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# User's Manual for the NASA Lewis Ice Accretion/Heat Transfer Prediction Code with Electrothermal Deicer Input

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# SUMMARY

A version of LEWICE has been developed that incorporates a recently developed electrothermal deicer code, developed at the University of Toledo by William B. Wright. This was accomplished, in essence, by replacing a subroutine in LEWICE, called EBAL, which balanced the energies at the ice surface, with a subroutine called UTICE. UTICE performs this same energy balance, as well as handles all the time-temperature transients below the ice surface, for all of the layers of a composite blade as well as the ice layer itself.

This new addition is set up in such a fashion that a user may specify any number of heaters, any heater chordwise length, and any heater gap desired. The heaters may be fired in unison, or they may be cycled with periods independent of each other. The heater intensity may also be varied. In addition, the user may specify any number of layers and thicknesses depthwise into the blade. Thus, the new addition has maximum flexibility in modeling virtually any electrothermal deicer installed into any airfoil.

It should be noted that the model simulates both shedding and runback. With the runback capability, it can simulate the anti-icing mode of heater performance, as well as detect icing downstream of the heaters due to runback in unprotected portions of the airfoil.

This version of LEWICE can be run in three modes. In mode 1, no conduction heat transfer is modeled (which would be equivalent to the original version of LEWICE). In mode 2, all heat transfer is considered to be caused by conduction, but no heaters are firing. In mode 3, conduction heat transfer where the heaters are engaged is modeled, with subsequent ice shedding.

When run in the first mode, there is virtually identical agreement with the original version of LEWICE in the prediction of accreted ice shapes. The code may be run in the second mode to determine the effects of conduction on the ice accretion process.

Work has been done in expanding the subroutines in LEWICE's PLOT3D routines to graph selected temperature distributions either depthwise at a specific chord location or chordwise at a specific depth. This would allow intermediate time-temperature results to be inspected at specific locations making use of existing capabilities and hardware with a minimum of new coding.

# INTRODUCTION

The formation of ice on the exterior surfaces of aircraft can have a considerable effect on flight performance, as it increases drag and decreases lift. Thus, an aircraft must be designed with the equipment necessary for ice removal or prevention. Basically, aircraft ice protection systems can be classified as either anti-icing or de-icing.

The anti-icing principle involves the prevention of ice formation on the protected area at all times. Typical anti-icing methods make use of chemicals and/or the passage of hot bleed air through channels below the surface on which ice formation is to be prevented. In contrast, de-icing involves the periodic removal of accreted ice by mechanical or thermal means. For ice removal systems, attention must also be given to uniform removal of ice. Itagaki (reference 1) elaborates on the dangers of non-uniform shedding. Various de-icing methods have been investigated, including pneumatic boots, electro-expulsive, pneumatic impulse, and electrothermal, which are among the more common concepts.

The pneumatic boot is essentially an exterior "skin" which is laminated to the surface to be de-iced. The boot is a flexible, rubber-like material which, when inflated, breaks the ice off the surface. Boots are relatively simple and efficient, but require frequent maintenance to ensure reliability.

Electro-expulsive de-icers are a relatively new development that is beginning to find applications. In this system a series of electromagnets is pulsed in cycles, flexing a metal abrasion shield. The flexing of this shield cracks any surface ice, causing it to be easily shed by the aerodynamic forces acting on the surface.

Pneumatic impulse de-icers are also a relatively new development. The shedding mechanism here is the same as in the electro-expulsive system, except that the abrasion shield is flexed by a shock wave moving down a series of branching tubes, ultimately guiding the shock wave to the

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abrasion shield surface. The shock wave is generated by a pulse of high pressure air released by a quick action solenoid valve. This system should be finding applications in the near future.

Electrothermal de-icing consists of cyclic heating of discrete elements by electrothermal means. The energy requirements are significantly less for de-icing systems than they are for anti-icing systems. From experimental studies, Stallabrass (reference 2) concluded that the electrothermal method has the most advantages as a de-icing mechanism, although it does have some maintainability/reliability problems. Werner (reference 3) has also reported that the electrothermal de-icing technique is the most commonly used method, and that it has been applied to both fixed-wing and rotary-wing aircraft.

The objective of an electrothermal de-icing system is to raise the composite blade surface/ice interface temperature above the melting temperature of ice, resulting in a very thin interfacial layer of liquid which reduces the ice adhesion to the blade surface. Aerodynamic and/or centrifugal forces can then readily sweep the unmelted ice from the surface. A typical electrothermal de-icer pad is essentially a composite body consisting of (1) a metal substrate (the main structure of the aircraft blade), (2) an inner layer of insulation, (3) a heating element, (4) an outer layer of insulation, and (5) an abrasion shield. Depending upon the construction and application of a blade/ heater mat combination, there may be additional layers. In a thermal analysis of the composite construction any glue or adhesive bonding the layers together may itself be considered layer. Figure 1 depicts a two-dimensional cut-away view of the typical construction of an electrothermal de-icer pad, as well as a representative set of materials and thicknesses used for fabrication. The cross-section shown represents a view of the heater pad normal to the run of the heating elements.

The heating element usually employed in an electrothermal de-icer pad consists either of a woven mat of wires and glass fibers or of multiple strips of resistance ribbon. The gaps which exist between the individual rows of mats or ribbons can reduce the effectiveness of the heating pad's de-icing performance, causing nonuniform melting of the ice. The two insulation layers, which usually consist of a resin impregnated glass cloth, serve to provide electrical insulation for the

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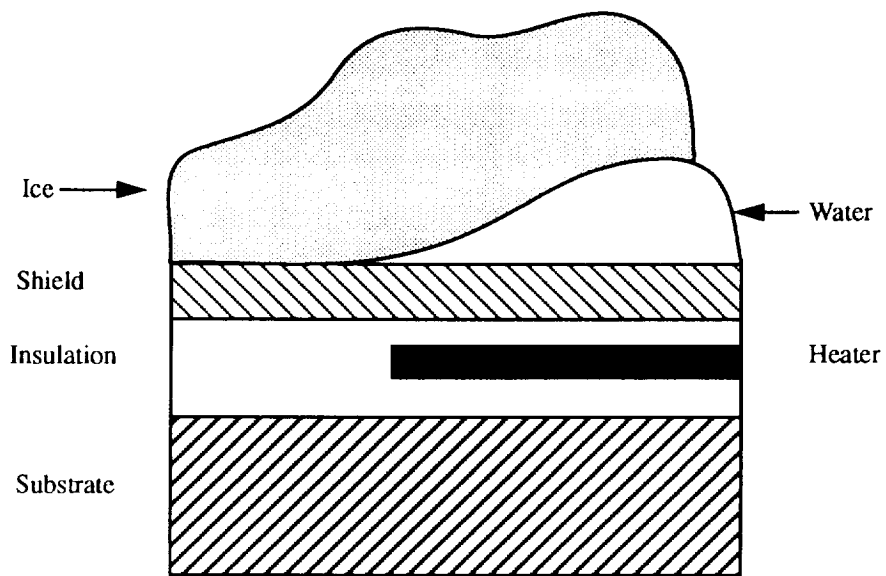
| Layer | Material | Thickness Inches | Diffusivity ft$^2$/hr |
|---|---|---|---|
| Substrate | 755-T6 Aluminum | 0.087 | 1.65 |
| Inner Insulation | Epoxy/Glass | 0.050 | 0.0087 |
| Heater | Nichrome | 0.004 | 0.138 |
| Outer Insulation | Epoxy/Glass | 0.010 | 0.0087 |
| Substrate | 304 Stainless | 0.012 | 0.15 |
| Ice | | 0.250 | 0.0445 |

Figure 1 - Typical materials and construction of an electrothermal de-icer pad.

heating element. In order to direct more heat flow toward the ice layer, it is necessary to use a greater thickness for the inner insulation than for the outer insulation. The abrasion shield serves to protect the de-icer pad from rain erosion as well as dust/sand erosion, and to provide more uniform heating, thus minimizing cold spots above the heater gaps.

The ability to predict the performance of an electrothermal de-icer pad is essential to the design and subsequent fabrication of these units. To accomplish this, some method of determining the time-temperature history throughout the pad needs to be developed. Figure 2 provides a pictorial representation of an electrothermal heater section that is part of an airfoil, with some indication of the nature of the thermophysics involved. Clearly, the conduction of energy is three-dimensional, and occurs in a curved, composite body. The temperature plot to the right of the figure provides a qualitative representation of a typical temperature distribution. The temperature is highest at the heater center, drops rapidly under the heater (where the insulation is thickest) and less rapidly in the direction of the ice (where the insulation is the thinnest).

Development of an analytical model for such a problem is virtually impossible. A numerical model is more realizable, but even this is somewhat impractical, unless some simplifications are made to the geometry and the thermophysics. Figure 3 illustrates three alterations to the full de-icing problem, each having different degrees of problem simplification. The one dimensional model is the simplest. In this model, all layers are assumed to be planes infinite in extent. The temperature at a given location is assumed to be constant throughout the plane containing that point. It is generally assumed that the layers are in perfect thermal contact and that they have constant material properties. Stallabrass (reference 2) appears to have been the first to attempt a numerical solution of an electrothermal de-icing problem using a one-dimensional model. His numerical scheme used an explicit finite difference method. Results agreed well with approximate analytical solutions for relatively short real times into the problem. To account for the effect of the phase change on the temperature transients within the composite blade, the node at the ice-abrasion shield interface was held at the freezing temperature until the estimated heat flux into the control

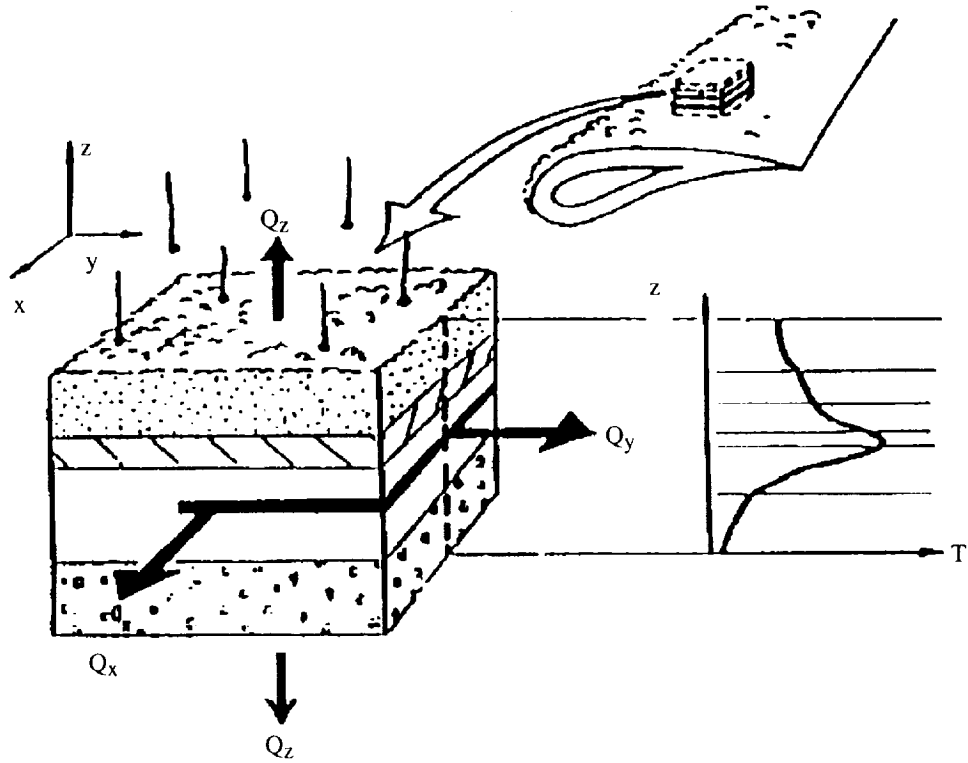Figure 2.—Qualitative representation of the thermophysics involved in an electrothermal de-icer pad.



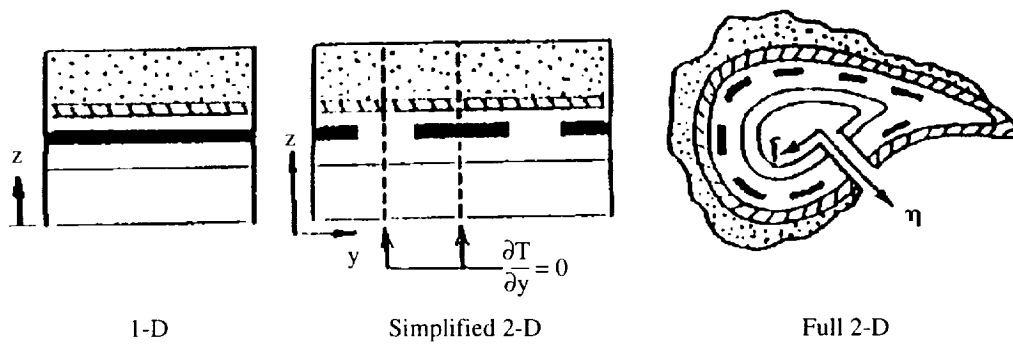1-D                    Simplified 2-D                    Full 2-D

Figure 3.—Degrees of simplification to the true thermophysics of the de-icing problem.

volume containing the node was deemed sufficient to cause melting.

Baliga (reference 4) modelled the same problem by handling the phase change heat transfer using a high heat capacity formulation. Marano (reference 5) applied the so-called enthalpy method to model the phase change problem. Gent and Cansdale (reference 6) solved the same problem for conduction only (no phase change), and obtained nearly the same results as Marano for conduction only.

The two-dimensional problem, represented by the middle schematic in figure 3, was solved by Chao (reference 7) and DeWitt, et al. (reference 8). Chao's work was a direct extension of Marano's one-dimensional numerical formulation and procedures to two dimensions. Of fundamental importance, the effect of the heater gap width on deicing performance was studied numerically.

Leffel (reference 9) provided detailed experimental results of the thermal transients induced by an electrothermal de-icing unit on a UH1H helicopter rotor blade section. These experimental results were initially used to validate the codes developed by Chao and Marano. The experimental results revealed that when the layers of a blade are sufficiently thin, and the curvature sufficiently gradual, Marano's one-dimensional code yields excellent results over most of the blade. Furthermore, it was found that there are two regions of potentially substantial inaccuracies (depending on heater wattages, material properties, etc.). These are at the immediate edges of the heater banks, and in the region of large curvature at the leading edge of the blade that wraps around the nose block.

Masiulaniec (reference 10) and Huang (reference 11) have successfully modelled the full two-dimensional airfoil, reducing the possibilities of inaccuracies in the regions of high curvature. Masiulaniec used a body fitted coordinate transformation that mapped the airfoil into a series of connected, rectangular computational zones. A solution was obtained in this transformed domain, with the solution then being 'unmapped' into real coordinates. The computational times required for this procedure were prohibitive. Techniques to numerically accelerate the computations need

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to be applied before the code would be considered for use by the commercial sector. Huang has modeled the same problem but with a finite element approach to capture the curvilinear effects. This approach provides more reasonable computational times, although if a sufficient number of points are included to accurately simulate the heater gaps, this approach also becomes too slow for use in the commercial sector.

More recently, Wright (reference 12) has developed a model of the electrothermal deicer pad. Although his model is a rectangular one, which does not allow for the effect of a curvilinear geometry on the heat transfer, it is much more comprehensive than previous models in accounting for the physics affecting the transient temperature profiles. His algorithms numerically model the concurrent phenomena of two-dimensional transient heat transfer, ice accretion, and ice shedding which arise from the use of an electrothermal pad. An implicit alternating direction method was used to simultaneously solve the heat transfer and accretion equations occurring in a multilayered body covered with ice. In order to model the phase change between ice and water, the method of assumed states was used. This method assumes a state for each node and then calculates a solution based on those assumptions. If all these phase assumptions are correct, the solution is complete. If not, new assumptions are made as to the state of each control volume and the solution is recalculated. This is repeated until no more control volumes are changing phase. The use of this technique is first seen in the open literature in the work of Roelke (reference 13). This method allows the equations to be linearized such that a direct solution is possible. An iterative procedure is also required to find the correct phase at each node. It is Wright's model that forms the basis for the electrothermal heater upgrade to LEWICE, NASA Lewis's ice accretion code.

# NOMENCLATURE

A     Area(ft)

$C_D$     Coefficient of drag (dimensionless)

$C_e$     Mass concentration of water in air at the edge of the boundary layer ($lb/ft^3$)

$C_p$     Heat capacity (BTU/lb°F)

$C_s$     Mass concentration of water in air at the surface ($lb/ft^3$)

D     Length of rotor arm (ft)

e     Evaporative pressure (psia)

F     Force per unit span (lbf/ft)

H     Enthalpy per unit volume ($BTU/ft^3$)

h     Heat transfer coefficient ($BTU/ft^2$-hr-°F)

$h_m$     Mass transfer coefficient (ft/hr)

k     Thermal conductivity (BTU/ft-hr-°F)

L     Lewis number (dimensionless)

$L_f$     Latent heat of fusion (BTU/lb)

$L_v$     Latent heat of vaporization (BTU/lb)

LWC    Liquid water content of air ($lb/ft^3$)

M     Mach number (dimensionless)

m       Mass (lb)

MW      Molecular weight (lb/mol)

N       Mass flux (lb/ft$^2$-hr)

$N_f$   Freezing fraction (dimensionless)

q"      Heat flux (BTU/ft2-hr)

q'"     Volumetric heat source (BTU/ft$^3$-hr)

R       Ideal gas constant (BTU/mol-°R)

$R_{rb}$   Mass flux of runback (lb/ft$^2$-hr)

$R_w$   Mass flux of impinging water (lb/ft$^2$-hr)

r       Recovery factor (dimensionless)

T       Temperature (°F)

t       Time (hr)

V       Velocity (ft/hr)

x       Parallel to the blade surface (ft)

y       Perpendicular to the blade surface (ft)

**Greek Letters:**

α       Thermal diffusivity (ft$^2$/hr)

β       Collection efficiency (dimensionless)

$\gamma$        Ratio of heat capacities Cp/Cv (dimensionless)

$\rho$        Density (lb/ft$^3$)

$\Omega$        Rotor speed (rpm)

Subscripts

a        accretion

aero        aerodynamic

air        air

c        centrifugal

conv        convection

e        edge of boundary layer

evap        evaporation

fh        frictional heat

i        node number

ice        ice

in        amount going in

k        layer number

ke        kinetic energy

lat        latent heat

| l | liquid phase |
|---|---|
| m | melt phase |
| nc | net amount of convection |
| new | new |
| o | total property |
| old | old |
| out | amount going out |
| r | melt range |
| rec | recovery property |
| s | surface |
| sol | solid phase |
| w | water |
| x | x-dependent |
| y | y-dependent |
| $\infty$ | free-stream property |

# FORMULATION AND DEVELOPMENT OF EQUATIONS

The previous electrothermal models that were discussed are accurate for the cases when de-icing occurs after the ice accretion process has occurred, with no further buildup of ice. They fail, however, to describe the phenomena of ice accretion during de-icing (or anti-icing), which represents the more realistic case that needs to be simulated. The discussion that follows explains how this additional physics is imbedded within the algorithms that numerically simulate the deicer.

Messinger (reference 14) appears to have been the first to develop a model for the prediction of ice accretion on airfoils. His model assumes steady-state, incompressible flow. Since then, Bragg (reference 15), Gent (reference 6) and Ruff and Berkowitz (reference 16) have updated this analysis to include two-dimensional, compressible flow. It is Ruff and Berkowitz's model that was contained within LEWICE prior to its upgrade with the electrothermal deicer. All of the above models consider the surface of the airfoil to be insulated. However, when an electrothermal device is activated during ice accretion, there is significant heat transfer throughout the blade and the ice. Clearly, there is a need to combine these two approaches such that the complete phenomena of icing can be modeled. The phenomena of ice accretion with heat sources would not be complete, however, without an analysis of how the ice is removed and an analysis of where it travels afterward. Again, much of the early work in ice adhesion was performed by Stallabrass (reference 2).

Recently, Scavuzzo (references 17 and 18) has developed a more advanced theoretical model for the prediction of ice shedding using a finite element analysis of the ice stresses. He also found expeimentally the relation of ice adhesion as a function of surface temperature. The method used in this work to predict shedding is based on Scavuzzo's experiments.

The solution method used in this study is an extension of the ADI method, which was shown by Wright (reference 19) to be the most efficient for the two-dimensional transient heat transfer in an electrothermal deicer pad. The ADI method is a direct solution method first developed by

Peaceman and Rachford (reference 20). However, a direct solution method requires a linear solution matrix.

There are two nonlinearities in the governing equations for this process. The first of these is the phase change of the water into ice. This nonlinearity occurs because during freezing (or melting), the enthalpy continues to change while the temperature remains constant. Since enthalpy is found in the governing equations for the ice, this non-linearity must be removed. This is performed by using the Method of Assumed States, developed by Schneider and Raw (reference 21).

Essentially, the Method of Assumed States eliminates the latent heat of the ice and replaces it with a very high heat capacity over a very small temperature range. Wright showed this temperature range to be, at most, $10^{-4}$ °F. By eliminating the latent heat, a linear relationship between enthalpy and temperature develops within each of the three phases: solid, liquid, and mush. A phase is assumed at each location and then the temperature profile is found. The phase of each control volume is then found and compared with the assumed phase. The second nonlinearity occurs at the ice accretion interface. There are two nonlinearities in the governing equation for this process. The first concerns the freezing fraction, which is the fraction of the impinging water which freezes. However, since the latent heat has already been replaced by a high heat capacity, the freezing fraction can be solved for in terms of the surface temperature.

The other nonlinearity in the ice accretion equation concerns the evaporation term. Within this term, there exists an evaporative pressure at the surface. The relationship between evaporative pressure and temperature is given by Antoine's equation, which is highly nonlinear. However, the magnitude of this heat loss term is small enough such that changes in the surface temperature at the accretion surface do not change the results drastically. Therefore, this term uses the temperature at the previous time step to determine the heat lost caused by evaporation.

In summary, the objective of this enhancement to LEWICE is to develop an efficient numerical model which combines all of the previous analysis in order to accurately predict ice accretion,

ice shedding, and two-dimensional thermal transients in an electrothermal pad.

## HEAT CONDUCTION AND PHASE CHANGE EQUATIONS

The following assumptions were made in the development of a mathematical model for heat conduction in a composite blade:

1. The thermal physical properties of the material composing each layer of the blade may be different, but do not depend on temperature.

2. Each layer is either isotropic or orthotropic, meaning that cross-derivative terms in the anisotropic heat equation are neglected, but that kx is not equal to ky.

3. There is perfect thermal contact between layers.

4. Curvature effects of the blade are not taken into account because the deicer thickness normal to the blade is thin compared to the effective blade thickness.

5. Thermal transients in the spanwise direction are ignored.

6. The ambient temperature and all heat transfer coefficients are constant with respect to time.

7. The density change due to melting is negligible, i.e., the effect of the volume contraction of the ice as it melts is neglected.

