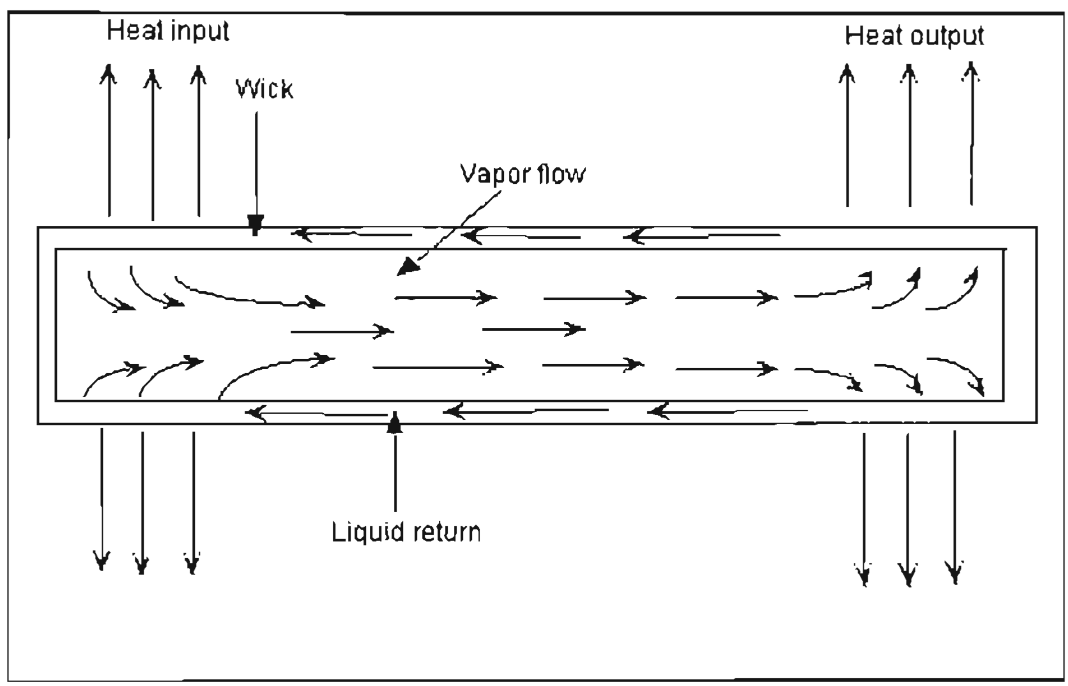

Figure 1.1 Schematic representation of the heat pipe

Figure 1.2 is a schematic, depicting the use of the heat pipe in a bridge deck deicing operation. An evaporator pipe or set of pipes is embedded into the ground near a bridge and filled with liquid, usually ammonia. The liquid is evaporated by the heat of the earth and the vapor travels upward into condenser pipes installed in the bridge deck. The vapor then gives up its heat to the deck, condensing in the process. Finally, the condensed liquid flows by gravity back down into the evaporator(s) to complete the cycle.

This system is passive in that it operates without need of pumps, control systems, external power, or any human intervention. The evaporation-condensation cycle is in operation whenever the bridge deck is cooler than the earth. Heat is removed from the earth even when ice wouldn't form. This extra removal of heat is not a problem from the standpoint of operating costs as there are none. But the pipe size and/or depth must be increased to compensate for the excessive heat loss.

The inside of each heat pipe must be carefully cleaned. Plumbing in the bridge deck must have just enough slope so that condensed liquid flows back to the evaporators. Because of the complications of preparing and constructing this de-icing system, the installation cost of the heat pipes is prohibitive—59% of the cost of the combined bridge and heating system (Nydahl et al., 1984).

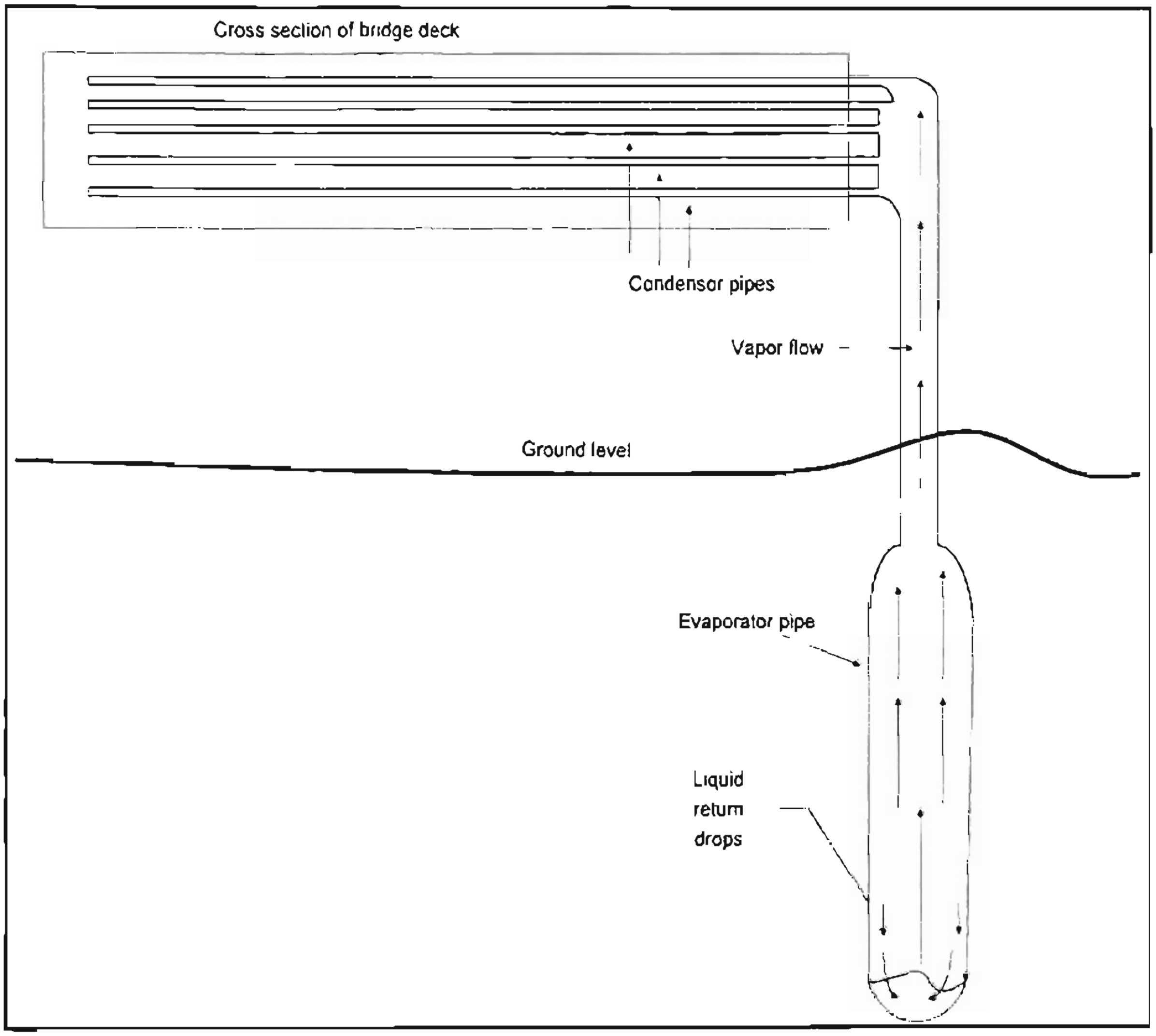

Figure. 1.2 Schematic arrangement of "heat pipe" bridge deck heating system

Furthermore, it is likely that one or a few condenser pipes may end up being installed without the required slope. Also, it may happen that not all plumbing is correctly cleaned (Nydahl et al., 1984). In both these circumstances, ice will form on the bridge near the problem pipe(s). The heating system cannot be repaired without tremendous cost and effort (e.g., tearing up the bridge deck or digging up the surrounding earth).

1.2.7.2 Active Geothermal Deck Heating Systems

Sufficient geothermal heat is available to eliminate preferential bridge deck icing, even in relatively cold climates. Therefore, a cost effective heat delivery system would have broad applicability throughout the United States. Active geothermal deck heating holds the promise of being economical. The term "active" means the heat system is controlled. Heat is conserved and any operating costs of conveying heat to the deck are minimized.

An experimental test set up was constructed in 1977 at Trenton by the New Jersey Department of Transportation to investigate an active geothermal system. The objective of the study was to provide design data for similar systems using embedded pipes and also the feasibility of utilizing the ground heat for de-icing road surfaces.

Pavement heating system at Trenton (New Jersey Department of Transportation) (Winters, 1977)

An experimental heated pavement was constructed to develop improved methods of snow and ice control. Wrought iron pipes and plastic pipes of varying diameters were embedded in slabs of Portland cement concrete and bituminous concrete. A heated solution of ethylene glycol was circulated through the pipes and readings were taken during snow fall to see the feasibility of the system. Geothermal heat was used to raise the temperature of the ethylene glycol. The antifreeze solution of 50 percent ethylene glycol and 50 percent water was circulated by a pump through heat exchangers buried below the pavement which extracted the heat from the ground and transferred it to the fluid which then was circulated through the embedded pipes in the slab. A grid of electric resistance wires heated the panels adjacent to the hydronically heated panels, to compare the performance of the two systems for the same test conditions.

Experimental facility: Two lanes of Portland cement concrete (pcc) and bituminous concrete (bc) built parallel to each other constituted the test site. Each was 13 feet wide and 123 feet long. The pcc slab was 9 inches thick and the bc slab was 7 inches thick and rested on a 6 inch macadam base. Each lane was subdivided into 8 separate test panels. The slabs are depicted in Fig. 1.3.

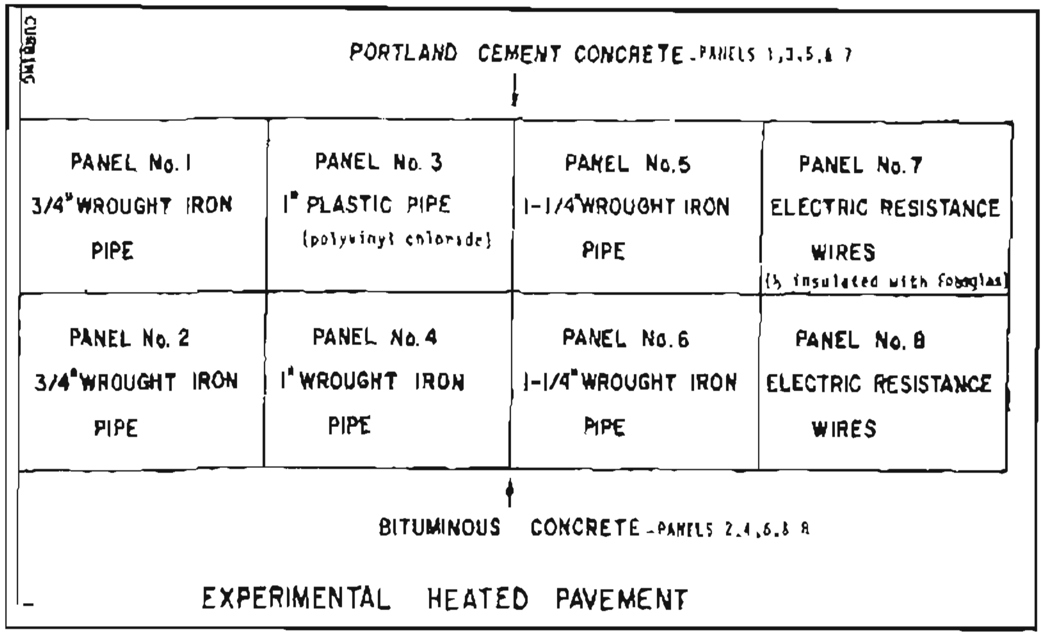

Figure 1.3 Plan view of experimental area

(Winters 1977, p. 11)

Pipes of nominal diameters of ¾, 1 and 1 ¼ inch were embedded at depths of 2 and 4 inches in the pavement, for all panels except 6 and 7. These panels were heated by electric resistance wires. Wrought iron pipes are used for all panels except 3, which used polyvinyl chloride (PVC) plastic pipes. Each hydronically heated panel, was divided into 3 areas which contained the pipes at 6 inch, 12 inch and 18 inch centers respectively (Fig. 1.4). The electrical panels (7 and 8) served as references.

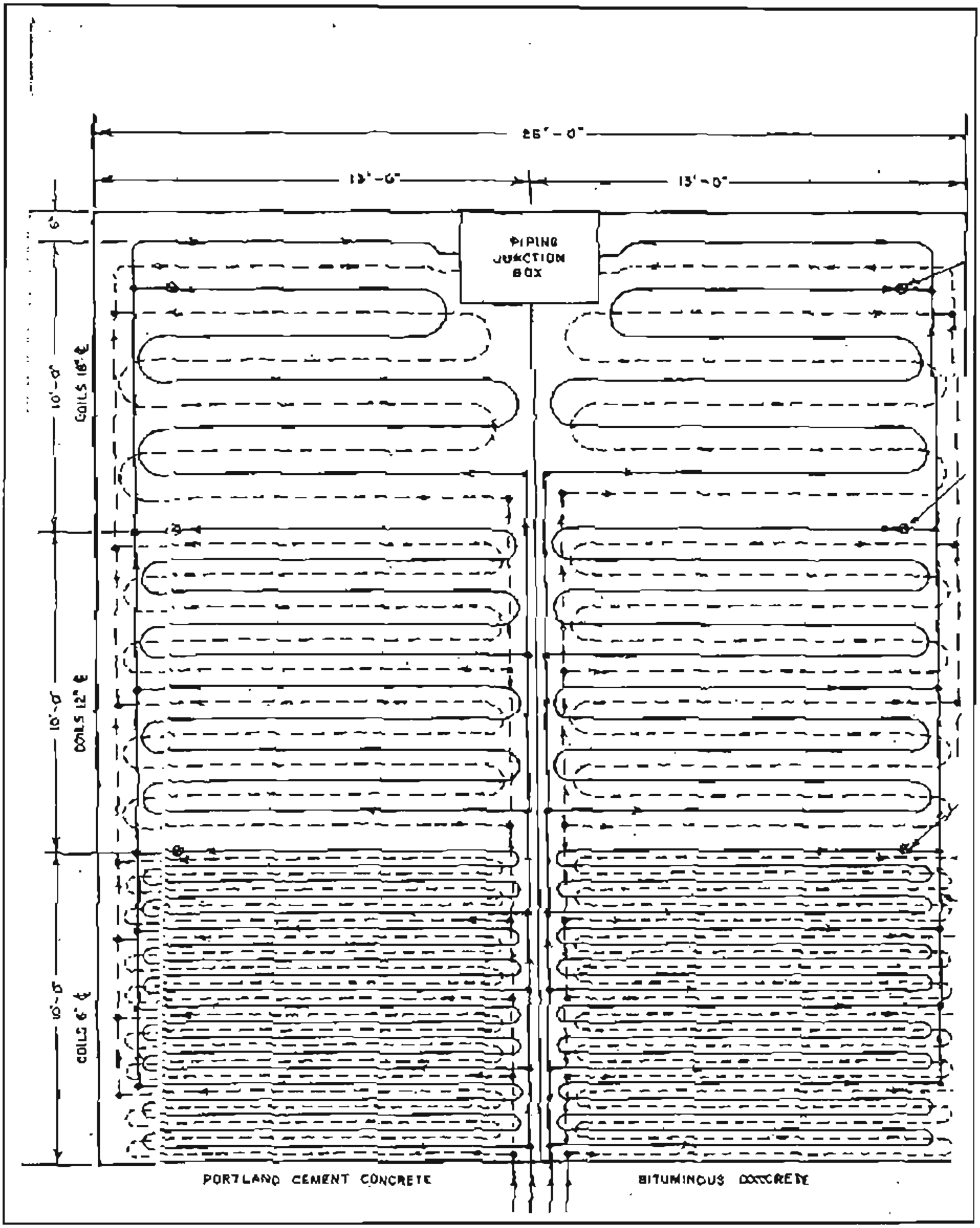

Figure 1.4 Two embedded pipe panels

(Winters 1977, p. 13)

Three heat exchangers were buried directly below the pavement. Figure 1.5 depicts the plan and section view of the buried heat exchangers. Heat exchanger 1 served panels 1 and 2, heat exchanger 2 served panels 3 and 4, and heat exchanger 3 served panels 5 and 6. Each heat exchanger was buried under the panels it served. Each heat exchanger consists of 2000 linear feet of 1-1/4 inch wrought iron pipe arranged in a grid and buried at a depth of 3 to 13 feet in the earth. The grid which measured 32' X 30.5' X 10', was made up of five layers of pipe installed with a horizontal and vertical spacing of 2 feet between pipes. The pipes were surrounded by sand fill. An 8 inch thick insulation was used below the pavement, under heat exchangers 1 and 2. A 6 inch vertical insulation covered heat exchanger 2.

The heat transfer fluid used was an antifreeze solution of approximately 60% water and 40 % ethylene glycol by volume. The fluid was circulated in a closed loop from the buried heat exchanger, to the pump house, to the test pavement, and back to the heat exchanger.

The temperature of the earth, pavement and antifreeze solution was monitored with 120 thermistors. The thermistors within the heat exchangers were placed during the backfill operation. The pavement thermistors were taped along the length of wooden dowels inserted in the pavement. The inlet and outlet fluid temperatures to the test panels were measured by thermometers.

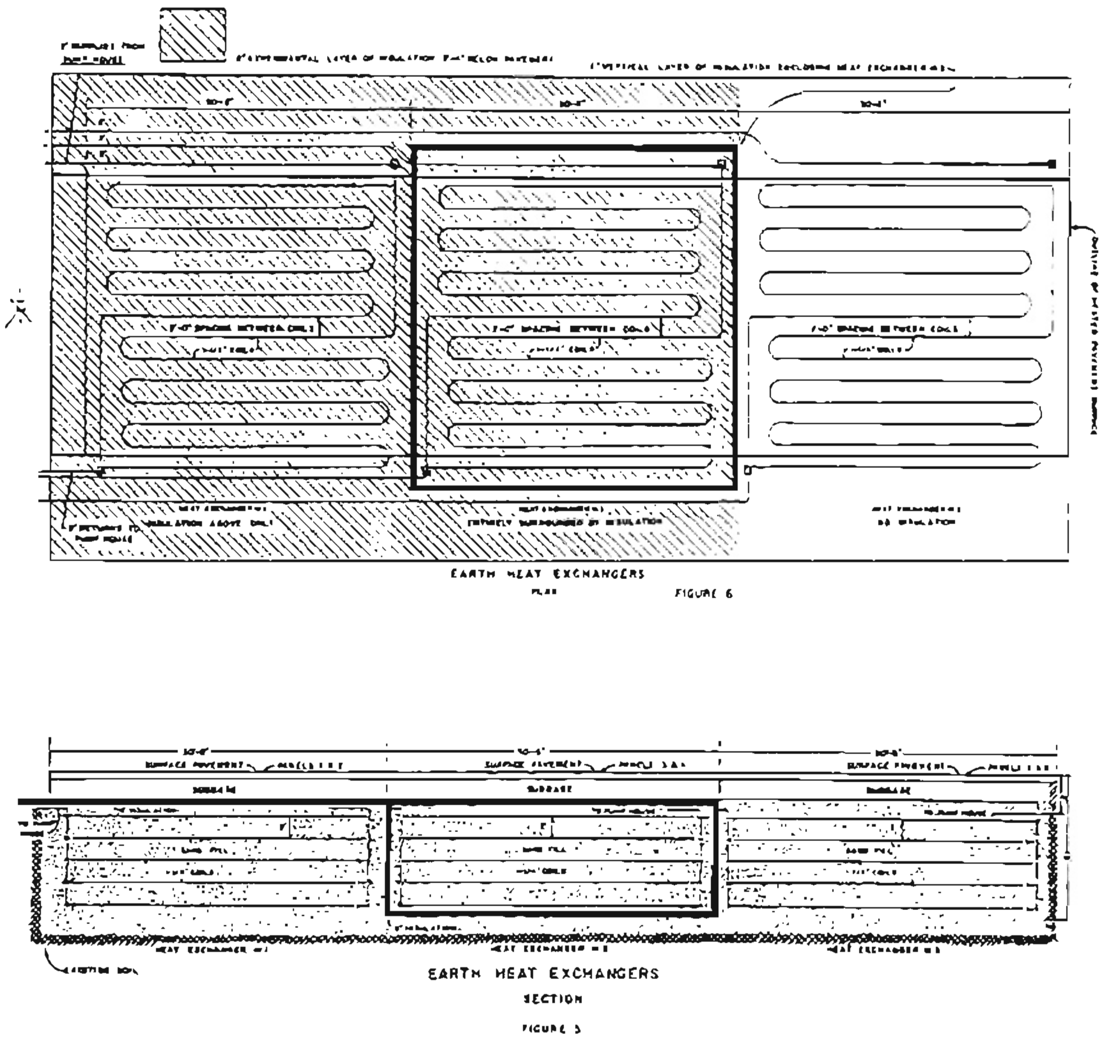

Figure 1.5 Plan and section view of the Heat exchangers

(Winters 1977, p. 15-16)

During the construction of the slabs, the pipes were placed in the forms before the concrete was poured. Pipes were supported on "chairs" which were welded to the reinforcing rods. Thermistors were placed at various locations at the heat exchangers and slab to monitor the temperature during the experimental phase.

Operation : During winter, daily forecasts were obtained and the system was activated if the snowfall was anticipated. If non-forecast snow began to fall, the system was turned on as soon as possible. During snowfall, observations of the pavement surface conditions and measurements of the depth of the snow were entered into a log book. Photographs were taken to supplement the written material. After snowfall ended, the data collection was continued until: (a) all the snow had melted from the surface, (b) no more snow was being melted by the system, (c) excess automobile traffic made data collection meaningless.

Supply fluid temperatures exiting from the ground heat exchangers varied, with lowest temperatures in February of 35°F to 40 °F, and highest temperatures obtained in December and April of 50°F to 55 °F for circulating fluid. No temperature controls were used. In the winter of 1972, a supplemental electric heater was used to raise the fluid temperature 85°F to 110 °F.

Findings: The active geothermal system proved to be feasible and melted the snow in all the major five snow storms which took place during the experimental period. The salient features of the study could be summarized as follows

- The geothermal system was an effective method for melting the snow and ice on the concrete pavement surface.
- The temperature of the heat transfer fluid obtained by using the earth heat exchanger ranged from 40 °F to 50 °F.
- The wrought iron pipes were found to be more effective in melting the snow than the plastic pipes. However that was attributed to the low temperature of the circulating fluid. It was expected that the effect of lower thermal conductivity of plastic would be insignificant for higher fluid temperatures of about 100 °F.
- The best results were obtained for a spacing of 6 inches between pipe centers, as compared to spacing of 12 inches or 18 inches.
- The average heat dissipated to the slab by the circulating fluid was approximately 100 Btu/sq. ft.
- The Portland cement concrete used had a thermal conductivity twice that of the bituminous concrete.
- The geothermal system was much cheaper to operate than the electric system primarily because of the demand charge of electricity.
- Running the system in the summer would 'charge' the ground reservoir which would lead to higher fluid temperatures in the following winter.

Ground source heat pump

The above study demonstrates the feasibility of such an active geothermal system to melt ice on the concrete surface. Increasing the temperature of the circulating fluid would improve the effectiveness of this de-icing system. A viable alternative to increase this temperature, whilst also making use of the earth heat, would be to incorporate a ground source heat pump into the system.

A ground source heat pump has been developed through pioneering research at Oklahoma State University (OSU) over the past 20 years. This thermal system has been used in many residential and commercial applications in the last decade and is even in use at the Oklahoma State Capitol. A ground-coupled heat pump can heat a home for about 35% of the cost of an electrical resistance system. Pipe liquid may be heated to temperatures above 100°F. In a bridge deck heating system, this level of heat would allow for a reduction in the amount of piping required.

Figure 1.6 shows the schematic representation of an active geothermal deicing system incorporating a ground source heat pump. Fluid could also be circulated on some hot days in the summer. The sun's radiant heat would be transported from the deck to "recharge" the ground. Heat removed during the previous cold season would be replaced.

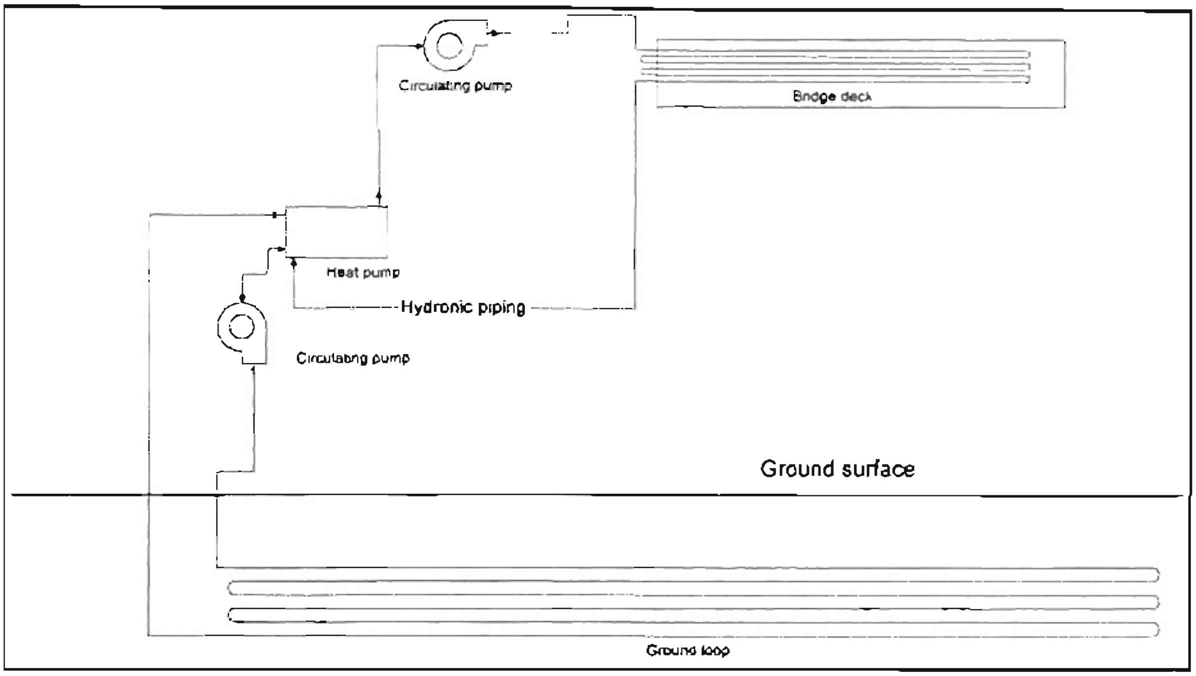

Figure 1.6 Active heat pump

1.2.8 Heat requirements for hydronic snow-melting systems

The *ASHRAE handbook* provides guidelines to calculate the amount of heat required to melt snow from a surface. The same heat requirements can be used for freezing rain or frost. Air temperatures during snowfall are lower than those during the occurrence of freezing rain or frost. Heat requirements calculated for melting snow for any surface will also be sufficient to melt ice due to freezing rain or frost. To determine the heat requirement for melting the snow on any surface, the snow melting phenomenon is to be considered. The first snow flakes fall on a warm and dry surface. This snow must be warmed up to 32°F before it is melted. On melting, a film of water is formed over the area, which, if the heat input is continued begins to evaporate. There is also a heat transfer from the surface to the atmosphere due to convection and radiation.

The heating requirement for snow melting depends on four atmospheric factors.

- Rate of snowfall
- Air temperature
- Relative humidity
- Wind velocity

The rate of snowfall determines the heat required to raise the temperature of the snow to 32°F and to melt it. Evaporation of the water from the surface depends on the wind speed, relative humidity, and the ambient temperature. The convection and radiation loss from the surface depends on the film coefficient and the temperature difference between the air and the slab surface.

Snow melting by using hydronic heating elements has been used before and its practicality has been proved in many installations. The source of heat for heating the circulating fluid may differ, as discussed in the previous sections. The heating requirements for such hydronic systems has been provided in the *ASHRAE Handbook*. It is the reference for most of the snow melting systems in North America and many other countries. Heating requirements are useful in designing the systems according to the class of snow-melting systems required and its location. The models for calculating heat requirements discussed in the following sections are not transient models. They assume quasi- steady state conditions. The surface is already heated and is ready to melt the snow as soon as it starts falling. The surface heating system is 'idled' for some time before actual snowfall.

Heat Requirement during Idling

Before actual snowfall, the system is idled so that at the beginning of snowfall, the heated surface will be ready to function. The idling load is calculated as the heat requirement to maintain the temperature of the surface above freezing. Chapman (1956) defined the idling heat load intensity (q_i) by the following equation:

$$q_i = (0.27\ V + 3.3)\ (t_p - t_m) \qquad (1.1)$$

where

V = Wind speed (mph)

t_p = Surface temperature(°F)

t_m = Mean outdoor temperature during freezing (°F)

Any snow melting system may be divided into three performance classes. The snow free area ratio (A_r), which is the ratio of snow free area to total snow melting area, can be used to define these classes.

i.e.

$$A_r = A_f / A_t \qquad (1.2)$$

where

A_r = Free area ratio

A_f = Free area (ft^2)

A_t = Total area (ft^2)

- Class 1 ($A_r = 0$): During snowfall, the entire surface is permitted to be covered with snow to a depth sufficient to prevent evaporation and heat transfer losses. The system is then expected to melt the snow.
- Class 2 ($A_r = 0.5$): During snowfall, 50 % of the surface is permitted to be covered with snow.
- Class 3 ($A_r = 1.0$): During snowfall, the entire surface is kept free from snow accumulation. The system must melt the snow so rapidly that the accumulation is zero. In this system the heat is lost from the surface of the melted snow to the atmosphere by radiation, convection and evaporation. Bridge decks are included in this class.

1.2.8.1 ASHRAE Handbook guidelines

The guidelines presented in the latest relevant *ASHRAE handbook* (1995) are based on work done by Chapman and Katunich (1956), who derived the general equation for the required slab output (q_o) to melt snow as:

$$q_o = q_s + q_m + A_r\,(q_e + q_h) \tag{1.3}$$

where

q_s = Sensible heat transferred to the snow (Btu/hr/ft^2)

q_m = Heat of fusion (Btu/hr/ft^2)

A_r = Ratio of snow free area to total area

q_e = Heat of evaporation (Btu/hr/ft^2)

q_h = Heat transfer by convection and radiation (Btu/hr/ft^2)

The sensible heat to warm the snow to 32°F is

$$q_s = s\, c_p\, \rho\, (32 - t_a) / 12 \tag{1.4}$$

where

s = Rate of snowfall (in. of water equivalent per hour)

c_p = Specific heat of snow (0.5 Btu/lb/°F)

ρ = Density of water equivalent of snow (62.4 lb/ft^3)

t_a = Air temperature (°F)

The heat of fusion q_m to melt the snow is given by

$$q_m = s\, h_f\, \rho / 12 \tag{1.5}$$

where

h_f = Enthalpy of fusion for water (143.5 Btu/lb)

The heat of evaporation q_e is

$$q_e = h_{fg}\, (0.0201\ V + 0.055)\, (0.188 - p_{av}) \tag{1.6}$$

where

h_{fg} = Heat of evaporation at the film temperature (Btu/lb)

V = Wind speed (mph)

p_{av} = Vapor pressure of moist air (in. of mercury)

The heat transfer q_h (convection and radiation) is

$$q_h = 11.4\,(0.0201\,V + 0.055)\,(t_f - t_a) \qquad (1.7)$$

where

t_f = Water film temperature (°F), usually taken as 33°F

Heat requirements for a hydronic snow melting system can be determined by using Equations (1.3) through Equations (1.7). The solution of the equations requires weather data. Annual averages or maximums of the weather parameters cannot be used as they may not be occurring simultaneously. A frequency analysis of the solutions to Equation (1.3) is performed over a period of several years for determining the required design heat output for any particular location. An analysis of 33 cities in the United States was performed. This data can be obtained in the *ASHRAE Handbook*. The maximum heat outputs for the different classes of snow melting system located at Oklahoma City as recorded by ASHRAE are:

q_o = 350 Btu/hr/ft^2 (Class 3)

q_o = 81 Btu/hr/ft^2 (Class 2)

q_o = 66 Btu/hr/ft^2 (Class 1)

Back and edge losses increase the required slab output. These losses may vary from 4 to 50 % (Adlam 1950). These losses can be minimized by insulating the edges.

1.2.8.2 Proposed modifications to the ASHRAE Handbook guidelines

The guidelines provided in the *ASHRAE Handbook* provide design information for 33 cities in the United States. Its fundamental dependence on the snowfall frequency analysis makes it unsuitable for other locations. Also comparison of the design data does not match well with installed systems. A study conducted by Kilkis (1994) suggested modifications to the existing guidelines, to develop a simple and universal technique, that was not as dependent on detailed meteorological data. This new method requires

- Design air temperature
- Wind speed
- Maximum recorded daily snowfall

The ASHRAE guidelines make use of the rate of snowfall. However this data is available only for selected locations. An expression is developed to determine the design rate of snowfall (s') for other locations

$$s' = (SF/24)\, C\, (\Omega / 62.4) \qquad (1.8)$$

where

SF = Maximum recorded snowfall in 24 hours (in. of snow). The SF values have been compiled from Adlam's (1950) studies, which reflect the U.S. Weather Bureau data

C = Snow melting performance class (dimensionless)

Ω = Density of snow (lb/ft^3)

Ω depends on the air temperature. A correlation given by using meteorological data from Adlam.

$$\Omega = 2.6 + 0.06\, t_a + 0.0027\, t_a^2 \qquad (1.9)$$

In Equation (1.7) q_h does not recognize the different contributions due to radiation and convection losses. A better approach would be to use different expressions for these different modes of heat loss. Using the equations developed by Williams (1976), we obtain:

$$q_h = q_r + q_c \quad (1.10)$$

where

q_r = Radiant heat loss (Btu/hr/ft^2)

For cloudy skies

$$q_r = 10.3 + 8.14*10^{-10}[(t_f + t_a) + 920]^3(t_f - t_a) - 7.68*10^{-10}[255.2 + t_a/1.8]^4 \quad (1.11)$$

For clear skies

$$q_r = 30.15 + 0.74\,(t_f - t_a) \quad (1.12)$$

q_c = Convective heat loss (Btu/hr/ft^2)

t_f = Film temperature (°F)

t_a = Air temperature (°F)

where

$$q_c = (0.14V + 0.39)\,(t_f - t_a) \quad (1.13)$$

Instead of using the air temperature obtained by the snowfall frequency, as in the ASHRAE guidelines, the design air temperature is used. However, this temperature does not coincide with the air temperature during actual snowfall. A simplistic expression has been derived to determine the coincident air temperature (t_c) during the snowfall by making use of the design air temperature.

$$t_c = t_b + \frac{(33 - t_b)}{(0.1 + 1.2C)} \qquad (1.14)$$

where

t_b = Design air temperature at 97.5% frequency level (°F)

C = Snow melting class

The evaporative heat load intensity (q_e) can be predicted in terms of the convective heat load intensity(Williams 1976):

$$q_e = (q_c / R)\,(p_s - p_{av}) / (t_f - t_a) \qquad (1.15)$$

where

$$R = 0.01\, p_a / 29.9 \qquad (1.16)$$

R = Bowen's ratio (in. Hg/ °F)

p_a = atmospheric pressure (in. Hg)

Heat requirement after snowfall

The previous discussions have dealt with calculating the heat load intensity to melt snow, during snowfall. However for classes 1 and 2, there remains some snow to be melted even after the snowfall. Frequently, a low air temperature follows the snowfall, and the sky may clear (Adlam 1950; Williamson 1967). This may lead to an increase in the snow melting heat load intensity, despite the absence of fusion and sensible heat loads. In these cases, the design heat load will be the post snowfall heat load (q_{oa}).

i.e.

$$q_o = q_{oa} \text{ if } q_{oa} > q_o \tag{1.17}$$

where

q_o = Design heat load (Btu/hr/ft^2)

q_{oa} = Post snowfall heat load post (Btu/hr/ft^2)

The same equations are used for calculating q_{oa} as were used for q_o, with the corresponding weather data after the snowfall period.

Algorithm for calculating design heat load for snow melting

Making use of all the equations derived for the different stages of snow melting, an algorithm was proposed to calculate the design heat load for such systems (Kilkis, 1994). Table 1 outlines the algorithm.

LOAD INTENSITIES			PERFORMANCE CLASS 1	PERFORMANCE CLASS 2	PERFORMANCE CLASS 3	COMMENTS
SNOW MELTING PHASE	q_s		Eqn. 1.4	Eqn. 1.4	Eqn 1.4	$t_a = t_c$ (Eqn. 1.14)
	q_m		Eqn. 1.5	Eqn. 1.5	Eqn. 1.5	$s = s'$ (Eqns. 1.8, 1.9)
	q_e		-	Eqn. 1.15	Eqn. 1.15	Adjust the wind speed.
	q_h	q_r	-	Eqn.1.11	Eqn.1.11	$q_h = q_r + q_c$
		q_c	-	Eqn.1.13	Eqn.1.13	
	q_o		$q_s + q_m$	$q_s + q_m + 0.5 (q_e + q_h)$	$q_s + q_m + q_e + q_h$	In class 1, if q_h > qm + qs then qo = qh. In class 2, if qh>qm+qs +0.5(qe + qh) then qo=qh
AFTER SNOW PERIOD	q_{ca}		Eqn.1.15	Eqn.1.15	Eqn.1.15	$t_a = t_b$
	q_{ha}	q_{ra}	Eqn.1.11	Eqn.1.11	0	$q_{ha} = q_{ra} + q_{ca}$
		q_{ca}	Eqn.1.13	Eqn.1.13	0	$t_a = t_b$
	q_{oa}		$q_{ca} + q_{ha}$	$q_{ra} + q_{ha}$	0	
IDLING	q_i		Eqn.1.1	Eqn.1.1	Eqn.1.1	$t_a = t_m$
DESIGN	q_y		$q_y > q_o$ or $q_y = q_o$			if $q_i > q_o$ and q_{oa}; $q_y > q_i$ if $q_{oa} > q_i$ and q_o; $q_y > q_{oa}$

TABLE 1.1

Proposed algorithm for snow melting load calculations

1.3 Objectives

The objectives of the project were the following

1. Build a test setup of an active ground source heat pump system, to prevent the ice formation on a concrete slab representative of a section of a bridge deck.
2. To investigate the thermal performance of the test setup and establish the feasibility of using such a deicing system.
3. Determine the heat requirements of the system to melt ice on the concrete surface.
4. Develop a finite difference model of the concrete slab and validate it by using experimental data from the test set-up and weather data from the Oklahoma weather station or the 'Mesonet'.
5. Use the model to study the thermal performance of the installed bridge deck de-icing system.

CHAPTER TWO

EXPERIMENTAL FACILITY AND INSTRUMENTATION

2.1 Overview

A prototype of an active ground source heat pump system has been built to investigate the feasibility of deicing a small scale model of a bridge deck. Figure 2.1 depicts the layout of the different components of the experimental facility. The main constituents of the test set up are

1. A 10 foot by 3 foot by 8 inch concrete slab representing a section of a bridge deck with embedded hydronic tubing
2. A water to water heat pump
3. The ground loop heat exchanger

4. The bridge loop
5. Instrumentation

The heat pump transfers heat from the ground loop heat exchanger to the bridge deck piping embedded in the bridge deck. The data acquisition equipment is used to monitor various parameters during the course of the experiment and records data into a personal computer in real time.

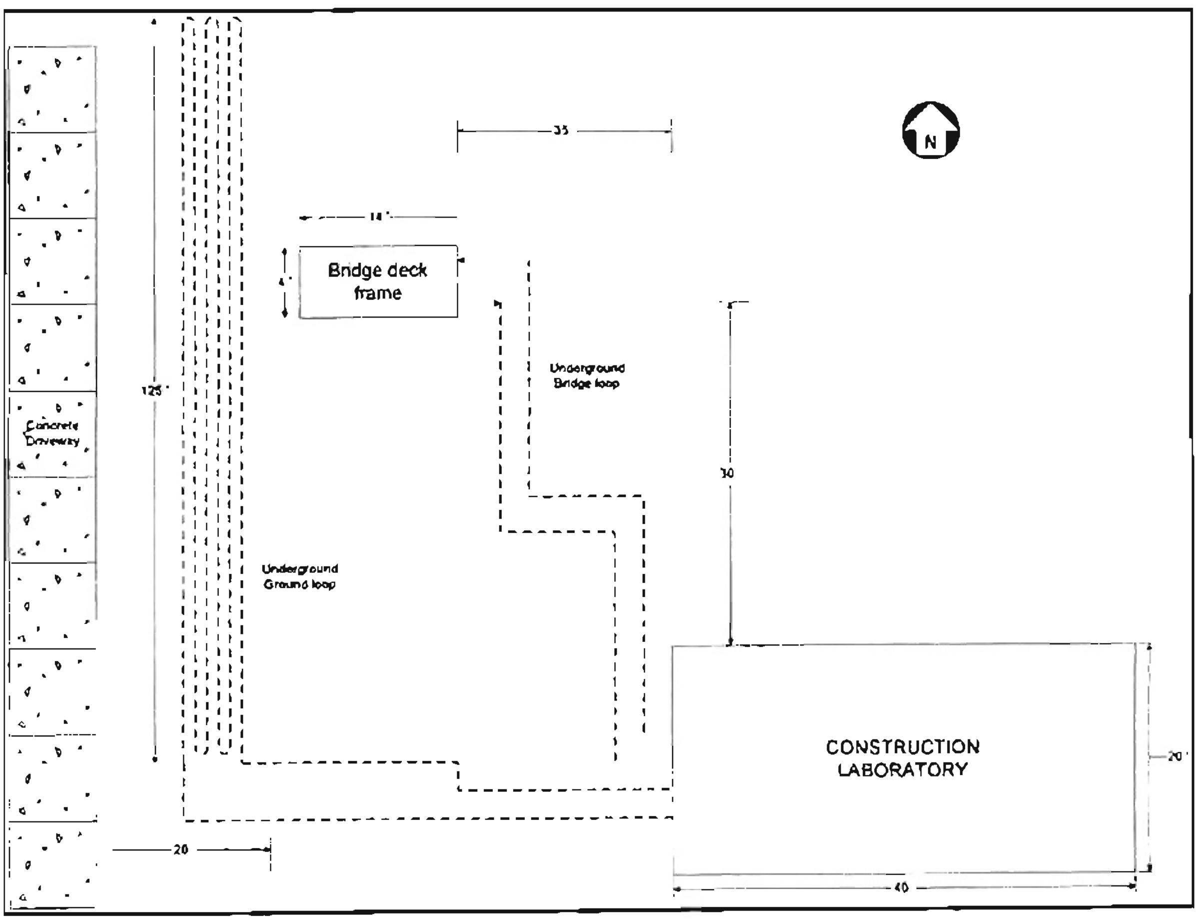

Figure 2.1 Schematic representation of the experimental layout

2.2 Experimental Facility

2.2.1 The Bridge deck section

The bridge deck test section is shown in Figure 2.2. It is placed in the open, for providing actual weather conditions, like radiation to the sky, etc. A scaffolding has been built on the side for easy access to the top surface of the slab. A steel frame has been built to support and raise the slab to a height of 7 feet above the ground.

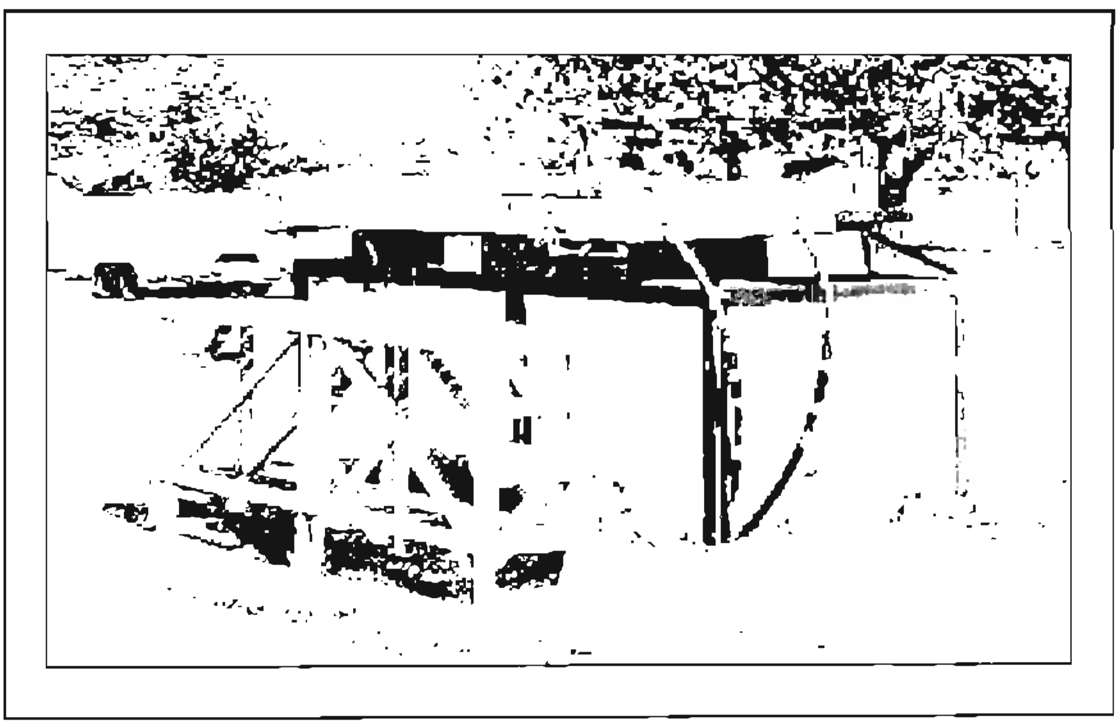

Figure 2.2 The experimental bridge deck section

2.2.1.1 The slab

Figure 2.3 shows the bridge deck section and all its construction details.

The Concrete slab:- The test section is an 8 inch thick, 3 foot by 10 foot concrete slab. The 10 foot length is one fourth of a typical roadway width of 40 feet. The 3 foot width is designed to accommodate six embedded pipes at equal spacing of 6.5 inches from each other. The 8 in. thickness is typical of an actual concrete bridge deck. The slab is made of Portland cement concrete, rock aggregates and sand. Rebar is present in the slab to reinforce the slab. A detailed description of the structural details is given by Liao (1996)

Pipes:- Six, polybutylene pipes, each 10 feet long with ¾ inch nominal diameter are embedded in the slab at a depth of 2.5 inches from the surface. The pipes centers are equally spaced from each other at 6.5 inches. The fluid inlet and outlet pipes are at a distance of 1.75 inches from the ends of the slab. The pipes have been connected to each other by 'U' shaped rubber tubing. This forms a continuous loop heat exchanger within the slab. The rubber tubing has been used instead of welded plastic joints to allow greater flexibility in changing the flow configurations for future work. Pressure/Temperature ports ('Pete's ports') have been inserted into the piping at the inlet and outlet of the slab. Fluid inlet and outlet temperatures are measured with thermocouple probes inserted into these ports.

Frame A wooden frame has been built around the slab to enclose the peripheral insulation and house the piping at the two ends of the slab. The pipe housing at the two ends has been provided with removable covers with handles for easy access to the insulated pipe ends. The frame has been painted to weatherproof it.

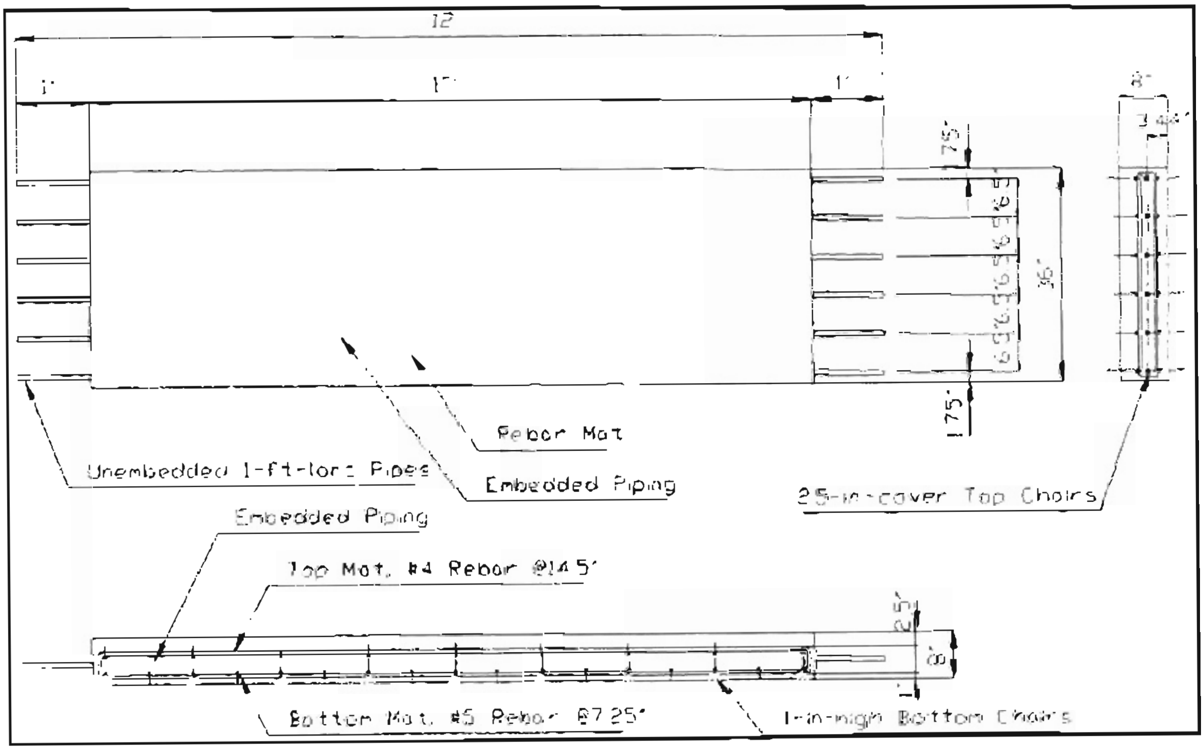

Figure 2.3 Constructional details of the slab

2.2.1.2 Insulation

The slab has been insulated on all four sides to minimize edge losses thereby allowing the test bridge deck to represent the mid section of a bridge deck (Fig 2.4). This assumes that the mid-section of a bridge deck has negligible horizontal heat transfer, and the primary mode of heat conduction is longitudinal. The 10 foot long sides are insulated by 6 inches of Styrofoam. The 3 foot sides are insulated by 1 inch of Styrofoam insulation. The insulation used was Dow Styrofoam sheets with an R value of 5. A 1 inch thickness of the Dow Styrofoam was used to insulate the slab bottom for certain experimental configurations.

Each of the polybutylene and rubber pipe loops is individually insulated with wrap around insulation for pipes. The insulation was then kept in place with duct tape. The entire pipe housing at the two ends has been filled with 'bead' foam insulation.

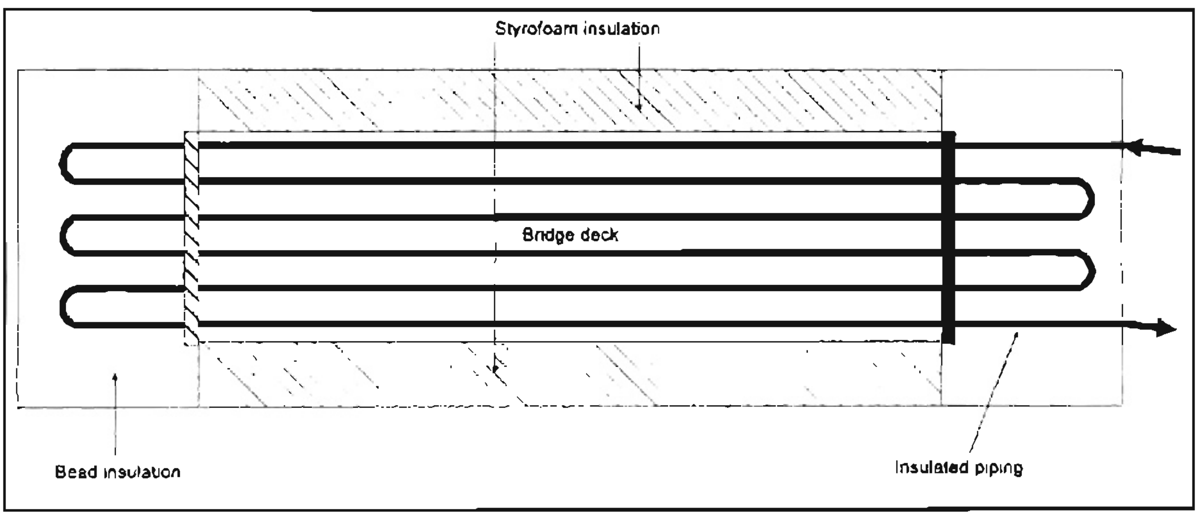

Figure 2.4 Schematic representation of slab insulation and piping

2.2.2 The Ground Source Heat pump system

2.2.2.1 The heat pump

Initially a water to water heat pump of 36,000 Btu/hr nominal capacity was connected to the system. After a few test runs, this heat pump was found to be too large. The heat pump raised the fluid temperature so high that the high temperature cut off was activated and the heat pump cut itself off during the test runs. An additional load of an air handler was connected downstream to offset the excess heat being produced by the heat pump. This, however lead to complications involving the fractions of the heat produced being diverted to the slab and the air handler. The problem was solved by installing a new lower capacity heat pump.

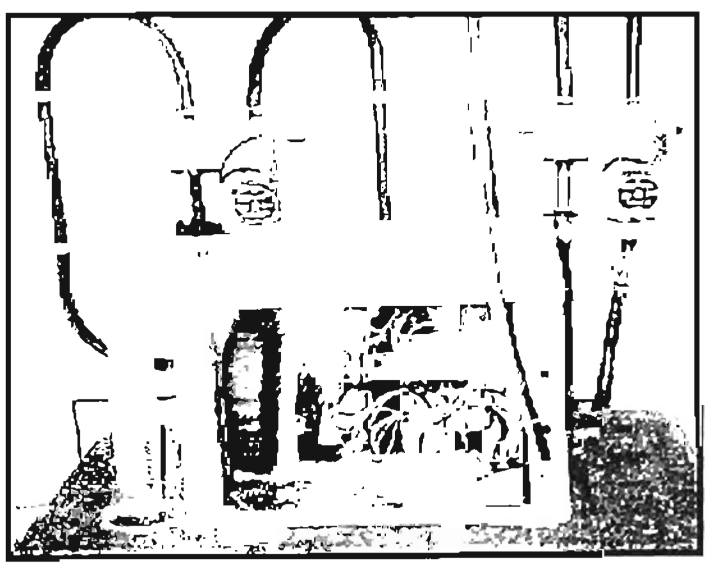

Figure 2.5 The heat pump

The present heat pump in use is a water to water heat pump with a nominal capacity of 18,000 Btu/hr. It uses the ground as its source and the test bridge deck section as its heating load. Pressure and temperature controls installed in the heat pump prevent the overloading of the system. However, no other controls have been utilized. Generally, the operation of a heat pump used in this application would be controlled with a thermostat, perhaps with a temperature sensor mounted in the pavement. However for these initial experiments, a continuous heating process was desired, so as to simplify the interpretation of the experimental results.

2.2.2.2 The ground loop heat exchanger

The heat exchanger buried in the ground is a horizontal ground loop. A circulating pump maintains the flow of the heat transfer fluid in the loop. The ground loop consists of 500 feet of piping made up of 4 polyethylene pipe lengths, each 125 feet long with a ¾ inch diameter. The 4 pipe lengths are buried in the same trench on top of each other at depths of 6 feet, 5 feet, 4 feet and 3 feet respectively (Jones, 1996). The ground loop is connected to the source side of the heat pump. The loop has been insulated at all parts where it is exposed to the environment. The location of the ground loop is shown in Figure 2.1

2.2.2.3 The bridge loop

The bridge deck is connected to the load side of the heat pump with 1 inch diameter high-density polyethylene piping. The piping is buried in the ground for most of its length, until it reaches the test section. The part exposed to the atmosphere is insulated with piping insulation. Under quasi-steady-state conditions, there is about a 5°F temperature drop between the heat pump outlet and the bridge deck inlet. A significant amount of heat, approximately 8000 Btu/hr, is lost to the ground before it reaches the bridge deck. For an actual system, this would be undesirable. For the experimental system, it may be thought of as simulating a larger bridge deck. In any case, the temperatures are measured at the inlet and outlet of the bridge deck so that heat input to the test section may be calculated.

2.2.2.4 The heat transfer fluid (GS-4™)

The heat transfer fluid circulated in the pipes is GS-4™. It is manufactured by Vanguard Plastics Inc. and is essentially a mixture of 50% potassium acetate and 50% water. It was developed at Oklahoma State University and is a low viscosity, environmentally safe antifreeze. Potassium acetate makes the solution biodegradable and non-hazardous. The properties of GS-4™ have been summarized in Table A-1 in Appendix A. The GS-4™ is mixed with water to form the heat transfer solution being used. The amount of freeze protection required decides the percentage of GS-4™ added to water. The properties of the brine solution also change with the amount of GS-4™ being used. For the purpose of this project, a 40 percent by weight (33 percent by volume) solution of GS-4™ has been used. This ensures a freeze protection of 10°F. The properties of this specific composition have been summarized in Table A-2 in Appendix A.

2.3 Instrumentation

The instrumentation equipment being used is for the purpose of

1. Temperature measurement
2. Flow measurement
3. Data acquisition

2.3.1 Temperature measurement

2.3.1.1 Temperature Sensors

The thermocouples used are constructed out of 20 gauge, shielded[1], T type thermocouple wire[2]. The thermocouple beads were formed using a thermocouple welder. The welded thermocouple junctions have been placed flush with the surface of the slab. This was achieved by grinding 1 inch long slits, parallel to the length of the embedded

1 Regrettably, the shielding was not properly grounded. This led to increased fluctuation in some of the temperature measurements due to EMF interference.

2 T20-2-510 wire -manufactured by The Pelican Wire Company, Inc.

pipes, on the surface of the slab to a depth of approximately 0.2 inches. The thermocouple wire was inserted in the slits and covered with cement paste till it was flush with the surface. An attempt was made to obtain a color close to that of the slab, so as to have a uniform absorptivity across the slab surface. A total of 28[3] thermocouples have been placed on the top surface. Eighteen of these have been placed directly over the pipes transporting the fluid and 10 between the pipes on the top surface of the slab.

Four thermocouples have been attached to the bottom surface of the slab. Two of them are directly below the inlet and outlet pipes and the other two are between two adjacent pipes. A configuration of all the thermocouples has been depicted in Figure 2.6 along with the labeling system used. A diagram with the dimensioned locations is provided in Appendix B. All thermocouple locations on the top surface directly above the pipes are denoted by numbers (1,2,...,28) and those between the pipes are labeled with letters (a,b,....j). Thermocouples on the slab bottom are labeled with numbers preceded by "bottom" (bottom1,....bottom4).

Two T-type thermocouple probes[4] have been inserted at the inlet and outlet of the bridge deck piping. In addition to measuring the inlet and outlet temperature, the probes are used to calculate the temperature drop in the fluid during its flow through the concrete slab. Two other similar probes have been connected to the input and output of the load side of the heat pump. This temperature measurement was used in a few experiments for calculating the temperature drop in the fluid due to its flow in the ground before it reaches

3 Not all thermocouples were used at anyone time. For any given experimental set up only 20 temperatures were measured.

4 Manufactured by Omega Engineering Inc.

the bridge deck and after it leaves the bridge deck and returns to the heat pump at the input side of the load section.

Two other thermocouple junctions are used to record the ambient air temperature and the ground temperature, just below the slab. The air temperature thermocouple is suspended below the slab surface, and was wrapped with aluminum foil which acted as a radiation shield. The thermocouple measuring the ground temperature was buried approximately ½ inch below ground level. All the temperature sensors were connected to a Fluke Hydra datalogger which recorded their output.

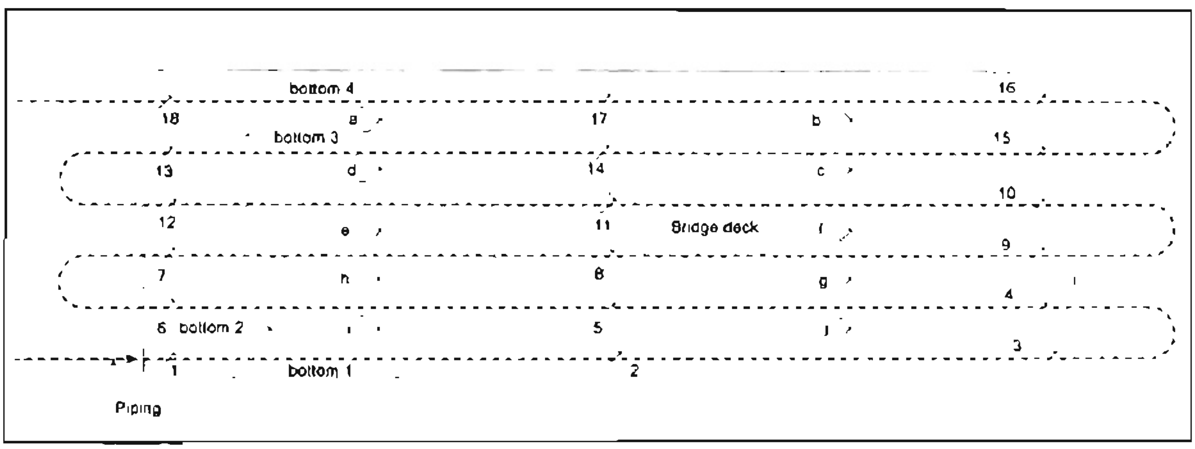

Figure 2.6 Locations of the thermocouple junctions on the slab

2.3.1.2 Calibration

Calibration of reference thermocouple and thermocouple probes

The thermocouples have been calibrated with the aid of a reference thermocouple. The reference thermocouple and the thermocouple probes were calibrated by using the ice point and the boiling point of water as references. The reference thermocouple to be calibrated was placed along with a reference thermometer in an ice bath insulated on all sides. After a while, thermal equilibrium was established between the thermocouple and the thermometer. At this point both the temperatures must be the same. The reference temperature was then adjusted with the help of the software incorporated in the data acquisition equipment. The reference thermocouple reading was offset by a factor of 'B' to coincide with the thermometer and the ice bath temperature of 0°C. This reference thermocouple and the thermometer were then elevated to the boiling point of water of 100 °C in an insulated container. The reference thermocouple temperature reading was then multiplied by a factor 'M' to coincide with the temperature of the thermometer.

The same procedure was followed for the calibration of the thermocouple probes. Hence each of the temperature measurements are modified as

$$T_{calibrated} = Mx + B$$

where

x : Raw temperature reading of thermocouple or thermocouple probe.

B : Offset factor used to conform calibrated temperature to the ice point.

M : Multiplier factor used to conform calibrated temperature to the boiling point.

This concluded the initial calibration procedure.

The next stage of calibration consisted of calibrating each of the individual thermocouples on the surface of the test bridge deck. Ideally these thermocouples should also be calibrated as done for the thermocouple probes. However due to time constraints, with the cold weather front being unpredictable, these thermocouples were placed in position on the slab and the readings were obtained. Later, all the thermocouple readings were corrected for the thermocouples after their individual calibration.

Individual calibration procedure

The entire slab surface was insulated and the heat pump was reversed to operate in the cooling mode. Thus the slab became the source and heat absorbed from the slab was rejected to the ground. The slab was cooled down to low temperatures typical of those recorded during the experiment. It was desired to calibrate the thermocouples at this low temperature. The insulation on all six sides of the slab ensured that there was minimal heat gain by any portion of the slab. The reference thermocouple was placed extremely close to the thermocouple being calibrated. Both these thermocouples were covered with toothpaste gel which substituted for heat transfer grease. This was covered with aluminum foil and some more local insulation. This entire set up established a thermal equilibrium between the two thermocouples. The layout is shown in Figure 2.7.

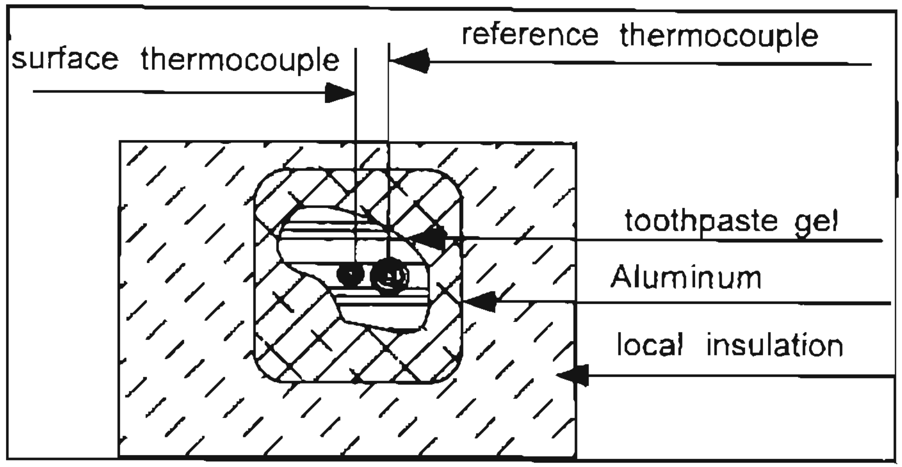

Figure 2.7 Surface thermocouple calibration

After the thermocouples had achieved equilibrium, readings were recorded for a period of one hour. The thermocouple being calibrated was offset by the constant difference observed between the two thermocouples. This set it equal to the reference thermocouple. This completed the calibration procedure for the thermocouple. The same procedure was carried out for all the surface thermocouples. After each of the thermocouples was calibrated, the readings taken previously were corrected using the individual calibration offsets.

2.3.2 Flow measurement

The flow measurement was done by a flowmeter. The flowmeter was located upstream of the bridge loop. It measured the flowrate of GS-4 flowing through the bridge deck.

2.3.2.1 The flowmeter

The flowmeter used is a turbine flowmeter[5]. A turbine flowmeter was preferred as it is simple, durable and provides good accuracy at a comparatively low cost. It provides a convenient pulse output which can be converted into the required output by a signal conditioner. The rated accuracy of the flowmeter is ±0.5% of the reading.

The flowmeter was installed with 4 feet of piping at its inlet side and 3 feet of piping at its outlet. For the ¾ inch nominal diameter pipe, this corresponds to approximately 65 pipe diameters upstream and 50 pipe diameters downstream. These dimensions are within the requirements of the flowmeter for providing a uniform flow at the turbine wheel.

The pulse output was picked up by an integrally mounted signal conditioner. This conditioner amplified the sensor output and converted it into a high level output which could be used by the data acquisition system. This output was less likely to be affected by ambient conditions, like an electronically noisy environment. The signal conditioner used for this project provided a 0-5 V dc output.

5 Model FTB-105 manufactured by Omega Engineering Inc.

2.3.2.2 Calibration of the flowmeter.

Bucket and stopwatch method

The principle difficulty in calibrating the flowmeter was that the fluid used was not water and the fluid temperature changed during experimentation which changed the fluid properties (the flowmeter was provided with calibration curves for water). The calibration of the flowmeter was accomplished by the "bucket and stop watch method" (Figure 2.8). The system plumbing was reconnected to travel through a "purge tank". In this system, the fluid returns through the purge tank. The return flow can be diverted from the open purge tank into an open bucket without disturbing the flow rate. The flow was diverted into a bucket for a fixed time interval, then the fluid collected was weighed on a balance scale. Simultaneously, voltage output from the flow meter was recorded at one second intervals. A simple average of these readings obtained in terms of dc volts was calculated to minimize error. This reading corresponded to the flowrate of the fluid in gallons per minute calculated for that particular voltage output.

The maximum amount of flowrate of the fluid flowing to the bridge is limited by the capacity of the circulating pump. This was found to be approximately 4 gpm. The flowmeter can read flows from 2 gpm to 29 gpm. Using the 'SPAN' adjustment of the signal conditioner, the voltage output signal from the signal conditioner was set to read from 0 to 6 gpm corresponding to the range of the voltage output of 0 to 5 volts. Calibration was carried out for a range of fluid temperatures to obtain calibration curves for the fluid being used.

Typical calibration procedure

Since the viscosity of the GS-4/water mixture varied with temperature, it was necessary to calibrate the flowmeter over a range of flowrates and temperatures. The following calibration procedure was followed for each of the temperature ranges. The fluid was heated or cooled to the required temperature by running the heat pump in the heating or cooling mode. The purge tank was connected in the system. This tank was used to "bleed" the fluid to the bucket.

At the required temperature, the fluid was made to flow at full throttle. This fluid was diverted to the bucket and the stopwatch was started simultaneously. For a period of 2 minutes, for low flows and 1.5 minutes for higher flows, the fluid was collected in buckets. At the end of the time duration, the fluid flow was diverted back to the purge tank. At the same time, the output of the flowmeter was recorded every second into a personal computer. The simple average of these outputs was taken as the constant output obtained at that particular flowrate. The fluid collected was carefully weighed on a balance and the amount of fluid flow was calculated in terms of gallons per minute (gpm). This flowrate corresponded to the voltage output recorded. The flow was then reduced by approximately 0.5 gpm and the procedure was repeated. As the flowmeter being used could not measure flows less than 2 gpm, the calibration was done for flows above that value. A plot of flowrate versus voltage output was made. This provided the calibration curve at the particular temperature. Calibration data plots for different temperatures are provided in Appendix C. During the test runs, a flowrate of 3 - 4 gpm was maintained.

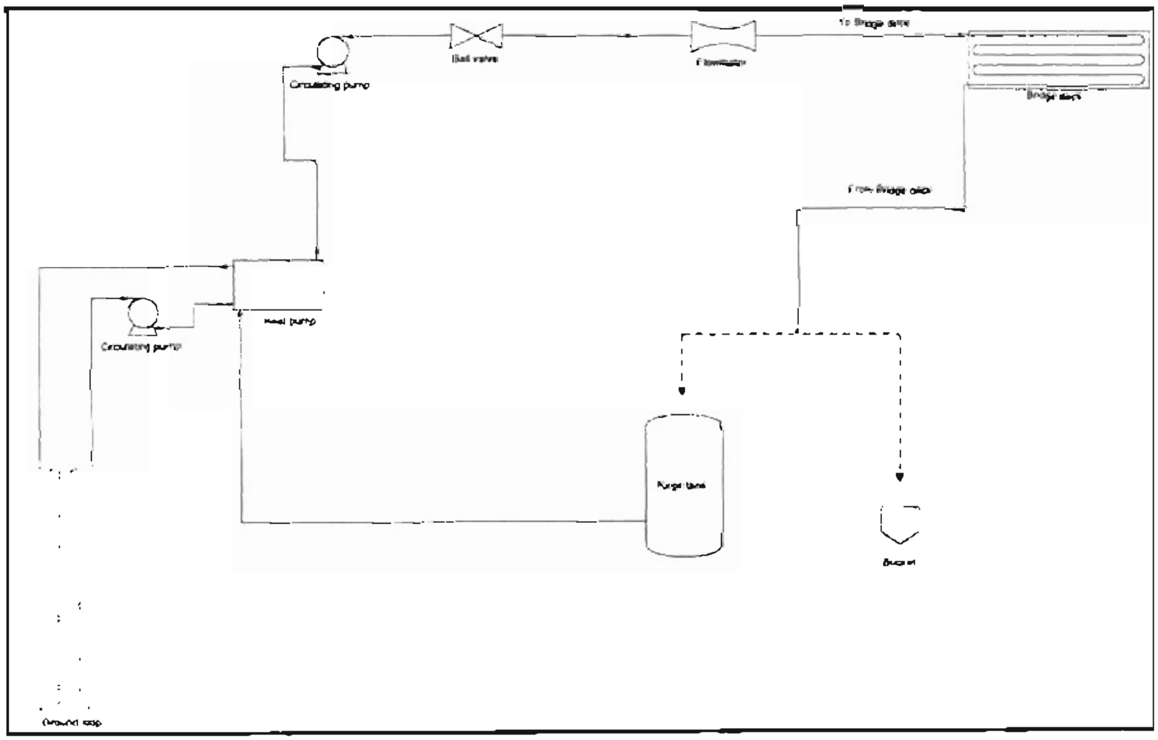

Figure 2.8 Flow calibration schematic

2.3.3 Data Acquisition

The data acquisition equipment used

1. A Fluke Hydra WL 2625A datalogger for the temperature measurement.
2. A DAS 800 board for the flow measurement.

2.3.3.1 Datalogger

The 2625A WL datalogger is a remote wireless data acquisition unit. It is placed at the site of the experimental bridge deck (as shown in the first Figure 2.1). The slab thermocouples and fluid thermocouple probes are connected to it. It has 21 input channels of which 20 are used. The 0^{th} channel is not being used as it does not support temperature measurement. Except for 2 channels which are connected to the inlet and outlet thermocouple probes, all the other working channels are connected to the surface thermocouples at various locations on the slab. The channel configuration for each experiment is detailed along with results in Appendix D. A detailed analysis of the inputs to each of these channels is provided in section 3. The data are broadcast by a remote modem to a base modem connected to a microcomputer by a RS-232 cable. The data are received and are recorded onto a file.

Wireless logger for Windows™ software

The raw data received from the Hydra are handled by the wireless logger software. The software is also used to configure each of the individual channels before downloading the data. It can be used to modify the following parameters of data acquisition.

1. Channel input type (thermocouple, voltage, resistance, etc.)

2. Data scan interval
3. Enable file recording
4. Name of file to be used
5. Mx +B factor (used for thermocouple calibration)
6. Measurement rate (slow / fast)
7. Communication parameters (modem speed, address, etc.)

The software can be used to obtain real time plots. The data file can later be viewed by using any spreadsheet package.

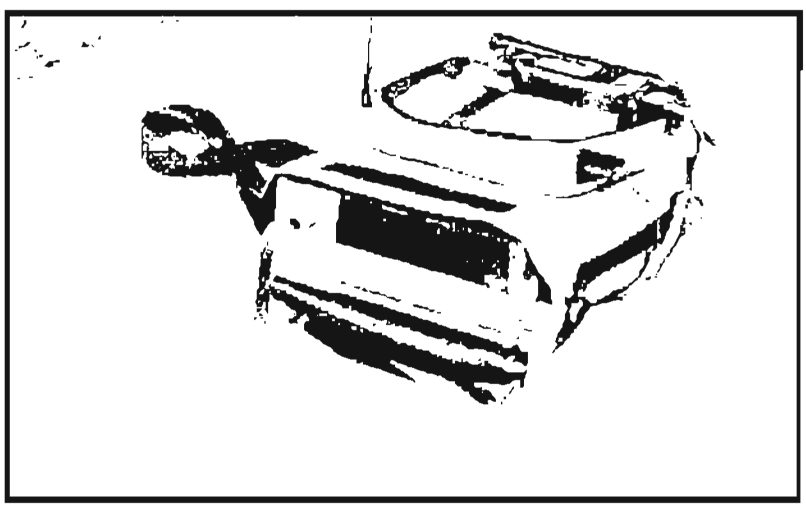

Figure 2.9 The 2625 WL datalogger

2.3.3.2 DAS 800

The flowmeter voltage output was measured by another microcomputer with a DAS 800 board in it. This board was also used for strain measurements[6] made on the bridge deck. The output of the flowmeter is in dc volts. The output terminals of the flowmeter were connected to the DAS 800 board. The output data was not stored but was recorded manually at intervals.