8. The phase change of the ice is assumed to occur over a small temperature interval near the true melting point rather than at the melting point itself.

With the above assumptions, the mathematical formulation for the problem of unsteady heat conduction in a chord-wise two-dimensional composite blade with electrothermal heating can be

represented as: $(\rho C_p)_k \frac{\partial T}{\partial t} = k_{x,k} \frac{\partial^2 T}{\partial x^2} + k_{y,k} \frac{\partial^2 T}{\partial y^2} + q'''_k$  (1)

For the ice layer, the governing equation in terms of the enthalpy is given by

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$$\frac{\partial H}{\partial t} = k_{ice}\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right) \tag{2}$$

In order to solve this problem, it is necessary to remove enthalpy from the governing equation above and replace it with temperature. The standard relationship between enthalpy and temperature is

$$H = \begin{bmatrix} (\rho C_p)_s T \\ (\rho C_p)_s T_{mp} < H < \rho_1 C_{p_s} T_{mp} + \rho_1 L_f \\ (\rho C_p)_s T_{mp} + \rho_1 L_f + (\rho C_p)_1 (T - T_{mp}) \end{bmatrix} \begin{bmatrix} T < T_{mp} \\ T_{mp} \\ T > T_{mp} \end{bmatrix} \tag{3}$$

However, this relationship is nonlinear, as there are multiple values for the enthalpy while the temperature remains at the melting temperature. The numerical method employed requires that a linear relationship exists, so that the coefficient matrix created can be easily inverted. To accomplish this, ice is assumed to melt over a very small temperature range near the melting temperature instead of at the melting temperature. The modified form of the enthalpy- temperature relationship is:

$$H = \begin{bmatrix} (\rho C_p)_s T \\ (\rho C_p)_s T_{mp} + \rho_1 L_f \dfrac{(T - T_{mp})}{T_r} \\ (\rho C_p)_s T_{mp} + \rho_1 L_f + (\rho C_p)_1 (T - T_{mp} - T_r) \end{bmatrix} \begin{bmatrix} T < T_{mp} \\ T_{mp} < T < T_{mp} + T_r \\ T > T_{mp} + T_r \end{bmatrix} \tag{4}$$

It is convenient to define a specific heat capacity in this melt region, which is given by:

$$(C_p)_m = \frac{(\rho_1 - \rho_s) C_{ps} T_{mp} + \rho_1 L_f}{\rho_m T_r} \tag{5}$$

where $\rho_m$ is the density of the region between solid and liquid, henceforth to be referred to as the 'mush' region. Therefore, the governing equation for the ice layer can be written as:

$$\begin{bmatrix} \frac{\partial}{\partial t}\rho C_{ps}T \\ \frac{\partial}{\partial t}\rho C_{pm}T \\ \frac{\partial}{\partial t}\rho C_{pl}T \end{bmatrix} = \frac{\partial}{\partial x}k_{ice}\frac{\partial T}{\partial x} + \frac{\partial}{\partial y}k_{ice}\frac{\partial T}{\partial y}$$

$$\begin{bmatrix} 0 \\ \left[(\rho C_p)_m - (\rho C_p)_s\right]T_{mp} \\ \left[(\rho C_p)_l - (\rho C_p)_s\right]T_{mp} + \left[(\rho C_p)_l - (\rho C_p)_m\right]T_r \end{bmatrix} \qquad (6)$$

where the top expression in each bracket is used for the solid phase, the middle expression is used for the mush phase, and the bottom expression is used for the liquid phase. As long as this range is small, the accuracy of the solution is not significantly altered. A melting range of $10^{-4}$ or smaller has proven to be necessary for this study. Since the temperature is not known prior to this calculation, the phase of the ice (solid, mush, or liquid) must first be assumed, the temperature calculated using the appropriate equation, and the phase checked at the end. This creates an iterative scheme to solve for the temperature within the composite body.

## BOUNDARY CONDITIONS FOR THE COMPOSITE BODY

There are three types of boundary conditions used for the composite body. They are:

1. Interior interfaces between layers of the composite body.

2. Constant temperature outer boundary conditions.

3. Convection outer boundary conditions.

At interior interfaces, the temperatures and heat fluxes are continuous, i.e.:

$$T_{i,j})_{layer1} = T_{i,j})_{layer2} \qquad (7)$$

$$-k_x\frac{\partial T}{\partial x})_{layer1} = -k_x\frac{\partial T}{\partial x})_{layer2} \qquad (8)$$

$$-k_y\frac{\partial T}{\partial y})_{layer1} = -k_y\frac{\partial T}{\partial y})_{layer2} \qquad (9)$$

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where Equation (8) or Equation (9) is used depending upon whether the interface in question is in the x-direction or in the y-direction.

Constant temperature interfaces are given by:

$$T_{i,j})_{surface} = T_\infty \qquad (10)$$

This type of boundary condition is rarely used for the simulation of a de-icer pad, but has been incorporated into the program which has been developed so that other heat transfer phenomena may be studied by the user.

Convection boundary conditions are given by:

$$-k_x \frac{\partial T}{\partial x})_{surface} = h\,(T_s - T_\infty) \qquad (11)$$

$$-k_y \frac{\partial T}{\partial y})_{surface} = h\,(T_s - T_\infty) \qquad (12)$$

Insulated boundary conditions are obtained by setting the heat transfer coefficient in the above equations to zero. There is another type of boundary condition used at the top surface of the ice, and it is derived in the next section.

## ACCRETION BOUNDARY CONDITION

In a previous numerical model of a de-icer pad, Wright (reference 19), the outer boundary condition at the top surface of the ice was assumed to be given by Equation 12 of the previous section. However, this is not adequate when the actual physics of the flow at the exposed surface are considered. The new approach is a modified version of that used by Gent and Cansdale (reference 6). There are several assumptions which need to be made in the development of an improved icing boundary condition. These are listed below.

1. The terms in the energy equation which are considered important are:

   a. convection losses.

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b. kinetic heating.

c. evaporative/sublimative cooling.

d. sensible heat gain/loss.

e. viscous losses.

f. latent heat gain.

All other terms are neglected.

2. Kinetic heating is adiabatic.

3. The Chilton-Colburn analogy is used to relate the mass loss caused by evaporation to a heat loss caused by evaporation.

4. Viscous dissipation is given by a 'recovery factor' as defined by Schlichting (reference 22).

5. Air is a perfect gas.

6. The Antoine equation is used to relate vapor pressure to static temperature. This implies that the molar volume of the liquid is negligible compared to that of the gas and that the heat of evaporation is independent of temperature.

7. Physical properties of air and water, except for air density, are independent of temperature.

8. Mass transfer is proportional to the concentration difference accross the boundary layer.

9. The ambient conditions of velocity and mass density are constants.

If dry air flows over the airfoil, the surface temperature would be increased beyond that of the ambient because of the compressible flow of air which strikes the surface of the blade, thereby imparting the kinetic energy of the air to the blade. Since this is presumed to be an adiabatic pro-

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cess, the local static temperature at the edge of the boundary layer would be given by:

$$T_e = \frac{T_o}{(1 + \frac{\gamma - 1}{2} M_e^2)}$$

(13)

Schlichting relates this temperature to the surface temperature through the 'recovery factor' r which is equal to $Pr^{1/3}$ for a turbulent boundary layer and $Pr^{1/2}$ for a laminar boundary layer. This is presumed to account for the viscous dissipation in the boundary layer. The final result is called the recovery temperature and is given by:

$$T_{rec} = \frac{T_o (1 + r \frac{\gamma - 1}{2} M_e^2)}{(1 + \frac{\gamma - 1}{2} M_e^2)}$$

(14)

where $T_{rec}$ is the recovery temperature. The amount of energy increase owing to the combined effects of the frictional heating by air and the viscous dissipation of the boundary layer is normally placed in terms of a convective flux:

$$q"_{fh} = h (T_{rec} - T_\infty)$$

(15)

The convective flux is described by Newton's Law of Cooling:

$$q"_{conv} = h (T_s - T_\infty)$$

(16)

When convection is combined with frictional heating, Eqs. 15 and 16 may be united into a net convective flux which is given by:

$$q"_{nc} = h (T_s - T_{rec})$$

(17)

An additional kinetic heating term is also present owing to the impact of the water droplets on the surface. This is given by:

$$q"_{ke} = \frac{R_w V_\infty^2}{2}$$

(18)

The heat loss caused by evaporation is determined by finding the mass transfer rate of water vapor leaving the surface of the blade and multiplying it by the heat of vaporization. Sublimation

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is handled in the same manner, but using the heat of sublimation. Since the latent heats of vapor-ization and sublimation are large, it takes only a small amount of mass to be removed by either process before a significant drop in surface temperature is realized. The driving force for this process is the concentration difference across the boundary layer, Cs-Ce, where the mass density, C, is given by:

$$C = \frac{e\,(MW)_w}{RT} \tag{19}$$

The evaporative mass flux of water vapor through the boundary layer can be described by:

$$N = h_m\,(C_s - C_e) \tag{20}$$

The heat loss is given by:

$$q''_{evap} = L_v N \tag{21}$$

Combining Eqs. 19 through 21, the evaporative heat loss can be written as:

$$q''_{evap} = \frac{L_v h_m\,(MW)_w}{R}\left(\frac{e_s}{T_s} - \frac{e_e}{T_e}\right) \tag{22}$$

The mass transfer coefficient can be replaced with the heat transfer coefficient via the Chilton-Colburn analogy between heat and mass transfer:

$$h_m = \frac{h}{(\rho C_p)_{air} L^{2/3}} \tag{23}$$

Replacing the density of air via the ideal gas law gives the net heat lost by evaporation as:

$$q''_{evap} = \frac{L_v h\,(MW)_w}{[P\,(MW)C_p]_{air} L^{2/3}}\left(e_s \frac{T_e}{T_s} - e_e\right) \tag{24}$$

The evaporative pressure at any location can be evaluated solely in terms of the local static temperature using Antoine's equation:

$$\log e_s = A - \frac{B}{T_s + C} \tag{25}$$

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where A, B, and C are empirical constants. Since the temperature at the edge of the boundary layer is given by equation 13 and the evaporative pressure is given by equation 25, the only unknown in equation 24 is the surface temperature.

The sensible heat transfer and the latent heat transfer are determined by tracing the thermodynamic path the incoming liquid takes to get to the surface temperature. The exact form of these equations depends upon how much heat is available after the other heat losses/gains have been considered. If the surface temperature is below the freezing point, the sensible and latent heat terms needed are the heating of the supercooled liquid up to freezing, the freezing of the water into ice (latent heat), and the subsequent cooling to the surface temperature. These three terms can be expressed in equation form as:

$$q''_{sens1} = -R_w C_{pl} (T_m - T_\infty)$$ (26)

$$q''_{lat} = R_w L_f$$ (27)

$$q''_{sens2} = -R_w C_{ps} (T_s - T_m)$$ (28)

If the surface is at the freezing point and hence only part of the ice freezes, the terms are the heating of the supercooled liquid up to freezing and the partial freezing of the water into ice (latent heat). These terms can be described by:

$$q''_{sens3} = -R_w C_{pl} (T_m - T_\infty)$$ (29)

$$q''_{lat} = N_f R_w L_f$$ (30)

Since the assumption has been made that ice melts over a small temperature range, the freezing fraction can be written in terms of the surface temperature:

$$N_f = \frac{T_m + T_r - T_s}{T_r}$$ (31)

Hence, the latent heat term for this case can be written as:

$$q''_{lat} = \frac{(T_m + T_r - T_s) R_w L_f}{T_r}$$ (32)

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If the surface temperature is above freezing, the sensible heat is given by:

$$q''_{sens1} = -R_w C_{pl} (T_s - T_\infty) \tag{33}$$

Additionally, there is a sensible heat transfer between the runback water and the region into which the water flows. This heat exchange is caused by the temperature distribution along the airfoil. These terms cannot be discounted, as they are quite significant for cases involving a considerable amount of runback. The form of the equations describing this sensible heat transfer is the same as those for the sensible heat terms above, but replacing $R_w$ with the mass flux of runback water, $R_{rb}$, and the ambient temperature, $T_\infty$, with the temperature of the runback water, $T_{rb}$.

The accretion boundary condition can be found by setting the heat flux at the outer surface equal to the sum of the heat fluxes described above. This can be written as:

$$-(k_y \frac{\partial T}{\partial s})_s = q''_{nc} + q''_{evap} - q''_{ke} - q''_{lat} \pm q''_{sens} \tag{34}$$

Note that the heat flux is directed outward, such that a term which results in a heat gain at the surface has a negative sign and a term which results in a heat loss has a positive sign. Replacing the heat fluxes in the equation above with the expressions described earlier gives:

$$\left(-(k_y \frac{\partial T}{\partial s})_s = h(T_s - T_{rec}) + \frac{L_v h (MW)_w}{[P(MW)C_p]_{air} L^{2/3}} \left(e_s \frac{T_e}{T_s} - e_e\right) - \frac{R_w V_\infty^2}{2}\right)$$

$$\begin{bmatrix} R_w C_{pl}(T_{mp} - T_\infty) + R_{rb} C_{pl}(T_{mp} - T_{rb}) - (R_w + R_{rb})((L_f + C_{ps})(T_m - T_s)) \\ R_w C_{pl}(T_{mp} - T_\infty) + R_{rb} C_{pl}(T_{mp} - T_{rb}) - (R_w + R_{rb}) \\ R_w C_{pl}(T_s - T_\infty) + R_{rb} C_{pl}(T_s - T_{rb}) - (R_w + R_{rb}) \end{bmatrix} \tag{35}$$

where the top expression in the brackets is used for the solid (ice) phase, the middle expression is used for the mush phase, and the bottom expression is used for the liquid (water) phase. As with the governing equations for conduction within the de-icer, the surface temperature is not known prior to this calculation, so that the Method of Assumed States must be used here as well.

## ACCRETION MASS BALANCE

In the previous section, conservation of energy was applied at the top surface of the ice. This resulted in the derivation of an appropriate boundary condition for the heat conduction equation. In this section, conservation of mass will be applied to the same surface to determine the amount of ice which forms on the blade. The additional assumptions which have been made in this derivation are:

1. All of the incoming water which does not freeze will flow into the next control volume as runback water, hence the flow of surface water is not shear driven.

2. Runback water flows in the direction opposed to the aerodynamic stagnation point. Because of this, no runback water can flow into the control volume which contains the stagnation point .

3. Any runback water which the stagnation point control volume generates is equally divided into the two control volumes on each side of this point.

Because of the above assumptions, the mass balance must be applied to the stagnation point control volume first, as the amount of runback water present elsewhere is dependent upon the amount generated at the stagnation point. The general form of the mass balance in terms of the mass fluxes is:

$$R_w + R_{rb, in} = R_c + R_a + R_{rb, out}$$ (36)

The mass flux of impinging water is given by:

$$R_w = \beta (LWC) V_\infty$$ (37)

The collection efficiency given above is simply the fraction of water droplets in a volume of water which impinges upon the surface, meaning that the droplet strikes the surface and remains there and does not splatter. The collection efficiency can be obtained by correlations with the ambient conditions, or by a separate computer program which calculates the trajectory of the droplets in the air and determines if they will strike the surface and if so, if they will splatter or

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remain upon the surface.

The mass flux of evaporation is given by:

$$R_e = \frac{q''_{evap}}{L_e} \tag{38}$$

One of the purposes of equations in the previous section was to obtain the freezing fraction, $N_f$. This is the fraction of impinging water which freezes. Hence, the amount of runback water leaving the control volume is obtained by multiplying the total amount of incoming water by the fraction which does not freeze. Hence:

$$R_{rb,out} = (R_w - R_{rb,in})(1 - N_f) \tag{39}$$

The mass flux of runback water coming in, $R_{rb,in}$, is zero at the stagnation point and is calculated from the previous volume's mass balance elsewhere. This is why it is necessary to start the calculations at the stagnation point. The mass flux of ice accretion is obtained by solving equation 36 for $R_a$ and substituting the above expressions to obtain:

$$R_a = (R_w - R_{rb,in})N_f - \frac{q''_{evap}}{L_e} \tag{40}$$

## ICE SHEDDING

The assumptions made in the development of an ice shedding model are:

1. The flow is two-dimensional, that is, the aerodynamic force has x and y-components only.

2. The forces holding the ice to the surface are determined from the bonding strength of the ice.

3. The bonding strength is dependant only upon the temperature at the ice/blade interface.

4. The ice sheds as a whole and not in sections.

5. Each spanwise section acts independently of the other sections.

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6. The ice will shed when the net average external forces exceed the net average force

holding the ice to the surface.

The aerodynamic force is computed by the formula:

$$F_{aero} = \frac{\rho_\infty V_\infty^2 A}{2} \tag{41}$$

The equations relating bonding strength of the ice versus temperature were obtained by curve-fitting experimental data provided by J. R. Stallabrass. The computational domain takes the x-direction to be along the surface of the airfoil in the chordwise direction. The y-direction is normal to the airfoil, and the z-direction is along the surface of the airfoil in the spanwise direction.

## ICE SHAPE TRANSFORMATION

This section describes how the ice shape is generated around the airfoil. The thickness of ice in the computational domain at each chordwise location is found by taking the mass flux of ice accretion, multiplying by the time step, and dividing by the ice density. The mass flux of ice accretion is found from equation (40): $R_a = (R_w - R_{rb, in}) N_f - \dfrac{q''_{evap}}{L_e}$

The thickness of ice normal to the surface is then:

$$y_{ice} = \left[ (R_w + R_{rb, in}) N_f - \frac{q''_{evap}}{L_v} \right] \frac{\Delta t}{\rho_{ice}} \tag{42}$$

If, at every point in the domain, the normal to the surface of the blade is determined and the rectangular height of the ice is added to this, a good approximation of the ice shape on the blade is obtained. However, this process creates a larger mass of ice than was calculated in the rectangular coordinates, as shown in figures 4 through 6.

The dashed line represents the ice shape after transformation, and the shaded regions represent

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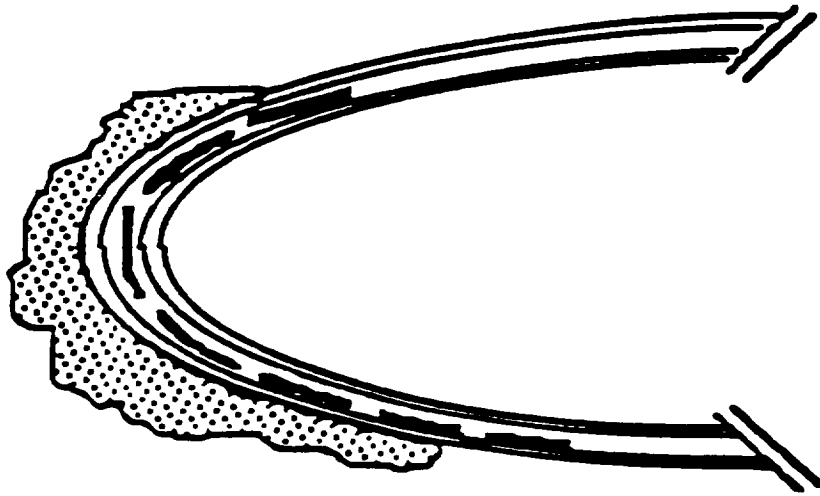
Figure 4 - Iced Airfoil equipped with electrothermal pads.
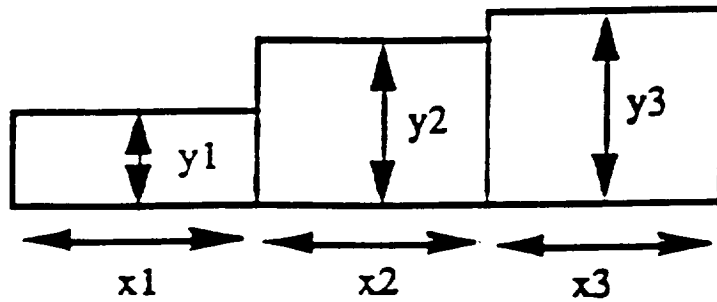


Figure 5 - Ice shape in rectangular coordinates.
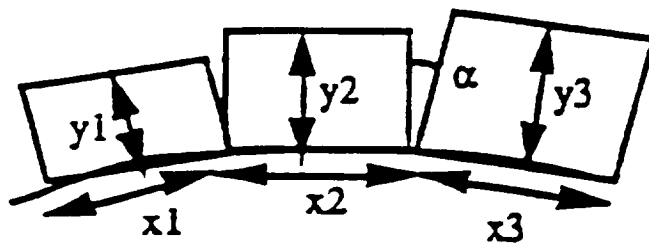


Figure 6 - Representation of ice shape on airfoil.

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the extra area (and hence the extra mass) added by this method of forming the ice shape. This extra area can be represented by a triangle. The heights of the transformed rectangles are diminished such that the total area remains the same between the rectangular plane and the transformed plane. This is done mathematically by first computing the angle "$\alpha$" between the rectangles. This is simply the difference between the angles formed by the sides of the adjacent rectangles and the horizontal. Then, the adjusted ice height, which is the one to be plotted normal to the blade surface, is given by

$$y_{i, new} = \frac{y_{i, old}(X_{i+1} - X_{i-1})}{(X_{i+1} - X_{i-1}) + y_{i-1} \sin \alpha} \tag{43}$$

Thus, the first nonzero block of ice will remain the same height, which is reasonable since this will be small, and the rest will be adjusted accordingly.

# COMPARISON WITH PREVIOUS ACCRETION MODELS

In the previous section, a model was developed to simulate the phenomena occurring around an electrothermal deicer during icing conditions. Each of these phenomena must be verified using other numerical codes or, if possible, by the use of experimental data. The validity of the heat transfer model used has been previously established by Wright (reference 19). Therefore, this section will deal with validating the accretion and shedding routines.

The accretion results of this program were compared to two other numerical models. The first model was developed by the Royal Air Establishment (RAE) under Gent and Cansdale (reference 6). The other code, LEWICE, was developed by NASA Lewis Research Center. Results of this second model can be found in the LEWICE users manual.

The case selected for comparison with the RAE model was used because heat transfer data and collection efficiency data were available for this run. In their report, Gent and Cansdale provide sample curves of heat transfer coefficient, collection efficiency, and the ratio of static pressure over total pressure. These values were read off from the plots as input into the program.

These curves were valid for a NACA 0012 airfoil with a .415 m chord at these conditions: $\alpha=8°$, M=0.4, and MVD=20 $\mu$m. There are nine runs in their paper under these conditions: for $T_\infty$ = -15 °C, -10 °C, and -5 °C; and for LWC = 0.1, 0.3, and 0.5 $g/m^3$. The comparison plot for LWC = 0.5 $g/m^3$ and $T_\infty$ = -10 °C is provided in figures 7 and 8. Other values produced similar results. As can be seen from these figures, the two programs produce very similar ice shapes. The minor differences which do exist are due to the inaccurate method in which the input data was provided. This theory is supported by the virtually identical agreement with the LEWICE code, for which more accurate input data was available.