6 These measurements are made for a parallel experiment being carried out on the same test set-up, for analyzing thermal stresses in the slab due to the flow of hot fluid through it (Liao, 1996).

CHAPTER THREE

DATA ANALYSIS

Data obtained from three different sources has been used in this project. The raw experimental data obtained from the instrumentation is used to calculate derived quantities to determine the performance of the bridge deck system.

1. Datalogger data

Temperature data from various locations on the slab are recorded by the 2625WL and stored in real time on the personal computer.

2. DAS 800 data

Flowmeter output is recorded manually at intervals by the DAS 800. The output is obtained in terms of volts.

3. 'Mesonet' data

The weather data was downloaded via the campus network from the Oklahoma 'Mesonet' Internet site.

3.1 Datalogger data

The following raw data was obtained for most tests using the datalogger:

1. Thermocouple measurements of eight slab surface locations just above the embedded pipes.
2. Thermocouple measurements of four slab surface locations between the embedded pipes.
3. Thermocouple measurements of four slab surface locations on the bottom surface of the slab.
4. Two thermal probe measurements of the inlet and outlet temperature of the fluid flowing through the slab.
5. One thermocouple to measure the air temperature.
6. One thermocouple to measure the ground temperature.

This totals 20 temperature measurements (°F) from the datalogger.

3.2 DAS 800

The DAS 800 displays the flowmeter voltage output (volts). This data was noted at irregular intervals.

Note: The DAS 800 board can be programmed to receive data at regular intervals and record it into a file. Regrettably this facility was not used during experimentation, and the flowrate data was manually noted at irregular intervals. Hence the flowrate used in the calculations is an average for large intervals during experimentation, and not the actual flowrate for smaller regular intervals, (as in the case of the datalogger data). This leads to an increased error in the calculations of the derived quantities.

3.3 'Mesonet' data

The 'Mesonet' is the weather station project in Oklahoma. A total of 108 stations across the state monitor various parameters of the weather continuously. The station in Stillwater is very close to the experimental site and its data is assumed to be the same as that at the site. A topographical map is provided in Appendix E, showing the location of the test bridge deck (marked as 'O' on map) with respect to the weather station (marked as 'X' on map). The weather data is downloaded using the OSU campus network from the 'Mesonet' site for the different days. The parameters of interest are

1. Air temperature (°F)

2. Wind direction (degrees from North)

3. Wind speed (m/sec)

4. Solar radiation (W/m^2)

5. Relative humidity (%)

6. Precipitation (inches of water)

This data is available from the weather station at intervals of 15 minutes. The weather data for each of the days the test was run has been provided in the APPENDIX. This data is used as an input for the computer model.

3.4 Computation of the derived quantities

The data is compiled and analyzed on the basis of the days on which they were recorded. The data has been recorded at 5 minutes intervals by the datalogger. The data has been recorded during the period of operation of the heat pump. The methodology for calculating the derived quantities used in the analysis is described in the following sections.

3.4.1 Average slab top surface temperature

The average slab top surface temperature has been calculated by using the slab temperature readings at various locations on the slab top surface. As the fluid flows through the slab, it transfers its heat to the slab thereby reducing in temperature. The areas of the slab just above the pipe have a higher temperature, than those between pipes. The slab temperature profile is depicted qualitatively in Figure 3.1.

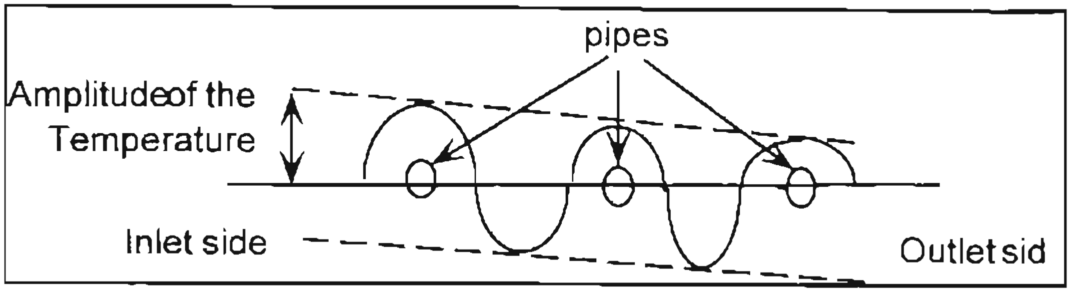

Figure 3.1 Temperature profile at the slab cross section

The amplitude of the temperatures will vary as the fluid flows through the slab. At the inlet side the temperature is higher and reduces as the fluid flows through the system. A weighted average of the thermocouple readings has been taken for our purpose to depict the average surface temperature. The temperature has been averaged over the pipes and between the pipes separately, as an unequal number of thermocouples measurements were used to calculate the two separate averages.

Hence

$$T_{avg} = \frac{\left[T_{above} + T_{between}\right]}{2} \qquad (3.1)$$

where

T_{avg} = Average top slab temperature (°F)

T_{above} = Average top slab temperature for locations directly above pipes

$$T_{above} = \sum_{a=1}^{n} \frac{T_a}{n}$$

T_a = Thermocouple readings above pipes (°F)

n = number of readings made above pipes

$T_{between}$ = Average top slab temperature for locations between pipes

$$T_{between} = \sum_{b=1}^{m} \frac{T_b}{m}$$

T_b = Thermocouple readings between pipes(°F)

m = number of readings made between pipes

There were eight thermocouples on the pipe and four between the pipes. A plot of the average surface temperature and the ambient air has been made to see the rise in the slab temperature with time as the hot fluid flowing through the slab transmits heat to it. The plots can be seen in the results section. The average slab surface temperature was used to determine the freezing condition of the surface along with a visual inspection.

3.4.2 Determination of the Heat flux

As the heated fluid flows through the slab, heat is conducted by the slab. This raises the temperature of the cold slab. The heat flux transmitted to the slab by the fluid can be calculated as

$$Q_{\text{input flux}} = \frac{\dot{m}\, Cp\, \Delta T}{A} \qquad (3.2)$$

Where

$Q_{input\ flux}$ = Heat flux to the slab by the fluid (Btu/hr/ft^2)

$\dot{m}$ = Mass flowrate of the fluid (lb/hr)

C_p = Specific heat of the fluid (Btu/lb/°F)

ΔT = Temperature difference of inlet and outlet of the slab (°F)

A = Area (ft^2)

3.5 Experimental Uncertainty Analysis

Any experimental procedure is subject to certain errors, which are the differences between the measured value and the actual value of a quantity. This difference may be due to a number of factors: instrument error, sensor error, sensor position error, human error, etc. For the complete study of any experimental procedure, an uncertainty analysis is necessary for a better understanding of the data. The uncertainty analysis done in this study follows the principles of Taylor [1982].

Uncertainty in experimental results can be of the following types

- Uncertainties in individual measurements, such as temperature measurement and flow measurement. These uncertainties are discussed in 3.5.1 through 3.5.4.
- Individual uncertainties may be further propagated by taking spatial averages, such as the average slab top surface temperature discussed in 3.5.6.

- Uncertainties are also propagated when individual measurement values are used to obtain derived quantities, such as the heat flux. This is discussed in 3.5.5

Uncertainty can be expressed as a fraction of the measured quantity, or as an absolute value. In some cases, both may be used. A fractional uncertainty may be expressed as:-

$$e_X = \pm y\% \qquad (3.3)$$

where

X is the measured quantity

y% is the magnitude of the fractional uncertainty

Hence maximum and minimum values of X can are:

$$X_{max} = \overline{X} + y\% * \overline{X} \qquad (3.4)$$

$$X_{min} = \overline{X} - y\% * \overline{X} \qquad (3.5)$$

If expressed as an absolute term, the uncertainty is independent of the quantity being measured.

$$e_X = \pm z \qquad (3.6)$$

where z is the absolute uncertainty and has the same units as X.

Hence maximum and minimum values of X can are:

$$X_{max} = \overline{X} + z \qquad (3.7)$$

$$X_{min} = \overline{X} - z \qquad (3.8)$$

Some quantities may contain both, fractional and absolute uncertainties. These uncertainties can be represented as:

$$e_x = \pm y\% \pm z \qquad (3.9)$$

3.5.1 Uncertainties in temperature measurement for surface thermocouples

The temperatures measurements for the slab surface have been made using the 2625 A WL datalogger. This datalogger provides the reading in temperature units. The datalogger has an inherent error in measuring this temperature which is provided in its specifications as being ±0.6°C or 1.08°F. The thermocouple wire is a T type wire and may have its own inherent uncertainty. However as the thermocouples were calibrated (using the Mx+B feature), this uncertainty is accounted for. The calibration procedure of the individual surface thermocouples as described in section 2.3.1.2 itself is estimated to have an error of ±1°F. This is because many of the same thermocouples had to be offset by different values at different temperatures with respect to the reference thermocouple. The calibration procedure was carried out at the typical low temperatures to minimize this error. For a typical temperature measurement the errors can be depicted as shown in Figure 3.2.

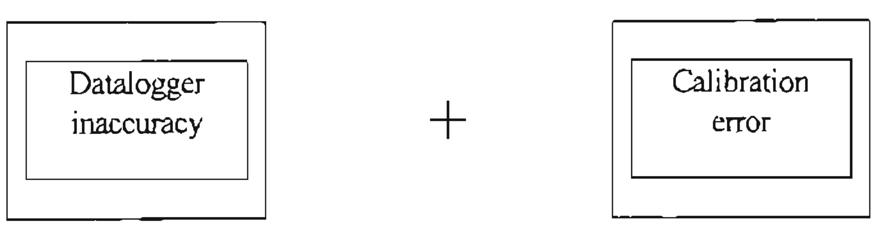

Figure 3.2 Source of errors in temperature measurement

These errors are independent and random and can thus be added in quadrature to determine the total uncertainty in the measurement of temperature using the 2625A WL datalogger and the thermocouples.

This is calculated as:

$$E_{temp} = \sqrt{\left(1.08^2 + 1^2\right)} \approx \pm 1.47°F \qquad (3.10)$$

3.5.2 Uncertainties in temperature measurement for thermocouples probes

The temperatures measurements for the inlet and outlet fluid temperatures have been made using the 2625 A WL datalogger. The calibration procedure used for the probes is direct and makes use of the ice point and the boiling point. As no intermediate reference thermocouple has been used, as in the previous case of the surface thermocouples, there is no uncertainty in the measurement due to calibration error. Hence the uncertainty for thermocouple probe measurement is only the datalogger error of ±1.08°F.

3.5.3 Uncertainty in the ΔT measurement

The temperature drop ΔT across the slab is used in the calculation of the heat input. ΔT was determined by using the measurements made by the thermocouple probes installed at the inlet and outlet of the concrete slab. Uncertainty in ΔT was determined directly by an experimental procedure.

The thermocouple probes were placed in an insulated vessel containing water at 95-100°F. This was the typical temperature measured by the inlet and outlet probes during experimentation. After equilibrium between the two probes was attained, the constant difference observed between the two probes was used as the uncertainty in measuring ΔT. Both the thermocouple probes had been adjusted with their respective Mx+B factors before readings were taken. The uncertainty thus obtained was 0.25 °F. Using the typical value of ΔT as 4°F, we obtain the fractional uncertainty as ±6.25%.

i.e. $$E_{\Delta T} = \pm 6.25\%. \qquad (3.11)$$

3.5.4 Uncertainties in flow measurement

The errors associated with the flow measurement are the errors in calibrating the flowmeter and the error due to the DAS 800. These errors give rise to an uncertainty in obtaining the flowrate in terms of gallons per minute for a voltage output. By following the calibration procedure for the flowmeter, we can identify the independent sources of error which contribute to the calibration error of the flowmeter.

While diverting the fluid when the stopwatch was started, it was observed that the fluid was not diverted exactly at the same time the stop watch started. Also some of the fluid spilt out at the time of switching buckets. This lead to some mass error. During weighing the fluid on the balance there may be some error in balancing the scale. All these errors lead to an uncertainty due to the mass determination of the fluid. For simplicity all these errors were converted to a percentage value.

The maximum time by which the start or stop time was missed was approximately 0.25 seconds. Considering the typical value of the flowrate was measured as 4 gallons per minute, this corresponds to 280g/sec, or 70 g of lost fluid. If we include the error due to balance and the fluid spilt out as 100 g total, we can estimate the total value of lost fluid or excess fluid to be 170g/sec. For a typical weight of a bucket being 10 kg or 10,000 g, this error equals ±1.7%. The error due to the datalogger is given as 0.09%.

During calibration the voltage fluctuated for a given flowrate over the period it was recorded. An average value of this voltage was taken as the value corresponding to the mass of fluid measured. The voltage was observed to fluctuate by 0.034 volts (within $\pm 2\sigma$). For the minimum value measured for calibration of 1.5 volts, this gives an uncertainty of 2.26%.

As all these errors are independent of each other, they can be added in quadrature to calculate the total error in calibrating the flowmeter.

$$E_{calib} = \sqrt{\left(1.7^2 + 0.09^2 + 2.26^2\right)} \approx \pm 2.83\% \qquad (3.12)$$

where E_{calib} = Calibration error

3.5.5 Uncertainties in the heat flux

The heat flux is a derived quantity, and is calculated by using other quantities which have their own individual uncertainties.

The heat flux ($Q_{input\ flux}$) is given as:

$$Q_{input\ flux} = \frac{\dot{m}\ Cp\ \Delta T}{A} \qquad (3.13)$$

If we assume that area of the slab used has negligible error, then the error in the heat flux is given by

$$Q_{input\ flux} = \dot{m}\ C_p\ \Delta T \pm \sqrt{\left(E_{\dot{m}}^{\ 2} + E_{C_p}^{\ 2} + E_{\Delta T}^{\ 2}\right)} \qquad (3.14)$$

where

$E_{\dot{m}}$ = Error in calculating mass flow rate

$E_{\Delta T}$ = Error in determining temperature drop

E_{Cp}= Error in calculating the specific heat.

Further

$$E_{\dot{m}} = \sqrt{\left(E_{gpm}^{\ 2} + E_{\rho}^{\ 2}\right)} \qquad (3.15)$$

E_{gpm} = Error in calculating mass flow rate

E_{ρ} = Error due to difference in density due to inexact GS-4 quantity mixed with water.

E_{ρ} occurs because, our calculation of mass flow rate in the heat flux equation assumes the specific density of GS-4 to be 1.11. The specific gravity of the fluid was measured with a hydrometer, which is presumed accurate to ±0.01, which corresponds to an error of 0.9%. The value of the specific gravity was used as an indicator, to obtain the corresponding concentration of the brine solution of 40% by weight (refer TABLE A-2 of Appendix A for GS-4 solution properties). The specific heat was calculated by using the curve fit provided in the GS-4 manual. The uncertainty of ±0.1 for determining the specific gravity led to an error in obtaining the required solution concentration. This gave rise to the error in calculating the specific heat. Using the curve fit equations provided in A-3 of Appendix A, the uncertainty in obtaining C_p was calculated as ±1.29%.

E_{gpm} is the uncertainty due to the volumetric flow rate of the fluid. This quantity is obtained by reading the voltage output of the DAS 800 and using the calibration curve obtained before hand. The error in the DAS 800 is 0.01% and the calibration error as calculated before is ±2.83%. Another source of error arises due to the assumption that the voltage reading does not change considerably over the duration of the test. The observed maximum value by which the voltage reading was observed to vary over a test period was 0.25 volts. For a reading for 4 volts at which the flow was held constant, this corresponds to an error of 6.3%.

Using the above values

$$E_{gpm} = \pm\sqrt{\left(0.01^2 + 2.83^2 + 6.3^2\right)} \approx \pm 6.9\,\% \qquad (3.16)$$

this gives us $E_{\dot{m}}$ as ±6.96%

$E_{\Delta T}$ is obtained from Equation 3.11 as ±6.25%

The heat flux can thus be calculated as

$$Q_{input\ flux} = \dot{m}\ C_p\ \Delta T \pm \sqrt{\left(6.96^2 + 6.25^2 + 1.29^2\right)} \qquad (3.17)$$

$$Q_{input\ flux} = \dot{m}\ C_p\ \Delta T \pm 9.44\% \qquad (3.18)$$

This gives the percentage uncertainty for determining the heat flux

3.5.6 Uncertainties in the average slab top surface temperature

The average slab temperature was calculated by using a weighted average of all the relevant thermocouples. The temperatures of the top slab surface have been taken at different locations on the slab. Some of the thermocouples were directly above the pipes on the slab and some have been placed in between the pipes.

Figure 2.6 shows the placement of the surface thermocouples. The temperatures on top of the slab will keep on decreasing as they get closer to the outlet. Figure 3.1 shows the variation of the temperature. An average of the slab surface temperatures does not take this aspect into account. This spatial average leads to an uncertainty in the value of the calculated average slab temperature. For the purpose of simplicity, it was estimated that the uncertainty in the calculated slab top surface temperature was ± 1°F.

CHAPTER FOUR

EXPERIMENTAL RESULTS

4.1 Overview of experiments performed

The major portion of the experiments were performed during the month of March. Tests began during the last week of February and continued through the month of March and first week of April. Only a few days had temperatures below freezing during this period. Results have hence been presented only for cold nights with air temperatures close to, or below freezing. The low temperatures occurred at night and most of the tests were hence run at night. Also, at night there is no additional heat gain by the slab due to the solar radiation and hence the total potential of this bridge deck deicing system could be tested.

Unfortunately there was no natural freezing precipitation during the test period, nor was there any snowfall. To study the effects of precipitation, it was necessary to make use of an artificial system of producing even precipitation. A hand held bottle spray was used to create a fine mist, which was sprayed at intervals on the slab.

The tests were carried out every night independent of the previous night's test. Each test typically started late at night and continued till early the next morning. In many cases the slab did not cool down from the preceding night's test run to the ambient temperature, before the start of the next test. In such cases, the slab was already preheated, especially the interior of the slab. An initial temperature profile across the cross section of the slab existed before the heat pump was started. During the duration of the entire test period, of approximately one month, the sunrise generally occurred between 6:30 am to 7: 00 am in the morning. It was desired to observe the time required for slab temperature to rise above freezing before sunrise, so as to minimize the effect of solar radiation. For most of the cold nights, the average slab surface temperature rose above the freeze line of 32 °F only after sunrise. For three test days presented, the ambient temperature was above freezing, and the deck did not freeze.

Each test run was analyzed independent of the previous night's test. The different experimental configurations for the tests consisted of:

- bottom of slab insulated or un-insulated
- precipitation applied to the slab surface
- different start times of test runs

4.2 Summary of experimental results

The results obtained for the different nights have been summarized in Table 4.1. The individual results for each night are discussed in the following sections. Detailed results are provided in Appendix D.

	Feb. 28-29	Mar 1-2	Mar 6-7	Mar 7-8
Bottom insulated	No	Yes	Yes	Yes
Precipitation	Yes	Yes	Yes	Yes
Start time of heat pump	10.30 p.m.	3.15 am	12.00 am	11.30 p.m.
Average air temperature	23	37	16	13
Average slab temp. before start of test (°F)	26	35	23	23
Time to raise slab temp above freezing (hr.)	2.2	N/A	9	10
Average heat input (Btu/hr/ft^2)	195	179	195	197
	Mar 8-9	**Mar 9-10**	**Mar 19-20**	**Mar 24-25**
Bottom insulated	Yes	Yes	Yes	Yes
Precipitation	Yes	No	No	No
Start time of heat pump	3.10 am	2.30 am	12.00 am	8.20 p.m.
Average air temperature	22	36	29	24
Average slab temp. before start of test (°F)	28	39	32	35
Time to raise slab temp above freezing (hr.)	2.5	N/A	N/A	N/A
Average heat input (Btu/hr/ft^2)	205	163	198	181

TABLE 4.1 Summary of experimental results

4.3 Description of experiments

A brief description of each of the experiments has been provided in this section. Each test has been titled with the two dates between which it was run. An example title of a night's test results would be March 7^{th} and 8^{th}. This test was started on 7th night and continued till 8th morning. In more than one case the test has started after 12:00 am. However to maintain a standard, the same nomenclature has been followed.

A summary plot and a weather plot corresponding to each day has been included with each test day description. The plots provide an overview of the variation of all relevant parameters over the time period of each test. The plots have been made with the absolute time (CST) as the reference.

Summary Plot

The summary plot of each day contains the following information:

- Inlet fluid temperature to the slab (°F)
- Outlet fluid temperature from the slab (°F)
- Heat flux into the slab due to the flow of heated fluid. (Btu/hr/.ft^2)
- The air temperature through the night (°F)
- The average slab upper surface temperature through the night (°F)

The sudden rise in the heat flux and inlet and outlet fluid temperatures in the plots indicates the start of the heat pump. The heat input in the slab starts to reduce as the test progresses. As the temperature of the slab rises, less heat from the fluid is input to the slab, thereby reducing the input flux. As a reference, a "freeze line" at 32°F, indicates when the slab surface temperature rose above freezing and the time required for this temperature to climb above the freezing temperature. The time at which the sunrise took place has also been provided. Where it is relevant, a note describing the precipitation applied is included in the summary plots. The air temperature is an indication of the ambient conditions. An extremely low air temperature increases the amount of time required for the slab temperature to rise above 32°F. Precipitation in the form of an even mist was added for some tests. For the nights with freezing low temperatures, an ice layer formed on the slab surface. The heat pump was run throughout the night, and shut off only after sunrise. In most cases, the slab top surface temperature rose above freezing only after sunrise with additional solar radiation.

Weather plot

The summary plot of each day contains the following information:

- Solar radiation (W / m^2) and
- Wind speed (mph)

The solar radiation indicates the time sunrise took place, and the amount of solar radiation. For most tests it is quite relevant, as the solar radiation was responsible for raising slab top temperature above freezing. The wind speed affects the surrounding air temperature by adding an additional 'chill factor', thereby reducing the air temperature to lower values. The weather information was downloaded from the Oklahoma "Mesonet". The weather information is obtained every 15 minutes as compared to the 5 minute recording of the datalogger used for the summary plots.

4.3.1 Individual test days

Descriptions of the tests run for individual days has been provided. Most of the tests were carried out under almost identical conditions, with some minor configuration changes.

4.3.1.1 Day 1 (February 28th and 29th)

The bottom of the slab was left un-insulated. The test was run with precipitation applied every 30 minutes. There was some ice formation and subsequent melting of the ice after the heat pump was started. However because of the decreasing ambient temperature and the constant rate of precipitation, the ice did not melt on all parts of the slab surface till after sunrise. This was the first test and the amount of precipitation was not recorded as the spray effectiveness was being tested The spike in the heat flux at 4:00 a.m. indicates a drop in inlet fluid temperature.

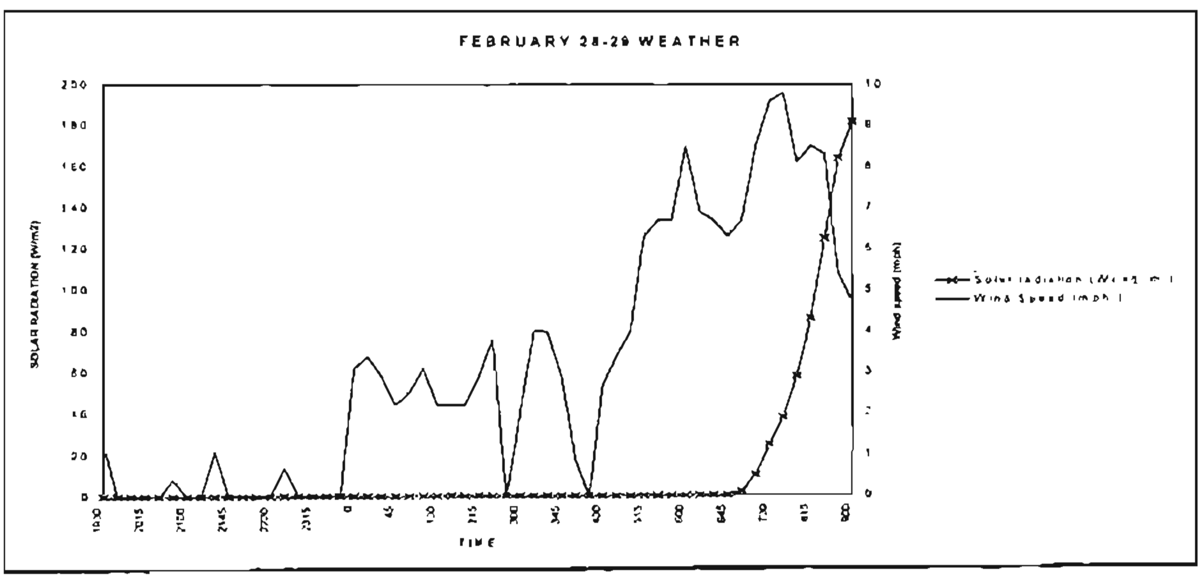

FIGURE 4.1 Weather Plot for February 28 -29th.

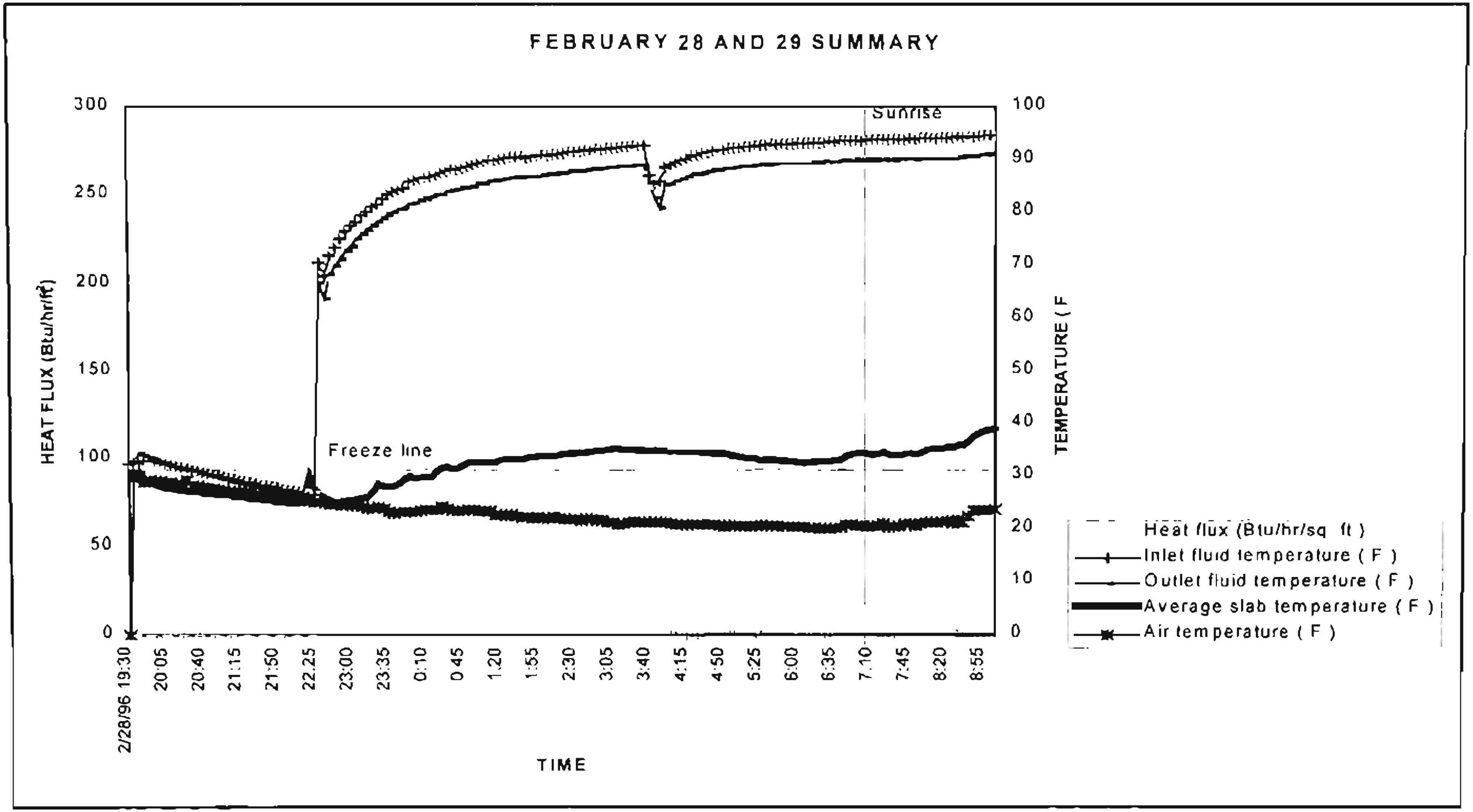

FIGURE 4.2 Summary plot for February 28 - 29th

4.3.1.2 Day 2 (March 1st and 2nd)

The bottom of the slab was insulated. All the tests done after this day were carried out with the bottom surface insulated. The weather forecast predicted freezing air temperatures for the night. However temperatures remained above 32°F until after sunrise. At 12:00 am, an attempt was made to cool the slab to the ambient temperature by pouring water on it. The heat pump was started initially at 12:30 am, but was then shut off instantly, to allow the slab to cool further. The slab was preheated due to running the test setup the previous night. As the ambient temperature started to rise, the heat pump was started again at 3:00 am. Artificial precipitation was provided by the hand held spray. 1400 cc of water was sprayed every 30 minutes on the slab from 3:00 am to 5:30 am. As the inlet fluid temperature rose, the slab temperature also continued to rise steadily. The slab temperature never went below freezing even though the ambient temperature decreased through the night. The insulation on the slab bottom prevented excessive loss of heat from the bottom boundary, as compared to the February 28th night configuration. The cause for the random fluctuations observed in the fluid temperatures after sunrise was not determined.

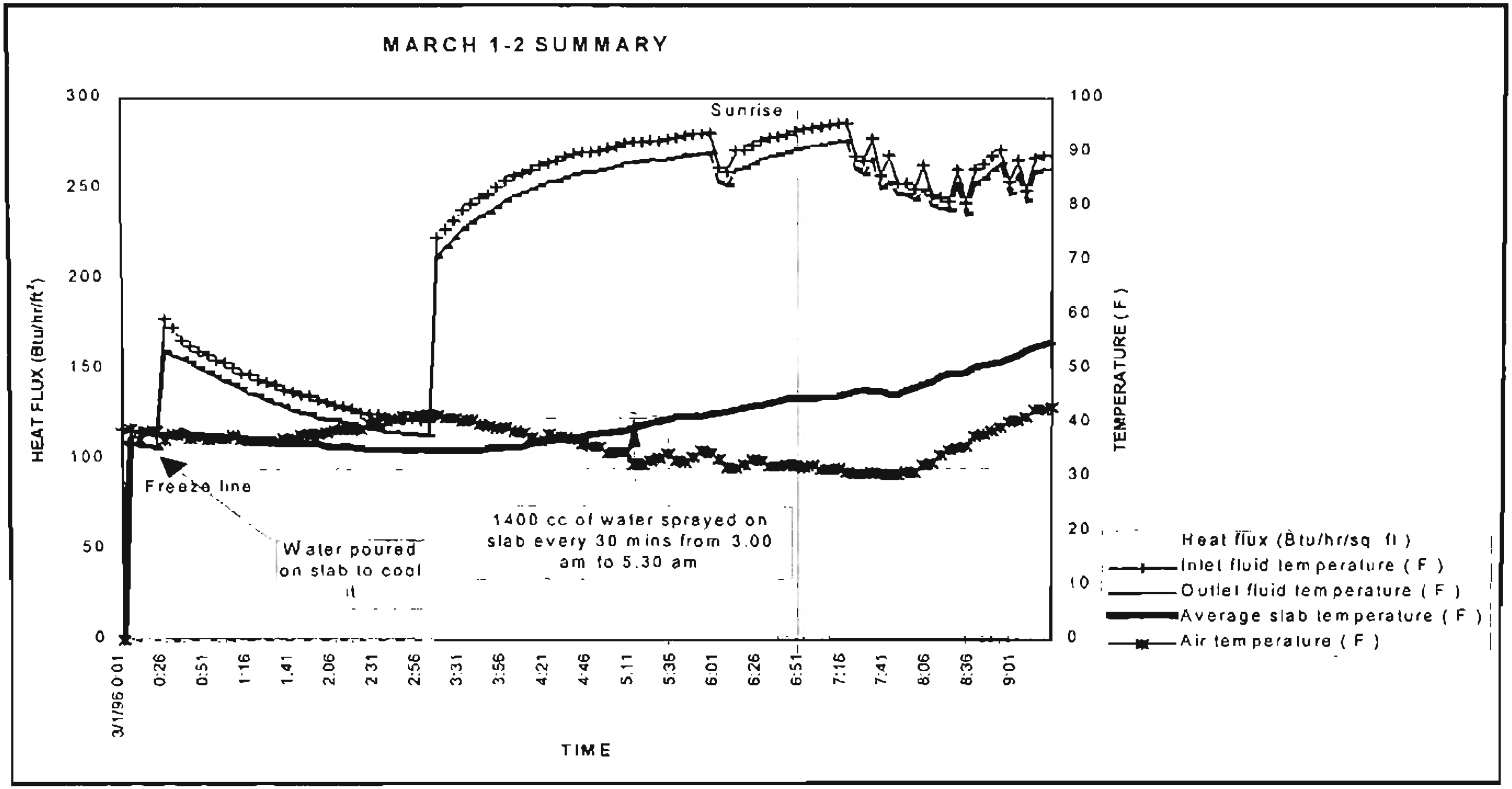

FIGURE 4.3 Summary plot for March 1st - 2nd

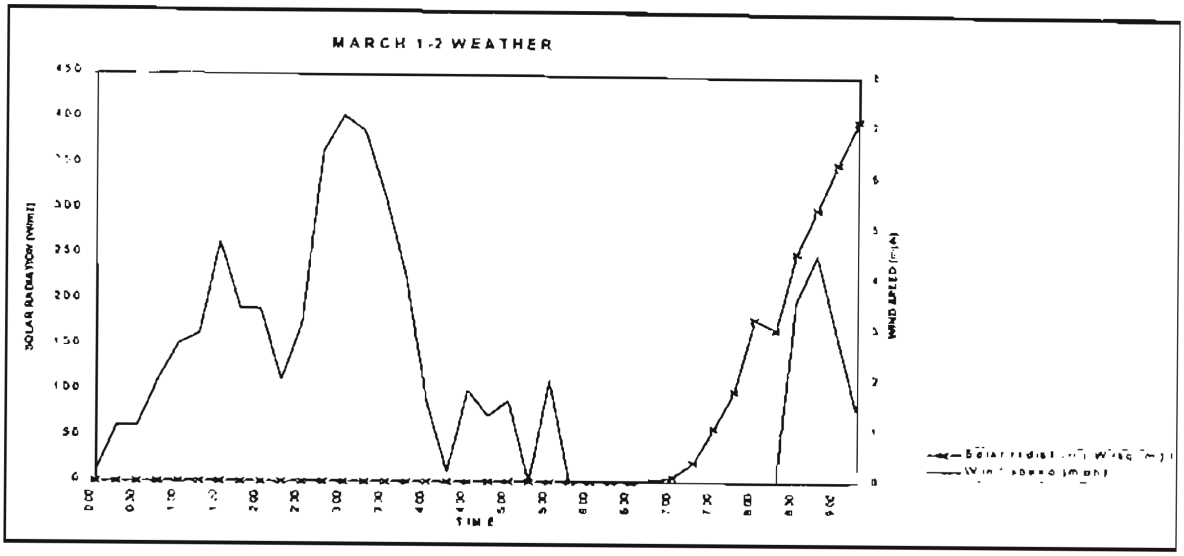

FIGURE 4.4 Weather plot for test run of March 1st - 2nd

4.3.1.3 Day 3 (March 6th and 7th)

A low ambient temperature reduced the slab top surface temperature below freezing. Artificial precipitation (5000 cc of spray water) sprayed on the surface at 10:00 p.m. had formed a layer of ice on the slab. The heat pump was started at 12:00 am. One bottle (700 cc) of water was sprayed every 30 minutes after that till 4:00 am. The spikes observed in the slab temperature from 12:00 a.m. to 4:00 a.m. indicate the times slab was sprayed with water. The water temperature was considerably higher, relative to the slab surface temperature. As the surface was sprayed, the thermocouples on the surface were sprayed with this higher temperature water. The slab temperature did not rise above freezing throughout the night. The slab started to warm up only later in the morning after 9:00 am.

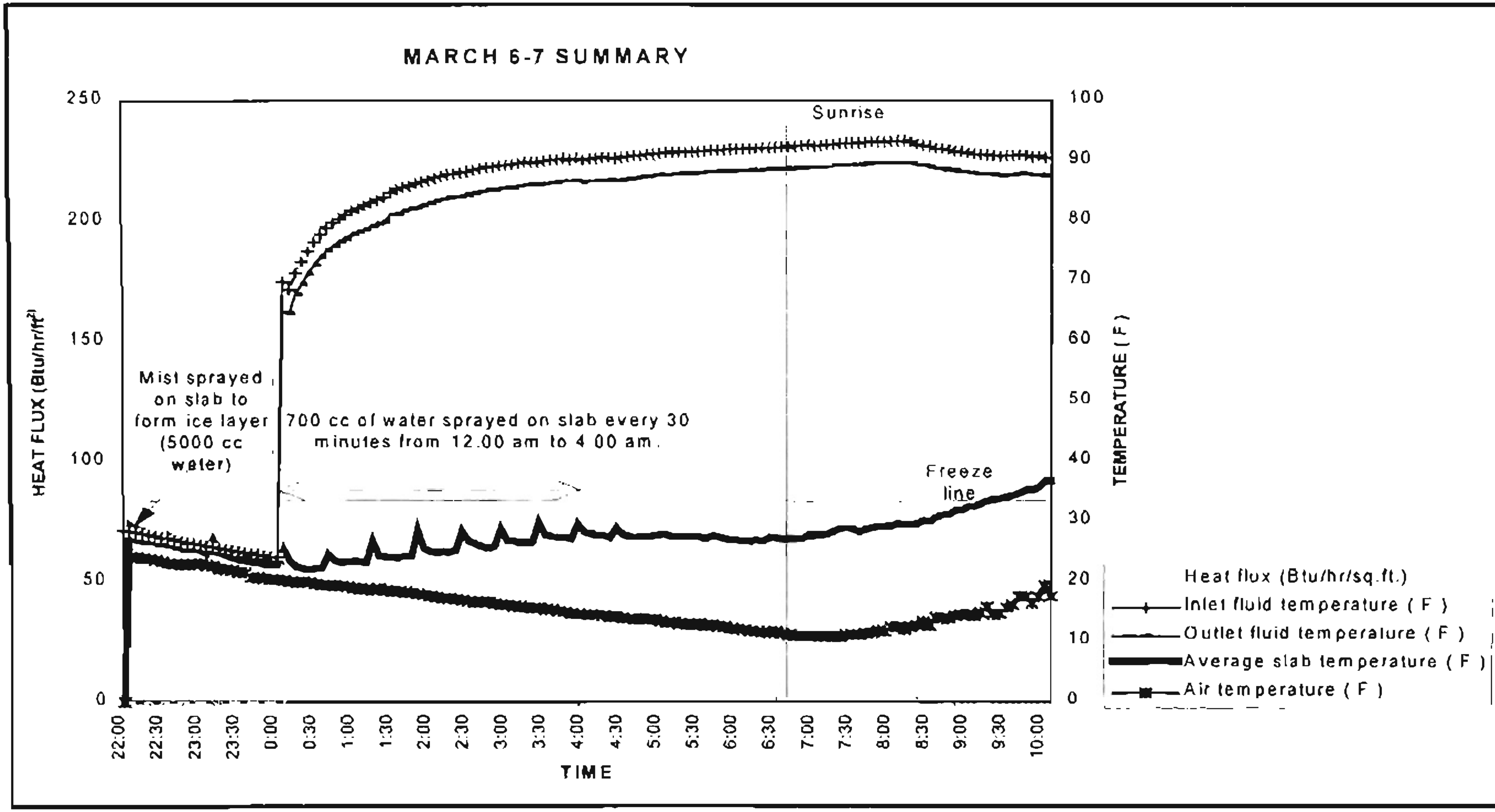

FIGURE 4.5 Summary plot for March 6th - 7th

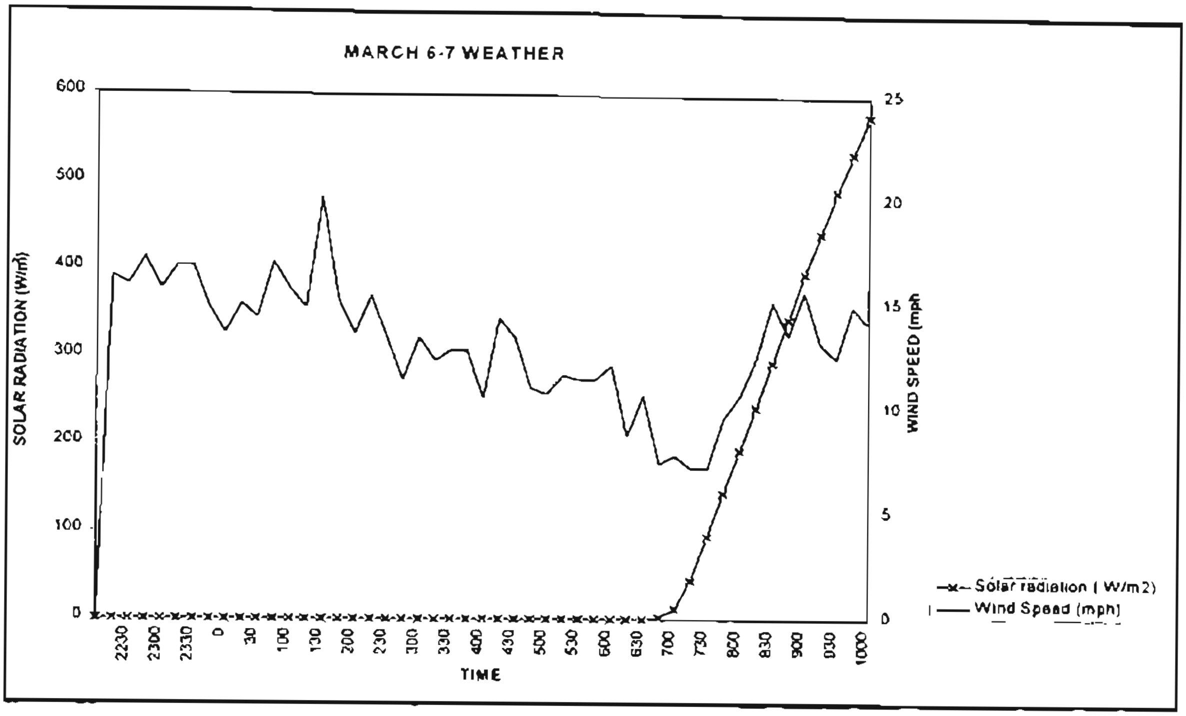

FIGURE 4.6 Weather plot for March 6 - 7th

4.3.1.4 Day 4 (March 7th and 8th)

Continuous application of precipitation and the low air temperature for the previous night's test prevented the temperature of slab surface from rising above the freezing line. For this night, continuos precipitation was stopped and the slab was sprayed only at the start of test with water (3500cc) to form a thin layer of ice on its surface. The heat pump was switched on at 11:30 p.m. During the night, the air temperature dropped extremely low, to approximately 10°F. The slab stayed frozen with ice until morning. The ice started melting at patches on the slab early in the morning at 6:00 am.

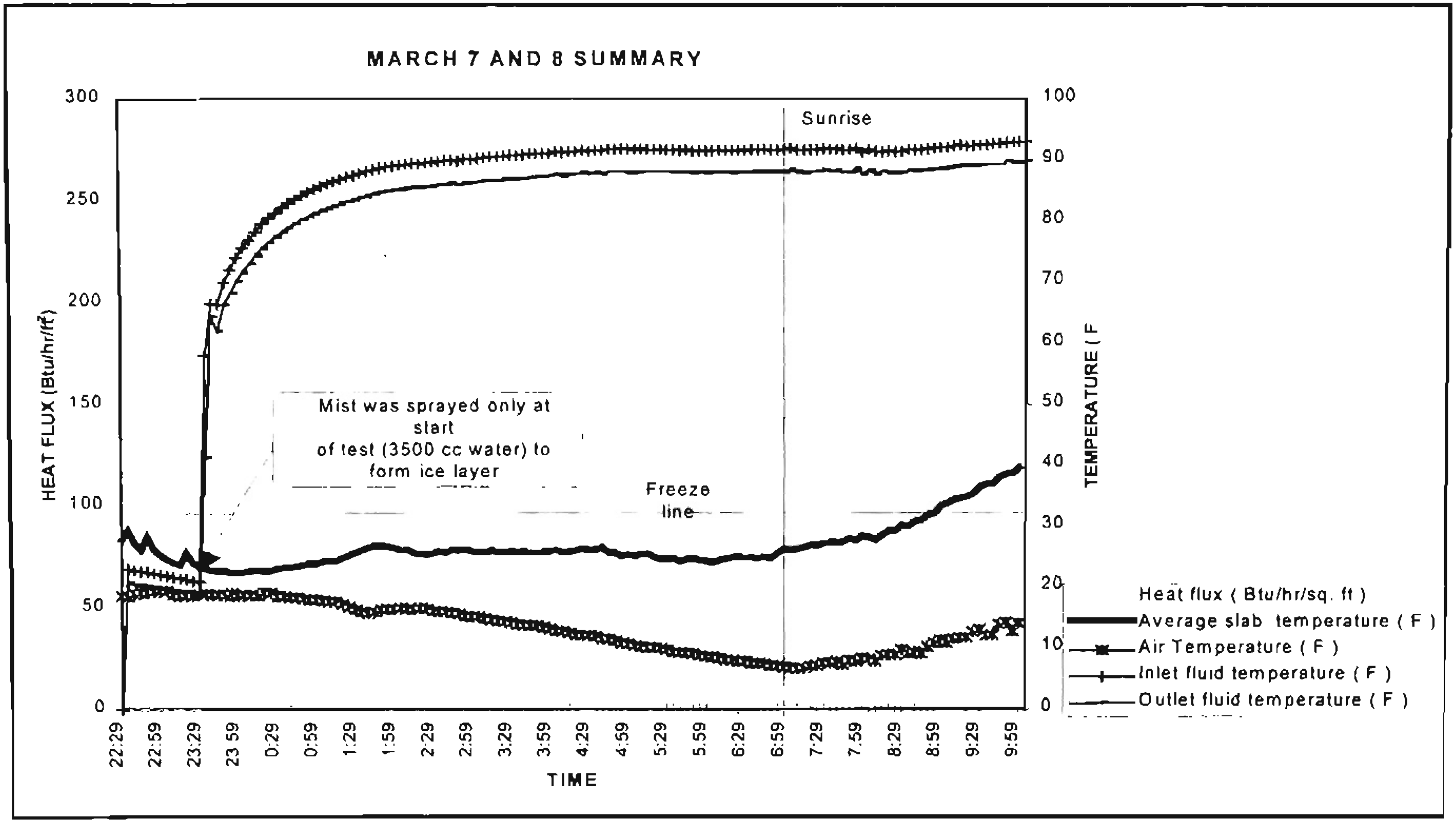

FIGURE 4.7 Summary plot for March 7 - 8th

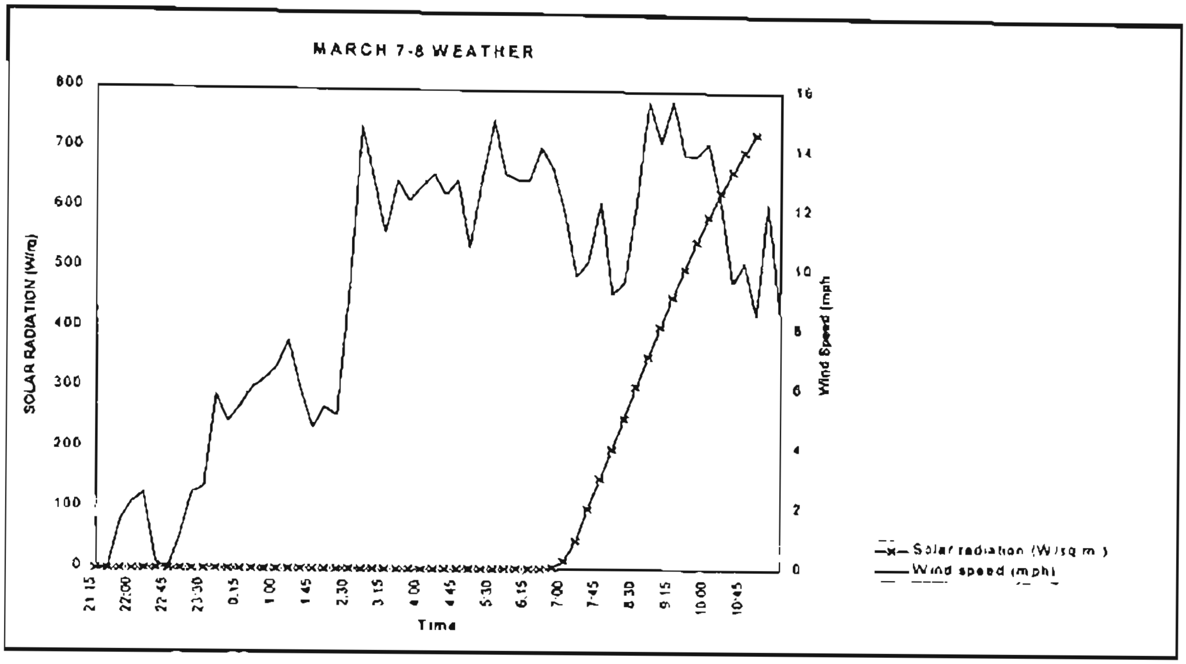

FIGURE 4.8 Weather plot for March 7th and 8th

4.3.1.5 Day 5 (March 8th and 9th)

This test was similar to the one carried out the previous night. The slab was sprayed with 3500 cc of water to form an ice layer on the slab surface. The heat pump was started at 3:00 am. The slab temperature was below freezing at that point. The slab temperature steadily rose through the night and went above freezing at about 4:30 am. This was a considerable difference from the previous night's results. The ambient temperature was not as low as that of the previous night and stayed in the 15°F- 25°F range. Another reason for the faster heating of the bridge deck may be attributed to the wind speed. There was no wind as compared to a wind speed of 13 mph on the previous night.

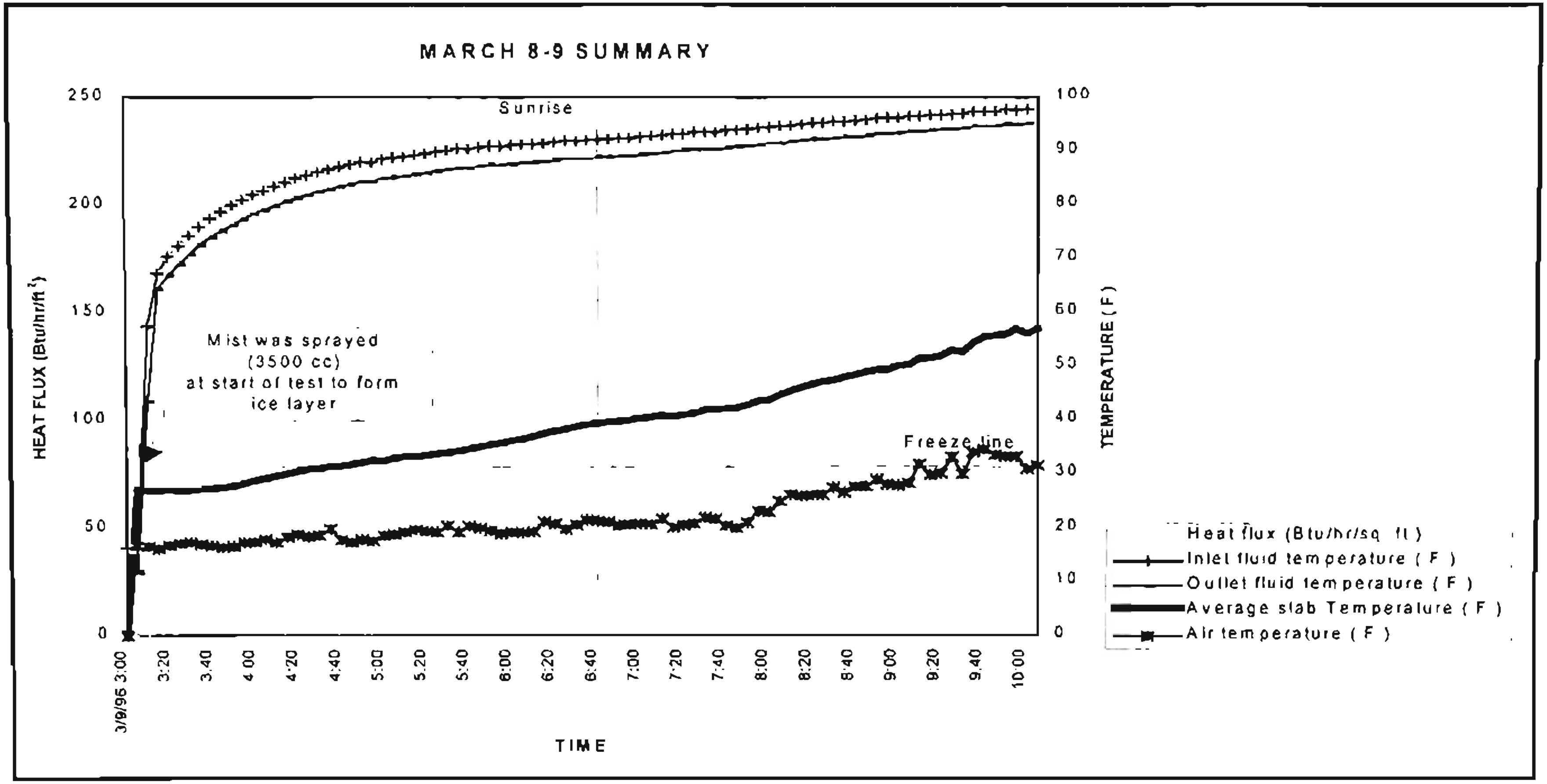

FIGURE 4.9 Summary plot for March 8th and 9th

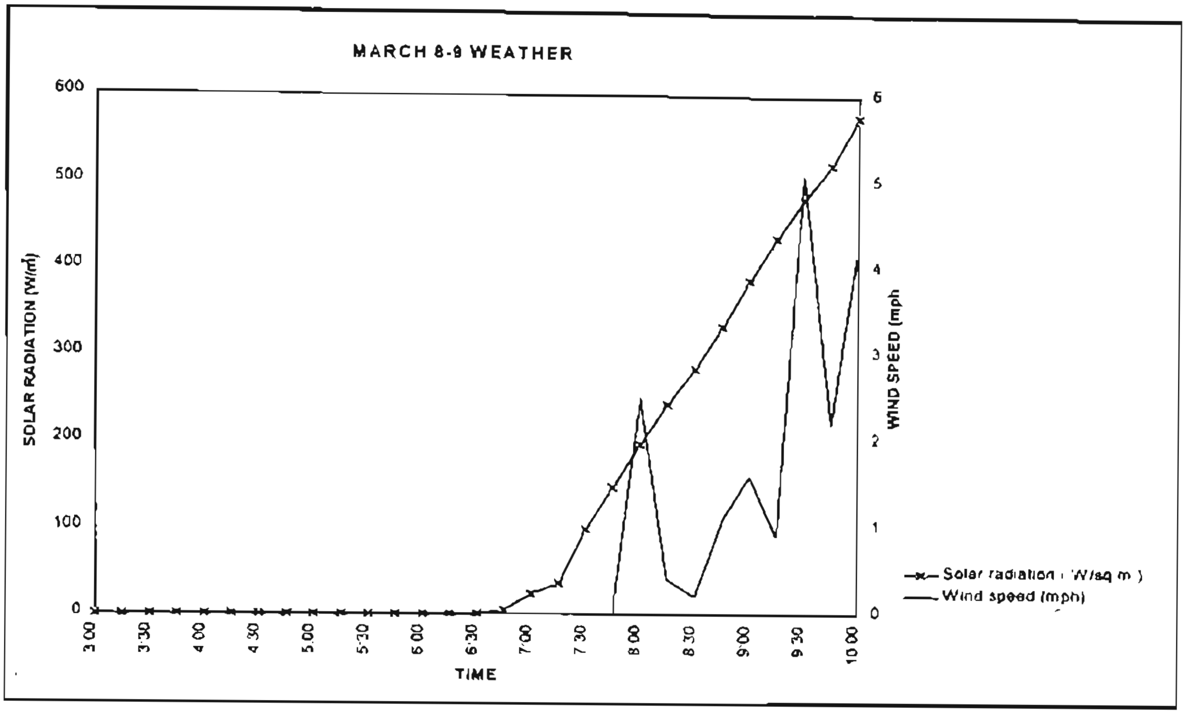

FIGURE 4.10 Weather plot for March 8th and 9th

4.3.1.6 Day 6 (March 9th and 10th)

No precipitation was used. The average slab temperature and the air temperature remained above freezing. The slab temperature increased steadily with the air temperature remaining almost constant. The rise in the surface temperature became sharper after sunrise. The heat input flux was the lowest for this test, dropping to as low as 120 Btu/hr./ft^2. A relatively high air temperature and slab temperature were responsible for this low heat input.

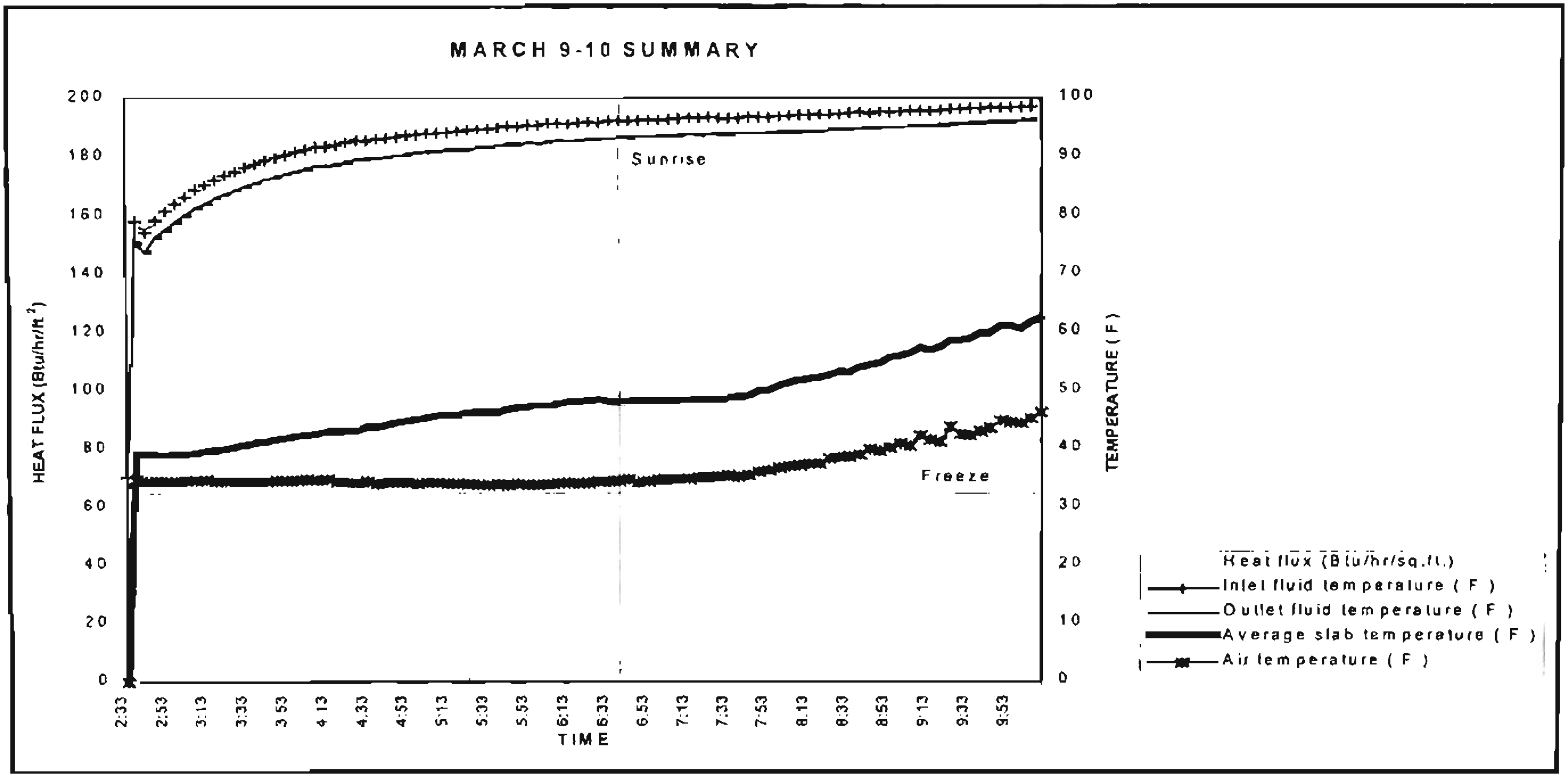

FIGURE 4.11 Summary Plot For March 9 - 10th

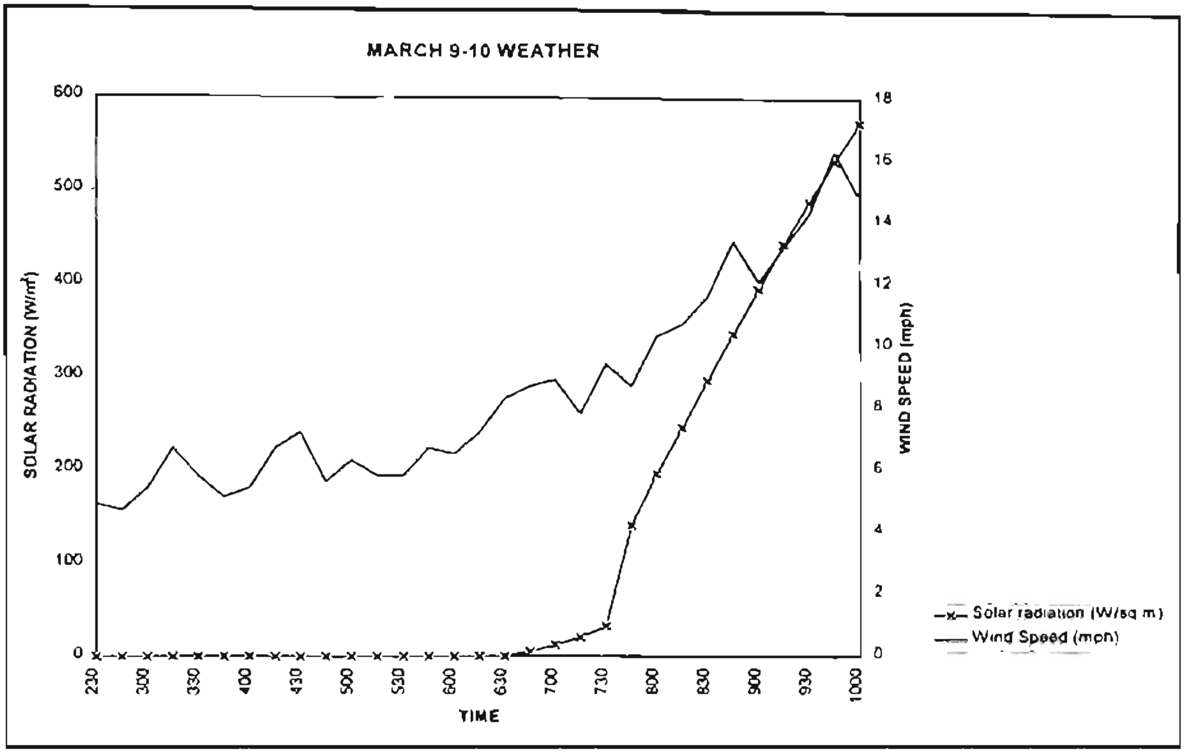

FIGURE 4.12 Weather Plot For March 9th and 10th

4.3.1.7 Day 7 (March 19th and 20th)

The next test was carried out after a 10 day interval period due to higher air temperatures in the 50-60°F range for the intermediate days. On this night, the air temperature dropped to 32°F. The slab temperature was also close to freezing. As soon as the heat pump was started, the slab surface temperature rose quickly above the freeze line and the heat input decreased.

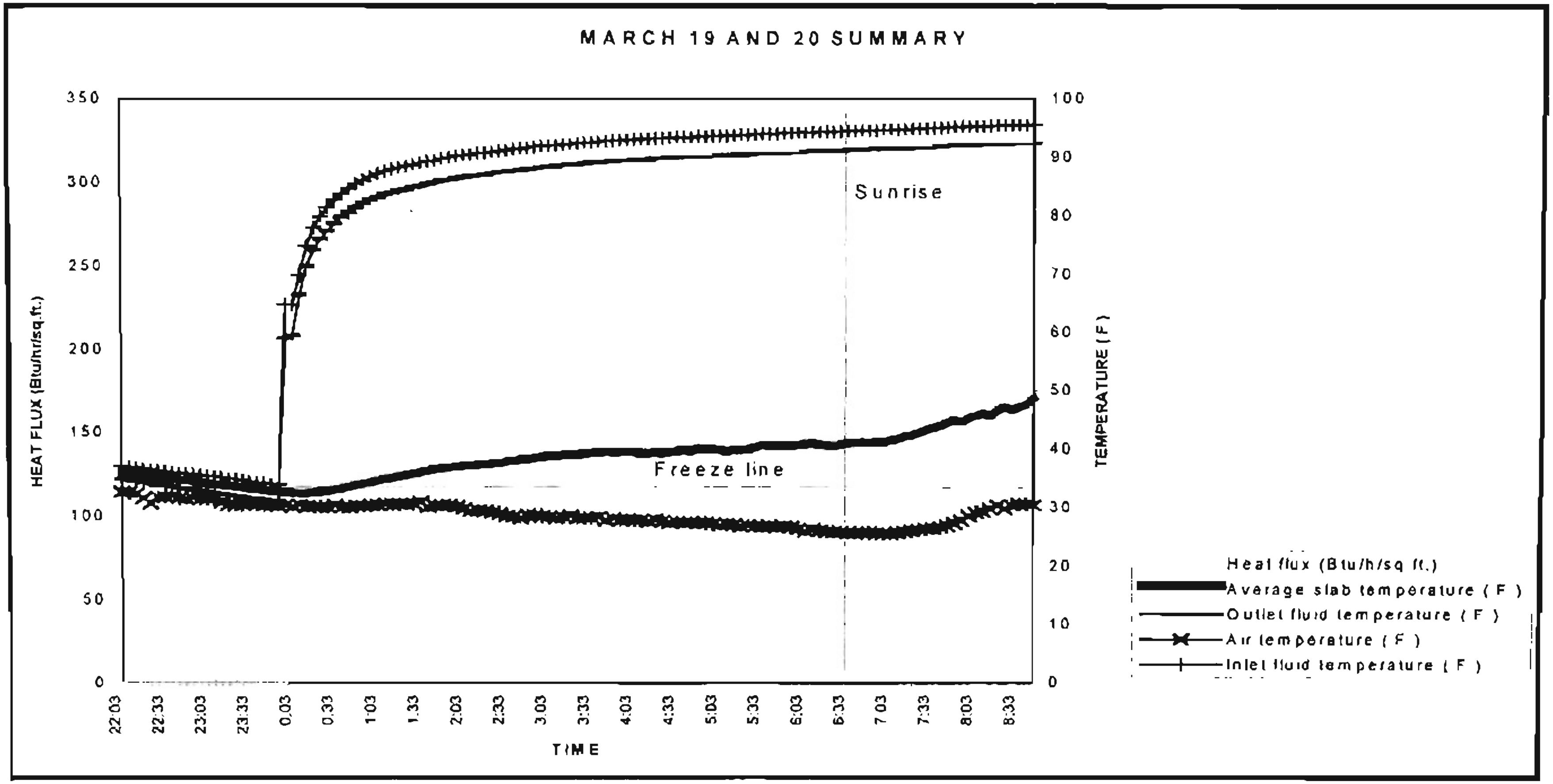

FIGURE 4.13 Summary plot for March 19 - 20th

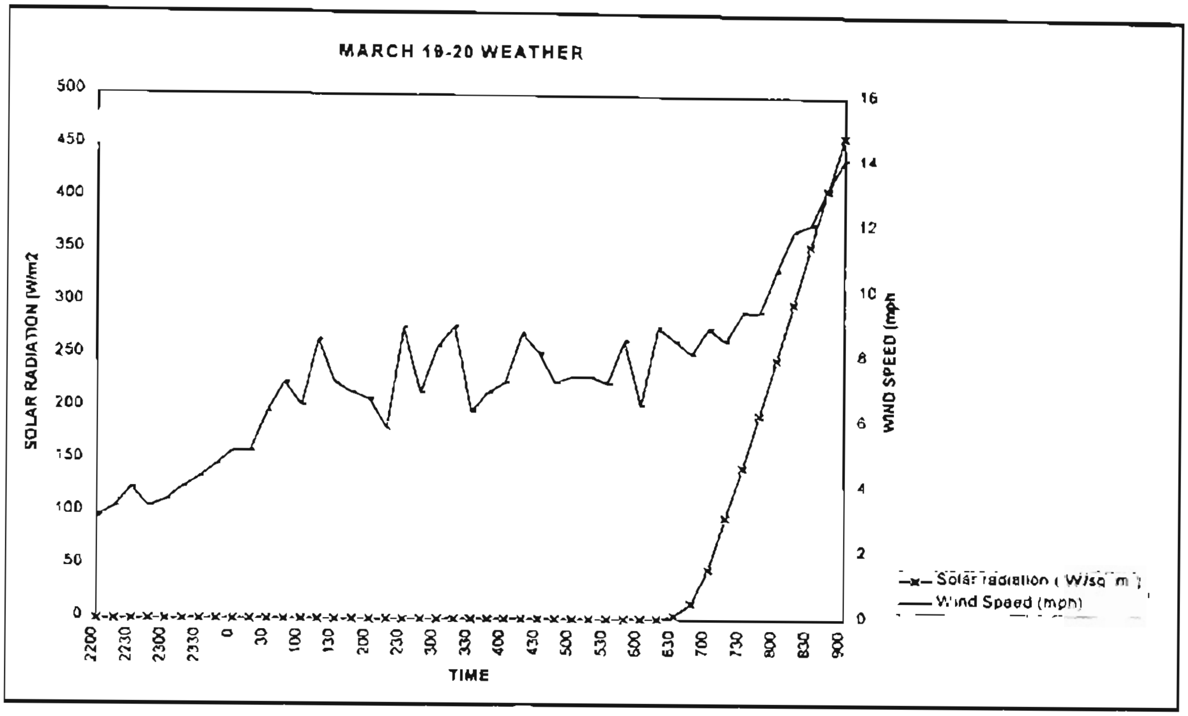

FIGURE 4.14 Weather plot for March 19 - 20th

4.3.1.8 Day 8 (March 24th and 25th)

The air temperature dropped below freezing. However as the heat pump had been run the previous day, the slab was sufficiently warmed up, with its surface temperature above freezing. With the heat pump putting in an almost constant heat flux of 180 Btu/hr/ft^2, the slab surface remained at an almost constant temperature just above freezing. The air temperature decreased into the low 20's and a high wind speed of 12 - 15 mph prevailed through the night.

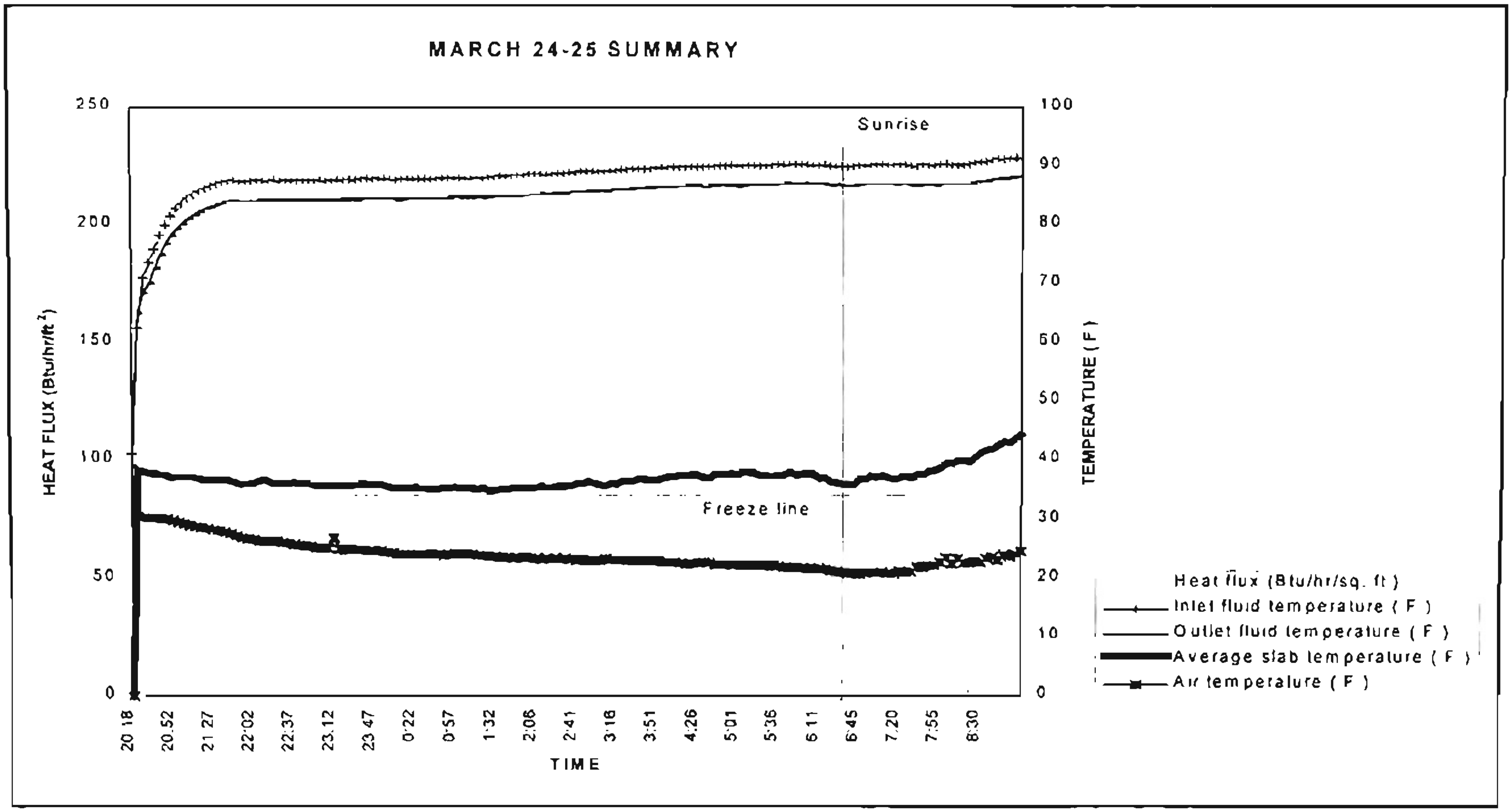

FIGURE 4.15 Summary plot for March 24 - 25th

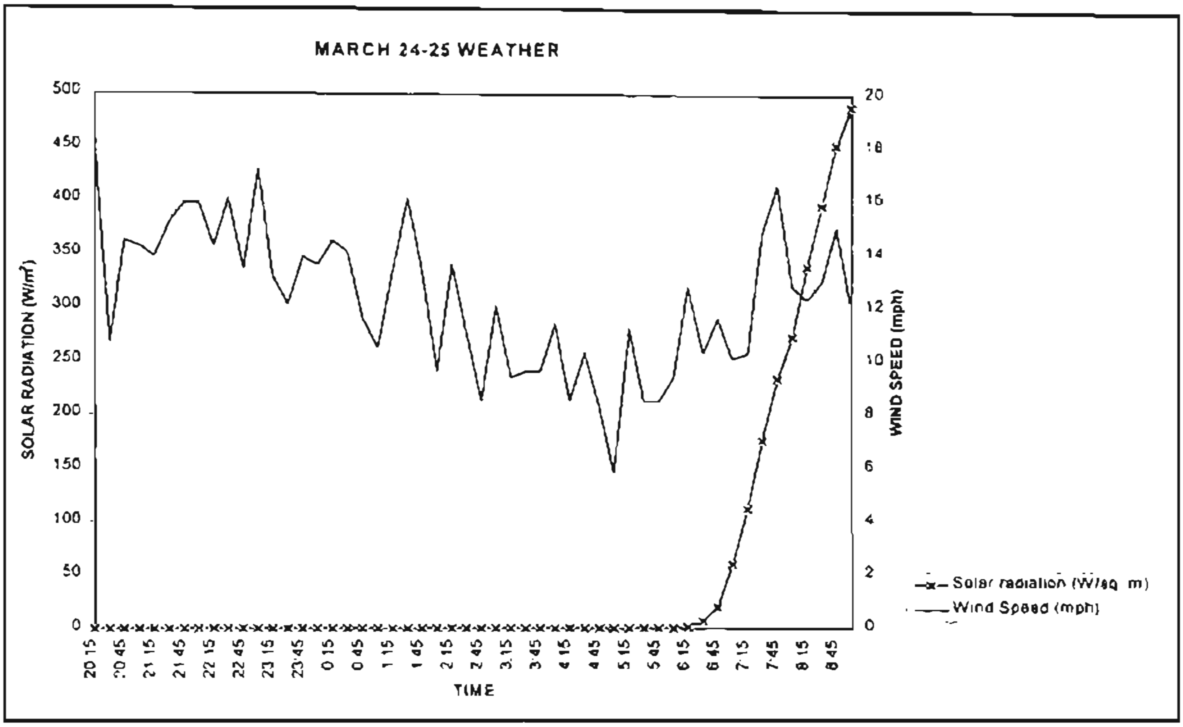

FIGURE 4.16 Weather plot for March 24 - 25th

A discussion of the experimental results has been presented in Chapter 6.

CHAPTER FIVE

THE COMPUTER MODEL

5.1 Overview

As an adjunct to the experimental study, a computer code has been written in FORTRAN to model the bridge deck It is a numerical model developed for future use in modeling such hydronic systems. The model will be useful in predicting the thermal performance of similar bridge decks for different configurations. Weather data and the inlet fluid temperature from the test runs has been used as input to the model and the results obtained from the program have been compared to the experimental results, to validate the model.

5.2 Literature review

Various approaches to model heat transfer in a snow melting slab have been studied Calculating the heat requirements for such systems has been presented in Chapter 1 The design of embedded snow melting systems is important, so the system can be optimized with respect to different arrangement of tubing, slab construction, fluid inlet temperature, and flowrate, etc This optimization helps in reducing the installation and operational costs of the snow melting system.

5.2.1 Steady - state models

A simplified model of a slab was developed by Kilkis (1994), which was essentially a simple design tool for engineers involving hand calculations as compared to the other computer models developed. Kilkis assumed the slab to be a composite fin. This model however assumes steady state, and does not give the temperature distribution during the slab heating up phase.

A technique developed by Schnurr and Rogers (1970) used a two dimensional finite difference model. However this model was also developed for steady state situations and instead of using fluid temperature, a surface temperature of the concrete at fluid boundary was defined. They studied the effect of wind velocity, heater spacing and snowfall rate on the performance of such snow melting systems

5.2.2 Transient models

A transient model was developed by Williamson (1967) It was an analytical model and was a one dimensional model. The solution of the diffusion equation for the surface temperature V is given by the following expression

$$T = \frac{-0.75Qt}{Kt_1}(kt)^{0.5} + \frac{0.75Q}{Kt_1}H(t - t_1)\left\{(t - t_1)\left[k(t - t_1)\right]^{0.5}\right\} + \frac{SH(t - t_2)}{K}\left\{k^{0.5}(t - t_2)^{0.5}\,2ierfc\frac{d}{2\left[k(t - t_2)\right]^{0.5}}\right\} \qquad (5.1)$$

where

T = Surface temperature of the slab

Q = Heat loss from the surface per unit area per unit time

K = Thermal conductivity of the material

k = Thermal diffusivity of the material

S = Heat output from unit area of heater per unit time

t = time

t_1 = time required to reach steady state

t_2 = time at which heat source S is activated

H $(t - t_1)$ = Heaviside unit function which has the property

H $(t - t_1)$ = 0, $t < t_1$ and H $(t - t_1)$ = 1, $t > t_1$

A detailed derivation and analysis of the Equation 5.1 can be found in Williamson (1967). The solution assumed a constant heat flux on the surface boundary of the slab and a constant heat source inside the slab. Also it was derived for one dimensional cases.

A transient numerical model was developed by Leal and Miller (1972). A computer model was developed by Leal, (1971), details of which can be obtained in his dissertation. However the model results obtained were based on the occurrence of no snowfall, though the heat transfer equations used were obtained from work done for snow melting systems by Chapman (1956), presented in Chapter 1. Also the heat source temperature was assumed to rise from the ambient temperature to maximum steady temperature instantly. Such a change is not possible in case of heating fluid conduits rather than electric conduits. The model developed was a two - dimensional numerical model.

5.2.2.1 O' Dell's model

It was desired to develop a simple three - dimensional numerical model which could be used for different configurations of the slab for different input parameters for transient conditions. This model was not explicitly for snow melting. Hence the relations obtained by Chapman for the boundary conditions of snow melting systems were replaced by more general expressions (discussed in 5.3). The model was based on work done for a three - dimensional slab with embedded piping by O' Dell (1994). O' Dell used an explicit finite difference solution as it was found to be more effective by reducing the computation time For large simulation periods, the computation time with an implicit method would increase computation time substantially, inspite of the time step limitation on explicit formulation for satisfying the stability criterion (discussed in 5.3.1.2). O' Dell's model assumed a combined linearized convection and radiation coefficient. No solar radiation gains or precipitation loads were incorporated and constant weather conditions were assumed throughout the simulation period. A constant inlet fluid temperature was assumed with a constant fluid velocity.

The model presented in the following sections is a modified version of O' Dells model Actual weather conditions were incorporated by using real time weather data, downloaded from the Oklahoma 'Mesonet'. The number of grid points was doubled from O' Dell's code for better accuracy. It is a transient model, however for each individual time step, quasi-steady state condition were assumed. Separate convection and radiation conditions on the boundaries were defined. Details of the model are provided in 5.3

In this study precipitation was not modeled. A detailed study conducted by NASA (Wright, 1988) for the numerical modeling of the melting of ice on a horizontal surface may be referred for this purpose. Analytical solutions for the same phenomenon may be derived to represent the heat transfer from the slab surface.

5.3 *Methodology*

5.3.1 Finite difference formulation

5.3.1.1 The three - dimensional grid

A finite difference solution for the bridge deck requires the creation of a three - dimensional grid. Differential equations representing the heat transfer in the slab are converted to algebraic equations known as discretization equations These equations are applied at discrete locations, the grid points, or nodes, arranged on the grid A control volume is constructed around each grid point and a heat balance is applied across each face of the control volumes. For the bridge deck, as the geometry of the slab is simple, we make use of the Cartesian coordinate system (x, y, z)

For the simplicity of calculations, the bridge slab with six embedded tubes connected by the U tubes was assumed to be a single length of slab with one long embedded pipe in the slab This single slab section represents the entire bridge slab and the pipes as if they are uncoiled and straightened out. The slab is assumed to be symmetrical along the longitudinal axis of the pipe. Hence only half of the slab is used in the model This reduces the number of grid points by half. Figure 5.2 depicts the bridge deck as assumed in the model A grid mesh divides this section into different nodes in the X, Y and Z directions. In the X-direction, the nodes are assumed to have a spacing of 1 foot. A smaller grid spacing in the X direction increased the total number of grid points, thereby increasing the computer time. A spacing of 0.08 ft in the X direction was initially implemented and the spacing was increased till no change in the results was observed. A 1 foot spacing in the X direction was found to give the same results as those achieved with the spacing of 0.08 feet. Grid independence was observed in results for any spacing below 1 foot. Grid spacing marginally larger than 1 foot did not significantly change the results, however, as the grid used is uniform, there was no node position at the edge. A larger grid spacing of 1.5 or 2 feet affected the results, hence a spacing of 1 foot was maintained

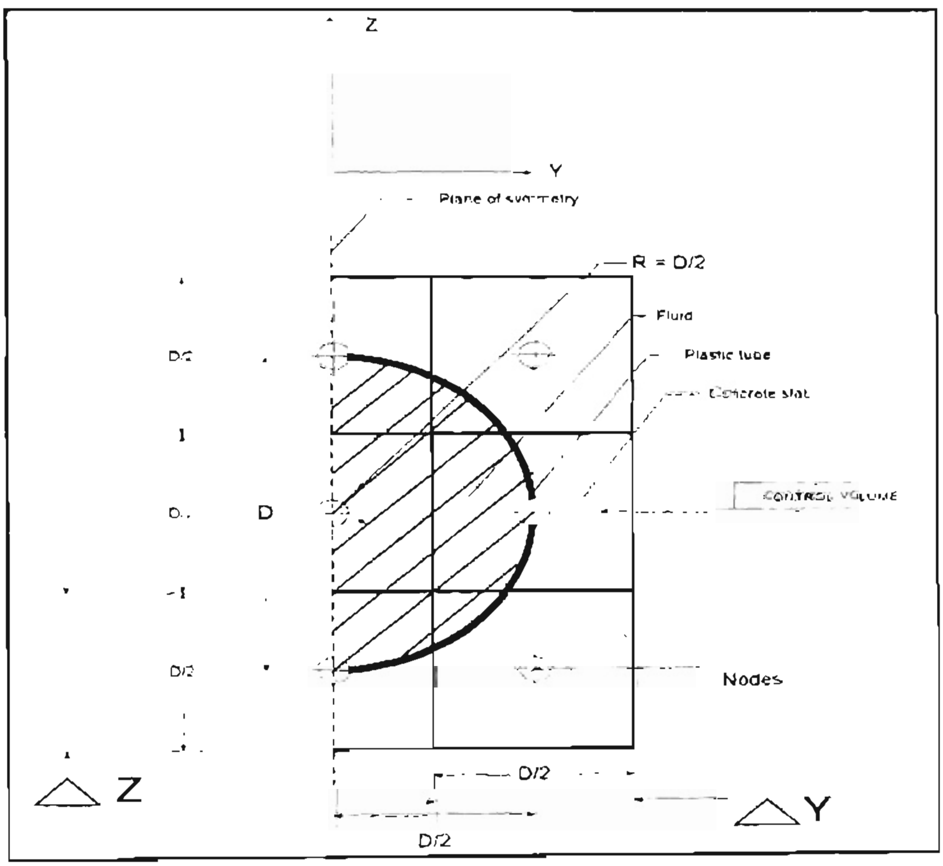

Figure 5.1 2-D cross sectional view of a fluid pipe node shown with control volumes

Figure 5.1 shows the grid cross-section of the fluid nodes, with the node locations. The cross hatched area is the tube of fluid. Only half of the tube is included, as symmetry is assumed. For simplicity, the outer radius of the plastic pipe is taken as the distance between two nodes, for the Y and Z direction, with one node located at the center of the pipe, the pipe radius is used as the spacing between two nodes. This simplifies the grid geometry, with a node in the center of the pipe and adjacent nodes about the pipe radius. The number of nodes in the Y or Z direction is calculated by truncating the following fraction to an integer.

$$N_{y,z} = S_{y,z} / (D/2) \tag{5.2}$$

where

$N_{y,z}$ = Number of nodes in the Y or Z direction

$S_{y,z}$ = Slab dimension in the Y or Z direction (ft)

D = Diameter of tube (ft)

All the nodes are surrounded by a control volume. A three - dimensional view is provided in Figure 5.3. Nodes 2 through 6 about the pure fluid node 1, as shown in Fig 5.1, are defined as composite nodes. The control volumes of these nodes include some fluid, some concrete and some plastic pipe. A new 'composite' property was defined for such nodes calculated by using a weighted average of the properties of the different materials depending on the volume fraction of the material contained in the node.

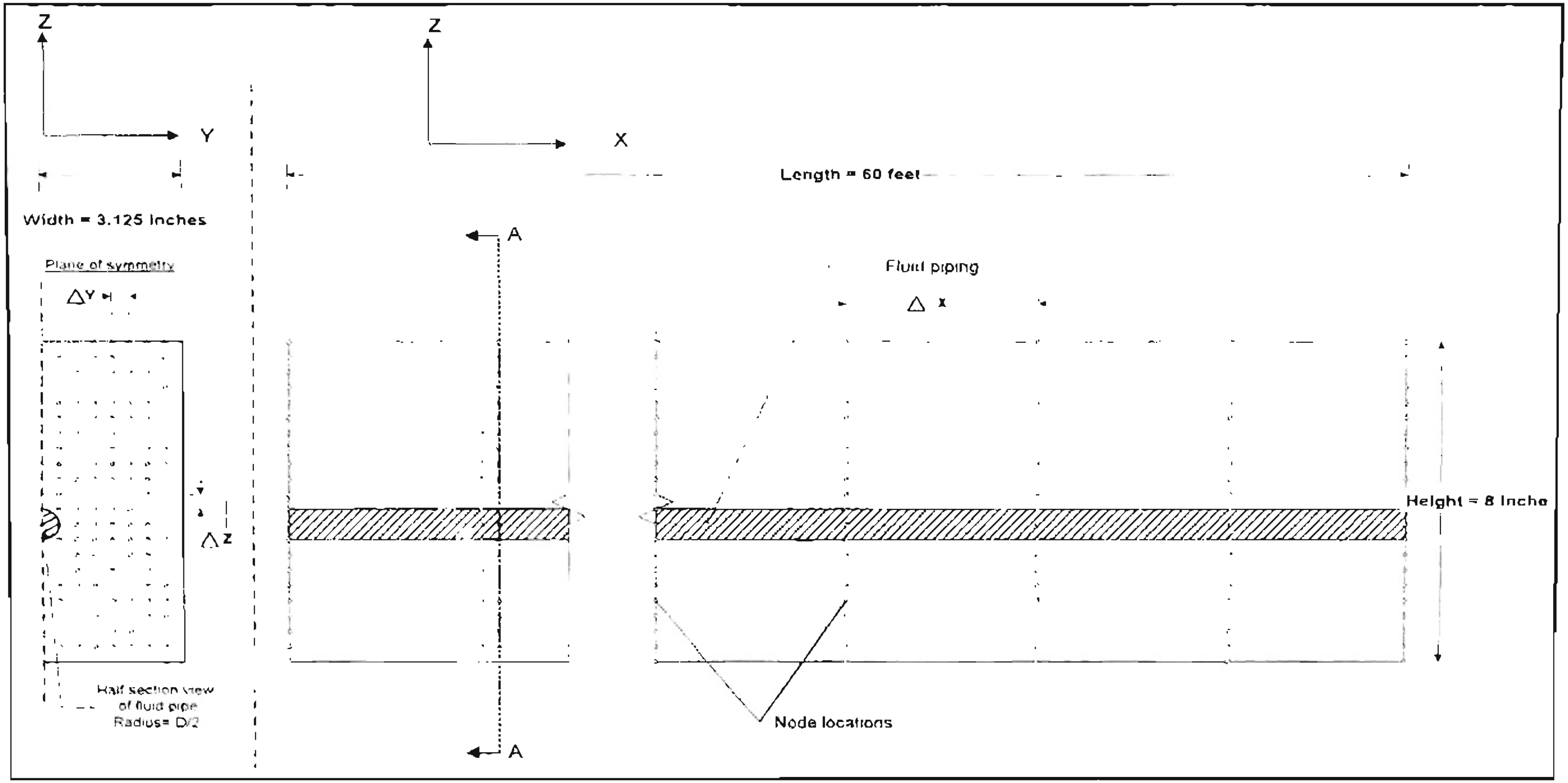

Figure 5.2 2 - D cross sectional view of the bridge slab section shown with the grid point positions

(Represents 6 slab sections, each 10 feet long, 6.25 inches wide, 8 inches thick)

5.3.1.3 Composite properties

Each of the nodes, has its own specific physical properties within its control volume, depending on its location. These properties, viz the density, specific heat and thermal conductivity are useful in calculating the heat transfer occurring between adjacent nodes. For the nodes located totally within the fluid or the concrete bridge, the properties of the respective materials are used However as discussed in the previous section, for the nodes containing more than one material, the composition is not uniform The control volume may consist of some concrete, some plastic and some fluid, as the case may be For a better representation of the properties of such nodes a 'composite' property is defined depending on the volume fraction occupied by the fluid, concrete or pipe material

Hence

$$P = \sum_{i=1}^{3} Vf_i \, p_i \qquad (5.3)$$

where

P = Composite node property (density, thermal conductivity, specific heat)

Vf_i = Volume fraction of material i

p_i = Property of material i

This approach was verified by running a test for calculating outlet fluid temperatures, and comparing them to the experimental results An agreement within

0.5-1 °F was attained (Refer Chapter 6). Another approach for specific heat. would be to weigh the specific heat property on basis of the mass of the material fraction (Croft and Lilley. 1977)

5.3.1.3 Time step

The finite difference model solves the descretisized heat transfer equations by using the explicit method. As a number of iterations are to be performed, the explicit method was used to reduce the computation time. Due to the inherent disadvantages of this method, there is a limitation to the size of the time step. The stability of the solution limits the maximum size of the permissible time step. The time step used in the program is 90% of the maximum allowable time step calculated as:-

$$\Delta t = \frac{\left(\frac{1}{\Delta x^2} + \frac{1}{\Delta y^2} + \frac{1}{\Delta z^2} \right)^{-1}}{2\alpha} \qquad (5.4)$$

where

Δt = Time step (hr)

Δx, Δy, Δz = Grid spacing in the X, Y, Z direction respectively

α = Maximum thermal diffusivity

$$\alpha = \frac{\max(k_p, k_{bridge}, k_{fluid})}{\left(\min\left(c_{pp}, c_{pbridge}, c_{pfluid}\right)\min\left(\rho_p, \rho_{bridge}, \rho_{fluid}\right)\right)} \qquad (5.5)$$

where

k = Thermal conductivity of material (Btu/hr/ft °F)

C_p = Specific heat of material (Btu/lb. °F)

ρ = Density of material (lb./ft^3)

Time step used in the program is 90% of the Δt value as calculated by Equation 5.4. This results in a time step of 12 seconds for the grid spacing described in the last section.

5.3.2 Heat balance

The model makes use of the heat balance approach. The total heat input to each node of a finite difference grid, is equal to the rate of energy accumulation in that node. This heat accumulation is used to calculate the temperature of the node at the next time step. For conduction only nodes

$$\Sigma Q_i = V_i \, \rho_i \, Cp_i \left[\frac{T_{i,t+\Delta t} - T_{i,t}}{\Delta t} \right] \tag{5.6}$$

where

ΣQ_i = Total heat input to the ith node (Btu/hr)

V_i = Volume of the node (ft^3)

ρ_i = Density of the material (lb/ ft^3)

Cp_i = Specific heat of the node (Btu/lb/°F)

$T_{i,t}$ = Temperature of the ith node at time t (°F)

Δt = Time step (hr)

On solving Equation (5.5) we can get the new node temperature as

$$T_{i,t+\Delta t} = (\Sigma Q_i)\ \Delta t\ /\ (V_i\ \rho_i\ Cp_i) + T_{i,t} \qquad (5.7)$$

For the fluid nodes, i.e. the nodes contained in the fluid piping, the temperature at any time step is calculated by using the temperature of the preceding node along the path of the fluid flow, at the same time step.

Hence

$$T_{i,t+\Delta t} = (\Sigma Q_i)\ /\ (\dot{m}\ Cp_i) + T_{i-1,t+\Delta t} \qquad (5.8)$$

where

ΣQ_i = net heat transfer into node i along the tube (Btu/hr)

$\dot{m}$ = mass flow rate of the fluid (lb/hr)

Cp_i = Specific heat (Btu/lb/°F) of the

$T_{i,t+\Delta t}$ = Temperature of the node along the tube at next time step

$T_{i-1,t+\Delta t}$ = Temperature of the preceding node along the tube at next time step

The incoming fluid temperature, for the first node (i.e. i = 0) is known from the experimental data. The other temperatures of the following nodes within the tube can be calculated by sequentially solving from nodes i = 0, (inlet) to i = imax (outlet) using Equation (5.7). A good validity check involves the comparison of the calculated outlet fluid temperature to the outlet temperature recorded during experimentation.

5.3.3 Total conductive heat input to individual nodes

In a 3-dimensional grid, each node is surrounded by 6 other nodes as shown in Figure 5.2. For end nodes, the number of surrounding nodes may be, 5 for sides, 4 for edges and 3 for corners.

Heat transfer takes place between the node and each of the surrounding adjacent nodes The sum of all the heat gain or loss, as the case may be, due to each surrounding nodes is the total heat input to the node

$$\sum_{i=1}^{6} q = q_{top} + q_{bottom} + q_{right} + q_{left} + q_{front} + q_{back} \qquad (5.9)$$

where

Σq = Total heat input to node (Btu/hr)

q_{top} = Heat input from top node (Btu/hr)

q_{bottom} = Heat input from bottom node (Btu/hr)

q_{right} = Heat input from right node (Btu/hr)

q_{left} = Heat input from left node (Btu/hr)

q_{front} = Heat input from front node (Btu/hr)

q_{back} = Heat input from back node (Btu/hr)

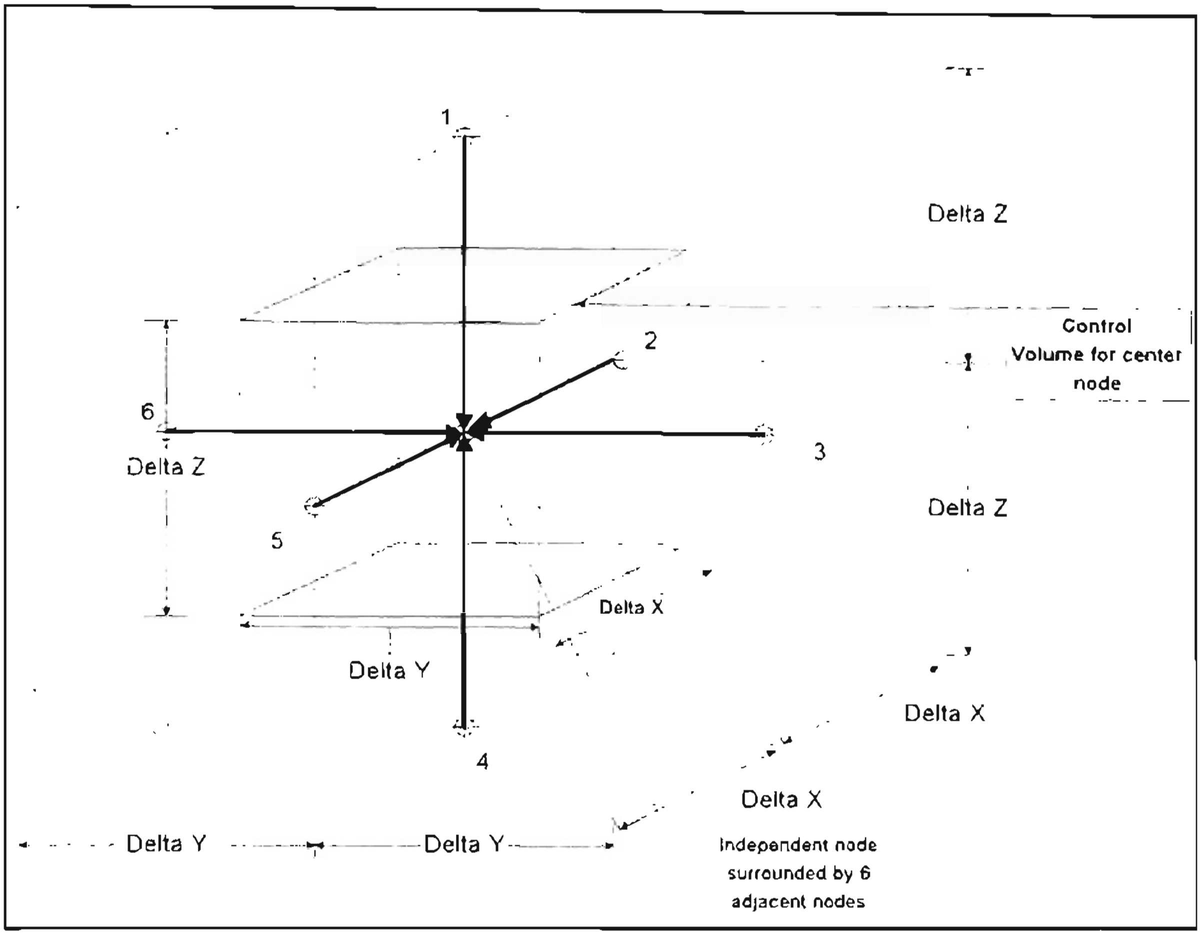

Figure 5.3 The independent node

For the small time step, a quasi steady state heat conduction is assumed between nodes. Each of these heat inputs is calculated as:-

$$q = k\,A\,(T_{adj} - T_{ijk}) \qquad (5.10)$$

where

q = Heat input from adjacent node (Btu/hr)

k = Thermal conductivity between the nodes (Btu/hr-ft-°F)

A = Area of heat transfer between the nodes (ft ^{2})

T_{adj} = Temperature of adjacent node (°F)

T_{ijk} = Temperature of node (°F)

5.3.4 Convective and radiative boundary conditions

The nodes located at the ends are exposed to the environment and heat transfer by virtue of convection and radiation takes place at these surfaces. The sides of the slab are insulated. Also, as symmetry is assumed along pipe axis, the axis of symmetry is considered to be adiabatic For the surfaces exposed to the environment, applying a exterior heat balance we obtain,

$$q_{conduction} = q_{solar} + q_{convection} + q_{radiation} \qquad (5.11)$$

where

$q_{conduction}$ = heat gain conducted by surface node (Btu/hr)

$$q_{solar} = Srad\ A \qquad (5.12)$$

applicable only for nodes exposed to the solar radiation

where

Srad = Incident solar flux (Btu/hr/ft^2)

A = node surface area (ft^2)

$$q_{convection} = h_c\ A\ (T_{ambient} - T_{i,j,k}) \qquad (5.13)$$

where

h_c = Convection heat transfer coefficient (Btu/hr-ft^2 °F)

Determination of h_c is detailed in 5.3.3.1

$T_{ambient}$ = Ambient temperature (°F)

$T_{i,j,k}$ = Node temperature (°F)

$$q_{radiation} = \sigma \, \alpha \, A \left(T_{sky}^{4} - T_{i,j,k}^{4} \right) \tag{5.14}$$

where

σ = 0.714 e -08, Stefan Boltzman constant (Btu/hr-ft^2 R^4)

α = Thermal absorptivity

T_{sky} = Sky temperature (°R)

Determination of T_{sky} is described in 5.3.3.2.

$T_{i,j,k}$ = Node temperature (°R)

Assuming the view factor to the sky is 1

The bottom of the slab is insulated for the all the experiments runs tested by the model.

5.3.3.1 Convection heat transfer coefficient

There are various models available to calculate the exterior convection heat transfer coefficient (h_c). The McAdams expression for h_c was used to calculate convection heat transfer in the computer model. The expression based on experiments done on a flat copper plate for a parallel flow of air (Clarke, 1985) gave the following relation

$$h_c = 5.678 * \left(a + b \left(\frac{V}{0.304} \right)^{n} \right) \tag{5.15}$$

where

h_c = Forced coefficient convection (W m^{-2} C^{-1})

V Parallel flow velocity (m/s)

a, b, n are empirical values

The value of a and b depends on wind direction, wind speed and nature of the surface Value of n depends on the wind speed. Table 5.1 provides the values for a, b and n.

However values of a and b from Table 5.1 were not used in the model These empirical constants were used as independent parameters to obtain a value for h_c which would provide a better match for top surface temperature Section 5 4 describes the procedure used to modify the value of the convection heat transfer coefficient h_c

	V< 4 88 m/s			4.88 ≤ V < 30.48 m/s		
	a	b	n	a	b	n
Smooth	0.99	0 21	1	0	0 50	0 78
Rough	1 09	0.23	1	0	0.53	0 78

TABLE 5.1 Empirical coefficients used in Equation 5.15

5.3.3.2 Calculation of the sky temperature

The sky temperature (T_{sky}) has been determined by using the Bliss relation.

$$T_{sky} = T_{air}\{0.8 + [\frac{T_{dewpoint} - 273}{250}]^{0.25}\} \qquad (5.17)$$

where

T_{sky} = sky temperature (°K)

T_{air} = air temperature (°K)

$T_{dewpoint}$ = dew point temperature (°K)

T_{air} is obtained from the weather data

$t_{dewpoint}$ is calculated from the air temperature and the relative humidity by using the relations provided in the *ASHRAE Handbook of Fundamentals*

<u>If the air temperature is below 32°F</u>

$$t_{dewpoint} = 90.12 + 26.142\,(\ln p_w) + 0.8927\,(\ln p_w)^2 \qquad (5.18)$$

where

$t_{dewpoint}$ = Dew point temperature (°F)

p_w = Water vapor partial pressure (psia)

calculated from

$$p_w = \phi\, p_{ws} \qquad (5.19)$$

ϕ = relative humidity, obtained from weather data.

p_{ws} = saturated water vapor pressure, (psia)

calculated from

$$\ln(p_{ws}) = c1/Ta_{rankine} + c2 + c3\,Ta_{rankine} + c4\,(Ta_{rankine}^2) + c5\,(Ta_{rankine}^3) + c6\,(Ta_{rankine}^4) + c7\,\ln(Ta_{rankine}) \quad (5.20)$$

where

$Ta_{rankine}$ = air temperature (°K)

and

c1= -10214.16	c2= - 4.8932631
c3= -0.0053769056	c4= 1.9202377 X 10^{-07}
c5= 3.5575832 X 10^{-10}	c6= -9.0344688 X 10^{-14}
c7= 4.1635019	

<u>If the air temperature is above 32°F</u>

$$t_{dewpoint} = a + b\,(\ln(p_w)) + c\,(\ln(p_w)^2) + d\,(\ln(p_w)^3) + e\,((p_w)^{0.1984}) \quad (5.21)$$

where

a=100.45	b= 33.193
c=2.319	d= 0.17074
e=1.2063	

and

$$\ln(p_{ws}) = c8/\,Ta_{rankine} + c9 + c10\,Ta_{rankine} + c11\,(Ta_{rankine}^2) + c12\,(Ta_{rankine}^3) + c13\,\ln(Ta_{rankine}) \quad (5.22)$$

where

c8 = -1.04 X 10^{04}	c9 = -1.13 X 10^{01}
c10= -2.70 X 10^{02}	c11= 1.29 X 10^{-05}
c12= -2.48 X 10^{-09}	c13= 6.5459673

5.3.3.3 Boundary condition for the insulated bottom

The bottom of the slab was insulated by 1 inch of insulation. However, after examining the results, it was determined that the insulation was not enough and there were air leaks in the insulation. There was a heat loss from the bottom boundary. To account for this heat loss, heat transfer from the bottom of the slab to the ambient air was assumed, through a layer of unknown resistance 'R'

i.e.

$$q_{bottom} = A^* (T_{ambient} - T_{i,j,k}) / R \qquad (5.23)$$

where

q_{bottom} = Heat gain to bottom node from ambient air (Btu/hr)

R = Resistance to account for insulation and air leaks $(Btu/hr/ft^2/°F)^{-1}$

The value of R was determined by a parameter estimation technique discussed in 5.4

5.3.5 Initial temperature profile

To model the slab temperature at any point in time, an initial starting guess for the temperature profile must be provided. In the case of the test runs, the slab temperatures at the top and bottom surfaces were known at the start of each test run. Due to the test runs being carried out on consecutive days, the slab did not totally cool down to the ambient temperature, and an initial temperature profile existed across the cross section of the preheated slab. Initial temperatures at the top and bottom surfaces of the slab were used to assume the existing initial temperature profile of the internal temperatures in the slab at the starting conditions.

The bottom of the slab was insulated in most cases and hence the bottom slab temperature was much higher than the exposed slab top surface temperature. High fluid temperature values at the inlet and outlet gave an indication of high internal fluid temperatures within the embedded pipes. An exponential temperature profile as depicted in Figure 5.4, was assumed to represent initial slab temperature profile

The temperature and depth of the nodes from the top surface were non-dimensionalized and an exponential relation was assumed between the temperature and depth

i.e. $$T^* = (X^*)^N \quad (5.24)$$

where

T^* = Non-dimensionalized temperature

$$T^* = (T - T_{bottom}) / (T_{top} - T_{bottom}) \quad (5.25)$$

T = Temperature at node

T_{top} = Temperature of top surface of the slab

T_{bottom} = Temperature of bottom surface of the slab

X^* = Non-dimensionalized depth of node from top surface

$$X^* = (X_{max} - X) / (X_{max}) \quad (5.26)$$

X = Depth of node from top surface

X_{max} = Maximum depth from top surface

N = Constant

Value of N was determined by a parameter estimation technique as detailed in 5.4.2

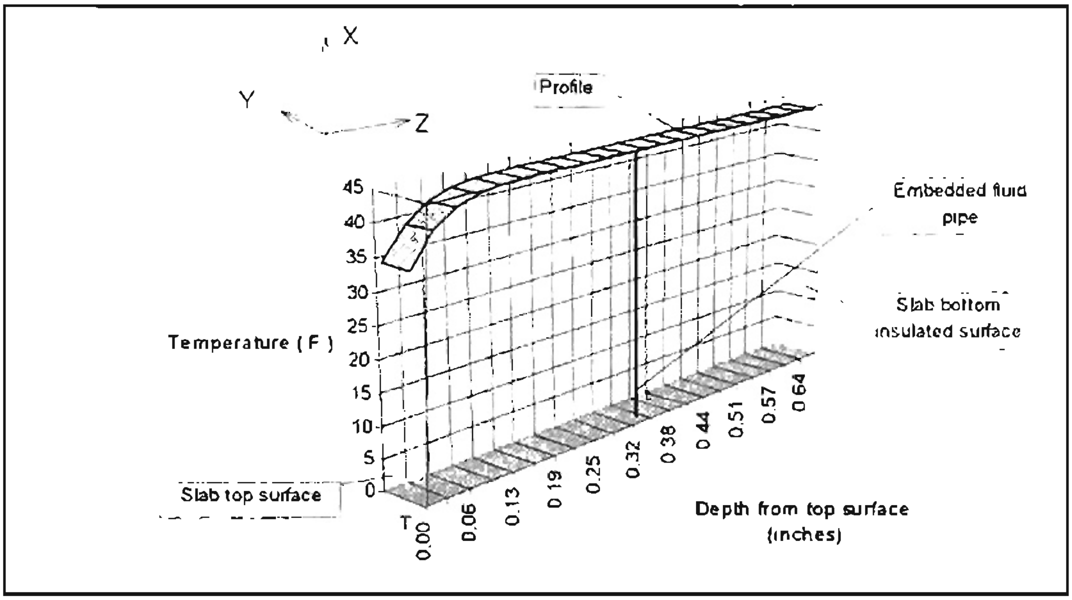

Figure 5.4 Typical initial temperature profile across slab cross section

5.3.6 Program BRIDGE3D

A listing of the FORTRAN code is provided in Appendix G along with the flowchart of the program in Appendix F. As input to the model, we use experimental data. The experimental data used as input to the model are the following:-

1 Slab section dimensions (ft)

2 Fluid pipe diameter (ft.)

3 Properties of the bridge material and the circulating fluid (Density, thermal conductivity and specific heat)

4. Run time (hr)

5 Input fluid temperature to the slab (°F)

6 Input fluid velocity (ft/s)

7. Air temperature (°F)

8. Wind speed (mph)

9 Solar radiation flux(W/m^2)

10. Wind direction (Degrees from north)

The inputs can be read directly from data files or may be considered as user inputs. Results are printed every five minutes corresponding to the experimental data, they are compared with

5.4 Model tuning and validation

An attempt was made to validate the model by running the program BRIDGE3D for test days The model was tested using experimental input data as described in the previous section. Results obtained from the model were matched with the experimental results.

In the initial runs the model results did not match the experimental results within the limits of uncertainty with the initial values of independent parameters used. Due to the variety of independent parameters. there was considerable amount of flexibility to obtain a better match A parameter estimation was carried out to obtain best results.

5.4.1 Nelder Mead Simplex method

A parameter estimation technique was employed to 'tune' the model to obtain better results A minimization method was used to minimize the difference between experimental results and model results. The method used was the Nelder Mead Simplex method in Multidimensions (Press et al., 1986).

The Nelder Mead downhill simplex method algorithm is useful in finding the minimum of a function of more than one independent variable. The algorithm uses the function evaluations to find a minima. It evaluates the function at different locations using initial guesses The algorithm then proceeds to 'zero in' on the minimum value of the function by moving to the least value of the function evaluations. After multiple iterations are performed, a minimum value of the function is calculated within a limit of tolerance as defined by the user

The Fortran code to perform the Nelder Mead simplex method was obtained from Press et al., 1986 The program, called AMOEBA (Appendix H), was modified and used as the main program with BRIDGE3D as a subroutine to minimize the function, using different independent parameters

Error Function

The function to be minimized was defined as the sum of squares of the difference between experimental results and calculated results

i.e

$$\text{Function} = \sum_{i}^{N} (T_{expt} - T_{model})^2 \qquad (5.27)$$

where

T_{expt} = Experimental average surface temperature at 5 minutes intervals

T_{model} = Calculated average surface temperature at 5 minutes intervals

N = Total number of 5 minute intervals during the simulation period

The top surface average temperature was used in the function to optimize all independent parameters, except R as defined in 5.3.3.3. For the optimal value of R, the equivalent resistance offered by the bottom insulation, the bottom surface average temperature was used to compute the function

5.4.2 Optimal values for material properties and empirical constants

Independent property values as obtained from property tables were used as initial guesses to evaluate the error function as defined in Equation 5.27. Experimental data from a particular day (Day7 - 19th -20th March) was used for evaluating the function and determine optimal values of properties and constants. Each individual property was considered as an independent parameter, and a univariate search was conducted to obtain the optimal value of each parameter, which provided the least value for the error function Table 5.2 provides the optimal values used in BRIDGE3D as determined by the above search methodology

Independent parameter	Value Used
Value of exponential power, N to determine initial temperature profile (refer 5.3.5)	15
Heat capacity of concrete (Btu/ft^3 °F)	30 1
Emissivity	0.9
Solar absorptivity	0 6
Concrete thermal conductivity (Btu/hr/ft °F)	0.8

TABLE 5.2 Optimal parameter values used in BRIDGE3D

5.4.3 Optimal values for equivalent resistance - 'R'

The insulation at the slab bottom was not attached properly to the slab bottom surface and air leaks between the insulation and slab bottom reduced the effectiveness of the insulation The equivalent resistance (R) offered by the insulation to the heat transfer from the bottom surface to the ambient air could not be determined accurately The Nelder Mead simplex program 'AMOEBA' was used to determine the value of R (Btu/hr/ft^2/°F)$^{-1}$

The program was run separately using experimental data from 3 days of the test period.

These days were used because of the absence of precipitation load on those days. The days used were

- Day 6 (March 9th and 10th)
- Day 7 (March 19th and 20th)
- Day 8 (March 24th and 25th)

The function to be minimized as defined in Equation 5.27, was calculated using the slab bottom surface temperatures. Different optimal values of R, for the minimum value of the error function were obtained for each of the 3 days. A match of the experimental results with the model results for each of the three days are provided in Figure 5.5, Figure 5.6 and Figure 5.7 respectively Matches between model data and experimental data has been achieved within an uncertainty value of ±2 to±3°F.

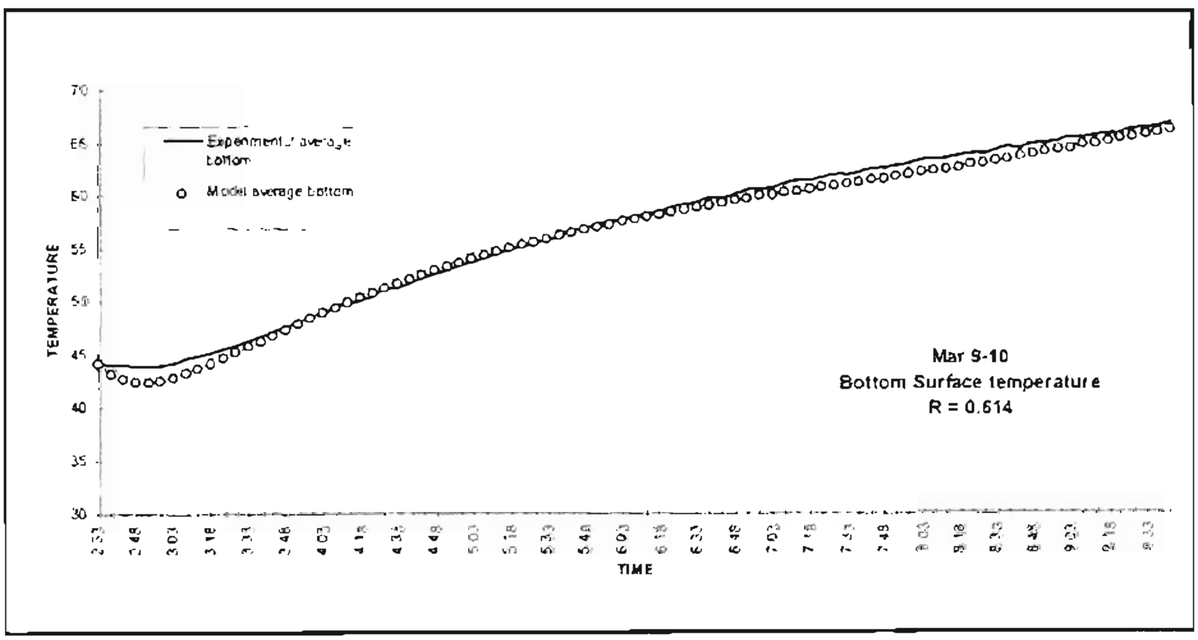

Figure 5.5 Comparison for March 9th and 10th

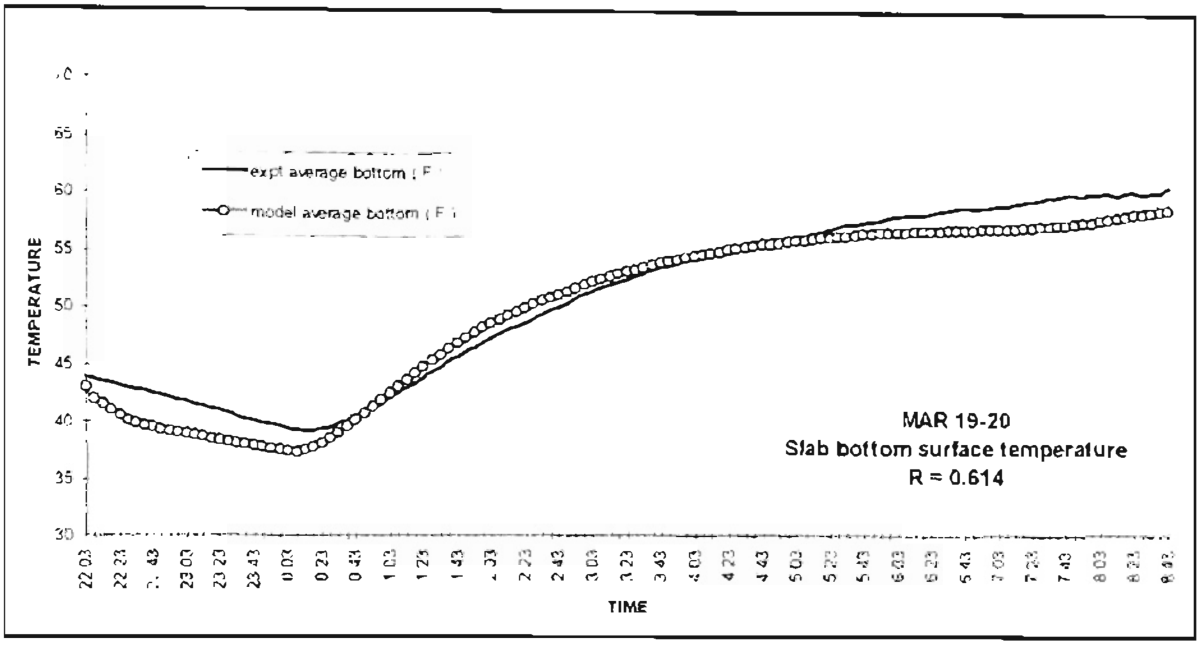

Figure 5.6 Comparison for March 19th and 20th

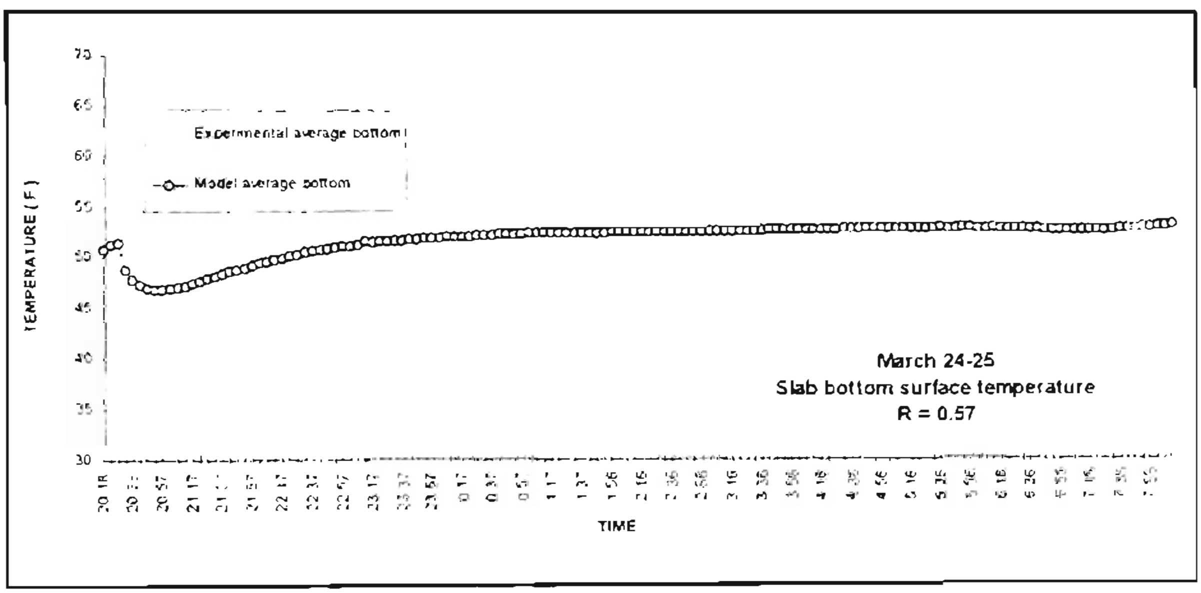

Figure 5.7 Comparison for March 24th and 25th

5.4.3 Optimal values for convection coefficient h_c

The convection coefficient h_c is calculated from Equation 5.15 as

$$h_c = 5.678\left(a + b\left(\frac{V}{0.304}\right)^n\right)$$

As discussed in 5.3.3.1, the values of the constants a and b are not used from Table 5.1, but have been used as independent parameters to determine the optimal value of h_c to minimize the error function. Program AMOEBA, applying the Nelder Mead Simplex method was used for this purpose. The error function was defined by using the slab top surface temperatures. The constants a and b were used as the independent parameters, for the minimization technique. Different values for a and b were obtained for the 3 test days. The results are presented in Figure 5.8, Figure 5.9 and Figure 5.10 respectively with the values of a and b used. Matches between model data and experimental data has been achieved within a uncertainty value of ±2 to±3°F.

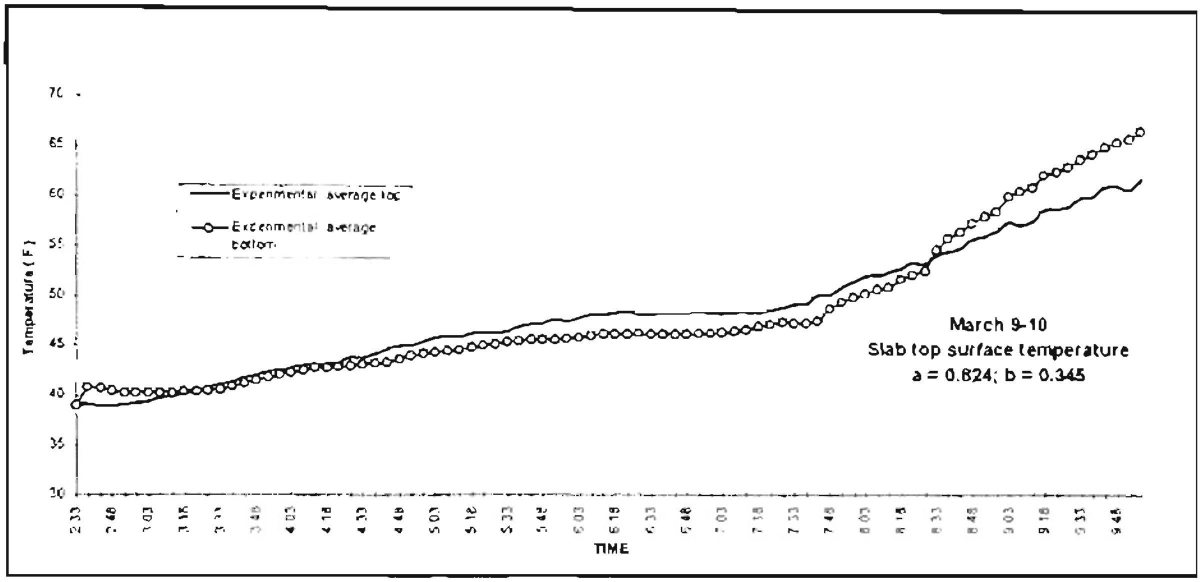

Figure 5.8 Comparison for March 9th -10th

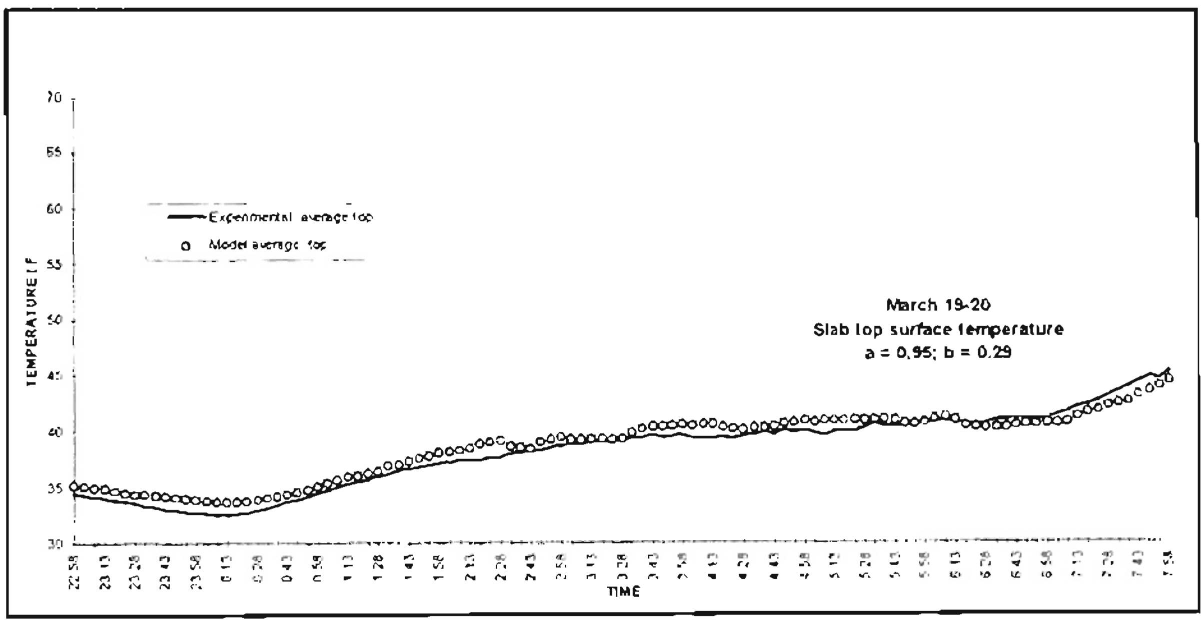

Figure 5 9 Comparison for March 19th -20th

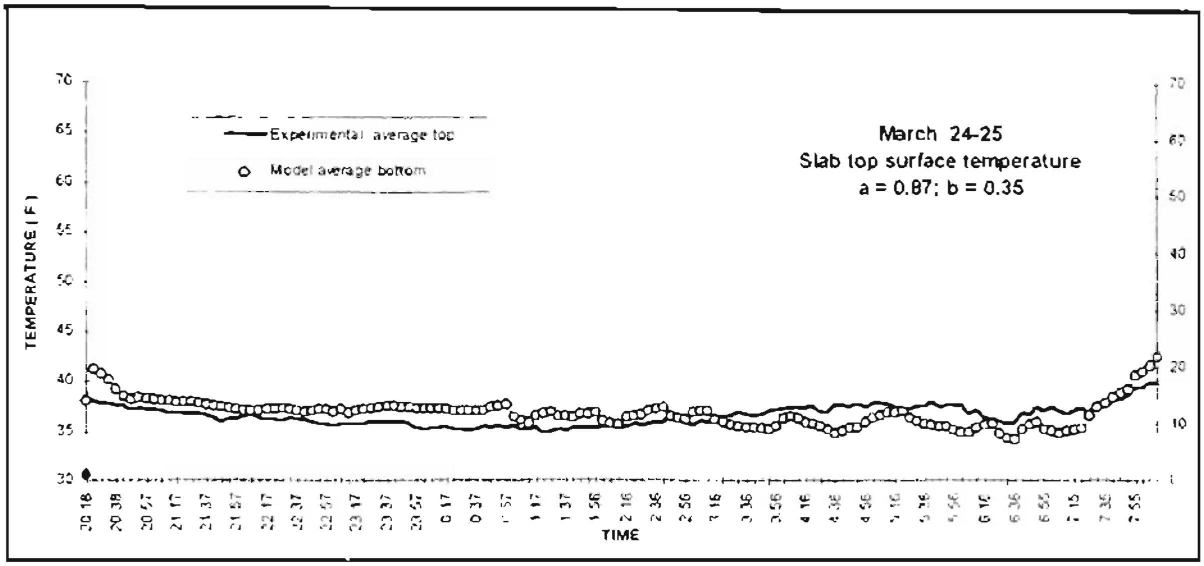

Figure 5.10 Comparison for March 24th -25th

5.4.4 Final model results

Different values of R and h_c were obtained for the three test days. Interchanging the values for the other days did not produce matches within an uncertainty limit of ±5°F It was required to find an general value of R and h_c which would give a match for all 3 days within low uncertainty limits. A separate Nelder Mead search was carried out for an optimum value of R and a and b of h_c. The error function defined was the sum of the error function of all 3 days

i.e.

$$\text{Function} = \left(\sum_{1}^{N} (T_{expt} - T_{model})^2\right)_{\text{Day } 6} + \left(\sum_{1}^{N} (T_{expt} - T_{model})^2\right)_{\text{Day } 7} +$$

$$\left(\sum_{1}^{N} (T_{expt} - T_{model})^2\right)_{\text{Day } 8} \qquad (5\ 28)$$

Minimizing the above error function, optimal values of R, a and b were obtained A univariate search was then performed in the vicinity of these values to obtain a better general value for the constants. Ultimately the following values were used in the final computer model BRIDGE3D.

R	0.614
a	0 775
b	0.35

Using the following values for the above constants, the model results were compared to the experimental results for the 3 test days

Validation of the model has been done by comparing the model results with the experimental results. The experimental results used as a check for the model were the following three temperatures:

- Average slab top surface temperature (°F)
- Average slab bottom surface temperature (°F)
- Outlet fluid temperature (°F)

The model was run for the 3 test days Experimental data as discussed in section 5.3.4 was used as an input to the model. An attempt was made to match the model results with the experimental results for each test run within the uncertainty error limits of the experimental data. Results were printed every 5 minutes. The results are presented in Figure 5.11, Figure 5.12 and Figure 5.13. The results matched with the experimental data within error limits of ±2°F

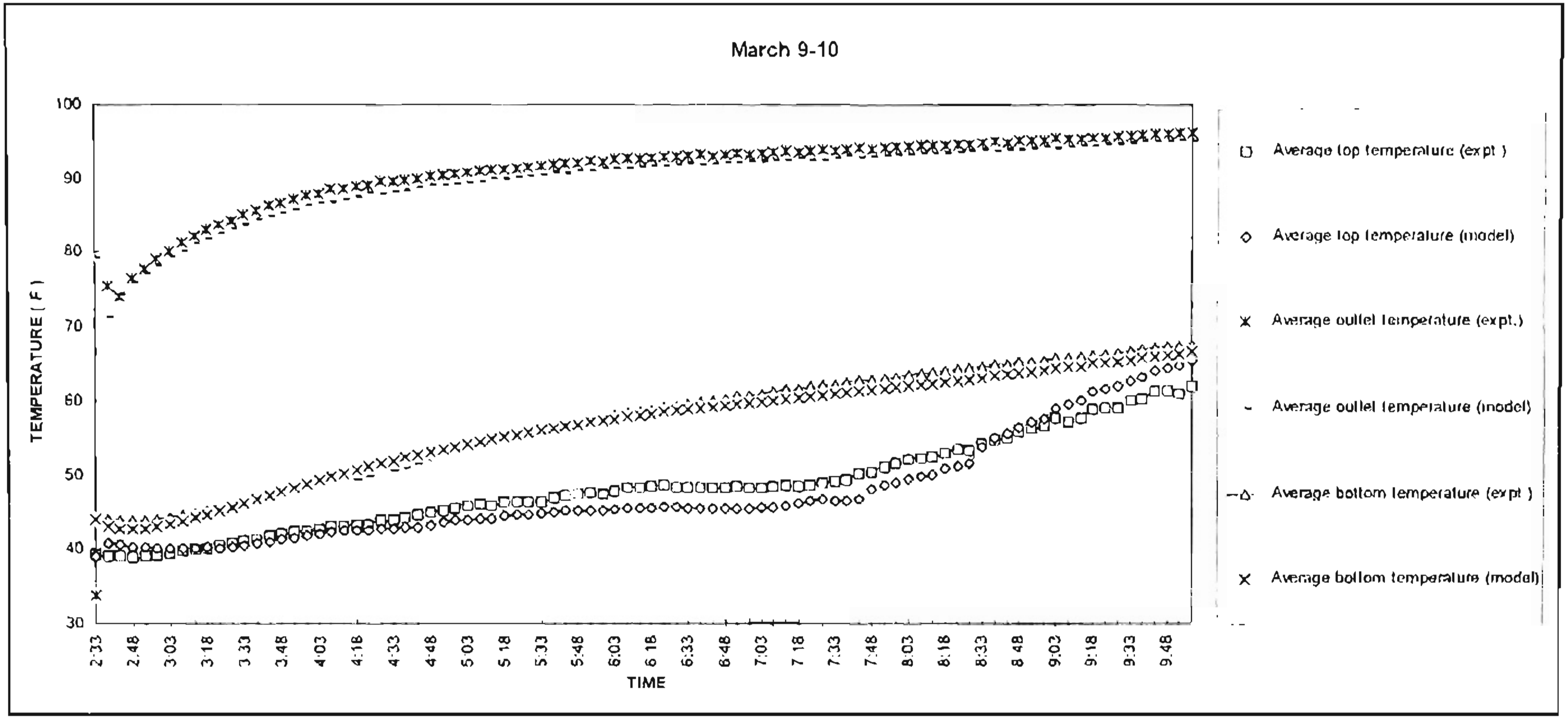

Figure 5.11 Final model results for 9th and 10th March

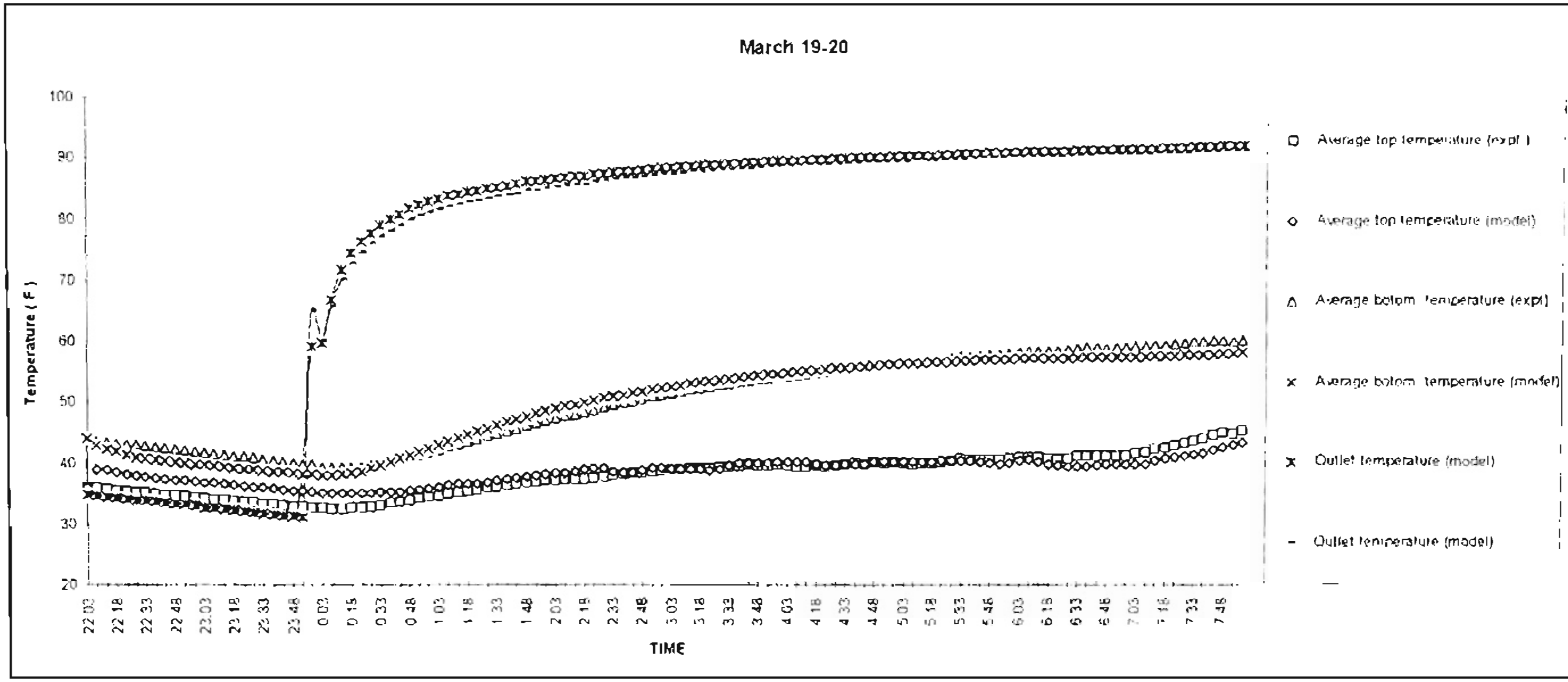

Figure 5.12 Final model results for 19th and 20th March

CHAPTER SIX

Discussion of the Results

6.1 Comparison of heat input results with previous models

One of the prime objectives of the study was to determine the amount of heat input required and the time of its application to prevent the concrete slab from freezing. Experimental results presented in Chapter 4 are analyzed to study the thermal performance of the experimental bridge deck heating system.

It can be seen that the heat input by the ground source heat pump raised the temperature of the slab over the ambient temperature for all days. However, in the case of the days with freezing ambient conditions, when precipitation was applied to the slab surface, this heat input alone was not sufficient to raise the temperature of the slab above freezing. Additional heat input in the form of solar radiation was necessary to raise the slab surface temperature above freezing. Figure 6.1 compares the heat inputs from the heat pump for the eight test days. The heat input noted is the average heat input for the each nightly test run. The heat inputs ranges from 160-205 Btu/hr./ft^2. The low value of 160 Btu/hr./ft^2 was recorded for a day with ambient temperatures relatively higher than those for the other test days. The average heat input for test runs with air temperatures below freezing was approximately 180 - 200 Btu/hr./ft^2. The heat fluxes have been provided with their error bars (± 9.4 %), as determined in Chapter 3.

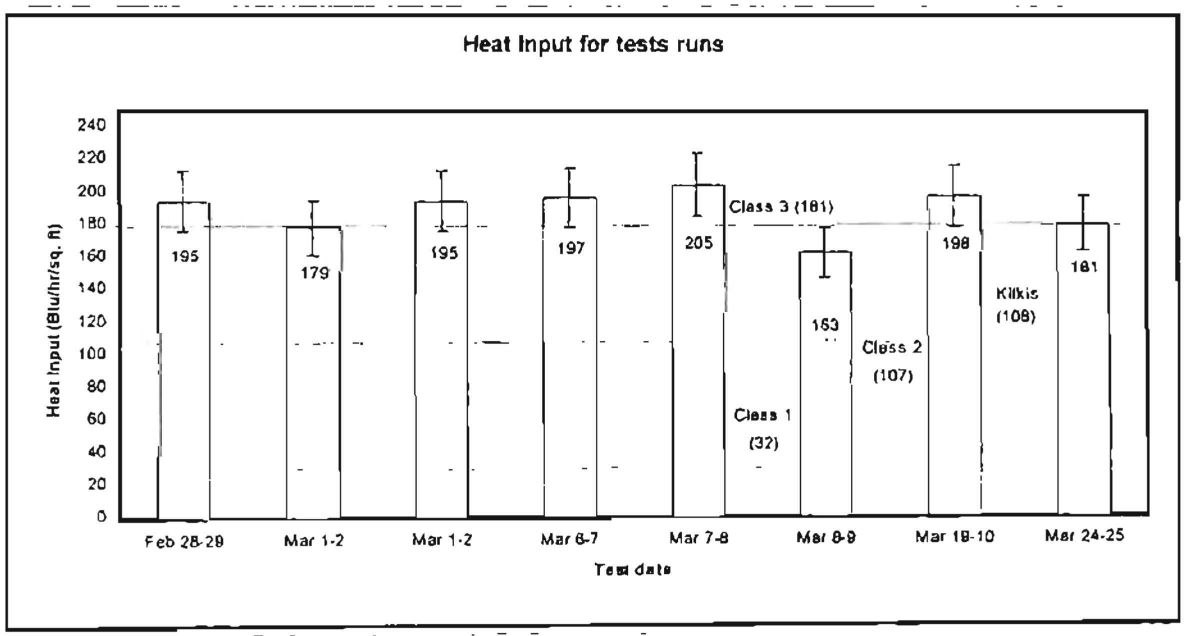

Figure 6.1 Heat input flux for test days

6.1.1 Heat requirements calculated using ASHRAE and Kilkis models.

Using the ASHRAE and Kilkis models for the day with the most severe weather conditions (March 7^{th} -8^{th}) encountered during experimentation, heating requirements were estimated for "snow melting", with the "snowfall rate" equivalent to the highest rate of artificial precipitation. Table 6.1 presents the results obtained for heat requirements for both the models, along with the input parameters used. The calculated heat inputs for all three snow melting classes by using the ASHRAE guidelines have been depicted in Figure 6.1 by the labeled horizontal lines. The dashed line in Figure 6.1 indicates the heat input requirement for a Class 3 system by applying the Kilkis model to the experimental site.

Input parameters	ASHRAE MODEL	KILKIS MODEL
Rate of snowfall (inch/hr)	0.04	0.04
Air temperature (°F)	13	13
Relative humidity (%)	40.5	40.5
Wind Speed (mph)	16	16
Film temperature (°F)	33	33
Coincident air temperature (°F)	not applicable	18.4*
Adjusted wind speed (mph)	not applicable	6
Sensible heat transferred to snow (Btu/hr/ft^2)	1.98	1.41
Heat of fusion (Btu/hr/ft^2)	29.84	29.84
Heat of evaporation (Btu/hr/ft^2)	64.05	18.34
Convection and radiation heat transfer (Btu/hr/ft^2)	85.87	not applicable
Convective heat transfer (Btu/hr/ft^2)	not applicable	17.86
Radiant heat transfer (Btu/hr/ft^2)	not applicable	40.95
Heating loads		
Idling load (Btu/hr/ft^2)	145	93
Snow melting - Class 1 (Btu/hr/ft^2)	32	93
Snow melting - Class 2 (Btu/hr/ft^2)	107	93
Snow melting - Class 3 (Btu/hr/ft^2)	181	108

* Measured value of 13°F used.

TABLE 6.1 Heat requirements for snow melting for test site

The three systems are classified on the basis of their performance of snow melting during snowfall. As there was no snowfall during the test period, the bridge deck heating system cannot be classified based on its snow melting performance.

The Kilkis and the ASHRAE models assume idling of the system to maintain the top slab temperature above freezing, before actually using it to melt any snow. The heat requirements in Table 6.1 for snow melting for the experimental were calculated for extreme conditions with the maximum amount of precipitation applied, which is not the case for all days. It can be seen that, **without idling, as the system was operated,** the Kilkis or the ASHRAE models may underpredict the heat requirements to melt the ice on the surface for some days. Both the models suggest that the heat input to the slab from the heat pump alone was sufficient to melt all the snow from the slab surface, leaving it totally snow free (A_r=1). During experimentation it was observed that the heat input on its own was not sufficient to melt all the ice formed by a high precipitation rate. Additional heat from solar radiation was necessary to raise the slab surface temperatures above freezing.

6.1.2 Idling

The heat requirements calculated by the ASHRAE and the Kilkis models to melt surface ice are based on the system being idled before actual melting begins. The slab would therefore be preheated to a temperature above freezing conditions. In the test runs, the slab was never idled and was always started cold before precipitation. This absence of idling was considered to be a prime reason the slab surface temperature did not rise above freezing conditions during the experimental runs. The numerical model was used to examine the importance of idling in the performance of the existing bridge deck system.

6.2 Transient performance of the system

Certain papers in the literature survey revealed that one of the main decisions while running such deicing systems was determining the time period required to start the system prior to the snowfall event, to prevent the bridge deck or road surface from freezing during snowfall. It was required to determine the amount of heat input required along with the time of its application to prevent the freezing of the bridge deck. It is necessary to know the transient response of the system to decide on the above factors. The availability of the transient response of such a deicing system would be useful in the design of 'smart' bridge decks.

6.2.1 'Smart' bridge deck

One of the long term objectives of the study is to build a 'smart' bridge deck (Spitler and Hogue, 1995). Such a system would use the local short term weather forecast to determine the heat input required and the corresponding time period to prevent any icing on the surface. In Oklahoma, the control on such a 'smart' bridge deck can be greatly enhanced by the use of the Oklahoma Mesonet. Data collected by the local Mesonet station can be analyzed and the weather conditions predicted accurately by computers. An automatic signal sent from the Mesonet base station would turn the heating system on and warm the bridge deck well in advance to prevent any icing on the surface. The system would be automatically turned off when the icing risk was past. Such a 'smart' system would need to know the transient response of the heating system.

6.2.2 Transient response using computer model.

The transient response of the installed system was studied for different ambient conditions and various input fluxes into the heating system. The computer model developed in Chapter 5 was used for this purpose.

The limitations to applying the computer model developed in Chapter 5 for the purpose of studying the bridge deck transient response were the following:

1. The computer model was developed for 'dry' conditions only. Any precipitation load was not included in the calculations. The model was used to determine response for dry conditions and some 'wet' conditions involving precipitation. If the precipitation load is neglected for 'wet' conditions, the model may under predict the heat input required. However the ensuing study gave a rough estimate of the heat requirements

and the response of the system. Future work in developing the computer model would incorporate precipitation loads.

2. Empirical coefficients and exact values for material properties used in the model were obtained by parameter estimation techniques (section 5.4). The values used were obtained by minimizing the sum of the squares of the differences between the model and experimental data from three days. These general values obtained after a parameter estimation were assumed to be consistent for different ambient conditions on different days.

The transient response of the system was studied using weather data from two test days from the Winter of 1995-96. These days were chosen because of the presence of low ambient temperatures and the occurrence of natural precipitation which later froze to form ice on the road surfaces. Transient performance of the system for Day 5 (March 7th and 8th) was also studied using the model, and results compared to experimental data.. Weather data was retrieved from the archives of the Oklahoma 'Mesonet'.

6.2.1.1 Test Day 1 (December 24-25th 1995)

There was some rainfall on the night of December 24th, which later froze and was converted to ice on the road surfaces. The hypothetical transient response of the installed system under the ambient conditions was studied by running the model by using the day`s weather data. A weather plot for the day from 12:00 am December 24th to 11:45 p.m. 25th December is provided in Figure 6.2.