For the comparison above, the current program was modified to use RAE's evaporation term. In the development of the governing equations, an alternative form of the heat lost due to evapo-
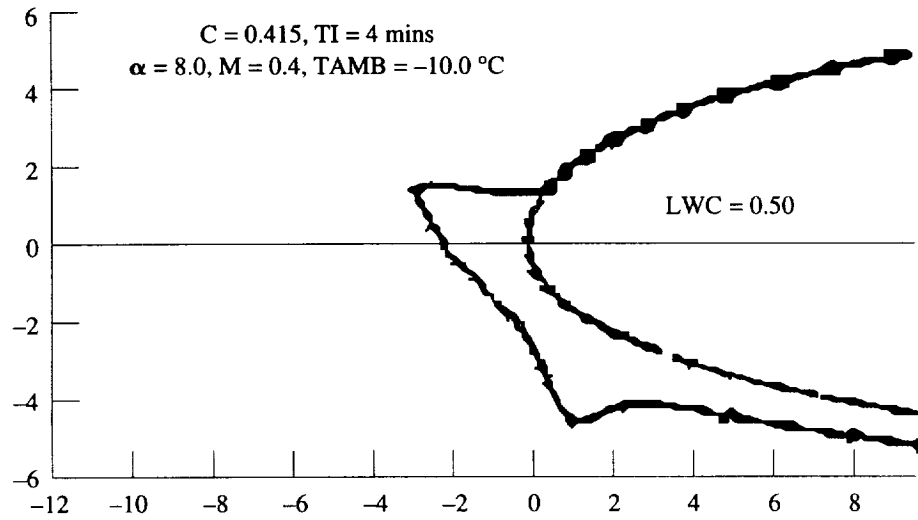
Figure 7.—RAE ice accretion prediction.

| | |
|---|---|
| Velocity (m/s) | = 130 |
| Temperature (°C) | = –10 |
| Pressure (KPa) | = 100 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 0.5 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 240 |
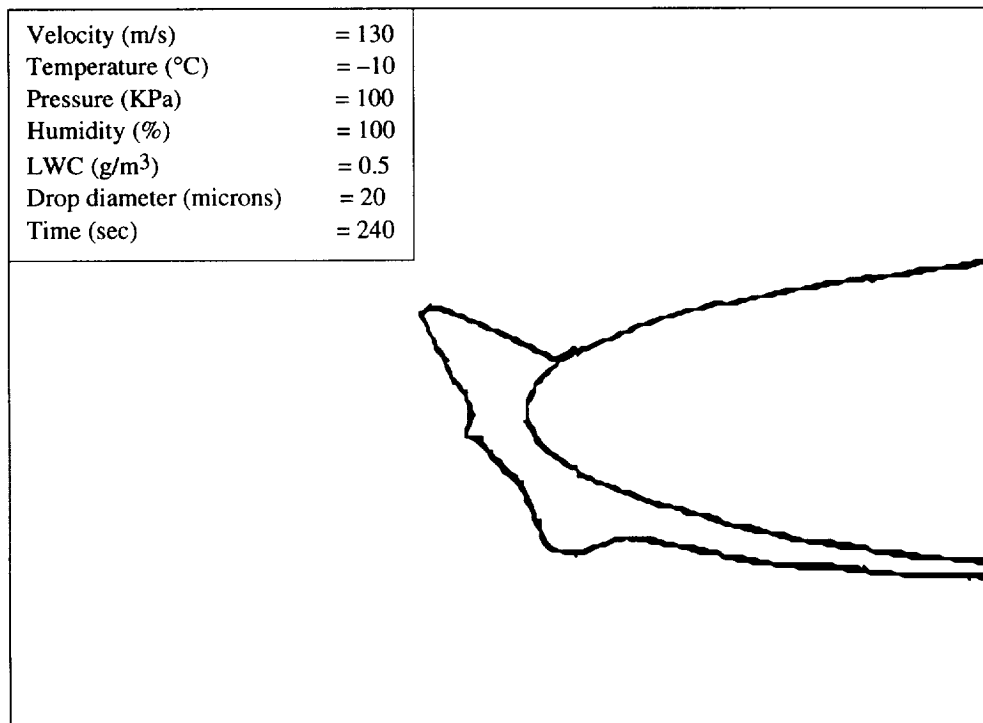


Figure 8.—Numerical ice accretion comparison on RAE case.

ration was produced. The RAE form was used in the previous comparison in order to show the equivalence of the accretion equations. Additionally, no conduction into the blade was allowed, nor was shedding allowed to occur. Again, this was done to show the prediction of the accretion model alone. Additional runs were produced to show the effects of the additional features within this program.

The same case as above was run using the new evaporation term and allowing conduction within the ice and airfoil. The airfoil properties are provided in Table I. As can be seen in figure 9, a much different ice shape is formed. As heat is lost into the airfoil, less of the impinging water runs back and the runback water which is produced travels a smaller distance before freezing. This results in the front horn appearing closer to the stagnation point.

The temperature and heat flux ($-k\partial T/\partial y$) within layer 3 at the stagnation point were plotted versus time for this case to show the effect of the ice accretion process on the blade. These plots are shown in figures 10 and 11. As can be seen from these plots, after an initial transient, the values are relatively constant. This effect can be seen in experimental data of ice accretion.

The current program was then compared to the original LEWICE code. The case used for comparison was example case 2 in the LEWICE users manual. This case was selected because it was a glaze ice accretion and was asymmetric. As can be seen from figures 12 and 13, excellent agreement is obtained between these two codes. This is due to the fact that the exact same heat transfer coefficients, static pressures, and collection efficiencies could be used for this comparison because, in both cases, these results were obtained from LEWICE's flow and trajectory modules. The experimental ice shape for these conditions is provided in figure 14 for comparison. Additionally, no conduction into the blade was allowed, nor was shedding allowed to occur. Again, this was done to show the prediction of the accretion model alone.

The same case was then repeated for the first minute of accretion with the addition of conductive effects. As can be seen in figure 15, this ice shape is not much different from the previous

## Table I - THERMAL PROPERTIES OF AIRFOIL

| Layer | Thickness inches | Thermal Conductivity BTU/hr-ft$^2$-°F | Thermal Diffusivity ft$^2$/hr |
|---|---|---|---|
| Aluminum D-spar | 0.087 | 102. | 2.83 |
| Epoxy/glass insulation | 0.050 | 0.22 | 0.0087 |
| Heater element | 0.004 | 7.60 | 0.138 |
| Epoxy/glass insulation | 0.010 | 0.22 | 0.0087 |
| Stainless steel abrasion shield | 0.012 | 8.70 | 0.15 |

| | |
|---|---|
| Velocity (m/s) | = 130 |
| Temperature (°C) | = -10 |
| Pressure (KPa) | = 100 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 0.5 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 240 |
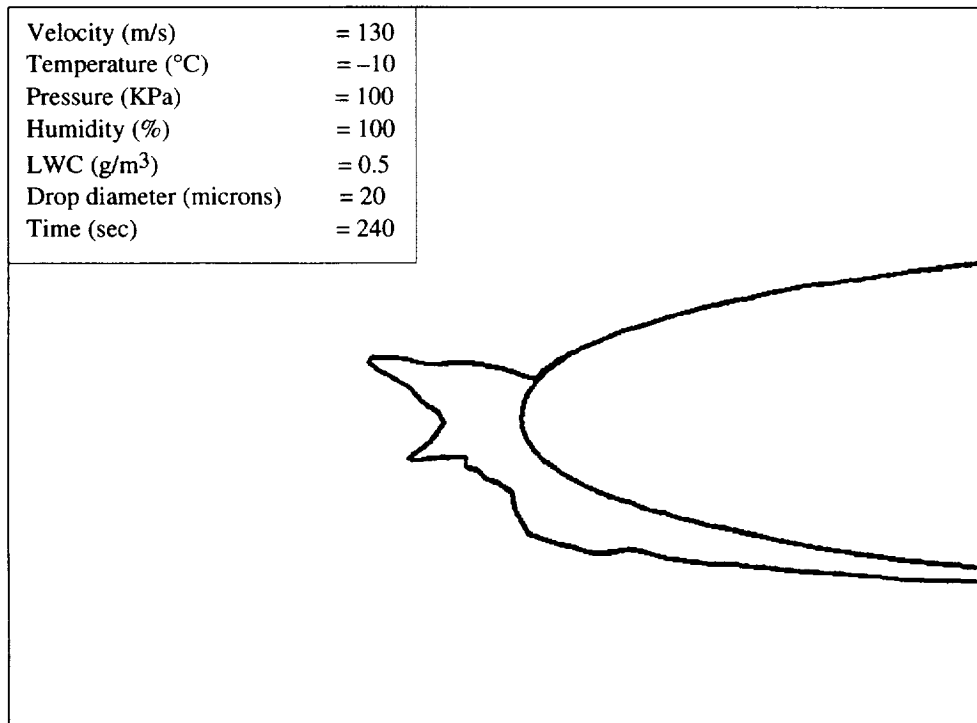
Figure 9.—Effects of conduction on RAE example case.

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| Velocity (m/s)           | = 130 |
| Temperature (°C)         | = -10 |
| Pressure (KPa)           | = 100 |
| Humidity (%)             | = 100 |
| LWC (g/m³)               | = 0.5 |
| Drop diameter (microns)  | = 20  |
| Time (sec)               | = 240 |
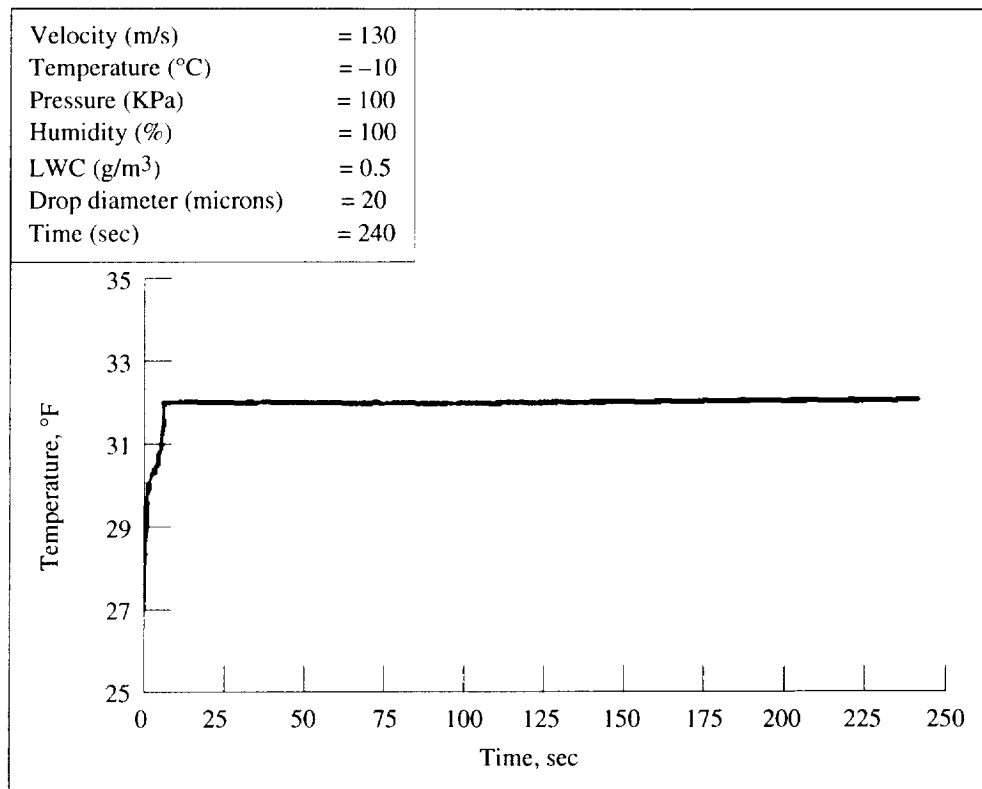


Figure 10.—Temperature of layer 3 at the stagnation point on RAE example case.

| Velocity (m/s)           | = 130 |
| Temperature (°C)         | = -10 |
| Pressure (KPa)           | = 100 |
| Humidity (%)             | = 100 |
| LWC (g/m³)               | = 0.5 |
| Drop diameter (microns)  | = 20  |
| Time (sec)               | = 240 |
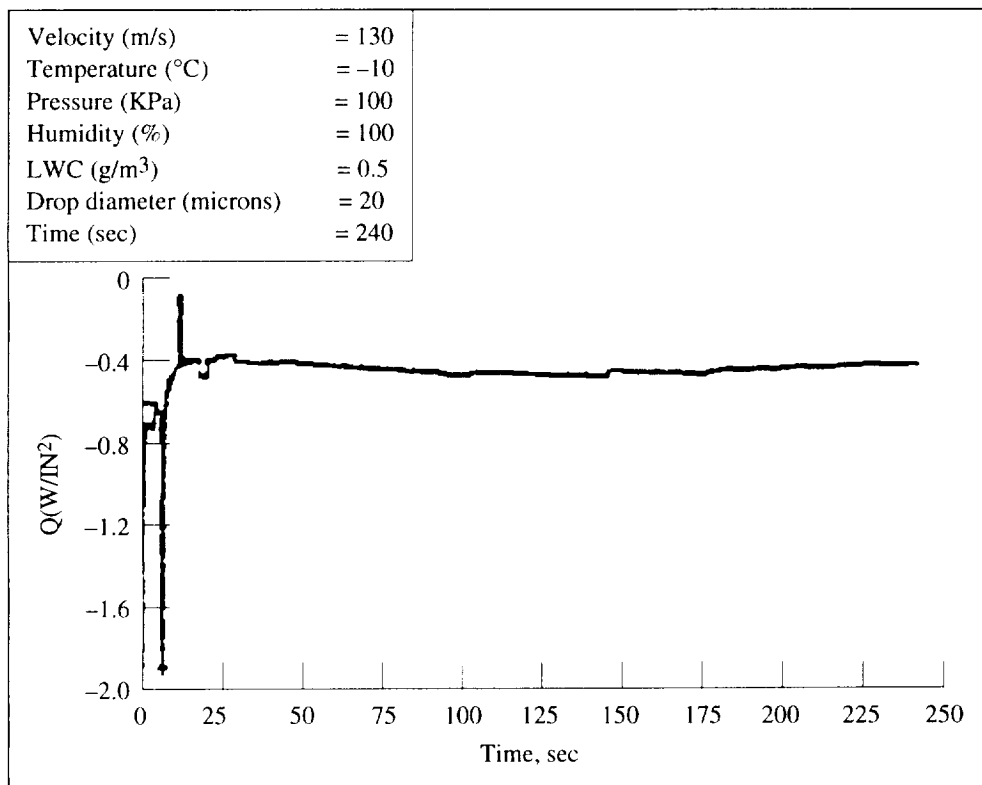


Figure 11.—Conductive flux through layer 3 at the stagnation point on RAE example case.

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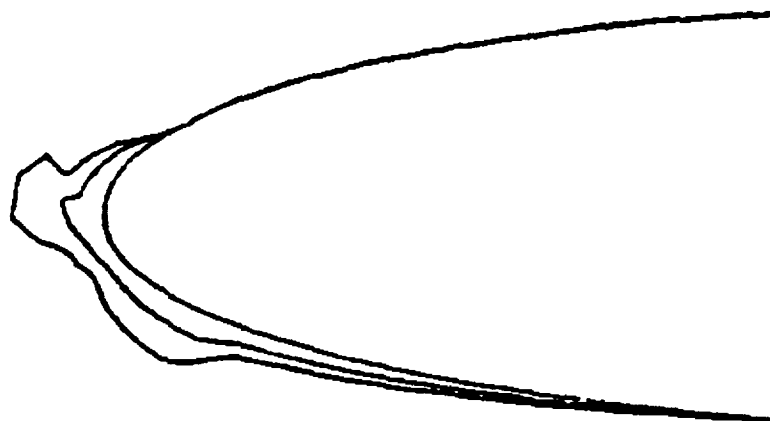
Figure 12.—LEWICE predicted ice accretion on example case 2.

| | |
|---|---|
| Velocity (m/s) | = 129.5 |
| Temperature (°C) | = −12.6 |
| Pressure (KPa) | = 90.78 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 0.5 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 120 |
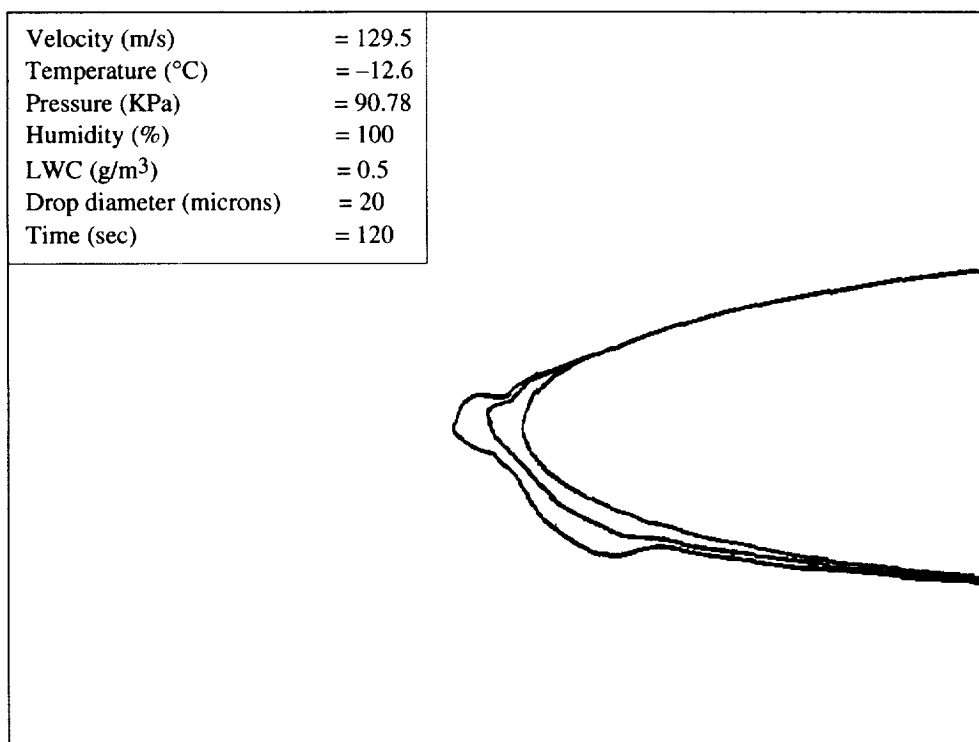


Figure 13.—Numerically predicted ice accretion on example case 2.
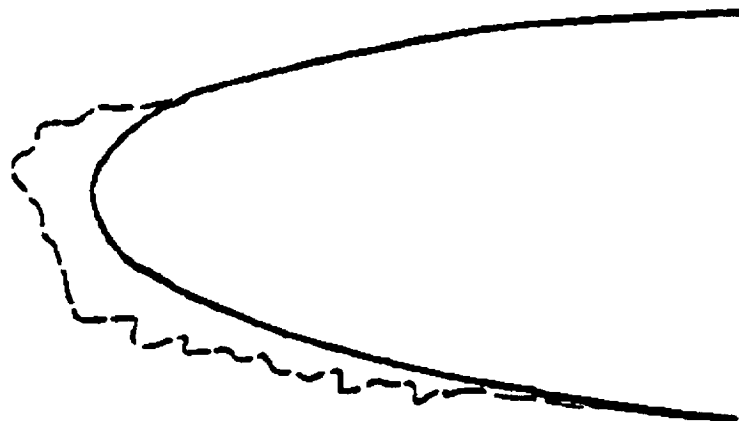
Figure 14.—Experimental ice accretion on example case 2.

| | |
|---|---|
| Velocity (m/s) | = 129.5 |
| Temperature (°C) | = –12.6 |
| Pressure (KPa) | = 90.78 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 0.5 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 120 |
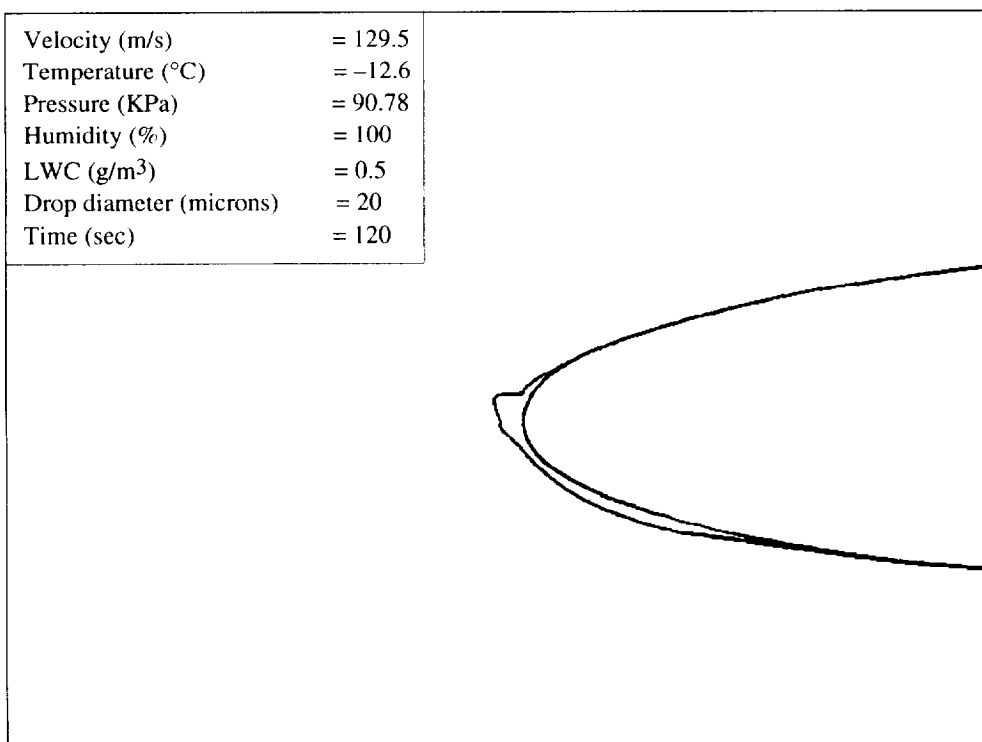


Figure 15.—Effects of conduction on example case 2.

cases, but if the flow code were to be updated for further accretion, the minor differences in the ice shape would be felt in the updated flow results. For this case, sample plots of temperature versus time and heat flux $(-k\partial T/\partial y)$ in layer three versus time at the stagnation point are shown. These are provided in figures 16 and 17. As can be seen from the time-dependent plots, the heat flux oscillates initially. It is felt that this is caused by the lagging of the evaporation term one time step in the conduction algorithm. This is necessary in order to linearize the matrix equations such that ADI can determine the solution.

This case was again repeated, this time turning on three electrothermal heaters in the airfoil. The heaters were located in layer three and were distributed around the tip of the airfoil as shown in figure 18. All wattages were 30 W/in$^2$. The ice shape predicted in figure 19 is much different than the previous cases, but since shedding is not considered in this run, the ice remains on the surface. Besides some runback accretion on the lower surface, the only place where ice forms is at the location of the horn in the previous cases. This is due to the extremely high heat transfer coefficient predicted by LEWICE at this location. Again, the transient temperature and heat flux at the stagnation point heater are provided in figures 20 and 21.

| Velocity (m/s) | = 129.5 |
| Temperature (°C) | = -12.6 |
| Pressure (KPa) | = 90.78 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 0.5 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 120 |

Figure 16.—Temperature of heater at the stagnation point on example case 2.

| Velocity (m/s) | = 129.5 |
| Temperature (°C) | = -12.6 |
| Pressure (KPa) | = 90.78 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 0.5 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 120 |

Figure 17.—Conductive flux through heater at the stagnation point on example case 2.

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Figure 18.—Distribution of heaters on example case 2.

| | |
|---|---|
| Velocity (m/s) | = 129.5 |
| Temperature (°C) | = –12.6 |
| Pressure (KPa) | = 90.78 |
| Humidity (%) | = 100 |
| LWC (g/m³) | = 0.5 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 120 |
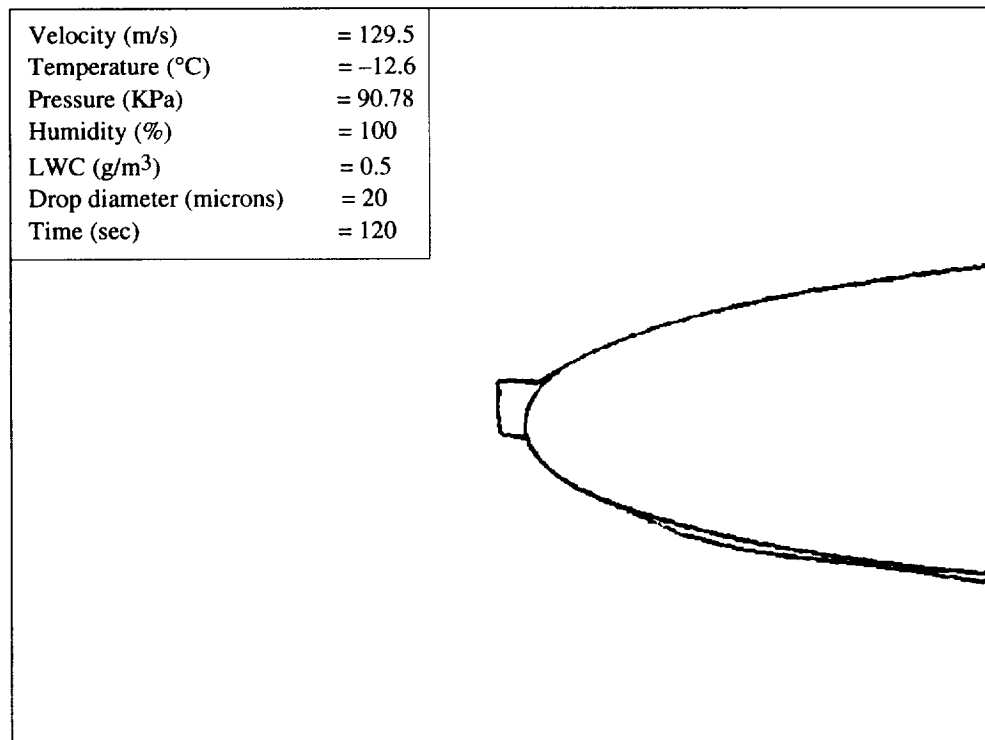


Figure 19.—Predicted ice shape with heat source on example case 2.

| Velocity (m/s) | = 129.5 |
| Temperature (°C) | = -12.6 |
| Pressure (KPa) | = 90.78 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 0.5 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 120 |
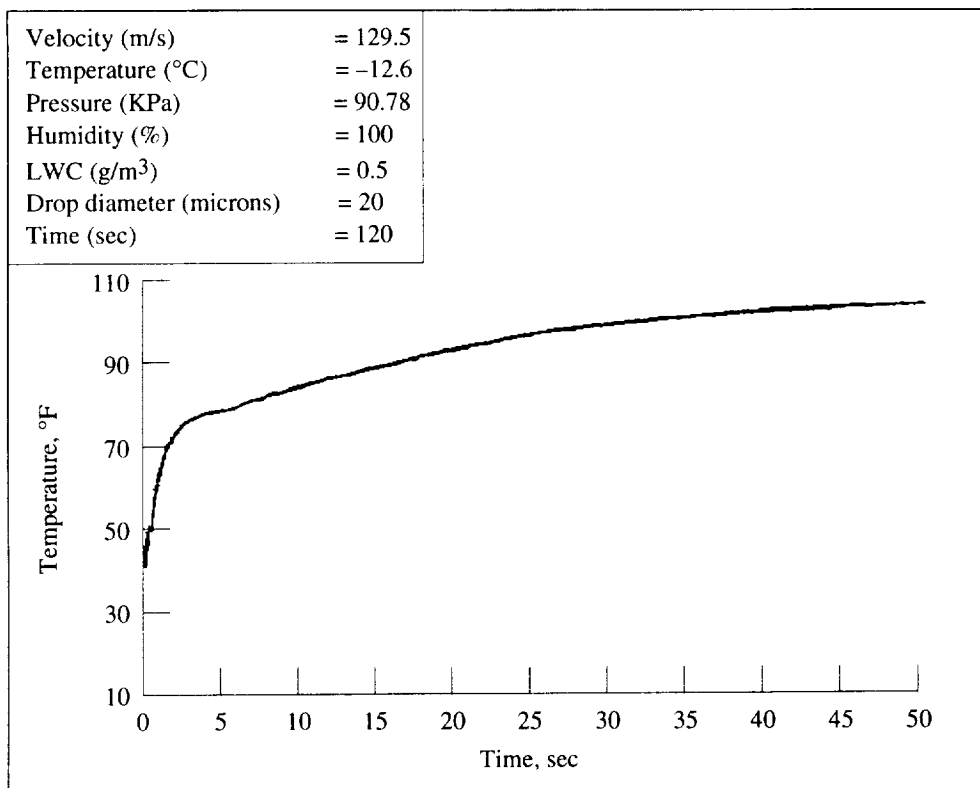
Figure 20.—Temperature of heater at the stagnation point on example case 2 with heat source.



| Velocity (m/s) | = 129.5 |
| Temperature (°C) | = -12.6 |
| Pressure (KPa) | = 90.78 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 0.5 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 120 |
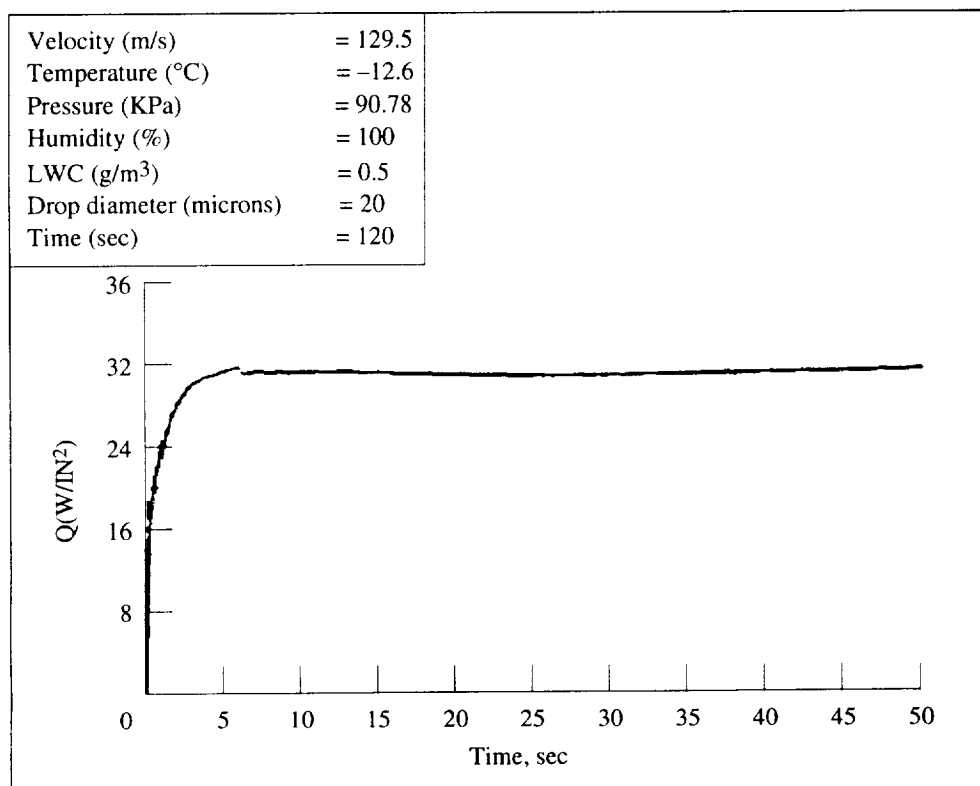
Figure 21.—Conductive flux through heater at the stagnation point on example case 2 with heat source.

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# COMPARISON WITH EXPERIMENTAL DATA

In order to further evaluate the code, a comparison was made with previously obtained exper-

imental data from Leffel (reference 9). The particular data set chosen was selected because it was

a case of cyclic heating and because the ice shed. The ice shape and thickness were known from

an identical accretion run performed earlier. A thirteen layer electrothermal pad is modeled. Prop-

erties of this pad are provided in table II. Eight heaters are modeled at three different cycle times,

as shown in figures 22 and 23. Figures 24 and 25 show the comparison between the experimental

ice shape and the predicted ice shape for these conditions. Conduction was neglected during the 5

min. accretion process. Considering the many arbitrary variables which had to be provided to

make this comparison, we feel that agreement is quite good. Figures 26 through 28 show the tem-

perature-time comparisons for this case at position 7 in the heater and the ice-abrasion-shield

interface. Experimental ice shedding occurred approximately 5 seconds after the heaters were

turned on compared with the numerical prediction of 0.3 seconds. Since the correlation between

bonding strength and surface temperature is accurate to within plus or minus 30 percent, this is a

reasonable prediction. The CPU time for this run using a 177 X 70 grid for 300 seconds of accre-

tion and 80 seconds of de-icing time on NASA's VM machine was 22 minutes, 27 seconds. This is

an acceptable value considering the complexity of the problem, the large size of the mesh, and the

long simulation time.

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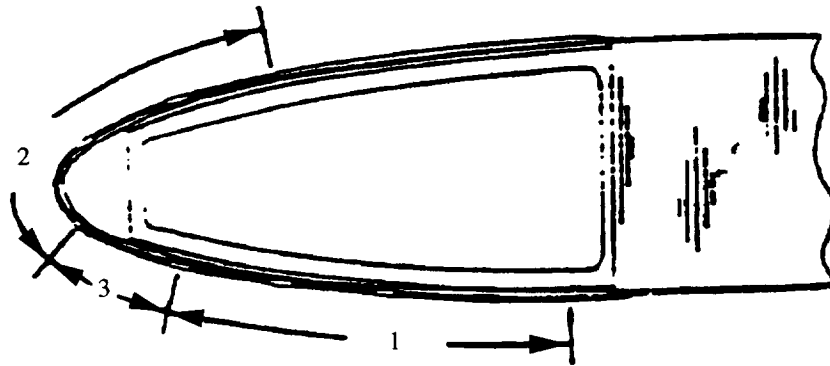
Figure 22.—Distribution of heaters on experimental case.
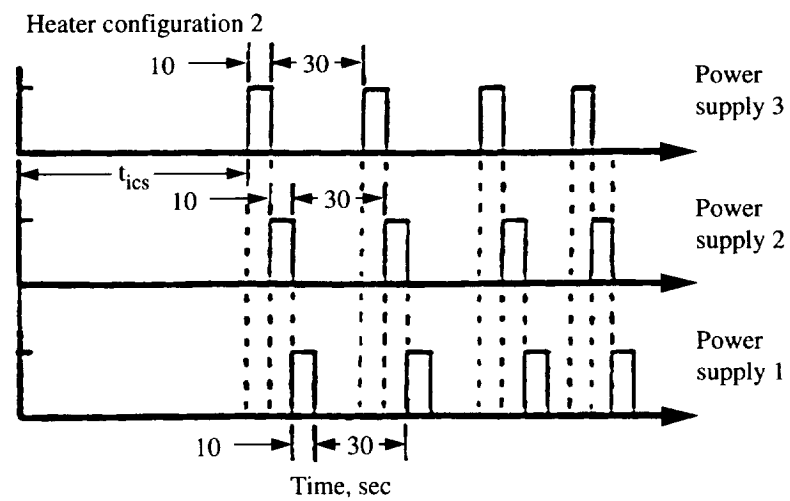


Figure 23.—Heater cycle times on experimental case.
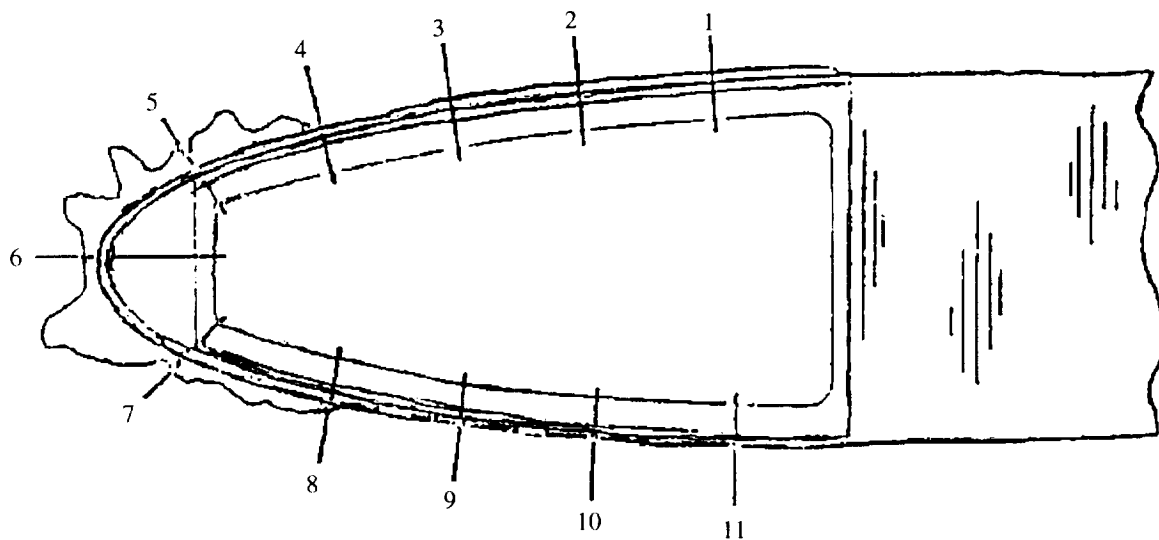
Figure 24.—Experimental ice accretion.

| | |
|---|---|
| Velocity (m/s) | = 89.4 |
| Temperature (°C) | = –3.89 |
| Pressure (KPa) | = 101.35 |
| Humidity (%) | = 100 |
| LWC (g/m³) | = 1.2 |
| Drop diameter (microns) | = 18.4 |
| Time (sec) | = 380 |
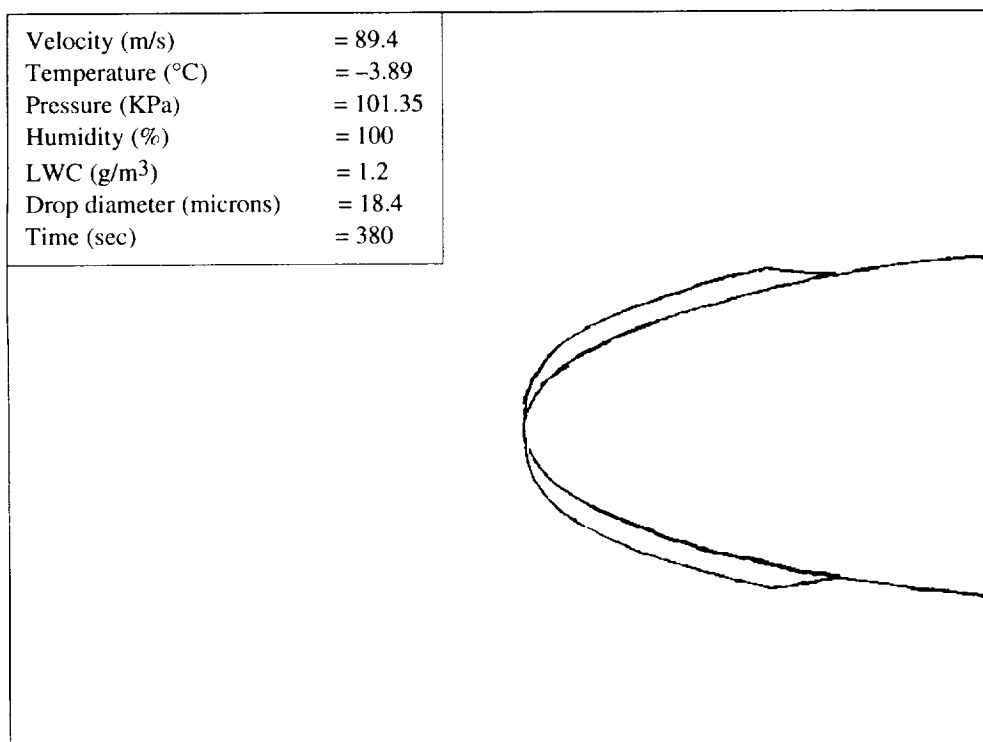


Figure 25.—Numerically predicted ice accretion.
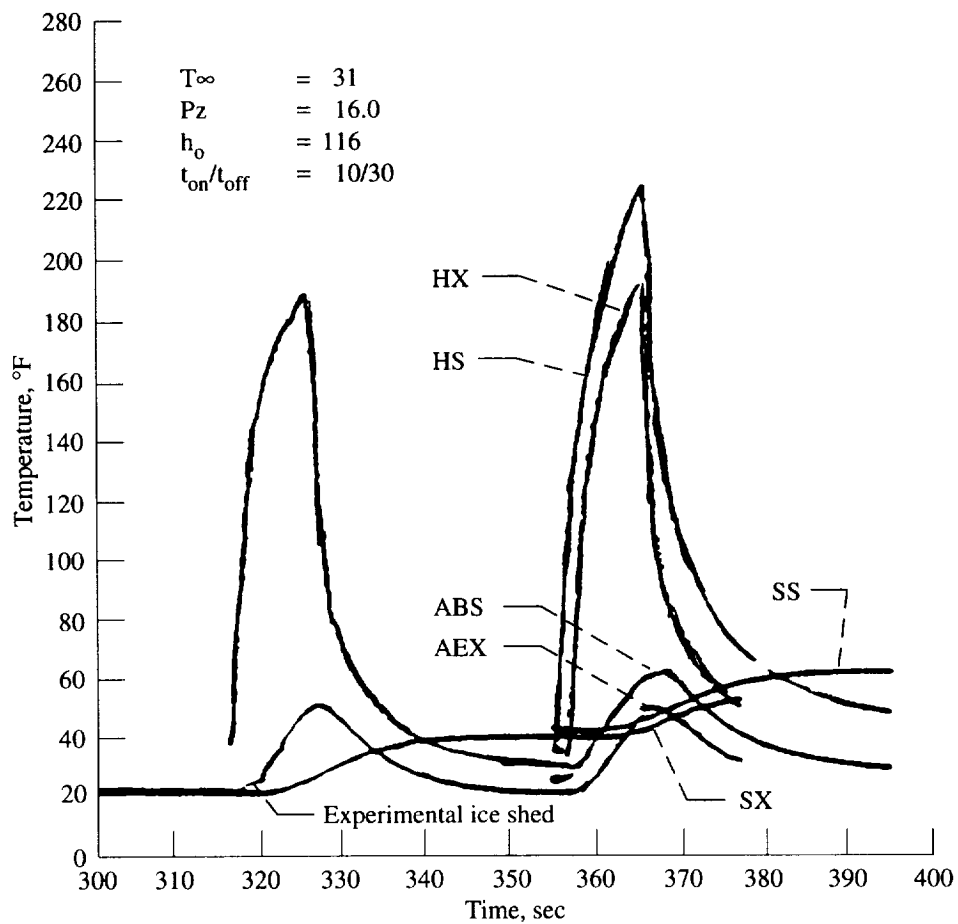
Figure 26.—Experimental temperature results at position 7.