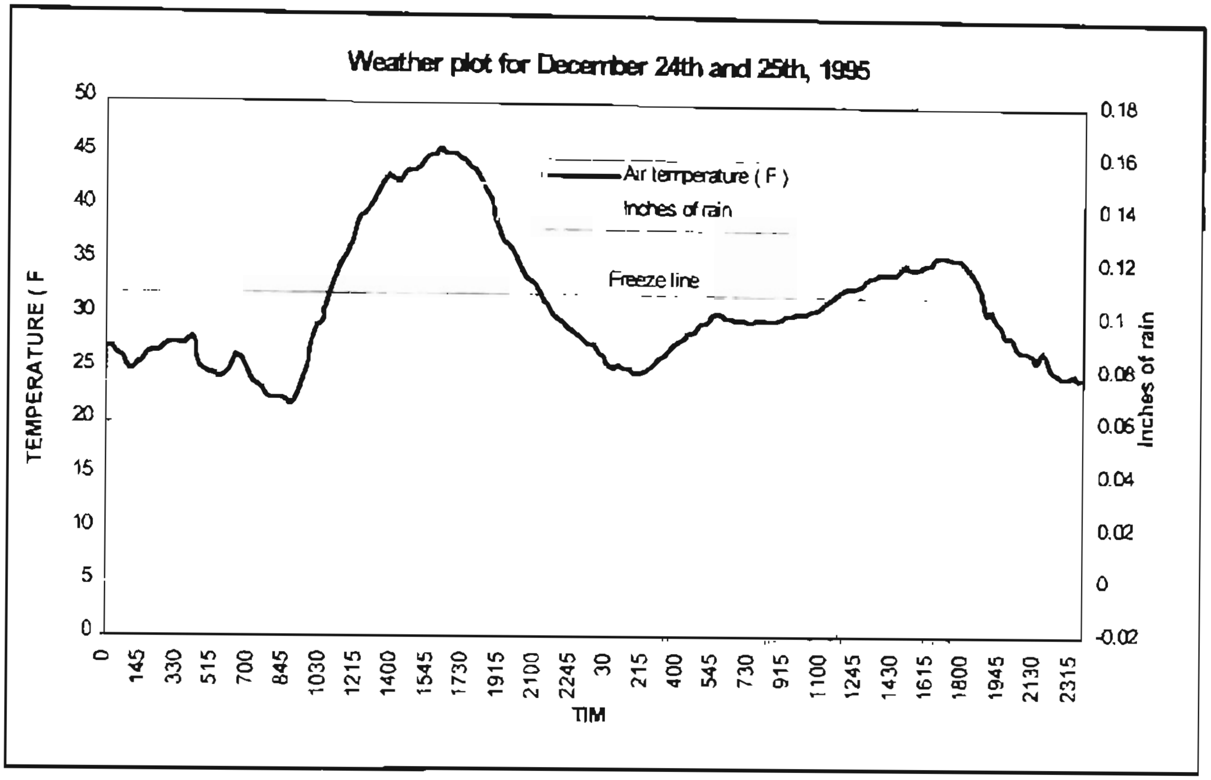

Figure 6.2 Weather plot for December 24th and 25th 1995

The program BRIDGE3D simulated the slab response to different heat inputs to the slab for the day's weather conditions. The heat input was varied by changing the fluid input temperature to the bridge deck. For the experimental bridge deck higher, fluid temperatures could be attained by replacing the present heat pump with a larger capacity heat pump.

Note: It was assumed that the fluid temperature reaches its maximum value as soon as the heating is switched on. In the case of a hydronic system using a heat pump, this would not be true, and the system would take some time to achieve its maximum temperature. However, as determining this time period would require a detailed study of the heating system assumed, it was not considered and an instant temperature rise was assumed.

Figure 6.3 shows the transient response of the slab for different entering fluid temperatures. As a reference, the temperature profile of the unheated slab top surface has also been provided. For each of the different fluid temperatures the critical time period to prevent slab freezing (assuming 33 °F as the cutoff temperature for the top slab surface) was determined by trial runs for each fluid temperature. Latest start times for each fluid temperature is provided in parenthesis in the Figure. Results were calculated every fifteen minutes. Minimum heating time periods to prevent freezing of the slab are presented to the nearest fifteen minute period in Table 6.2.

TEST DAY 1 December 24th and 25th 1995		
Entering Fluid Temperature (° F)	Minimum operation time period before to prevent freezing (minutes)	Average Heat Flux (Btu/hr/ft^2)
50	75	70
60	60	110
70	60	151
90	45	233

TABLE 6.2 Transient response of the slab (test day 1)

It must be noted that the above heat requirements and heat inputs do not take into account the precipitation occurring during the simulation period. If the precipitation is accounted for, the heat inputs requirement would be larger. Some of the heat input would be used to melt ice (if freezing rain or snow occurs) and to evaporate water from the surface of the slab. In addition, the convection heat transfer may be higher when the bridge surface is wet. As can be seen from Table 6.1, the evaporative load can be a high load requirement. The results in Table 6.2 underpredict the heat requirement because precipitation is not accounted for. The results however give a general idea as to the response of the system. The evaporative load for all heat inputs will remain the same and can be added as a constant value to the heat flux calculated by the model.

For this night, the minimum time period required to raise the slab temperature was 45 minutes, with a minimum entering fluid temperature of 90°F. A temperature of 60°F was sufficient to raise the temperature above freezing for a minimum start time of 60 minutes.

The average input heat fluxes for various inlet temperatures are summarized in Table 6.2. The heat fluxes vary and Figure 6.4 depicts the heat flux over time for the corresponding entering fluid temperature.

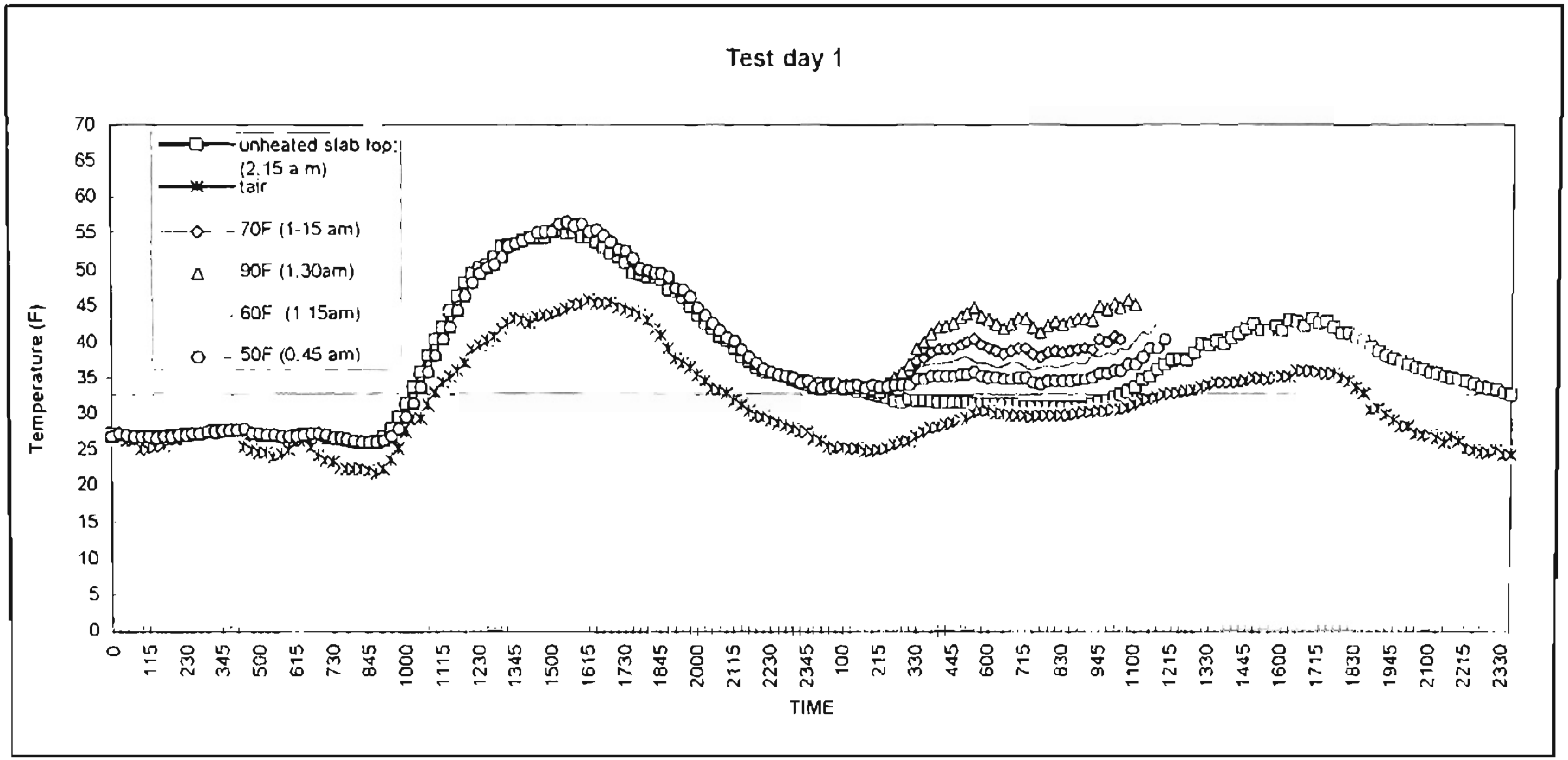

Figure 6.3 Transient response of slab top surface (test day 1)

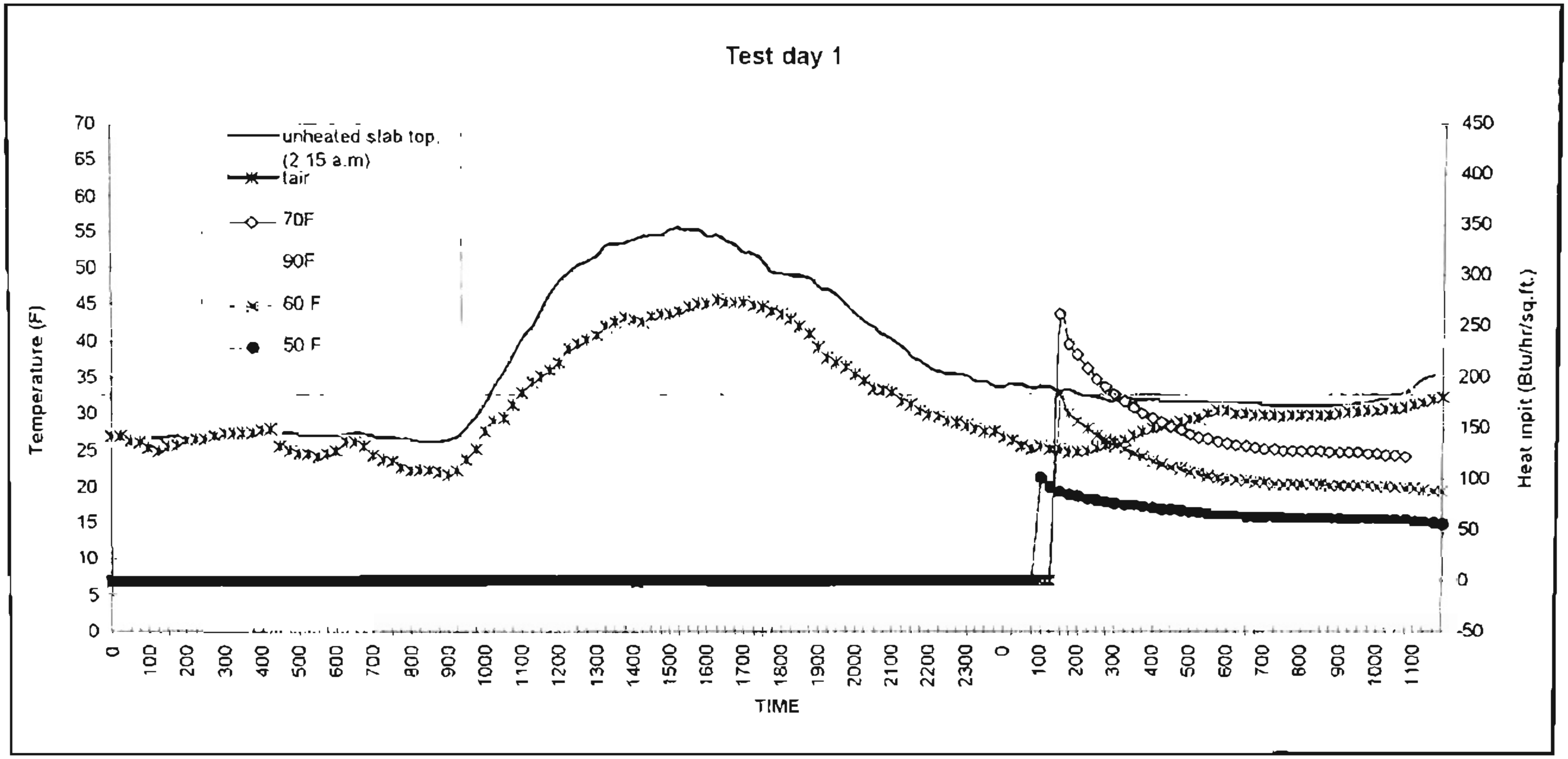

Figure 6.4 Heat input fluxes to the slab (test day 1)

6.2.1.2 Test day 2 (February 5th and 6th)

Similar to the simulation carried out for test day 1, a simulation to determine the transient response of the slab for different entering fluid temperatures and the minimum critical time period required to prevent the slab from reaching a temperature below 33°F was carried out. The weather condition for the period is depicted in Figure 6.5. Rainfall was followed by a drop in the ambient temperature which formed ice on the road surfaces, leading to hazardous road conditions. The response of the slab temperature is presented in Figure 6.6.

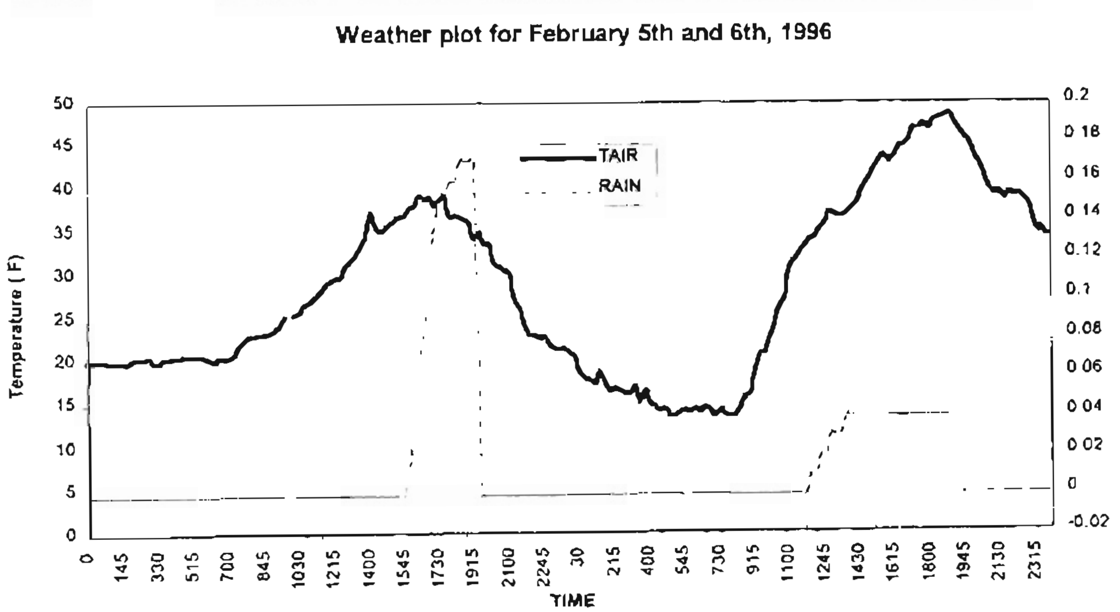

Figure 6.5 Weather plot for February 5^{th} and 6^{th} 1996

TEST DAY 2		
Entering Fluid Temperature (° F)	Minimum operation time period to prevent freezing (minutes)	Average Heat Flux (Btu/hr/ft^2)
50	never rises above freezing	85
60	30	110
70	30	123
80	15	200

TABLE 6.3 Transient response of the slab (test day 2)

A temperature of 80°F was sufficient to prevent freezing of the slab, if the system was switched on 15 minutes in advance of when freezing would have occurred. Beyond 30 minutes a temperature of minimum 60°F was required. Temperatures below 60°F could not raise temperature above freezing in time. Fluid of 50-55 °F, with an input of 85 Btu/hr/ft ^{2} was circulated but could not raise the slab above freezing inspite of being run for a period of 48 hr. in advance of the specific freezing event. Flux data is provided in Figure 6.7.

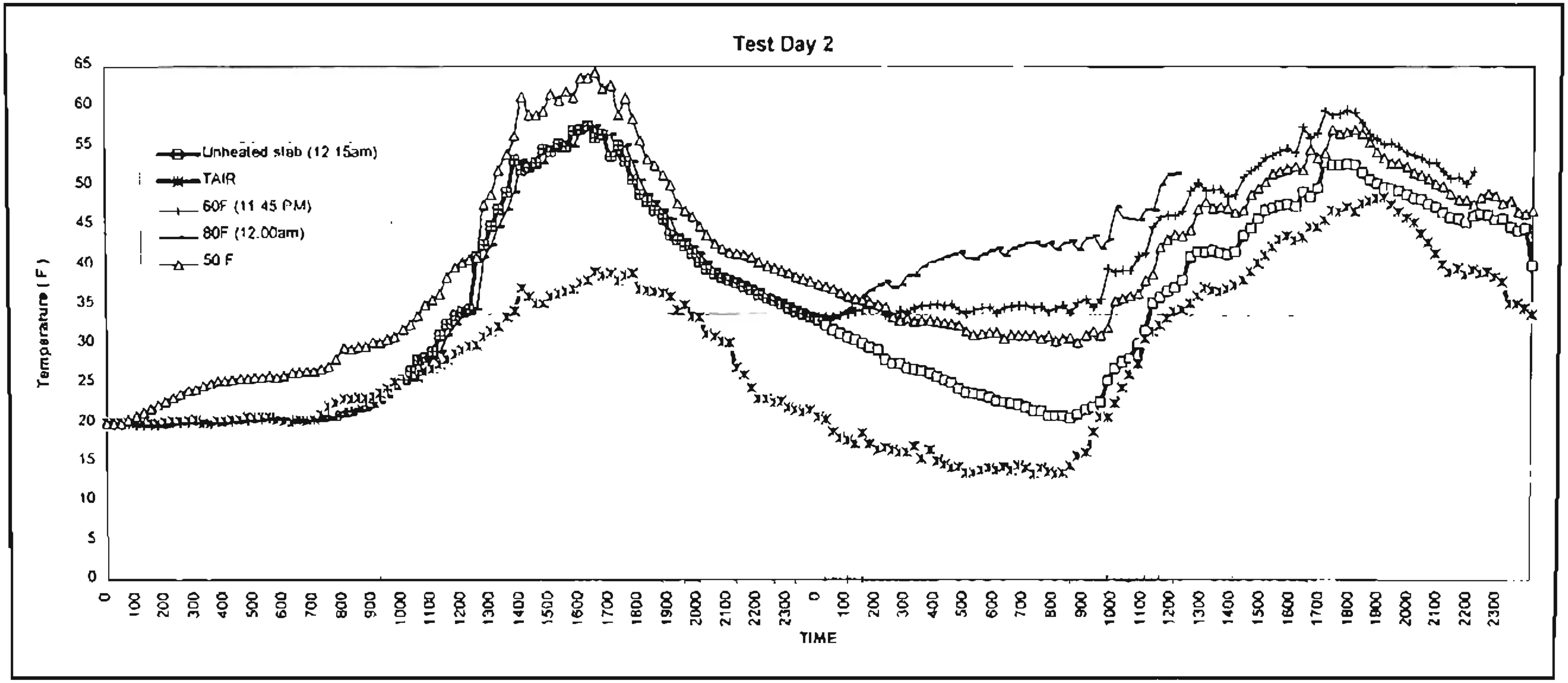

Figure 6.6 Transient response of slab top (test day 2)

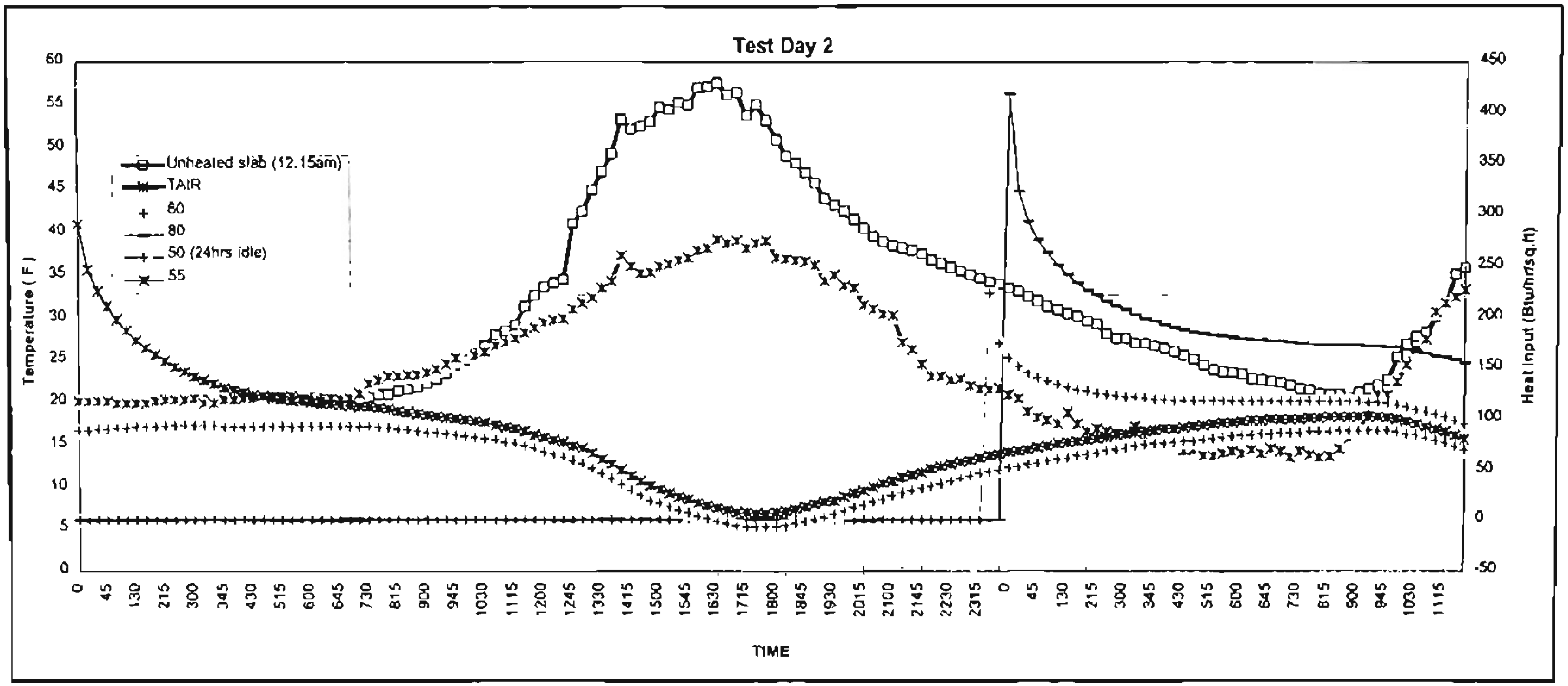

Figure 6.7 Heat input fluxes to the slab (test day 2)

6.2.1.3 Test day 3 (day 5 - March 7th and 8th)

The model was also tested for one of the experiment days which had an artificial precipitation load. On March 7th and 8th, artificial precipitation was sprayed on the slab at the start of the experiment. Weather conditions were much more severe[1] than those for the previous test days. The heat pump was started two hours after spraying the surface. The slab temperature did not rise above freezing, till sunrise.

The model attempted to duplicate the experimental data. Figure 6.8 shows the transient response of the slab using the model, labeled "93F (23.30 p.m.)". The experimental temperature data is lower than the model results, this could be attributed to the precipitation effect. The model does not account for the precipitation and hence predicts temperatures higher than actual. The trend in the data is however the same. The model also predicts that the slab would not have reached temperatures above freezing till sunrise. Heat input due to the heat pump is depicted in Figure 6.9.

A range of input temperatures and application times were simulated to investigate other operating strategies. Only two temperatures are presented here. The first is the same temperature as that of the actual inlet temperature, but was applied for more than 24 hours, labeled as "93F (0 a.m.)". The second simulation plotted, is for an inlet temperature of 130°F, applied at 12 a.m. on 7th March. Heat input flux for this temperature was approximately 350 Btu/hr/ft^2.

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[1] Freezing precipitation does not usually occur in Oklahoma under the sort of extremely cold conditions (clear sky) that were present on March 7th and 8th. A statistical analysis will be necessary to determine if there is any significant probability of precipitation under these conditions.

Although this represents an extreme requirement (inlet temperature of 130°F), it is not at all clear if freezing precipitation ever occurs under the cold clear sky conditions. Further analysis of the historical weather data is needed.

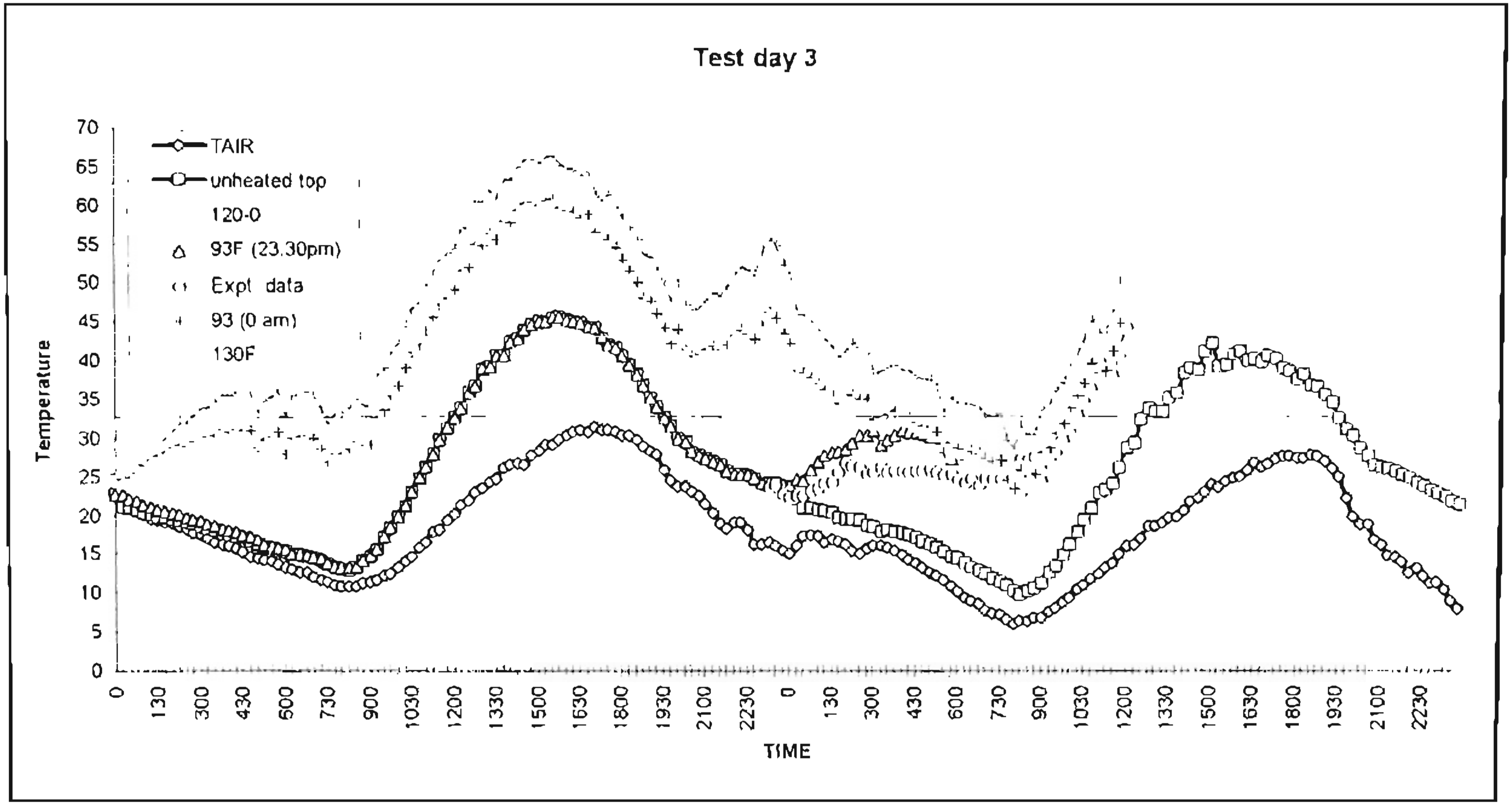

Figure 6.8 Transient response of slab top surface (test day 3)

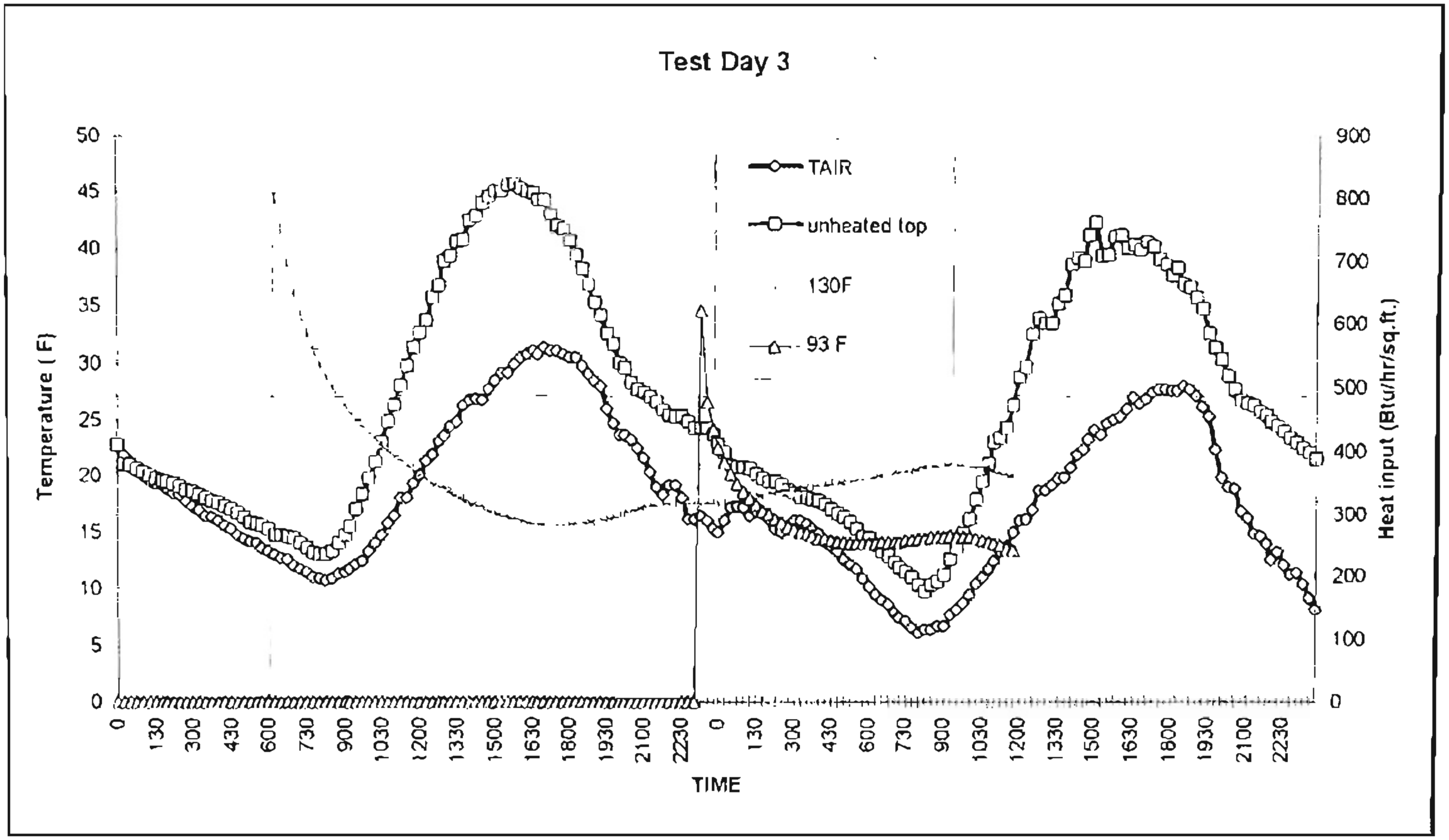

Figure 6.9 Heat input fluxes to the slab (test day 3)

6.2.1.4 Heat loss calculated by BRIDGE3D and ASHRAE

The heat flux as calculated by the ASHRAE model required for a day like test day 3 would be approximately 225 Btu/hr/ft ^{2}. This heat flux is valid for snow melting incidence, whilst there was no snowfall on test day 3. However these would provide an upper bound for the heat input requirement as the precipitation load for test day 3 does not exist. Simulation for test day 3 shows that a heat input of 350 Btu/hr/ft ^{2} was required to keep surface temperature above freezing. The reason for this could be attributed to the convection and radiation losses, as calculated by both models (ASHRAE and BRIDGE3D). The relations provided by ASHRAE guidelines underpredict the convective and radiative losses for the bridge test slab. The ASHRAE relations derived for road surfaces and pavvements may not be relevant to the test slab. Figure 6.10 provides a comparison of the convective and radiative losses as calculated by the ASHRAE relations and the computer model BRIDGE3D for test day 3.

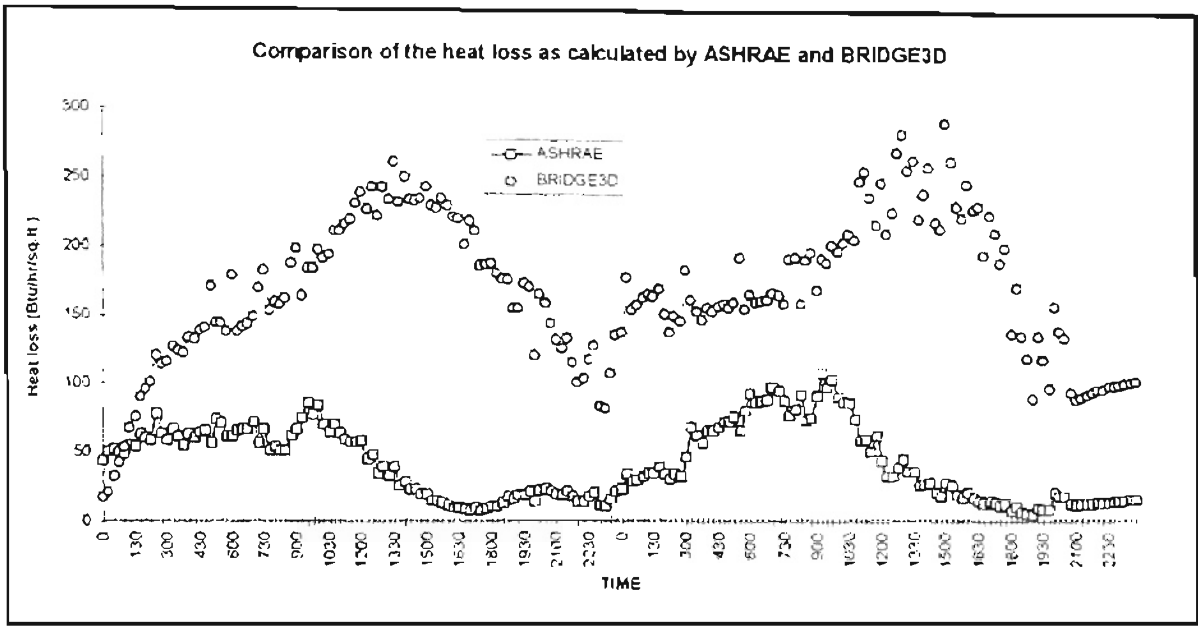

Figure 6.10 Heat loss comparison between ASHRAE and BRIDGE3D

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

An experimental facility was constructed to study the feasibility of using ground source heat pumps for bridge deck deicing. The test bridge deck built was essentially a concrete slab insulated on all sides, except the top to represent the middle section of a bridge deck. Due to the time spent initially on building the experiment and putting it into operation, the snow season for the year was missed. Experiments were hence performed by simulating artificial precipitation by using a hand held spray. A very detailed numerical model was developed and validated using the experimental data. Based on the experiments run and subsequent simulations performed, using the numerical model, the following conclusions can be made about the bridge deck deicing system:

- The bridge deck deicing system, as built, appears to be a feasible method, however the system was unsuccessful in melting any ice during the test phase. This was because for all the experiments performed, the system was switched on only after the slab temperature was below freezing. A more careful review of the literature revealed the necessity for the idling of such snow melting systems in advance of the freezing conditions to effectively melt snow / ice on the slab surface. The design heat requirements for snow melting systems presented in the ASHRAE handbook presume idling of the system prior to the freezing event. For low input fluxes, and extremely low air temperatures, the system does not raise the slab temperature above freezing, despite idling the system.
- The present system was found to be very slow in melting the ice formed on the slab surface. This was primarily due to the relatively low temperature of the circulating fluid in the pipes. The heat flux input to the slab was not high enough to melt ice for low air temperatures and high precipitation rates.
- For higher rates of precipitation, the ice did not melt until added heat flux from solar radiation warmed the deck the following morning.
- Heat input to the bridge deck was between 150 - 200 Btu/hr/ft^2. The design heat load for this kind of system according to the ASHRAE guidelines was

recommended to be 181 Btu/hr/ft^2 for snow melting, using weather data from the coldest day during experimentation phase.

- The computer model developed to predict the performance of the bridge deck calculated higher inputs those recommended by ASHRAE guidelines, despite calculating the input heat flux requirements for ASHRAE by using the most extreme weather conditions. The computer model predicted the transient response of the system and calculated higher input requirements for the system than those developed by ASHRAE. Convection and radiation losses as calculated by ASHRAE were found to be much lower than those computed by the numerical model.

7.2 Recommendations

The experimental facility and numerical model were used to investigate the feasibility of a bridge deck deicing system. While several aspects of the feasibility were established, there are some additional questions which need to be addressed. The absence of snow and other weather conditions precluded further experimental investigations. The following recommendations for a further study can be made:

- Perform some experiments while idling the system and running it prior to the application of precipitation.
- A statistical study of the weather should be made to determine the day with the most severe weather conditions under which natural precipitation occurs. The system should be sized with the requirements calculated by using these weather conditions.
- Only about 30-40 % of the heat output delivered by the heat pump went to the slab. There was considerable amount of heat loss to the ground and also to the atmosphere. This limited the input heat flux for the experimental facility. A higher inlet temperature can be achieved by using a higher capacity heat pump, or adding an auxiliary heater, or reducing the underground pipe heat loss by insulating the pipes.
- The insulation thickness for the bottom of the bridge slab insulation was small. The insulation thickness and air tightness should be improved to reduce unnecessary weather losses.

- The instrumentation and experimental procedure should be modified for more accurate results. Specific improvements that need to be made include grounding the thermocouples wire shields and taking voltage readings from the flow meter continuously throughout the experiment and not at discrete intervals. More careful calibration of inlet and outlet thermal probes is necessary and more internal slab temperatures should be acquired.
- The computer model should be modified to incorporate precipitation.
- Further validation and improvement of the model by acquiring more experimental data under a wider range of conditions.

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APPENDICES

Appendix A

GS-4™ Properties

GS-4™ properties
Fluid Properties and Engineering Guide
Vanguard Plastics, Inc.

TABLE A-1

Product specifications

COMPOSITION	50 % minimum potassium acetate plus corrosion inhibitors, by weight
APPEARANCE	Clear, green mobile liquid. free from matter in suspension
DENSITY at 68 °F	10.4 - 10.8 lb./gal
VISCOSITY	
at 68 °F	6.4 cp typical
at 32 °F	12.3 cp typical
FLASH POINT	Non- flammable
FREEZING POINT	Less than -58 °F
MISCIBILTY WITH WATER	Complete
STORAGE	Should be stored and handled in its original containers or in equipment made of polyethylene, stainless steel, lacquer lined, mild steel or glass.

TABLE A-2

Properties of Brine solution used in experiment

Properties	GS-4
% by Volume	33 %
Freeze point (°F)	12
Specific heat (Btu/lb. °F)	0.87
Specific gravity	1.11
Viscosity (centipoise)	3.1
Thermal Conductivity (Btu/hr. ft.°F)	0.22

A-3

Regression Analysis of Property Data GS-4™ Heat Transfer Fluid

1. Viscosity

$$\log(\mu) = (-0.135)\,T_k + (2.62 \times 10^{-4})\,T_k^{\,2} + (0.172)\,(0.506\,C) + (-5.64 \times 10^{-4})$$
$$(T_k\ (0.506\,C)) + 17.5$$

where

μ = Viscosity (centipoise)

T_k = Temperature (° K)

C = Concentration (% wt.)

2. Density

$$\rho = (-2.26 \times 10^{-4})\,T_c + (6.06 \times 10^{-3})\,(0.506\,C) + 0.99$$

where

ρ = Density (gm/cc)

T_c = Temperature (° C)

3. Specific Heat

$$C_p = (-6.77 \times 10^{-3})\,(0.506\,C) + (1.4 \times 10^{-4})\,T_c + 1.01$$

where

C_p = Specific Heat (Btu/lb °F)

4. <u>Thermal Conductivity</u>

$$k = (7.17 \times 10^{-4})\, T_c + (8.5 \times 10^{-1})\,(0.506\, C) + (1.8/(0.506\, C) + 0.107$$

where

k = Thermal Conductivity (Btu/hr./ft/°F)

5. <u>Freezing point</u>

$$\text{Freezing point} = (-0.167)\,(0.506\, C) + (-2.06 \times 10^{-2})\,(0.506\, C)^2 + 0.0$$

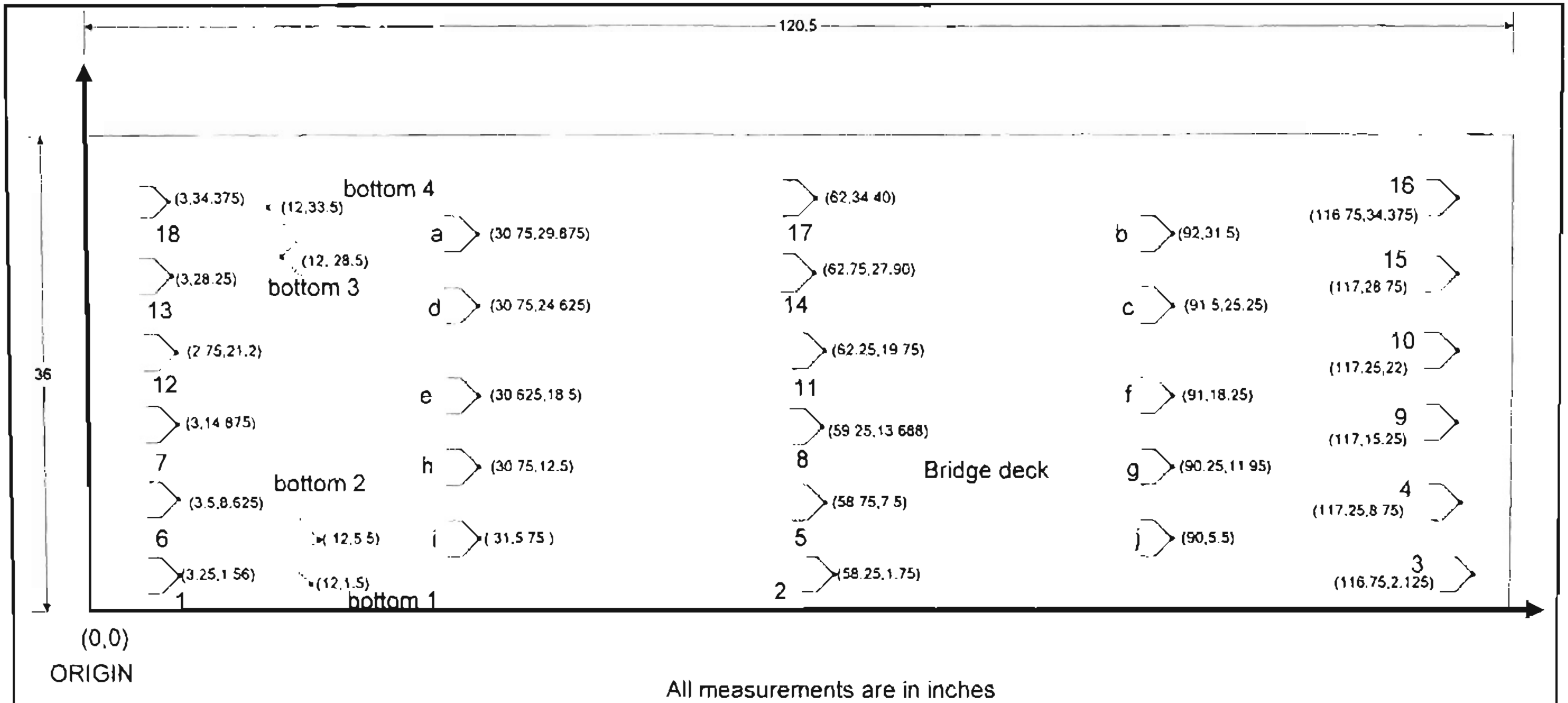
where

Freezing point = °C

GS-4 is nominally 50% potassium acetate by weight.

Appendix B

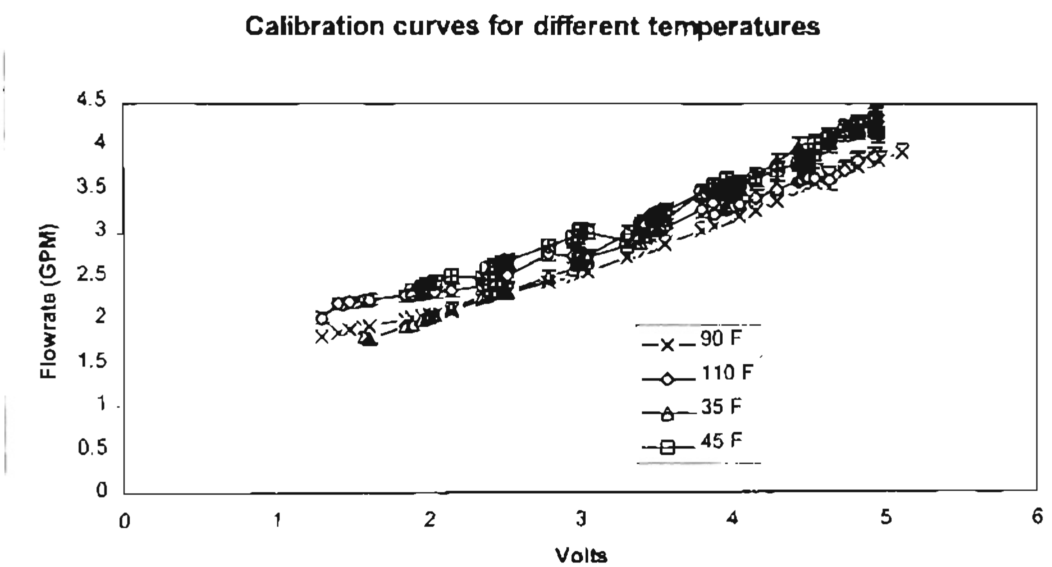
Locations of thermocouple junctions on the slab surface



Dimensioned locations of the thermocouples

Appendix C

Flowmeter calibration curves


Calibration curves for different temperatures
Flowrate (GPM)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1
2
3
4
5
6
Volts
90 F
110 F
35 F
45 F

Appendix D

Individual results for 8 test days

Channel no.	1	2	3	4	5	6	7
Label	1	2	ground temp	4	5	6	7
TIME	"Degrees F	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F	Degrees F	"Degrees F"
19:30	28.464	29.1348	30.0411	31.0523	30.6532	29.8114	30.2016
19:35	28.3957	29.3347	30.2408	31.1371	30.6616	29.6284	30.3249
19:40	27.6447	27.9334	30.1423	29.3939	29.185	28.7634	28.8843
19:45	26.9383	27.8033	29.6679	28.3444	28.7867	27.8278	28.6774
19:50	26.7401	27.6054	29.7002	27.9548	28.4739	27.2073	28.3642
19:55	26.578	27.2133	29.6535	27.6778	28.1203	27.0837	28.1638
20:00	26.4948	27.1302	29.2259	27.518	27.8838	26.8084	28.0422
20:05	26.5024	27.0994	29.3867	27.2185	27.6994	26.6623	27.9346
20:10	26.4529	26.8196	29.8352	27.0154	27.4964	26.5743	27.9619
20:15	26.4641	26.8308	29.1187	26.8346	27.3156	26.5087	28.0116
20:20	26.5076	26.951	29.7365	26.7627	27.2438	26.3214	27.9397
20:25	26.3198	26.8787	28.9748	26.575	27.0562	26.172	27.8673
20:30	26.2888	26.6941	28.7522	26.3903	26.9868	26.2179	27.8363
20:35	26.2071	26.5741	28.7859	26.3472	26.8668	26.0593	27.6779
20:40	26.0373	26.4045	28.1564	26.2543	26.774	25.9665	27.5851
20:45	26.0437	26.3724	28.4695	26.2222	26.665	26.0497	27.6299
20:50	25.9652	26.294	28.0844	26.1438	26.625	25.9327	27.4745
20:55	25.8232	26.1907	27.7893	26.0019	26.5216	25.9447	27.4096
21:00	25.7723	26.1398	27.892	25.9125	26.4707	25.8553	27.2049
21:05	25.5321	25.9384	27.3069	25.7494	26.1923	25.6151	27.0418
21:10	25.4354	25.8033	27.2488	25.7297	26.1726	25.5954	27.0606
21:15	25.3209	25.7274	27.2882	25.5383	25.9813	25.5194	26.9462
21:20	25.2062	25.5743	27.7114	25.4621	25.9051	25.4047	26.87
21:25	25.0867	25.4166	26.1704	25.3043	25.9011	25.4008	26.6352
21:30	24.9088	25.1618	26.4158	25.2419	25.6849	25.2229	26.5344
21:35	24.8213	25.2284	26.5592	25.1545	25.5975	25.1355	26.37
21:40	24.5975	24.8123	26.182	24.9308	25.4508	25.0658	26.2618
21:45	24.434	24.7645	25.5955	24.8445	25.4415	24.8253	26.0215
21:50	24.3454	24.676	25.661	24.6789	25.122	24.8138	25.9715
21:55	24.1571	24.4109	26.1272	24.7219	24.9338	24.8182	25.8218
22:00	24.0354	24.3279	26.7749	24.4848	24.8508	24.504	25.8159
22:05	23.9047	24.2358	33.6857	31.0694	24.8358	24.6431	25.7623
22:10	23.799	25.1699	31.5976	29.9323	28.1906	24.3447	25.5411
22:15	29.1484	26.5214	30.8007	27.5235	30.6477	30.1886	32.5294
22:20	26.6316	24.8452	30.7401	26.8099	27.483	27.5214	29.1002
22:25	25.3666	24.6956	30.4385	25.9687	26.5269	26.2961	28.1834
22:30	24.7741	24.2571	30.3856	25.3768	25.8967	25.7043	27.3232
22:35	24.3397	23.8998	30.069	25.1739	25.3089	25.2703	26.9281
22:40	24.1941	23.6771	30.1541	24.7204	24.9323	24.9708	26.5904
22:45	24.1005	23.7377	30.0612	24.5883	24.9543	25.1469	26.5739
22:50	24.2836	24.2291	29.8603	24.9253	25.2143	24.9832	26.6798
22:55	24.297	24.8202	29.8353	24.5535	25.4587	25.1122	26.6547
23:00	24.6692	25.1919	29.7455	24.9255	25.6765	25.2915	26.9108
23:05	25.0924	25.7684	29.745	25.0019	25.6759	25.5604	27.1025
23:10	25.4732	25.9564	29.9705	25.1517	25.8641	26.0564	26.9829

February 28th and 29th

Channel no.	8	9	10	11	12	13	14
Label	8	bottom 2	air temp	11	bottom 3	13	14
TIME	"Degrees F	Degrees	"Degrees F	"Degrees F"	"Degrees F	"Degrees F	Degrees
19:30	34.1999	32.7538	29.7348	31.3413	32.4868	31.374	31.0738
19:35	34.3229	32.9147	30.0112	31.5025	32 6096	31.4589	30.9675
19:40	33.3838	32.6639	28.9551	30.1423	32.3969	29.4462	29.8744
19:45	32.8334	32.2293	29.3232	28.9401	32.0384	29.0861	28.8251
19:50	32.1383	32.0324	29.049	28.4356	31.8033	28.7732	28.5506
19:55	31.7085	31.9858	29.1555	28.1203	31.6422	28.2275	28.0819
20:00	31.319	31.8269	28.7277	27.8454	31.6359	27.9524	27.9221
20:05	31.0582	31.7198	28.8119	27.5843	31.567	27.8447	27.6226
20:10	30.8554	31.5561	28.7242	27.3044	31.2886	27.6416	27.3812
20:15	30.6364	31.4526	28.6204	27.0083	31.1469	27.3454	27.2388
20:20	30.4111	31.4194	29.2769	26.7443	31.1519	27.312	27.0133
20:25	30.3004	31.2327	28.1695	26.6334	30.9652	27.1242	26.9025
20:30	30.0007	31.1255	28.2153	26.4871	30.7814	26.9394	26.6793
20:35	29.8424	30.8532	28.0188	26.2517	30.662	26.9347	26.5593
20:40	29.788	30.7226	27.811	26.1203	30.4932	26.688	26.3511
20:45	29.6791	30.3847	27.7021	25.9343	30.2317	26.5789	26.1651
20:50	29.6007	30.4596	27.6238	25.8173	30.1918	26.5004	26.0482
20:55	29.459	30.0507	27.4438	25.7908	29.9359	26.3969	25.9447
21:00	29.1775	30.0383	27.2009	25.6244	29.8469	26.192	25.8168
21:05	29.1682	29.9525	26.8843	25.4996	29.7228	26.1827	25.7691
21:10	29.0332	29.8564	27.2872	25.3644	29.7032	26.0475	25.5954
21:15	28.9573	29.7042	26.9809	25.2499	29.6276	25.933	25.5579
21:20	28.6889	29.6284	27.0585	25.0581	29.3603	25.8953	25.3277
21:25	28.685	29.3947	26.7087	24.9386	29.2031	25.6988	25.1697
21:30	28.5072	29.3326	26.4927	24.8377	29.1794	25.5979	25.1844
21:35	28.4199	29.2457	26.6361	24.6731	28.9008	25.4719	24.9814
21:40	28.1963	29.0231	26.3358	24.6419	28.9081	25.2866	24.9502
21:45	28.1485	29.0138	26.365	24.5555	28 7838	25.1616	25.0179
21:50	27.983	28.964	26.315	24.5055	28.849	25.1501	24 8138
21:55	27.9105	28.8918	25.5885	24.2401	28.6234	25.0775	24.5485
22:00	27.712	28.5792	25.5825	24.157	28.5408	25.0715	24.4654
22:05	27.6969	28.5259	25.3365	24.2576	28.4492	24.8637	24.7587
22:10	29.9376	28.5358	25.462	26.6545	28.4208	24.8352	26.7699
22:15	33.927	28.4264	25.3907	30.3417	28.273	31.5597	31.0301
22:20	31.1487	28.2506	25.1371	27.2909	28.0204	29.3169	28.3273
22:25	29.5795	27.9864	25.2956	25.9115	27.8329	28.0551	26 6806
22 30	28.6421	27.9717	24.9342	25.3963	27.7798	27 1182	26.2045
22:35	28.1698	27.7694	24.6925	24.731	27.6542	26 6078	25.5014
22:40	27.6779	27.7779	24.8553	24.4699	27.6244	26.347	25.3175
22:45	27.6999	27.915	24.5304	24.4534	27.7615	26.0611	25.1854
22:50	27.5747	28.0973	25.0217	24.4823	28.0589	26.3979	25.1373
22:55	27.8192	27.9571	24.38	24.7269	27.9571	26.4113	25.2662
23:00	27.883	28.2125	24.3282	24.7522	28.366	26.5904	25.33
23:05	27.7669	28.4037	24.2505	24.8287	28.5955	26.6668	25.4064
23:10	28.0707	28.8213	23.8606	25.2482	28.7446	26.7395	25.941

February 28th and 29th

Channel no.	15	16	17	18	19	20
Label	bottom 4	16	bottom 1	18	inlet	outlet
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
19:30	33.4782	30.8444	32.4105	31.7228	32.3488	32.576
19:35	33.7532	31.0057	32.3807	32.0367	32.5098	32.6988
19:40	33.3122	30.2188	32.435	30.4476	32.5261	34.4302
19:45	32.9541	29.7828	31.9621	29.7436	32.969	33.9202
19:50	32.8718	29.3555	31.7651	29.0096	32.9248	33.495
19:55	32.6346	28.8489	31.7567	28.5411	32.8402	33.2197
20:00	32.5521	28.5359	31.4831	28.2279	32.605	32.7558
20:05	32.407	28.4285	31.3378	27.8133	32.4598	32.4198
20:10	32.2815	28.0722	31.2122	27.6871	32.1052	32.1416
20:15	32.1018	28.0067	31.0705	27.3527	31.8872	31.7326
20:20	31.9541	27.743	30.999	27.0888	31.663	31.4701
20:25	31.8821	27.6706	30.774	27.0163	31.5145	31.207
20:30	31.584	27.4093	30.5902	26.7547	31.2161	31.0232
20:35	31.5411	27.251	30.3178	26 5962	30.982	30.636
20:40	31.3342	27.1582	30.3019	26.4649	30.7367	30.4288
20:45	31.1112	26.934	29.9638	26.1635	30.4369	30.1672
20:50	31.0332	26.8556	29.9622	26.2005	30.2439	30.0125
20:55	30.854	26.906	29.8593	26.0201	30.141	29.6415
21:00	30.6122	26.7014	29.6937	25.8921	29.8989	29.4375
21:05	30.5647	26.5768	29.5313	25.8059	29.6598	29.16
21:10	30.5069	26.4802	29.4734	25.7477	29.5253	28.9104
21:15	30.3166	26.3274	29.2446	25.5562	29.258	28.758
21:20	30.126	26.0589	29.1304	25.3645	28.9905	28.4902
21:25	29.9691	26.055	29.0499	25.245	28.9482	28.3329
21 30	29.8688	25.8388	28.7961	25.1441	28.656	27.9637
21:35	29.7053	25.9054	28.7858	25.0566	28.3387	27.8381
21:40	29.5211	25.7203	28.7547	24.8713	28.3844	27.6918
21:45	29.3969	25.5185	28.6305	24 7078	28.1065	27.3368
21:50	29.4621	25.4685	28.619	24.7734	27.9415	27.2485
21:55	29.1984	25.0879	28.3166	24.5851	27.5235	26.9455
22:00	29.1158	25.082	28.1573	24.5792	27.4791	26.6705
22:05	28.9859	27.605	28.0272	24.6798	27.3104	26.5401
22 10	28.9192	25.8084	28.1522	24.5356	27.0899	26.2808
22:15	28.7715	25.5447	28.0428	31.3352	26.8264	25.9786
22:20	28.5957	25.0986	27.8669	30.8924	26.4194	25.9561
22:25	28.4468	25.1416	27.5642	28.7141	26.6161	25.229
22:30	28.2019	24.8186	27.5111	27.3561	70 5998	66.7984
22:35	28.3066	24.4613	27.3854	26.7693	68.1816	63.8554
22:40	28.2	24.2	27.394	26.3933	71.9089	68.442
22:45	28.1069	24.1835	27.6847	26.1845	73.3837	69.9957
22:50	28.3275	24.6365	27.8671	26.5211	75.0439	71 2254
22:55	28.1874	24.6884	28.0723	26.2652	76.5053	72.8387
23:00	28.481	24.9834	28.3276	26.9441	77.4695	73.6616
23:05	28.8638	25.1754	28.5955	27.2125	78.2277	74.9309
23:10	28 898	25.3637	29.1279	27.2083	79.451	75.8691

February 28th and 29th

Channel no.	1	2	3	4	5	6	7
Label	1	2	ground temp	4	5	6	7
TIME	"Degrees F	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F	Degrees F	"Degrees F"
23:15	25.9014	27.0754	29.5925	28.6139	27.1377	26.6382	27.7568
23:20	27.5367	27 6721	29.537	28.8649	28.2721	28.8857	29.927
23:25	27.6428	28.1616	29.4896	27.8206	27.7258	28.1863	29.4195
23:30	27.8156	28.3725	29.5854	27.3025	27.7835	28.0905	29.0936
23:35	28 043	28.5229	29 4294	26.8772	27.7038	28.0876	29.1291
23:40	28.4333	29.1425	29.3978	27.3448	28.2478	28.5546	29.5193
23.45	28.4373	29.3379	29.2103	31.1022	29.6699	29.1337	29.8301
23:50	28.6385	31.259	29.1048	31.7609	29.7177	29.4113	30.0695
23:55	28.6849	30.5411	29.1128	31.0814	29.3044	28.9595	29.9242
0:00	28.9863	30.6887	29.2609	30.2734	29.4524	29.1076	30.0339
0:05	29.1077	30.8098	29.0757	29.6676	29.4589	28.9991	30.2319
0:10	29.2036	30.8291	28.9801	29.3424	29.5165	29.1334	30.1746
0:15	29.7967	31.3442	29.0371	31.0822	30.9508	29.9563	30.538
0:20	31.1632	31.9825	29.0649	32.4461	31.0168	32.0483	33.0126
0:25	31.1144	32.8109	28.8627	32.6263	31.8469	31.4267	32.0472
0:30	31.2929	32.2264	29.0417	32.2704	30.9937	31.4905	31.7288
0:35	31.1573	32.3581	29.2889	31.9443	31.355	31.3167	31.5549
0:40	31.3984	32.4081	28.7643	31.9561	32.0161	31.8634	33.4766
0 45	31.5583	32.682	28.4647	32.2684	32.9389	32.5193	33.2928
0:50	31.8704	32.8792	28.2796	32.6565	32.8311	32.6404	33.6428
0:55	31.8833	32.892	28.1007	32.5168	32.7677	32.1572	33.2742
1:00	31.9007	33.0998	28.1565	32.496	32.6706	32.0982	33.0244
1:05	31.9219	33.2734	27.9476	32.3265	32.6918	32.0431	32.8547
1:10	31.9828	33.4484	27.932	32.4636	32.6001	31.9131	32 6483
1 15	32.2534	33.7183	27.782	32.5052	33.0993	32.7561	33.3771
1.20	32.0052	33.8133	27.6859	32.6385	33.2707	32.5461	33.7011
1:25	31.8897	33.7743	27.8768	32.5613	33.1935	32 1254	33.2042
1:30	31.7463	33.7456	27.6175	32.7613	33.3934	31.982	33.1754
1:35	31.7811	33.9325	27.5373	32.6054	33.39	31.8641	33.1338
1 40	32.0527	34.051	27.4265	32.7623	33.4324	32.8317	33.8249
1 45	31.9753	34.126	26.926	32.8756	33.4314	32.9739	33.8619
1:50	32.0883	34 657	27.0763	32.836	33.5442	32.7818	33.8986
1:55	32.2109	34.8171	27 0095	32.8059	33 5904	32.7899	33.9448
2:00	32.1939	34 5721	26.6081	32.8652	33.6496	32.5821	33.8134
2 05	32.1088	34.5253	26.5608	32.8946	33.6028	32.4208	33.6903
2:10	32.376	35.2476	26.484	32.9327	33.7933	32.6116	33.8428
2:15	32.7299	35.486	26.6484	33.0957	33.88	33.2323	34.044
2:20	32.7395	35.5715	26 5428	33.0672	33.8516	33.3181	34.0537
2:25	32.7837	35.4636	26.3566	33.1114	33.8576	33.2098	33.9835
2:30	32.7677	35.5996	26.3789	33.1335	33.9178	33.1557	34.0056
2:35	32.864	35.7715	26.5146	33.1155	33.8998	33.0614	33.9876
2:40	32.992	36.3922	26.7204	33.1672	33.9133	33.1512	34.0011
2:45	33.2808	36.3003	26.6273	33.2653	34.0114	33.4019	34.1755
2:50	33.2714	36.1012	26.3487	33.256	34.0401	33.4306	34.2424
2 55	33.4717	36.111	26.2432	33.3038	34.088	33.3642	34 2903

February 28th and 29th

Channel no.	8	9	10	11	12	13	14
Label	8	bottom 2	air temp	11	bottom 3	13	14
TIME	"Degrees F	Degrees	"Degrees F	"Degrees F"	"Degrees F	"Degrees F	Degrees
23:15	28.8067	28.9029	24.0198	25.5996	29.0562	27.8591	26.3306
23:20	29.0586	29.3072	24.1568	26.6209	29.4221	31.4824	27.6581
23.25	29.0879	29.7577	23.8776	26.3042	30.1022	29.291	27.3034
23:30	29.1841	29.7769	23.2409	26.5158	29.93	29.0802	27 3611
23:35	29.2966	29.8506	22.9291	26.6667	30.0803	29.0006	27.4351
23:40	29.726	30.5461	23.1676	27.1345	31.0814	29.3524	28.0176
23:45	30.2292	30.2824	23.2875	27.4843	30.3971	31.118	28.597
23:50	30.776	30.3683	23.2198	27.7625	30.5213	31.3952	28.5298
23:55	30.7073	30.95	23.3437	27.7705	30.8735	30.638	28.6145
0:00	30.9322	31.518	23.57	28.0723	31.709	30.518	28.918
0:05	31.0537	31.257	23.6151	28.1939	31.6772	30.4862	29.0757
0:10	31.0347	31.4291	23.6732	28.1749	31.8874	30.3906	29.0951
0:15	32.8537	31.7914	23.6148	30.3389	32.1732	30.8685	30.4155
0:20	32.6519	32.3536	24.2986	29.7927	32.8877	31.814	30.558
0:25	32.7944	32.4194	23.8637	29.9353	32.572	31.7653	30.5475
0:30	32.4756	32.979	23.4651	29.846	33.0934	31.3322	30.8025
0:35	32.8374	33.2631	23.444	30.1696	33.3012	31.6935	30.8198
0:40	33.4612	33.275	23.5331	31.0229	33.6941	32.0493	31.9016
0:45	34.1561	33.8535	23.7332	31.2975	34.0439	32.5529	32.1758
0:50	34.621	33.6697	23.6628	31.2277	34.1648	32.9413	32.0298
0:55	34.4048	33.6445	23.367	31.1259	34.0253	32.8015	32.1572
1:00	34.2694	34.1569	23.5003	31.1051	34.5375	32.7806	32.2127
1:05	34.2142	34.6728	23.406	31.1263	34.4064	32.7255	32.3103
1 10	34.1988	35.342	22.6566	31.3019	34.9237	32.7101	32.4474
1:15	34.9657	35.5735	22.7374	31.8402	35.1173	32.9807	32.8324
1:20	35.2517	36.2382	22.486	31.9355	35.6304	33.0378	32.8894
1:25	35.2889	36.9204	22 7555	32.0108	35.7814	33.0368	32.8884
1:30	35.3745	37.1194	22.3013	32.0966	35.4487	33 1225	32.9359
1:35	35.2948	37.609	22.1432	32.1695	36.0153	33.0427	32.9325
1:40	35.4136	37.8407	22.2249	32.3265	36.0956	33.2378	32.975
1:45	35.6794	37.4985	21.9918	32.4781	36.3603	33.3512	33.0883
1:50	35.7542	38.8987	22.2223	32.6292	37.0799	33.2735	33.2012
1:55	35.8004	39.285	21.9985	32.6373	37 1259	33.396	33.2474
2:00	35.8978	38.1704	21.9813	32.6584	36.6537	33.5315	33.3829
2:05	35.889	38.0859	22.2817	32.726	36.9485	33.4465	33.7552
2:10	36.0034	38 5783	21.9338	32.8023	37.1003	33.5228	34.1741
2:15	36.1664	38.5888	21.9445	33.0035	37.1488	33.6859	35.326
2:20	36.2522	38.5984	21.7609	33.0513	37.31	33.6955	34.8793
2:25	36.0296	38.112	21.8057	33.2098	36.785	33.6634	35.1135
2:30	36.2422	38.3613	21.5573	33.2319	37.0346	33.7618	35.2496
2:35	36.3385	38.2297	21.9259	33.3283	37.1305	33.82	35.3837
2:40	36.314	39.3409	21.8623	33.5324	37.5611	33.9098	35 7393
2:45	36.4882	39.1357	21.5751	33.9352	38 0756	34.008	36.0651
2:50	36.8597	39.8072	21.7203	34.3067	38.1421	33.9986	36 4355
2:55	37 1739	39.2496	21.2272	34.4306	38.1518	34.1608	36 5591

February 28th and 29th

Channel no.	15	16	17	18	19	20
Label	bottom 4	16	bottom 1	18	Inlet	outlet
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
23:15	29.2861	26.1383	29.2861	29.1318	80.1406	76.6339
23:20	29.6519	27.8117	29.8816	30.9521	81.097	77 4495
23:25	30.1404	27.265	29.9874	30.0248	81.5923	78.1636
23:30	30.2744	27.3995	30.2362	29.8909	82.6173	78.8677
23:35	30.5011	27.3967	30.2333	30.0412	83.3331	79.5145
23:40	31.2343	27.9792	31.1578	30.3158	83.9138	80.0255
23:45	31.0472	28.7504	30.9325	31.5435	84.3481	80.5338
23:50	31.2095	28.8749	31.2095	32.0113	84.608	80.7948
23:55	31.5996	28.9979	31.5996	31.7137	85.8338	81.6662
0:00	32.2435	29.2992	32.3198	31.7085	86.0438	81.8052
0:05	32.3262	29.3822	32.2499	31.7149	86.4077	82.2428
0:10	32.6889	29.6314	32.3455	31.7342	86.6405	82.6204
0:15	33.0506	30.3772	32.593	32.0965	86.7652	82.8534
0:20	33.4976	30.3667	33.3833	32.3532	87.1131	83.3465
0:25	33.6014	30.5857	33.3728	32.648	87.4607	83.3725
0:30	33.9317	30.6496	33.8174	32.4446	87.7706	83.8991
0:35	34.1774	31.011	34.2916	32.4237	88.1083	84.1665
0:40	34.684	31.0611	34.1511	32.7409	88.1193	84.3929
0.45	34.8812	31.4121	34.653	32.786	88.4473	84.7581
0:50	35.2301	31.6097	34.6596	33.0215	88.6678	84.8718
0:55	35.2049	31.7372	34.6724	33.0725	89.0367	84.7764
1:00	35.5643	32.0218	35.1462	33.1661	89.3026	85.4377
1:05	35.6235	32.1958	35.6615	33.2254	89.5721	85.4218
1:10	36 026	32.4093	36.5956	33.2481	89.8429	85.8371
1:15	36.3333	32.7561	36.7508	33.3278	89.8105	85.912
1:20	36.6937	33.2707	37.1111	33.5754	90.042	86.0729
1:25	36.9963	33.727	38.0579	33.5744	90.1836	86.2868
1:30	36.8159	33.7744	38.3323	33.6981	90.3349	86.4387
1:35	37.2298	34.228	39.0482	33.7709	90.4386	86.5428
1:40	37.31	34.6129	38.9012	34.0038	90.5139	86.5469
1:45	37.5744	34.9923	38 7108	34.0408	90.2992	86.8175
1:50	38.2929	35 4471	40.1089	34.3059	90.4759	86.8519
1:55	38.4145	35 5692	40.4569	34.8468	90.6972	86.8025
2:00	38.2083	35.5902	39.2304	34.7157	90.8594	87.0012
2:05	38.2753	35.7715	38.9947	34.9733	90.78	87 136
2 10	38.7298	35.8476	39 6378	35.1255	90.9225	87.279
2:15	38.6267	36.086	39.4592	35.5544	91.0035	87.3962
2:20	38.9769	36.1715	39.4687	35.602	91.1905	87.5124
2:25	38.6422	36.2535	39.4369	35.57	91.4097	87.7325
2:30	39.0048	36.2755	39.1562	35.8201	91.4659	87.7532
2:35	38.987	36.3715	39.214	35.7261	91.5559	87.8793
2:40	39.4166	36.385	40.1727	35.9676	91.6753	87.9634
2:45	39.7409	36.8244	40.0811	36.5592	91.7313	88.0911
2:50	39.8828	37.1186	40.714	36.36	91.9004	88.1895
2:55	39 8169	37.1662	40.1949	36.2558	91.8029	88.2344

February 28th and 29th

Channel no.	1	2	3	4	5	6	7
Label	1	2	ground temp	4	5	6	7
TIME	"Degrees F	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F	Degrees F	"Degrees F"
3 00	33.493	36.246	26.2647	33.4394	34.2615	33.4998	34.3878
3:05	33.5887	36.0757	26.1305	33.6113	34.2811	33.5955	34.4073
3:10	33.437	35.7347	25.7849	33.4977	34.2436	33.6343	34.4842
3:15	33.1195	35.3424	25.6568	33.6375	34.2692	33.5836	34.3954
3:20	33.0621	35.2852	25.9836	33.6943	34.326	33.4119	34.4904
3:25	32.7846	34.9706	25.819	33.6456	34.3535	33.4394	34.3274
3:30	33.0529	35.2	25.8974	33.7233	34.393	33.2884	34.2908
3:35	33.0964	35.2813	25.8258	33.5763	34.2841	33.2175	34.1055
3:40	32.9888	35.3261	25.9097	33.6973	34.3671	33.1481	34.1123
3:45	32.8676	35.2813	25.7873	33.5762	34.3983	32.9506	34.0292
3:50	32.8769	35.2526	25.6813	33.814	34.4837	33.0743	34.1529
3:55	32.7066	34.8929	25.7788	33.7963	34.3899	32.904	33.9827
4:00	32.9564	35.2178	25.6845	33.703	34.4108	32.8106	33.9655
4:05	32.6764	34.9388	25.6713	33.6519	34.3978	32.6068	33.7618
4:10	32.4232	34 7245	25.4543	33.7037	34.4496	32.6206	33.7375
4:15	32 5097	34.8107	25.5416	33.7139	34.4978	32.8215	33.6714
4:20	32.4348	34.8501	25.312	33.6392	34.4231	32.7467	33.8253
4:25	32.3351	34.5988	25.25	33.6921	34.2476	32.5326	33.6876
4:30	32.1987	34.4247	25.0737	33.6701	34.3399	32.4343	33.5512
4:35	32.0372	34.3018	25.0263	33.5851	34.2549	32.1965	33.3135
4:40	31.847	34.2265	24.9114	33.7001	34.1795	32.0827	33.2379
4:45	31.8079	34.1875	25.1032	33.585	34.1405	31.8909	33.0462
4:50	31.9353	34.3144	24.9235	33.5977	34.1152	31.8273	33.0971
4:55	31.5913	33.8575	25.0387	33.5593	33.8864	31.5597	32.7914
5:00	31.4343	33.9295	24.8804	33.5552	33.8537	31 4791	32.4053
5:05	31.1068	33.6794	24.6658	33.3811	33.3652	31.0752	32.2307
5:10	30.9644	33 842	24.6378	33.2772	33.1088	30.9327	31.8589
5:15	30.8591	33.5849	24.8014	33.2484	32.9275	30.8657	31.7919
5:20	30.495	33.108	24.6656	32.9998	32.4498	30.5397	31.3895
5.25	30.5659	33.331	24.6214	32.918	32.4824	30.3428	31.3074
5:30	30.4874	33.329	24.8121	32.7636	32.4805	30.2644	31.1906
5:35	30 7986	33.5247	24.7019	32.7307	32.3331	30.1549	31.2725
5:40	30.721	33.5235	24.5465	32 4245	32.3319	30.0006	31.0417
5:45	30.6924	33.4951	24.6719	32.2816	32.2271	30.0103	30.9366
5:50	30.6515	33.1115	24.6692	32.584	32.9111	29.9693	31.0104
5:55	30.6891	32 7299	24.63	32.1638	32.4146	29.739	30.8567
6:00	30.5425	32.7743	24.5208	32.0175	32.192	29.6305	30.7099
6:05	30.7946	32.9875	24.3895	31.8493	32.291	29.6149	30.6944
6:10	31.0325	33.415	24.4752	31.5524	32.4521	29.7384	30.8561
6:15	31.2019	33.6598	24.4533	31.607	32.3923	29.64	30.8343
6:20	31.2031	33.623	24.493	31.4173	32.3935	29.7178	30.6824
6:25	31.232	33.6137	24 4836	31.408	32.3842	29.6702	30.7113
6:30	31.2963	33.7919	24.7027	31.2431	32.4865	29.6963	30.814
6:35	31.5025	34.0735	25.0262	31.2583	32.578	29.7881	30.8675
6 40	32.1921	35.1784	25.5677	31.3752	33.4192	30.3645	31 4055