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| Velocity (m/s) | = 89.4 |
|---|---|
| Temperature (°C) | = –3.89 |
| Pressure (KPa) | = 101.35 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 1.2 |
| Drop diameter (microns) | = 18.4 |
| Time (sec) | = 380 |
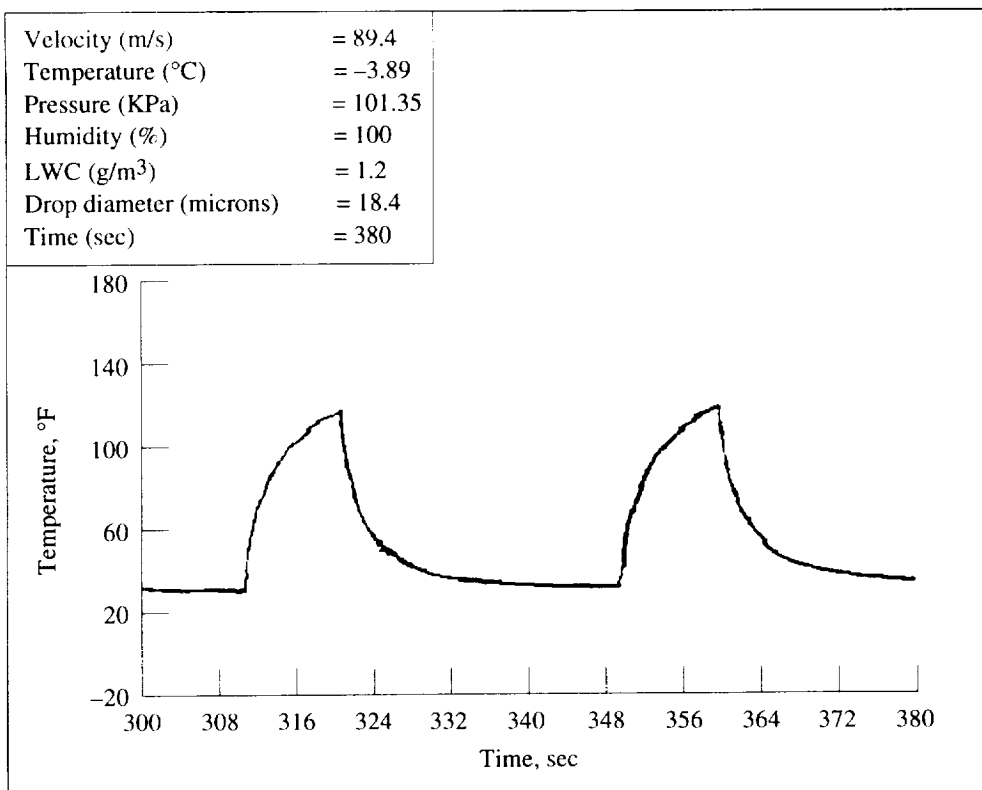
Figure 27.—Numerical prediction of heater temperature at position 7.

| Velocity (m/s) | = 89.4 |
|---|---|
| Temperature (°C) | = –3.89 |
| Pressure (KPa) | = 101.35 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 1.2 |
| Drop diameter (microns) | = 18.4 |
| Time (sec) | = 380 |
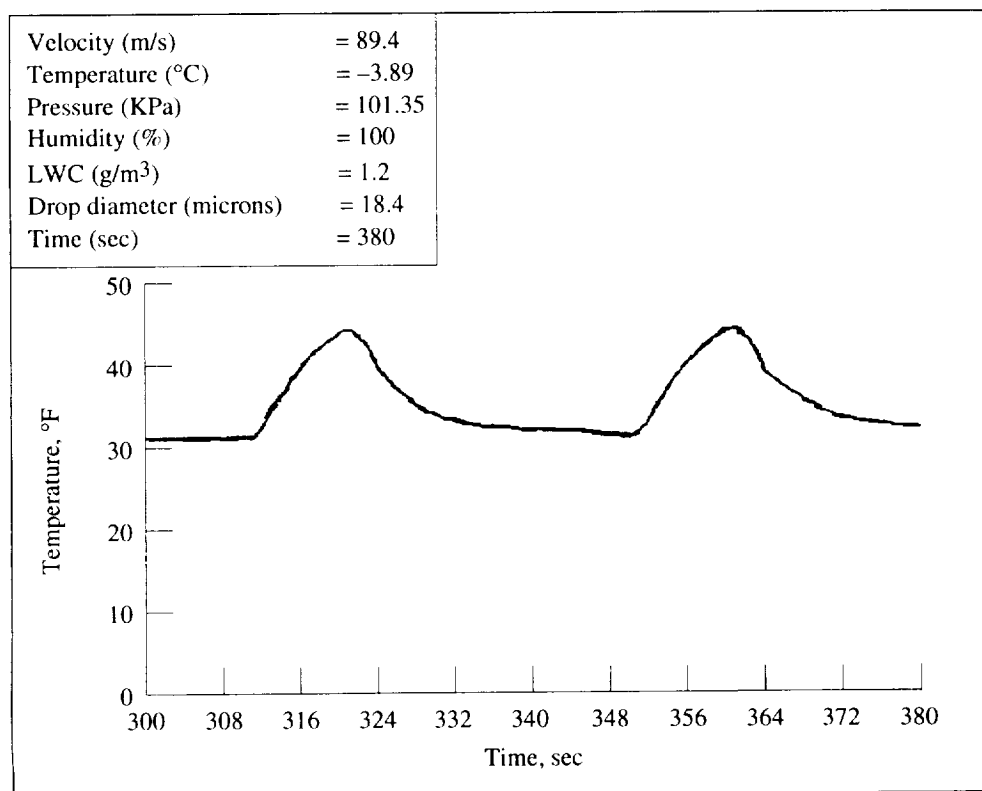
Figure 28.—Numerical prediction of ice/abrasion shield interface temperature at position 7.

## Table II - PHYSICAL CONSTRUCTION AND PHYSICAL PROPERTIES OF MATERIALS USED IN THE HELI-COPTER BLADE AND ELECTROTHERMAL DEICER

| Layer | Nodes | Thickness, in | Thermal conductivity, BTU/hr-ft-°F | Thermal diffusivity ft2/hr |
|---|---|---|---|---|
| Abrasion shield stainless steel | 6 | 0.030 | 8.7 | 0.15 |
| Adhesive epoxy | 4 | 0.0168 | 0.1 | 0.0058 |
| Insulation epoxy/glass | 4 | 0.0138 | 0.22 | 0.0087 |
| Adhesive epoxy | 4 | 0.0082 | 0.1 | 0.0058 |
| Heater element copper | 4 | 0.0065 | 60.0 | 1.15 |
| Adhesive epoxy | 4 | 0.0082 | 0.1 | 0.0058 |
| Insulation epoxy/glass | 4 | 0.0138 | 0.22 | 0.0087 |
| Adhesive epoxy | 2 | 0.0082 | 0.1 | 0.0058 |
| Blade skin stainless steel | 4 | 0.020 | 8.7 | 0.15 |
| Film adhesive FM 1000 | 3 | 0.01 | 0.1 | 0.0058 |
| Doubler aluminum | 10 | 0.05 | 102.0 | 2.83 |
| Film adhesive FM 1000 | 3 | 0.01 | 0.1 | 0.0058 |
| Doubler aluminum | 31 | 0.175 | 102.0 | 2.83 |

# DEICER INPUT FILE AND VARIABLES

This section is intended to help the user work with the input data for both the electrothermal deicers and all the layers of the airfoil below the surface of the abrasion shield where the airfoil is embedded. By properly inputting values and 'tagging' the appropriate variables, a user may numerically 'construct' virtually any airfoil/heater configuration for simulation. Any number of layers may be specified, each having its own thickness and material properties. Even the adhesive bonding between two layers can be accounted for by treating the adhesive as a separate layer having its own thickness and properties.

The heaters themselves may be specified to have different lengths, gap widths, intensities, firing sequences, etc., as well as having a different number of heaters within the deicing blanket. Thus there is maximum flexibility in using the code to simulate most airfoils, heater configurations and designs, as well as the operating conditions of the heaters.

The data files and input variables needed to run LEWICE before this version with the electrothermal upgrade will not be repeated here, since there has been no change made to those files and variables or how they are used. The additional input needed to run this version of LEWICE has all been placed in a separate data file called DEICE DATA. A numerical 'toggle' can be engaged in this data set, essentially turning it off, thus allowing LEWICE to be run in its original form prior to the electrothermal upgrade. The data file DEICE DATA is broken up into five sections: "Data for the Composite Body" which reads in the layers, thicknesses, heater geometry and configuration, and material property data for the composite body; "Data for the Heater" which reads in power densities and cycle times; "Boundary Condition Data" which reads in any boundary or initial condition that needs to be input that is not passed through or is not computed in the unmodified version of LEWICE; "Ice Property Data" which reads in the physical properties of the ice, the initial ice shape if one exists, the ambient conditions; and "Time Step and Input/Output Parameters" which reads in the time steps, the simulation time, and the print/plot options for the

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program.

Please refer to the hard copy of DEICE DATA found at the end of this section when reading the remainder of this section. Note that there is some brief documentation of some of the more commonly used variables within the body of DEICE DATA that will aid in the editing of the data set for a new airfoil/heater geometry and/or new operating conditions. The text that follows provides a more detailed explanation of those variables with an explanation of the remaining variables, broken down by the five input sections.

VM System: Before running this version of LEWICE, a filedef needs to be assigned to DEICE DATA prior to the execution of the code, along with the original data set file. If the filedef is not assigned just prior to execution, then it must be placed in as part of the exec file, if an exec file is used to compile and run the program. The procedure to define filedefs is machine dependent, thus the user will have to determine how this is done on the CPU unit that is being used to execute the code.

## DATA FOR THE COMPOSITE BODY

This version of LEWICE simulates the heat transfer in an airfoil by unwrapping it at the trailing edge and laying it flat on a two-dimensional rectangular plane. The y-direction is the direction normal to the airfoil surface and the x-direction is measured along the chord. The z-direction, along the span of the blade, is not modeled. This enhancement is not limited to the modeling of airfoils alone. As long as the assumption of a two-dimensional rectangular computational model remains valid, and accurate values of boundary conditions are computed or passed through by other subroutines, any component (engine inlet, windshield, etc.) can be modeled.

Using this information, the number of layers in the y-direction (L) is the number of different materials used in the construction of the deicer pad/airfoil. The number of sections in the x-direction (NX) is the number of heaters plus the number of heater gaps. Within each section (a

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particular heater or heater gap) the spacing between nodes is uniform. The grid spacing between individual sections, however, will not necessarily be the same. Additionally, a user can specify two or more grid spacings within a heater section by specifying two or more sub-sections within that section, each having the same thermal properties and watt densities, but having different lengths and different numbers of nodes. This feature can be used to place more grid points where the heater meets the gap to look at the large temperature gradient which exists there.

The next set of data specifies the physical properties of the deicer pad and the number of nodes within each layer. The units required for each property are given in the data file. Each line of data in this region represents a layer in the composite body. Therefore, the number of lines of physical property data must equal the number of layers specified by the variable L (the number of layers). If they are not equal, a run error will occur when the program tries to read in the set of comment statements that follow as data. The previous chapter provides an explanation of what the orthotropic factor is. For most materials, all values of this variable should be set equal to one. The limits on input are that the number of layers must be less than 30 and the sum of the nodes minus the number of layers plus 2 must be less than 190.

The next sub-section provides the physical properties and number of nodes for the heater layer. The thermal properties given here will be used only in the heater layer, which is specified in the next data section. Again, each line of data represents a region of constant nodal spacing. This means that each line provides data for a heater, or data for a gap. The number of lines in this region must be equal to the value of the variable NX (the number of sections in the layer containing the heaters). A run error will occur if the number of lines is different. The limits on input in the x-direction are the same as those for the y-direction given above.

The sum of the lengths of the heaters and the gaps represents the distance along the surface of the airfoil starting at the bottom of the tail, going around the stagnation point and back to the tail. However, this distance may not be known to the user. Because of this, the actual lengths of these end segments are determined by the program, which computes the actual distance around the

airfoil using the coordinates of the clean airfoil. The program then lengthens or shortens the end segments so that the sum of the individual segments is equal to the distance around the airfoil. In the printed output of the data, the program will list the actual lengths of the end segments that were used.

## DATA FOR THE HEATER

There are three methods used by the program to model a heat source. The method used is selected by the user by inputting a value for the variable IH from 1 to 3. For a value of IH=1, the program will not use any heat source terms and will ignore the rest of the data input from this section. This has previously been used only for debugging purposes, but the capability remains to use this option.

For a value of IH=2, the program will assume that the heater is a point heater, i.e., it has a zero thickness. In this case the heat source is not applied in the energy equation, but at the boundary between two adjoining layers in the deicer pad. This option was provided because the heater thickness is very thin. However, previous studies using this assumption (reference 5) have shown that using this option will overpredict the temperature in the deicer pad because there is no heater material for the source to have to diffuse through. For this case the user must supply values for the variables L1 and L2 which represent the layers between which the heater resides. The value of L1 must be one less than the value of L2. The variable IJ below this is not used if IH=2.

For a value of IH=3, the program will treat the heater as a volumetric heat source within one of the layers of the deicer. This is the option most often used and is the form of the heat source used in the governing equations presented in the previous chapter. For this case the user must supply a value for the variable IJ, which represents the layer in the y-direction that the heater is in. The program counts the bottom layer of the deicer as layer 1. This will be the first layer listed in the composite body data file. The variables L1 and L2 are not used by the program if IH=3.

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For either IH=2 or IH=3, there are five options which can be specified to determine the style of heater to be modeled. This option is specified by the variable IHQ. For a value of IHQ=1, all heaters remain on at their specified wattages for the entire simulation. The on/off times and lag times provided below this value are ignored for IHQ=1. This option has been used to determine the maximum amount of heating a particular configuration can provide.

For a value of IHQ=2 the heaters are on at their specified wattages for the amount of time given by the variable TON, then are off for the amount of time specified by the variable TOFF. The cycle then repeats for the duration of the simulation. The variable TLAG, the lag time, is used to turn the heaters off for a specified period of time before the cycle begins. This allows for ice accretion to take place for a period of time before the first heater turns on. After TLAG seconds have expired, that heater will turn on and begin its cycle. After this time, the value of TLAG is no longer used. Note that all sections, including the heater gaps, will have a wattage assigned to them. For a heater gap, the wattage will be zero. For a wattage of zero, the on time, off time, and lag time are not used, since there is no heater in that section to turn on and off.

For a value of IH=3, the heater will cycle as described above, but initially the heater wattage will be zero and will increase in a linear fashion to the wattage provided after TON seconds. The heater then turns off for TOFF seconds. For a value of IHQ=4, the heater will start at the given wattage, but will oscillate around that value in a sinusoidal manner for the duration of the on time, then it will turn off. These heater options were provided in previous deicer models developed at the University of Toledo, but have never been used by the code developer except to verify that the options work as designed. If you wish to design a deicer which operates in this fashion, you are sure to welcome the options to numerically model it using this program.

## BOUNDARY CONDITION DATA

Because the computational field is two-dimensional, there are four boundary conditions which need to be specified. These are assigned by the variables ICB1, ICB2, ICB3, and ICB4. A

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value of 1 for any of these parameters will denote a constant temperature boundary condition at that surface. A value of 2 for any of these parameters will denote a convective ($q = h \, \Delta T$) boundary. A value of 3 will denote an accretion boundary, and can only be used at the top surface of the grid where icing occurs. Convective boundaries are normally used at the other three surfaces.

The variable IBC2 defines the boundary condition to be used at the top surface of the ice and can have three values whereas the other surfaces can have only two. A value of 3 for IBC3 denotes the accretion boundary where kinetic heating, evaporation, latent heat, and sensible heat transfer occur as well as convection.

IBC1 is used for the bottom of the deicer, which is in the interior of the airfoil. This boundary is normally assumed to be insulated (h1=0) or to have a free convection boundary (h1 approximately = to 1 through 10). ICB3 is at the left boundary and ICB4 is at the right boundary. Both of these boundaries are normally considered to be insulated for the deicer pad. Since the entire airfoil is being modeled, both of these boundaries occur at the tail end of the airfoil and any boundary condition other than an insulated boundary at both surfaces would not be realistic.

The variables TX1, TX2, TX3, and TX4 provide the temperature at which the respective boundary will be held constant if a constant boundary condition is used. These values are ignored if a convective boundary is used. TG1, TG3, TG4, H1, H3, and H4 provide the ambient temperature and heat transfer coefficient at the bottom, left, and right sides, respectively. These values are ignored if a constant boundary condition is used. One application for using different boundary conditions and various ambient temperatures is for code verification with known solutions to heat transfer problems. The heat transfer coefficients at the top surface are passed to the program from LEWICE via a COMMON bloc. The ambient temperature at the top surface is also passed through by LEWICE.

Embedded within the boundary condition data section are several 'toggles' that determine if the program will consider certain special features. The toggle ICOND is used to control heat

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conduction into the airfoil during the icing period before the heaters are turned on. If ICOND=1, conduction will be neglected during icing and if ICOND=2, conduction will always be considered. This feature has two very important purposes. First, it is used to compare ice shapes generated with this version of LEWICE to those generated by the original LEWICE, and with the RAE's ice accretion code, neither of which considers conduction within the blade. Second, it is used to greatly reduce the computational time of the code.

With no heat source in the blade, the effects of conduction on the ice shape are small for many cases. The effect of conduction is seen in the resulting temperature profile around the blade. By neglecting conduction, the ice accretion energy balance at the top surface possesses no terms that change with time, other than those which are provided by LEWICE's flow/trajectory codes. Therefore, the solution to the temperature profile and the amount of ice accretion at each node is easily obtained, whereas if conduction is considered, it is a transient process. For example, if the flow code is updated every minute, and the time step of the conduction algorithm is 0.1 second, this represents a difference of having to perform 600 calculations if the conduction algorithm is considered versus only once if it is neglected.

The next variable, INIT, determines the temperature distribution to be used at time=0.0 for the simulation. If INIT=1, all of the temperatures are set equal to the ambient temperature. This option has been used for comparison with previous deicer programs which can only specify a constant initial temperature. If INIT=2, the temperature distribution in the deicer is set equal to the recovery temperature distribution. This is the surface temperature distribution the blade would obtain in dry conditions, that is, only kinetic heating and convective losses are considered. This is the most widely used option, as this most accurately models the actual temperature distribution in the blade when accretion starts. If INIT=3, the temperature distribution in the deicer is set equal to the accretion temperature distribution. This temperature distribution is obtained by solving the energy equation assuming no conduction. This option has been used to study the effects of conduction into or out of the blade, and whether this conduction is significant or not.

The next variable, ISH, determines if shedding of the ice is to be considered. Again, for comparison with previous programs in this area which do not model shedding, this feature needs to be turned off. If shedding is not considered, the blade information is not used except in the contribution of the speed to the kinetic heating term. For ISH=1, shedding is not considered, and for ISH=2, shedding of the ice is considered.

## ICE PROPERTY DATA

The first variable, IG, determines whether or not a change of phase will occur in the top layer of the grid. In a normal deicing run, the ice is the top layer of the composite body and is the only layer which can undergo phase change from solid to liquid. However, this option, IG=1, can be used to study the thermal behavior of a deicer pad under non-icing conditions. That is, there are only layers of metal, insulation, adhesive, etc., and there is no ice layer. Physical property data for ice and water in this section is ignored if there is no phase change. For IG=1, phase change in the top layer is not considered. For IG=2, phase change is considered in the top layer.

The next set of data provides physical property data for the ice and air. Most of these are self explanatory. The melting range, TR, is the temperature range over which icing occurs. Due to the numerical methods employed by the program, this range needs to exist and must be equal to or less than 10-4.

The next set of data provides the initial ice shape for the airfoil. This option is a throwback to the era in which the University of Toledo deicing codes did not calculate the amount of ice accretion, but used this option to specify the ice shape. Still, if the user wishes to start the simulation with something other than a clean airfoil, this capability still exists within the program and is useful in comparing the results of this code to previous deicer programs. The variable NP specifies the number of points the user wishes to input in the variable ice shape. The x-value (XP) and y-value (YP) correspond to the x-y coordinates of the ice on the rectangular grid. The program will then linearly interpolate between each point to generate a variable ice shape to start the

simulation. When a clean airfoil is desired at the start of a run, one needs to make sure that all values of YP are set to zero.

The actual thickness of the top layer of the simulation is specified with this input. The value specified in 'Data for the Composite Body' is only used for the purpose of determining the 'delta y' in the top layer. This is true even when the user specifies the top layer to be something other than ice. For example, if the user wishes to model just the deicer pad with no ice formation and no phase change potential, the thickness in this input should be set equal to the thickness of the top layer of the deicer pad. The last set of data in this section specifies the rotor speed and location. This information is used in shedding the ice and in the kinetic heating term in the energy balance. If a rotor is not being modeled, simply specify RPM=0.

## TIME STEP AND INPUT/OUTPUT PARAMETERS

The first part of this section specifies the time step to be used by the conduction algorithm. Note that the same time step does not have to be used for the entire simulation. This option was provided so that a smaller time step could be used to better resolve certain phenomena. For example, if experimental shedding data were available using a high speed camera and the shedding time could be determined to a hundredth of a second or even a thousandth of a second, the time step of the program could be lowered in this time interval to compare with these values. Each of the first two time steps (DTAUI, DTAUM) specified are used for the number of time steps given below it (NISP, NMSP). The last time step (DTAUF) is used for the remainder of the simulation.

The next input variable sets the maximum number of input iterations for the phase change calculation. The program assumes a phase (solid, mush, liquid) for each node, then calculates the temperature profile in the grid based on that assumption. The program then checks each phase to determine if that assumption was correct. If any of the assumptions were incorrect, new assumptions are made based on the predicted temperatures and a new temperature profile is calculated. If JCOUNT iterations are reached, the program will use the last temperature profile

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calculated and continue with the simulation. The program will also print out to the main output file the number of iterations used at any time step where it had to use more than 3 iterations. If several of the time steps require JCOUNT iterations, the results of the program will be suspect and the user will be provided with an error message.

The next variable, NPRT, provides the number of time steps at which the x-y coordinates of the ice shape will be printed out. This output is provided in addition to the ice shape output that LEWICE provides. Place the four digit integer of the time step that you wish below the four X's in the comment statement. The number of time steps provided must be equal to the value of NPRT. Note that the program asks for time step, and not the time. This requires the user to take the time at which you desire printout and divide by the time step provided above. For example, if the user wants to print out the coordinates of the iced airfoil after two minutes (120 seconds), take 120 seconds and divide by the time step for the conduction algorithm, which is usually 0.1 sec, which will result in a value of 1200 for the desired time step.

The last series of input data specifies the times and location when and where the user wishes printed output of the temperatures. These values are also the default plot options which will be used if the user wishes to plot the output. This is much more convenient than inputting all of this information at the terminal. There are five types of printed output that the user can specify. Currently, only one type of printed output can be specified per run. However, other types of output can be specified for plotting purposes.

There are five types of temperature output which can be specified by the user. All five have been used for one purpose or another. The variable IOTYPE selects the type of output the user wants. The variable NPTS specifies how many points are to printed out. There must be NPTS number of lines of input data following this statement. For IOTYPE=1, the program will print time in the first column and temperature in each of the following columns. Each column of temperatures is a user specified point in the grid. This type of output is comparable to the type of output generated by a thermocouple.

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The format to specify which point to print out has been designed so that users can input information they know rather than information that has to be calculated. For IOTYPE=1, the left column of integers specifies the section number in the x-direction where the requested point is located and the right column of integers specifies the layer number in the y-direction of the requested point. The left column of characters specifies where within that section (left (L), middle (M), right (R)) the user wishes output. Similarly, the right column of characters specifies where within the requested section (bottom (B), middle (M), top (T)) the user wishes output. Hence the user does not have to count nodes to be able to print out a certain point.

As an example, consider a heater mat with 11 heaters. Assume that there is a small gap between each heater. For 11 heaters there will be 12 gaps. The large unheated section from the tail point at the bottom surface to the edge of the first heater counts as a gap, albeit a large one, as does the large unheated section from the edge of the eleventh heater to the tail point on the upper surface. If the user wants to print out the time-temperature history of the node at the top of the sixth heater, in the middle of that heater, the following procedure is used. First, the user notes that in the gap-heater-gap setup used in the data file, heater five is the tenth section in the simulation (always count sections starting at the left of the grid and composite body layers from the bottom). Let's say that the heating element in this pad is the ninth layer in composite counting up from the bottom. Therefore, the user would identify this point with the designation 0012 M 0009 T in the proper format as seen in the example data file. This will print out the time-temperature history of the node in the middle of section 12 and at the top of layer 9. This is easier than adding nodes to find that this may be node 40 in the x-direction and node 37 in the y-direction. Each successive point desired is determined in the same manner. Note that due to the formatted output, the program will print zero's in the remainder of the columns where there is no data and that if more than 10 points are specified, points 11 through 20 will be printed below the results for points 1 through 10.

For IOTYPE=2, the program will print the distance along the chord, measuring from the stagnation point, in the leftmost column and temperature in the remaining columns. This shows the

variation of temperature with respect to chord distance at specified times and y-values. This type of output is comparable to the parameter plots used by LEWICE, which plots temperature, heat transfer coefficient, and so forth, as a function of distance along the airfoil. The left column of integers specifies the time step at which printout is needed and the right column specifies the layer in the y-direction. The left column of characters is not used for this print option and the right column of characters again pinpoints where within the layer the output is needed.

For example, if the user wishes to print out the ice-abrasion shield interface temperature after 10 seconds, the following procedure is used. First, 10 seconds is divided by the time step, usually 0.1, seconds to obtain 100. If the abrasion shield layer is 13 and the ice layer is 14, the user may specify this interface as either the top of layer 13 or the bottom of layer 14. Therefore, the data input for this would be 0100  T 0013  T. Note that although the left character is not used, the formatting of the input requires that it remain there. The selection of a 'T' is purely arbitrary.

For IOTYPE=3, the program will print the distance normal to the surface of the airfoil (y-direction) as measured from the substrate in the first column and temperatures in the remaining columns. This shows how the temperature varies in the y-direction at a selected chord and time. The left column of integers is used for the time step of the output and the right column is used for the section number in the x-direction, counting from the left boundary (the bottom of the tail). Note that the section number in the x-direction is in a different location than for IOTYPE=1. This is because the left column is used primarily to hold the time step. The left column is used for the section number only for IOTYPE=1, where both the section number and layer number need to be specified. The left column of characters is not used for this print type, and the right column of characters contains information on the location within the section where the printout is requested.

For example, if the user wants to print out the temperature distribution at the stagnation point after 10 seconds, the following procedure would be used. First, the time step of 100 would be calculated in the same manner as it was for IOTYPE=2. Then, the user determines that the stagnation point is in the middle of section 12, as performed for IOTYPE=1. Therefore the format

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of the input data for this case would be 0100 T 0012 M. Again note that the left character is provided even though it is not used by the program.

For IOTYPE=4, all data is provided at every time step in the simulation. This has been used for debugging purposes only, and it is not recommended to the user. The program will print the distance in the y-direction in the leftmost column, then will print the first 10 temperatures starting from the left side of the grid in the remaining columns. If there are more than 10 nodes in the x-direction, the program will repeat the above formatting for nodes 11 through 20, and so on. The time of the simulation to that point will precede the temperatures. For this type of output, all of the data in the four columns below IOTYPE is ignored, but for formatting purposes, the number of lines of input in this section must be the same as the value of NPTS.

For IOTYPE=5, all of the grid points are again printed, but only at the time steps provided in the left column of the input data. The other columns are not needed for this print type, but must remain because of the input format for this section. The format of the output is the same as for IOTYPE=4. This is the same type of output provided for earlier University of Toledo codes and has been kept so that direct comparisons of temperatures can be made between the temperature results of this program and the previous results.

# OUTPUT FILES LOCATED WITHIN SUBROUTINE UTICE

There are twelve different output files for the subroutine UTICE, which is the root computational module for the electrothermal upgrade of LEWICE. The output of UTICE is put into various files so that the user can more easily find the necessary output without having to traverse through much unneeded information. The output is printed in column form, so that most PC graphics software can more easily read the information in for plotting purposes. These output data files are provided in the order of the variables IO1 through IO12 in subroutine UTICE, which define the file numbers for outputting the data.

The first output file is called UTICE OUTPUT. Output going to this file is identified in the program by the variable IO1. This file contains the echo of the input data. This is helpful so that the user can check that the correct information was input. This file also prints out the ice shape using the rectangular computational grid. A zero will indicate no ice, a value of 9 will indicate the ice-abrasion shield interface, a value of 1 indicates an interior ice node, and the values 2 through 8 indicate an ice-ambient interface. By viewing this output, a user can get an idea of what the ice shape looks like.

This file also contains the number of phase iterations the program used at any particular time step. This information is printed only when the number of iterations used is greater than or equal to 3. This is useful in pinpointing when most of the ice is changing into liquid, and to make sure that the limit of iterations is not being reached. If the limit on the number of phase iterations (normally 20) is being reached several times during a run, the output may not be accurate.

The next output file, XY DATA, contains the x-y coordinates of the iced airfoil at the time steps given by the input variable ITIME. Output going to this file is identified in the program by the variable IO2. This file is the result of a mapping routine in UTICE, and not the result of LEWICE's mapping routine. There may be a difference between the two shapes because UTICE will always grow ice normal to the clean airfoil, whereas LEWICE will grow ice normal to the ice

shape at the previous time step.

The next two data files, HTC DATA1 and HTC DATA2, contain the x-coordinates and y-coordinates of the airfoil, the collection efficiencies, the static pressures at the edge of the boundary layer, and the heat transfer coefficients around the airfoil. Output going to these files is identified in the program by the variables IO3 and IO4. HTC DATA1 prints out this information using the grid in UTICE, and HTC DATA2 prints out this information using the grid in LEWICE. This was performed so that the user can compare the values that LEWICE generates with the values that UTICE uses. These values, after using the proper unit conversions, will be the same if there are no bugs in the program. These two files have been instrumental in locating the bugs which did exist and which were eliminated. The LEWICE output is in metric units, and the UTICE output is in English units.

The next output file, FORCE DATA, contains the results of the shedding routine. Output going to this file is identified in the program by the variable IO5. The first column is time, the second column is the adhesion force holding the ice on, and columns 3 through 5 are the components of the sum of the external forces in the 'z', 'x', and 'y' directions, respectively. These are found from the components of the aerodynamic force. The external force increases linearly with the mass of accreted ice, so this will increase with time. The adhesion force is dependent upon the bonding strength, which in turn is assumed to be solely a function of the temperature at the ice-abrasion shield interface. This will vary during the course of a run, especially when the deicer is firing.

The next output file, TEMPS DATA, contains the printed output of the nodal temperatures in the format specified by the user. Output going to this file is identified in the program by the variable IO6. The formatting is performed using the IOTYPE variable in the INOUT DATA input file and by the columns of integers and characters below IOTYPE. The first column in this output file will be the independent variable x, y, or t and the other columns will be the specified temperatures.

The next output file, ACCRET TEMPS, contains the printed output of the temperature and enthalpy at the ice-ambient surface assuming no conduction into the blade. Output going to this file is identified in the program by the variable IO7. This information is generated by solving the accretion energy balance at each nodal location. The first column will contain the distance from the stagnation point, in inches. The second column is the temperature at that location in degrees Fahrenheit, and the third column is the enthalpy at that location in units of BTU's per cubic foot. For those cases in which conduction into the blade has been neglected (using the input variable ICOND) and no heaters are fired, this file contains the actual temperatures at each location.

The next output file, YPN DATA, contains the amount of ice accretion at each node in the rectangular computational grid. Output going to this file is identified in the program by the variable IO8. The first column will contain the distance from the stagnation point in inches. The second column contains the amount of ice at that location. This file, along with the output file DICE DATA, was also useful in debugging the program. It is also useful for finding the maximum amount of ice accretion on the airfoil. This information is printed using the nodal locations used by DEICE.

The next data file, QENER DATA, contains the printed output of the terms in the accretion energy balance. Output going to this file is identified in the program by the variable IO9. These terms are calculated assuming no conduction into the airfoil. The first column contains the distance from the stagnation point in inches. The second column contains the amount of heat lost due to convection in watts per square meter. This set of units was used so that comparisons could be made between the relative importance of the heater wattage to these values. The third column contains the amount of heat gained from kinetic heating with the air. The fourth column contains the additional amount of kinetic heat gain due to the impinging water droplets. The fifth column is the amount of heat lost due to evaporation. The sixth column contains the sensible and latent heat transfer from the impinging supercooled water droplets. The seventh column contains the sensible and latent heat transfer from the water which enters this node from the previous node. For cases

where there is a large amount of runback, this term will be larger than the previous value. The last column contains the sum of the previously described heat fluxes, and since conservation of energy applies, this value should always be very close to zero. This was done to check the program to see if indeed energy is conserved by the calculation.

The next output file, QPART DATA, contains the heat fluxes in the energy balance including conduction. Output going to this file is identified in the program by the variable IO10. The output format is the same as the previous data file, except for the last two. The next-to-the-last column is the heat flux due to conduction in the y-direction, and the last column is the sum of the heat fluxes, including conduction. If the last column is not zero, this represents the heat flux due to conduction in the x-direction.

The next output file, DICE DATA, contains the incremental amount of ice which will be added to the LEWICE ice shape once UTICE has completed a time-set of computations. Output going to this file is identified in the program by the variable IO11. The first column is the distance from the stagnation point in meters. The second column contains the amount of ice accretion, in meters, which is to be added in that time step. This is the same information which is printed in the file YPN DATA, except the information in DICE DATA is printed using the nodal spacing used in LEWICE. Again, a comparison of the values between these two output files can be made to check the interaction between the two programs.

The final output file, MASS DATA, contains the mass fluxes of each term in the accretion mass balance. Output going to this file is identified in the program by the variable IO12. The format of this output is the same as that found in the usual LEWICE output file EXAMPLE1 OUTPUT. The first column is the distance from the stagnation point in meters. The second column contains the heat flux through the ice-abrasion shield interface due to conduction. This is the same value as the conduction heat flux in the previous output file. This was included in this file to make the output have the same format as the usual LEWICE output. The third column contains the mass flux impinging at that location in kilograms per square meter. The fourth column contains the mass flux

entering the control volume due to runback. The fifth column contains the mass flux lost due to evaporation. The sixth column contains the total mass flux entering the control volume, which is the sum of columns three and four. Finally, the last column contains the net mass flux remaining in the control volume, which is determined by subtracting column five from column six.

# INTERACTIVE INPUT AND OUTPUT

In addition to the interactive input/output that the original version of LEWICE required, there are additional interactive requirements in the upgraded version. This is intended primarily as a convenience, since the interactive information asked for is mainly either a verification of input data, or for variables that may or may not be desired, depending upon the object/intent of that particular run. Only the added interactive requirements will be discussed here.

After asking for the standard LEWICE input, the program will access the subroutine WINPUT, which allows the user to check the input file before S24Y, the LEWICE flow module, is executed. In this subroutine, the user will be asked two questions. The first one will ask if the data printed on the screen is satisfactory, meaning that this is the data the user wishes to input. If the answer is no, the program will stop running and will prompt you to make the necessary changes in the input data file. In this manner, the user can see what data the program is reading in, so that the user knows that everything has been input in the required format. Before this feature was added, it was disappointing to see LEWICE complete the flow and trajectory modules only to come across an input error in the deicer module such that the run had to be manually stopped.

The second question asks the user if the rest of the data within that section should be viewed. Initially, it is useful to view all of the input information to familiarize the user with the data being input. The user is prompted for the answers to these two questions in each section of the data file. Later on, it is helpful to skip over these sections which have not been changed, so that the terminal input by the user is minimized.

At the start of routine UTICE in LEWICE, the subroutine SETTYP is accessed. SETTYP determines the type of plot options that the user wants. This routine will not be accessed unless the user selects parameter plots in the LEWICE plot options. This routine will then ask you to select from 10 plot options and up to 3 ways to plot those options. Only temperatures can be plotted as a function of y-direction, because this is the only one of the 10 which is a function of the y-direction.

Time dependent plots are limited to temperature, the total heat flux, and the runback mass flux because the others either did not depend upon time or provided no new information.

If a plot type is selected by the user which is the same as the type selected in the input data file using the variable IOTYPE, the user will be asked if these options are to be used for plotting as well. When specifying plot options, it is not necessary to respecify the values in the input data file INOUT DATA. If the option selected is not the default option, the program will prompt the user for the same type of input as the input data file asks for, namely layer numbers and positions, and time steps for output. If the plot style is different from the default value, the program will simply prompt the user for data to be input. The user is encouraged to use the default options, as this saves a significant amount of tedious inputting of values at the terminal. Care must be taken to input the data in the requested format. Inputting the data in the incorrect format may cause the program to plot nonexistent points.

The selection of the plot options is performed separately from the actual plotting of the data, so that the program only has to store those values which need to be plotted. This was done not to save on computational time, but to save on virtual memory space by allowing the arrays needed for the plotting routines to have a smaller value. This was necessary because the program does require a lot of virtual memory to store all of the information it generates. This program has been run on the University of Toledo's VAX system, so there should be no difficulty with installation of this upgrade to LEWICE on another VAX or larger system with a FORTRAN compiler. The prompts for the actual plotting of the data, such as the minima and maxima for the plot, are the same as for the existing LEWICE parameter plots. In addition, the program will give you the plot number and style immediately prior to plotting so that the user may keep track of which plot is being presented. Enter '0' and press RETURN to get rid of this message and to see the plot.

Provided in the next few pages are a sample of the screen messages and typical interactive input/output in a normally executed run for LEWICE with the electrothermal upgrade.

FILE: MANUAL    NWK    A          VM/SP CONVERSATIONAL MONITOR SYSTEM

```
Ready; T=0.01/0.06 08:34:29
iceb example1
DMKTDK355I DASD is being cleared
DASD 300 DEFINED 0030 CYL
DMSACP723I C (500) R/O
DMSLIO740I Execution begins...
TIME =  0.

ENTER DESIRED ICING TIME (SEC), (F10.1)
380.

ARE NEW PLOT OPTIONS DESIRED? (Y/N)
y

AVAILABLE PLOT OPTIONS
   0 - NO PLOTS
   1 - PARAMETER PLOTS ONLY
   2 - TRAJECTORY PLOTS ONLY
   3 - PARAMETER AND TRAJECTORY PLOTS
ENTER PLOT OPTION (I1)
1
THIS QUESTION WILL SKIP ALL ERROR CHECKING OF INPUT.
DO YOU WISH TO SEE ALL THE DATA IN THIS SECTION?
ANSWER Y OR N.
y

TOTAL NUMBER OF LAYERS                L= 14
NUMBER OF HEATER SECTIONS             NX= 23
IS THE INPUT DATA SATISFACTORY? ANSWER Y OR N.
y
COMPOSITE BODY DATA
DO YOU WISH TO SEE ALL THE DATA IN THIS SECTION?
ANSWER Y OR N.
y
```

| # NODES | LENGTH(IN) | CONDUCTIVITY (BTU/FT*HR*F) | DIFFUSIVITY FT**2/HR | KY/KX |
|---|---|---|---|---|
| 5 | 0.07500 | 102.000000 | 2.830000 | |
| 3 | 0.01000 | 0.100000 | 0.005800 | |
| 5 | 0.05000 | 102.000000 | 2.830000 | |
| 3 | 0.01000 | 0.100000 | 0.005800 | |
| 4 | 0.02000 | 8.700000 | 0.150000 | |
| 2 | 0.00820 | 0.100000 | 0.005800 | |
| 4 | 0.01380 | 0.220000 | 0.008700 | |
| 4 | 0.00820 | 0.100000 | 0.005800 | |
| 4 | 0.00650 | 60.000000 | 1.150000 | |
| 4 | 0.00820 | 0.100000 | 0.005800 | |
| 4 | 0.01380 | 0.220000 | 0.008700 | |
| 4 | 0.00820 | 0.100000 | 0.005800 | |
| 6 | 0.03000 | 8.700000 | 0.150000 | |
| 21 | 0.25000 | 1.290000 | 0.044600 | |

| # NODES | LENGTH(IN) | CONDUCTIVITY (BTU/FT*HR*F) | DIFFUSIVITY FT**2/HR |
|---|---|---|---|
| 8 | 5.50000 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |

| | | | |
|---|---|---|---|
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 8 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 14 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 26 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 41 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 26 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 14 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 8 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 8 | 6.50000 | 0.100000 | 0.005800 |

```
IS THE INPUT DATA SATISFACTORY? ANSWER Y OR N.
n
PLEASE CHANGE THE FILE DEICE3 DATA
TO REFLECT THE PROPER DATA AND RERUN THE CASE.
IT IS NOT NECESSARY TO RECOMPILE.
DASD 500  DETACHED




LEWICE IS NOW COMPLETE. REMEMBER TO ERASE THE RESTART FILE.
Ready; T=0.47/0.95 08:37:03
hardcopy off  manual nwk
```

```
Ready; T=0.02/0.07 15:33:40
iceb example1
DASD is being cleared
DASD 300 DEFINED 0030 CYL
195 replaces G (195)
C (500) R/O
Execution begins...
TIME =  0.

ENTER DESIRED ICING TIME (SEC), (F10.1)
250.

ARE NEW PLOT OPTIONS DESIRED? (Y/N)
y

AVAILABLE PLOT OPTIONS
   0 - NO PLOTS
   1 - PARAMETER PLOTS ONLY
   2 - TRAJECTORY PLOTS ONLY
   3 - PARAMETER AND TRAJECTORY PLOTS
ENTER PLOT OPTION (I1)
1
THIS QUESTION WILL SKIP ALL ERROR CHECKING OF INPUT.
DO YOU WISH TO SEE ALL THE DATA IN THIS SECTION?
ANSWER Y OR N.
y

TOTAL NUMBER OF LAYERS                 L= 14
NUMBER OF HEATER SECTIONS              NX= 23
IS THE INPUT DATA SATISFACTORY? ANSWER Y OR N.
y
COMPOSITE BODY DATA
DO YOU WISH TO SEE ALL THE DATA IN THIS SECTION?
ANSWER Y OR N.
y
```

| # NODES | LENGTH(IN) | CONDUCTIVITY (BTU/FT*HR*F) | DIFFUSIVITY FT**2/HR | KY/KX |
|---|---|---|---|---|
| 5 | 0.07500 | 102.000000 | 2.830000 | |
| 3 | 0.01000 | 0.100000 | 0.005800 | |
| 5 | 0.05000 | 102.000000 | 2.830000 | |
| 3 | 0.01000 | 0.100000 | 0.005800 | |
| 4 | 0.02000 | 8.700000 | 0.150000 | |
| 2 | 0.00820 | 0.100000 | 0.005800 | |
| 4 | 0.01380 | 0.220000 | 0.008700 | |
| 4 | 0.00820 | 0.100000 | 0.005800 | |
| 4 | 0.00650 | 60.000000 | 1.150000 | |
| 4 | 0.00820 | 0.100000 | 0.005800 | |
| 4 | 0.01380 | 0.220000 | 0.008700 | |
| 4 | 0.00820 | 0.100000 | 0.005800 | |
| 6 | 0.03000 | 8.700000 | 0.150000 | |
| 21 | 0.25000 | 1.290000 | 0.044600 | |

| # NODES | LENGTH(IN) | CONDUCTIVITY (BTU/FT*HR*F) | DIFFUSIVITY FT**2/HR |
|---|---|---|---|
| 8 | 6.50000 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |

| | | | |
|---|---|---|---|
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 8 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 14 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 26 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 41 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 26 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 14 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 8 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 8 | 6.50000 | 0.100000 | 0.005800 |

```
IS THE INPUT DATA SATISFACTORY? ANSWER Y OR N.
y
INTERNAL HEAT GENERATION IN SLAB NUMBER        JJ= 9
                              BETWEEN NODE   NO1= 24
                                  AND NODE   NO2= 27
HEATER DATA
DO YOU WISH TO SEE ALL THE DATA IN THIS SECTION?
ANSWER Y OR N.
y
```

| | | | | |
|---|---|---|---|---|
| 1 | 30.00000 | 5.00000 | 60.00000 | 120.00000 |
| 2 | 30.00000 | 60.00000 | 60.00000 | 120.00000 |
| 3 | 30.00000 | 5.00000 | 60.00000 | 120.00000 |

```
STEP FUNCTION HEAT INPUT IN WATTS/IN*IN
IS THE INPUT DATA SATISFACTORY? ANSWER Y OR N.
y

FULL ACCRETION BALANCE IS USED AT TOP SURFACE


COMPOSITE BODY TEMPERATURES ARE INITIALIZED

0 THE ACCRETION BALANCE TEMPERATURE PROFILE


CONDUCTION INTO THE BLADE IS NOT CONSIDERED BEFORE THE HEATER(S) TURN ON.

SHEDDING OF ICE IS CONSIDERED

IS THE INPUT DATA SATISFACTORY? ANSWER Y OR N.
y
```

72

PHYSICAL PROPERTY DATA
DO YOU WISH TO SEE ALL THE DATA IN THIS SECTION?
ANSWER Y OR N.
y


CONVECTION OCCURS        AT  J=1
         AMBIENT TEMPERAT URE     TG1=      9.400000DEG.F
         HEAT TRANSFER COEFF.     H1 =      1.000000B.T.U/HR.FT.FT.DEG.F
INSULATED BOUNDARY CONDITION ON LEFT SIDE.

INSULATED BOUNDARY CONDITION ON RIGHT SIDE.