February 28th and 29th

Channel no.	8	9	10	11	12	13	14
Label	8	bottom 2	air temp	11	bottom 3	13	14
TIME	"Degrees F	Degrees	"Degrees F	"Degrees F"	"Degrees F	"Degrees F	Degrees
3:00	37.4234	39.7246	21.2488	34.8324	37.8698	34.1821	36.9219
3:05	37.3288	38.0408	20.7266	34.5855	37.0551	34.2778	36.7516
3:10	37.3294	38.0415	20.9209	34.3578	36.3347	34.1642	36.6004
3:15	37.4691	37.8395	21.1792	34.3453	36.2463	34.3421	36.5879
3:20	37.6019	38.1235	21.2757	34.326	36.0751	34.3609	36.4928
3:25	37.7054	37.9235	21.3036	34.3535	35.9885	34.2741	36.672
3:30	37.6688	37.8491	21.2277	34.3549	36.3318	34.2756	36.6735
3:35	37.5601	37.9302	21.2331	34.246	35.8433	34.1666	36.489
3:40	37.681	37.2926	21.3174	34.2909	35.9261	34.2496	36.4578
3:45	37.522	37.4753	21.2717	34.246	35.9953	34.3951	36.413
3:50	37.3792	37.295	21.2038	34.4076	35.9286	34.214	36.3084
3:55	37.5896	38.1112	20.9147	34.4279	36.0248	34.3867	36.5185
4:00	37.6105	38.0563	20.8973	34.601	36.3116	34.2934	36.6532
4:05	37.7116	38.2327	20.8453	34.5119	36.1467	34.3565	36.6782
4:10	37.8395	38.3979	20.7431	34.4876	36.0465	34.1798	36.5401
4:15	37.7736	38.2566	20.9471	34.7642	36.3604	34.3805	36.6641
4:20	37.5088	37.8791	20.7936	34.5373	36.2479	34.1914	36.5517
4:25	37.1812	36.7941	20.8862	34.1334	35.4649	34.2443	36.2627
4:30	37.3876	37.4551	20.7477	34.1876	35.3289	34.1462	36.3547
4:35	37.7211	37.2567	20.8162	34.2169	35.7002	34.1374	36.346
4:40	37.6837	37.1815	20.6619	34.1795	35.2448	34.1381	36.4226
4:45	37.4547	37.0669	20.4674	34.0263	35.358	34.2134	36.2699
4:50	36.9347	35.9407	20.7128	33.582	34.4959	34.1881	35.7888
4:55	37.2008	36.1683	20.5187	33.5816	34.5336	34.0734	35.7125
5:00	36.8922	35.8983	20.6308	33.2345	33.9203	33.9931	35.4043
5:05	36.7182	35.4206	20.4924	33.0984	34.089	34.0094	35.3065
5:10	36.8047	35.2789	20.4642	33.0326	34.0233	33.9436	35.2409
5:15	36.9283	36.0103	20.59	32.9657	34.1088	33.7624	35.1742
5:20	36.718	35.0782	20.6472	32.5643	33.5175	33.7043	34.6217
5:25	36.7124	35.2628	20.5253	32.5206	33.6643	33.5844	34.6542
5:30	36.9008	34.9947	20.717	32.5949	33.6243	33.4299	34.6142
5:35	36.9061	35.2661	20.6062	32.6765	33.5915	33.4352	34.6956
5:40	36.8288	34.8466	20.4888	32.7516	33.6685	33.0907	34.5422
5:45	37.0288	35.5027	20.4211	32.8757	33.4856	33.1004	34.8563
5:50	36.455	35.0437	20.4571	33.0636	33.4829	32.9832	34.7775
5:55	36.1877	35.3093	20.379	32.6435	33.1774	32.7536	34.6247
6:00	36.0035	34.1743	20.3466	32.3065	33.1075	32.7217	34.4788
6:05	36.3309	34.9199	20.1371	32.5962	33.0539	32.6299	34.6536
6:10	36.6061	35.2326	20.2233	32.8336	33.5198	32.4857	34.8143
6:15	36.6225	35.4771	20.0849	32.85	33.4219	32.4258	34.7926
6:20	36.5475	34.7177	20.1637	33.0038	33.3468	32.5033	34.7938
6:25	36.8048	35.0888	20.0379	33.3376	33.2232	32.3413	35.0128
6:30	36.983	35.0768	20.1032	33.6303	33.2874	32.4437	35.1148
6:35	37.1504	35.5101	20.3124	34.0645	33.6074	32.5353	35.5861
6:40	37.8373	37.2589	20.7797	34.866	34.6758	32.7667	36.3482

February 28th and 29th

Channel no.	15	16	17	18	19	20
Label	bottom 4	16	bottom 1	18	inlet	outlet
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
3:00	39.7624	37.377	40.5559	36.315	92.1072	88.3972
3:05	39.2523	37 1689	39.0632	36.2965	92.0899	88.4155
3:10	38.9503	36.942	38.9881	35.9933	92 2327	88 5589
3:15	38.7486	36.9295	38.7486	35.9807	92.3277	88.6185
3:20	38.8051	36.7964	39.07	35.7715	92.3808	88.6361
3:25	38.6431	36.7858	38.7945	35.6469	92.4775	88.8403
3:30	38.9474	36.6355	38.7203	35.7243	92.5499	88.8774
3.35	38 612	36.3371	38.7634	35.5396	92.6615	88.9181
3:40	38.6566	36.4198	38.3158	35.6985	86.9282	85.5997
3:45	38.7634	36.2991	38.309	35.4635	85.3825	82.6514
3:50	38.6591	36.2704	38.2047	35.6629	85.8211	80.7175
3:55	38.6793	36.2527	39.0578	35.7592	88.4861	85.2271
4:00	39 1921	36.3116	38.9272	35.8561	88.9697	85.4617
4:05	38.9143	36.2606	38.99	35.6151	89.4926	86.0225
4:10	38.663	36.2743	39.155	35.5148	89.8621	86.3575
4:15	38.9381	36.2086	39.2408	35.753	90.2993	86.7964
4:20	38.9016	36.096	38.7502	35.7164	90.7637	87.1554
4:25	38.6514	35.7309	37.9696	35.5411	90.92	87.348
4:30	38.2888	35.709	38.3645	35.4812	91.1843	87 5419
4:35	38.4694	35.8522	37.9012	35.3584	91.4607	87.7838
4:40	38 0913	35.7769	37.9776	35.3211	91.6749	88.0345
4:45	38.2798	35.6621	37.8252	35.0159	91.8164	88.1408
4:50	37.6105	35.2567	36.4344	34.8004	91.8994	88 3313
4:55	37.7239	35.1803	36.8896	34.724	92.1125	88.3668
5:00	37.151	34.8339	36 5818	34 4915	92.2153	88.47
5:05	37.0155	34.7741	36 2944	34 4697	92.3017	88.6281
5:10	36.95	34.6323	36 4566	34.2898	92.4536	88.7449
5:15	37.0352	34.5275	36.6937	34.4514	92.4268	88 7894
5.20	36 5979	34.2031	35.9524	34.0507	92 5859	88.8778
5:25	36 5544	34.1214	35 3008	34.0452	92.6518	89.0153
5:30	36.5525	33.929	35.3749	34.2336	92 7565	88.9778
5:35	36.6716	33.82	36 0642	34 1247	92.9747	89.0898
5:40	36.5186	33.8189	35.5691	34.1997	92.7959	89.16
5:45	36.4523	33 8285	35.8827	34.0951	92.9115	89.2047
5 50	36.4117	33.8258	35.614	34.0924	92.9445	89.2022
5 55	36.1832	33.6728	35.8794	33 9775	92 9795	89 2373
6 00	36.0756	33 6411	34.631	34 0219	93 0564	89.2432
6 05	36.1361	33.5113	35.4142	34 1968	93.113	89.3714
6:10	36.2965	33.7484	35.7647	34.4719	93.0854	89.3437
6:15	36.3888	33.6886	35.9711	34.4883	93.1718	89 3948
6.20	36.3141	33.6136	35.2122	34.6798	93 1729	89 4315
6:25	36.2669	33.6805	35.925	34.7086	93.2708	89.6368
6:30	36.1409	33.7446	35.1909	34.8106	93.4016	89.5185
6.35	36.4218	33.9883	36.0801	35.1682	93 3802	89.604
6 40	37.3347	34 6758	37 9034	35.7027	93.5244	89.8201

February 28th and 29th

Channel no.	1	2	3	4	5	6	7
Label	1	2	ground temp	4	5	6	7
TIME	"Degrees F	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F	Degrees F	"Degrees F"
6:45	32.492	35.515	25.9855	31 4462	33.7567	30.8181	31.7826
6:50	32.8101	35.9456	25.9986	31.4974	33.9982	30.9458	31.9103
6:55	32.7328	36.0585	26.0361	31.6492	34.2638	30.8301	31.9093
7:00	32.5409	35.6396	25.6886	31.6479	33.996	30.5229	31.7551
7:05	32.3815	35.367	25 6817	31.412	33.6464	30.4397	31 7483
7:10	32.6183	35.5268	25.5742	31.4581	33.8067	30.4475	31.565
7:15	33.3675	36.1969	26.0226	31.4066	34.0981	30.8167	31.9341
7:20	32.5121	35.497	25.8519	31.4282	33.7768	30.5706	31.4586
7:25	32.3642	35.2358	25.4718	31.1655	33.3624	30.231	31.3103
7:30	32.0955	35.1583	25.7782	31.1258	33.4752	30.1147	31.2705
7 35	32.8584	35.7279	26.0859	31.011	33.7418	30.3441	31.5764
7 40	32.7362	35 7961	26.3857	31.1942	33.9244	30.4128	31 6833
7:45	32.7185	35.6266	26.214	31.2147	33.9449	30.4716	31.4743
7:50	33.1012	36.0456	26.4461	31.2161	34.0605	30.3582	31.7052
7:55	33 4475	36.4662	26.8338	31.4867	34.5586	30.8204	31.8231
8:00	33.8051	36.8981	27.2714	31.5398	34.8778	30.95	32.0291
8:05	33.6196	36.5618	27.0459	31.6211	34.9207	30.9932	31.9958
8:10	33.7965	36.8516	27.3011	31.6075	34.9452	30.9796	32.0587
8:15	34.1302	37.1838	27.676	31.7512	35.3925	31.3527	32.3171
8:20	34.097	36.8854	27.6809	31.756	35.1312	31.2811	32.322
8:25	34.5636	37.5017	28.1514	31.9187	35.5973	31.4821	32.5993
8:30	34.688	37.5876	28.5836	32.0434	35.7215	31.5306	32.5714
8:35	35.6877	38.7344	29.5146	32.3599	36.4544	32.1528	33.2317
8:40	37.0673	40.2211	30.9817	32.7924	37.757	32.9288	33.7787
8:45	37.7709	41.0723	31.7289	32.9661	38.6115	33.1789	34 105
8:50	38.2316	41.7946	32.0405	33.3151	39.1474	33.4136	34.3397
8:55	38.0679	41 7449	32.3718	33.5696	38.9839	33.6301	34.48
9:00	38 6812	42.2044	32 9514	33.8056	39.4453	33.6756	34.7541

February 28th and 29th

Channel no.	8	9	10	11	12	13	14
Label	8	bottom 2	air temp	11	bottom 3	13	14
TIME	"Degrees F	Degrees	"Degrees F	"Degrees F"	"Degrees F	"Degrees F	Degrees
6:45	38.1361	37.5948	20.8517	35.431	34.6704	33.0666	36.7983
6:50	38.339	37.3423	20.6325	35.748	34.7975	33.194	37.0389
6:55	38.376	36.962	20.554	35.823	34.3018	33.1931	37.1517
7:00	38.2988	36.3915	20.4365	35.5178	33.8437	33.3825	37.1125
7:05	38.2161	36.5746	20.5846	35.473	33.9512	33.1088	36.992
7:10	38.2999	35.9369	20.5151	35.4429	34.0733	33.1929	37.1516
7:15	38.7046	36.7969	21.0439	35.9617	34.7071	33.3704	37.5555
7:20	38.2321	34.9188	20.291	35.3751	33.3577	33.2775	37.1598
7:25	38.0468	35.0375	20.412	35.0756	33.0574	33.1677	36.8609
7:30	38.1593	35.0741	20.5267	35.2262	33.2846	33.1281	36.8974
7:35	38.3112	35.8342	20.914	35.6442	33.8561	33.1279	37.2007
7:40	38.6833	35.6744	21.0222	35.9784	34.1529	33.2727	37.5343
7:45	38.5517	35.0105	20.5395	35.8088	33.602	33.3695	37.4409
7:50	38.5911	36.3039	21.0444	36.0381	33.6796	33.4853	37.6697
7:55	39.05	36.6488	21.2413	36.6488	34.4825	33.9079	38.1277
8:00	39.2166	36.7775	21.295	36.9292	34.7637	34.1133	38.4454
8:05	39.1836	36.5926	21.2226	37.01	34.1596	34.1182	38.3746
8:10	39.3598	36.3893	21.3637	37.0344	33.9557	34.0665	38.5126
8:15	39.6164	37.1013	21.5093	37.4806	34.746	34.1718	38.9579
8:20	39.4695	35.5114	21.0497	37.2579	34.3323	34.3291	38.887
8:25	39.9345	36.5469	21.7564	37.7227	35.1792	34.5295	39.2752
8:30	40.0585	36.4052	21.2638	38.074	35.3034	34.692	39.588
8:35	40.6002	37.5545	22.3583	38.9939	36.4164	34.2462	40.355
8:40	41.484	39.9522	23.5301	40.1412	38.1738	34.8685	41.3872
8:45	41.4673	40.2	23.5902	40.8044	38.3843	36.1449	42.0871
8:50	41.6247	41.0747	23.6735	41.4143	39.2609	36.8728	42.7337
8:55	41.7261	40.7606	23.6226	41.5531	38.6811	37.0884	43.0606
9:00	42.3764	41.2209	23.7459	42.0507	39.1805	37.8927	43.5573

February 28th and 29th

Channel no.	15	16	17	18	19	20
Label	bottom 4	16	bottom 1	18	inlet	outlet
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
6:45	37.3294	34.9748	38.3148	36.0394	93.5549	89.8507
6:50	37.3802	34.9497	38.1761	36.2802	93.567	89 7203
6:55	37	35.1008	37.8721	36.3172	93.6371	89.8619
7:00	36.6572	34.8714	37.1125	36.316	93.5649	89.9321
7:05	36.8023	34.6744	37.4092	36.3092	93.6651	89.8545
7:10	36.7342	34.7964	36.886	36.431	93.7434	89.8975
7:15	37.5934	35.1635	37.5934	36.8733	93.7666	89 9207
7:20	36.3629	34.7666	35.8311	36.4392	93.7866	89 9765
7:25	36.0257	34.3907	35.9877	36.5198	93.7554	90 0521
7:30	36.2141	34.6176	35.1881	36.4044	93.825	89.9438
7:35	36.6696	34.6936	36.5557	36.708	93.7894	90.015
7:40	36.6618	35.0281	36.51	36.8141	93.8177	90.0433
7:45	36.3405	34.8964	35.1246	36.9104	93.9787	90.0981
7:50	36.4938	35.0879	37.0251	36.8738	93.8735	90.0281
7:55	37.0283	35.5854	37.6729	37.5599	94.0539	90 1737
8:00	37.2327	35.7902	37.1189	37.8021	94.0677	90.1875
8:05	36.9721	35.8331	37.7305	37.8449	94.0369	90.2278
8:10	36.8827	35.8196	37.262	37.7935	93.9887	90 2863
8:15	37.291	36.2664	37.7838	38.2772	94.1223	90.3135
8:20	36.9544	36.2712	36.0054	38.3577	94.0913	90.3181
8:25	37.9122	36.6228	37.3057	38.7085	94.136	90.3274
8:30	37.695	36.7468	37.278	39.0215	94.2875	90.4082
8:35	38.6911	37.7062	38.3881	39 4489	94.1915	90.4899
8.40	39.9522	38.8554	41.0099	40.3313	94.31	90.6801
8·45	40.1245	39.3305	41 4083	40.9567	94.3298	90.6644
8·50	40.7726	40.2061	42.3946	41.3402	94.5127	90.8481
8:55	40.7228	40.4207	41.968	41.3659	94.5723	90.9079
9:00	40.9567	40.6924	42.4653	41.4487	94.5438	91.0217

February 28th and 29th

Channel no.	1	2	3	4	5	6	7
Label		2	ground temp	4	J	I	7
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
3/1/96 0:01	37.091	38.9599	36.2631	35.7083	38.1198	38.9831	39.1233
0:06	37.094	38.8116	36.0763	35.6733	37.744	38.8725	39.0126
0:11	36.8948	38.2346	36.2946	35.9677	37.5071	38.6738	38.9274
0:16	36.6456	38.0996	36.5388	35.4903	37.6372	38.5765	38.7164
0:21	36.3182	37.9245	36.0975	34.9724	37.1208	37.9089	38.5032
0:26	36.3741	37.5636	36.3052	34.9524	36.8732	38.192	38.4074
0:31	37.2101	38.3978	35.8507	35.7516	37.9357	38.6477	39.583
0:36	36.7131	37.6368	35.7329	35.0638	37.0602	38.0757	38.8975
0:41	36.4064	37.4443	35.9958	34.9467	37.0572	38.2242	38.5534
0:46	36.2572	37.1817	35.8484	34.4549	36.4528	37.8479	38.2906
0:51	36.3024	37.3405	35.5877	34.5763	36.6877	37.6277	38.4874
0:56	36.0113	36.6708	35.4103	34.0562	35.8273	37.3369	37.7036
1:01	36.161	37.0857	35.8262	33.8256	37.305	37.9793	38.1946
1:06	36.1137	36.7352	35.4748	33.8924	36.4612	37.7047	37.8059
1:11	35.7803	36.4781	35.2171	33.8628	35.9381	37.1821	37.7005
1:16	35.1796	36.5235	35.2246	33.2228	36.1354	37.0379	37.3664
1:21	35.38	36.0405	35.349	33.5379	35.5761	37.162	37.1489
1:26	35.0027	36.1952	35.542	32.9311	35.6929	36.8613	36.8479
1:31	34.8253	35.9043	35.4407	32.8676	35.4777	36.5324	36.7087
1:36	34.7202	36.103	35.4116	33.334	35.4867	36.1996	37.0215
1:41	34.6947	36.1156	35.6523	33.2323	35.8032	36.5919	36.9202
1:46	34.6609	36.0818	35.6564	33.2746	35.7314	36.3303	36.7344
1:51	34.7996	35.8786	35.871	33.223	35.68	36.5068	36.721
1:56	34.3988	35.5926	35.6227	32.8978	35.2037	36.1447	36.3207
2:01	34.3044	35.3844	35.7185	32.8794	34.9193	36.0504	36.1123
2:06	34.7095	35.3709	35.895	33.2852	34.8678	36.1129	36.403
2:11	34.1566	35.3129	35.8369	32.9221	35.0379	35.9029	36.1929
2:16	34.3062	35.0063	36.0242	32.9956	34.8451	36.0523	35.9621
2:21	34.0322	34.9608	35.5608	32.9119	34.4192	35.4747	35.9165
2:26	34.0414	34.8559	36.1019	33.0354	34.4283	35.712	35.7355
2:31	34.0665	35.071	36.2028	33.2892	34.6056	35.699	35.7986
2:36	33.9255	34.8543	36.2901	33.3767	34.3506	35.4442	35.5436
2:41	33.9108	35.0296	36.5791	33.6667	34.3358	35.3534	35.4528
2:46	33.9879	35.2205	36.7698	33.9342	34.3748	35.4685	35.5679
2:51	34.1794	35.5256	37.1124	34.316	34.6043	35.5837	35.6832
2:56	34.0624	35.4848	37.1096	34.2751	34.5634	35.3907	35.5662
3:01	34.017	35.5535	37.1782	34.3439	34.6703	35.2694	35.559
3:06	33.8141	35.465	37.0519	34.1792	34.4295	35.0667	35.5464
3:11	33.8192	35.3562	36.9812	34.3746	34.7009	35.0719	35.4374
3:16	33.9312	35.5059	37.1307	34.2963	34.7367	35.1077	35.5113
3:21	34.0473	35.8494	37.1704	34.4502	34.7005	35.0334	35.8174
3:26	34.1708	35.6689	36.7623	34.1931	34.6717	34.9286	35.7506
3:31	34.5378	36.1488	36.9385	34.5601	34.8863	35.1812	36.1554
3:36	34.5811	36.2299	36.5263	34.4511	34.7775	35.3005	36.0846

March 1st and 2nd

Channel no.	8	9	10	12	12	13	15
Label	8	Bottom 2	Air temp	11	Bottom 3	13	A
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"
3/1/96 0:01	44.2278	47.35	39.0303	40.0892	46.2256	39.0307	39.2518
0:06	44.2308	47.3904	36.9873	40.0166	46.1536	38.8823	39.2169
0:11	43.7687	47.2687	38.4939	39.8181	45.9942	38.6455	39.2453
0.16	43.6717	47.0601	38.586	39.7589	45.7853	38.8134	39.1103
0.21	42.9308	46.5495	36.8947	39.0923	45.6493	38.373	38.5945
0:26	42.6841	46.6422	37.9742	39.1858	45.5544	38.1265	38.7259
0:31	43.4407	46.3809	37.8238	39.7921	45.4805	39.5661	40.0514
0:36	42.5681	46.3022	37.0617	39 1075	45.289	38.7293	39.3668
0:41	42.4895	46.3367	37.4379	39.1045	45.1733	38.461	39.2503
0:46	42.0762	46.1142	36.9095	38.6908	44.913	38.0466	38.8743
0:51	41.8943	46.0088	37.2582	38.4708	45.0329	38.2055	38.5029
0:56	41.1879	45.9463	37.157	37.8774	44.82	37.5355	38.2124
1:01	42.4719	45.719	37.7615	39.4274	44.4045	38.7844	39.6111
1:06	41.5171	45.7473	36.9559	38.5477	44 4329	37.7137	38.7313
1 11	40.844	45.4554	36.7366	37.8364	44.2532	37.4186	38.0199
1:16	41.268	44.8995	36.7061	37.8817	43.7341	37.464	37.8757
1:21	40 8239	45.1726	36.6785	37.6646	43.8195	36.9049	37.8481
1:26	41.0161	44.6871	36.5295	37.5917	43.4838	37.0217	37.5097
1:31	40.8395	44.5494	37.0735	37.4907	43.3459	36.8066	37.4087
1:36	40.8484	44.3703	37 1583	37.0066	43.3924	36.8915	37 0382
1.41	40.9746	44.082	37 7775	37.3605	43.1037	36.9041	37.1267
1:46	40.7515	43.9357	38 0091	37.213	43.0702	36 9083	36 9032
1:51	41.0032	44.2233	37.9199	37.2375	43.0946	36.705	37.0795
1:56	40 3769	43.6014	38.3164	36.6482	42.8109	36.2668	36.4139
2:01	40 3208	43.6209	38.6769	36.592	42 7928	35.9445	36.2437
2:06	40 2315	43.9086	38.8905	36.5026	43 043	35 969	36 4202
2:11	40.401	43.4372	38.6435	36.5585	42.6089	35.911	36.2102
2 16	40.2847	43.5099	38.8301	36.4799	42.5686	35.6421	36.2076
2 21	39.8222	43 0131	40 0329	35.9408	42.4481	35.3684	35.554
2 26	39.9072	43.0598	40.231	35.8739	42.3441	35 2634	35.7532
2.31	40.1976	42 9717	40.3315	35.937	42 3313	35 4406	35.7403
2.36	40 2089	42.5686	40.7582	35.6063	42 041	35 0334	35.2953
2:41	40.5732	42 5163	41.3097	35.5156	41 9509	34 9425	35.2426
2:46	40.8014	42.3665	41 122	35.5925	41.9142	35.0196	35.2435
2 51	41.4841	42.33	41.5382	35.5557	41.9153	35.173	35.3968
2 56	41.2542	42.1764	41 6485	35.5148	41 7617	34.9799	35 2799
3 01	41 2848	41.943	41 5282	35.5076	41.5282	34 9346	35 2346
3:06	41 1588	41 6289	40.912	35.191	41 2894	34.6174	34.9938
3:11	41.0124	41.4454	40.8038	35.2721	41.219	34.5845	34 8087
3:16	41.0481	41.4809	40.3484	35 384	41.1791	34.6203	34.9587
3:21	41.1634	41.5204	40 5768	35.3477	41.1808	34 8125	35.0366
3:26	40.9076	41.2655	39.7547	35.357	41.1523	34.7456	34.8176
3:31	41.1592	41 667	39.4765	35.6475	41.4407	35 1127	35.2985
3:36	40.4068	41.6722	38.952	36.2985	41.5591	35.3082	35.3038

March 1st and 2nd

Channel no.	15	17	17	18	19	20
Label	Bottom 4	B	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"
3/1/96 0:01	47.2751	38.56833	46.4881	38.5012	38.9718	36.3533
0:06	47.2031	38.23013	46.3786	38.3148	38.6719	36.2043
0:11	46.969	38.10693	46.2192	38.4947	38.4352	35.8909
0:16	46.9102	38.38873	46.0854	38.3596	38.6409	35.6792
0:21	46.6995	37.79613	45.6493	38.1066	38.1248	35.3133
0:26	46.3797	37.66233	45.7045	37.8233	59.3877	53.3443
0:31	46.4184	38.68733	45.3303	39.4528	57.7256	52.4896
0:36	46.1897	37.88733	45.3266	38.7299	55.4248	51.9645
0:41	46.0741	37.88433	45.4362	38.3861	54.3824	51.2906
0:46	45.739	37.43153	45.2135	38.0098	53.3069	50.2485
0:51	45.9713	37.59063	45.0329	38.2065	52.607	49.5087
0:56	45.6086	36.80593	44.9327	37.5369	51.651	48.7361
1:01	45.2686	38.32173	44.7803	38.4064	51.2388	47.7609
1:06	45.1843	37.32613	44.8838	37.6771	50.2968	47.1898
1:11	45.1175	36.76483	44.4412	37.3442	49.147	46.4108
1:16	44.6741	36.92433	44.1478	36.9723	49.0048	45.4424
1:21	44.6843	36.47873	44.3836	36.6687	48.0422	45.1145
1:26	44.3489	36.55763	43.7848	36.53	47.5957	44.2153
1:31	44.2111	36.30433	43.6845	36.3528	47.0462	43.5882
1:36	44.4079	36.23723	43.3547	36.7415	46.1925	43.1453
1:41	44.0444	36.47793	43.2167	36.3744	45.8297	42.2534
1:46	43.9733	36.33003	42.9949	36.2646	45.1579	41.8805
1:51	44.0729	36.35463	43.0569	36.1753	45.0319	41.6031
1:56	43.6014	35.91613	42.7355	35.623	44.2976	40.8657
2:01	43.4704	35.59353	42.6798	35.3766	43.8281	40.6586
2:06	43.6828	35.58003	42.8171	35.5912	43.3254	40.6452
2:11	43.3996	35.75023	42.3828	35.3051	43.1172	39.9072
2:16	43.1711	35.51933	42.4179	35.1123	42.5871	39.7533
2:21	43.0508	35.13123	42.0335	35.0667	41.8633	39.1026
2:26	42.7962	35.10233	42.0426	34.8476	41.6837	38.9225
2:31	42.8587	35.27963	41.9543	34.9108	41.6331	38.796
2:36	42.4932	34.98643	41.6262	34.6557	41.0404	38.2391
2:41	42.3279	35.00973	41.5361	34.6029	40.8369	38.2244
2:46	42.2535	35.01073	41.5748	34.6419	40.649	37.96
2:51	42.33	35.20223	41.4628	34.7953	40.839	37.9991
2:56	42.101	35.12323	41.2713	34.5261	40.4584	37.7309
3:01	41.943	35.00183	41.0754	34.5569	40.3378	37.6858
3:06	41.5158	34.72273	40.7987	34.2398	73.9092	67.7492
3:11	41.4454	34.76593	40.7283	34.283	67.721	67.4251
3:16	41.5187	34.83983	40.7638	34.3569	74.3475	70.8175
3:21	41.4827	34.80353	40.8789	34.549	75.8354	72.5295
3:26	41.2278	34.69863	40.8881	34.6725	77.5087	74.1003
3:31	41.5162	34.98963	41.403	35.1535	79.3374	75.9361
3:36	41.4836	34.99493	41.5968	35.3869	80.532	77.1353

March 1st and 2nd

Channel no.	1	2	3	4	5	6	7
Label		2	ground temp	4	J	I	7
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
3:41	34.8578	36.2782	36.7264	34.7659	35.054	35.5771	36.2851
3:46	35.0824	36.2367	36.1914	34.3819	34.8984	35.6115	36.2435
3:51	35.4175	36.6091	36.1844	34.3369	34.9674	35.8326	36.5026
3:56	36.1044	37.105	36.2254	34.7203	35.4646	36.2914	37.0754
4:01	36.453	37.6423	35.9284	34.8032	35.6234	36.64	37.386
4:06	36.7216	37.8725	35.7034	34.9202	35.7023	36.7189	37.4269
4:11	36.9996	38.1499	35.6778	35.2748	35.9047	37.1866	37.5912
4:16	37.2374	38.4251	35.5361	35.5511	36.0669	37.2728	37.7912
4:21	37.528	38.7151	35.5233	35.5004	36.2439	37.4118	38.0061
4:26	37.7872	39.0115	35.175	35.5702	36.5794	37.7469	38.2654
4:31	38.3353	39.5206	35.0787	35.6639	36.7489	38.1057	38.7001
4:36	38.6273	39.6609	35.1819	36.0707	36.8897	38.4736	38.9166
4:41	38.9584	39.878	35.0201	36.0991	36.8042	38.502	38.907
4:46	38.9804	39.9756	34.8902	36.349	37.0539	38.6755	39.1564
4:51	39.1682	40.2007	34.7366	36.4235	37.1283	38.8255	39.3443
4:56	39.9687	41.0751	34.5909	36.8853	38.0065	39.5131	39.9943
5:01	40.2743	41.4932	34.442	37.0403	38.3885	39.8946	40.4515
5:06	40.7028	41.9208	34.4551	37.5083	39.007	40.3612	40.7292
5:11	41.0742	42.329	34.3729	37.8811	39.3791	40.7329	40.9877
5:16	41.4028	42.7322	33.7906	38.211	39.784	41.1372	41.3923
5:21	41.839	43.1298	33.4312	38.9137	40.221	41.7246	41.9046
5:26	41.8126	43.2163	33.0614	39.0384	40.3078	41.585	41.8781
5:31	41.9677	43.2958	33.3326	38.8158	40.1232	41.7025	41.9579
5:36	41.9841	43.5379	33.3492	38.8701	39.9508	41.7943	41.9744
5:41	42.4634	43.7904	33.8718	39.1998	40.6199	42.1607	42.4165
5:46	42.5997	44.0391	33.6287	38.7693	40.681	42.2971	42.7038
5:51	42.8685	44.1946	33.2529	39.0394	41.0637	42.5662	42.8976
5:56	43.4314	44.6435	33.2892	39.4913	41.4768	43.0917	43.3104
6:01	43.6557	44.98	33.2496	39.6411	41.4754	43.4291	43.535
6:06	44.1255	45.3362	33.5352	39.9998	41.7579	43.6735	43.9301
6:11	44.0432	45.2915	33.223	39.917	42.0899	43.7416	43.9606
6:16	44.5936	45.7657	33.0951	40.3946	42.6039	44.1043	44.4741
6:21	44.754	46.2632	32.9147	41.0465	43.1035	44.6408	44.7852
6:26	45.1738	46.6819	32.7689	41.6566	43.6369	45.1359	45.1303
6:31	45.2788	46.5245	33.1043	41.2342	43.2154	45.0531	45.0851
6:36	45.2327	46.516	32.8288	41.1501	43.4326	45.0446	45.2645
6:41	45.1029	46.274	32.3917	41.2838	43.2649	44.8772	45.0594
6:46	45.3593	46.867	32.4997	41.5791	43.8228	45.3215	45.5792
6:51	45.4872	46.9946	32.6677	41.2172	44.026	45.149	45.5569
6:56	45.7352	47.2793	32.7672	41.8058	44.124	45.5473	45.7676
7:01	46.0489	47.7045	32.781	42.0833	44.551	45.9362	46.2318
7:06	46.5451	47.9751	32.5992	42.9583	45.0856	46.4702	46.3532
7:11	46.4883	48.1427	32.5032	43.3529	45.2915	46.7883	46.3339
7:16	46.3466	48.0014	32.3972	43.0225	45.2247	46.5716	45.8915

March 1st and 2nd

Channel no.	8	9	10	12	12	13	15
Label	8	Bottom 2	Air temp	11	Bottom 3	13	A
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"
3:41	40.0002	42.2481	39.2651	36.081	41.9842	35.5849	35.8464
3:46	39.6932	42.2068	38.4667	36.1914	42.1691	35.6193	35.7288
3:51	39.6483	42.4637	38.1946	36.2604	42.5014	35.9166	35.9499
3:56	40.2959	43.1446	37.4017	36.7568	43.0317	36.5276	36.5606
4:01	40.6059	43.5654	36.6498	37.1052	43.3396	36.9143	36.985
4:06	40.4194	43.7565	37.9801	37.1081	43.6813	37.0691	37.1019
4:11	40.5834	44.2577	37.3481	37.4997	44.1073	37.2713	37.4557
4:16	40.7452	44.6813	37.3204	37.6617	44.4934	37.4334	37.7693
4:21	40.8082	45.1195	36.9663	37.649	44.8941	37.6863	37.9083
4:26	40.7263	45.2636	36.0491	37.946	45.1134	37.8697	38.0537
4:31	41.0092	45.7692	35.649	38.1153	45.5815	38.3045	38.3746
4:36	41.0361	46.471	35.6	38.0286	46.2836	38.521	38.6288
4:41	41.2537	46.724	34.3733	38.2084	46.4241	38.7009	38.8465
4:46	41.3515	47.158	34.5478	38.5335	46.8208	38.8745	39.1335
4:51	41.3122	47.606	34.5463	38.5321	47.2315	39.0624	39.3213
4:56	42.1132	48.0616	32.3426	39.1063	47.6873	39.8638	39.933
5:01	42.3812	48.5512	32.3459	39.4123	47.99	40.2831	40.2387
5:06	42.7722	49.2369	32.9313	39.8412	48.4519	40.5985	40.7807
5:11	43.1061	49.5298	33.4588	40.1753	48.7824	40.668	40.9635
5:16	43.5105	49.7804	34.2857	40.5043	49.108	40.9971	41.2168
5:21	43.9093	50.4361	33.0119	40.9789	49.6895	41.5095	41.8796
5:26	44.0714	50.5964	32.7182	41.1788	49.8126	41.5962	41.9286
5:31	43.8494	51.0109	33.7136	41.1077	50.3022	41.7892	42.0838
5:36	43.7903	51.6235	34.8723	40.9731	50.7289	41.8812	42.2887
5:41	44.3832	52.1344	34.4429	41.453	51.2403	42.3232	42.6926
5:46	44.595	52.3808	33.362	41.665	51.3751	42.6481	42.7913
5:51	44.8641	52.6093	31.7268	42.0096	51.5666	42.8042	43.0602
5:56	45.3898	53.0911	31.6104	42.347	52.0119	43.1792	43.435
6:01	45.6519	53.4987	32.3724	42.647	52.42	43.4791	43.6217
6:06	46.0092	54.1115	33.2303	43.0798	52.8476	43.8741	44.1294
6:11	46.2278	54.2159	33.0324	43.2608	53.0637	43.9046	44.235
6:16	46.7033	54.5368	31.9505	43.4356	53.4595	44.3051	44.6352
6:21	47.127	54.9551	31.9608	43.7844	53.581	44.541	44.8709
6:26	47.622	55.4068	32.2729	44.2423	53.922	44.886	45.2907
6:31	47.6144	55.6959	32.1888	44.4226	54.1745	44.9912	45.4334
6:36	47.7936	55.8358	31.7602	44.5269	54.2775	45.133	45.4624
6:41	47.6263	56.0042	32.2391	44.3594	54.5205	44.9655	45.4077
6:46	48.1455	56.5536	31.3924	44.8039	54.9595	45.5978	46.1145
6:51	47.7853	56.7908	31.4461	44.3306	55.123	45.7633	46.0172
6:56	48.0709	56.9614	31.6221	44.7293	55.2939	45.8237	46.115
7:01	48.6849	57.3079	30.9481	45.1185	55.4557	46.0625	46.3162
7:06	49.3685	57.6495	30.6512	45.6154	55.761	46.1839	46.5875
7:11	49.649	58.0002	30.6315	45.9338	56.0014	46.1646	46.8681
7:16	49.3949	58.0084	30.9076	45.867	56.1948	45.9101	46.6514

March 1st and 2nd

Channel no.	15	17	17	18	19	20
Label	Bottom 4	B	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"
3:41	41.7957	35.50013	42 135	35.8534	81.5859	78 1933
3:46	41.8675	35.42043	42.4329	36.0018	82.3019	78.8398
3:51	42.1622	35 48953	42.9534	36.3367	83.6604	79.8792
3:56	42 542	35.98703	43.5963	36.9091	84.8112	81.1429
4:01	42.9255	36.45003	43.9792	37.3713	85.7493	82.0848
4:06	43.192	36.56703	44.3582	37.7155	86.1817	82.6628
4:11	43.6183	36.92133	44.8966	37.9174	86.7659	83.2493
4:16	44.0423	36.96963	45.4325	38.1172	87.598	83.9052
4:21	44.4056	36.99483	45.9078	38.3318	88.1219	84.503
4:26	44.6251	37.36843	46.2393	38.4393	88.5089	84.7841
4:31	44.9807	37.61383	46.9316	38.9492	89.168	85.41
4:36	45.6458	37.83053	47.5951	39.1654	89.7284	86.0443
4:41	45.8615	37.82103	47.8477	39.3829	90.0758	86.3216
4:46	46.2585	38.10863	48.3559	39.6697	90.0966	86.4499
4:51	46.632	38.22093	48.9154	39.9329	90.3447	86.699
4:56	47.0881	38.75813	49.2582	40.5818	90.7782	87.0985
5:01	47.5408	39.02663	49.8217	40.925	91.1018	87.4949
5:06	48.0403	39.38053	50.4691	41.391	91.7546	88.1145
5:11	48.4833	39.79083	50.8734	41.5736	91.9623	88.2874
5:16	48.7341	40.15823	51 1981	41.9021	91.9875	88.3841
5:21	49.3533	40.78463	51.7409	42.489	92.1499	88.6542
5:26	49.5139	41.02263	52.1245	42.7263	92.0538	88.4864
5:31	49.8916	40.95133	52.5754	42.8059	92.4134	88.8117
5:36	50.3558	40.96783	52.9265	42.7094	92.6777	89 1127
5:41	51 0166	41 52373	53.5481	43 0753	93.094	89.5663
5:46	51.226	41.54713	53 7569	43.3622	93.3646	89 6596
5:51	51.3803	41.92983	54.1336	43.5932	93.4405	89 8428
5:56	51.8256	42.30543	54.6145	43.9677	93.6873	90.1263
6 01	52.1594	42 49253	54.9471	44.2295	87.3095	84 5483
6 06	52.736	43.03903	55 4106	44 6991	86.576	84.0638
6:11	52 8405	43 29563	55.626	44.8799	90.5676	86.9227
6:16	53.2364	43.47053	55.8723	45.167	90.5548	87.2675
6:21	53.6182	43.78203	56.1788	45.44	91.3834	88 099
6.26	54.0706	44 24033	56.6298	45.7469	92.2077	88 8907
6.31	54.2859	44 30803	56.8444	45 8895	92 6982	89 3829
6:36	54 426	44 45003	56.9471	46 1061	93.0099	89.6958
6:41	54 669	44 43283	57.2633	46.0889	93.3488	90.0716
6:46	55.1821	44.61453	57.627	46.6076	93 9817	90.7068
6.51	55.3827	44.21593	57.9008	46 8103	94 3155	90 9705
6:56	55.6277	44 31403	58 1451	46.908	94.5853	91 2413
7:01	55.8635	44 66623	58.3803	47.3337	94 8463	91.5389
7:06	56.1687	45.31423	58.7214	47.3425	95.1736	91.7962
7 11	56.4089	45 70823	58 8871	47.6228	95.4034	92.0624
7 16	56.6393	45.60373	59.2275	47 4438	95 482	92.0702

March 1st and 2nd

Channel no.	1	2	3	4	5	6	7
Label		2	ground temp	4	J	I	7
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
7:21	46.5721	48.3759	32.9318	42.6466	45.2253	46.4222	46.3803
7:26	46.052	47.9694	32.8223	41.7472	44.742	45.8643	46.0472
7:31	45.6918	48.1713	33.0282	41.6868	44.7194	45.7292	45.912
7:36	46.5457	48.8353	33.5529	42.9212	45.499	46.6207	46.579
7:41	46.8391	49.165	33.394	43.3664	45.9053	47.139	46.9478
7:46	47.2681	50.0403	33.7541	44.1355	46.597	48.0172	47.1897
7:51	47.6776	50.7836	34.2848	44.6217	46.8195	48.3143	47.2999
7:56	48.9044	51.7817	35	45.7777	47.9725	49.6151	48.1916
8:01	49.306	52.2189	35.7127	46.3682	48.4119	50.1659	48.6316
8:06	49.3039	52.3283	35.5965	46.4036	48.4471	50.0144	48.2924
8:11	49.5213	52.3588	35.6277	46.809	48.6273	50.3063	48 4729
8:16	50 5255	53.2104	36.042	47.9286	49.7444	51.5335	49.517
8:21	51.103	53.4514	36.0985	47.7597	49.7999	51.8497	50.208
8:26	51.6586	54.1164	36.5886	48.2427	50.0205	51.9209	50.7276
8:31	52.0644	54.4094	36.7365	47.9769	49.9046	52.1404	51.2089
8:36	52.899	54.9445	37.0562	48.7033	50.6294	52.938	51.8217
8:41	53.5683	55.5006	37.4734	49.1518	51.114	53.4587	52.4554
8:46	54.442	56.2237	37.7964	50.5896	52.2135	54.8155	53.2569
8:51	55.1531	57.0067	38.2193	50.9684	52.666	55.3039	53.8954
8:56	55.7455	57.4126	38.4835	51.042	52.9626	55.5997	54.5265
9:01	56.5173	57.9239	38.5907	51.3711	53.4025	56.2608	55.0034
9:06	57.1631	58.5312	38.9482	52.0208	53.8277	56.9439	55.7624
9:11	58.1369	59.5397	39.7551	53.1491	54.9536	57.8073	56.6649
9:16	58.4361	59.9857	39.9477	53.3757	54.8459	57.8109	56 7055
9:21	59.4387	60.6912	40.8978	54.05	55.7414	58.6297	57 5262
9:26	60.0418	61.3299	42.0805	54 5827	55.9396	59.0121	58.0574
9:31	60 7674	61.87	47.329	55 2387	56.4835	59.4065	58.6376
9:36	61.5329	62.6708	52.0266	56.3795	56.9197	60.0628	59.0733
9:41	62.2514	63.3145	54.0175	57.2872	57.716	60.6353	59.4623
9:46	63.2262	64.0307	56.1515	58.1936	58.4373	61.3545	59.9616
9:51	64.029	64.9788	57.7012	59 2963	59.3552	62.0489	60.4364
9.56	64.4675	65.5265	58 7343	59.4052	59.2796	62.1207	61.0986
10:01	64.9218	66.0532	59 3764	59.4933	59.4415	62.135	61 2235
10:06	65.7976	66.8541	61.9892	60.6325	60.1385	62 7198	61.7358
10:11	66.4619	67.2249	62.8404	60.8956	60.5861	63.3866	62 5145
10:16	66.9272	68.0546	63.9687	61.5847	61.165	63.6701	63.1296
10.21	67.819	68.8717	65 7067	62.2613	61.7683	64.7123	63 8059

March 1st and 2nd

Channel no.	8	9	10	12	12	13	15
Label	8	Bottom 2	Air temp	11	Bottom 3	13	A
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"
7.21	49.0957	58.5634	30.6405	45.5674	56.5658	46.5112	46.877
7 26	48.2378	58 4942	30.416	44.6709	56.4595	46.2158	46.5068
7:31	48.5529	58 8414	30.393	44.31	56.5113	46.2308	46.7093
7:36	49.8187	59.0913	31.0341	45.4282	56.7989	46.7473	47.1878
7:41	50.2242	59.3434	30.8747	45.8722	57.1257	47.0784	47.7807
7:46	51.1765	59.5815	32.267	46.6017	57.3274	47.3952	48.3965
7:51	51.7349	59.8375	32.5699	46.8242	57.4361	47.6177	48.843
7.56	52.9222	60.0144	34.0867	48.1272	57.7985	48.097	49.9565
8:01	53.696	60.4844	34.9524	48.6415	58.011	48.6117	50.731
8 06	53.6193	60 5192	35.3305	48.3775	57.9719	48.1229	50.6916
8:11	54.0226	60.7705	35.6657	48.8196	58.1132	48.0412	50.8341
8:16	55.099	60 8775	37.6357	49.9741	58.4053	48.6366	51 9117
8:21	55.452	60.7481	37.8816	50.4774	58.5341	48.9915	52.3767
8:26	55.8949	60.9658	38.4842	50.5487	58.6786	49.2499	52.82
8:31	56.337	61.0356	39.1616	50.955	58.7855	49.3956	53.2254
8:36	56.9844	61.1618	40.3497	51.9026	59.0229	50.0095	53.9477
8 41	57.6154	61.4565	40.4631	52.5728	59.3921	50.4204	54.7278
8:46	58 4135	61.5493	41.1624	53.745	59.522	51.1117	55.341
8:51	59 1975	61.7761	42.5259	54.3824	59.7493	51.8635	56.1628
8:56	59.6408	61.812	42.4874	55.0868	60.1173	52.5705	56.7177
9:01	60.0417	61.7322	42.9707	55.6369	60.148	53.0482	57.0448
9 06	60.7607	61.9326	44.1915	56.6168	60.5331	53.8832	57.8384
9 11	61.881	62.3127	44.3167	57.7393	60.6927	54.8988	58.8857
9:16	61.9584	62 2426	42.5139	57.7058	60.8068	54.6052	58.7415
9:21	62 7387	62.6159	44.8145	59.0048	61.1807	55.5761	59 6702
9.26	63.3782	62.5553	44.7526	59 5715	61.2673	56 1826	60 0891
9:31	63.9927	62.7274	45 0787	60.2975	61.6238	56.801	60 778
9 36	64.5001	62.9769	44 4695	60 8056	61.8735	56.6448	60.6595
9:41	65.1816	63 1432	46.2163	61.5248	62.1504	56.7754	60.8263
9 46	65 7887	63.4928	46.8356	62.1327	62.3902	57.2762	61.3613
9:51	66.6282	63.8917	48.0288	63.0469	62.8264	57.7153	62 019
9 56	66.9935	63.9266	46.6787	63.6329	63.1186	58.4534	62.6427
10 01	67.1911	64.1611	47 6672	63.6839	63.39	58 5417	62.3258
10 06	67.884	64.451	48.1126	64.1941	63.6067	59 1294	62.9474
10:11	68.2191	64.7497	49.3891	64 713	63 8323	60.1317	63.9447
10 16	68 6482	65.1426	48.5562	64 996	64.0422	60.9327	64.5951
10.21	69.4678	65.267	52.0786	65.78	64.4235	61.3895	65 123

March 1st and 2nd

Channel no.	15	17	17	18	19	20
Label	Bottom 4	B	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"
7:21	57.0101	45.26613	59.5972	47.8938	89.3686	86.9714
7:26	57.0149	44.25553	59.7865	47.7488	88.6239	86 1173
7:31	57.2887	43.93173	59.9118	47.8386	92.6272	88.8479
7:36	57 613	44.67553	60.1982	48.279	85.7694	83.5422
7:41	57.8656	45.19563	60.3763	48.6841	89.587	84.5049
7:46	58.0671	46.07663	60.6509	48.8879	84.2741	82.3668
7:51	58.2866	46.33713	60.7961	49.2221	84.3795	82.1848
7:56	58.5377	47.97943	61.0464	49.6254	83.2954	81.3861
8:01	58.9717	48.53173	61.2213	48.6068	87.7998	83.1387
8:06	59.0804	48.11773	61.1455	49.95	82.0985	80.2226
8:11	59.2583	48.67263	61.4335	50.13	83.9958	84.96
8:16	59.4394	49.94063	61.5037	50.4997	81.7648	79 6719
8:21	59.3097	50.33243	61.5584	50.7417	80.9906	79.3288
8:26	59.5647	50.44113	61.5551	51.1112	86.8726	84 0384
8:31	59.6346	50.84793	61.7352	51.0327	80 6954	78 7444
8:36	59.8348	51.61013	61.7878	51.3842	86.9199	84.3369
8:41	60.1668	52.20663	61.9718	51.4588	87.9208	85.3048
8:46	60.1861	53.12003	62.0278	51.7391	89.3316	86.684
8:51	60.45	53.90743	62.1808	52.0803	90.5492	87.9051
8:56	60.6334	54.38983	62.2535	52.4518	84.5798	82.5654
9:01	60.4798	54.86673	62.3945	52.5944	88 6882	85.9313
9:06	60.6805	55.66293	62.5579	53.2435	82.9746	81 2086
9:11	61.098	56.56543	62.8275	54.0736	89.037	86.4959
9:16	61 0647	56.27233	62.7575	54.3743	89 5042	86 8571
9:21	61 4385	57.24153	63.0938	54.8997	90.8993	88.3634
9:26	61.4514	57.58783	63.1434	55.2466	91.837	89.161
9 31	61 6238	57.98333	63.3522	55.7912	92.7146	89.9342
9 36	61.8735	58.16043	63.6381	56.1169	93.3819	90.6748
9 41	62.0401	58 66073	63.9512	56.3216	93.8265	91.1563
9 46	62 3534	59 38213	64 1537	56.8594	94 5545	91.8508
9.51	62.7896	60.04183	64.6256	57.2985	95.0459	92.4504
9:56	62.8981	60.55673	64.8073	57.9257	95.2214	92.6264
10:01	63.0961	60.34963	65.0415	58.1988	95.6957	93.0665
10:06	63.3496	61 08363	65.4043	58.7495	96.0108	93.347
10 11	63.6487	61.53133	65.6661	59.604	96.2637	93.6006
10.16	64.1156	61 88933	65 8389	60.4052	96 6076	94.0165
10.21	64.2768	62.82413	66 1462	61 3778	96 8691	94.2432

March 1st and 2nd

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	J	I
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F
22:00	25.5199	28.9192	30.6291	26.9289	28.3325	27.2446
22:05	25.0414	27.4461	30.5362	32.4625	28.2777	26.6133
22:10	24.9026	26.6935	30.3601	26.3128	28.5613	27.8578
22:15	24.3303	26.1229	30.251	25.2799	26.8017	25.9803
22:20	24.0506	25.8056	30.0883	30.679	31.3124	25.5857
22:25	23.8866	25.8728	29.9638	27.1444	26.6671	26.3841
22:30	26.2867	26.5768	29.7846	25.2343	29.5176	27.5493
22:35	24.661	25.6839	29.6991	25.2253	25.9399	27.4635
22:40	23.7004	25.264	29.5875	24.5354	25.2506	25.8521
22:45	23.4473	25.0117	29.5279	24.1671	25.0752	25.4457
22:50	23.324	24.8886	29.4821	24.0439	24.8751	25.2456
22:55	23.2006	24.65	29.5512	23.9206	24.7134	24.9683
23:00	22.839	24.1738	29.4224	23.4437	24.16	24.4147
23:05	23.7604	26.0162	29.3791	25.0961	27.2712	25.758
23:10	22.4541	24.599	29.1939	23.4838	24.7009	24.5704
23:15	22.2283	23.9501	29.0084	23.0653	24.0132	24.0751
23:20	21.9801	23.5098	28.839	22.5857	23.5728	23.5959
23:25	21.6482	23.1401	28.7016	22.2927	23.2416	23.3804
23:30	21.5885	22.9649	28.5275	22.0399	23.0663	23.205
23:35	21.3799	22.7954	28.3207	21.8702	22.8196	23.1127
23:40	21.211	22.6655	28.1916	21.7401	22.7282	22.9827
23:45	20.8877	22.343	28.0631	21.4557	22.4056	22.66
23:50	20.8512	22.2294	27.7967	21.3033	22.2919	22.585
23:55	20.8937	22 1946	27.8004	21.3071	22.2957	22.6274
0:00	21.6822	23.3284	27.6228	22.6744	27.5861	25 9198
0:05	20 6676	22.278	27.5763	22.6663	24.2317	22.8269
0:10	20.2197	21.8314	27.478	21.5238	22.4349	22.2255
0 15	20.1902	21.7246	27 4103	21.1073	22.0576	21.9639
0:20	20.3338	21.6746	27.2838	20.9024	21.6209	21 6817
0:25	20.4164	21.9502	27.2121	20.9462	21 742	21.7642
0.30	20.8264	22 2819	27.1193	21.0076	21.6873	21.9416
0:35	22.9874	22.8179	27.0763	23.2447	23.7297	22.6329
0 40	21.3699	23.7113	26.9671	22 6717	22.7323	22.2138
0:45	21.2389	23.5423	26.7986	22.0773	22.3698	22.315
0:50	21.7752	23.8067	26.7932	21.9945	22 3644	22 5801
0:55	21.8098	23.9569	26.6739	21.9905	22 4376	22.692
1:00	21.6821	23 9068	26.5855	21.8629	22.2714	22.5645
1 05	21.8508	23.8436	26.4455	21.8381	22.2853	22.5398
1:10	23.7834	25.9622	26 3315	23.8474	27.0837	25.858
1:15	22.2409	24.348	26.2567	23.0779	23.563	23.0842
1:20	22.3335	24.6713	26.1565	22.7842	23.2309	23.2539
1:25	22.4433	24.7808	26.035	22 7009	23.2634	23.1705
1:30	22.5767	24.6826	25.9755	22 5252	22.9334	23.188
1:35	23.0244	25.2058	25.8828	22.6253	23 1493	23.5197

March 6th and 7th

Channel no.	7	8	9	10	11	12	13
Label	7	8	Bottom 2	Air temp	11	Bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
22:00	28.9505	35.0538	37.4832	24.1774	31.8519	36.0791	28.3232
22:05	26.9747	32.8214	37.2395	24.0838	29.5794	35.873	26.4235
22:10	26.5282	31.7645	37.0648	23.9448	28.6749	35.622	26.9772
22:15	25.6096	30.9652	36.8429	23.8348	27.4912	35.3616	25.5974
22:20	25.2915	30.8788	36.6815	23.7479	27.9038	35.238	25.1253
22:25	25.3589	31.0226	36.4442	23 4294	27.0877	35.0002	25.578
22:30	25.4097	32.5673	36.1905	23.1329	28.8652	34.7461	26.0139
22:35	25.9017	31.1409	36.0677	23.0466	27.0526	34.6231	26.1974
22:40	24.98	30.1466	35.8051	22.9727	26.4025	34.36	25.1222
22:45	24.6885	29.8564	35.6699	22.9898	26.1503	34.1484	24.6766
22:50	24.6037	29.6569	35.4724	22.9823	25.9505	33.9505	24.5148
22:55	24.3646	29.4187	35.1988	23.0905	25.7505	33.7526	24.1985
23:00	23.9259	28.9435	34.9949	22.7675	25.1976	33.3959	23.9529
23:05	24.6929	29 6303	34.7617	22.6079	26.2317	33.3147	24.6038
23:10	23.6956	28.8296	34.6159	22.2279	25.3915	33.283	23.7227
23:15	23.7403	28.4125	34.3935	22.0793	24.7428	33.0221	23.3425
23.20	23.3377	28.0115	34.1492	21.9858	24.4568	32.7773	22.9785
23.25	22.9672	27.7194	33.9746	21.6538	24.1259	32.5643	22.6853
23.30	22.8303	27.6216	33.7255	21.5555	23.9893	32.3147	22.5097
23:35	22.7378	27 4524	33.5201	20.8048	23.9357	32.2235	22.3786
23:40	22.569	27.3613	33.2775	20.7132	23.8058	32.0568	22.2097
23:45	22.3232	27.078	33.1497	20.6221	23.3678	31.8907	21.9639
23:50	22.2094	26.9646	32.8851	20.4694	23.3314	31.6638	21 8113
23:55	22.2132	27.0069	32.6981	20.4344	23.3738	31.4766	21.7764
0:00	23.9673	28.9463	32.4452	20.2163	25.3543	31.3379	23.2605
0:05	22.2968	27.0517	32.2846	20.0918	23.5344	31.1388	21.7827
0:10	21.7719	26.4903	32.0342	19.9538	22.9723	30.8881	21.3738
0:15	21.6261	26.1522	31.8905	20.0793	22.6338	30.6677	21 1893
0:20	21.5373	25.9478	31.8029	19.9904	22.5065	30.6565	21 2166
0:25	21.7748	26.0687	31.8844	19.7241	22.6275	30 8527	21 3767
0:30	21.991	26.0527	31.9831	19.4752	22.766	31.0662	21.5543
0 35	23.3403	27.0509	32.2457	19.4318	23.7652	31.4056	26.5674
0 40	22.7278	26.5172	32.5189	19.3991	23.5398	31.6409	23.1032
0:45	22.5969	26.4253	32.7712	19.3454	23.4092	31.9317	22.6244
0:50	22.8622	26.497	33.1091	19.2624	23.3652	32.3462	22.735
0:55	22 8968	26 5315	33.5243	18.9866	23.3997	32.7237	22 6922
1:00	22.8852	26.5585	33.8557	18.8584	23.2723	33.1317	22.758
1.05	22.9378	26.5338	34.3264	18 8724	23.209	33 4123	22.8106
1 10	24.6387	29.7301	34.6702	18.6407	26 6775	33.985	24.5883
1:15	23.2892	27 3084	35.0527	18.9146	24.0229	34.1014	23.3551
1:20	23.2658	27.0923	35.524	18.5805	23.9609	34.6112	23.2931
1:25	23.4529	27.1248	35.9359	18.3413	24.032	35.0237	23.4029
1 30	23.4318	27.1037	36.3708	18.3977	23.9337	35 3831	23.4976
1:35	23.6865	27.2806	36.8488	18.2264	24.1108	35.8236	23.7135

March 6th and 7th

Channel no.	14	15	16	17	18	19	20
Label	A	Bottom 4	B	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
22:00	31.1943	35.6992	31.07213	36.4209	29.2501	28.5359	27 1905
22.05	29.264	35.569	32.05003	36 2148	26.5851	28.3661	26.9435
22:10	29.5474	35.2039	31 98873	36.0399	28.0217	28.2277	26 7665
22:15	27.9809	35.0194	29.31453	35.8177	25.6827	28.0032	26.5415
22:20	27.472	34.8577	30.64593	35.6181	24.9412	27.8399	26.3779
22:25	28.1918	34.7339	28.71973	35.4185	25.3938	27.6382	26.1759
22:30	27.6282	34.4036	29.65253	35.2405	24.9053	27.3816	25.9957
22:35	28.6938	34.2425	27.95513	35.0796	25.6281	27.2189	25.7943
22:40	27.2384	33.9792	27.30503	34.8546	24.6299	26.9532	25.6436
22:45	26 7942	33.9199	26.97593	34.6432	24.2228	26.7396	25.3526
22:50	26.5175	33.6077	26.81463	34.4455	24.061	26.5398	25.268
22:55	26.2022	33.3335	26.49913	34.2477	23.9376	26.3783	25.1449
23:00	25.6879	32.9003	25.98473	34.0054	23.4991	26.1335	24.9768
23:05	29.2169	32.9715	29.47653	33.81	29.0332	25.9745	24.8175
23:10	26.2666	32.9398	26.75603	33.6259	24.0794	25.7885	24.6698
23:15	25.5029	32.7551	25.99213	33.4033	23.275	25.6021	24.5217
23'20	24.9859	32.3958	25.43663	33.1967	22.7952	25.3934	24.3127
23:25	24.6165	32.259	24.95153	32.9839	22.5022	25.1783	24 1745
23.30	24.3258	32.0857	24.69923	32.7344	22.2493	25.0418	24.0378
23:35	24.2335	31.9563	24.56843	32.5287	22.0795	24.8341	23.8684
23:40	24.1037	31.8659	24 43853	32.3622	21.9106	24.7043	23.7385
23:45	23.7815	31.6234	24.07753	32.1579	21.6262	24.5366	23.6092
23:50	23.6679	31.4728	24.00263	31.9693	21.4737	24.3846	23.457
23:55	23.6717	31.2855	23.89053	31.7439	21.4388	24.1955	23.2677
0 00	26 7679	31.1469	27.14193	31.5672	22.4975	24.0941	23.1662
0.05	24.1796	30.9095	24.59163	31.2917	21.2514	69 9327	64.882
0 10	23.4633	30.6204	23.75933	31.0792	20.9587	68.5985	64.7148
0 15	23.0476	30.3235	23.34353	30.9736	20.8129	71 4876	67.9094
0:20	22.7658	30 1592	23.02293	31.1153	20 7628	73 3677	69.6514
0:25	22.8868	30 3555	23.18263	31 3496	21 1165	75 1142	71.369
0:30	23.064	30 5309	23.12793	31.6776	21 3715	76 5841	72.8088
0:35	26.336	30.7175	25.97853	32.093	25.6518	77.9177	74 1118
0'40	24.7634	30.8383	25.52243	32.4807	22.8812	78.9706	75 1693
0 45	24.1702	31.1677	24.73653	32.9238	22.6732	79.7504	75.9162
0 50	24.2419	31.5062	24.49953	33.4521	22.8996	80 4662	76 6713
0:55	24.1992	31 8459	24 37973	34 0195	23.0114	81.0746	77.2462
1:00	24.1491	32 0254	24.25233	34 5791	23 1543	81 7116	77 886
1:05	24 1244	32.3827	24.03463	34 9732	23.2455	82.1202	78.3325
1:10	30.3504	32.9561	27.69533	35.5449	27.5214	82.5169	78.7309
1'15	26.2083	32.882	25.42683	36.0029	24.3295	83.022	79.1299
1 20	25.4921	33.507	24.97943	36.5115	24.0361	83.4312	79.6851
1:25	25.1779	33.9581	24.93473	37.0368	24.2229	83.8563	79.9678
1.30	25.1568	34.2418	24.75933	37.547	24.2403	84.7334	80.9926
1 35	25.2566	34.7971	24.89783	38.0621	24.4559	85 1847	81 3021

March 6th and 7th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	J	I
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F
1.40	22.9416	25.1233	25.7233	22.5811	23 0279	23.3597
1:45	27.7466	26.0389	25.6388	22.9211	28.1765	29.8118
1 50	23.6833	25.7086	25.5776	22 8984	24 9256	24.9494
1:55	23.3395	25.5583	25.4656	22.9019	24.1585	24.259
2:00	23.3234	25.5038	25.2955	22.8471	23.8339	24.0886
2:05	23.4754	25.8475	25.2931	23.0378	23.9086	24.1634
2:10	23.3901	25.8779	25.1695	23.2227	23.9391	24 001
2 15	23.8444	26.1767	25.0837	23.2911	24 0846	24 3008
2 20	30.5356	26.761	24.9762	29.1431	27.3627	26.696
2:25	25.3496	26.9089	24.8934	25.2206	25.8583	25.4591
2.30	24.9529	27.0125	24.8433	24.6313	25.308	25.332
2:35	24.3695	26.5078	24.7608	24.0864	24.8405	24 7872
2:40	23.9023	26.2728	24.6793	23.6963	24.3352	24.6286
2:45	24.6752	26.9661	24.6426	23.9681	24.7224	24.9773
2:50	28.4816	31.4844	24.4893	28.6206	29.4854	26.2101
2:55	26.2555	27.7356	24.4519	25.7033	25.9561	25.2875
3:00	26.0377	27.8636	24.2721	25.3314	25.8152	25.647
3:05	25.5425	27.5234	24.2001	24.913	25.3585	25 4596
3:10	25.5255	27.775	24.0673	24.819	25.38	25.6735
3:15	25.4703	27.95	24.012	24.8022	25.3633	25.6568
3:20	31 5265	30.8185	23.9326	25.5699	26.8991	29.9159
3:25	26.7819	28.7588	23.8617	24.8447	25.752	26.7763
3:30	26.5465	28.6391	23.7411	24.8014	25.6318	26.6947
3:35	26.4481	28.6559	23.6808	24.7412	25.7256	26.7499
3:40	26 0111	28.5271	23.6282	24 7658	25.6732	26 7744
3 45	25 5764	28.0174	23 4624	24 6387	25.4693	26.3016
3:50	26.4554	28 4333	23.2636	31.0785	27.7309	31.2802
3:55	25.9478	28.7706	23.2174	27.0103	27.0323	27 5949
4:00	26.1927	28.9761	23.1929	25.8328	26.4316	27.5322
4 05	26 0377	28 7452	23.0373	25 447	26.2767	27 2238
4 10	25 9967	28 8958	22.9961	25.3674	26 1588	27.2212
4:15	25 6928	28 4784	22 9228	24.9864	25.7397	26.764
4 20	25.7204	28.5824	22 8346	27.7047	27.7267	29 0945
4.25	25.1015	27.8896	22 6772	25.5115	26.7255	26.6349
4:30	25.3435	28.0539	22.6495	25.253	26.3521	26 492
4 35	25.2963	27.9685	22.5249	24.9748	26.0358	26.4448
4:40	25.4985	28.5148	22.4573	25.023	26.084	26.7621
4:45	26.1918	28 6688	22.458	24.8697	25.7	26.955
4:50	26.6505	28.9726	22.3394	24 8285	25.7743	27.3366
4:55	26.8066	29.3196	22.3805	25.1005	26.0845	27.6078
5.00	25.9564	29.1621	22.2601	25.1731	26.2723	27.2962
5:05	25.389	28.6357	22.1154	24.8364	25.8976	26.768
5:10	25 4713	28 7942	22 0821	24.8803	25.903	26.7734
5 15	25.44	28.6864	22.0119	24.8874	26.0639	26.6267

March 6th and 7th

Channel no.	7	8	9	10	11	12	13
Label	7	8	Bottom 2	Air temp	11	Bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
1:40	23.4491	27.198	37.2606	18.1819	23.951	36.16	23.5535
1:45	31.285	29.3456	37.6323	17.9411	29.9378	36.4943	27.5524
1:50	24.6158	28.3615	38.0647	17.8404	25.7701	36.8894	24.7582
1:55	24.1947	28.0186	38.5227	17.6106	24.965	37.3101	24.4145
2:00	23.9855	27.887	38.8854	17.4777	24.7563	37.6355	24.3598
2:05	24.2534	28.0387	39.2993	17.2808	24.908	38.1637	24.5503
2:10	24.0909	27.9536	39.7074	17.2726	24.9769	38.5344	24.3879
2:15	24.3523	28.2143	40.1524	17.147	25.0837	38.9801	24.6106
2:20	26.0953	29.2992	40.5003	16.9994	26.8615	39.3663	27.4676
2:25	25.4346	28.8322	40.9855	16.7601	26.1638	39.7767	26.5006
2:30	25.3459	28.859	41.2761	16.5926	25.9214	40.1432	26.0656
2:35	24.9163	28.6228	41.6103	16.665	25.6081	40.3268	25.521
2:40	24.6418	28.3876	41.9077	16.6215	25.3342	40.5114	25.2469
2:45	24.9523	28.6202	42.3241	16.4287	25.6055	41.0418	25.4414
2:50	31.6735	30.3503	42.6641	16.2348	30.3647	41.3823	26.8281
2:55	25.9179	29.7755	43.0418	16.158	27.2225	41.6852	26.0211
3:00	25.8538	29.6731	43.3933	15.9372	26.8512	42.0372	26.0726
3:05	25.6278	29.4861	43.6993	15.9034	26.4334	42.3061	25.9237
3:10	25.5722	29.4691	44.0212	15.7303	26.4549	42.6285	25.8681
3.15	25.6325	29.4524	44.3808	15.5573	26.4766	42.9888	26.0439
3.20	32.0772	33.5893	44.6792	15.672	28.2026	43.2501	31.4513
3:25	27.0609	30.4548	44.9859	15.3273	27.3644	43.482	29.9266
3:30	26.6714	30.0278	45.3192	15.4005	26.9754	43.7407	28.4264
3:35	26.5728	30.0446	45.5609	15.0664	27.0307	44.0581	27.9441
3:40	26.4433	30.0307	45.885	14.9352	26.9399	44.3828	27.7381
3:45	26.2394	30.096	46.0614	14.6894	26.7747	44.522	27.3424
3:50	28.8859	31.1263	46.2809	14.6055	27.4989	44.7419	27.6441
3:55	26.8804	30.5434	46.6484	14.5197	27.5297	45.0725	27.3291
4:00	26.6636	30.4422	46.9245	14.5339	27.3902	45.3867	27.2663
4:05	26.5085	30.3644	47.1856	14.4156	27.197	45.5357	27.0345
4:10	26.5059	30.3618	47.4453	14.374	27.2713	45.8335	27.0704
4 15	26.2789	30.1354	47.5989	14.1827	27.0447	45.9499	26.8436
4:20	27.4222	31.7354	47.8129	14.1716	28.0321	46.0893	27.7167
4.25	26.034	30.8892	47.9598	13.9733	27.4918	46.124	26.7528
4:30	26.0065	30.5548	48.195	13.9062	27.426	46.4346	26.6869
4:35	25.9978	30.3926	48.411	13.6238	27.2253	46.6136	26.5628
4:40	26.123	30.4407	48.7196	13.9073	27.235	46.8855	26.6879
4:45	26.2777	30.2494	48.9072	13.6343	27.1588	47.0735	26.8039
4:50	26.5445	30.3619	49.0541	13.7098	27.3098	47.2207	27.032
4:55	26.6239	30.4027	49.2433	13.4386	27.4274	47.4853	27.1883
5:00	26.4656	30.6286	49.4633	13.1212	27.4231	47.5933	26.9532
5:05	26.1674	30.3314	49.5475	13.2094	27.2793	47.7152	26.6553
5:10	26.1343	30.4135	49.6648	13.0193	27.2078	47.8701	26.6222
5:15	26.0644	30.459	49.8211	12.9483	27.2817	48.139	26.6293

March 6th and 7th

Channel no.	14	15	16	17	18	19	20
Label	A	Bottom 4	B	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
1.40	25.1355	35.0579	24.81513	38.549	24.3732	85.6095	81.6927
1:45	30.0056	35.3546	29.76753	38.9958	26.3298	85.8173	82.0093
1:50	27.7208	35.8263	26.40323	39.5031	25.0367	86.1901	82.2758
1:55	26.8021	36.2855	25.86763	39.9603	24.9632	86.4797	82.6385
2:00	26.3631	36.5354	25.58193	40 3601	24.9086	86.7867	82.9469
2:05	26.4761	37.1402	25.69513	40.8488	25.2529	87.1421	83.2679
2:10	26.2757	37.5114	25.72553	41.2938	25.2448	87.4563	83.5835
2:15	26.4977	37.9955	25.94793	41.7379	25.4286	87.6984	83.8625
2:20	30.4953	38.4201	29.03103	42.1605	30.5414	87.813	83.9776
2:25	28.6892	38.8688	27.52773	42.5694	28.3904	88.0221	84.1517
2:30	27.9869	39.198	27.17013	42.9724	27.1502	88.1899	84.392
2:35	27.4823	39.2683	26.81853	43.2683	26.6067	88.4348	84.6379
2:40	27.1321	39.3774	26.42923	43.6779	26.2946	88.6449	84.8131
2:45	27.2877	40.0598	26.66203	44.0558	26.4119	88.8608	85.0657
2:50	28.5938	40.4007	26.73983	44.3951	30.2109	88.933	85.2099
2:55	27.9042	40.704	26.77953	44.8096	27.9123	89.1481	85.3542
3:00	27.9171	41.2452	26.94633	45.1227	27.3877	89.2671	85.4737
3:05	27.8638	41.4388	26.87443	45.4656	27.2391	89.3789	85.6218
3.10	27.9052	41.7616	27.01133	45.7492	27.1837	89.5771	85.8208
3:15	27.9653	42.1976	27.22533	46.1081	27.2438	89.7398	85.9843
3:20	31.2574	42.4969	30.40803	46.4059	27.9711	89.6664	85.9821
3:25	29.5032	42.6914	28.38203	46.7119	28.1693	89.7792	86.0237
3:30	28.9619	42.988	28.06993	47.082	27.9342	89.9173	86.1983
3:35	28.8253	43.268	27.89473	47.3231	27.8359	90.0399	86.3571
3.40	28.8881	43.6683	27.84233	47.5342	27.8987	90.1695	86.4872
3 45	28.6849	43.8076	27.71563	47.7852	27.7721	90.3014	86.5839
3:50	31.3211	44.0277	31.58163	48 0416	28.3804	90 1892	86.5428
3:55	29 7831	44 4338	30.50263	48.3709	28.0659	90.3247	86 6789
4:00	29.529	44 6354	29.32873	48.6838	28.0415	90.0883	86.5131
4 05	29.183	44 8598	28.79053	48.7948	27.8485	90.2654	86.5836
4 10	29.2954	45.1953	28.71123	49.054	27.9995	90.3699	86 7601
4 15	28.9544	45.2367	28 29283	49.2447	27.6963	90.5517	86 7995
4:20	30.399	45 3387	30.85053	49.4209	28.8365	90.4347	86.8609
4.25	29 2856	45.3359	31.26853	49.6049	28.1048	90.3964	86.7867
4:30	29.1048	45.8345	29 44113	49.8022	27.8086	90.5491	86.8684
4 35	29.0195	46.0136	28.93383	49 9805	27.6848	90.6835	87.0391
4.40	29.0292	46.2857	28 86683	50.2138	27.7329	90.8349	87 1554
4:45	29.0682	46 4738	28.71393	50.4384	27.8103	90.9068	87.3348
4:50	29.1805	46.6587	28.51943	50.5478	27.9229	91.0111	87.4038
4:55	29.3746	46.9608	28.79053	50.7366	28.0788	91.1202	87.549
5:00	29.4086	47.1439	28.90123	50 8443	28.0361	91 2229	87.6164
5:05	29.1501	47.116	28 60403	50.9657	27.7388	91.3032	87.6256
5:10	29.0404	47.3085	28 64773	51.0827	27.7057	91.3437	87 7377
5:15	29.1242	47.5027	28.65493	51.2387	27.7128	91 4215	87.8516

March 6th and 7th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	J	I
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F
5,20	25.8163	29.0609	21.926	25.0329	26.1708	26.8873
5:25	26.1095	29.0081	21.834	24.7488	25.6177	27.1418
5:30	25.3497	28.4433	21.7665	24.72	25.666	26.4981
5.35	26.2346	29.3241	21.689	25.028	26.089	27.2283
5.40	26.2568	29.1931	21.7114	24.7422	25.7266	27.2505
5:45	25.61	28.7025	21.5252	24.5954	25.5415	26.9888
5:50	25.1106	28.1287	21 4489	24.2111	25.1962	26.2978
5:55	25.2305	28.3247	21.2985	24.2926	25.4315	26.3022
6:00	24.5995	27.8884	21.0902	24.2008	25.3014	25.8643
6:05	24.8455	28.2098	21.0663	24.2927	25.3546	26.0715
6 10	24.9766	28.3786	20.9658	24 3853	25.6011	26.164
6:15	24.593	27.9969	20.8513	24.2714	25.1794	25.9733
6.20	25.693	29.0148	20.757	24.6784	25.6244	26.8795
6:25	25.5589	28.8048	20.8157	24.4671	25.5673	26.8224
6:30	25.6179	28.5187	20.7202	24.1023	25.126	26 6892
6:35	25.4329	28.756	20.6502	24.4566	25.6722	26.4659
6:40	25.033	28.5113	20.519	24.5573	25.6189	26.2972
6:45	24.8255	28.4582	20.4265	24.5809	25.5655	26.2054
6.50	25.9961	29.4696	20.3648	24.9434	26.2736	27.067
6:55	25.5484	29.139	20.3402	24.9574	26.0184	26.9656
7·00	25.9987	29.2424	20.3674	24.8304	26.1608	27.1079
7:05	26.309	29.3982	20.3313	24.8716	25.9712	27.3795
7·10	27.0426	30 1666	20.4121	25.3369	26.359	28.0355
7 15	27.6471	30.692	20.4797	25.6349	26.8871	28.7929
7·20	27.4802	30 8315	20.4662	25 9293	27.2578	28.7412
7:25	26.6824	30.42	20 4365	25 9382	27 1515	28.2131
7.30	26.1059	30.229	20.5141	25.6691	26.6907	27 7143
7:35	27.6276	30.7489	20.6537	25.6922	26.368	28 6583
7·40	27.0526	31.0938	20.6547	26.2317	26 9454	28.5826
7·45	27.1989	31 1629	20.8798	26.5319	27 2837	28.4986
7·50	28.3363	31.378	21.0205	26.095	26.5398	29.1747
7.55	27.5418	31 3129	21.1093	26.7213	27.3194	28.6493
8·00	28.0531	31.8977	21.1993	27.4634	27.9075	29.0451
8·05	27.3191	31.4733	21.272	27 4203	27.6342	28 4269
8:10	27.521	31.4449	21 3593	27.5453	27.6057	28.5902
8:15	28.3823	31.7673	21 6475	27.3321	27 0085	29.0674
8·20	28.6895	32.34	21.8414	28 0617	28.0837	29.7574
8.25	28.2242	32.1442	22.0683	27.9799	27.7717	29.4076
8.30	29.8001	33.0638	22.2664	28.9814	28.6968	30 1017
8:35	29.7463	33.3531	22.444	29.3871	29.0644	30.5071
8:40	29.8433	33.3735	22 7351	29.3311	28.9317	30.3745
8:45	30 7109	33 9703	23.0703	30.352	30.1445	31.4711
8:50	30.6756	33 9732	23.2663	30.0489	29.8413	31.3593
8 55	31.5239	35.4254	23.6599	30.8212	30.3079	32.2835

March 6th and 7th

Channel no.	7	8	9	10	11	12	13
Label	7	8	Bottom 2	Air temp	11	Bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
5:20	26.1329	30.5656	50.0368	12.8613	27.4368	48.243	26.6208
5:25	26.1953	30.2441	50.172	13.0813	27.1534	48.2288	26.6447
5:30	25.9356	30.2155	50.2561	12.7391	27.048	48.388	26.3852
5:35	26.3206	30.5224	50.4426	12.8564	27.3936	48.5749	26.6929
5:40	26.2658	30.3527	50.5761	12.5267	27.2622	48.5966	26.5997
5:45	26.0805	30.1296	50.6577	12.4949	27.0389	48.7532	26.4916
5:50	25.6579	29.9003	50.7334	12.2611	26.7326	48.6794	26.1078
5:55	25.6237	29 9815	50.8495	12.1872	26.8138	48.8332	26.1506
6:00	25.3007	29.8517	50.9099	12.0156	26.6839	48.8564	25.828
6:05	25 5853	30.02	51.0733	11.7955	26.7371	49.0576	26.0352
6:10	25.6394	30.1507	51.1629	11.6545	26.8679	49.1848	26.0508
6:15	25.2942	29.9604	51.2391	11.6954	26.7927	49.1864	25.86
6:20	26.0095	30.4043	51.4092	11.5215	27.3136	49.4317	26.3821
6:25	25.9138	30.3857	51.503	11 7377	27.2568	49.4509	26.4789
6:30	25.8188	29.9839	51.5601	11.3666	26.8931	49.5456	26.3455
6:35	25.8648	30.3369	51.5673	11.2173	27.0926	49.6275	26.3914
6.40	25.5417	30.2837	51.6647	11.0845	27.001	49.7625	26.1841
6:45	25.6038	30.4223	51.7993	11.0301	27.1398	49.9347	26.2462
6:50	26.0433	30.8984	51.889	10.9677	27.8083	49.9873	26.5698
6:55	26.1729	30 9124	51.977	10.9427	27.6687	50.1502	26.6992
7:00	26.2384	30.901	52.0777	10.9703	27.734	50 2137	26.7262
7 05	26.5491	31.0187	52.1175	10.973	27.8135	50.3283	27.075
7:10	26.9756	31.367	52.3068	10.7801	28.3156	50.4434	27.3858
7:15	27.3888	31.4722	52.3717	10.8485	28.6125	50.5084	27.7218
7:20	27.2601	31 8421	52.3588	11.2272	28.8292	50.6447	27.7085
7:25	27 0382	31 7743	52.3674	11.2363	28.7231	50.728	27.5253
7:30	26.4227	31 4296	52.5537	11.1973	28.3398	50.7654	27.0257
7 35	27.0616	31.3377	52 6133	11.4562	28.4013	50 8625	27.3949
7.40	27.1011	31.8752	52.6515	11.4965	28.8241	51.0126	27.4727
7:45	27 1322	32.0595	52.7933	11.9201	29.0467	51.1174	27.5807
7:50	27 3104	31 8156	52.8913	11.7098	28.9177	51 1783	27.5666
7:55	26 7832	32.2099	52.9022	12.4657	29.1589	50.891	27.1936
8.00	27.2188	32.7199	53.0258	12 5567	29.8224	51.3504	27.4751
8:05	26.791	32.5239	53.0585	12 0036	29 5497	51.3086	26.9707
8:10	27 1471	32.8016	53.1052	12 5228	29 6361	51.3554	27.2112
8 15	27.7025	32.5891	53.1591	12.8144	29.5001	51.2976	27 2284
8 20	28.2408	33.1252	53.271	13.3626	30.3044	51 4098	27.6516
8:25	27.89	33.0819	53 3033	12.7313	30.1845	51.2185	27.4159
8:30	28.8931	33.7366	53 4194	14.144	30.8013	51.5585	28 0354
8:35	29 4529	34.2177	53.5159	13 8546	31.3591	51.7669	28.4805
8 40	29.2817	34.3528	53.573	13.9537	31.3796	51.6751	28.4627
8 45	29.9977	34.9131	53.7468	14.41	31.9402	51.9611	29.2175
8:50	30.1922	34 9541	53.7125	14 452	31.9813	51.7405	29 4121
8:55	30.7742	35 1906	53 8684	14 6159	32.4468	52.0458	30.1094

March 6th and 7th

Channel no.	14	15	16	17	18	19	20
Label	A	Bottom 4	B	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
5:20	29.2306	47.7565	28.87663	51.4168	27.8195	91.4136	87 8436
5:25	29.1012	47.7049	28.47833	51.5145	27.6514	91.5425	87 973
5:30	28.8809	47.7893	28.44973	51.6358	27.4692	91.6583	88.0178
5:35	29.1875	48.0886	28.64153	51.8219	27.7379	91.7293	88.1606
5:40	29.0947	48.0354	28.35663	51.918	27.6449	91 8211	88.217
5:45	29.0252	48.1547	28.28703	51.9622	27.5369	91.8633	88.3308
5:50	28.7963	47.9313	28.09613	52.075	27.2691	91.9355	88.3318
5:55	28.8006	48.1974	28.17733	52.1537	27.1582	92.0106	88.3716
6:00	28.6326	48.1832	28.00903	52.2512	26.9515	92.0682	88.4651
6 05	28.6857	48.5342	28.02373	52.34	27.0815	92.0819	88.4788
6:10	28.7395	48.6989	28.23133	52.4666	27 1354	92.1318	88.5646
6:15	28.6261	48.6257	28.07933	52.5055	26.945	92.1333	88.4948
6:20	29.1462	48 9459	28.48503	52.6381	27 5045	92.1889	88.5863
6 25	29.2426	48 853	28.46643	52.7689	27.5627	92.2073	88 6404
6 30	29 1481	48.9477	28.21813	52.7888	27.3912	92.2618	88 6595
6 35	29.0405	49.1045	28.30233	52.8704	27.437	92.3398	88.702
6:40	29.064	49.2769	28.44113	52.9304	27.2685	92.3971	88.7953
6:45	29.2025	49.3745	28.61823	53.0276	27.4073	92 4545	88.8886
6:50	29.6014	49 6139	28 97923	53 08	27 7302	92 5401	88 9389
6:55	29 6919	49.7022	29.03153	53 1679	27.821	92 6596	89 0589
7:00	29 7571	49.8031	29.02013	53.2684	27.8863	92.5069	89 0126
7:05	30.1044	49 955	29.25303	53.3454	28.196	92.6516	89 0864
7:10	30.4521	50.0702	29.52463	53.4601	28.5446	92.7612	89.1608
7 15	30.7866	50.2099	29.82153	53.5249	28.8415	92.7876	89.1873
7:20	30.8499	50.3089	30.07643	53 5863	28.8282	92.8819	89.3176
7:25	30.9352	50.3176	30.12363	53 6321	28.6837	92.8901	89.3616
7:30	30.7824	50 1685	29.85553	53.6694	28.3003	92 9613	89 433
7:35	31.0731	50 191	29.95533	53.729	28.5536	93.0182	89.4545
7 40	31.4946	50.4159	30.45423	53 8414	28.6696	93.0902	89.5625
7 45	31.602	50.4834	30.48523	53.9458	28.7774	93.19	89 627
7 50	31.8936	50.2085	30.50953	54 0065	28.7633	93 177	89 6853
7.55	31.9049	50.1822	30 71223	54 0918	28 4678	93 1875	89.6957
8:00	32.1463	50.7539	31.29863	54.1409	29.0554	93.2345	89 7429
8:05	32.2181	50.5255	31.37043	54.2107	28.5523	93.3367	89.7742
8:10	32 4569	50.5351	31.45673	54.2945	28.7922	93.3103	89.8547
8:15	32.5503	50.2906	31.35913	54 3854	28.886	93.0775	89.6567
8:20	32.9704	50.7014	31.66553	54 46	29 2314	92.7582	89.3719
8.25	33.1179	50.1368	31.88983	54 4922	28.8814	92.5758	89 1888
8:30	33.3514	50.813	32 20023	54.6082	29.346	92.4025	89.0148
8.35	33 7552	50 9097	32.45223	54.7045	29.522	92.0681	88 7505
8:40	33 89	50.8178	32.73993	54.7615	29 4659	92.016	88.6269
8 45	34 1443	51.1787	33.03303	54.8238	29.9515	91.8267	88.5797
8:50	34.3757	50.8459	33 45563	54.8637	29.8778	91.5804	88 3682
8:55	34.6878	51 1888	33 88273	54.9824	30.1916	91.5162	88.2681

March 6th and 7th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	J	\
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F
9:00	32.1401	35.4686	24.0124	30.3294	29.5479	32.7467
9:05	32.696	36.9322	24.4971	31.0011	29.9524	32.9591
9:10	32.6504	37.3038	25.5681	31.5284	30.901	32.7228
9:15	33.2361	37.5827	27.6579	31.5041	30.3796	33.5373
9:20	32.9124	37.9429	29.4797	31.9053	31.1254	33.6711
9:25	33.7728	38.7594	31.4144	31.9273	31.3384	33 9216
9:30	34.1676	39.3406	33.184	32.5137	32.0016	34 2023
9:35	34.7818	40.177	34.3321	32.9384	32 5029	34.3599
9:40	35.8161	40.7132	34.7205	33.2893	32.7014	34.7864
9:45	37.1607	40.5028	34.7366	33.0768	32.1836	35.221
9:50	36.7071	40.7686	33.7104	33.0023	32.3379	35.4508
9:55	37.7518	42.3724	32.7402	33.328	32.9689	36.6872
10:00	37.4547	41.9265	31.8305	33.4485	32.937	36.5416

March 6th and 7th

Channel no.	7	8	9	10	11	12	13
Label	7	8	Bottom 2	Air temp	11	Bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
9:00	31.2769	34.9669	53.8364	14.3088	32.4139	51.7529	30.4592
9:05	31.7959	35.332	53.969	14.8387	32.7027	52.0721	31.0168
9:10	32.056	35.7439	53.9617	15.8453	32.8478	52.1765	31.3918
9:15	32.2991	35.7959	54.0495	14.5328	33.1285	52.041	31.635
9:20	32.1275	35.9677	54.0684	14.7069	33.3766	52.0973	31.6927
9:25	32.6843	36.1802	54.2012	15.7068	33.4367	52.1559	32.0969
9:30	32.7748	36.6133	54.2893	16.111	33.7937	52.3931	32.4547
9:35	33.0474	37.532	54.2573	17.6347	34.256	52.5472	32.8037
9:40	33.5132	38.3001	54.4506	17.6039	34.7205	52.8153	33.1168
9:45	33.9488	37.708	54.355	16.4137	34.318	52.4217	33.4
9:50	34.103	38.0519	54.3566	17.5054	35.1947	52.3489	33.5543
9:55	34.4669	39.5915	54.674	19.3915	36.9627	53.0019	33.9182
10.00	34.7398	38.9526	54.68	17.6108	36.3996	52.7103	34.4579

March 6th and 7th

Channel no.	14	15	16	17	18	19	20
Label	A	Bottom 4	B	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
9:00	34.8833	50.6719	33.96423	54.9503	30.2351	91.3076	88.0587
9:05	35.2854	50.9915	34.21463	55.0457	30.6013	91.1855	87.9005
9.10	36 8357	51.1706	34.32143	55.0755	30.8615	91.0005	87.7863
9:15	37.191	50.6248	34.48763	55.1261	30.9136	90.9422	87.7635
9:20	37.4759	50.9049	34.65943	55.1821	30.9713	90.8535	87.7102
9:25	37.801	50.9636	34.79563	55.2034	31.2227	90.7316	87.5521
9:30	37.2841	51.3129	35.11433	55.2914	31.5426	90.7804	87.6011
9:35	36.91	51.5417	35.42413	55.3707	31.8153	90 8566	87.6776
9:40	37.2593	51 8102	35.85043	55.4896	32.2051	91.0064	87.8636
9:45	37.0098	51.0061	36.05673	55.4312	32.7936	90.879	87.7358
9:50	38.9446	51 1196	36.24853	55.4328	33.3673	90.7026	87.5945
9:55	41.2334	51.8853	36.91523	55.5644	33.9217	90.7577	87.6498
10:00	40.7109	51.407	37.68063	55.5704	34.6132	90.5498	87.5484

March 6th and 7th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	j	l
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
20:18	36 1442	39.869	34.2881	34.5699	36.9469	37.6972
20:23	35.9774	39.6654	34.3113	34.3268	36.6286	37.5307
20.28	35.8269	39.3645	34.1985	34.1379	36.3264	37.2666
20:33	35.6964	39.3102	34.1985	34.0072	36.4238	37.326
20:38	35.513	39.09	34.1985	33.8234	36.0887	36.9532
20:43	35.5444	39.1211	34.1985	33.8548	36.0441	36.8707
20:47	35.2224	39.0277	34.1985	33.5322	35.5324	36 4732
20:52	35.3533	39.0823	33.4953	33.5111	35.6633	36.566
20:57	35.4353	39.1639	33.387	33.479	35.5933	36.4961
21:02	35.3828	39.3007	33.3343	33.3883	35.5788	36.4436
21:07	35.3383	39.332	32.794	33.3437	35.3063	36.2092
21:12	35.0782	39.3381	32.5331	33.083	35.0843	35.9494
21:17	35.0801	39 4533	32.3824	33.0849	34.8961	35.7613
21:22	35.1886	39.41	32.3005	33.0793	34.7384	35 8317
21:27	35.2803	39.69	32.1253	33.0187	34.678	35.7713
21.32	35.2046	39.6148	31.8584	32.8285	34.6783	35.6197
21:37	35.1014	39.7012	31.602	32.7631	34.499	35.5545
21:42	34.9895	39.59	31.1839	32.5747	34.2348	35.2525
21:47	34.5319	39.4378	30.6094	32.1922	33 777	34.8711
21:52	34.7915	39.5067	30.6094	32.338	33.9225	35.0165
21:57	34.9621	39.6005	30.8505	32.2802	33.9409	35.111
22:02	35.3662	39.8132	30.8363	32.4567	34.1932	35.5151
22:07	35.5344	39.9804	33.1815	32.5112	34.3998	35.7214
22:12	35.1301	39.9186	30.3694	32.258	33 995	35.2791
22:17	34.8526	39 7185	30.7405	32.0559	33.679	35.0395
22.22	35.0863	39.7995	30.593	32.0614	33.8749	35.045
22:27	34.9102	39.6624	30.6454	31.9992	33.5844	34.9831
22:32	35 102	39.8907	30.5324	32.0391	33.9669	35.289
22:37	35.0011	39.8282	30.4691	31 9377	33 7896	35.112
22:42	34 8821	39.8989	90.8085	31.8183	33 7086	35.031
22:47	34.7114	39.6539	30.1012	31.7616	33.5758	34.8603
22:52	34.569	39.6258	30.0728	31.4659	33.1665	34.6418
22:57	34 4942	39.5893	29.921	31.3144	33.1678	34 4909
23:02	34 4581	39.4022	29.9612	31.3546	33.0173	34 4928
23:07	34.5242	39 4301	30.2573	31.4209	33.1597	34.635
23.12	34.4531	39.5106	30.1475	31.2732	33.2409	34.602
23:17	34.6633	39 4549	30.0911	31.3314	33.1466	34.5839
23:22	34.5433	39 4112	30.0851	31.2873	33.1788	34.578
23:27	34.8972	39.5738	30 1732	31.4134	33.4189	34.8559
23:32	34.8139	39.6045	30.166	31.5972	33.2975	34.8868
23:37	34 992	39.6303	30.0008	31.4323	33.4378	34.9508
23:42	34.6954	39.6001	30.1999	31.3636	33.4074	34.7302
23:47	34.8549	39.5318	30.169	31.5237	33.567	34.8897

March 7th and 8th

Channel no.	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
20:18	38.519	42.682	53.1738	30 4722	38.5099	50.1188	37.9338
20:23	38.2388	42.3649	52.8617	30.3042	38.2673	49.8055	37.6155
20:28	38.0126	42.1772	52.6399	30.2674	38.0408	49.5082	37.3893
20:33	37.9582	42.312	52.2887	30.2124	38.0243	49.4172	37.3348
20:38	37.6613	41.9404	51.9601	30.1808	37.917	48.9379	37.1137
20:43	37.6926	41.8203	51.8418	30.0976	37.8343	48.7818	37.0311
20:47	37.447	41.1591	51.4889	29.8882	37.5124	48.2406	36.7474
20:52	37.5018	41.3274	51 431	29.5223	37.8333	48.4443	36.8782
20:57	37.5078	41.3712	51.3251	29.2602	37.8773	48.4876	36.8842
21:02	37.4554	41.3189	51.2736	28.939	37.9768	48.3985	36.8697
21:07	37.3729	41.0474	51.3045	28.8175	37.7803	48.3547	36.7493
21:12	37.0753	40.6747	51.2359	28.5936	37.6724	48.0614	36.5855
21:17	36.9632	40.4492	51.2377	28.4421	37.7503	47.9884	36.6053
21:22	37.0336	40.33	51.3068	28.2831	37.8207	47.9829	36.4858
21:27	37.0112	40.2697	51.4339	28.0302	37.9123	48.1105	36.4634
21:32	36.9736	40.1943	51.4715	27.8771	37.7987	48.1483	36.4638
21:37	36.8705	40.1293	51.6685	27.581	37.9615	48.1964	36.4366
21:42	36.6447	39.6764	51.6706	27.1992	37.6217	47.8243	36.1728
21:47	36.3777	39.1821	51.6696	26.8139	37.4686	47.6735	35.8677
21:52	36.4089	39.479	51.7747	26.6533	37.6139	48.0038	35.9369
21:57	36.5413	39.4973	52.0907	26.5566	37.8223	48.2838	36.0314
22:02	36.7552	39.8246	52.3002	26.3116	38.2639	48.7934	36.2833
22:07	36 9613	40.22	52.5023	26.2511	38.47	49.0337	36.4895
22 12	36.5953	39.5512	52.5158	26.2651	38.1801	48.6361	36.1614
22:17	36.4319	39.2743	52.5419	26.2152	38.0548	48.5128	36.036
22:22	36.3994	39.3936	52.6962	26.0284	38.0223	48.7425	36.0415
22:27	36.2995	39.104	52.8216	25.8888	37.8465	48.4572	35 9035
22:32	36 4912	39.4852	52.9348	25.6981	38.0761	49.2066	36 0573
22.37	36 3143	39.3845	53.0593	25.5189	37.9752	48.9952	36.0324
22:42	36.2334	39.2658	53.0917	25.3985	38.0084	49.0278	35.9895
22:47	36 2149	39.0955	53.2223	25.3797	37.8759	48.8601	35.8189
22:52	35 9585	38.5736	53.2319	25.1201	37.6957	48.6454	35.6005
22:57	35.8076	38.6509	53.3075	24.9673	37.659	48.7588	35.5638
23:02	35.8476	38.5389	53.3466	24.9692	37.5469	48.7233	35 4896
23.07	35 8756	38 7188	53.5226	26.8444	37.7269	48.9004	35 5557
23:12	35 8426	38 7997	53.5647	24.9256	37.7319	49 0922	35.5607
23:17	35.9386	38.7437	53.5843	24.7918	37.7139	48 9624	35.5807
23:22	35.8566	38.7378	53.6528	24.7472	37.7079	48.9939	35.5367
23:27	36.0203	39.0531	53.8127	24.6818	37.9474	49.4163	35 7384
23:32	36 0511	38.932	54.0286	24.6746	38.0162	49.4466	35.6932
23:37	36 0771	39.0339	53 9797	24.5853	37.9662	49 5468	35.7572
23:42	36.0087	38.9276	54.0986	24.593	37.8219	49 3676	35.7648
23:47	36.016	39 1247	54.1058	24.6004	37 9432	49.3747	35.7721

March 7th and 8th

Channel no.	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"	"Degrees F"
20:18	39.4808	48.4748	38.79863	51.2378	39.2358	41.0339	38.9888
20:23	39.239	48.1609	38.63223	50.925	38.9552	62.4778	65.025
20:28	38 9755	47.9004	38.44413	50.628	38.6908	71.0198	68.3952
20:33	39.0726	48.1086	38.46553	50.3506	38.7123	73.6624	70.1316
20:38	38 7384	47.2541	38.20673	50.1332	38.491	75.9926	72.7235
20:43	38.6939	47.2475	38.08633	49.9773	38.5223	78.304	75.1136
20:47	38.2215	45.9928	37.57523	49.885	38.2764	80.0574	76.8715
20:52	38.3899	46.7594	37.74393	49.9763	38.4453	81.5521	78.2616
20:57	38.3201	46.6154	37.74993	49.9822	38.5273	82.818	79 3866
21:02	38.3814	46.826	37.65953	50.0426	38.6647	83.6674	80.2744
21:07	38.1855	46.2572	37.50123	50.2229	38.6202	84.4877	81.0609
21:12	37.9642	45.5879	37.24163	50.3035	38.4744	85.1755	81.6787
21:17	37 8144	45.2143	37.12963	50.4919	38.4763	85.6437	82.2202
21:22	37.8468	45.2088	37.04813	50.673	38.5087	86.2122	82.7902
21:27	37.7865	45.3744	36.98773	50.8374	38.4863	86.6569	83.1284
21:32	37.8248	45.0368	36 95013	51.0615	38.5626	86.9796	83.4879
21:37	37.7977	45.1978	36.84703	51.2213	38.5735	87.2405	83.7854
21:42	37.4586	44 8994	36.50723	51.3725	38.2717	87.4931	84.0388
21:47	37 1541	43.9963	36.20213	51.5578	38.0427	87.5637	84.1096
21:52	37.2991	44.8917	36.34743	51.7002	38.1879	87.3784	83.9596
21:57	37.3554	45.2479	36.44183	51.9418	38.2443	87.4315	83.977
22:02	37.6447	46.2847	36.73173	52.0769	38.6101	87.4898	83.9637
22:07	37.9642	46.8256	37.05183	52.2789	38.8162	87.5767	84.1944
22:12	37.5989	45.5265	36.64783	52.4414	38 4882	87.6255	84.1715
22:17	37.4358	45.1398	36.48443	52.6164	38.3629	87.5075	84.1967
22:22	37 5551	45.6333	36.56593	52.7706	38.4444	87.5842	84 166
22.27	37.3037	45.1967	36.20003	52.8588	38.2685	87.4543	84.1075
22:32	37 6467	46.2492	36.65773	52.972	38.4982	87.5275	84.1809
22:37	37.546	45.8495	36.48083	53.1336	38.3973	87.5398	84.1574
22.42	37.5032	45 9573	36.43803	53.2776	38.3924	87.571	84.1887
22 47	37.371	45.4136	36.34343	53.3711	38.2979	87.5894	84 243
22:52	37 0772	44.9726	36.04913	53 455	37.9657	87.5628	84.2163
22:57	37.1164	45.0114	36.01233	53.5677	37.9669	87.5998	84.3611
23:02	36.9666	45.126	36.05233	53.644	37.8929	87.6016	84.2194
23 07	37 0704	45 6417	36.00423	53.7456	38 0349	87 4848	84.1361
23.12	37 1134	45 7217	36 04733	53 7505	38.0399	87.5969	84.2864
23 17	37 0954	45 5913	36.06733	53 9187	37.9458	87.6515	84.2694
23:22	37 0895	45 623	36.02333	53.9872	37.9399	87.6459	84.2638
23:27	37.4044	46.5346	36.30093	54.1099	38.2935	87.7283	84.3823
23:32	37.3214	46.64	36.25583	54.2144	38.1723	87.65	84.3756
23:37	37.4611	46.6656	36.43383	54.2768	38.2743	87 7818	84.5077
23.42	37.4309	46 1858	36.36543	54.3957	38.3199	87.8964	84.5508
23:47	37.514	46 4929	36.37273	54 4029	38.2132	87.8317	84.4859

March 7th and 8th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	j	I
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
23:52	34.5591	39.5404	29.8714	31.3032	33.0041	34 5177
23:57	34.2528	39.3496	29.6398	30.9193	32.6973	34.2494
0:02	34.2251	39.2087	29.5737	30.7768	32.4407	34.1075
0:07	34.3583	39.1898	29.6694	30.9488	32.6886	34.3169
0:12	34.4641	39.1814	29.5844	30.7875	32.7565	34.2704
0:17	34.4651	39.258	29.3938	30.8649	32.948	34.3094
0:22	34.248	39.1558	29.3938	30.6851	32.4637	34.1684
0:27	34.0739	39.0963	29.3832	30.7397	32.518	33.9942
0:32	34.0368	38.946	29.3832	30.6642	32.4809	33.9952
0:37	34.0968	38.9678	29.3832	30.648	32.541	34 1314
0:42	34.3801	39.1736	29.4233	30.7414	32 7867	34.3767
0:47	34.2198	39.1277	29.4534	30.7332	32 6261	34.2163
0:52	34.3593	39.2663	29.5172	30.9115	32.8039	34.5462
0:57	34.1174	39 2529	29.427	30.7069	32.5616	34.2282
1:02	34.4348	39.1901	29.44	30.7963	32.7652	34 4314
1:07	34.0218	39.1201	29.3308	30.6108	32.504	34.0183
1:12	34.0359	39.0585	29.4216	30.625	32.48	34.2228
1:17	34.2004	39.1841	30.4674	30.752	32.5304	34.2731
1:22	33.7656	38.9792	30.4674	30.2771	31.9802	33.8382
1:27	33.8963	38.9577	29.0513	30.2937	32.1112	33.969
1:32	34.3179	38.9983	29.0924	30.6406	32.3048	34.3525
1:37	34.1234	39.0699	28.8967	30.5218	32.377	34.2342
1:42	34.4303	39.2613	28.8967	30.6389	32.5701	34.465
1:46	34.2134	39.4238	29.1022	30 7269	32 5434	34.5146
1:51	34.433	39.2262	29.0168	30.6034	32 4965	34.5439
1:56	34.3463	39.329	29.0444	30.478	32.3715	34.4952
2:01	34.5416	39.3339	28.9728	30.4448	32.529	34.5382
2:06	34.8954	39.4965	28.9459	30.7239	32.8074	34 8541
2:11	34.5325	39 325	28.9637	30.5122	32 5581	34 415
2:16	34.5148	39.3074	29 1375	30.6856	32.6166	34.5876
2:21	34.6936	39.5228	29 1643	30.7505	32.7196	34.8806
2:26	34.6089	39.552	29.0406	30.6271	32.7871	34.8339
2:31	34.7412	39 4944	29.0588	30.76	32.8053	34.7759
2 36	35.1244	39.6107	29.1768	31.0687	33.1513	35 1213
2:41	34 8604	39.8396	28.949	30.9563	33.2297	35.0473
2:46	35.4694	40 0669	29.1797	31.2626	33.5733	35.6944
2:51	35 1557	40.0195	29 0933	31 1383	33.4874	35.3046
2:56	34 7899	39.8074	28 9164	30.6561	33.0448	34 9389
3:01	34.5687	39.701	99.6209	30.625	32.7087	34.6415
3:06	34.956	39.8212	29.2369	31.2433	33.4017	35.181
3:11	34.893	39 8719	29.0585	30.9508	33.1861	35.0799
3:16	35.2752	40.2138	29.367	31.564	33.7595	35.5762
3:21	35.4549	40.2035	29.1267	31 5154	33.4826	35.6799

March 7th and 8th

Channel no.	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
23:52	35.7204	38.6397	54.077	24.3779	37.7238	49.3458	35 5906
23:57	35.4141	38.22	54.0752	24.2989	37.4939	49.0077	35.2464
0:02	35.4245	38.0783	54.1225	24.0395	37.3142	48.9431	35.1045
0:07	35.4816	38.2873	54.2153	24.0202	37.4093	49.2234	35.1997
0:12	35.5113	38.241	54.3186	24.0117	37.5149	49.1405	35.1532
0:17	35.5502	38.5078	54.3195	23.9355	37.4398	49.4776	35.2683
0:22	35.4093	38.1392	54.2934	23.947	37.4131	49.1898	35.0513
0:27	35.2352	38.1934	54.2721	23.9634	37.2773	49.2805	34.9914
0:32	35.2362	38.0423	54.3101	23.9258	37.2022	49.0572	34.9162
0:37	35.2581	38.0642	54.4429	23.9866	37.3001	49.1535	35.0143
0:42	35.5033	38.4611	54.5708	23.8494	37.6211	49.6557	35.1834
0:47	35.4192	38.339	54.5258	24.0341	37.4229	49.5731	35.0611
0:52	35.5206	38.4782	54.5876	24.1754	37.7522	49.6353	35.2387
0:57	35.2787	38.2368	54.5744	24.0075	37.5488	49.3606	35.0349
1:02	35.4819	38.4777	54.6241	23.9434	37.5617	49.6347	35.2
1:07	35.1831	38.1033	54.4812	23.9877	37.3773	49.3041	34.9393
1:12	35.1972	38.0794	54.5692	23.8477	37.4294	49.2432	34.9153
1:17	35.2856	38.2056	54.6553	23.7829	37.5556	49.6288	34.9656
1:22	34.8508	37.5814	54.5656	23.5739	37.0455	48.9406	34.607
1:27	35.0196	37.712	54.6558	23.6677	37.252	49.1436	34.6616
1.32	35.2889	38.0189	54.7699	23.4776	37.4829	49.5946	34.9308
1:37	35.0564	37.9388	54.6917	23.512	37.4788	49.4038	34.8506
1:42	35.3252	38.3212	54.8796	23.3214	37.6712	50.0784	35.0053
1:46	35.2986	38.3327	54.9279	23.4489	37.6446	49.9403	35.0167
1.51	35.366	38.2859	54.9193	23.3628	37.7499	49.969	35.0841
1:56	35 3173	38 0473	54.9832	23.3906	37.6633	49.7719	35.0735
2:01	35.3984	38.3183	54.988	23 2798	37.7442	49.9635	35 1165
2:06	35.6001	38.6716	55.0734	23 137	37.9076	50.3106	35.2801
2.11	35.3132	38.3852	55.0163	23.3093	37.5832	49.88	35 0694
2 16	35 3717	38 4056	55.0362	23.3299	37.6416	50 1239	35 0898
2.21	35.5886	38 5461	55.1364	23.1639	37.8581	50 4113	35.3067
2:26	35 5799	38 6514	55.2021	23.3095	37.9254	50.552	35.2219
2:31	35.56	38.7075	55.1827	23.1349	37.9056	50.3459	35.24
2:36	35.8292	39.0522	55.2598	23.0607	38.2883	50.7965	35.5473
2.41	35.8314	39.1302	55.2248	23.1015	38.0246	50.9105	35 5495
2 46	36.2123	39.5104	55.3738	22.9477	38.5569	51.2467	35 8924
2.51	36.0126	39 3491	55.4386	22.8993	38.3575	51 1627	35 7307
2.56	35.7229	38 9461	55.4157	23.0686	38 0682	50 6922	35.479
3:01	35.5397	38.4973	55.3855	23.2302	37.8093	50.5126	35 2578
3 06	35.889	39.1877	55.5034	23.1213	38.3859	51.0415	35.6831
3:11	35.902	39.0868	55.5161	23.1345	38.323	50.9424	35.6201
3 16	36.2462	39 6959	55.7035	23.0593	38.8184	51.3917	35.8883
3:21	36.2359	39 5718	55.6934	23 0102	38.8081	51.3816	35.954

March 7th and 8th

Channel no.	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"	"Degrees F"
23:52	37.2191	45.6762	36.07723	54.4484	37.9558	87 8755	84.6016
23 57	36.8378	44.9985	35.80923	54.4837	37.6878	87.8023	84.564
0:02	36.8102	45.159	35.70543	54.531	37.546	87.7404	84.4662
0:07	36.8671	45.966	35.80053	54.5867	37.6411	87.6868	84 3765
0:12	36.8208	45.7326	35.79213	54.6527	37.6327	87.7862	84.4404
0:17	37.0115	46.3713	35.94523	54.6165	37.6717	87.7871	84.5489
0:22	36.7571	45.7447	35.65223	54.7018	37.4928	87.8335	84.4878
0:27	36.8112	45.573	35.74453	54.7176	37.433	87.7772	84.5389
0:32	36.6983	45 5364	35.63133	54.7185	37.3959	87.8139	84.504
0:37	36.7202	45 7833	35.65333	54.7771	37.4558	87.8345	84.5605
0:42	37.0406	46 7	35.97443	54.8677	37.7009	87.8504	84.5405
0:47	36.9567	46.2421	35.89033	54.8227	37.5787	87.8785	84.5688
0:52	37.1337	46.5295	35.95363	54.9216	37.7181	87.9381	84.6285
0:57	36.9685	45.691	35.78803	54.9065	37.5525	88.0328	84.7951
1:02	37.0572	46.5289	35.95303	54.9582	37.6795	88.0091	84.6997
1:07	36 8351	45.3715	35.73043	55.0008	37.4189	87.9787	84.705
1:12	36.7733	45.8733	35.59243	54.9774	37.433	87.8846	84.6826
1:17	36.9373	46.523	35.87093	55.1378	37.4452	88.0392	84.7657
1:22	36.4279	45.1564	35.28433	54.9738	37.0488	87.9527	84.679
1 27	36.4823	45.5856	35.37683	54.9899	37.1414	88.0397	84.7662
1:32	36.7508	46.6387	35.56993	55.0297	37.4485	88 1138	84.8047
1:37	36.7467	46 1471	35.52773	55.0257	37.3303	88.2172	84.9442
1:42	37 0148	47 0492	35.91053	55.0651	37.4849	88.3268	84.9824
1:46	37.0262	47.0979	35.84593	55.1134	37.5724	88.3376	85.029
1:51	37 0934	47.0893	35.87523	55.0678	37.6017	88.4366	85.0566
1:56	37.0069	46.7042	35.78853	55.2058	37.477	88.4624	85.1183
2:01	37.1637	46.9339	35.94563	55.2477	37.596	88.5743	85.2664
2 06	37 3268	47.6942	36 14713	55.3701	37.7976	88.585	85.2771
2:11	37 1167	46.925	35.86053	55.3131	37.5109	88.6016	85.2937
2:16	37.137	47.3946	35.95693	55.333	37.7595	88.5135	85.2054
2:21	37.3532	47 9449	36.17363	55.3589	37.8241	88.61	85.338
2 26	37 3825	47 899	36.16493	55.4246	37.8154	88.6733	85.3656
2 31	37.4385	47.5799	36.10703	55.4423	37.7575	88.6904	85 3827
2:36	37 7828	48.5557	36.52813	55.5565	38.1406	88.8361	85.493
2:41	37.8228	48.2212	36.56823	55.5586	38.1807	88 8381	85.495
2:46	38.2404	49 3061	36.91083	55.6334	38.5234	88.9817	85.6032
2:51	38 1172	48 8482	36 82533	55.6982	38.3238	89.0441	85.7374
2:56	37 7526	47 7402	36.49793	55 7123	38.0723	89.0578	85.7512
3:01	37.4563	46.9606	36.23883	55.7563	37.7752	89.0287	85.7936
3:06	37.8423	48.6144	36.58783	55.8371	38.2003	89.0709	85.7284
3:11	37.8553	48 2532	36.56283	55.8498	38.2893	89 1546	85.884
3 16	38.2363	49.4888	36.98263	55.9259	38.5572	89.1922	85.85
3 21	38.2639	49.2545	36.89643	55.9529	38.6229	89.2539	85.9478

March 7th and 8th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	j	l
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
3:26	35.5283	40.3519	29.0857	31.3218	33.7465	35.6392
3:31	35.8476	40 5559	29.2545	31.7191	34.1045	36.2625
3:36	35 426	40 741	29.0593	31.6391	34.0629	35.803
3:41	35.3641	40 4531	29 0735	31.5006	33.8105	35.6652
3:46	35.3892	40.5534	29.1371	31.6784	33.9117	35.7282
3:51	35.456	40.8085	29.396	32.0891	34.4354	36.2509
3:56	35.5806	41.0076	29.2151	32.2142	34.5221	36.3754
4:01	36.0159	41.2135	29.0028	31.9264	34.5015	36.6586
4:06	36.072	41.3823	28.9827	32.2499	34.7479	36.7906
4:11	36.3168	41.3614	28.8082	32.1525	34.6888	36.6178
4:16	36.095	41.2919	28.9292	32.1203	34.6187	36.5858
4 21	36.3043	41.349	29.1405	32.1399	34.7904	36.6812
4:26	35.8366	41.1108	28.8985	31.6698	34.1696	36.2135
4:31	35.9362	41.172	28.9223	31.6936	34.1933	36.2371
4:36	36.4126	41 4565	29.3264	32.4776	35.0129	36.9792
4:41	36.0215	41 5207	29.2384	32.3518	35.0015	36.9678
4:46	36.0886	41.4741	28.9994	32.2283	34.8405	36.7692
4:51	36.5317	41.7255	28.9102	32.4447	34.9421	37.1362
4:56	36.3377	41.5706	28.9059	32.1353	34.5956	36.7904
5:01	37.0347	41.7352	28.8817	32.3019	34.9899	37 2976
5:06	37.0113	41.825	28.9347	32.2021	35.0045	37.1984
5:11	36.7416	41 7078	28.9347	32.236	34.696	37.1183
5:16	36.6179	41.5473	28.6906	31.6537	34.4199	36.6911
5:21	36 4345	41.5914	28 6971	31.7365	34.2741	36.4697
5:26	36 1714	41.4809	28 6997	31.9299	34.2767	36.4723
5 31	36.2436	41.5526	28.926	32.1934	34.5394	36.8482
5 36	36.6511	41.618	28.7241	31.8398	34 4913	36.9141
5 41	36.4919	41 7991	29.2149	32.5192	35.0163	37.1723
5:46	36.0737	41.6855	29 2149	32.0608	34.6735	36.7543
5:51	36.277	41 7742	29.2149	32.1506	34.6489	36.9196
5:56	36 5852	41.8917	28 5041	32.0788	34.6534	37.0758
6:01	36.4089	41 8674	28.4794	32.016	34 6669	36.7857
6 06	35.9705	41.3192	28.4794	31.5753	33 7327	36.0815
6 11	36.196	41.5054	28 3795	31.4966	33.9589	36.3451
6:16	35.4061	41.0608	27.7352	30.8551	32.9764	35.5551
6:21	34 9349	40 7818	27 7352	30.8018	33.1138	35 4261
6.26	34.8336	40.6813	27.6562	30.5853	32 7836	35 0966
6:31	34.6541	40.39	27.5902	30.3284	32 6036	34.9171
6.36	34.9496	40.419	27 6197	30 4725	32.5567	35.0605
6.41	35.6758	40.9135	28.4295	31.4701	33.7801	36.2427
6:45	34.9209	40 9565	28 4295	31.6282	34.0139	35.7162
6:50	35.8053	41.3814	28 9435	32.3253	34.709	36 6758
6:55	35.0957	41.3562	28.6496	32 2616	34 3792	36.1948

March 7th and 8th

Channel no.	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
3.26	36.3092	39.7209	55.7649	22.9303	38.8054	51.677	36.0273
3.31	36.6666	40.1533	55.8911	22.7914	39.2381	51.9901	36.3847
3:36	36.397	39.9223	55.9618	23.0581	39.0448	51.9493	36.2291
3:41	36.4112	39.8226	55.9014	22.8793	38.7554	51.8514	36.1673
3:46	36.3982	39.8855	55.9999	22.8661	38.8942	52.0249	36.1923
3:51	36.5791	40.4071	56.0281	22.6637	39.2644	52.3138	36.3731
3:56	36.8556	40.645	56.1496	22.6744	39.4267	52.5103	36.5737
4:01	36.873	40.5487	56.1665	22.6535	39.6336	52.5646	36.705
4:06	37.081	40.7941	56.2213	22.5173	39.8412	52.7311	36.8371
4:11	37.06	40.9246	56.3119	22.3414	39.7444	52.785	36.93
4:16	37.1039	40.7412	56.3548	22.4634	39.6746	52.828	36.86
4:21	37.1234	40.7985	56.3738	22.5605	39.7319	52.8843	36.9175
4:26	36.8456	40.2561	56.4362	22.7029	39.4166	52.6493	36.6396
4:31	36.8312	40.2038	56.4963	22.6496	39.3265	52.7841	36.5873
4:36	37.2697	41.1337	56.5535	22.2456	39.9158	53.1392	37.0258
4:41	37.3343	41.0467	56.6536	22.3114	39.9803	53.2397	37.0904
4:46	37.2115	40.8863	56.7559	22.3409	39.8956	53.1937	37.0814
4:51	37.4268	41.1768	56.7438	22.2123	40.1862	53.4789	37.2967
4:56	37.3467	40.7561	56.8137	22.324	39.8031	53.2146	37.1027
5:01	37.7401	41.2244	56.8644	22.1449	40.2338	53.5628	37.5341
5:06	37.6788	41.0496	56.9896	22.121	40.1726	53.5399	37.359
5:11	37.5608	40.8182	57.0225	22.3487	40.0926	53.3128	37.3548
5:16	37.3612	40.4295	57.013	22.1068	39.6281	53.3032	37 0793
5:21	37 2157	40.3222	57.0932	22.036	39.5966	53.3094	37.0097
5:26	37 1044	40.4385	57.1328	22.0773	39.6371	53.4979	36.9364
5:31	37 2526	40.6622	57 1662	22 0735	39.9366	53.6058	37.1225
5 36	37.4324	40.6143	57.1934	21.8699	39.8508	53.7074	37.1884
5 41	37 5768	41.0993	57.1862	21.7464	40.2223	53.8488	37.4087
5.46	37.3105	40.7579	57.2967	21.9005	39.9565	53.8483	37.1805
5:51	37.286	40.8092	57.4208	21.7595	40.0078	53.8986	37.2319
5:56	37 4423	40.8136	57.4251	21.5706	40.0881	53.9401	37.3122
6:01	37.3799	40.8271	57.4383	21 623	39.9879	53.9533	37.2498
6:06	36.9794	39.8589	57.4551	21.718	39.3986	53.0409	36.7735
6 11	37.0151	40.122	57.4899	21.4835	39.3963	53.6707	36.8092
6 16	36.5292	39.0298	57.5345	21.2206	38.9112	53.0092	36 2853
6.21	36.2481	39.0528	57.446	21 128	38 6685	53.1061	36.1563
6:26	36.0328	38 8757	57 4954	20.9474	38.4535	52.821	36.017
6:31	35.8913	38 6585	57 4318	20.8421	38.3124	52.7199	35.7996
6:36	35.9967	38.6498	57.4973	20.8719	38.3795	52 7857	35.8288
6:41	36.6848	39.944	57.5751	20 721	39.4458	53.6077	36.4029
6:45	36 4242	39.9493	57.6543	20.8039	39.2236	53.6129	36.2943
6:50	36.8902	40.7553	57.6641	20 9691	39.954	53.8458	36.7603
6:55	36.6749	40 5027	57 6764	20 8658	39 4738	53.6351	36.6589

March 7th and 8th

Channel no.	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"	"Degrees F"
3.26	38.337	49.5134	37.12153	56.0244	38.6582	89.3229	85.9811
3.31	38.8447	50.3498	37.47863	56.1506	39.0153	89.4802	86.1388
3:36	38.576	49.5623	37.39913	56.1841	38.8978	89.5839	86.207
3:41	38.5901	49.4642	37.26133	56.2349	38.798	89.4901	86.2919
3:46	38.5771	49.8995	37.28633	56.2593	38.785	89.5136	86.2797
3:51	38.9088	50.7488	37.77063	56.3615	39.0796	89.6835	86.3427
3:56	39.1465	51.0203	37.81913	56.4089	39.242	89.7292	86.3884
4:01	39.2774	51.0373	37.91233	56.4259	39.3353	89.7098	86.4764
4:06	39.4468	51.3533	38.08213	56.4806	39.4672	89.834	86.5293
4:11	39.5015	51.2209	38.06123	56.6083	39.598	89.8499	86.5811
4:16	39.4696	51.1895	38.02923	56.6511	39.5281	89.8555	86.6225
4:21	39.5269	51.2831	38.23823	56.7071	39.5475	89.9095	86.6051
4:26	39.1744	50.1151	37.77113	56.7695	39.1561	89.8626	86.6296
4.31	39.0087	50.6234	37.68093	56.8666	39.1417	89.8134	86.5087
4:36	39.5591	51.7993	38.30853	56.8497	39.6937	89.9756	86.6356
4:41	39.6613	51.9744	38.29723	56.9128	39.7582	90.0007	86.6965
4.46	39.5767	51.5931	38.06073	57.0151	39.7114	90.028	86.8312
4:51	39.8669	52.1396	38.31373	57.0399	39.9264	90.0876	86.7836
4:56	39.6358	51.1668	38.11993	57.1469	39.7706	90.0837	86.7797
5:01	40.1034	52.0375	38.58883	57.1605	40.0878	90.0611	86.7571
5:06	40.0045	51.6048	38.52753	57.2117	40.0645	90.1105	86.8066
5:11	39.8113	51.1161	38.33383	57.2446	39.9845	90.1422	86.9099
5:16	39.5746	50.7336	38.17233	57.3091	39.6713	90.133	86.8649
5:21	39.4675	50.9264	37.95123	57.3523	39.6018	90.0677	86.8352
5:26	39.3944	51.339	37.95383	57.3918	39.5665	90.0701	86.8734
5:31	39.5799	51.6335	38.06393	57.4252	39.7524	90.138	86.8699
5:36	39.6455	51.6236	38.24343	57.4524	39.8183	90.2713	86.9678
5:41	39.9029	52.4729	38.50143	57.5192	40.0005	90.2644	86.9966
5:46	39.6754	52.0628	38.27343	57.5557	39.7344	90.2281	86.9961
5:51	39.7266	52.1132	38.24893	57.5688	39.8237	90.3121	87.0803
5:56	39.8067	52.341	38.32923	57.6471	39.8661	90.3163	87.0487
6:01	39.858	51.5721	38.30483	57.6972	39.8796	90.329	86.9541
6:06	39.1564	49.7987	37.52543	57.677	39.3278	90.1668	86.9346
6:11	39.2676	51.065	37.75083	57.7118	39.3255	90.129	86.8967
6:16	38.5183	49.5801	36.96153	57.7195	38.764	90.1721	86.8325
6:21	38.3897	50.1255	36.87063	57.6679	38.5971	90.0153	86.6753
6:26	38.1372	49.5406	36.61753	57.6804	38.344	89.9916	86.8663
6:31	37.9963	49.2522	36.51413	57.6538	38.2406	89.8945	86.6616
6:36	37.9118	49.5425	36.54343	57.7192	38.2699	89.922	86.6534
6:41	38.7871	51.7472	37.38283	57.797	38.9195	89.9971	86.7286
6:45	38.7924	51.7152	37.46413	57.7652	38.9249	90.1449	86.8768
6:50	39.3324	52.2837	38.15713	57.7751	39.4284	90.1544	86.8863
6:55	39.2692	51.7747	37.90423	57.7504	39.2892	90.1305	86.8982

March 7th and 8th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	j	l
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
7:00	35 639	41.5934	28.6496	32.1965	34.5425	36.7375
7:05	35.0989	41.5101	28.2309	31.9977	34.116	36.122
7:10	35.1545	41.3768	27.6347	31.3282	33.6767	36.0256
7:15	35.048	41.422	28.2179	32.1375	34.065	36 337
7:20	35.2834	41.6176	27.9182	32.1066	34.1484	36 648
7:25	34.8472	41.5999	27.7851	31 936	33.864	36.3644
7:30	34.9981	41.6741	28.7428	32.9646	34.8521	37 274
7:35	34.4528	41.8876	28.7683	33.1805	34.9154	36 844
7:40	35.2029	42.3291	28.7577	33.1699	35.323	37.8575
7:45	35.015	42.5571	28.7598	33.553	35.5152	37 9354
7:50	34.8577	42.7779	29.2912	34.3473	36.2316	38 1576
7:55	36.2091	43.3258	29.734	34.9773	36.9359	39.3904
8:00	36.4334	43.5855	29.424	34.3652	36.5151	39.0842
8:05	37.3848	43.8139	30.2309	35.0147	36.9732	39.8436
8:10	37.4054	43.9471	30.0221	34.8452	36.8801	39.6751
8:15	37.5731	43.9255	30.1914	34.7853	36.4788	39.5777
8:20	38.418	44.4628	30.9679	35.519	37.3247	40.4208
8:25	39.2108	45.1741	31.7683	36.3145	38.1563	41.325
8:30	39.8022	45.4607	31.7683	36.5664	38.4455	41.5378
8:35	40.3276	45.5322	31.7683	36.5628	38.5555	41.9114
8:40	40.5555	46.5455	32.5155	37.5879	39.4268	42.7418
8:45	40.9301	46.8422	32.7415	38.2289	40.0286	43.078
8:50	41.373	46.7949	32 1972	37.7265	39.4895	43.1057
8:55	42.6202	47.4344	31.8186	38.2221	40.2107	44.0496
9:00	41.5866	47.8676	31.9553	39.9083	41.742	44 1842

March 7th and 8th

Channel no.	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
7:00	36.9139	40.7032	57.8352	21.032	40.0155	53.9433	36.8599
7:05	36.526	40.2784	57.7165	20.7915	39.6286	53 6754	36 5481
7:10	36.3536	39.8031	57.6966	20.732	39.3808	53.4696	36.4518
7:15	36.3992	40.3035	57.7409	21.1656	39.7674	53 4026	36.5352
7:20	36 4444	40.3486	57.711	21.0569	39 7746	53.484	36.6185
7:25	36.0844	40.1034	57.8045	21.0774	39.7189	53.0203	36.2966
7:30	36.3113	40.9357	57.6924	21.9274	40.3617	53.0935	36.6753
7:35	36.1465	41.0746	57.68	21.7598	40.3491	53 267	36.5867
7:40	36.478	41.6318	57.7437	22.0585	40.9443	53.5541	36.9938
7:45	36.4802	41.861	57.7828	22.0993	41.2491	53.4818	37.0719
7:50	36.665	42.2718	57.7038	22.7125	41.6222	53.3653	37.2186
7.55	37.332	43 0489	57.7985	23.5065	42.5504	53.572	37 8849
8:00	37.4424	42.7809	57.8321	22.4214	42.2069	53 4199	37 8814
8:05	38 0524	43.2748	57.8349	23.39	42.8519	53.5714	38.2634
8.10	38 1109	43.2198	57.818	22.5227	42.9102	53 4801	38.3219
8:15	38.127	42.8959	57.8337	22.4618	42.7374	53 0125	38.338
8:20	38.7071	43.738	57.7709	22.7826	43.5414	53.5071	38.8041
8 25	39.5764	44.5282	57.9539	22.6647	44.4066	53.8396	39.4837
8.30	40.0168	45.0045	57.9775	23.3844	44.6566	53.7519	39.8862
8:35	40.4293	44.9633	57.974	23.5738	44.9167	53.5253	40.1474
8.40	41 0732	45.8307	58.123	23.0345	45.8212	54.121	40 9424
8:45	41.2969	46.3546	58.1202	23.9579	46.3448	54.1182	41.1661
8:50	41.6647	45.8555	58.0735	23.6391	46.1845	53.8112	41.2695
8:55	42.3094	46 5735	58.1874	24.028	46.9017	54.0372	41.7634
9:00	42.633	47.9104	58.2458	24.5901	47 5994	54 2815	42 238

March 7th and 8th

Channel no.	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	inlet	outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"	"Degrees F"
7:00	39.583	52.3814	38.06703	57.8352	39.4142	90.2837	87.016
7:05	39.4238	51.2561	37.83153	57.7904	39.1405	90.2405	86.9727
7:10	39.29	50 5649	37.73523	57.7706	38.8924	90.2214	86.9178
7:15	39.6757	51.0571	38.00833	57.7779	39.0897	90.1928	86.8533
7:20	39.9099	50 5048	38.20513	57.785	39.059	90.2353	86.9674
7:25	39.7786	49.4793	38.07353	57.8415	38.6235	90.1828	86.9506
7:30	40.3067	50.5606	38.60313	57.7663	39.0779	90.1102	86.8063
7:35	40.4074	50 4735	38.77993	57.791	39.0652	90.0269	86.7944
7:40	41.0391	51.0972	39.29973	57.8177	39.4342	90.1955	86.8202
7:45	41.3809	50.7264	39.60473	57.8567	39.588	90.1618	86.858
7:50	41.6023	51.2061	39.97803	57.8517	39.7726	90.0856	86.7816
7:55	42.5285	50.966	40.79343	57.8725	40.6278	90.2127	86.9806
8:00	42.6003	50.0672	40.75213	57.906	40.6243	90.3164	87.013
8:05	43.0177	50.8909	41.09513	57.9089	41.0817	90.2121	86.98
8:10	43.1888	50.2769	41.19123	57.818	41.0644	90.1958	86.9637
8:15	43.0541	49.2472	40.98053	57.9447	40.9669	90.1753	86.9788
8:20	43.6679	50.3414	41.63403	57.9558	41.5461	90.3288	87.0612
8:25	44.4934	51.0108	42.53773	58.0278	42.1494	90.5766	87.2381
8:30	45.0436	50.6244	42.93883	58.0144	42.665	90.7064	87.404
8:35	45.0025	50.397	42.93533	58.0479	42.9259	90.81	87.5436
8:40	45.9424	51.405	43.69003	58.1969	43.6823	91.0251	87.7592
8:45	46.3898	51.5885	44.21423	58.2311	44.1699	91.2362	87.8995
8:50	46.3049	50.7958	43.97843	58.2213	44.2354	91 1912	87 9258
8.55	47.0204	51 0972	44.84703	58.3353	44.9548	91.3723	88.1074
9:00	47.679	51.7896	45.65813	58.3936	45.5792	91.4286	88.2352

March 7th and 8th

Chanel	1	2	3	4	5	6	7
Label	1	2	ground temp	4	j	l	7
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F	"Degrees F"
3:00:00 AM	22.2665	25.9513	20.0267	21.2096	26.7839	27.8074	25.5917
3:05	22.3341	26.0186	20.2109	21.1225	26.8511	27.7594	25.5821
3:10	22.4678	25.9978	20.5387	22 455	26.7151	27.6234	25.5227
3:15	22.7264	26.4088	21.2627	22.0954	27.2027	28.0724	25.7036
3:20	22.4467	26.2458	21.4856	21.8541	26.963	27.7944	25.6173
3:25	22.7409	26.6152	21.9735	21.8779	26.833	27.8948	25.8336
3:30	22.9711	27.0745	22 4359	21.8763	26.9467	27.97	26.1402
3:35	23.482	27.2754	22.6769	21.9627	26.9557	27.979	26.3418
3:40	23.8333	27.5864	23.0671	22.1214	27.0365	28.0214	26.6152
3:45	24.1821	28.125	23.2233	22.355	27.1535	28.1766	26.9248
3:50	24.8659	28.805	23.5994	22.9244	27.6427	28.7422	27.5302
3:55	25.567	29.5785	24.0703	23.3955	28.1493	29.095	28.0376
4:00	26 3406	30.2712	24.2673	23.9398	28.5369	29.6356	28.5026
4:05	26.9271	30.969	24.4701	24.7205	29.1216	30.0667	28.858
4:10	27.2604	31.3767	24.4962	25.4012	29.6836	30.4753	29.0759
4:15	27.9671	31.8886	24.8974	25.9556	29.929	30.8735	29.7818
4:20	28.8147	32.1594	25.1324	26.5362	30.4684	31.3743	30.2838
4:25	29.0965	32.478	25.3386	26.9724	30.6348	31.5025	30.5655
4:30	29.7276	32.8011	25.5494	27.1827	30.9588	31.7881	31.0813
4:35	29.8746	32.8331	25.5432	26.3698	30.8381	31.8965	31.0369
4:40	30.381	33.4516	25.5138	26.9552	31.0381	32.0201	31.505
4:45	30.8428	34.1396	25.5552	28.0328	31.4231	32.2521	31 9285
4 50	31.4472	34.8551	25.7791	28.601	31.8742	32.5504	32.189
4 55	31.4501	35.124	25.5125	28 8338	31.8771	32.4006	32.2301
5 00	31.9497	36.0006	25.8236	29.6029	32 4526	32.8997	32.997
5 05	32 1728	36 4501	25.8946	30 0562	32.6755	33.0845	33.3346
5:10	32.0449	36.5506	25.8811	30 1576	32.4715	33 0711	33.3976
5:15	32.2606	36 8407	25.8292	30.6414	32.5725	33.2485	33.5368
5:20	32.6311	37 512	25.895	31.1271	32.6759	33.428	33.6783
5:25	32.7444	37.8896	25.9708	31.0878	32.7511	33.5794	33.8679
5 30	33.1082	38.3266	26.0686	31.1849	32.8861	33.7905	33.9648
5.35	33.5658	38.8944	26.1074	31 7581	33.0008	34.0956	34.1176
5:40	34 4643	39.4084	26.3227	32 1625	33.2903	34.8416	34.1785
5:45	34.9626	39 7144	26.4034	32.2426	34.1699	35.8339	34.3347
5:50	35.2735	39 7966	26 2563	32.0203	34.481	36.2964	34.4176
5:55	36.0732	40 1383	26 2956	32.3274	35.0152	36.8297	34.4956
6:00	36.366	40.6559	26.2085	32.6215	35 6883	37.312	34 5608
6 05	36.6526	41.0916	26.2681	32.7568	36.4686	37.8637	34.8484
6:10	37 4012	41.5718	26.2195	32.823	37.0276	38.4978	35.942
6:15	37 6707	41.9528	26.3391	32.9035	37.373	38 8806	36.5544
6:20	38.3003	42 315	26 4397	33.0032	37.9269	39.2823	36.9957
6:25	38.2048	42 6719	26 5735	33.1358	38.4373	39.8678	37.2797
6:30	38.8872	43.162	26 6513	33.3653	38.8924	40.2467	37.7361

March 8th and 9th

Chanel	8	9	10	11	12	13	14
Label	8	Bottom 2	Air temp	11	Bottom 3	13	a
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
3:00:00 AM	32.6332	33.0597	16.7241	29.391	33.6314	25 3484	29.4204
3:05	32.5088	32.8595	16.6365	29.3814	33.5457	25.3002	29.2576
3:10	32.335	32.8007	16.109	29.0159	33.3345	25.1637	29.1219
3:15	32.4764	32.7891	16.7982	29.3873	33.361	25.2676	29.1485
3:20	32.4289	32.4747	17.1781	28.995	33.0469	25.2198	28.9476
3:25	32.3376	32 4219	17.3966	29.0951	33.0703	25.3205	29.0095
3:30	32.4892	32.5348	17.0448	29.3235	33.2593	25.6272	29.1229
3:35	32.5747	32 6582	16.7425	29.524	33.4208	25.7903	29.2086
3.40	32.5021	32.9673	16.435	29.6429	33.6914	26.3333	29.4425
3:45	32.6187	33.1215	16.6315	29.7977	33.9979	26.6044	29.6358
3:50	32.9915	33 4929	17.3221	30.362	34.4069	27.056	30.0855
3:55	33.42	33.8435	17.4857	30.8288	34 8713	27.602	30.4761
4:00	33.6535	34.3427	17.9566	30.9476	35.2938	27.9519	30.7481
4:05	33.8927	34.8472	17.3444	31.0722	35.6837	28 1539	30 9874
4:10	34.1478	35.2533	18.3817	31.3656	36.1653	28.4486	31.2045
4:15	34.3545	35.763	18.8249	31.7251	36.6744	29.2316	31.4495
4:20	34.5111	36.2986	18.4792	31.7671	37.1715	29.5038	31.6827
4:25	34.6009	36.7676	18 726	31.9716	37.5262	29.8623	31 7344
4:30	35.0008	37.2788	19.9087	32.1425	38.0369	30.3784	31 9818
4:35	35.0328	37 7656	17.8057	32.1364	38.5233	30.6402	32.2048
4:40	35 1562	38.1913	17.4259	32.4506	38.9864	31.0318	32.6718
4:45	35.4261	38.8001	17.8567	32.6061	39.5189	31.3407	32.9036
4 50	35.686	39 4364	17 6551	32.7899	40.0791	31 6014	33.1636
4 55	35.5364	39 7795	18.6297	32.7165	40.3842	31 6807	33.0902
5:00	35.8064	40 4628	18.8659	33.0247	40.9915	32.2951	33.3221
5 05	36 0292	40.9856	19.3257	33.3237	41.4008	32.6711	33.3543
5:10	36 3206	41.2744	19.7776	33.5009	41.6893	32.7722	33 1884
5:15	36.9166	41 827	19.4149	34.0971	42.2417	32 8734	33.4039
5:20	37.4002	42.3815	19.2873	34.5428	42.6829	33.0531	33 5834
5:25	37.6273	42.8702	20.4883	35.0363	43.0961	33 1665	34.0777
5:30	38.0661	43 3424	19 3072	35.5511	43.6058	33.3016	35.0119
5:35	38.4085	43 8694	20 3158	36.1214	44 0575	33.4163	35 9628
5 40	38 8489	44.4183	19 9901	36 4858	44 5311	33.5535	36.5173
5 45	38 8147	44 9856	19.4897	36 5274	44.948	33.6335	36 9386
5:50	39.0492	45.3302	18.9143	36.7998	45.2175	33.6783	37 2867
5 55	39.3546	45 7449	19.2267	37.1051	45.7449	33 8326	37.6678
6:00	39.5333	46.1842	19.1378	37.2837	46.0717	33 974	38.0738
6:05	40.123	46 6548	19.2756	37 6838	46.3923	34.0712	38.322
6:10	40.6815	47.132	21.2808	38.2042	46.9072	34.2136	38.9937
6:15	41 0265	47.5856	20.8204	38.7386	47.2485	34.4463	39 4142
6:20	41.277	47 9455	19.8367	38 7997	47.6461	35.117	39.551
6:25	41 9763	48 3751	20 6305	39.4611	48.0009	35.5918	40.0607
6:30	42 1663	48.8621	21.4445	39 5754	48.4133	36.049	40.2884

March 8th and 9th

Chanel	15	16	17	18	19	20
Label	Bottom 4	b	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
3:00:00 AM	33.86	28.91413	31 495	24.2778	16.4209	12.0036
3.05	33 7362	28.98123	31.409	24.2296	16.2942	11.8762
3:10	33 6013	28.65343	31.2355	23.9387	57.536	43.538
3:15	33.6658	28.87203	31.3002	24.1198	67.3844	64.5968
3 20	33.2756	28 70923	31.0235	23.8404	70.5883	67.0795
3:25	33.1846	28.61773	31.0852	24.2113	72.4306	69.0754
3:30	33.1831	28.65453	31.3512	24.6725	74.3905	70.8606
3:35	33.2302	28.70193	31.7804	25.1054	76.0662	72.6886
3:40	33.4628	28.82103	32.1661	25.61	77.5894	73.9999
3:45	33.5789	28.93793	32.5494	26.1506	78.783	75.1984
3.50	33.9119	29.35003	33.1117	26.756	80.0002	76.2757
3:55	34.3005	29.81793	33.6912	27.4555	80.9803	77.4046
4:00	34.6472	30.16693	34.2666	27.8821	81.9558	78.3479
4:05	34.9994	30.48323	34.7711	28.2374	82 756	79.1153
4:10	35.4054	30.85373	35.2913	28.7237	83.4987	79.8971
4:15	35.839	31.29033	36.1809	29.2761	84.2671	80.6326
4:20	36.4505	31.52363	36 7162	29.9694	84.952	81.3203
4 25	36.7296	31.65193	37.2608	30.2891	85.538	81.8727
4:30	37.203	31.86123	37.9233	30.8047	86.1996	82.4651
4:35	37.6519	31.96983	38.4475	31.2574	86.6591	82.9265
4:40	38.0777	32.13163	39.0621	31.6866	87.0967	83.4019
4:45	38.5729	32.24923	39.708	32.0333	87.5284	83.8713
4:50	39.2094	32.39493	40.4191	32.408	88.0221	84 4028
4 55	39 4392	32.35963	40.8374	32.3727	87 9176	84.3697
5 00	40 1228	32.70653	41.5952	32.7193	88.492	84.9104
5.05	40 608	33 04413	42.1173	32.8278	88.8434	85.2274
5.10	40.8214	33.14533	42.481	32.8526	88.938	85 3223
5:15	41.3366	33.43723	43.1081	32.9537	89.2466	85.668
5.20	41 9292	33 73133	43.6617	33.1333	89.5929	85.9799
5.25	42 3051	33 61583	44.2248	33.2085	89.8415	86.301
5:30	42 8529	33.71273	44 7338	33 4197	90.1459	86 5709
5 35	43 2674	33.78933	45.2975	33.6487	90.4313	86 8574
5:40	43.7414	34.04083	45.8829	33.862	90.4169	86.8788
5 45	44.1588	34.27323	46.3367	34.0943	90.6341	87.2041
5.50	44.5789	34 85133	46.7932	34.3294	90.9253	87 4606
5:55	45.0315	35.76653	47.282	34.7499	90.8557	87.355
6:00	45 4712	36 13573	47.7579	34.8911	91.0946	87.6663
6:05	45.7922	36.80273	48.2276	35.3684	91.1143	87.7575
6.10	46 2699	37 55203	48.7039	36.0425	91.2472	87 891
6 15	46.6865	38.04943	49.0819	36.882	91.3935	87 9663
6:20	47 0094	38.26243	49.5159	37.3986	91.5933	88.2741
6:25	47.4394	39.00073	49.9446	37.9476	91.895	88.5054
6:30	47.8521	39.38033	50.356	38.4031	91.7891	88.5419

March 8th and 9th

Chanel	1	2	3	4	5	6	7
Label	1	2	ground temp	4	j	l	7
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F	"Degrees F"
6:35	39.1209	43.2815	26.6581	34.4381	39.0882	40.4045	38.0463
6:40	39.2886	43.4107	26.521	35.1011	39.4072	40.572	38.2903
6:45	39.368	43.452	26.2941	35.3329	39.4865	40 538	38.3699
6:50	39.592	43.3738	26.0218	35.9378	39.6726	40.7617	38.5565
6:55	39.2271	43.8006	25.8815	36.4826	40.1015	41.077	38.5698
7:00	39.3056	43.8035	25.8844	36.789	40.18	41.3818	39.1789
7:05	39.8761	43.9947	25.8493	37.0578	40.3721	41.3851	39 4474
7:10	40.0557	43.8351	25.8782	35.796	39.7961	41 0738	39.438
7:15	40.5129	44.2148	25.8822	36.3315	40.2156	41.4174	39.9718
7:20	40.7261	44.5771	25.8301	37.1906	40.5044	41.7436	40.1476
7:25	41.0182	45.2053	26.0124	37 5976	41.1361	42.2993	40.5536
7:30	41.3902	45.5002	26.0839	37.8953	41.3571	42.4825	40.7752
7:35	41.4029	45 7753	26.0199	38.0975	41.4829	42.6082	40.5989
7:40	41.2651	45 8633	26.3025	38.6406	41.4583	42.6966	40.7254
7:45	42.1259	46.3441	26.6418	39.693	42.0926	43.2549	41.2101
7:50	42.2577	47.0744	26.6994	40.5051	43.2035	43.9135	41.2667
7:55	42.8874	47.6999	27.0344	40.9474	43.6443	44.3165	41.4826
8:00	43.7281	48.423	27.393	42.0914	44.5591	45.3061	42.4766
8:05	43.7963	49.1259	27.7698	42.8377	45.5659	45.7872	42.5828
8:10	45.11	49.7961	28.1518	43.7766	46.2017	46.4608	43.561
8:15	45.9957	50.6389	28 5584	44.5885	46.8988	47.0081	44.3743
8:20	45.9995	50.7172	29.3287	44.5171	46.8651	47.1992	45.1303
8:25	46.7321	51.2216	29.6175	44.0864	46.8853	47.2943	45.7895
8:30	47.4627	52.0595	30.2493	45.0446	47.5034	48.0247	46.1465
8:35	47.9668	52.486	30.6879	45.55	47.895	48.7155	46.8771
8:40	48.4666	52 9456	31.2751	46.2011	48.3574	49.1776	47.1532
8:45	48.8162	53 4417	31.8233	46.3268	48.5575	49.6018	47 3163
8:50	48 7021	53.8112	32.5846	46.6995	48.2937	49 6371	47 6142
8:55	49.1333	54.462	33.2533	47.2814	48.9119	50.5904	48 421
9:00	49.5628	54.8515	33.6534	47 637	49.1174	50 9448	48.5895
9:05	51 1921	56.025	34.935	48.7466	50.2623	52.2739	50.1105
9:10	50.8931	56.2095	37.327	48.8954	50.075	52.4593	49 9977
9:15	51.2631	56.7249	39 8231	49.0794	50.7436	52.6799	50 107
9:20	53.2665	57.6427	42.0058	50.3792	51.8919	54 1604	51 1831
9:25	53.1306	57 7663	44.1273	50.1682	51.3833	53 8017	50.5613
9:30	54.4613	59 2733	46.1108	52.0248	53.3858	55.6881	51.6368
9:35	55.9838	60.3809	47.3869	53.254	54.576	56.5793	52 7194
9:40	55.9397	60.6318	47.6419	53.4328	55.0142	56.9796	53.1964
9:45	56.2173	61.2389	46.7613	53.7855	55 1437	57.2939	53.252
9:50	57.5198	62.2021	46.0558	54.6834	55.8549	58.2994	54.1517
9:55	56.7153	61 2554	44.6765	53.3934	54.8635	57.2365	53 3803
10:00	58.2372	62.364	43.629	54.6613	55.8699	58 0186	54 1668

March 8th and 9th

Chanel	8	9	10	11	12	13	14
Label	8	Bottom 2	Air temp	11	Bottom 3	13	a
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
6:35	42.5132	49.2424	21.3739	39.7712	48.7565	36.5877	40.6729
6:40	42.6808	49.6322	21.1972	40.0144	49.1092	36 984	40.6516
6:45	42.6467	49.8973	20.5814	39.8291	49.3371	37.3293	40.6553
6:50	43.286	50.3423	20.6946	40.2419	49.7824	37.7058	41.03
6:55	43.5635	50.7285	20.7857	40.4819	50.0568	38.0984	41.2321
7:00	43.9438	51.0296	20.7111	40.6736	50.3956	38.4803	41.5746
7:05	44.1734	51.4429	21.7984	40.9789	50.7719	39.014	41.9174
7:10	43.7868	51.6945	20.0849	40.7431	50.9864	39.1939	41.8326
7:15	44.2057	52.0709	20 554	41.1245	51.3258	39.5385	42.1006
7:20	44.5694	52.3927	20.8502	41.4507	51.5362	39.8657	42.3511
7:25	45.2755	52.9039	22.001	42.195	52.0851	40 3852	43.1325
7:30	45.5338	53.159	21.8022	42 4912	52.3032	40.5311	43.2778
7:35	45.5465	53.3203	20.4989	42.3531	52.4647	40.7328	43.4411
7:40	45.6725	53.7049	20.0085	42.3662	52.6636	40.7836	43.7176
7:45	46.3057	54.1071	21.0479	42.8494	52.9548	41.0793	44.1625
7:50	47.4147	54.5712	23.1551	43.8467	53.3452	41.4002	44.6325
7:55	47.5918	54.8205	22.9897	44.1745	53.855	41.2762	44.321
8:00	48.5804	55.2411	24.9313	45.0515	54.1275	41.8552	45.4985
8:05	49.5857	55.6051	26.1175	45.9454	54.4549	42.2632	46.2422
8:10	50.1083	55.9741	25.8849	46.6187	54.8244	42.827	46.953
8:15	50.9915	56 2928	26.0234	47.2033	55.1435	43.2641	47.3502
8:20	51.5187	56.7409	26.1042	47.5441	55.5552	44.0209	48.4397
8 25	51 9872	56.8719	27 4317	47.9012	55.6864	44.3046	48 8339
8:30	52.641	57 2978	26.6058	48.4065	56.224	44.6245	49 3388
8:35	53 1434	57 426	27.5457	49.0969	56.2783	45.0556	49.8419
8:40	53.679	57.7353	27.598	49.5961	56.5139	45.52	50.3781
8:45	54 0275	58.0441	28 8774	50 3558	56.7121	46.0214	50.6897
8:50	54 1373	58 4117	28 0316	50 4658	57.2284	46.2822	51.1727
8:55	54.9021	58.801	27.7452	51.2689	57.3962	47.09	51.8636
9:00	55.0323	58.9671	28.2632	51.3993	57.4886	46.9962	51.9567
9:05	56.3587	59.4348	31 8098	52 8762	57 9201	48.37	52.9495
9:10	56.2837	59 5079	29.7443	52.8011	57 9934	48.2944	53.1721
9:15	56 6896	60 0216	30.0477	53.2075	58.4342	48.5536	53 5784
9:20	57 9819	60.1993	33.1348	54.3527	58.723	49.295	54.2406
9:25	57.6608	60.4701	29 9008	54 0684	58.7727	48.8964	53.9933
9 30	59.544	60 9055	33.9791	56.1021	59 5412	50.3846	55 4716
9 35	60 6555	61 3124	34.5139	57.0668	59.9488	51.2074	56 1779
9:40	60.9072	61.7841	33.4784	57.7257	60.3474	51.2376	56.6525
9:45	61.3318	61.7653	33.1542	58.0397	60.3287	51.1814	56.5966
9:50	62.2615	62.2137	33 1993	58 7856	61.0725	51.7476	57 7511
9 55	61.3113	62 444	30.8806	58.0932	60.5663	50.6756	57.4278
10:00	62.055	62.6331	31.5357	58.6897	60.9033	51.8746	58.099