THE PHASE CHANGE IN THE ICE LAYER IS CONSIDERED

LATENT HEAT OF ICE                        HLAM =   143.399994B.T.U./LB
THERMAL CONDUCTIVITY OF WATER             AKL  =     0.320000B.T.U./HR.FT.DEG.F
DENSITY OF WATER                          DEL  =    62.399994LB/CU.FT
SPECIFIC HEAT * DENSITY OF WATER          CPL  =    62.212799B.T.U./CU.FT.DEG.F
DENSITY OF ICE                            DES  =    57.399994LB/CU.FT.
THE MELTING TEMPERATURE                   TMP  =    32.000000DEG.F

ICE MELTING RANGE                         TR   =     0.000010DEG.F
HEAT OF VAPORIZATION                      HVAP =  1075.159910 BTU/LB
HEAT CAPACITY OF AIR                      CPAIR =     0.250000 BTU/LB*DEG F
NUMBER OF POINTS IN ICE SHAPE APPROXIMATION  NP = 2
        X-COORDINATE XP =   0.00000        Y-COORDINATE YP =   0.00000
        X-COORDINATE XP =  30.37717        Y-COORDINATE YP =   0.00000
AMBIENT TEMPERATURE,TINF =    9.320 DEG. F
LIQUID WATER CONTENT,LWC =    0.5000 G/M**3
AMBIENT VELOCITY,VINF =  424.737549 FT/S
DROPLET DIAMETER,DROP =   20.0000 MICRONS
AMBIENT PRESSURE,PINF =   13.161913 PSI
ANGLE OF ATTACK,ALPHA =   0.000 DEG
IS THE INPUT DATA SATISFACTORY? ANSWER Y OR N.
y
TIME STEP AND DEFAULT PLOT OPTIONS
DO YOU WISH TO SEE ALL THE DATA IN THIS SECTION?
ANSWER Y OR N.
y

INITIAL TIME STEP                         DTAUI =     0.100000SECS
                   FOR TIME STEPS NISP   = 10
INTERMIDIATE TIME STEP                    DTAUM =     0.100000SECS
                   FOR TIME STEPS NMSP   =100
FINAL TIME STEP                           DTAUF =     0.100000SECS
NUMBER OF SECONDS IN THE SIMULATION    TIMEOUT =     250.0000 SEC
MAXIMUM NUMBER OF ITERATIONS FOR PHASE ROUTINE  JCOUNT = 20


X-Y COORDINATES OF THE ICE SHAPE WILL BE PRINTED OUT
AT THE FOLLOWING TIME STEPS
        1200

```
          1800
          2400
          2500
X-LAYER  WHERE(L-M-R)  Y-LAYER  WHERE(B-M-T)

    8       M           9        T
    8       M          13        T
   10       M           9        T
   10       M          13        T
   12       M           9        T
   12       M          13        T
   14       M           9        T
   14       M          13        T
   16       M           9        T
   16       M          13        T
IS THE INPUT DATA SATISFACTORY? ANSWER Y OR N.
y

THE POTENTIAL FLOW FIELD IS NOW BEING CALCULATED

      XO           YO                          XP        YP        S          DT

   UPPER SURFACE LIMIT          LOWER SURFACE LIMIT
      YOU          SU               YOL          SL
   0.1114E-01   0.4066E-01      -0.1115E-01  -0.4093E-01


          AVAILABLE PLOT OPTIONS
          0  -  NO PLOTS
          1  -  TEMPERATURE
          2  -  HEAT FLUX DUE TO CONVECTION
          3  -  HEAT FLUX DUE TO KINETIC HEATING
          4  -  HEAT FLUX DUE TO EVAPORATION
          5  -  HEAT FLUX DUE TO SENSIBLE HEAT
          6  -  HEAT FLUX DUE TO LATENT HEAT
          7  -  NET HEAT FLUX AT SURFACE
          8  -  IMPINGING MASS FLUX
          9  -  MASS FLUX DUE TO EVAPORATION
          10 -  MASS FLUX DUE TO RUNBACK
     ENTER OPTION NUMBER (I2)
01

          SECONDARY PLOT OPTIONS
          THE Y-DIRECTION IS NORMAL TO THE BLADE SURFACE
          0  -  NO PLOTS
          1  -  TIME DEPENDANT PLOTS AT A SPECIFIED X,Y LOCATION
          2  -  CHORD DEPENDANT PLOTS AT A SPECIFIED Y AND TIME
          3  -  Y-DEPENDANT PLOTS AT A SPECIFIED CHORD AND TIME
     ENTER OPTION NUMBER (I2)
03
THE VALUE OF IOTYP IS NOT EQUAL TO THE DEFAULT VALUE
GIVEN IN THE INPUT DATA SET (DEICE3 DATA).
IF THE VALUE INPUT HERE IS GOING TO BE USED MORE OFTEN,
IT IS STRONGLY RECOMMENDED THAT YOU CHANGE THE DEFAULT VALUE.
```

THERE ARE 2500 TIMESTEPS IN THE SIMULATION

HERE ARE 23 SECTIONS IN THE X-DIRECTION
HEATER   1 IS IN SECTION  10
HEATER   2 IS IN SECTION  12
HEATER   3 IS IN SECTION  14

INPUT THE LAYER IN THE X-DIRECTION THAT YOU WISH TO PLOT
FORMAT I2
12
INPUT WHICH POINT (LEFT [L], MIDDLE [M], OR RIGHT[R]) YOU WISH TO PLOT
FORMAT A1
m

INPUT THE TIME STEP AT WHICH YOU WANT THE DATA PLOTTED
FORMAT I5
2400
DO YOU WISH TO INPUT ANOTHER PAIR OF POINTS? (Y OR N)
n

        SECONDARY PLOT OPTIONS
          THE Y-DIRECTION IS NORMAL TO THE BLADE SURFACE
          0  -   NO PLOTS
          1  -   TIME DEPENDANT PLOTS AT A SPECIFIED X,Y LOCATION
          2  -   CHORD DEPENDANT PLOTS AT A SPECIFIED Y AND TIME
          3  -   Y-DEPENDANT PLOTS AT A SPECIFIED CHORD AND TIME
   ENTER OPTION NUMBER (I2)
00

        AVAILABLE PLOT OPTIONS
          0  -   NO PLOTS
          1  -   TEMPERATURE
          2  -   HEAT FLUX DUE TO CONVECTION
          3  -   HEAT FLUX DUE TO KINETIC HEATING
          1  -   HEAT FLUX DUE TO EVAPORATION
          5  -   HEAT FLUX DUE TO SENSIBLE HEAT
          6  -   HEAT FLUX DUE TO LATENT HEAT
          7  -   NET HEAT FLUX AT SURFACE
          8  -   IMPINGING MASS FLUX
          9  -   MASS FLUX DUE TO EVAPORATION
          10 -   MASS FLUX DUE TO RUNBACK
   ENTER OPTION NUMBER (I2)
00

        SECONDARY PLOT OPTIONS
          THE Y-DIRECTION IS NORMAL TO THE BLADE SURFACE
          0  -   NO PLOTS
          1  -   TIME DEPENDANT PLOTS AT A SPECIFIED X,Y LOCATION
          2  -   CHORD DEPENDANT PLOTS AT A SPECIFIED Y AND TIME
          3  -   Y-DEPENDANT PLOTS AT A SPECIFIED CHORD AND TIME
   ENTER OPTION NUMBER (I2)
00
TIME =    120.00 SEC
TIME =    122.00 SEC
TIME =    124.00 SEC
                                                    75

```
TIME =     126.00 SEC
TIME =     128.00 SEC
TIME =     130.00 SEC
TIME =     132.00 SEC
TIME =     134.00 SEC
TIME =     136.00 SEC
TIME =     138.00 SEC
TIME =     140.00 SEC
TIME =     142.00 SEC
TIME =     144.00 SEC
TIME =     146.00 SEC
TIME =     148.00 SEC
TIME =     150.00 SEC
TIME =     152.00 SEC
TIME =     154.00 SEC
TIME =     156.00 SEC
TIME =     158.00 SEC
TIME =     160.00 SEC
TIME =     162.00 SEC
TIME =     164.00 SEC
TIME =     166.00 SEC
TIME =     168.00 SEC
TIME =     170.00 SEC
TIME =     172.00 SEC
TIME =     174.00 SEC
TIME =     176.00 SEC
TIME =     178.00 SEC
TIME =     180.00 SEC
TIME =     182.00 SEC
TIME =     184.00 SEC
TIME =     186.00 SEC
TIME =     188.00 SEC
TIME =     190.00 SEC
TIME =     192.00 SEC
TIME =     194.00 SEC
TIME =     196.00 SEC
TIME =     198.00 SEC
TIME =     200.00 SEC
TIME =     202.00 SEC
TIME =     204.00 SEC
TIME =     206.00 SEC
TIME =     208.00 SEC
TIME =     210.00 SEC
TIME =     212.00 SEC
TIME =     214.00 SEC
TIME =     216.00 SEC
TIME =     218.00 SEC
TIME =     220.00 SEC
TIME =     222.00 SEC
TIME =     224.00 SEC
TIME =     226.00 SEC
TIME =     228.00 SEC
TIME =     230.00 SEC
TIME =     232.00 SEC
TIME =     234.00 SEC
```

```
TIME =     236.00 SEC
TIME =     238.00 SEC
TIME =     240.00 SEC
TIME =     242.00 SEC
TIME =     244.00 SEC
TIME =     246.00 SEC
TIME =     248.00 SEC
TIME =     250.00 SEC
DEICER OUTPUT PLOT NUMBER   1 TYPE #   1
ENTER 0 AND HIT RETURN TO CONTINUE
0
Graphics device NOT assigned.
ENTER desired device name or HELP HELP.
CEGDIN100R DEFAULT to CANCEL.
b77b1t
Device B77B1T attached.
```

```
PLOT #   1 OF VARIABLE =   1 DEP. VARIABLE #   1
  MAXIMUM VALUES: TIME (S)      0.25000E+03 T (F)          0.83724E+02

  MINIMUM VALUES: TIME (S)      0.00000E+00 T (F)          0.00000E+00

  ENTER MAXIMUM X-AXIS VALUE.
300.
  ENTER MINIMUM X-AXIS VALUE.
0.
  ENTER MAXIMUM Y-AXIS VALUE.
300.
  ENTER MINIMUM Y-AXIS VALUE.
0.
  IF YOU WOULD LIKE A DIFFERENT SCALE, ENTER 1.
  IF NOT, ENTER 0.
10
PLOT #   2 OF VARIABLE =   1 DEP. VARIABLE #   1
  MAXIMUM VALUES: TIME (S)      0.25000E+03 T (F)          0.83724E+02

  MINIMUM VALUES: TIME (S)      0.00000E+00 T (F)          0.00000E+00

  ENTER MAXIMUM X-AXIS VALUE.
300.
  ENTER MINIMUM X-AXIS VALUE.
0.
  ENTER MAXIMUM Y-AXIS VALUE.
300.
  ENTER MINIMUM Y-AXIS VALUE.
0.
```

```
IF YOU WOULD LIKE A DIFFERENT SCALE, ENTER 1.
IF NOT, ENTER 0.
0
PLOT #    1 OF VARIABLE #   1 DEP. VARIABLE #    1
  MAXIMUM VALUES: TIME (S)       0.25000E+03 T (F)          0.16628E+03

  MINIMUM VALUES: TIME (S)       0.00000E+00 T (F)          0.00000E+00

  ENTER MAXIMUM X-AXIS VALUE.
300.
  ENTER MINIMUM X-AXIS VALUE.
0.
  ENTER MAXIMUM Y-AXIS VALUE.
300.
  ENTER MINIMUM Y-AXIS VALUE.
0.
  IF YOU WOULD LIKE A DIFFERENT SCALE, ENTER 1.
  IF NOT, ENTER 0.
0
PLOT #    1 OF VARIABLE #   1 DEP. VARIABLE #    1
  MAXIMUM VALUES: TIME (S)       0.25000E+03 T (F)          0.37921E-02

  MINIMUM VALUES: TIME (S)       0.00000E+00 T (F)          0.00000E+00

  ENTER MAXIMUM X-AXIS VALUE.
300.
  ENTER MINIMUM X-AXIS VALUE.
0.
  ENTER MAXIMUM Y-AXIS VALUE.
300.
  ENTER MINIMUM Y-AXIS VALUE.
0.
  IF YOU WOULD LIKE A DIFFERENT SCALE, ENTER 1.
  IF NOT, ENTER 0.
0.
PLOT #    1 OF VARIABLE #   1 DEP. VARIABLE #    1
  MAXIMUM VALUES: TIME (S)       0.25000E+03 T (F)          0.27000E+02

  MINIMUM VALUES: TIME (S)       0.00000E+00 T (F)          0.00000E+00

  ENTER MAXIMUM X-AXIS VALUE.
300.
  ENTER MINIMUM X-AXIS VALUE.
0.
  ENTER MAXIMUM Y-AXIS VALUE.
300.
  ENTER MINIMUM Y-AXIS VALUE.
0.
  IF YOU WOULD LIKE A DIFFERENT SCALE, ENTER 1.
  IF NOT, ENTER 0.
0.
PLOT #    1 OF VARIABLE #   1 DEP. VARIABLE #    1
  MAXIMUM VALUES: TIME (S)       0.25000E+03 T (F)          0.23046E-02

  MINIMUM VALUES: TIME (S)       0.00000E+00 T (F)          0.00000E-00
```

```
 ENTER MAXIMUM X-AXIS VALUE.
300.
 ENTER MINIMUM X-AXIS VALUE.
0.
 ENTER MAXIMUM Y-AXIS VALUE.
300.
 ENTER MINIMUM Y-AXIS VALUE.
0.
 IF YOU WOULD LIKE A DIFFERENT SCALE, ENTER 1.
 IF NOT, ENTER 0.
0.
DEICER OUTPUT PLOT NUMBER   2 TYPE #   1
ENTER 0 AND HIT RETURN TO CONTINUE
0


  NACA 0012  : EXAMPLE 1         : TIME= 250.000 SEC

 ICING CONDITION:

        STATIC TEMPERATURE (C)          260.55
        STATIC PRESSURE (PA)          90748.00
        VELOCITY (M/S)                  129.46
        LWC (G/M**3)                      0.50
        DROPLET DIAMETER (MICRONS)       20.00


 ICE ACCRETION DATA:

        STAGNATION POINT                 70
        TRANSITION POINTS (LOWER,UPPER)  68       71
        ICING LIMITS (LOWER,UPPER)       42       98
        NUMBER OF POINTS                139
        NUMBER OF SEGMENTS ADDED          0

           AVAILABLE PLOT OPTIONS
             0  -  NO PLOTS
             1  -  ICED GEOMETRY
             2  -  YO VS S
             3  -  BETA VS S
             4  -  VE VS S
             5  -  TE VS S
             6  -  PE VS S
             7  -  TSURF VS S
             8  -  HTC VS S
             9  -  XK VS S
            10  -  ICE DENSITY VS S
            11  -  FFRAC VS S
    ENTER OPTION NUMBER (I2)
01

ENTER PERCENT OF GEOMETRY TO BE PLOTTED (F10.0)
15.
```

```
            AVAILABLE PLOT OPTIONS
                0  -   NO PLOTS
                1  -   ICED GEOMETRY
                2  -   YO VS S
                3  -   BETA VS S
                4  -   VE VS S
                5  -   TE VS S
                6  -   PE VS S
                7  -   TSURF VS S
                8  -   HTC VS S
                9  -   XK VS S
                10 -   ICE DENSITY VS S
                11 -   FFRAC VS S
      ENTER OPTION NUMBER (I2)
08
 MAXIMUM VALUES: S=    0.54419,  HTC    1236.27612
 MINIMUM VALUES: S=   -0.54361,  HTC       0.00000

 ENTER MAXIMUM X-AXIS VALUE.
0.2
 ENTER MINIMUM X-AXIS VALUE.
-0.2
 ENTER MAXIMUM Y-AXIS VALUE.
1300.
 ENTER MINIMUM Y-AXIS VALUE.
0.
ENTER 1 IF EXPERIMENTAL DATA IS TO BE PLOTTED
IF NOT, ENTER 0
0
 IF YOU WOULD LIKE A DIFFERENT SCALE, ENTER 1.
 IF NOT, ENTER 0.
0

            AVAILABLE PLOT OPTIONS
                0  -   NO PLOTS
                1  -   ICED GEOMETRY
                2  -   YO VS S
                3  -   BETA VS S
                4  -   VE VS S
                5  -   TE VS S
                6  -   PE VS S
                7  -   TSURF VS S
                8  -   HTC VS S
                9  -   XK VS S
                10 -   ICE DENSITY VS S
                11 -   FFRAC VS S
      ENTER OPTION NUMBER (I2)
03
 MAXIMUM VALUES: S=    0.54419,  BETA      0.64460
 MINIMUM VALUES: S=   -0.54361,  BETA      0.00000

 ENTER MAXIMUM X-AXIS VALUE.
0.2
 ENTER MINIMUM X-AXIS VALUE.
-0.2
```

80

```
 ENTER MAXIMUM Y-AXIS VALUE.
1.0
 ENTER MINIMUM Y-AXIS VALUE.
0.0
ENTER 1 IF EXPERIMENTAL DATA IS TO BE PLOTTED
IF NOT, ENTER 0

 IF YOU WOULD LIKE A DIFFERENT SCALE, ENTER 1.
 IF NOT, ENTER 0.
0

           AVAILABLE PLOT OPTIONS
           0  -  NO PLOTS
           1  -  ICED GEOMETRY
           2  -  YO VS S
           3  -  BETA VS S
           4  -  VE VS S
           5  -  TE VS S
           6  -  PE VS S
           7  -  TSURF VS S
           8  -  HTC VS S
           9  -  XK VS S
          10  -  ICE DENSITY VS S
          11  -  FFRAC VS S
   ENTER OPTION NUMBER (I2)
00

 TIME STEP COMPLETE: TIME=  250.000

 ICING TIME INPUT HAS BEEN REACHED

 PROGRAM OPTIONS
    1 - CONTINUE ICING, USE PREVIOUS FLOW FIELD
    2 - CONTINUE ICING, CALCULATE NEW FLOW FIELD
    3 - TERMINATE PROGRAM
3

 MESSAGE SUMMARY: MESSAGE NUMBER - COUNT

                          209      511  OR OVER
PRT FILE 0411  TO  LRCG3D   COPY 001   NOHOLD
Device DISCONNECTED from VM/GRAPH3D.
DASD 500  DETACHED


17:49:43


MSG FROM LRCG3D  : GRAPH3D PLOT SENT TO B77B1_TALARIS


LEWICE IS NOW COMPLETE. REMEMBER TO ERASE THE RESTART FILE.
Ready; T=549.76/1168.92 17:49:49
hardcopy off manual exampl
```

```
NACA 0012  : EXAMPLE 1
&S24Y
ILIFT= 1
IPARA= 1
IFIRST= 3
ISECND= 3
IPVOR= 1
INCLT= 0
CLT= 0.0
ICHORD= 0
CCL= 0.0
IND= 1
ISOL= 0
IPRINT= 0
IFLLL= 1
&END
```

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1.0000000 | 0.9899999 | 0.9800000 | 0.9700000 | 0.9500000 | 0.9250000 | 6 | 0 | 3 |
| 0.9000000 | 0.8750000 | 0.8500000 | 0.8250000 | 0.8000000 | 0.7750000 | 6 | 0 | 3 |
| 0.7500000 | 0.7250000 | 0.7000000 | 0.6750000 | 0.6500000 | 0.6250000 | 6 | 0 | 3 |
| 0.6000000 | 0.5750000 | 0.5500000 | 0.5250000 | 0.5000000 | 0.4750000 | 6 | 0 | 3 |
| 0.4500000 | 0.4250000 | 0.4000000 | 0.3750000 | 0.3500000 | 0.3250000 | 6 | 0 | 3 |
| 0.3000000 | 0.2750000 | 0.2500000 | 0.2250000 | 0.2000000 | 0.1750000 | 6 | 0 | 3 |
| 0.1500000 | 0.1250000 | 0.1000000 | 0.0900000 | 0.0800000 | 0.0700000 | 6 | 0 | 3 |
| 0.0600000 | 0.0500000 | 0.0450000 | 0.0400000 | 0.0350000 | 0.0300000 | 6 | 0 | 3 |
| 0.0250000 | 0.0200000 | 0.0150000 | 0.0100000 | 0.0075000 | 0.0050000 | 6 | 0 | 3 |
| 0.0037500 | 0.0025000 | 0.0022500 | 0.0020000 | 0.0017500 | 0.0015000 | 6 | 0 | 3 |
| 0.0012500 | 0.0010000 | 0.0008750 | 0.0007500 | 0.0006250 | 0.0005000 | 6 | 0 | 3 |
| 0.0003750 | 0.0002500 | 0.0001250 | 0.0000000 | 0.0001250 | 0.0002500 | 6 | 0 | 3 |
| 0.0003750 | 0.0005000 | 0.0006250 | 0.0007500 | 0.0008750 | 0.0010000 | 6 | 0 | 3 |
| 0.0012500 | 0.0015000 | 0.0017500 | 0.0020000 | 0.0022500 | 0.0025000 | 6 | 0 | 3 |
| 0.0037500 | 0.0050000 | 0.0075000 | 0.0100000 | 0.0150000 | 0.0200000 | 6 | 0 | 3 |
| 0.0250000 | 0.0300000 | 0.0350000 | 0.0400000 | 0.0450000 | 0.0500000 | 6 | 0 | 3 |
| 0.0600000 | 0.0700000 | 0.0800000 | 0.0900000 | 0.1000000 | 0.1250000 | 6 | 0 | 3 |
| 0.1500000 | 0.1750000 | 0.2000000 | 0.2250000 | 0.2500000 | 0.2750000 | 6 | 0 | 3 |
| 0.3000000 | 0.3250000 | 0.3500000 | 0.3750000 | 0.4000000 | 0.4250000 | 6 | 0 | 3 |
| 0.4500000 | 0.4750000 | 0.5000000 | 0.5250000 | 0.5500000 | 0.5750000 | 6 | 0 | 3 |
| 0.6000000 | 0.6250000 | 0.6500000 | 0.6750000 | 0.7000000 | 0.7250000 | 6 | 0 | 3 |
| 0.7500000 | 0.7750000 | 0.8000000 | 0.8250000 | 0.8500000 | 0.8750000 | 6 | 0 | 3 |
| 0.9000000 | 0.9250000 | 0.9500000 | 0.9700000 | 0.9800000 | 0.9899999 | 6 | 0 | 3 |
| 1.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 1 | 1 | 3 |
| 0.0000000 | -0.0018740 | -0.0036110 | -0.0052390 | -0.0082510 | -0.0117000 | 6 | 0 | 4 |
| -0.0149080 | -0.0179530 | -0.0208880 | -0.0237390 | -0.0265150 | -0.0292210 | 6 | 0 | 4 |
| -0.0318550 | -0.0344110 | -0.0368870 | -0.0392810 | -0.0415850 | -0.0437950 | 6 | 0 | 4 |
| -0.0459040 | -0.0479060 | -0.0497930 | -0.0515600 | -0.0531980 | -0.0546980 | 6 | 0 | 4 |
| -0.0560510 | -0.0572430 | -0.0582620 | -0.0590900 | -0.0597070 | -0.0600940 | 6 | 0 | 4 |
| -0.0602260 | -0.0600760 | -0.0596120 | -0.0587940 | -0.0575700 | -0.0558790 | 6 | 0 | 4 |
| -0.0536360 | -0.0507320 | -0.0470040 | -0.0452280 | -0.0432520 | -0.0410380 | 6 | 0 | 4 |
| -0.0385350 | -0.0356740 | -0.0340820 | -0.0323620 | -0.0304960 | -0.0284620 | 6 | 0 | 4 |
| -0.0262300 | -0.0237260 | -0.0207970 | -0.0172480 | -0.0150780 | -0.0123860 | 6 | 0 | 4 |
| -0.0106990 | -0.0086200 | -0.0081360 | -0.0076230 | -0.0070750 | -0.0064850 | 6 | 0 | 4 |
| -0.0058470 | -0.0051460 | -0.0047660 | -0.0043630 | -0.0039310 | -0.0034620 | 6 | 0 | 4 |
| -0.0029450 | -0.0023560 | -0.0016320 | 0.0000000 | 0.0016320 | 0.0023560 | 6 | 0 | 4 |
| 0.0029450 | 0.0034620 | 0.0039310 | 0.0043630 | 0.0047660 | 0.0051460 | 6 | 0 | 4 |
| 0.0058470 | 0.0064850 | 0.0070750 | 0.0076230 | 0.0081360 | 0.0086200 | 6 | 0 | 4 |
| 0.0106990 | 0.0123860 | 0.0150780 | 0.0172480 | 0.0207970 | 0.0237260 | 6 | 0 | 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0.0262300 | 0.0284620 | 0.0304960 | 0.0323620 | 0.0340820 | 0.0356740 | 6 | 0 | 4 |
| 0.0385350 | 0.0410380 | 0.0432520 | 0.0452280 | 0.0470040 | 0.0507320 | 6 | 0 | 4 |
| 0.0536360 | 0.0558790 | 0.0575700 | 0.0587940 | 0.0596120 | 0.0600760 | 6 | 0 | 4 |
| 0.0602260 | 0.0600940 | 0.0597070 | 0.0590900 | 0.0582620 | 0.0572430 | 6 | 0 | 4 |
| 0.0560510 | 0.0546980 | 0.0531980 | 0.0515600 | 0.0497930 | 0.0479060 | 6 | 0 | 4 |
| 0.0459040 | 0.0437950 | 0.0415850 | 0.0392810 | 0.0368870 | 0.0344110 | 6 | 0 | 4 |
| 0.0318550 | 0.0292210 | 0.0265150 | 0.0237390 | 0.0208880 | 0.0179530 | 6 | 0 | 4 |
| 0.0149080 | 0.0117000 | 0.0082510 | 0.0052390 | 0.0036110 | 0.0018740 | 6 | 0 | 4 |
| 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 0.0000000 | 1 | 1 | 4 |

```
&TRAJ1
GEPS= 0.4999999E-04
DSHIFT= 0.20E-02
VEPS= 0.9999999E-03
LCMB= 0
LCMP= 0
LEQM= 1
LSYM= 0
LYOR= 1
LXOR= 1
NBDY= 1
NEQ= 4
NPL= 15
NSEAR= 50
NSI- 1
TIMSTP= 0.9999999E-03
&END
&TRAJ2
CHORD= 0.5334
G= 0.0
PIT= 0.0
PITDOT= 0.0
PRATK= 0.0
XORC= -4.0
XSTOP= 0.50
YOLIM= 0.9999999E-04
YOMAX= 0.50E-01
YOMIN= -0.50E-01
YORC= 0.9999996E-01
&END
&DIST
FLWC= 1.0, 9*0.0
DPD= 20.0, 9*0.0
CFP= 1.0, 9*0.0
&END
&ICE
VINF= 129.46000000
LWC= 0.500
TAMB= 260.5500
PAMB= 90748.000
RH= 100.0
DPMM= 20.0
XKINIT= 0.00035
SEGTOL= 1.50
&END
```

```
------------------------------------------------------------------
                 DATA   FOR   THE   COMPOSITE   BODY
------------------------------------------------------------------
         THIS IS THE FIRST OF FIVE DATA FILES USED FOR PROGRAM NASAUT.
         BODY - HEAT - BOUND - PROP - INOUT DATA FILES ARE CURRENTLY USED.
            COMMENTS:
         LAYERS IN THE Y-DIRECTION MAKE UP THE DIFFERENT MATERIALS IN THE
      DEICER - ABRASION SHIELD, INSULATION, HEATER, ETC.
         SECTIONS IN THE X-DIRECTION ALLOW FOR DIFFERENT PHYSICAL PROPERTIES
      ONLY IN THE HEATER LAYER, I.E., HEATER-GAP-HEATER. NODAL STRUCTURE
      (DX) IS USED IN EVERY LAYER.
         MAKE SURE THE NUMBER OF LAYERS (VALUE OF L) EQUALS THE NUMBER OF
      LINES OF DATA PROVIDED. THE SAME GOES FOR THE NUMBER OF HEATER SECTIONS.
         IF ICE IS CONSIDERED, IT IS THE TOP LAYER. THE LENGTH (THICKNESS) OF
      THE TOP LAYER GIVEN HERE IS USED ONLY TO DETERMINE DY IN THE ICE LAYER.
      THE ACTUAL THICKNESS OF THE ICE IS GIVEN INITALLY IN THE PROP DATA FILE.
      ICE THICKNESS DURING THE SIMULATION IS GIVEN BY THE ACCRETION ALGORITHM.
         LIMITS ON INPUT: 190 NODES IN Y-DIRECTION (ACTUAL NODES USED =
      NUMBER INPUT - NUMBER OF LAYERS + 2). LIMIT OF 29 LAYERS IN Y-DIRECTION
      LIMIT OF 190 NODES IN X-DIRECTION (NO DOUBLE COUNTING AS ABOVE). LIMIT
      OF 29 SECTIONS IN X-DIRECTION (TOTAL OF HEATERS + GAPS).
------------------------------------------------------------------
```