March 8th and 9th

Chanel	15	16	17	18	19	20
Label	Bottom 4	b	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
6:35	48.1955	39 53843	50.773	38 7128	91.9732	88.6554
6:40	48.5484	39 89553	51.1993	39.0699	92.1309	88.885
6:45	48.8138	39.78573	51.5384	39.1115	92.17	88.8528
6:50	49.2968	40.31243	52.0198	39.4112	92.345	88.9928
6 55	49.5714	40.66603	52.368	39.6893	92.3219	89.0767
7 00	49.9103	40.97123	52.6685	39.8434	92.5735	89.3648
7 05	50.2869	41.23903	53.081	40.5648	92.7187	89.5106
7:10	50.5761	40.77623	53.2949	41.0464	92.9231	89.6443
7:15	50.9157	41.08253	53.7077	41.4277	93.1755	89.9332
7:20	51.2008	41.37133	54.0661	41.3389	93.1984	90.0988
7:25	51.7126	42.11643	54.5019	41.6308	93.5086	90.2676
7:30	51.9309	42.41293	54.7937	41.7387	93.5747	90.4051
7:35	52.1296	42.23703	54.9175	41.6005	93.5156	90.4171
7:40	52.4403	42.06143	55.3014	41.9907	93.8119	90 6075
7:45	52.806	42.62073	55.6287	42.5496	93.9476	90.815
7:50	53.1593	43.88293	56.0549	42.7944	94.1428	91.0108
7:55	53.409	43.83463	56.3408	43.0851	94.3101	91.1431
8:00	53.9046	44.90083	56.7236	43.5871	94.4639	91.4042
8:05	54.2321	46.05883	57.198	43.994	94.6701	91 5399
8:10	54.6388	46.84523	57.4552	44.5563	94.7748	91.7517
8:15	54.958	47.20533	57.7364	44.9171	94.9733	91.9509
8:20	55.3698	47.54643	58 4424	45.4467	95.2249	92.2389
8:25	55.501	47.86643	58.3145	45.6171	95.244	92.2225
8:30	56.0017	48.40973	58.8135	45.9738	95.51	92.5249
8:35	56.0189	48.68923	58.9046	46.0288	95.4556	92.5414
8:40	56.3658	48.96463	59.2133	46.2299	95.6455	92.6608
8:45	56.601	49.35183	59.4846	46.6556	95.7642	92.851
8:50	57 1173	49.16283	59.9992	46.5036	96.081	93.1688
8:55	57.3962	49.78113	60.2402	47.011	96.1708	93.2588
9:00	57.5996	49 46333	60.4061	46.6549	96.153	93.312
9:05	58.068	50.94533	60.8361	47.8413	96.4598	93.5843
9:10	58 1413	50 64593	60.9828	47.5785	96.4591	93.5481
9:15	58.6189	50.86713	61.4588	48.3617	96.7042	93.8649
9:20	58.76	52.01673	61.5626	49.0655	96.6977	93.8939
9:25	59.0312	51.17183	61.8697	48.8167	96.8514	94.0481
9:30	59.5412	53.77293	62 2676	49.2957	96.951	94.2189
9:35	59.9119	54.92693	62 7107	50.7163	97.271	94.5043
9:40	60.2737	55.32843	63.0345	50.7465	97.2996	94.5685
9:45	60.3287	55.45803	63.0893	50.9141	97.317	94 6214
9:50	60 8883	56.42943	63.6104	52.337	97.677	95.0888
9:55	60.898	55.66023	63.7302	52.4212	97.5802	94.9209
10:00	61.1611	56.29623	63 919	53.2451	97.762	95.0678

March 8th and 9th

Chanel	1	2	3	4	5	6
Label	1	2	ground temp	4	J	I
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
2:33	36.5099	39.7041	35.7575	36.911	39.4702	39.6145
2:38	36.3987	39.5933	35.8361	36.724	39.3972	39.5414
2:43	36.3501	39.4694	35.8254	36.6375	39.1975	39.3417
2:48	36.3693	39.4129	35.8447	36.6186	39.0654	39.2852
2:53	36.5317	39.7258	35.9312	36.7431	39.1894	39.2957
2:58	36.7742	40.0049	35.908	36.9476	39.2419	39.3861
3:03	37.0637	40.2553	35.856	37.0853	39.3036	39.41
3:08	37.6117	40.7253	35.9872	37.4815	39.6232	39.8053
3:13	37.7741	40.9623	35 77	37.6438	39.6717	39.816
3:18	38.2047	41.391	35.8599	37.8851	39.9123	40.1701
3:23	38.625	41.8094	35.8637	38.2297	40.1805	40.4384
3.28	38.7234	42.171	35.8485	38.4795	40.543	40.5743
3:33	39.3594	42.6909	35.8412	38.8129	40.8378	40.9826
3:38	39.6137	42.9817	35.9068	39.0295	40.9784	41.1609
3 43	40.2259	43.4781	35.8763	39.453	41.4385	41.5835
3:48	40.5484	43.8743	35.8968	39.5868	41.6474	41.8302
3:53	40.8556	44.2176	35.9019	39.932	41.8787	42 0992
3:58	40.9732	44.3346	35.8683	40.1252	41.9584	42 2544
4:03	41.3126	44.6724	35.8301	40.3139	42.2974	42.3295
4:08	41.7704	44.9404	35.9873	40.6212	42.6039	42.7869
4:13	41.6312	44.952	35.771	40.7083	42.5779	42.7232
4:18	41.7483	45.0685	35.737	40.75	42.6571	42.8025
4:23	41.8628	45.1825	35 6624	40.8647	42.8844	42.8415
4:28	42.4112	45.8407	35.9113	41.489	43.5449	43.4271
4:33	42.651	45.9294	35.6212	41.5028	43.4457	43.5537
4:38	43.0582	46.3347	35.5761	41.8351	43.7773	43.923
4:43	43.5613	46.9103	35.704	42.2258	44.167	44.4632
4:48	43.6816	47.1049	35.6356	42.4969	44.5127	44.5083
4:53	44.0363	47.3831	35.6139	42.5131	44.7542	44.75
4 58	44.1976	47.8055	35.6629	42 9006	44.9153	45.099
5:03	44.7067	48.1625	35.6078	43.2976	45.4239	45.3825
5:08	44.7573	48.2128	35.6209	43.5363	45 6245	45.5832
5:13	44.3938	48.2625	35.5953	43.4358	45.6368	45.3326
5:18	45.0233	48.7391	35.51	43.7274	45.9277	45.6613
5.23	45.0416	48.9067	35.4524	43.7457	45.9834	45.9423
5:28	45.0009	48.7168	35.2592	43.7426	45.9428	45.7891
5:33	45.0913	48.8441	35 2747	43.8331	45.9956	45.9169
5:38	45.6639	49.339	35.2843	44.3313	46.5674	46 4141
5:43	45.7877	49.6488	35.4477	44.6431	46.8034	46.6877
5:48	46.0313	49.8165	35.2004	44.8119	46.9343	46.9312
5:53	46.0293	50.0011	35.4265	44.9977	47.3443	47.0042
5:58	45.7639	49.9983	35.1575	44.8071	47.2666	46.8514
6:03	46.1068	50.3019	35.3529	45.3755	47 5339	47.194

March 9th and 10th

Chanel	7	8	9	10	11	12	13
Label	7	8	Bottom 2	Air temp	11	Bottom 3	13
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
2:33	38.3156	43.8388	45.501	34.845	40.3419	42.982	37 275
2:38	38.1665	43.8414	45.2408	34.5052	40.2689	42.9093	37.2776
2:43	38.08	43.6799	45.1552	34.5706	40.0694	42.7481	37.1531
2:48	38.0613	43.5857	45.0991	34.3616	40.1641	42.6919	37.0964
2:53	38.2994	43.634	44.9969	34.5244	40.1746	42 7024	37.4485
2:58	38.5416	43.6487	45.0866	34.6534	40.3782	42.8677	37.7289
3:03	38.793	43.6725	45.2605	34.6394	40.4021	43 1174	37.9045
3:08	39.189	43.9915	45.6905	34.7707	40.6836	43.5108	38.3387
3:13	39.3512	44.0399	45.7386	34.5151	40.8453	43.7472	38.4632
3:18	39.5922	44.1669	46.09	34.5671	41.0479	44.0619	38.7423
3:23	39.8988	44.4723	46.3563	34.4187	41.3158	44.4792	39.0869
3:28	40.1863	44.7588	46.7161	34.4415	41.6402	44.652	39.4882
3:33	40.6707	44.9401	47.1212	34.4723	41.7839	45.2459	39.8215
3:38	40.8493	45.1558	47.5229	34.538	42.0375	45.5734	40.0759
3:43	41.3102	45.5022	47.9421	34.6596	42.4595	46.1812	40.4993
3:48	41.5194	45.7484	48.299	34.604	42.7435	46.5389	40.8598
3:53	41.7888	45.904	48.8276	34.6852	42.9745	46.9562	41.016
3:58	41.9442	45.8331	49.243	34.7657	42.9412	47.3726	41.2092
4:03	42.1327	46.2468	49.5791	34.6514	43.1669	47.5596	41.5111
4:08	42.4397	46.5153	50.3309	34.7708	43.5485	48.3133	41.9315
4:13	42.4891	46.6021	50.3424	34.3639	43.4472	48.4745	41.8676
4:18	42.493	46.5309	50.8685	34.2918	43.4888	48.8523	42.0602
4:23	42.5699	46.6075	51.2055	34.2171	43.6407	49.0406	42.1748
4:28	43.2315	47.192	51.8222	34.4283	44.1503	49.6215	42.7611
4:33	43.2076	47.0554	52.0965	34.0234	44.0889	49.7846	42.6995
4 38	43 6527	47.3866	52.499	34.3209	44.3826	50.2629	43.107
4 43	44.1559	47.8135	52.9219	34.2968	44.9225	50.687	43 5729
4 48	44 3139	48 1588	53.3756	34.3424	45.1928	51.1791	43 8062
4.53	44 4807	48.3626	53.7633	34.0162	45.4343	51.4933	44 1235
4:58	44 7925	48.7486	54.1827	34.2176	45.858	51.9884	44.4354
5:03	45.2644	48.9567	54.5001	34.2384	46.1037	52.3439	44.7193
5:08	45.3525	49.2695	54.9583	34.0993	46.2666	52.6545	44.8827
5 13	45.1393	49 1319	55.2673	34.0737	46.1289	53.0015	44.8574
5 18	45.5435	49.5349	55.6291	34.0262	46.5697	53.4014	45.224
5.23	45.6745	49.5632	55.9807	33.9305	46.5129	53.6425	45.1671
5.28	45 5587	49.5501	56.3111	33.775	46.5098	54.011	45.3143
5.33	45.6867	49.6777	56.6966	33.9429	46.6001	54.249	45.4048
5:38	46.1469	50.174	56.9281	33.762	47.2091	54.407	45.865
5:43	46.2707	50.335	57.5312	34.04	47.3327	55.0119	46.1015
5:48	46.4395	50.578	57 6605	33.8303	47.5384	55.1045	46.2326
5:53	46.5876	50.838	58.1392	33.8664	47.8359	55.5847	46.4558
5:58	46.5848	50.7978	58.2473	33.9017	47.8331	55.6931	46.3404
6 03	46.8152	51.0648	58.7698	34.0974	48.0629	56.2172	46 5708

March 9th and 10th

Chanel	14	15	16	17	18	19	20
Label	A	Bottom 4	B	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"
2:33	39.0129	44 0733	40.14773	44.2613	36.8971	35.203	33.8306
2:38	39.0533	43.8126	40.03683	44.0759	36 7099	79.1918	75.4639
2:43	38.967	43.7269	39.87483	43.9902	36.8891	77.2673	73.9306
2:48	38.9105	43.5578	39.85623	44.0092	36.7565	79.3803	76.4498
2:53	38.8453	43.4554	39.90463	44.0949	37.1465	80.9041	77.7257
2:58	39.0872	43.5076	39.99493	44.3727	37.5026	82.1775	78.9675
3:03	39.2246	43.6819	40.05673	44.7347	37.9057	83.3141	80.1083
3:08	39.6201	43.9999	40.33863	45.2775	38.4533	84.5146	81.3491
3.13	39.6686	44.1233	40.50053	45.5134	38.8426	85.2417	82.0787
3 18	39.9094	44.3251	40.66563	45.9775	39.1593	86.1502	82.9904
3.23	40.4423	44.6295	40.97183	46.4313	39.6927	86.9052	83.6763
3:28	40.7294	44.9901	41.29663	46.941	40.169	87.6058	84.3077
3:33	40.7978	45.2834	41.62933	47.4583	40.653	88.2778	85.018
3:38	41.014	45.7236	41.76993	47.9347	41.0202	88.8392	85.6172
3:43	41.5121	46.1812	42.19253	48.391	41.5183	89.4527	86.233
3:48	41.7589	46.5389	42.40153	48.9721	41.8782	89.9355	86.6101
3:53	42.1034	46.9562	42.63293	49.5376	42 1472	90.3679	87.1514
3:58	42.1077	47.2977	42.71263	49.99	42.4531	90.7994	87.6202
4 03	42.2961	47.7843	43.05173	50.475	42.8297	91.2621	87.9416
4 08	42.8289	48.3507	43 39613	51.0769	43.3621	91.694	88.5179
4 13	42.8028	48.5867	43.44543	51.3866	43.449	91.7761	88.5289
4:18	42.9574	49.0018	43.56233	51.8748	43.6411	92.0644	88.8539
4:23	42 9965	49.4516	43.75203	52.323	43.8683	92.4568	89.105
4:28	43 6949	49.9203	44.26213	52.9389	44.453	92.8317	89 5882
4:33	43.5581	50.1206	44.05003	53.25	44.354	92 7736	89.6369
4 38	43.7769	50.5241	44.49463	53.6891	44.7229	92.9801	89.8085
4:43	44.3925	50.9108	44.84693	54 1114	44.9997	93.1352	89.9642
4 48	44.7007	51.3655	45.23043	54.6015	45.3451	93.3554	90.2207
4 53	44 8673	51.7169	45.35933	54.9887	45.5866	93.6547	90 4142
4:58	45 329	52.1374	45.74593	55.4817	45.8977	93.736	90 6738
5 03	45 4998	52.4928	46.06703	55.7615	45.9183	93.8974	90.8002
5 08	45 8881	52.9149	46.26773	56.219	46.3054	93.9806	90.9193
5 13	45.8254	53.2619	46.24243	56.5275	46.2062	94.1342	91.1802
5:18	46.1164	53.6245	46.53353	56 9628	46 4595	94 3383	91.207
5:23	46.1721	53 9398	46.66433	57 3508	46 5902	94.462	91.3311
5:28	46.2816	54.3453	46.58613	57.7177	46 7371	94.6009	91.5416
5:33	46.3344	54.6204	46.67653	57.9916	46 7899	94.6863	91.6629
5:38	46.7939	54.9637	47.17363	58.3336	47.1741	94.8725	91 8497
5:43	47 03	55.4571	47.40973	58.825	47.4475	95.1666	92.1093
5.48	47.1984	55.6237	47.57823	58.954	47.5035	94.9715	91.9846
5 53	47.5336	56.0666	47.91353	59.5058	47.7636	95.2886	92.3383
5:58	47.4184	56.175	47.83573	59.5769	47.4987	95.2859	92.1934
6:03	47 7982	56.6617	48.21563	60.0985	47 8784	95.5389	92.4828

March 9th and 10th

Chanel	1	2	3	4	5	6
Label	1	2	ground temp	4	J	I
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
6:08	46.5217	50 7144	35.3554	45.6782	47.9106	47.6833
6:13	46.7273	50.7325	35.2598	45.7714	48 0036	47.7389
6:18	46.7368	50.8165	35.3835	45.856	48.1627	47.7485
6:23	46.6484	50 9895	35.56	46.1425	48.4485	47.8474
6:28	46.2032	50.7706	35.3747	45.8472	48.154	47.5525
6:33	46.1549	50.6107	35.3637	45.7238	48.1432	47.4668
6:38	46.0688	50.7488	35.5045	45.8628	48.2818	47.4557
6:43	46.529	50.8335	35.2108	45.798	48.2172	47.6906
6:48	46.0947	50.6627	35.1886	45.8512	48.1954	47.5565
6:53	46.5934	50.9721	35.3141	45.975	48.2815	47 6801
6:58	46.5787	50.9202	35.1091	45.6977	47.9675	47.5531
7:03	46.6201	50.8495	34.9229	45.6266	47.9714	47.6318
7:08	46.6881	50.8426	35.144	45.9572	48.2263	47.8121
7:13	46.8268	50.8688	35.2847	46.021	48.3274	47.726
7:18	46.464	50.6944	35.1068	45.9581	48.302	47 7755
7:23	47.0534	51.0196	35.3626	46.2103	48.4787	48 0647
7:28	47.1786	51.2186	35.4136	46.4855	48.6784	48.3394
7:33	47.5192	51.4828	35.3412	46 6764	48.9809	48.6423
7:38	47.5506	51.663	35.4111	47 0825	48.975	48.7859
7:43	48.4749	52.4705	35.8558	48.0819	49.8974	49.7464
7:48	48.4332	52.8009	35.8514	48.4889	50.229	49.7794
7:53	49.2518	53.429	36.1135	49.27	50.8592	50.7088
7:58	49.9002	53.9994	36.3551	49.8435	51.5435	51.2071
8:03	50.7056	54.652	36.643	50.3504	51.9004	51 8252
8:08	51 2168	54.9379	36.8976	50.5634	52.0385	52 1124
8:13	51 4126	55.1327	37.1728	50.722	52.3457	52 3453
8:18	51.5411	55.4829	37.4174	51.1115	52 7345	52 6226
8:23	52 3788	55 9088	37.8153	52.0239	53.3478	53.3479
8.28	52 0146	55 6576	37.9751	51.7342	53.2444	52 9096
8 33	53.3195	56 8449	38.3566	52 7044	54.0272	54 3619
8 38	53.5328	57.0572	38.8389	53.2153	54.5373	54.3523
8 43	54.3095	57.4235	38.8354	53 472	54.7936	54.7944
8.48	54.8918	58.3357	39.4668	54 5745	55.7832	55 7845
8:53	55.4708	58.4321	39.6788	54.7084	56.0281	56 1777
8 58	55.7391	59.0314	39.9902	55.1623	56.4443	56 5199
9:03	56 897	59.9629	40.68	56.1726	57.527	57.3811
9 08	56 4358	59 6143	41.3423	55 7111	57.0292	56.846
9:13	56.7199	60.0446	43.1391	56.4028	57.572	57.4261
9 18	58.4881	61.0321	45.0496	57 3579	58.5996	58.8609
9 23	58.4664	61.3417	46.5286	57.4842	58.7626	58.9131
9:28	58.5763	61.5247	48.1007	57.5942	58.6139	59.0599
9:33	59.6935	62.5639	49.3444	58.7124	59.7678	60.103
9.38	59.8361	62.5957	50 3848	58.7444	59.8734	60.098

March 9th and 10th

Chanel	7	8	9	10	11	12	13
Label	7	8	Bottom 2	Air temp	11	Bottom 3	13
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
6:08	47.1177	51.516	59.0307	34.176	48.4769	56.4049	46.9858
6:13	47.2109	51.5341	59.1963	34.0803	48.495	56.571	46.9665
6:18	47.333	51.6557	59.5379	34.1661	48.7663	56 7285	47.0886
6:23	47.3945	51.8665	59.9674	34.3809	48.9398	57 2335	47.3375
6:28	46.9867	51.647	60.1196	34.3857	48.6454	57.3492	47.0423
6:33	47.0134	51.5241	60.4039	34.4888	48.5598	57.6344	47.0315
6:38	47.0773	51.7373	60.7985	34.744	48.7731	58.0303	47.1704
6:43	47.2001	51.7475	60.7717	34.2596	48.8581	58 1143	47 1431
6:48	47.1032	51.8004	61.1923	34 3897	48.8363	58.2776	47 1588
6:53	47 302	51.9238	61.6084	34 7436	48.8476	58.7321	47 1701
6:58	47.3248	51.5728	61.6676	34.6526	48.5712	58.7915	47 2303
7:03	47.2912	51.6141	61.8922	34.7327	48.5003	58.8322	47.1967
7:08	47.4342	51.8313	62.2165	34.8017	48.5681	59.01	47.3022
7:13	47.5729	51.9696	62.5733	35.0946	48.7813	59.442	47.5159
7:18	47.435	51.8696	62.6219	34.9927	48.8307	59.3432	47.3031
7:23	47.6497	52.0835	63.0162	35.2485	48.8205	59.6652	47.4802
7:28	47.8499	52.3203	63.1758	35.4516	49.2444	59.8254	47.7553
7:33	48.1531	52.6599	63.2527	35.2651	49.4721	59.8289	47.9461
7:38	48.2221	52.7659	63 4673	35.5632	49.4288	60.0812	47.9776
7:43	48.6976	53.6127	63.8603	36.0837	50.3883	60.3652	48.4532
7:48	48.581	53.7948	63.856	36.3452	50.6452	60.5452	48.4488
7:53	48.989	54.6852	64.146	36.7589	51.499	60.7995	48.8567
7:58	49.4888	55.2197	64.3795	37.0382	52 1084	60.8128	49 2817
8:03	49 9219	55.5391	64.6577	37.2121	52.5024	61 3501	49.4531
8:08	50 2473	55.7514	64.7571	37.4665	52.566	61.4866	49.7038
8:13	50 593	56.0212	64.9498	37.5141	52.7244	61 6433	49 8255
8:18	50.9085	56.4838	65.1496	38.3269	53.3362	61.6966	50.1038
8:23	51.4867	57 0965	65.3876	38.535	53.9492	61 8621	50.3837
8:28	51.3829	56.9189	65.5056	38.6947	53.7344	61 8333	50.2425
8:33	52 3922	57 738	65.728	39.038	54.5913	62.2774	51.0663
8:38	52.7178	58.2476	66.0847	39.9736	55.0641	62.562	51 4296
8:43	53.2356	58.5406	66.008	39 7432	55.3944	62.3747	51.9481
8:48	53.8566	59 5291	66.3993	40.2984	56.4207	62.8412	52.6443
8:53	54.214	59 7737	66 4216	40 9634	56.7025	62.7901	53.002
8:58	54 8918	60 3004	66 6865	40.557	57 1555	62 9826	53 6434
9:03	55 644	61 234	66.9886	42.3022	58.2746	63.4697	54.2479
9:08	55.3301	60.6999	67.0085	41.5686	57.5552	63.3795	53.7476
9:13	55.6149	61 3159	67.216	41.2167	58.2087	63.5511	54 0329
9:18	56.9059	62.2687	67.3918	43.922	59.3835	63.7277	54.9546
9:23	57.2177	62.5053	67.5166	42.5448	59 5833	63.7062	55.1928
9:28	57.2908	62.6518	67.7715	42.3177	59 5824	64.1457	55.6372
9:33	58.337	63.5093	67.9638	43 081	60 6615	64.1921	56.5369
9:38	58 406	63 7253	68.2146	43.6029	60.5828	64.5174	56.5319

March 9th and 10th

Chanel	14	15	16	17	18	19	20
Label	A	Bottom 4	B	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"
6:08	48.1376	56.9233	48.59253	60.3222	48.068	95 6475	92.6628
6:13	48.2305	57 0893	48.64803	60.5243	48.0861	95 4875	92.6089
6:18	48 4272	57 3208	48.76993	60.8654	48 0957	95 6737	92.7602
6:23	48 5634	57 8254	49.01843	61.2206	48.2694	95.8381	92.9606
6:28	48.381	57 904	48.76113	61.3357	47.9747	95.7717	92.9295
6 33	48.2954	58.1891	48.82523	61.6196	47.7392	96.0093	93.0258
6:38	48.434	58.6216	48.88903	61.9768	47.9154	96.1405	93.2284
6.43	48.4442	58.7056	48.74953	62.0972	48.0004	96.0085	93 1316
6:48	48.5346	58.9795	48.91483	62.4068	48.0535	96.0941	93.2529
6:53	48.5459	59.3967	48 96353	62.7856	48.2144	96.2464	93.4412
6:58	48.3068	59.4561	48.64943	62.8814	48.1998	96.1971	93.3207
7:03	48.3106	59.7182	48.65333	63.1058	48.4655	96.3069	93 4309
7:08	48.4534	60.1171	48 72123	63.3561	48.5708	96.3358	93 5664
7 13	48.6667	60.3274	48.93463	63.7492	48.5971	96.6083	93 7687
7 18	48 4916	60.3023	48.90923	63.6875	48.422	96.4781	93.6027
7 23	48 6684	60 7346	49.12343	64.1181	48.6737	96.6808	93 8414
7 28	48.943	60.8945	49.24843	64.3141	48.9481	96.5867	93.8535
7:33	49 1709	60.9349	49.47633	64.3176	48.9891	96.5547	93.8214
7:38	49 4639	61.2237	49.65733	64.5319	49.3195	96.6552	93.8867
7·43	50 1997	61.5441	50.61763	64.961	49.7193	96.8922	94.1245
7:48	50.3821	61.5767	51.02393	64 8834	49.6029	96.782	93.9785
7.53	51.1991	61.8675	51.69173	65 1731	50.0474	96 7785	94.1169
7:58	51.7717	62 0647	52.22713	65.3329	50.658	96.9682	94.2361
8:03	52 1288	62 3437	52.65873	65.6842	50.9782	97.0596	94.2569
8:08	52 2669	62 4066	52 72243	65.82	51.2657	97.1907	94.3884
8·13	52.6487	62 5631	53.10423	65.9392	51.2752	97.1997	94.4329
8·18	53.2236	62 8002	53.45593	66.1388	51.6274	97.251	94.5198
8.23	53.8369	63 0389	54 06953	66.3766	51.8321	97.2685	94 6437
8:28	53.9194	63 1204	54.22643	66.4578	51.8775	97 3469	94.6869
8:33	54.5164	63.3802	54.89793	66.6799	52.327	97.5615	94.7603
8.38	55.212	63.7011	55.40813	66 9996	52.3545	97.6583	94.9283
8:43	55.5796	63.6243	55.55313	66 9962	52.4627	97 4783	94.8541
8:48	56.5689	64.0167	56.76553	67 3505	52.8977	97 7147	95.0911
8:53	56.9618	63.9289	56 89923	67.3728	53.2923	97.6655	95.0773
8·58	57.5628	64 1211	57 46373	67.5642	53.3384	97.7445	95.1566
9.03	58 46	64.5343	58 43553	67.9391	54.1285	97.9657	95.4138
9:08	58.2952	64 3341	58.01173	67.9225	54.0373	97.8789	95.2913
9:13	58.9483	64.6889	58.77643	68.1297	54.3594	97.9027	95 3506
9:18	59 7905	64 9019	59.43463	68.3054	55.169	98 0372	95.4501
9.23	60.1009	64.9904	59.70843	68.5396	55.073	98 1225	95.5356
9.28	60.4687	65 0995	59.74443	68 7942	55.5914	98 1922	95 7117
9:33	61.2524	65.3657	60 86133	68.9133	56.1202	98.2721	95.721
9:38	61.5053	65.544	60.85633	69 0908	56 3746	98 3027	95.8225

March 9th and 10th

Chanel	1	2	3	4	5	6
Label	1	2	ground temp	4	J	I
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
9:43	61.1723	63.523	50.8046	59.6764	61.0252	61.5078
9:48	60.678	63.471	50.6771	59.8453	61.0466	61.0872

March 9th and 10th

Chanel	7	8	9	10	11	12	13
Label	7	8	Bottom 2	Air temp	11	Bottom 3	13
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
9:43	59.5614	64.3606	68.516	44.9282	61.734	64.8568	57.7635
9:48	59.2503	64.6028	68.5372	44.5743	61.5713	64.9881	57.859

March 9th and 10th

Chanel	14	15	16	17	18	19	20
Label	A	Bottom 4	B	Bottom 1	18	Inlet	Outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"
9:43	62.398	65.8097	61.78723	69.4284	57.1987	98.5235	96.0439
9:48	62.6401	65.8676	62 14013	69.4861	57.7382	98.4381	95.9583

March 9th and 10th

Chanel	1	2	3	4	5	6
Label	1	2	ground temp	4	j	i
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F
22:03	33.7569	35.332	33.8018	33.4366	34.8668	36.15
22:08	33.6351	35.2105	33.7943	33 391	34.7072	36.0285
22:13	33.4778	35.0916	33.7132	33.2337	34.5882	35 8716
22:18	33.3493	34.8875	33.6228	33.1052	34.4219	35 6675
22:23	33.232	34 7325	33.5818	33.026	34.3048	35.5505
22:28	33.0898	34.5907	33.4396	32.8838	34.2009	35.3707
22:33	32.961	34.4241	33.4251	32.7931	33.9961	35.2422
22:38	32.8496	34.313	33.3519	32.6436	33 8849	35.093
22:43	32 6508	34.2669	33.1914	32.4448	33.7626	35.047
22:48	32.4482	34.1028	33.027	32.204	33 6364	34 8068
22:53	32.2913	33.8703	32.8703	32.009	33 4799	34.6504
22:58	32.1107	33.7282	32.7278	31.8283	33.2995	34 4702
23:03	31.9943	33.5361	32.8023	31.8265	33.1834	34.2781
23:08	31.8822	33.3862	32.6903	31.7144	33.0334	34.1282
23:13	31.7558	33.222	32.7166	31.6643	32.9072	34.0021
23:18	31.6984	33 1647	32.6592	31.5688	32.7736	33 8686
23:23	31.5533	33.0199	32.5524	31.4619	32.6287	33.8
23:28	31.498	32.9267	32.5354	31.4066	32.5735	33 6306
23:33	31.1973	32.6267	32.3495	31.1441	32.2733	33.3687
23:38	31.1235	32.515	32.5047	31.1849	32.2377	33.2951
23:43	31.0045	32.3963	32.4241	30 9513	32.1571	33.1001
23:48	30.8856	32.2777	32.3436	30 9089	32.0003	32.9815
23:53	30 7159	32.1084	32.2123	30.7392	31.8308	32 8504
23.58	30.6316	32.0243	32.09	30.6168	31 7467	32.7281
0:03	30.6383	31 9165	32.2112	30.6617	31.677	32.6585
0:08	30.5204	31 9134	32.1699	30.5438	31.5975	32.5409
0:13	30.614	32.0067	32 187	30.5609	31.5764	32.5198
0:18	30.8534	32.2456	32 197	30.7621	31.701	32 5298
0 23	31 0544	32.5224	32.2832	30.8867	31 749	32.616
0:28	31 4082	32.8752	32.2549	31.0876	31 9115	32.7403
0 33	31.699	33 2034	32.2783	31 3021	32.0495	32 9163
0.38	32.111	33.5382	32.3848	31.5614	32.3467	33.1371
0:43	32.4397	33.9802	32.37	31.7757	32.4845	33.3892
0:48	32 8021	34.3037	32.3129	31.9094	32.7707	33 5609
0 53	33.1332	34.5959	32.3389	32 1263	32.9873	33.7393
0.58	33.5266	34.9123	32.3132	32.3294	33.2283	34.0564
1:03	33.7879	35.211	32.346	32.5148	33.4516	34.2795
1:08	34 0736	35.6859	32.2888	32.6864	33.6611	34.4889
1:13	34.4108	35.9463	32.2452	32.9098	33.8081	34 75
1:18	34.7099	36.1687	32.2399	33.057	34.0312	34.9349
1.23	34.9776	36.4357	32.2031	33.2489	34.299	35.1645
1:28	35.2072	36.7026	32.1283	33.3647	34.4527	35.3561
1.33	35.495	37.0656	32 0356	33.5389	34.6647	35.568

March 19 and 20th

Chanel	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
22:03	36.0979	41.4047	44.6219	31.9331	23.2948	43.6819	35.5117
22:08	35.9763	41.0944	44.5018	32.0401	24.0204	43.524	35.314
22:13	35.8193	40.8245	44.3466	31.7679	24.2854	43.2933	35.1189
22:18	35.6149	40.7346	44.1446	31.601	24.1554	43.1288	34.9906
22:23	35.4978	40.618	43.9161	31.7126	24.0367	42.9376	34.8734
22:28	35.3559	40.4767	43.7381	31.5701	24.0471	42.7971	34.7314
22:33	35.2272	40.2349	43.5733	31.5556	24.1096	42.5944	34.5646
22:38	35.0779	40.0862	43.4258	31.4822	24.0354	42.4844	34.4533
22:43	34.9557	40.0782	43.2296	31.0538	23.41	42.2503	34.331
22:48	34.8295	40.0664	43.0296	30.6212	22.5482	42.0877	34.2429
22:53	34.6349	39.9105	42.8372	30.464	21.964	41.8951	34.0482
22:58	34.4545	39.731	42.6589	30.5889	21.6649	41.7166	33.9059
23:03	34.3765	39.5016	42.5064	30.7019	22.5524	41.5639	33.7135
23:08	34.1884	39.2763	42.3204	30.7043	22.9025	41.3777	33.5253
23:13	34.0622	39.0747	42.1679	30.5012	23.2767	41.215	33.4371
23:18	33.9286	38.9417	42.0258	30.4819	23.2572	41.045	33.3035
23:23	33.8219	38.7595	41.8448	30 4131	23.2264	40.9016	33.1585
23:28	33.6904	38.5906	41.6394	30.5107	23.4021	40.6959	33.027
23:33	33.3902	38.2536	41.267	30.2096	23.1369	40.3609	32.7648
23:38	33.3546	38.1041	41.1564	30.48	23.6799	40.1367	32.691
23:43	33.1976	38.0238	40.9256	30.2461	23.5212	40.0191	32.5722
23:48	33.0408	37.9056	40.7704	30.2802	23.4397	39.8259	32.4153
23:53	32.9095	37.8129	40.6028	30.1486	22.8049	39.6581	32.2839
23:58	32.7871	37.691	40.4062	30.179	22.7198	39.5369	32.1997
0 03	32.7175	37.4695	40.2995	30 5301	23.2672	39.3166	32.0918
0:08	32.6379	37.3522	40.1453	30.106	23.1868	39.2	32.0123
0:13	32.7314	37.3312	40.0488	30.0849	23.3199	39 1412	32.0675
0:18	32.8941	37.2651	40.0965	30.3628	23.6003	39.189	32.2304
0 23	33 0949	37.313	40.1819	30.3344	23.8417	39.3879	32 4694
0.28	33.2955	37.3228	40.3427	30 4591	24 0831	39 5112	32.7083
0.33	33.5479	37.4603	40.5548	30 4443	24.0682	39.7991	32.9226
0:38	33.8068	37.6044	40.8867	30.6657	24.4072	40.0557	33.2198
0:43	34.1352	37.7418	41.1741	30.5362	24.6235	40.3056	33.5483
0:48	34.4212	37.913	41.5327	30.6702	24.2574	40.7401	33.8344
0 53	34.6757	38.091	41 8978	30.658	24.4765	41.1056	34.0891
0:58	34.9166	38.2554	42.287	30 7469	24 489	41.4952	34.3681
1:03	35.2159	38 478	42.6962	31.0092	24.4451	41.9425	34.6675
1:08	35.4252	38.7249	43.0917	30.2252	24.3487	42.376	34.953
1:13	35.6862	38.8335	43.538	30.4111	24.536	42.7098	35.2521
1:18	35.9472	38.9801	43.9466	30.4058	24.4921	43.0811	35.4751
1:23	36.1767	39.1713	44.3992	30.4454	24.4164	43.5341	35.7427
1:28	36.3302	39.4004	44 8516	30.2939	24.1866	44.0246	35.9723
1 33	36.618	39.6498	45.2487	29.8948	23.8615	44 4221	36.2601

March 19 and 20th

Chanel	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
22.03	37.5577	43 6443	37.25223	43 4185	34.4872	37.277	34.9193
22:08	37.2847	43.4111	37.01693	43.1852	34.3274	37.1178	34.7216
22:13	37.0142	43.218	36.78413	42.9921	34.1321	36.9231	34.4883
22:18	36.8863	43.0911	36.61803	42.8275	33.9656	36.7572	34.3218
22:23	36.7695	42 8999	36.50113	42.6739	33.8103	36.6403	34.1284
22:28	36.5899	42.7217	36.35933	42.458	33.7062	36.4987	33.9482
22.33	36.3856	42.5567	36.19283	42.293	33.6156	36.3323	33.8195
22:38	36.2746	42.3336	36.00573	42.1452	33.428	36.1833	33.6319
22:43	36.1526	42.2503	35.92163	41.9487	33.2675	36.0614	33.4714
22:48	36.1027	42.1254	35.87173	41.7484	33.1793	35.9735	33.3451
22:53	35.9086	41.9705	35.71543	41.5557	33.0226	35.8553	33.1884
22:58	35.8047	41.792	35.57333	41.3771	32.8801	35 7133	33.0078
23:03	35.4988	41.5262	35.34323	41.1866	32.7257	35.5975	32.7771
23:08	35.311	41.3022	35.15533	41.038	32.5374	35.4478	32.5888
23:13	35.1471	41.1018	34.95313	40.8375	32.411	35.2838	32.4242
23:18	34.9757	40.894	34.78163	40.6675	32.2773	35.0745	32.2523
23:23	34.8312	40.7883	34.63693	40.4862	32.1704	35.006	32.069
23:28	34.6619	40.5071	34.50563	40.3182	32.0006	34.8368	31.9374
23:33	34.3242	40.2097	34.16763	40.0208	31.7764	34.5372	31.6367
23.38	34.1745	39.8344	34.09393	39.7966	31.7026	34.4256	31.5247
23:43	34.0559	39.8301	33.93713	39.641	31.5837	34.2689	31.3675
23:48	33.8993	39.6369	33.81863	39.4856	31.4267	34.1505	31.2486
23 53	33.8064	39.5446	33.72563	39.3177	31.3334	33.9814	31.1936
23:58	33.7224	39.3478	33.56523	39 1965	31.211	64.8818	59.0996
0:03	33.5385	39.0518	33.45753	38.9761	31.1794	64.8149	59.5492
0:08	33.421	38.973	33.33993	38.8973	31.0998	70.0055	66.5676
0:13	33.3618	38.8006	33.28063	38.9142	31.1934	74.9666	71.5483
0 18	33 3718	38 6213	33.29063	39.0755	31.4709	78.1607	74.2833
0 23	33 4579	38.669	33.37683	39.3879	31.7483	80.0103	76.2134
0.28	33.5821	38.7544	33.50113	39.738	32.1018	81.6041	77.5612
0:33	33.796	38.9669	33.60083	40.1014	32.4306	82.8487	78.8475
0:38	34.0166	39.0346	33.85973	40.5469	32.8423	83.8466	79.922
0:43	34.3066	39.3227	34.07373	41.0986	33.2852	84.7295	80.7728
0:48	34 5161	39.6443	34.24543	41.5704	33.6474	85.536	81.5828
0:53	34 7705	39.9347	34.50003	42.0863	34.0162	86.1333	82.2188
0:58	35.0111	40.1359	34.74093	42.5885	34.3713	86 7533	82 7696
1 03	35.3101	40.6217	35.00213	43.1481	34.7846	87.2847	83.2316
1:08	35 6333	41.1692	35.24963	43 6562	35.07	87 6243	83.7163
1:13	35.856	41.428	35.43453	44 1775	35.4449	87 9766	84.0342
1 18	36 1167	41.8	35.65753	44.6984	35 7057	88.2573	84.3162
1 23	36.308	42.216	35.84903	45.2257	36.0111	88.5086	84.6044
1.28	36.5753	42.6697	36.11673	45.7152	36.3164	88.7241	84.9643
1:33	36.9008	43.1431	36.36653	46.2244	36.642	89 0657	85 164

March 19 and 20th

Chanel	1	2	3	4	5	6
Label	1	2	ground temp	4	j	i
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F
1:38	35.8249	37.5082	31.9089	33.6028	34.9568	35.8599
1:43	35.9927	37.6756	31.8103	33.7712	35.0868	35.9898
1:48	36.0949	37.8533	31.7603	33.8355	35.3411	36.092
1:53	36.2387	37.9588	31.6758	33.9797	35.3709	36.2358
1:58	36.3862	38.1438	31.5568	34.0895	35 4426	36.3834
2:03	36.6135	38.3326	31.4418	34.1652	35 6321	36 5728
2:08	36.7403	38.4968	31.3401	34.1781	35.6451	36.6617
2 13	36.8913	38.4203	31.3011	34.1393	35.7203	36.7368
2:18	36.908	38.4371	31.2416	34.1942	35.6991	36.7536
2:23	37.1146	38.5674	31.1822	34.3253	35.8299	36.9223
2:28	37 2273	38.7177	31.1429	34.3622	35.9428	37.1109
2:33	37.5566	39.0462	31.0545	34.4645	36.0828	37.4025
2:38	37.5827	39.1856	31.0425	34.6047	36.2607	37.5044
2:43	37.8428	39.256	30.999	34.8658	36.3694	37.6509
2:48	37.8376	39.3642	30.9938	34.7845	36.4401	37.7594
2:53	38.1423	39.7059	30.9189	35.0142	36.5934	37.9884
2:58	38.2466	39.8099	30.8713	35.0809	36.8117	38.0548
3.03	38.451	39.9383	30.7718	35.1341	36.9027	38.2215
3:08	38.328	39.929	30.7241	35.0866	36.8175	38.1742
3:13	38.55	39.9993	30.6806	35.3095	37.1157	38.3585
3:18	38.6719	40.0832	30.6508	35.2038	36.9723	38.4804
3:23	38.8493	40.0713	30.6005	35.1919	37.1121	38.4307
3:28	38 9576	40.1794	30.5953	35.2627	37.2965	38.6148
3:33	39.0105	40.4209	30.5339	35.3917	37.3494	38 8191
3 38	39.0499	40 4602	30 4973	35.3933	37.3889	38.8964
3 43	39.2919	40 5507	30.436	35.4464	37.5556	38.9872
3:48	38 9597	40 408	30 4444	35 4928	37.3744	38.8062
3:53	38.9789	40.6159	30 3491	35.664	37.4316	38.9012
3:58	39.0967	40.6579	30.3151	35.5544	37 739	39.019
4:03	38.9067	40.2041	30.2378	35.2876	37.3971	38.7153
4:08	38.9797	40.1259	30.1968	35.2468	37.2807	38.7505
4.13	39.022	40.0548	30.2013	35.3273	37.2472	38.7928
4:18	38.9755	40.2728	30.1926	35.3186	37 2765	38.822
4:23	38.8426	40.1024	30.1347	35.3752	37 2192	38.7269
4 28	38.9815	40.3165	30.0456	35.4387	37.4342	38.8281
4:33	39.1759	40 5482	29 9743	35.5199	37.6289	39.0225
4:38	39 2713	40 7566	29 956	35.6157	37.7244	39.1937
4:43	39.0122	40.4981	30.0001	35 4315	37.6165	38 9723
4 48	39 4134	41.0115	29.985	35.6065	38 1319	39.4115
4 53	39.1849	40.7081	29.9834	35.6809	37.7515	39.2586
4:58	39.3696	40.8546	29 9023	35.4865	37 785	39.292
5.03	39.1758	40.5858	29.8594	35.5578	37.6667	39.2116
5:08	39 1442	40.2523	29.7891	35.2221	37 4076	38.9908

March 19 and 20th

Chanel	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
1:38	36.9098	39 979	45.6496	29 4997	23.3861	44.8986	36.5899
1:43	37.0777	40.1466	46.0781	29.5541	23.0162	45.3275	36 7958
1:48	37.2558	40.4001	46 5165	29.5039	22.8497	45.7288	37.0118
1:53	37.3995	40.4299	46.9582	29.1892	22.996	46.0584	37 1556
1:58	37.5091	40.5393	47.3286	29.0316	22.8371	46.4667	37.341
2:03	37.7363	40.6525	47.7775	28.6095	22.798	46 8036	37.4924
2:08	37.8251	40.7033	48.127	28.5075	22.3474	47.1911	37.657
2:13	37.9002	40.7404	48.5377	28.2766	22.5012	47.5274	37.7321
2:18	37.9929	40.6814	48.9281	28 7537	22.6729	47.7685	37 7868
2:23	38.1994	40.8119	49.2437	28.7708	22.8446	48.122	37.9554
2:28	38.312	40.8865	49.691	28.578	22.8049	48.4576	38.1439
2:33	38.5276	41.064	50.0526	28.4509	22.6382	48.7825	38.3595
2:38	38.6674	41.3172	50.4515	28.2855	22.4715	49.1445	38.5371
2:43	38.7759	41.3499	50.7821	28.3953	22.6981	49.3636	38.6456
2:48	38.8844	41.4204	51.1126	28.6968	22.8474	49.6947	38.7919
2:53	39.1133	41.7247	51.4496	28.2382	22.5399	50.1069	39.0965
2:58	39.2176	41.8667	51.813	28.3055	22.3371	50.3963	39.2007
3:03	39.3842	41.9953	52.1258	28.2441	22.2366	50.7096	39.4051
3:08	39.3748	42.0237	52.4516	28.4263	22.1883	50.9987	39.4336
3:13	39.521	42.2454	52.707	27.884	22.1057	51.2546	39 5798
3:18	39.5672	42.0647	53.0128	28.2377	22.1915	51 4864	39.5881
3:23	39.631	42.204	53.2614	27.9187	22.1407	51.661	39.6519
3:28	39.8151	42.4257	53.5909	27.9518	22.0967	51 9538	39 7981
3:33	39.9058	42.4407	53.8286	27.7751	21.9187	52.2665	40.0022
3:38	39.9452	42.5556	54.0902	27.9303	21.9977	52.4914	40.0416
3:43	40.1494	42.7596	54.4021	27.6385	21.8197	52.7295	40.2079
3:48	39.9685	42.5412	54.633	27.9539	22.1375	52.8492	40.1028
3:53	40 0256	42.5982	54.9117	27 7432	22 1959	53.0913	40 1976
3:58	40.2191	42.8669	55 1014	27 4788	22.0456	53.3558	40.2775
4:03	39.9912	42.6394	55.3603	27 5547	22.1607	53.355	40.1254
4:08	39.9507	42 4477	55.543	27.4752	22.2739	53.4639	40.0471
4:13	39 993	42.3765	55.7698	27.5181	22 3558	53.6169	40.0515
4:18	40.06	42.5191	55.9838	27.4325	22.4243	53.7571	40 1564
4:23	40.0028	42.4242	56.2242	27.4129	22.4432	53.8868	40.0992
4:28	40 0282	42.7141	56 3973	27 2851	22.1985	54.1717	40.238
4 33	40.2604	42.946	56.5876	27.0214	21.8558	54.3997	40.4701
4:38	40 4314	43 1168	56.8291	27 1567	21 5278	54.7532	40.641
4:43	40.3237	42.9715	56.9828	27 1626	21.6111	54.7588	40.4955
4:48	40.7247	43.523	57.1532	26.8016	21.4023	55.1152	40.8585
4:53	40.5341	43.1439	57.3367	26.9921	21.6716	55.0766	40.668
4:58	40.5297	43.2905	57.4804	26.7955	21.5897	55.2206	40.7014
5:03	40.4116	43.097	57.6978	26.7523	21.6236	55.2903	40.5456
5:08	40.2665	42.801	57.8148	26.9124	21.7847	55.2963	40.3628

March 19 and 20th

Chanel	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
1.38	37.1922	43.6956	36.69643	46.6998	37.0093	89.2684	85.4392
1:43	37.4358	44.0499	36.90223	47 1652	37.215	89.4617	85.7408
1:48	37.8032	44.4894	37.15633	47.603	37.4687	89.8429	86.0519
1:53	37.8709	44.7444	37.22413	48.0442	37.6502	89.9422	86 1874
1:58	38.0561	45 1534	37.33373	48.4888	37.7975	90.2232	86 4339
2:03	38.1694	45.5284	37.48513	48.9371	37.9866	90.3653	86.5766
2:08	38.3717	45.9539	37.61183	49.3608	38.151	90.4843	86.8034
2:13	38.4088	46.1782	37.64903	49.7336	38.1882	90.6973	86.9099
2:18	38.4634	46.3073	37.70373	50.1608	38.2428	90.7131	86.9973
2:23	38.5939	46.6989	37.87233	50.5132	38.4112	90.9069	87.2635
2:28	38.7443	46.9602	38.02303	50.9224	38.5616	91.0483	87.4054
2:33	38.9596	47.4354	38.20083	51.2836	38.8148	91.1796	87.5015
2:38	39.2127	47.873	38.41633	51.6445	39.0679	91.3464	87.6332
2:43	39.3211	48.055	38.52493	51.9747	39.1384	91.4483	87.7356
2:48	39.4294	48.3117	38.59553	52.3047	39.2467	91.5502	87.9093
2:53	39.6958	48.8742	38.78663	52.6412	39.551	91.694	88.0537
2:58	39.9133	49.2388	38.96673	53.0041	39.6551	91.8986	88.2234
3:03	40.0041	49.6273	39 13333	53.2421	39.8593	91.9484	88.3805
3:08	40.1081	49.6553	39.23753	53.6046	39.8877	92.0818	88.5145
3:13	40.2919	50.0983	39.42173	53.8597	39.9959	92.1481	88.581
3:18	40.2624	50.1811	39.39213	54.165	40.042	92.227	88.6959
3:23	40.3639	50.4306	39.53173	54.4504	40.1058	92.3936	88.7918
3:28	40.5099	50.6866	39 64003	54.7052	40.2895	92.4598	88.8939
3 33	40 676	51.0743	39 80643	54.9797	40.3801	92.5094	89.0865
3 38	40 7531	51.2995	39.88373	55.241	40.3817	92.6175	89.088
3 43	40 9192	51 6125	39.97443	55.4782	40.6234	92.7028	89.2092
3:48	40.8142	51.5089	39.94493	55.7459	40.4428	92.7816	89.3597
3:53	40.9467	51 8631	39.92633	55.913	40.5375	92.9063	89.4492
3:58	41.1398	52.2025	40 11973	56 1766	40.6929	92.9458	89.4532
4.03	40 9501	51.8665	40.00543	56.3611	40.541	92.9806	89.4881
4 08	40.8719	51.9383	39.96493	56.5807	40.3871	93.0491	89.5212
4 13	40.8008	52.0172	39.96933	56.7701	40.316	93.0532	89.5967
4:18	40 981	52.3438	39.92283	56.9468	40.4585	93.1517	89.7312
4.23	40.924	52.2875	39.90353	57.15	40.4014	93.2046	89.7486
4 28	41 1003	52.7591	40.08023	57.3598	40.5401	93 2994	89.8794
4:33	41.2943	53.1734	40.31243	57.5129	40.6964	93.3753	89.8844
4 38	41.5404	53.4531	40 48343	57.6432	40.9427	93.3939	90 0455
4:43	41 4329	53.1984	40.41353	57.7967	40.7596	93.4348	90.0866
4:48	41.8708	53.9643	40.85223	58.004	41.1223	93.5628	90.1438
4:53	41.6051	53.6655	40.58603	58.1134	40.932	93.5258	90.1423
4 58	41 7516	53.9956	40.65723	58.2938	40.9653	93.5926	90.1737
5.03	41.5583	53 8052	40.53923	58 4371	40.8851	93.6593	90.2763
5:08	41.4513	53.5512	40.35633	58.5541	40.627	93.7006	90.3178

March 19 and 20th

Chanel	1	2	3	4	5	6
Label	1	2	ground temp	4	J	I
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F
5:13	39.4691	40.6521	29.7734	35.3965	37.6574	39.3159
5:18	39.2862	40.6205	29.7414	35.5168	37.5878	39.2086
5:23	39.4444	40.6651	29.71	35.5616	37.7462	39.3289
5:28	39.7918	41.2004	29.6024	35.7587	37.8671	39.79
5:33	39.9245	41.6343	29.507	35.8161	38.568	39.9983
5:38	39.4458	41.27	29.4817	35.677	38.3536	39.5951
5:43	39.4427	41.1161	29.3636	35.5979	38.3505	39.592
5:48	39.5642	41.275	29.3336	35.644	38.4344	39.7514
5:53	39.4251	41.3248	29.2309	35.6562	38.295	39.6501
5:58	39.7339	41.5573	29.1223	35.8145	38.4907	39.8833
6:03	39.7842	41.6075	29.0967	35.8651	38.7682	40.047
6:08	39.8409	41.8147	29.1158	35.846	38.7114	40.1793
6:13	39.6814	41.5803	29.0308	35.5338	38.6273	40.0198
6:18	39.3678	41.23	29.0195	35.7506	38.4648	39.744
6:23	39.5322	41.2808	28.9946	35.7258	38.0994	39.7194
6:28	39.7032	41.5267	28.9763	35.8976	38.5357	40.0038
6:33	40.121	41.6795	28.9783	35.7477	38.8783	40.2704
6:38	39.9809	41.9167	28.9896	36.0247	38.7759	40.4327
6:43	39.8921	41.7905	29.0529	36.0115	38.914	40.3817
6:48	39.8654	41.8391	29.179	36.1744	38.8494	40.2793
6:53	40.1829	41.892	29.1944	36.3036	38.8646	40.4835
6:58	40.0605	41.8076	29.3001	36.4842	38.9312	40.4744
7:03	39.7624	41.9625	29.4577	36.7541	39.4272	40.6675
7:08	40.1269	42.3258	29.5207	37.082	39.565	41.145
7:13	40.4468	42.7199	29.6535	37.4788	40.0739	41.54
7:18	40.3293	43.1297	29.8407	37.5883	40.2964	41.8376
7:23	41.0224	43.444	30.1222	37.9428	40.6496	42.5296
7:28	41.2446	43.9285	30.3475	38.4686	41.2869	43.0528
7:33	41.3804	44.2516	30.6	38.7941	41.9506	43.3389
7:38	41.4608	44.7824	30.911	39.3287	42.1817	43.8332
7:43	42.1445	45.4628	31.26	39.8629	42.7516	44.5902
7:48	42.3406	45.8455	31.5352	40.4749	42.9852	45.0488
7:53	42.1172	45.4356	31.7671	40.0622	42.762	44.5629
7:58	43.319	46.2196	32.1836	40.8139	43.4736	45.5362
8:03	43.8869	46.448	32.3781	41.044	43.7781	45.765
8:08	44.734	46.8052	32.7419	41.2906	43.9863	46.2729
8:13	44.3117	46.1594	32.9235	41.0929	43.7893	45.7011
8:18	45.4345	47.0918	33.3768	42.0693	44.7249	46.8599
8:23	46.0674	47.8352	33.867	42.8175	44.9452	47.267
8:28	45.9369	47.1063	34.0011	42.0838	44.2885	46.7619
8:33	46.79	47.6958	34.6008	42.8655	44.655	47.6144
8:38	47.1515	47.9819	35.0059	43.191	45.0173	47.9382
8:43	48.3213	49.0751	35.7378	43.9528	46.3774	48.9951

March 19 and 20th

Chanel	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
5:13	40.5158	43.05	57.9106	26.666	21.5754	55.5037	40.6119
5:18	40.4842	43.0562	58.1385	26.7492	21.5818	55.621	40.6559
5:23	40.5288	43.2519	58.293	26.6793	21.6275	55.776	40.7005
5:28	40.7628	43.4478	58.4109	26.379	21.1704	56.0425	40.9722
5:33	41.0088	44.1463	58.5775	26.014	20.2992	56.3578	41.218
5:38	40 8326	43.8949	58.7377	26.2578	20.6998	56.3332	41.042
5:43	40.8674	43.9673	58.8086	26 0623	20.6966	56.4784	41.0767
5:48	40.9889	44.0509	58.9273	25 9167	20.7049	56.5604	41.1603
5:53	40.8876	43.9875	59.0499	25.8905	20.4461	56.7204	41.1346
5:58	41.0828	44.1447	59.2038	25 7815	20.2201	56.8747	41.3298
6:03	41.1709	44 4589	59.2899	25 7173	20.0003	57.1091	41.4556
6:08	41 2653	44 44	59 419	25.698	20.0972	57.1645	41 4744
6 13	41.1815	44.3186	59.5216	25.805	20.36	57.2304	41.4283
6 18	40.9437	44.1944	59.5846	25.7168	20.6974	57.1456	41.2285
6:23	40.9568	43.9057	59.7081	25.6532	20.827	57.1954	41.1283
6:28	41 1655	44.3027	59.875	25.5963	20.6536	57.3628	41.3746
6:33	41.3564	44 5686	59.9138	25.5214	20.5782	57 5127	41.4899
6:38	41 4053	44.542	60.0723	25.7252	20 6284	57.7086	41 6143
6 43	41.4299	44.755	60.1331	25.8657	20 8472	57.8066	41.6388
6:48	41.3276	44.5775	60.2176	26.0692	21.4392	57.6695	41.5743
6:53	41.4561	44.5928	60.3431	26.2002	21.7644	57.7953	41.5896
6:58	41.3337	44.6591	60.4448	26.3832	22.0644	57.8234	41 5805
7:03	41 4891	45 1909	60.5227	26.426	23.0349	57 9385	41.8867
7:08	41.74	45.3282	60.6202	26.643	23.9861	57 8884	42.1374
7:13	41.8709	45 8353	60.7111	26.93	24.621	58 1645	42.419
7:18	41 9045	46 0193	60 8176	27 3099	25 3872	58.3083	42.4903
7:23	42.2198	46.3713	60 9413	27 7843	26 209	58.4692	42 8053
7 28	42 4796	47.0063	61.0476	28.5473	27.0888	58.6128	43.1779
7:33	42.6909	47.5549	61 1434	29.1453	27.9566	58.7828	43 5771
7:38	42 7713	47.7852	61.222	29.3802	28.8054	58.7877	43.8833
7:43	43 1155	48.3907	61.3004	29.8065	29 8831	59.088	44.2269
7:48	43.3493	48.661	61.4552	30.4266	30.6561	59.1324	44.4603
7:53	43.1636	48 5511	61 4947	29.8553	31.3851	59.0243	44 1997
7:58	43.6123	49 1477	61 6018	30.4259	32.3744	59.2055	44.61
8:03	43.8418	49.3762	61.6421	30.7355	33.0647	59.1352	44.7641
8:08	44.2761	49.6211	61.7354	30.6795	34.1138	59.3396	45.0473
8.13	44.2295	49.4998	61.8739	30.4409	34.7898	59 1093	44 888
8:18	45 0907	50.2074	61.9067	32.5379	35 6222	59 3268	45.5604
8.23	45.687	50.6515	62.049	31.3492	36.9841	59.5433	46.006
8:28	45.6314	50.0721	62.0314	30.7958	37.1176	59 1565	45.8754
8:33	46.2231	50 4372	62.0223	31.4743	37.6771	59 2951	46.3541
8:38	46.6228	50.7608	62.1933	31.0787	38.5729	59.4297	46.7911
8:43	47.6449	52.0787	62.3865	32.3869	40.0956	59 7712	47 7377

March 19 and 20th

Chanel	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
5.13	41.6246	54.1305	40 56773	58.7236	40 8759	93 7571	90 3388
5:18	41.6308	54.1366	40.57393	58 8405	40.8821	93.7984	90.309
5.23	41.7508	54.4033	40.69423	58.958	41.0399	93.8048	90 4223
5:28	42.0219	54.8558	40.92813	59.1127	41.1603	93.918	90.5003
5.33	42 5312	55.3941	41.47623	59.2423	41.5947	93.9716	90.5897
5.38	42.3555	55.0356	41.33793	59.3286	41 381	94 019	90.7086
5:43	42 3902	55.2552	41.33483	59.4732	41.4157	94.0516	90 7057
5:48	42 4736	55.3744	41.41853	59.5549	41.537	94.1302	90.7489
5:53	42 5234	55 4976	41.35503	59.6405	41.4736	94 1061	90 8315
5:58	42.6804	55.6892	41.55023	59.7574	41.5554	94.183	90 8375
6:03	42.8813	56.0721	41.71373	59.8434	41.7565	94.2302	90.9205
6:08	42 9754	56.0906	41.77033	59 9725	41.7376	94.2834	90.9739
6:13	42.8541	56.0824	41.68653	60 0381	41 6916	94 3465	91.0729
6:18	42.6924	55.8492	41.44893	60 138	41 5674	94.3361	91.0268
6:23	42.5171	55.788	41.31093	60.2614	41 3918	94 3485	91.0748
6.28	42.8382	56 2521	41.59503	60.3544	41.6379	94.4025	91.0934
6:33	43.0286	56.5133	41 82363	60 467	41 7908	94.4398	91.1665
6 38	43 1903	56.5983	41.94793	60.5516	41 8774	94.4858	91.2482
6 43	43 2901	56.6965	42 01023	60.6124	41.9773	94 5798	91.2713
6 48	43 2258	56.3369	41.90803	60.6968	41 8375	94 5546	91.2817
6 53	43.241	56.4259	41.99873	60.7854	41.8904	94.5689	91.3317
6.58	43 2696	56 38	42.14053	60.8502	41 919	94.6668	91.3587
7:03	43.8008	56.5693	42.63523	60.9281	42.2249	94.6708	91 3983
7·08	44 0884	56.371	42.73493	61.0255	42.3623	94 6937	91 4212
7:13	44.5948	56.8327	43.28033	61.1533	42.6814	94.7457	91 4735
7·18	44.8914	56.7546	43.61523	61.2229	42.7903	94.8481	91 5407
7.23	45.3555	57.0269	44.04273	61 3096	43.0673	94.8253	91.5533
7 28	45.9145	57 2818	44.56533	61 4159	43.5148	94 8922	91.6205
7:33	46 4998	57.489	45.07683	61.5117	43.7632	94 9844	91.713
7:38	46 8797	57 4199	45 42013	61 5902	44 0315	94 9891	91.8244
7:43	47 4467	57 7207	45.98853	61.7054	44 4125	95.1	91 9002
7 48	47 7914	57.7652	46.29653	61 7865	44 6833	95.1781	91 943
7 53	47 8689	57.1389	46.26173	61.8628	44 498	95.2161	92 0167
7 58	48.4644	57 5425	46.85873	62 0066	45 0959	95.2838	92 0135
8 03	48 7298	57.5091	47.16233	62.0837	45.2873	95.2872	92 088
8.08	49.049	57.5289	47.55733	62 177	45.5327	95.2707	92 1426
8.13	48.9279	56 5948	47 51093	62.2786	45.4486	95.3331	92 2052
8.18	49.5593	57 3681	48.18133	62.3482	46.1577	95.4356	92 2014
8:23	50 1519	57 4001	48.62563	62.4904	46 7902	95.5017	92.3033
8.28	49.91	56.494	48.27073	62.5831	46.6972	95.5202	92.3929
8:33	50.2368	56 8922	48 48613	62.6108	47 1752	95.5469	92.3841
8.38	50 6715	56.7681	48.99693	62.7081	47.6864	95 4635	92 4071
8 43	51 7996	57.7026	50.05333	62.8277	48.7062	95.5788	92 4517

March 19 and 20th

Chanel	1	2	3	4	5	6
Label	1	2	ground temp	4	j	i
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F
8 48	48.6675	49.3088	36 4312	44.5263	46.612	49.229
8:53	49.5808	50.3326	38.0408	45.4064	47.1529	50.3658
8 58	50.441	50.7816	39.4809	45.5957	47.9032	50 8898

March 19 and 20th

Chanel	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
8:48	48.0667	52.2004	62.3592	32.8545	40.5964	59.6331	48.0844
8:53	48.8321	52.9634	62.5593	33.2144	42.0469	60.1289	48.8495
8:58	49.4323	53.6364	62.7815	33.4067	43.0281	60.278	49.3747

March 19 and 20th

Chanel	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
8 48	51.9955	57.3792	50.28713	62 9107	48.9776	95 6233	92.4964
8 53	52.8682	58.0612	51.08773	63.0372	49.8535	95.6743	92.6542
8:58	53 465	58.1737	51.83533	63.1858	50.527	95.7822	92.7624

March 19 and 20th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	j	I
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
20:18	36.1442	39.869	34.2881	34.5699	36.9469	37.6972
20:23	35.9774	39.6654	34.3113	34 3268	36.6286	37.5307
20:28	35.8269	39.3645	34.1985	34.1379	36.3264	37.2666
20:33	35.6964	39.3102	34.1985	34.0072	36.4238	37.326
20:38	35.513	39.09	34.1985	33.8234	36.0887	36.9532
20:43	35.5444	39.1211	34.1985	33.8548	36.0441	36.8707
20:47	35.2224	39.0277	34.1985	33.5322	35.5324	36 4732
20:52	35.3533	39.0823	33 4953	33.5111	35.6633	36.566
20:57	35.4353	39.1639	33.387	33.479	35.5933	36 4961
21:02	35.3828	39.3007	33.3343	33.3883	35.5788	36.4436
21:07	35.3383	39.332	32.794	33.3437	35.3063	36.2092
21:12	35.0782	39.3381	32.5331	33.083	35.0843	35.9494
21:17	35.0801	39.4533	32.3824	33.0849	34.8961	35.7613
21:22	35.1886	39.41	32.3005	33.0793	34.7384	35.8317
21:27	35.2803	39.69	32.1253	33.0187	34.678	35.7713
21:32	35.2046	39.6148	31.8584	32.8285	34.6783	35.6197
21:37	35.1014	39.7012	31.602	32.7631	34.499	35.5545
21:42	34.9895	39.59	31.1839	32.5747	34.2348	35.2525
21:47	34.5319	39.4378	30.6094	32.1922	33.777	34.8711
21:52	34.7915	39.5067	30.6094	32.338	33.9225	35.0165
21:57	34.9621	39.6005	30.8505	32.2802	33.9409	35.111
22 02	35.3662	39.8132	30 8363	32.4567	34.1932	35.5151
22 07	35.5344	39.9804	33 1815	32.5112	34 3998	35.7214
22 12	35.1301	39 9186	30 3694	32.258	33.995	35.2791
22:17	34.8526	39 7185	30 7405	32 0559	33.679	35 0395
22:22	35.0863	39 7995	30.593	32 0614	33 8749	35.045
22.27	34.9102	39 6624	30.6454	31 9992	33.5844	34.9831
22:32	35.102	39.8907	30.5324	32.0391	33.9669	35.289
22.37	35.0011	39.8282	30.4691	31.9377	33.7896	35.112
22:42	34.8821	39.8989	90.8085	31.8183	33.7086	35.031
22 47	34 7114	39.6539	30.1012	31.7616	33.5758	34.8603
22:52	34 569	39.6258	30.0728	31.4659	33.1665	34 6418
22:57	34.4942	39.5893	29.921	31 3144	33.1678	34.4909
23:02	34 4581	39 4022	29 9612	31.3546	33 0173	34 4928
23:07	34.5242	39 4301	30 2573	31 4209	33 1597	34.635
23:12	34.4531	39 5106	30 1475	31 2732	33.2409	34.602
23:17	34.6633	39.4549	30.0911	31.3314	33 1466	34.5839
23:22	34.5433	39.4112	30.0851	31.2873	33.1788	34.578
23 27	34.8972	39.5738	30.1732	31 4134	33.4189	34.8559
23 32	34.8139	39.6045	30.166	31.5972	33.2975	34.8868
23:37	34.992	39.6303	30.0008	31.4323	33.4378	34.9508
23:42	34 6954	39.6001	30.1999	31.3636	33.4074	34.7302
23:47	34 8549	39.5318	30 169	31.5237	33 567	34.8897

March 24th and 25th

Channel no.	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
20:18	38.519	42.682	53.1738	30 4722	38.5099	50.1188	37.9338
20:23	38.2388	42.3649	52.8617	30 3042	38.2673	49.8055	37.6155
20:28	38.0126	42.1772	52.6399	30.2674	38.0408	49.5082	37.3893
20:33	37.9582	42.312	52.2887	30.2124	38.0243	49.4172	37.3348
20:38	37.6613	41.9404	51.9601	30.1808	37.917	48.9379	37.1137
20:43	37.6926	41.8203	51.8418	30.0976	37.8343	48.7818	37 0311
20:47	37 447	41 1591	51 4889	29.8882	37.5124	48.2406	36.7474
20:52	37.5018	41.3274	51.431	29.5223	37.8333	48.4443	36 8782
20:57	37.5078	41.3712	51.3251	29.2602	37.8773	48.4876	36.8842
21:02	37.4554	41.3189	51.2736	28.939	37.9768	48.3985	36.8697
21:07	37.3729	41.0474	51.3045	28.8175	37.7803	48.3547	36.7493
21:12	37.0753	40.6747	51.2359	28.5936	37.6724	48.0614	36.5655
21:17	36.9632	40.4492	51.2377	28.4421	37.7503	47.9884	36.6053
21:22	37.0336	40.33	51.3068	28.2831	37.8207	47.9829	36.4858
21:27	37.0112	40.2697	51.4339	28.0302	37.9123	48.1105	36 4634
21:32	36.9736	40.1943	51.4715	27.8771	37.7987	48.1483	36.4638
21:37	36.8705	40.1293	51.6685	27.581	37.9615	48.1964	36.4366
21:42	36.6447	39.6764	51.6706	27.1992	37.6217	47.8243	36.1728
21:47	36.3777	39.1821	51.6696	26.8139	37.4686	47.6735	35.8677
21:52	36.4089	39.479	51.7747	26.6533	37.6139	48.0038	35.9369
21:57	36.5413	39.4973	52.0907	26.5566	37.8223	48.2838	36.0314
22:02	36.7552	39.8246	52.3002	26.3116	38.2639	48.7934	36.2833
22:07	36.9613	40.22	52.5023	26.2511	38.47	49.0337	36.4895
22:12	36.5953	39.5512	52.5158	26.2651	38.1801	48 6361	36.1614
22:17	36.4319	39.2743	52.5419	26.2152	38.0548	48.5128	36.036
22:22	36.3994	39.3936	52.6962	26 0284	38.0223	48.7425	36 0415
22:27	36.2995	39.104	52.8216	25.8888	37.8465	48.4572	35.9035
22:32	36.4912	39.4852	52.9348	25.6981	38.0761	49.2066	36 0573
22:37	36 3143	39 3845	53.0593	25.5189	37.9752	48.9952	36 0324
22:42	36 2334	39 2658	53.0917	25.3985	38.0084	49 0278	35.9895
22:47	36.2149	39.0955	53.2223	25 3797	37 8759	48 8601	35.8189
22:52	35.9585	38.5736	53.2319	25 1201	37.6957	48.6454	35.6005
22 57	35.8076	38.6509	53.3075	24.9673	37.659	48.7588	35.5638
23:02	35.8476	38.5389	53.3466	24.9692	37.5469	48.7233	35.4896
23:07	35 8756	38.7188	53.5226	26.8444	37.7269	48.9004	35.5557
23:12	35 8426	38 7997	53.5647	24.9256	37.7319	49.0922	35.5607
23:17	35 9386	38 7437	53.5843	24.7918	37.7139	48.9624	35.5807
23:22	35.8566	38 7378	53.6528	24.7472	37 7079	48.9939	35 5367
23:27	36.0203	39.0531	53.8127	24 6818	37 9474	49.4163	35 7384
23 32	36.0511	38.932	54.0286	24 6746	38.0162	49 4466	35.6932
23:37	36.0771	39.0339	53.9797	24.5853	37.9662	49.5468	35.7572
23 42	36 0087	38.9276	54.0986	24 593	37.8219	49.3676	35.7648
23:47	36.016	39.1247	54 1058	24.6004	37.9432	49.3747	35.7721

March 24th and 25th

Channel no.	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
20:18	39 4808	48.4748	38.79863	51.2378	39.2358	41.0339	38.9888
20 23	39.239	48.1609	38.63223	50.925	38.9552	62.4778	65 025
20:28	38 9755	47.9004	38.44413	50.628	38 6908	71.0198	68.3952
20:33	39.0726	48.1086	38.46553	50.3506	38.7123	73.6624	70.1316
20:38	38.7384	47.2541	38.20673	50.1332	38.491	75.9926	72.7235
20:43	38.6939	47.2475	38.08633	49.9773	38.5223	78.304	75.1136
20:47	38 2215	45.9928	37.57523	49.885	38.2764	80.0574	76.8715
20:52	38.3899	46.7594	37.74393	49.9763	38.4453	81.5521	78.2616
20:57	38.3201	46.6154	37.74993	49.9822	38.5273	82.818	79.3866
21:02	38.3814	46.826	37.65953	50.0426	38.6647	83.6674	80.2744
21:07	38 1855	46.2572	37.50123	50.2229	38.6202	84.4877	81.0609
21:12	37.9642	45.5879	37.24163	50.3035	38.4744	85.1755	81.6787
21:17	37.8144	45.2143	37.12963	50.4919	38.4763	85.6437	82.2202
21:22	37.8468	45.2088	37.04813	50.673	38.5087	86.2122	82.7902
21:27	37.7865	45.3744	36.98773	50.8374	38.4863	86.6569	83.1284
21:32	37.8248	45.0368	36.95013	51.0615	38.5626	86.9796	83.4879
21.37	37.7977	45.1978	36.84703	51.2213	38.5735	87.2405	83.7854
21 42	37.4586	44.8994	36.50723	51.3725	38.2717	87.4931	84.0388
21.47	37.1541	43.9963	36.20213	51.5578	38.0427	87.5637	84.1096
21:52	37.2991	44.8917	36.34743	51 7002	38.1879	87.3784	83.9596
21:57	37.3554	45.2479	36.44183	51.9418	38.2443	87.4315	83.977
22:02	37.6447	46.2847	36.73173	52.0769	38.6101	87.4898	83.9637
22.07	37.9642	46 8256	37.05183	52.2789	38.8162	87.5767	84 1944
22:12	37 5989	45 5265	36 64783	52.4414	38.4882	87 6255	84.1715
22:17	37 4358	45 1398	36 48443	52.6164	38.3629	87 5075	84 1967
22.22	37 5551	45 6333	36.56593	52.7706	38 4444	87.5842	84 166
22:27	37 3037	45 1967	36.20003	52.8588	38.2685	87.4543	84 1075
22:32	37.6467	46 2492	36 65773	52.972	38.4982	87 5275	84.1809
22:37	37 546	45 8495	36.48083	53.1336	38.3973	87 5398	84.1574
22 42	37 5032	45.9573	36.43803	53.2776	38.3924	87.571	84 1887
22:47	37.371	45.4136	36.34343	53.3711	38.2979	87.5894	84 243
22.52	37.0772	44 9726	36.04913	53.455	37.9657	87 5628	84.2163
22:57	37 1164	45.0114	36.01233	53.5677	37.9669	87.5998	84.3611
23 02	36 9666	45.126	36.05233	53.644	37.8929	87.6016	84.2194
23 07	37.0704	45.6417	36.00423	53.7456	38.0349	87.4848	84.1381
23 12	37 1134	45.7217	36.04733	53.7505	38.0399	87.5969	84.2864
23 17	37 0954	45.5913	36.06733	53.9187	37.9458	87.6515	84.2694
23:22	37.0895	45.623	36.02333	53.9872	37.9399	87.6459	84.2638
23.27	37.4044	46.5346	36.30093	54 1099	38.2935	87.7283	84 3823
23 32	37.3214	46.64	36.25583	54.2144	38 1723	87.65	84.3756
23 37	37.4611	46.6656	36 43383	54 2768	38.2743	87.7818	84.5077
23:42	37.4309	46 1858	36.36543	54.3957	38 3199	87.8964	84.5508
23.47	37.514	46.4929	36 37273	54.4029	38.2132	87.8317	84.4859

March 24th and 25th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	j	I
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
23:52	34.5591	39.5404	29.8714	31.3032	33.0041	34.5177
23:57	34.2528	39.3496	29.6398	30.9193	32.6973	34.2494
0:02	34.2251	39.2087	29.5737	30.7768	32.4407	34.1075
0:07	34.3583	39.1898	29.6694	30.9488	32.6886	34.3169
0:12	34.4641	39.1814	29.5844	30.7875	32.7565	34.2704
0:17	34.4651	39.258	29.3938	30.8649	32 948	34.3094
0:22	34.248	39.1558	29.3938	30.6851	32.4637	34.1684
0:27	34.0739	39.0963	29.3832	30.7397	32.518	33.9942
0:32	34.0368	38.946	29.3832	30.6642	32.4809	33.9952
0:37	34.0968	38.9678	29.3832	30.648	32.541	34.1314
0:42	34.3801	39.1736	29.4233	30.7414	32.7867	34.3767
0:47	34.2198	39.1277	29.4534	30.7332	32.6261	34.2163
0:52	34.3593	39.2663	29.5172	30.9115	32.8039	34.5462
0:57	34.1174	39.2529	29.427	30.7069	32.5616	34 2282
1:02	34.4348	39.1901	29.44	30.7963	32.7652	34.4314
1:07	34.0218	39.1201	29.3308	30.6108	32.504	34.0183
1:12	34.0359	39.0585	29.4216	30.625	32.48	34.2228
1:17	34.2004	39.1841	30.4674	30.752	32.5304	34.2731
1:22	33.7656	38.9792	30.4674	30.2771	31 9802	33.8382
1:27	33.8963	38.9577	29.0513	30.2937	32.1112	33.969
1:32	34.3179	38.9983	29.0924	30.6406	32.3048	34.3525
1:37	34.1234	39.0699	28.8967	30.5218	32.377	34 2342
1:42	34.4303	39.2613	28.8967	30.6389	32.5701	34.465
1:46	34 2134	39.4238	29.1022	30.7269	32.5434	34 5146
1:51	34.433	39.2262	29.0168	30.6034	32 4965	34 5439
1:56	34 3463	39 329	29.0444	30.478	32.3715	34.4952
2:01	34 5416	39.3339	28.9728	30 4448	32 529	34.5382
2:06	34 8954	39.4965	28.9459	30.7239	32.8074	34.8541
2:11	34 5325	39.325	28.9637	30.5122	32.5581	34.415
2:16	34.5148	39.3074	29.1375	30.6856	32.6166	34.5876
2 21	34.6936	39.5228	29.1643	30.7505	32.7196	34.8806
2 26	34.6089	39 552	29.0406	30.6271	32.7871	34.8339
2 31	34.7412	39.4944	29.0588	30 76	32.8053	34.7759
2 36	35.1244	39.6107	29.1768	31.0687	33.1513	35.1213
2 41	34 8604	39 8396	28.949	30.9563	33.2297	35.0473
2 46	35.4694	40.0669	29 1797	31.2626	33.5733	35.6944
2 51	35.1557	40.0195	29 0933	31.1383	33 4874	35 3046
2 56	34.7899	39.8074	28 9164	30.6561	33.0448	34.9389
3:01	34.5687	39.701	99 6209	30.625	32 7087	34.6415
3:06	34.956	39.8212	29.2369	31 2433	33 4017	35.181
3:11	34.893	39.8719	29 0585	30 9508	33.1861	35 0799
3:16	35.2752	40 2138	29 367	31.564	33.7595	35.5762
3:21	35.4549	40 2035	29 1267	31.5154	33 4826	35 6799

March 24th and 25th

Channel no.	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
23:52	35.7204	38.6397	54.077	24.3779	37.7236	49.3458	35.5906
23:57	35.4141	38.22	54.0752	24.2989	37.4939	49.0077	35.2464
0:02	35.4245	38.0783	54.1225	24.0395	37.3142	48.9431	35.1045
0:07	35.4816	38.2873	54.2153	24.0202	37.4093	49.2234	35.1997
0:12	35.5113	38.241	54.3186	24.0117	37.5149	49.1405	35.1532
0:17	35.5502	38.5078	54.3195	23.9355	37.4398	49.4776	35.2683
0:22	35.4093	38.1392	54.2934	23.947	37.4131	49.1898	35.0513
0:27	35.2352	38.1934	54.2721	23.9634	37.2773	49.2805	34.9914
0:32	35.2362	38.0423	54.3101	23.9258	37.2022	49.0572	34.9162
0:37	35.2581	38.0642	54.4429	23.9866	37.3001	49.1535	35.0143
0:42	35.5033	38.4611	54.5708	23.8494	37.6211	49.6557	35.1834
0:47	35.4192	38.339	54.5258	24.0341	37.4229	49.5731	35.0611
0:52	35.5206	38.4782	54.5876	24.1754	37.7522	49.6353	35.2387
0:57	35.2787	38.2368	54.5744	24.0075	37.5488	49.3606	35.0349
1:02	35.4819	38.4777	54.6241	23.9434	37.5617	49.6347	35.2
1:07	35.1831	38.1033	54.4812	23.9877	37.3773	49.3041	34.9393
1:12	35.1972	38.0794	54.5692	23.8477	37.4294	49.2432	34.9153
1:17	35.2856	38.2056	54.6553	23.7829	37.5556	49.6288	34.9656
1:22	34.8508	37.5814	54.5656	23.5739	37.0455	48.9406	34.607
1:27	35.0196	37.712	54.6558	23.6677	37.252	49.1436	34.6616
1:32	35.2889	38.0189	54.7699	23.4776	37.4829	49.5946	34.9308
1:37	35.0564	37.9388	54.6917	23.512	37.4788	49.4038	34.8506
1:42	35.3252	38.3212	54.8796	23.3214	37.6712	50.0784	35.0053
1:46	35.2986	38.3327	54.9279	23.4489	37.6446	49.9403	35.0167
1:51	35.366	38.2859	54.9193	23.3628	37.7499	49.969	35.0841
1:56	35.3173	38.0473	54.9832	23.3906	37.6633	49.7719	35.0735
2:01	35.3984	38.3183	54.988	23.2798	37.7442	49.9635	35.1165
2:06	35.6001	38.6716	55.0734	23.137	37.9076	50.3106	35.2801
2:11	35.3132	38.3852	55.0163	23.3093	37.5832	49.88	35.0694
2:16	35.3717	38.4056	55.0362	23.3299	37.6416	50.1239	35.0898
2:21	35.5886	38.5461	55.1364	23.1639	37.8581	50.4113	35.3067
2:26	35.5799	38.6514	55.2021	23.3095	37.9254	50.552	35.2219
2:31	35.56	38.7075	55.1827	23.1349	37.9056	50.3459	35.24
2:36	35.8292	39.0522	55.2598	23.0607	38.2883	50.7965	35.5473
2:41	35.8314	39.1302	55.2248	23.1015	38.0246	50.9105	35.5495
2:46	36.2123	39.5104	55.3738	22.9477	38.5569	51.2467	35.8924
2:51	36.0126	39.3491	55.4386	22.8993	38.3575	51.1627	35.7307
2:56	35.7229	38.9461	55.4157	23.0686	38.0682	50.6922	35.479
3:01	35.5397	38.4973	55.3855	23.2302	37.8093	50.5126	35.2578
3:06	35.889	39.1877	55.5034	23.1213	38.3859	51.0415	35.6831
3:11	35.902	39.0868	55.5161	23.1345	38.323	50.9424	35.6201
3:16	36.2462	39.6959	55.7035	23.0593	38.8184	51.3917	35.8883
3:21	36.2359	39.5718	55.6934	23.0102	38.8081	51.3816	35.954

March 24th and 25th

Channel no.	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
23:52	37.2191	45.6762	36.07723	54 4484	37 9558	87.8755	84.6016
23:57	36 8378	44.9985	35.80923	54.4837	37.6878	87.8023	84.564
0:02	36.8102	45.159	35.70543	54.531	37.546	87.7404	84.4662
0:07	36.8671	45.966	35.80053	54.5867	37.6411	87.6868	84.3765
0:12	36.8208	45.7326	35.79213	54.6527	37.6327	87.7862	84.4404
0:17	37.0115	46.3713	35.94523	54.6165	37.6717	87.7871	84.5489
0:22	36.7571	45.7447	35.65223	54.7018	37.4928	87.8335	84.4878
0:27	36.8112	45 573	35.74453	54.7176	37.433	87 7772	84.5389
0 32	36.6983	45.5364	35.63133	54.7185	37.3959	87.8139	84.504
0:37	36.7202	45.7833	35.65333	54.7771	37.4558	87.8345	84.5605
0 42	37.0406	46.7	35.97443	54.8677	37.7009	87.8504	84.5405
0 47	36.9567	46.2421	35.89033	54.8227	37.5787	87.8785	84 5688
0:52	37.1337	46.5295	35.95363	54.9216	37.7181	87.9381	84.6285
0.57	36 9685	45.691	35.78803	54.9085	37.5525	88.0328	84.7951
1:02	37 0572	46.5289	35.95303	54.9582	37.6795	88.0091	84.6997
1:07	36.8351	45.3715	35.73043	55.0008	37.4189	87.9787	84.705
1:12	36.7733	45.8733	35.59243	54.9774	37.433	87.8846	84.6825
1:17	36.9373	46.523	35.87093	55.1378	37.4452	88.0392	84.7657
1.22	36.4279	45.1564	35.28433	54.9738	37.0488	87.9527	84.679
1.27	36 4823	45.5856	35.37683	54.9899	37.1414	88.0397	84.7662
1.32	36.7508	46.6387	35.56993	55.0297	37.4485	88.1138	84.8047
1 37	36 7467	46.1471	35.52773	55.0257	37.3303	88.2172	84 9442
1:42	37.0148	47 0492	35.91053	55.0651	37.4849	88.3268	84 9824
1:46	37.0262	47 0979	35.84593	55.1134	37.5724	88.3376	85.029
1:51	37 0934	47 0893	35.87523	55.0678	37.6017	88.4366	85.0566
1:56	37 0069	46 7042	35.78853	55.2058	37.477	88.4624	85 1183
2:01	37.1637	46.9339	35.94563	55.2477	37.596	88.5743	85 2664
2:06	37.3268	47.6942	36.14713	55.3701	37.7976	88.585	85.2771
2:11	37.1167	46.925	35.86053	55.3131	37.5109	88.6016	85.2937
2:16	37.137	47.3946	35.95693	55.333	37.7595	88.5135	85.2054
2:21	37.3532	47 9449	36.17363	55 3589	37 8241	88.61	85.338
2:26	37.3825	47 899	36.16493	55.4246	37.8154	88.6733	85.3656
2 31	37.4385	47 5799	36 10703	55.4423	37.7575	88.6904	85 3827
2.36	37.7828	48.5557	36.52813	55.5565	38.1406	88.8361	85.493
2:41	37.8228	48.2212	36.56823	55.5586	38.1807	88.8381	85 495
2:46	38.2404	49.3061	36.91083	55.6334	38.5234	88.9817	85 6032
2:51	38.1172	48 8482	36.82533	55.6982	38.3238	89.0441	85.7374
2:56	37.7526	47.7402	36.49793	55.7123	38.0723	89.0578	85.7512
3:01	37 4563	46.9606	36.23883	55.7563	37.7752	89 0287	85 7936
3 06	37.8423	48.6144	36.58783	55 8371	38.2003	89.0709	85.7284
3 11	37.8553	48.2532	36.56283	55 8498	38.2893	89 1546	85.884
3:16	38.2363	49.4888	36.98263	55.9259	38.5572	89.1922	85.85
3:21	38.2639	49.2545	36.89643	55.9529	38.6229	89.2539	85 9478

March 24th and 25th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	j	1
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
3.26	35.5283	40.3519	29.0857	31 3218	33.7465	35.6392
3:31	35.8476	40.5559	29.2545	31.7191	34.1045	36.2625
3:36	35.426	40.741	29.0593	31.6391	34.0629	35.803
3:41	35.3641	40.4531	29.0735	31.5006	33.8105	35.6652
3:46	35.3892	40.5534	29.1371	31.6784	33.9117	35.7282
3:51	35.456	40.8085	29.396	32.0891	34.4354	36.2509
3:56	35.5806	41.0076	29.2151	32.2142	34.5221	36.3754
4:01	36.0159	41.2135	29.0028	31.9264	34.5015	36.6586
4:06	36.072	41.3823	28.9827	32.2499	34.7479	36.7906
4:11	36.3168	41.3614	28.8082	32.1525	34.6888	36.6178
4:16	36.095	41.2919	28.9292	32.1203	34.6187	36.5858
4:21	36 3043	41.349	29.1405	32.1399	34.7904	36.6812
4:26	35.8366	41.1108	28.8985	31.6698	34.1696	36.2135
4:31	35.9362	41.172	28.9223	31.6936	34.1933	36.2371
4:36	36 4126	41.4565	29.3264	32.4776	35.0129	36.9792
4:41	36.0215	41.5207	29.2384	32.3518	35.0015	36.9678
4:46	36.0886	41.4741	28.9994	32.2283	34.8405	36.7692
4:51	36.5317	41.7255	28.9102	32.4447	34 9421	37.1362
4:56	36.3377	41.5706	28.9059	32.1353	34.5956	36.7904
5:01	37.0347	41.7352	28.8817	32.3019	34.9899	37.2976
5:06	37.0113	41.825	28.9347	32.2021	35.0045	37.1984
5:11	36.7416	41.7078	28.9347	32.236	34 696	37.1183
5:16	36.6179	41 5473	28.6906	31.6537	34.4199	36.6911
5:21	36.4345	41.5914	28.6971	31 7365	34.2741	36.4697
5:26	36.1714	41 4809	28.6997	31.9299	34.2767	36.4723
5:31	36.2436	41.5526	28.926	32.1934	34.5394	36.8482
5:36	36.6511	41 618	28.7241	31.8398	34 4913	36.9141
5:41	36.4919	41.7991	29.2149	32 5192	35.0163	37 1723
5:46	36.0737	41.6855	29.2149	32.0608	34.6735	36 7543
5:51	36.277	41.7742	29.2149	32.1506	34.6489	36 9196
5:56	36.5852	41.8917	28.5041	32.0788	34.6534	37.0758
6:01	36.4089	41.8674	28 4794	32.016	34.6669	36.7857
6:06	35.9705	41.3192	28 4794	31.5753	33 7327	36.0815
6:11	36.196	41.5054	28.3795	31.4966	33.9589	36.3451
6:16	35 4061	41.0608	27 7352	30.8551	32.9764	35 5551
6:21	34 9349	40.7818	27.7352	30.8018	33.1138	35.4261
6:26	34 8336	40.6813	27.6562	30 5853	32.7836	35.0966
6:31	34.6541	40.39	27.5902	30 3284	32.6036	34.9171
6:36	34.9496	40.419	27.6197	30.4725	32.5567	35.0605
6:41	35.6758	40.9135	28.4295	31 4701	33.7801	36.2427
6:45	34.9209	40.9565	28.4295	31.6282	34.0139	35.7162
6.50	35.8053	41.3814	28.9435	32.3253	34.709	36.6758
6.55	35.0957	41.3562	28.6496	32.2616	34.3792	36 1948

March 24th and 25th

Channel no.	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
3:26	36.3092	39.7209	55.7649	22.9303	38.8054	51 677	36.0273
3:31	36.6666	40.1533	55.8911	22.7914	39.2381	51.9901	36.3847
3:36	36.397	39.9223	55.9618	23.0581	39 0448	51.9493	36.2291
3:41	36.4112	39.8226	55.9014	22 8793	38.7554	51.8514	36.1673
3:46	36.3982	39.8855	55.9999	22.8661	38.8942	52 0249	36.1923
3:51	36.5791	40.4071	56 0281	22.6637	39.2644	52.3138	36.3731
3:56	36.8556	40.645	56.1496	22.6744	39.4267	52.5103	36.5737
4:01	36.873	40.5487	56.1665	22.6535	39.6336	52.5646	36 705
4:06	37.081	40.7941	56.2213	22.5173	39.8412	52.7311	36.8371
4:11	37.06	40.9246	56.3119	22.3414	39.7444	52.785	36.93
4:16	37.1039	40.7412	56.3548	22.4634	39.6746	52.828	36.86
4:21	37.1234	40.7985	56.3738	22.5605	39.7319	52 8843	36.9175
4:26	36.8456	40.2561	56.4362	22.7029	39.4166	52.6493	36.6396
4:31	36.8312	40.2038	56.4963	22.6496	39.3265	52.7841	36.5873
4:36	37.2697	41.1337	56.5535	22.2456	39.9158	53.1392	37.0258
4:41	37.3343	41.0467	56.6536	22.3114	39.9803	53.2397	37.0904
4:46	37.2115	40.8863	56.7559	22.3409	39.8956	53.1937	37.0814
4:51	37.4268	41.1768	56.7438	22.2123	40.1862	53.4789	37.2967
4:56	37.3467	40.7561	56.8137	22.324	39.8031	53.2146	37 1027
5:01	37.7401	41.2244	56.8644	22.1449	40.2338	53.5628	37.5341
5:06	37.6788	41.0496	56.9896	22.121	40.1726	53.5399	37.359
5:11	37.5608	40.8182	57.0225	22.3487	40.0926	53.3128	37.3548
5:16	37 3612	40.4295	57.013	22.1068	39.6281	53.3032	37.0793
5:21	37.2157	40.3222	57.0932	22.036	39 5966	53.3094	37.0097
5:26	37.1044	40.4385	57.1328	22.0773	39.6371	53.4979	36.9364
5:31	37 2526	40.6622	57.1662	22.0735	39.9366	53.6058	37.1225
5:36	37.4324	40.6143	57.1934	21.8699	39.8508	53.7074	37.1884
5:41	37 5768	41 0993	57.1862	21.7464	40.2223	53.8488	37 4087
5:46	37.3105	40.7579	57.2967	21.9005	39.9565	53.8483	37 1805
5:51	37 286	40.8092	57.4208	21.7595	40.0078	53.8986	37 2319
5:56	37.4423	40.8136	57.4251	21.5706	40.0881	53.9401	37.3122
6:01	37.3799	40.8271	57.4383	21.623	39.9879	53.9533	37.2498
6:06	36.9794	39.8589	57.4551	21.718	39.3986	53.0409	36 7735
6:11	37.0151	40.122	57.4899	21.4835	39.3963	53.6707	36 8092
6:16	36.5292	39 0298	57.5345	21.2206	38.9112	53.0092	36.2853
6:21	36.2481	39 0528	57.446	21.128	38.6685	53.1061	36.1563
6:26	36.0328	38 8757	57 4954	20.9474	38.4535	52.821	36 017
6:31	35 8913	38.6585	57 4318	20 8421	38.3124	52.7199	35 7996
6:36	35.9967	38 6498	57 4973	20 8719	38.3795	52.7857	35 8288
6:41	36.6848	39.944	57.5751	20.721	39.4458	53.6077	36 4029
6:45	36.4242	39 9493	57 6543	20.8039	39.2236	53 6129	36.2943
6:50	36.8902	40.7553	57 6641	20.9691	39.954	53.8458	36.7603
6:55	36.6749	40.5027	57.6764	20 8658	39 4738	53.6351	36.6589

March 24th and 25th

Channel no.	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
3:26	38.337	49.5134	37.12153	56.0244	38.6582	89.3229	85.9811
3:31	38.8447	50.3498	37.47863	56.1506	39.0153	89.4802	86.1388
3:36	38.576	49.5623	37.39913	56.1841	38.8978	89.5839	86.207
3:41	38.5901	49.4642	37.26133	56.2349	38.798	89.4901	86.2919
3:46	38.5771	49.8995	37.28633	56.2593	38.785	89.5136	86.2797
3:51	38.9088	50.7488	37.77063	56.3615	39.0796	89.6835	86.3427
3:56	39.1465	51.0203	37.81913	56.4089	39.242	89.7292	86.3884
4:01	39.2774	51.0373	37.91233	56.4259	39.3353	89.7098	86.4764
4:06	39.4468	51.3533	38.08213	56.4806	39.4672	89.834	86.5293
4:11	39.5015	51.2209	38.06123	56.6083	39.598	89.8499	86.5811
4:16	39.4696	51.1895	38.02923	56.6511	39.5281	89.8555	86.6225
4:21	39.5269	51.2831	38.23823	56.7071	39.5475	89.9095	86.6051
4:26	39.1744	50.1151	37.77113	56.7695	39.1561	89.8626	86.6296
4:31	39.0087	50.6234	37.68093	56.8666	39.1417	89.8134	86.5087
4:36	39.5591	51.7993	38.30853	56.8497	39.6937	89.9756	86.6356
4:41	39.6613	51.9744	38.29723	56.9128	39.7582	90.0007	86.6965
4:46	39.5767	51.5931	38.06073	57.0151	39.7114	90.028	86.8312
4:51	39.8669	52.1396	38.31373	57.0399	39.9264	90.0876	86.7836
4:56	39.6358	51.1668	38.11993	57.1469	39.7706	90.0837	86.7797
5:01	40.1034	52.0375	38.58883	57.1605	40.0878	90.0611	86.7571
5:06	40.0045	51.6048	38.52753	57.2117	40.0645	90.1105	86.8066
5:11	39.8113	51.1161	38.33383	57.2446	39.9845	90.1422	86.9099
5:16	39.5746	50.7336	38.17233	57.3091	39.6713	90.133	86.8649
5:21	39.4675	50.9264	37.95123	57.3523	39.6018	90.0677	86.8352
5:26	39.3944	51.339	37.95383	57.3918	39.5665	90.0701	86.8734
5:31	39.5799	51.6335	38.06393	57.4252	39.7524	90.138	86.8699
5:36	39.6455	51.6236	38.24343	57.4524	39.8183	90.2713	86.9678
5:41	39.9029	52.4729	38.50143	57.5192	40.0005	90.2644	86.9966
5:46	39.6754	52.0628	38.27343	57.5557	39.7344	90.2281	86.9961
5:51	39.7266	52.1132	38.24893	57.5688	39.8237	90.3121	87.0803
5:56	39.8067	52.341	38.32923	57.6471	39.8661	90.3163	87.0487
6:01	39.858	51.5721	38.30483	57.6972	39.8796	90.329	86.9541
6:06	39.1564	49.7987	37.52543	57.677	39.3278	90.1668	86.9346
6:11	39.2676	51.065	37.75083	57.7118	39.3255	90.129	86.8967
6:16	38.5183	49.5801	36.96153	57.7195	38.764	90.1721	86.8325
6:21	38.3897	50.1255	36.87063	57.6679	38.5971	90.0153	86.6753
6:26	38.1372	49.5406	36.61753	57.6804	38.344	89.9916	86.8663
6:31	37.9963	49.2522	36.51413	57.6538	38.2406	89.8945	86.6616
6:36	37.9118	49.5425	36.54343	57.7192	38.2699	89.922	86.6534
6:41	38.7871	51.7472	37.38283	57.797	38.9195	89.9971	86.7286
6:45	38.7924	51.7152	37.46413	57.7652	38.9249	90.1449	86.8768
6:50	39.3324	52.2837	38.15713	57.7751	39.4284	90.1544	86.8863
6:55	39.2692	51.7747	37.90423	57.7504	39.2892	90.1305	86.8982

March 24th and 25th

Channel no.	1	2	3	4	5	6
Label	1	2	ground temp	4	j	l
TIME	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"
7:00	35.639	41.5934	28.6496	32.1965	34.5425	36.7375
7:05	35.0989	41.5101	28.2309	31.9977	34.116	36.122
7:10	35.1545	41.3768	27.6347	31.3282	33.6767	36.0256
7:15	35.048	41.422	28.2179	32.1375	34.065	36.337
7:20	35.2834	41.6176	27.9182	32.1066	34.1484	36.648
7:25	34.8472	41.5999	27.7851	31.936	33.864	36.3644
7:30	34.9981	41.6741	28.7428	32.9646	34.8521	37.274
7:35	34.4528	41.8876	28.7683	33.1805	34.9154	36.844
7:40	35.2029	42.3291	28.7577	33.1699	35.323	37.8575
7:45	35.015	42.5571	28.7598	33.553	35.5152	37.9354
7:50	34.8577	42.7779	29.2912	34.3473	36.2316	38.1576
7:55	36.2091	43.3258	29.734	34.9773	36.9359	39.3904
8:00	36.4334	43.5855	29.424	34.3652	36.5151	39.0842
8:05	37.3848	43.8139	30.2309	35.0147	36.9732	39.8436
8:10	37.4054	43.9471	30.0221	34.8452	36.8801	39.6751
8:15	37.5731	43.9255	30.1914	34.7853	36.4788	39.5777
8:20	38.418	44.4628	30.9679	35.519	37.3247	40.4208
8:25	39.2108	45.1741	31.7683	36.3145	38.1563	41.325
8:30	39.8022	45.4607	31.7683	36.5664	38.4455	41.5378
8:35	40.3276	45.5322	31.7683	36.5628	38.5555	41.9114
8:40	40.5555	46.5455	32.5155	37.5879	39.4268	42.7418
8:45	40.9301	46.8422	32.7415	38.2289	40.0286	43.078
8:50	41.373	46.7949	32.1972	37.7265	39.4895	43.1057
8:55	42.6202	47.4344	31.8186	38.2221	40.2107	44.0496
9:00	41.5866	47.8676	31.9553	39.9083	41.742	44.1842

March 24th and 25th

Channel no.	7	8	9	10	11	12	13
Label	7	8	bottom 2	air temp	thin slab	bottom 3	13
TIME	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F"
7:00	36.9139	40.7032	57.8352	21.032	40.0155	53.9433	36.8599
7:05	36.526	40.2784	57.7165	20.7915	39.6286	53.6754	36.5481
7:10	36.3536	39.8031	57.6966	20.732	39.3808	53 4696	36.4518
7:15	36.3992	40.3035	57.7409	21.1656	39.7674	53.4026	36.5352
7:20	36.4444	40.3486	57.711	21 0569	39.7746	53.484	36.6185
7:25	36.0844	40.1034	57.8045	21.0774	39.7189	53 0203	36.2966
7:30	36.3113	40.9357	57.6924	21.9274	40.3617	53.0935	36.6753
7.35	36.1465	41.0746	57.68	21.7598	40.3491	53.267	36.5867
7:40	36.478	41.6318	57.7437	22.0585	40.9443	53.5541	36.9938
7:45	36.4802	41.861	57.7828	22 0993	41.2491	53.4818	37 0719
7:50	36.665	42.2718	57.7038	22.7125	41.6222	53.3653	37.2186
7:55	37.332	43.0489	57 7985	23.5065	42.5504	53.572	37.8849
8:00	37.4424	42.7809	57.8321	22.4214	42.2069	53.4199	37.8814
8:05	38.0524	43.2748	57.8349	23.39	42.8519	53.5714	38.2634
8:10	38.1109	43.2198	57.818	22.5227	42.9102	53.4801	38.3219
8:15	38.127	42.8959	57.8337	22.4618	42.7374	53.0125	38.338
8:20	38.7071	43 738	57.7709	22.7826	43.5414	53.5071	38.8041
8:25	39.5764	44.5282	57.9539	22.6647	44.4066	53.8396	39.4837
8:30	40.0168	45.0045	57.9775	23.3844	44.6566	53.7519	39.8862
8:35	40.4293	44.9633	57.974	23.5738	44 9167	53.6253	40.1474
8:40	41.0732	45.8307	58.123	23.0345	45.8212	54.121	40.9424
8:45	41.2969	46.3546	58.1202	23.9579	46.3448	54.1182	41.1661
8:50	41.6647	45.8555	58.0735	23.6391	46.1845	53.8112	41.2695
8:55	42.3094	46.5735	58.1874	24.028	46.9017	54.0372	41.7634
9:00	42 633	47.9104	58.2458	24.5901	47.5994	54.2815	42.238

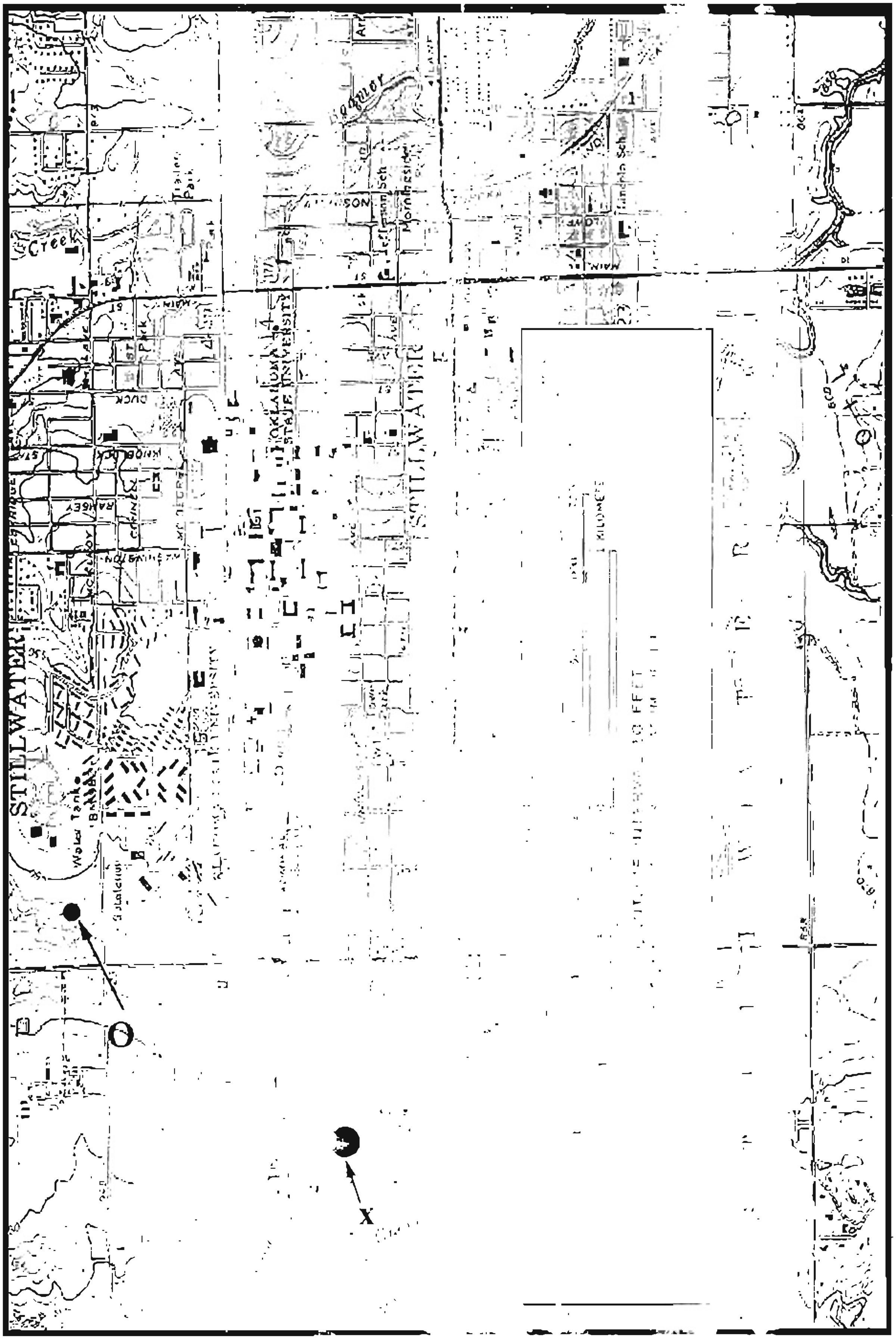
March 24th and 25th

Channel no.	14	15	16	17	18	19	20
Label	a	bottom 4	b	bottom 1	18	Inlet	outlet
TIME	"Degrees F"	"Degrees F	"Degrees F"	"Degrees F"	"Degrees F	"Degrees F	"Degrees F"
7:00	39.583	52.3814	38.06703	57.8352	39.4142	90.2837	87.016
7:05	39.4238	51.2561	37.83153	57 7904	39.1405	90.2405	86.9727
7:10	39.29	50.5649	37.73523	57.7706	38 8924	90.2214	86.9178
7:15	39.6757	51.0571	38.00833	57.7779	39.0897	90 1928	86.8533
7:20	39.9099	50.5048	38.20513	57.785	39.059	90.2353	86.9674
7:25	39.7786	49.4793	38.07353	57.8415	38.6235	90.1828	86.9506
7:30	40.3067	50.5606	38.60313	57.7663	39.0779	90.1102	86.8063
7:35	40.4074	50.4735	38.77993	57.791	39.0652	90.0269	86.7944
7:40	41.0391	51.0972	39.29973	57.8177	39.4342	90.1955	86.8202
7:45	41.3809	50.7264	39.60473	57.8567	39.588	90.1618	86.858
7:50	41.6023	51.2061	39.97803	57.8517	39.7726	90.0856	86.7816
7:55	42 5285	50.966	40.79343	57.8725	40.6278	90.2127	86.9806
8:00	42.6003	50.0672	40.75213	57.906	40.6243	90.3164	87.013
8:05	43.0177	50.8909	41.09513	57.9089	41.0817	90.2121	86.98
8:10	43.1888	50.2769	41.19123	57.818	41.0644	90.1958	86.9637
8:15	43.0541	49.2472	40.98053	57.9447	40.9669	90 1753	86.9788
8:20	43.6679	50.3414	41.63403	57.9558	41.5461	90.3288	87.0612
8:25	44.4934	51.0108	42.53773	58.0278	42.1494	90.5766	87.2381
8:30	45.0436	50.6244	42.93883	58.0144	42.665	90.7064	87.404
8:35	45.0025	50 397	42.93533	58.0479	42.9259	90.81	87.5436
8:40	45.9424	51.405	43.69003	58.1969	43.6823	91.0251	87.7592
8:45	46.3898	51.5885	44.21423	58.2311	44.1699	91.2362	87.8995
8:50	46.3049	50.7958	43.97843	58.2213	44.2354	91.1912	87.9258
8:55	47.0204	51.0972	44 84703	58.3353	44.9548	91.3723	88.1074
9:00	47.679	51.7896	45.65813	58.3936	45 5792	91 4286	88.2352

March 24th and 25th

Appendix E

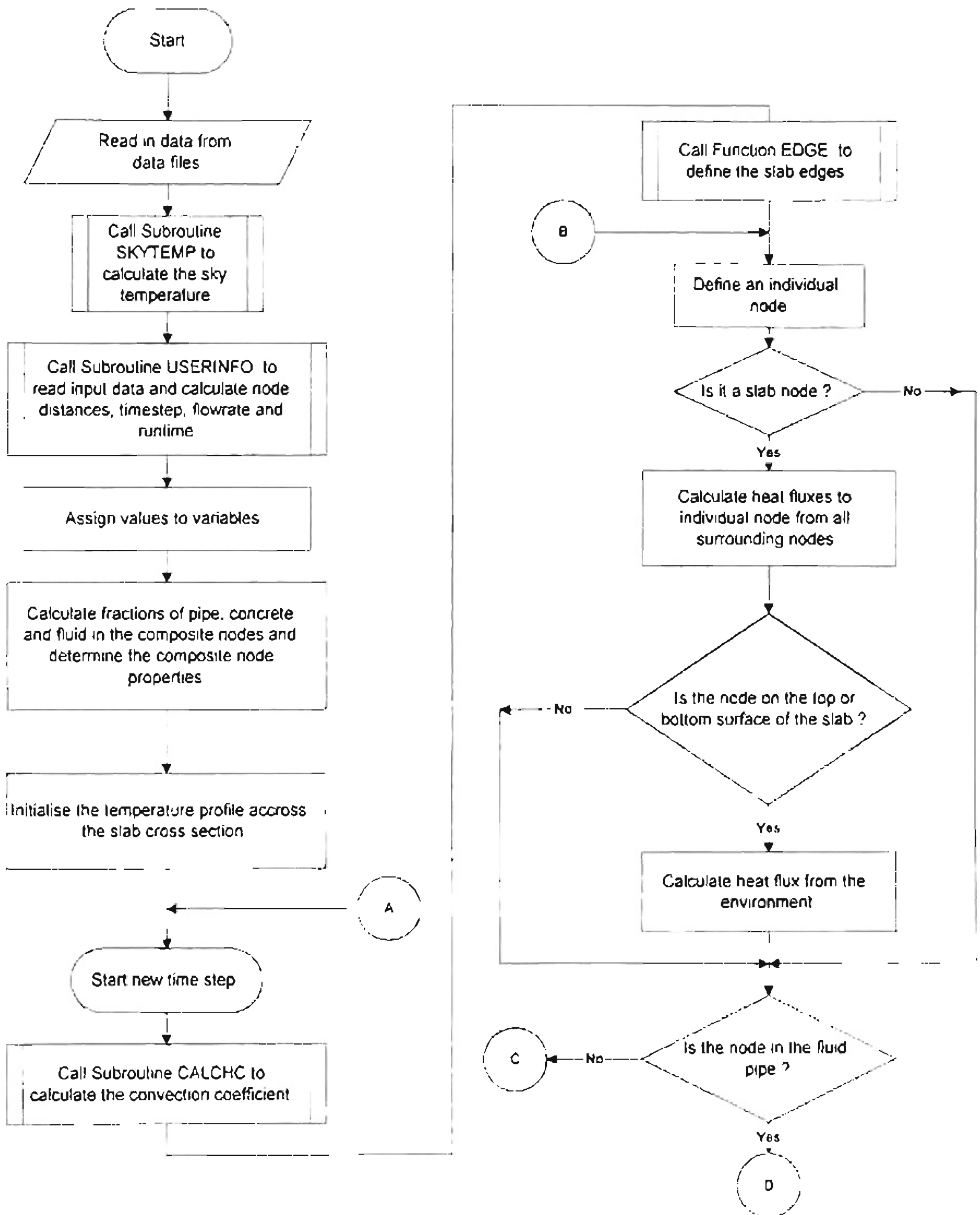
Topographical map of the experimental site area

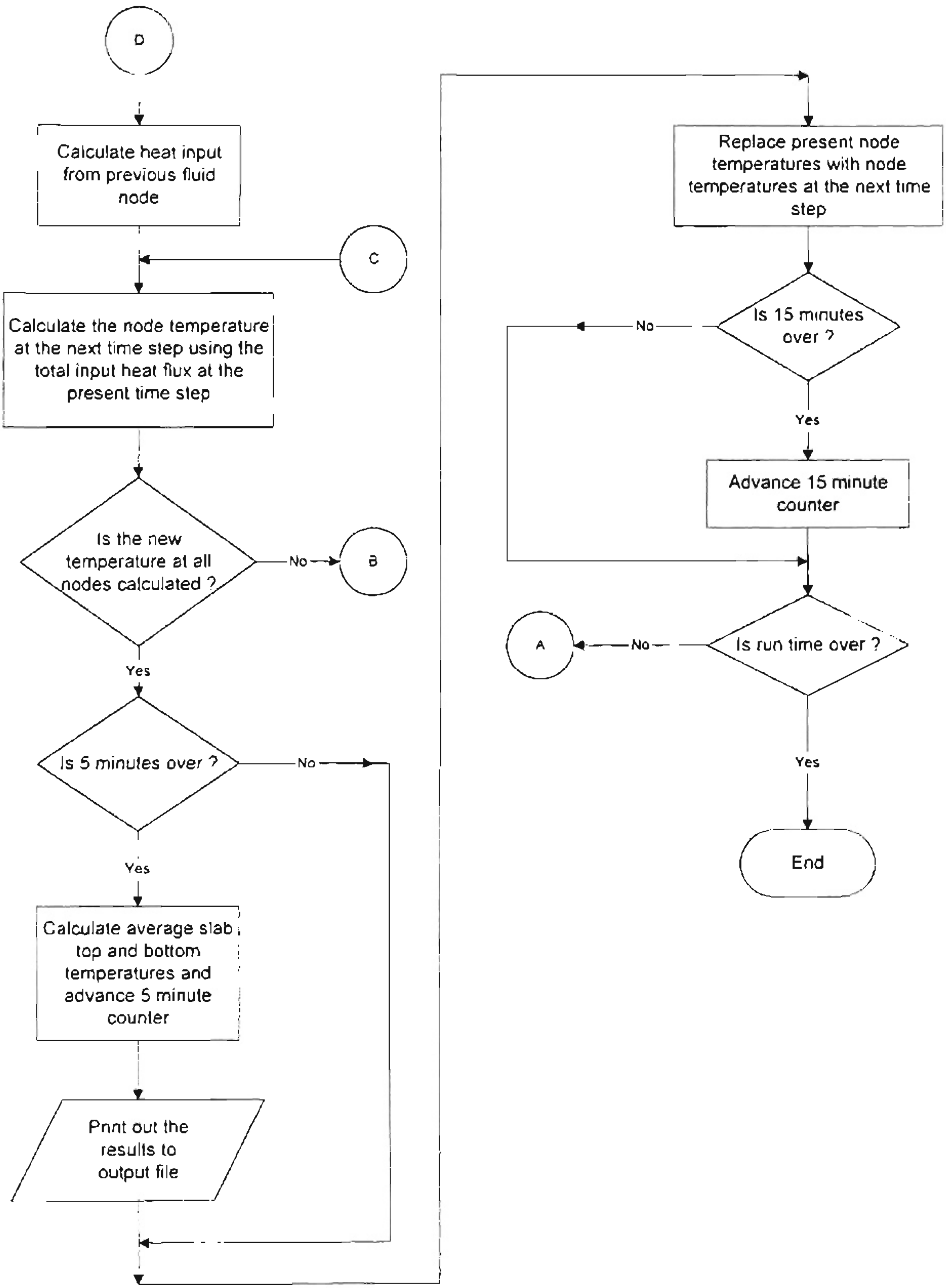

STILLWATER
OKLAHOMA STATE UNIVERSITY
O
X

Appendix F

Flowchart of program BRIDGE3D

Flowsheet of Program BRIDGE3D




D
Calculate heat input from previous fluid node
C
Calculate the node temperature at the next time step using the total input heat flux at the present time step
Is the new temperature at all nodes calculated ?
No
B
Yes
Is 5 minutes over ?
No
Yes
Calculate average slab top and bottom temperatures and advance 5 minute counter
Print out the results to output file
Replace present node temperatures with node temperatures at the next time step
Is 15 minutes over ?
No
Yes
Advance 15 minute counter
Is run time over ?
No
A
Yes
End

Appendix G

Listing of program BRIDGE3D

```
      program BRIDGE3D
C**********************************************************************
C     3-Dimensional explicit finite Difference heat transfer model
C       of Bridge Deck
C     Core source code written by Brian O' Dell(1994)

C     Modified by Ojas S. Wadivkar (1996)
C**********************************************************************

      implicit real(a-z)
      INTEGER  nwthr,nexpt,nxnodes,nynodes,nznodes
      PARAMETER (nwthr=35)
      PARAMETER (nexpt=91)
      PARAMETER (nxnodes=70)
      PARAMETER (nynodes=10)
      PARAMETER (nznodes=25)
      INTEGER  i, j, k, imax, jmax, kmax, edge, iedge, jedge, kedge,
     *         num_iterations, tube_zpos,sum_5,sumdelt,
     *        jmax1,jmax2,jmax3
      DIMENSION  Tnew(0:nxnodes,0:nynodes,0:nznodes),
     *            Told(0:nxnodes,0:nynodes,0:nznodes)
     REAL     time, delta_t, delta_x, delta_y, delta_z, RHOb, Cpb, Ktb,
     *        RHOf,Cpf,Ktf,q,dx, dy, dz,Mdot, RHO, Cp, Kt,D,qconv,qradn
     *     L(0:nxnodes,0:nynodes,0:nznodes),Tmeanf(0:nxnodes)
      REAL   qsolar,hc,hf,depth,flowrt,power,R,Tavgb,Tavgt
      REAL   fractp1,fractp2,Cpp,Ktp,RHOp,Dout, sectP, semiP

      REAL  fractb1, fractf1,RHOc1, CPc1, Ktc1,sectA,hyp,fractf3,
     *      fractb2, fractf2,RHOc2,CPc2, Ktc2,semiA,fractf4,fractf5

      REAL  a,relh(nwthr),wspd(nwthr),wddir(nwthr),srad(nwthr),
     * Tsky(nwthr),Tamb(nwthr),rain(nwthr),Tfluid(nexpt),
     * Tair(nexpt),Texpt(nexpt)

      COMMON /bridge_data/ Tnew,Told,time,imax,jmax1,jmax2,jmax3,
     *                 kmax, delta_x, delta_y, delta_z, delta_t,
     *                 num_iterations, tube_zpos
      COMMON /other/ RHOb, Cpb,Ktb,RHOf,Cpf,Ktf,D,V, Mdot,flowrt,
     *                     height,RHOp, Cpp, Ktp

C**********************************************************************
C     Opening data files

C     Material properties
      OPEN (unit = 10, file = 'thermal.dat', status = 'old')
C     Slab dimensions
      OPEN (unit = 14, file = 'user.dat', status = 'old')
C     Weather data
      OPEN (unit =11, file = 'm9-10.dat', status='old')
C     Experimental data
      OPEN (unit =5, file = 'mex9-10.dat', status='old')
C     Result Output file
      OPEN (unit = 2, file = 'slab.dat', status = 'old')

C     Read the weather file created by "MESONET"
C     relh(percent),Tamb(F),wddir(deg. from north)
C     srad(W/m^2),wspd(m/sec),Tfluid(F)

     do 1204 n=1,nwthr
      read(11,*)a,relh(n),Tamb(n),wddir(n),srad(n),wspd(n)

Calculate the sky temperature using Bliss model
      call skytemp(relh(n),Tamb(n),Tsky(n))

 1204 continue
```

```
C       Read the experimental data file

        do 1205 d=1,nexpt
          read(5,*)a,Texpt(d),Tfluid(d),Tair(d)

 1205   continue


C        Read in the bridge,fluid and pipe properties

        READ(10,*) RHOb, Cpb, Ktb, RHOf, Cpf, Ktf, RHOp, Cpp, Ktp


C       Read in data from file/user
C        (Slab dimensions,fluid velocity,etc.)

        CALL userinfo()

Call for user info
        write(*,*)'Input power for initial temp profile?'
        read (*,*) power

Close all data files
        close(10)
        close(14)
        close(11)
        close(5)

Calculate the thermal properties of the composite fluid/bridge nodes.

Composite properties of the sector fluid nodes(2)

Calc fluid area fraction

        Dout= D + (0.125/12)
        hyp = ((delta_y/2.)**2 + (delta_z/2.)**2)**0.5
       sectA = (((D/2 - hyp)**2)*3.14159)/4
        fractf2 = sectA/(delta_y*delta_z)

Calculate pipe area fraction
        sectP = (((Dout/2-hyp)**2)*3.14159/4 - sectA)
        fractp2 = sectP/(delta_y*delta_z)

Calculate bridge area fraction
        fractb2 = 1 - fractf2-fractp2

        RHOc2 = fractf2*RHOf + fractb2*RHOb + fractp2*RHOp
        Cpc2 = fractf2*Cpf + fractb2*Cpb +fractp2*Cpp
        Ktc2 = fractf2*Ktf + fractb2*Ktb + fractp2*Ktp

Composite properties of the semifluid nodes (1

Calc fluid area fraction
        semiA = ((3.14159*(D**2)/4)- (delta_y*delta_z)- 4*sectA)/4
        fractf1 = semiA/(delta_y*delta_z)

Calculate pipe area fraction
        semiP = ((3.14159*(Dout**2)/4)- (delta_y*delta_z)-
        *          (4*(((Dout/2-hyp)**2)*3.14159/4)) )/4 - semiA
        fractp1 = semiP/(delta_y*delta_z)

Calculate bridge area fraction
        fractb1 = 1 - fractf1-fractp1
        RHOc1 = fractf1*RHOf + fractb1*RHOb     + fractp1*RHOp
        Cpc1 = fractf1*Cpf + fractb1*Cpb +  fractp1*Cpp
```

```
      K... = fractf1*Ktf + fractb1*Ktb +  fractp1*Ktp

 Calculate the fraction of fluid flow in the pipe nodes

      fractf3      = ((delta_y*delta_z)/2)/(3.14159*(D**2)/4)
      fractf4 =  (semiA)/2/ (3.14159*(D**2)/4)
      fractf5 =  (semiA)/(3.14159*(D**2)/4)


 Constants used.

        sabsorb=0.6
        tabsorb=0.9
       sigma = 0.1714E-8
        R = 0.614
        c= 1
        h =1

.C     Initialize the temperature vectors using an exponential initial
 C     temperature profile.

       depth = 0.0

 C     Enter initial surface temperatures

       write(*,*)'Enter top temperature'
       read(*,*)Ttop
       write(*,*)'Enter bottom temperature'
       read(*,*)Tbottom

       do 10 k = 0, kmax
          do 20 i = 0, imax
           if ((i .lt. 20)  .or. (i .gt.50))then
            jmax = jmax1
           else
               jmax = jmax2
           endif
            do 30 j = 0, jmax

              Tnew(i,j,k) = 0.0

              Xndim = (depth-height)/(0.- height)

              Told(i,j,k) = (((Xndim)**power)*(Ttop-Tbottom)) + Tbottom

   30 continue
   20 continue


       depth = depth + delta_z

   10 continue


C      Initialize the time variable and counters to zero.

       time = 0.0
       sumdelt=0
       sum_5 = 0

cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc

C      Begin calculation of the new temperatures by calculating the
```

```
C      heat fluxes to each node point

       DO 1000 m = 0,num_iterations

Calculate heat transfer coefficient for convection

      call calchc(wspd(h),hc)

Calculate incident solar flux after convering it to Btu/hrft**2

        qsolar = sabsorb*(srad(h)*3.412)/10.76

Calculating the flux to the node from all sides


C       Defining the edges of the slab

       do 60 i = 0, imax

           if((i .lt. 10)  .or. (i .gt.50))then
             jmax = jmax1
           else
               jmax = jmax2
           endif

          do 70 j = 0, jmax
             do 80 k = 0, kmax


                q = 0.0

                iedge = edge(i,imax)
                jedge = edge(j,jmax)
                kedge = edge(k,kmax)

                dx = delta_x / (2**abs(iedge))
                dy = delta_y / (2**abs(jedge))
                dz = delta_z / (2**abs(kedge))

 Compute heat influx from back node.
                      if (iedge.ne.-1) then
                  if ((j .eq. 0)).and.((k.ne.tube_zpos).or.
     .              (k.ne.(tube_zpos+1)).or.(k.ne.(tube_zpos-1)))))then
                    Kt = Ktb
                  elseif((j .eq. 1).and.(k.ne.tube_zpos))then
                    Kt = Ktb
                  else
                    Kt = Ktb
                  endif

                          q = q + (Kt*dy*dz/delta_x)*(Told(i-1,j,k)-
     .        Told(i,j,k))
                 end if

 Compute heat influx from front node.
                 if (iedge.ne.1) then
                       if((j .eq.0).and.((k.ne.tube_zpos).or.
     .             (k.ne.(tube_zpos+1)).or.(k.ne.(tube_zpos-1))))then
                   Kt = Ktb
                 elseif((j .eq. 1).and.(k.ne.tube_zpos))then
                   Kt = Ktb
                 else
                           Kt = Ktb
                 endif
                          q = q + (Kt*dy*dz/delta_x)*(Told(i+1,j,k)-
     .Told(i,j,k))
                 endif
```

```
Compute heat influx from left node.
              if (jedge.ne.-1) then
                  if(j .eq. 1)then
                      if ((k.eq.tube_zpos)) then
                      Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktf))
                          elseif((k.eq.(tube_zpos-1))
     *                .or.(k.eq.(tube_zpos+1)))
     *                 then
                      Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktc2))
                   else
                                Kt = Ktb
                         endif
                  elseif(j .eq. 2)then
                      if ((k.eq.tube_zpos)) then
                      Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktb))
                       elseif((k.eq.(tube_zpos-1)) .or.(k.eq.(tube_zpos+1)))
     *                 then
                      Kt = 1.0 / ((0.5/Ktc2) + (0.5/Ktb))
                   else
                                Kt = Ktb
                         endif
                  else
                      Kt = Ktb
                  endif

                      q = q + (Kt*dz*dx/delta_y)*(Told(i,j-1,k)-Told(i,j,k))

                    end if

Compute heat influx from right node.
              if (jedge.ne.1) then
                  if(j .eq. 0)then
                      if ((k.eq.tube_zpos)) then
                      Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktf))
                          elseif((k.eq.(tube_zpos-1)) .or.(k.eq.(tube_zpos+1)))
     *                then
                      Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktc2))
                   else
                                Kt = Ktb
                         endif
                  elseif(j .eq. 1)then
                      if ((k.eq.tube_zpos)) then
                      Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktb))
                          elseif((k.eq.(tube_zpos-1)) .or.(k.eq.(tube_zpos+1)))
     *                then
                      Kt = 1.0 / ((0.5/Ktc2) + (0.5/Ktb))
                   else
                                Kt = Ktb
                         endif
                  else
                      Kt = Ktb

                  endif

                      q = q + (Kt*dz*dx/delta_y)*(Told(i,j+1,k)-Told(i,j,k))

                    endif

Compute heat influx from top node.
              if (kedge.ne.-1) then
                      if(j .eq. 0)then
                  if((k .eq.(tube_zpos-1)).or.(k .eq.(tube_zpos+2)))then
                     Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktb))
                  elseif((k .eq. tube_zpos).or.(k .eq.(tube_zpos+1)))then
                                Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktf))
                   else
```

```
                    Kt = Ktb
          endif

               elseif(j .eq. 1)then
          if((k .eq.(tube_zpos-1)).or.(k .eq.(tube_zpos+2)))then
             Kt = 1.0 / ((0.5/Ktc2) + (0.5/Ktb))
          elseif((k .eq. tube_zpos).or.(k .eq.(tube_zpos+1)))then
                    Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktc2))
           else
                    Kt = Ktb
          endif
          else
               Kt = Ktb

         end if

              q = q + (Kt*dx*dy/delta_z)*(Told(i,j,k-1)-Told(i,j,k))
       end if


Compute heat influx from bottom node.
       if (kedge.ne.1) then
              if(j .eq. 0)then
          if((k .eq.(tube_zpos+1)).or.(k .eq.(tube_zpos-2)))then
             Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktb))
          elseif((k .eq. tube_zpos).or.(k .eq.(tube_zpos+1)))then
                    Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktf))
           else
                    Kt = Ktb
          endif

              elseif(j .eq. 1)then
          if((k .eq.(tube_zpos)).or.(k .eq.(tube_zpos-1)))then
             Kt = 1.0 / ((0.5/Ktc1) + (0.5/Ktc2))
          elseif((k.eq.(tube_zpos-2)).or.(k .eq.(tube_zpos+1)))
               then
                    Kt = 1.0 / ((0.5/Ktc2) + (0.5/Ktb))
           else
                    Kt = Ktb
          endif
          else
               Kt = Ktb

         end if

              q = q + (Kt*dx*dy/delta_z)*(Told(i,j,k+1)-Told(i,j,k))
       end if


Considering the solar heat flux and weather loss
Convection and radiation for the top surface

       if (kedge.ne.0) then
          if(kedge .eq. -1)then


            qconv =  hc*(Tair(c)-Told(i,j,k))

                qradn      = sigma*absorb*((Tsky(c)+460.)**4
                       -(Told(i,j,k)+460.0)**4)

                q = q  +  qsolar*dx*dy)+ qconv*dx*dy + qradn*dx*dy

         else

c       If bottom is insulated with insulation resistance R
```

```
              q = q + ((Tair(c)-Told(i,j,k))*dx*dy)/ (R+0.0000001)

c        If bottom is un-insulated
c              q = q
c    *               + (hc*dx*dy*(Tair(c)-Told(i,j,k)))
c    *              + sigma*absorp*dx*dy*((Tair(c)+460.)**4
c    *               -(Told(i,j,k)+460.0)**4)



          end if
        endif


Compute heat loss of fluid nodes.
               if ((j.eq.0).and.(Mdot.gt.0))then
                if ((k.eq.tube_zpos).or.(k.eq.tube_zpos+1)
     *                 .or.(k.eq.tube_zpos-1))then
                   L(i,j,k) = q
                endif
               endif
               if ((j.eq.1).and.(Mdot.gt.0).and.(k.eq.tube_zpos))then
                     L(i,j,k) = q
               end if

Calculate the new node temperature.
               if ((j.eq.0).and.((k.eq.(tube_zpos+1))
     *                .or.(k.eq.(tube_zpos-1))))then
                      RHO = RHOc1
                  Cp = Cpc1
               elseif((j.eq.0).and.(k.eq.tube_zpos))then
                  RHO = RHOf
                  Cp = Cpf
                elseif((j.eq.1) .and.((k.eq.(tube_zpos+1))
     *                .or.(k.eq.(tube_zpos-1))))then
                    RHO = RHOc2
                  Cp = Cpc2
                    elseif((j.eq.1).and.(k.eq.tube_zpos))then
                  RHO = RHOc1
                  Cp = Cpc1
                    else
                         RHO = RHOb
                    Cp = Cpb
               end if
                Tnew(i,j,k) = ((q*delta_t)/(RHO*Cp*dx*dy*dz))+Told(i,j,k)
                Qsum = Qsum + q

 80       continue
 70     continue
 60  continue


c       Use next experimental data after 5 minutes

       if(sum_5 .eq. (int(1..+0.08333/delta_t)) .or. m .eq. 0)then
               c = c+1
       endif

c       The flow of fluid is started

       if(Tfluid(c) .lt. 50)then
        Mdot = 0.0
       else
```

```
          Mdot = flowrt
          endif



C     Use sequential solution technique to find new fluid temperatures.

      do 85 i = 0,imax
           if ((i.eq.0).and.(Mdot.ne.0)) then
              Tnew(i,0,tube_zpos)= Tfluid(c) +
     +                   (L(i,0,tube_zpos /((Mdot*fractf3)*Cpf))
              Tnew(i,0,tube_zpos+1)= Tfluid(c) +
     *                   (L(i,0,tube_zpos+1)/((Mdot*fractf4)*Cpcl))
              Tnew(i,0,tube_zpos-1)= Tfluid(c) +
     *                   (L(i,0,tube_zpos-1)/((Mdot*fractf4)*Cpcl
              Tnew(i,1,tube_zpos) = Tfluid(c) +
     *                   (L(i,1,tube_zpos)/((Mdot*fractf5)*Cpcl))

           elseif (Mdot.ne.0) then
             Tnew(i,0,tube_zpos)=Tnew(i-1,0,tube_zpos)+
     *                                 (L(i,0,tube_zpos)/((Mdot*fractf3)*Cpf))
             Tnew(i,0,(tube_zpos+1))=Tnew(i-1,0,(tube_zpos+1))
     *                  +(L(i,0,(tube_zpos+1))/((Mdot*fractf4)*Cpcl))
             Tnew(i,0,(tube_zpos-1))=Tnew(i-1,0,(tube_zpos-1))
     *                  +(L(i,0,(tube_zpos-1))/((Mdot*fractf4)*Cpcl))
             Tnew(i,1,tube_zpos) = Tnew(i-1,1,tube_zpos) +
     *                      (L(i,1,tube_zpos)/((Mdot*fractf5)*Cpcl))


              end if

   85 continue

C      Print slab surface temp (middle) at start and
C      at every 5 minute interval

      if(sum_5 .eq. int(0.5+0.08333/delta_t) .or. m .eq. 0)then
       fiv=int(0.5+0.08333/delta_t)

C      Initialize variables

            sum_5=0
           Tbot = 0
              Ttop = 0
              Tavgb = 0
           Tavgt = 0
       do 990 i = 0, imax

              Tbot = Tbot + Told(i,0,kmax)
              Ttop = Ttop + Told(i,0,0)

Calculate the fluid temperature

              Tmeanf(i) =  (Tnew(i,0,tube_zpos)+Tnew(i,0,(tube_zpos+1))+
     .                        Tnew(i,0,(tube_zpos-1))+Tnew(i,1,tube_zpos))/4

  990    continue


Calculate average top and bottom surface temperatures

          Tavgb = Tbot/(imax+1)
          Tavgt = Ttop/(imax+1)

C      Print results to file and screen
```

```
      write(2,*)Tnew(0,0,tube_zpos),Tmeanf(60),
     *         Tavgt,Tavgb

      write(*,*)h,Tnew(0,0,tube_zpos),Tmeanf(60),
     *  Tavgt,Tavgb

       time = time + delta_t

      endif

C     Replace the 'old' temperature array with the 'new' array for the next
C     time step.

      do 90 i = 0,imax

           if (i .lt. 10)  .or. (i .gt.50))then
            jmax = jmax1
           else
               jmax = jmax2
           endif
         do 100 j = 0, jmax
            do 110 k = 0, kmax

               Told(i,j,k) = Tnew(i,j,k)


  110          continue
  100      continue
   90 continue


C      Use data for the next 15 minutes interval

       if(sumdelt .eq. (int(0.5+0.25/delta_t)))then
               h = h+1
             sumdelt=0
             qconv=0
                qradn=0

       endif

Counter is incremented

      sumdelt=sumdelt+1
      sum_5 =sum_5+ 1



1000  CONTINUE

       end
```

```
      SUBROUTINE userinfo()
C*********************************************************************
C     Purpose: To read in data from data files, or user
C
C     Input variables: Multiple
C     Output variables: Multiple
C*********************************************************************

      INTEGER  imax, kmax, num_iterations, tube_zpos
      INTEGER  nxnodes,nynodes,nznodes
      PARAMETER (nxnodes=70)
      PARAMETER (nynodes=10)
      PARAMETER (nznodes=25)
      DIMENSION  Tnew(0:nxnodes,0:nynodes,0:nznodes),
     *           Told(0:nxnodes,0:nynodes,0:nznodes)

      REAL  time, delta_t, delta_x, delta_y, delta_z, length, width1,
     *      width2,width3,height, RHOb, Cpb, Ktb, RHOf, Ktf, D,
     *      run_time, V, Mdot,RHOp, Cpp, Ktp, flowrt

      COMMON /bridge_data/Tnew,Told,time,imax,jmax1,jmax2,jmax3,
     *                 kmax, delta_x, delta_y, delta_z, delta_t,
     *                 num_iterations, tube_zpos
      COMMON /other/ RHOb, Cpb, Ktb, RHOf,Cpf,Ktf,D,V,Mdot,flowrt,
     *               height,RHOp, Cpp, Ktp

C     Read in the dimensions of the bridge, in feet.
C     All these user inputs have been input in a file for our specific
C     case

      write(*, 2001)
 2001 format('0Section length (along tube, in feet) : ')
      read(14,*) length
      write(*, 2002)
 2002 format(' Section width (perpendicular to tube, in feet) : ')
      read(14,*) width1
      read(14,*) width2
      read(14,*) width3

      write(*, 2003)
 2003 format(' Section height (vertical dimension, in feet) : ')
      read(14,*) height

C     Read in the tube information.
      write(*, 2005)
 2005 format('1TUBE INFORMATION')
      write(*, 2006)
 2006 format('0Tube diameter (in inches) : ')
      read(14,*) D

C     Convert tube diameter to units of feet.
      D = D/12.0

C   Compute the node spacing so that the tube fits entirely in one node,
C     with the node size in the x-direction 1 foot.

      imax = int(length/1.0)
      delta_x = length/imax

      jmax1 = int(width1/(D/2.) + 0.5)    ! account for rounding error.
      delta_y = width1/jmax1
```

```
      jmax2 = int(width2/delta_y)
      jmax3 = int(width3/delta_y)


      kmax = int(height/(D/2.) + 0.000001)
      delta_z = height/kmax

     write(*, 2007) delta_z
 2007 format('0The node spacing in the z-dir is ',f6.4,' feet.')
      write(*, 2008) delta_z
 2008 format(' Enter the node location (n>1) of the tube center (',f6.4,
     *          '*(n + 0.5) feet] :       ')
      read(14,*) tube_zpos


C     Compute the maximum allowable time step size based on stability
C     criterion for the explicit method.

      delta_t=0.5*min(RHOb, RHOf,Rhop)*min(Cpb, Cpf,Cpp)
     *              /max(Ktb,Ktf,Ktp)
      delta_t = delta_t/((1/delta_x**2)+(1/delta_y**2)+(1/delta_z**2))

C     Use a conservative value of 90% of the maximum for actual
C     calculations.
            delta_t = 0.9*delta_t

C     Request a run-time for the simulation.

      write(*, 2010) delta_t*3600
 2010 format('0The time step is ',f6.2,' seconds.')
      write(*, 2011)
 2011 format('Enter the desired run time of the simulation, in HOURS:')
      read(*,*)run_time


C     Convert the run-time to th number of iterations.

      num_iterations = int(0.5 + run_time/delta_t)
      write(*,*)num_iterations

C     Request the user to input the fluid velocity.
      write(*, 2015)
 2015 format('0Enter the fluid velocity (ft/sec) : ')
      read(14,*) V

C     Convert the velocity to units of ft/hr.

      V = V*3600

C     Compute the maxx flow rate of the fluid.(lb/hr)

      flowrt = RHOf*V*(3.14159*(D**2)/4)


      RETURN

      END
```

```
C      Function edge
C***************************************************************************
C      Purpose: Define a function which returns a value of 1 or -1 if a
C      node is at the edge of the model, 0 otherwise.
C***************************************************************************

       integer function edge(v,v_limit)

       integer v, v_limit

       if (v.eq.0) then
          edge = -1
       else if (v.eq.v_limit) then
          edge = 1
       else
          edge = 0
       end if

       return
       end
```

```
      subroutine calchc(wdspd,hc)
C*************************************************************************
C     Purpose: To calculate and return the value of the convection
C     heat transfer coefficient (hc)
C
C     Input parameters:
C     wdspd-Wind speed(mph)
C
C     Output parameters:
C     hc- Convection heat transfer coefficient(Btu/hr-ft^2-F)
C
C*************************************************************************
      Real a,b,n,V,hc
      real wdspd
C
C     Convert speed to m/sec.
C
       V= (wdspd/2.25)


      if (V .lt. 4.88)then

             n = 1
      else
             n = 0.78
      endif
C
C     Use general values for a and b, obtained by parameter estimation.
C
             a = 0.94
             b = 0.31

C     Calculate the value of convection coefficient

       hc = 5.678*(a+b*(V/0.3048)**n)

C     Convert from (W/m^2 C to Btu/hr-ft^2-F) units

         hc =  0.1761*hc

      return
      end

C*************************************************************************
```

```
      subroutine skytemp(relh,Tamb,Tsky)
C*****************************************************************
C     Purpose: To calculate and return the sky temperature
C
C      Input variables:
C     relh- Relative humidity (%)
C     Tamb- Ambient Temperature(F)
C
C      Output variables:
C     Tsky- Sky temperature (F)
C
C*****************************************************************
      real Tsky,Tamb,lnpws,relh

      real*4 c1,c2,c3,c4,c5,c6,c7,c8,c9,c10,c11,c12,c13
      real*4 a,b,c,d,e,pw,tdew,Trankine

C     Assign values to the constants (ASHRAE 1993)

      c1=   -10214.16
      c2=   -4.8932631
      c3=   -0.0053769056
      c4=    1.9202377E-07
      c5=    3.5575832E-10
      c6=   -9.0344688E-14
      c7=    4.1635019
      c8 =  -1.04E+04
      c9 =  -1.13E+01
      c10=  -2.70E-02
      c11=   1.29E-05
      c12=  -2.48E-09
      c13=   6.5459673
      a=     100.45
      b=     33.193
      c=     2.319
      d=     0.17074
      e=     1.2063

C      Convert temperature from Farenhiet to Rankine

      Trankine = Tamb+459.67

C      Calculating the dew point temperature (F)

      if (Tamb .lt. 32)then
       lnpws = c1/Trankine    + c2 + c3*Trankine + c4*(Trankine**2)
     *       + c5*(Trankine**3) + c6*(Trankine**4) + c7*log(Trankine)

      pw = relh*(exp(lnpws))

      tdew = 90.12 + 26.142*(log(pw)) - 0.8927*((log(pw))**2)

      else

       lnpws = c8/Trankine + c9 + c10*Trankine + c11*(Trankine**2)+
     *        c12*(Trankine**3) + c13*log(Trankine)

       pw = relh*(exp(lnpws))

      tdew = a + b*(log(pw))+ c*((log(pw))**2) + d*((log(pw))**3)
     *     + e*((pw)**0.1984)
```

```
      endif
C     Calculate sky temp using Bliss relation
       Tsky = ((Tamb-32)/1.8 + 273)*
     *          ((0.8 + (tdew-32)/1.8)/250)**0.25)
       Tsky = 1.8*(Tsky-273) + 32
      return
      end
```

Appendix H

Listing of program AMOEBA

```
      PROGRAM AMOEBA
C
C    Nelder Mead Downhill Simplex Method in Multidimensions
C    Program used to optimize the values of independent parameters
C     and determine least square error between experimental data and
C     model results
C    Numerical Recipes; (Press et al.
C*********************************************************************
      INTEGER NP,MP
      real FTOL
      PARAMETER(NP=2,MP=3,FTOL=1.0E-4)
      INTEGER i,iter,j,ndim
      real famoeb,p(MP,NP),x(NP),y(MP)
      EXTERNAL famoeb
C*********************************************************************
C     Provide the first guesses for the independent parameter


      DATA p/0.45,0.62,0.8,0.8,0.4832,0.62/
      ndim=NP

      OPEN(26,file='test.out',status='unknown')

      do 12 i=1,MP
        do 11 j=1,NP
          x(j)=p(i,j)
11      continue

        y(i)=famoeb(x)
12    continue

      call amoeba(p,y,MP,NP,ndim,FTOL,famoeb,iter)
      write(26,'(/1x,a,i3)') 'Number of iterations: ',iter
      write(26,'(/1x,a)') 'Vertices of final 3-D simplex and'
      write(26,'(1x,a)') 'function values at the vertices:'
      write(26,'(/3x,a,t11,a,t23,a,t35,a,t45,a/)') 'I',
     *      'X(I)','Y(I)','Z(I)','FUNCTION'
      do 13 i=1,MP
        write(26,'(1x,i3,4f12.6)') i,(p(i,j),j=1,NP),y(i)


13    continue
       END

ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
      SUBROUTINE amoeba(p,y,mp,np,ndim,ftol,funk,iter)
      INTEGER iter,mp,ndim,np,NMAX,ITMAX
      real ftol,p(mp,np),y(mp),funk
      PARAMETER (NMAX=20,ITMAX=5000)
      EXTERNAL funk
      INTEGER i,ihi,ilo,inhi,j,m,n
      real rtol,sum,swap,ysave,ytry,psum(NMAX),amotry
      iter=0

1     do 12 n=1,ndim
        sum=0.
        do 11 m=1,ndim+1
          sum=sum+p(m,n)
11      continue
        psum(n)=sum
12    continue
```

```
2     ilo=1
      if (y(1).gt.y(2)) then
        ihi=1
        inhi=2
      else
        ihi=2
        inhi=1
      endif
      do 13 i=1,ndim+1
        if(y(i).le.y(ilo)) ilo=i
        if(y(i).gt.y(ihi)) then
          inhi=ihi
          ihi=i
        else if(y(i).gt.y(inhi)) then
          if(i.ne.ihi) inhi=i
        endif
13    continue
      rtol=2.*abs(y(ihi)-y(ilo))/(abs(y(ihi))+abs(y(ilo)))
      if (rtol.lt.ftol) then
        swap=y(1)
        y(1)=y(ilo)
        y(ilo)=swap
        do 14 n=1,ndim
          swap=p(1,n)
          p(1,n)=p(ilo,n)
          p(ilo,n)=swap
14      continue
        return
      endif


      if (iter.ge.ITMAX) pause 'ITMAX exceeded in amoeba'
      iter=iter+2
      ytry=amotry(p,y,psum,mp,np,ndim,funk,ihi,-1.0)
      if (ytry.le.y(ilo)) then
        ytry=amotry(p,y,psum,mp,np,ndim,funk,ihi,2.0)
      else if (ytry.ge.y(inhi)) then
        ysave=y(ihi)
        ytry=amotry(p,y,psum,mp,np,ndim,funk,ihi,0.5)
        if (ytry.ge.ysave) then
          do 16 i=1,ndim+1
            if(i.ne.ilo)then
              do 15 j=1,ndim
                psum(j)=0.5*(p(i,j)+p(ilo,j))
                p(i,j)=psum(j)
15            continue
              y(i)=funk(psum)
            endif
16        continue
          iter=iter+ndim
          goto 1
        endif
      else
        iter=iter-1
      endif
      goto 2
      END
```

```
      FUNCTION amotry(p,y,psum,mp,np,ndim,funk,ihi,fac)
      INTEGER ihi,mp,ndim,np,NMAX
      real amotry,fac,p(mp,np),psum(np),y(mp),funk
      PARAMETER (NMAX=20)
      EXTERNAL funk
      INTEGER j
      real fac1,fac2,ytry,ptry(NMAX)
      fac1=(1.-fac)/ndim
      fac2=fac1-fac
      do 11 j=1,ndim
        ptry(j)=psum(j)*fac1-p(ihi,j)*fac2
11    continue
      ytry=funk(ptry)
      if (ytry.lt.y(ihi)) then
        y(ihi)=ytry
        do 12 j=1,ndim
          psum(j)=psum(j)-p(ihi,j)-ptry(j)
            p(ihi,j)=ptry(j)
12      continue
      endif
      amotry=ytry
      return
      END
```

VITA

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