TOTAL NUMBER OF LAYERS IN THE Y-DIRECTION        L= 014
TOTAL NUMBER OF HEATER SECTIONS IN THE X-DIRECTION  NX= 023
DATA FOR EACH LAYER:

```
------------------
```

| # OF NODES | LENGTH (IN) | CONDUCTIVITY (BTU/FT*HR*F) | DIFFUSIVITY (FT**2/HR) |
|---|---|---|---|
| 05 ALM | 0000.07500 | 000102.000000 | 000002.830000 |
| 03 ADH | 0000.01000 | 000000.100000 | 000000.005800 |
| 05 ALM | 0000.05000 | 000102.000000 | 000002.830000 |
| 03 ADH | 0000.01000 | 000000.100000 | 000000.005800 |
| 04 STL | 0000.02000 | 000008.700000 | 000000.150000 |
| 02 ADH | 0000.00820 | 000000.100000 | 000000.005800 |
| 04 INS | 0000.01380 | 000000.220000 | 000000.008700 |
| 04 ADH | 0000.00820 | 000000.100000 | 000000.005800 |
| 04 HTR | 0000.00650 | 000060.000000 | 000001.150000 |
| 04 ADH | 0000.00820 | 000000.100000 | 000000.005800 |
| 04 INS | 0000.01380 | 000000.220000 | 000000.008700 |
| 04 ADH | 0000.00820 | 000000.100000 | 000000.005800 |
| 06 STL | 0000.03000 | 000008.700000 | 000000.150000 |
| 21 ICE | 0000.25000 | 000001.290000 | 000000.044600 |

DATA FOR EACH HEATER/GAP SECTION:

```
----------------------------------
```

|  | # OF NODES | LENGTH (IN) | CONDUCTIVITY (BTU/FT*HR*F) | DIFFUSIVITY (FT**2/HR) |
|---|---|---|---|---|
| G | 08 | 0006.50000 | 000000.100000 | 000000.005800 |
| H 1 | 04 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 03 | 0000.06100 | 000000.100000 | 000000.005800 |
| H 2 | 04 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 03 | 0000.06100 | 000000.100000 | 000000.005800 |
| H 3 | 08 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 03 | 0000.06100 | 000000.100000 | 000000.005800 |
| H 4 | 14 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 03 | 0000.06100 | 000000.100000 | 000000.005800 |

| | | | | |
|---|---|---|---|---|
| H 5 | 26 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 03 | 0000.06100 | 000000.100000 | 000000.005800 |
| H 6 | 41 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 03 | 0000.06100 | 000000.100000 | 000000.005800 |
| H 7 | 26 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 03 | 0000.06100 | 000000.100000 | 000000.005800 |
| H 8 | 14 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 03 | 0000.06100 | 000000.100000 | 000000.005800 |
| H 9 | 08 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 03 | 0000.06100 | 000000.100000 | 000000.005800 |
| H 10 | 04 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 03 | 0000.06100 | 000000.100000 | 000000.005800 |
| H 11 | 04 | 0001.00000 | 000060.000000 | 000001.150000 |
| G | 08 | 0006.50000 | 000000.100000 | 000000.005800 |

--------------------------------------------------------------------
DATA   FOR   THE   HEATER
--------------------------------------------------------------------

THIS IS THE SECOND OF FIVE DATA FILES USED FOR THE PROGRAM DEICE3.
BODY - HEAT - BOUND - PROP - INOUT DATA FILES ARE CURRENTLY USED.

COMMENTS:

| | | |
|---|---|---|
| IF NO HEAT SOURCE IS PRESENT | IH | = 1 |
| IF POINT HEAT SOURCE IS PRESENT | IH | = 2 |
| IF INTERNAL HEAT GENERATION IN A SLAB OCCURS | IH | = 3 |
| IF CONSTANT HEAT INPUT IS USED | IHQ | = 1 |
| IF STEP FUNCTION HEAT INPUT IS USED | IHQ | = 2 |
| IF RAMP FUNCTION HEAT INPUT IS USED | IHQ | = 3 |
| IF SINE FUNCTION HEAT INPUT IS USED | IHQ | = 4 |

--------------------------------------------------------------------

IF USING A POINT HEAT SOURCE, THE VALUE OF IJ IS NOT USED. IF USING A
FINITE THICKNESS HEATER, THE VALUES L1 AND L2 ARE NOT USED BY THE
PROGRAM. THE LINE MUST NOT BE DELETED, HOWEVER, DUE TO FORMATTING.

MAKE SURE THE NUMBER OF LINES OF HEATER POWER DENSITIES EQUALS THE
NUMBER OF HEATER SECTIONS GIVEN IN BODY DATA FILE. ALSO BE SURE THAT THE
WATTAGES ARE IN A HEATER SECTION, NOT IN A GAP.

LAG TIME IS THE AMOUNT OF TIME, STARTING FROM THE BEGINNING OF THE
SIMULATION, BEFORE THAT HEATER BEGINS ITS CYCLE. THE HEATER WILL THEN BE
ON FOR THE DURATION OF THE ON TIME, THEN WILL TURN OFF FOR THE AMOUNT
GIVEN IN THE OFF SECTION, AND THEN WILL TURN ON AGAIN.  LAG TIME ALLOWS
FOR ICE ACCRETION BEFORE THE HEATER CYCLES BEGIN. USE THIS OPTION WHEN
YOU WANT THE PROGRAM TO START AT A POINT WHERE ICE HAS ALREADY FORMED ON
THE BLADE.

IF IH = 1, THERE ARE NO HEATERS AND THE PROGRAM WILL DISALLOW ANY
POWER DENSITIES INPUT.

--------------------------------------------------------------------
TYPE OF HEAT SOURCE                                    IH= 003
FOR IH=2   POINT HEAT SOURCE         BETWEEN SLAB      L1= 009
                                     AND   SLAB        L2= 010
FOR IH=3   INTERNAL HEAT GENERATION IN SLAB            IJ= 009
TYPE OF HEAT SOURCE USED                               IHQ= 002

| HEATER DENSITY (WATTS/IN**2) | TIME ON (SEC) | TIME OFF (SEC) | LAG TIME (SEC) | |
|---|---|---|---|---|
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00000.0000 | 0020.00 | 0040.00 | 0130.00 | H 1 |
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00000.0000 | 0020.00 | 0040.00 | 0128.00 | H 2 |

| | | | | |
|---|---|---|---|---|
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00000.0000 | 0020.00 | 0040.00 | 0126.00 | H 3 |
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00000.0000 | 0020.00 | 0040.00 | 0124.00 | H 4 |
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00030.0000 | 0005.00 | 0060.00 | 0120.00 | H 5 |
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00030.0000 | 0060.00 | 0060.00 | 0120.00 | H 6 |
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00030.0000 | 0005.00 | 0060.00 | 0120.00 | H 7 |
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00000.0000 | 0020.00 | 0040.00 | 0124.00 | H 8 |
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00000.0000 | 0020.00 | 0040.00 | 0126.00 | H 9 |
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00000.0000 | 0020.00 | 0040.00 | 0128.00 | H 10 |
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |
| 00000.0000 | 0020.00 | 0040.00 | 0130.00 | H 11 |
| 00000.0000 | 0010.00 | 0000.00 | 0000.00 | G |

```
-----------------------------------------------------------------
                    BOUNDARY   CONDITION   DATA
-----------------------------------------------------------------
     THIS IS THE THIRD OF FIVE DATA FILES USED FOR PROGRAM DEICE3.
     BODY - HEAT - BOUND - PROP - INOUT DATA FILES ARE CURRENTLY USED.
        COMMENTS:
        FOR CONSTANT TEMPERATURE BOUNDARY CONDITIONS AT J=1 IBC1=1
         "       "              "            "          "  AT J=M IBC2=1
         "       "              "            "          "  AT I=1 IBC3=1
         "       "              "            "          "  AT I=N IBC4=1
         "   CONVECTION BOUNDARY CONDITIONS         AT J=1 IBC1=2
         "        "          "            "          AT J=M IBC2=2
         "        "          "            "          AT I=1 IBC3=2
         "        "          "            "          AT I=N IBC4=2
         "   ACCRETION BOUNDARY CONDITION           AT J=M IBC2=3
     BOUNDARY CONDITIONS FOR A DEICER ARE NORMALLY INSULATED ON THE LEFT
AND RIGHT SIDES, INSULATED (OR LOW H VALUE) AT THE BOTTOM, AND A
VARIABLE H AT THE TOP SURFACE. I.E., ALL SIDES HAVE CONVECTION BOUNDARY.
     OTHER OPTIONS ARE GIVEN IF THE USER WISHES TO INVESTIGATE OTHER TWO
DIMENSIONAL HEAT TRANSFER PHENOMENA NOT INVOLVING A DEICER.
        IF CONDUCTION IS CONSIDERED ICOND=2
        IF CONDUCTION IS NOT CONSIDERED ICOND=1
        IF SHEDDING IS CONSIDERED ISH=2
        IF SHEDDING IS NOT CONSIDERED ISH=1
-----------------------------------------------------------------
BOUNDARY AND INITIAL CONDITIONS:
---------------------------------
TYPE OF BOUNDARY CONDITION               AT J=1 IBC1= 2
                                         AT J=M IBC2= 3
                                         AT I=1 IBC3= 2
                                         AT I=N IBC4= 2
    IBC1=1, CONSTANT TEMPERATURE AT J=1  TX1 = 000010.000000 DEG.F
    IBC2=1,        "          "   AT J=M  TX2 = 000010.000000 DEG.F
    IBC3=1,        "          "   AT I=1  TX3 = 000010.000000 DEG.F
    IBC4=1,        "          "   AT I=N  TX4 = 000010.000000 DEG.F
      CONVECTION DATA FOR BOTTOM. LEFT, AND SIDE BOUNDARIES
```

```
IBC1=2, AMBIENT  TEMPERATURE  AT J=1  TG1 = 000009.400000 DEG.F
IBC3=2,     "          "       AT I=1  TG3 = 000005.000000 DEG.F
IBC4=2,     "          "       AT I=N  TG4 = 000005.000000 DEG.F
        HEAT TRANSFER COEFF. AT J=1  H1 = 000001.000000 BTU/H.F.FT2
            "       "       "   AT I=1  H3 = 000000.000000 BTU/H.F.FT2
            "       "       "   AT I=N  H4 = 000000.000000 BTU/H.F.FT2
      IS CONDUCTION USED DURING TLAG? 1=NO. 2=YES.   ICOND = 1
INITIALIZE BLADE TEMPS TO WHICH VALUES (SEE ABOVE)    INIT = 3
IS SHEDDING CONSIDERED?        1=NO 2=YES            ISH = 2
```

--------------------------------------------------------------------
                    ICE    PROPERTY    DATA
--------------------------------------------------------------------

   THIS IS THE FOURTH OF FIVE DATA FILES USED IN THE PROGRAM DEICE3.
   BODY - HEAT - BOUND - PROP - INOUT DATA FILES ARE CURRENTLY USED.
      COMMENTS:
      IF PHASE CHANGE IS CONSIDERED IG=2
      IF PHASE CHANGE IS NOT CONSIDERED IG=1
      PROGRAM ASSUMES THAT IF ICE IS PRESENT, IT IS THE TOP LAYER. SOME
PHYSICAL PROPERTIES OF ICE ARE TAKEN FROM THE DATA GIVEN IN BODY DATA
FILE FOR THE TOP LAYER.
      INITIAL ICE SHAPE CAN BE INPUT HERE. IT IS RECOMMENDED THAT YOU LET
THE PROGRAM DETERMINE THE ICE SHAPE (USE LAG TIME IN HEATER) AND LEAVE
THIS AT ZERO. ALWAYS PUT IN AT LEAST 2 POINTS FOR INITIAL ICE SHAPE.
      SET VALUE OF INIT = 1 IF YOU WANT THE BLADE TO BE INITIALIZED TO
THE AMBIENT TEMPERATURE. SET VALUE OF INIT = 2 IF YOU WANT THE BLADE TO
BE INITIALIZED TO THE RECOVERY TEMPERATURE, WHICH IS THE AMBIENT
TEMPERATURE + KINETIC HEATING -BOUNDARY LAYER LOSSES. SET VALUE OF
INIT = 3 IF YOU WANT THE BLADE TO BE INITIALIZED TO THE ACCRETION
TEMPERATURE ASSUMING NO HEAT TRANSFER INTO THE BLADE.

--------------------------------------------------------------------
```
IS PHASE CHANGE CONSIDERED? IF YES, IG=2. IF NO, IG=1.  IG = 2
LATENT HEAT OF ICE                   HLAM = 000143.400000 B.T.U./LB
   "     CONDUCTIVITY "    "         AKL  = 000000.320000 B.T.U./HR.FT.F
DENSITY OF WATER                     OEL  = 000062.400000 LB./CU.FT
SPECIFIC HEAT*DENSITY OF WATER       CPL  = 000062.212800 B.T.U./CU.FT'F
DENSITY OF ICE                       OES  = 000057.400000 LB./CU.FT
THE MELTING TEMPERATURE              TMP  = 000032.000000 DEG.'F.
THE MELTING RANGE IS ( < 1. E-5 )    TR   = 00.0000100000 DEG.'F.
HEAT OF VAPORIZATION                 HVAP = 001075.160000 B.T.U./LB
HEAT CAPACITY OF AIR                 CPAIR = 000000.250000 B.T.U./LB 'F.
NUMBER OF POINTS FOR INITIAL ICE SHAPE      NP = 002
X-VALUE   0000.00000  Y-VALUE 0000.00000
          0030.37716           0000.00000
```

--------------------------------------------------------------------
              TIME    STEP    AND    INPUT/OUTPUT    PARAMETERS
--------------------------------------------------------------------

   THIS IS THE LAST OF FIVE DATA FILES USED FOR THE PROGRAM DEICE3.
   BODY - HEAT - BOUND - PROP - INOUT DATA FILES ARE CURRENTLY USED.
      COMMENTS:
      TIME STEP FOR A PROBLEM WHERE THE UNSTEADY-STATE SOLUTION IS WANTED
SHOULD NOT BE GREATER THAN 0.1 SEC. IF A STEADY-STATE PROBLEM IS BEING
SOLVED USING THIS PROGRAM, LARGER TIME STEPS MAY BE UTILIZED.
      VARIABLE TIME STEPS CAN BE USED TO STUDY PHENOMENA WHICH ARE KNOWN
TO OCCUR DURING A SPECIFIC PERIOD. IT HAS BEEN USED TO DETERMINE EXACT
TIME OF INITIAL MELTING AND SHEDDING. BUT IT IS NOT NECESSARY TO DO THIS

BECAUSE OF THE NUMERICAL METHOD USED, THE PROGRAM NEEDS TO ASSUME
THE PHASE OF THE ICE/WATER (SOLID, MUSH, LIQUID) AT EACH NODE AND TO
CHECK THIS AGAINST THE SOLUTION MATRIX. 10 ITERATIONS (OR LESS) HAVE
BEEN SUFFICIENT IN THE PAST. EXTREMELY COMPLEX PROBLEMS MAY REQUIRE MORE
     YOU WILL KNOW IF YOU NEED MORE ITERATIONS.
     NUMBER OF POINTS TO BE OUTPUT IS NEGLECTED IF IOTYPE = 4.
     POSITION DATA (X OR Y LAYER) IS IGNORED IF 'OTYPE = 5.
     VALUES ARE NEEDED FOR FORMATTING. HOWEVER, FOR IOTYPE = 4, YOU CAN
INPUT NPTS = 0 IF YOU WISH.
     LIMITS ON INPUT: VALUE OF NPRT = 50 (HENCE LIMIT ON TEMP. LOCATIONS
AND TIMES YOU CAN SPECIFY); VALUE OF NPTS = 50 (LIMIT OF NUMBER OF ICE
PROFILES PRINTED OUT).
     FOR IOTYPE = 1, THE LEFT NUMBER INPUT IS THE X-SECTION NUMBER YOU
WANT PRINTED OUT. THE CHARACTER NEXT TO IT DESIGNATES WHETHER YOU WANT
THE LEFT (L), MIDDLE (M), OR RIGHT (R) NODE OF THIS SECTION. THE RIGHT
NUMBER IS THE Y-LAYER YOU WANT PRINTED OUT AND THE CHARACTER NEXT TO IT
IS FOR THE BOTTOM (B), MIDDLE (M), OR TOP (T) NODE OF THIS LAYER.
     FOR IOTYPE = 2 OR = 3, THE LEFT NUMBER IS THE TIME STEP AT WHICH
OUTPUT IS GIVEN. FOR IOTYPE = 2, THE RIGHT VALUE IS THE Y-LAYER OF THE
NODES TO BE OUTPUT AND FOR IOTYPE = 3, IT IS THE X-SECTION OF THE NODES
OUTPUT. THE LEFT CHARACTER IS IGNORED, AND THE RIGHT ONE IS DESCRIBED
ABOVE FOR EACH TYPE (X OR Y).
     FOR IOTYPE = 4, EVERYTHING IS PRINTED OUT, SO THE PROGRAM WILL
IGNORE ITEMS INPUT. I RECOMMEND LEAVING SOMETHING THERE SO THAT YOU
DON'T FORGET THE FORMATTING OF THE DATA FOR OTHER TYPES OF OUTPUT.
     FOR IOTYPE = 5, EVERYTHING BUT THE LEFT NUMBER IS IGNORED. THE LEFT
VALUE IS THE TIME STEP AT WHICH YOU WANT THE OUTPUT.
     THE FORMAT FOR THE NPRT VALUES IS THE SAME AS THAT FOR IOTYPE = 5.

---------------------------------------------------------------------

```
INITIAL TIME STEP                          DTAUI = 000000.100000 SECS.
                    FOR TIME STEPS         NISP  = 0010
INTERMIDIATE TIME STEP                     DTAUM = 000000.100000 SECS.
                    FOR TIME STEPS         NMSP  = 0100
FINAL TIME STEP                            DTAUF = 000000.100000 SECS.
 NUMBER OF PHASE CHANGE ITERATIONS         JCOUNT = 020
NUMBER OF ICE SHAPES TO BE OUTPUT     NPRT = 004
PUT VALUE XXXX IN SPOTS MARKED BY X'S
          1200
          1800
          2400
          2500
```

IF IOTYPE = 1, PRINTS T(TIME) AT X1,Y1; X2,Y2; ETC.
IF IOTYPE = 2, PRINTS T(X) AT TIME1,Y1; TIME2,Y2; ETC.
IF IOTYPE = 3, PRINTS T(Y) AT X1,TIME1; X2,TIME2; ETC.
IF IOTYPE = 4, PRINTS ALL NODES AT ALL TIMESTEPS
IF IOTYPE = 5, PRINTS T(X,Y) AT TIME1, TIME2; ETC.

```
TYPE OF OUTPUT REQUESTED                        IOTYPE = 001
NUMBER OF POINTS TO BE OUTPUT                     NPTS = 010
          0008  M          0009  T
          0008  M          0013  T
          0010  M          0009  T
          C010  M          0013  T
          C012  M          0009  T
```

```
0012  M        0013  T
0014  M        0009  T
0014  M        0013  T
0016  M        0009  T
0016  M        0013  T
```

| Velocity (m/s) | = 129.46 |
| Temperature (°C) | = –12.60 |
| Pressure (KPa) | = 90.75 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = .50 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 250 |
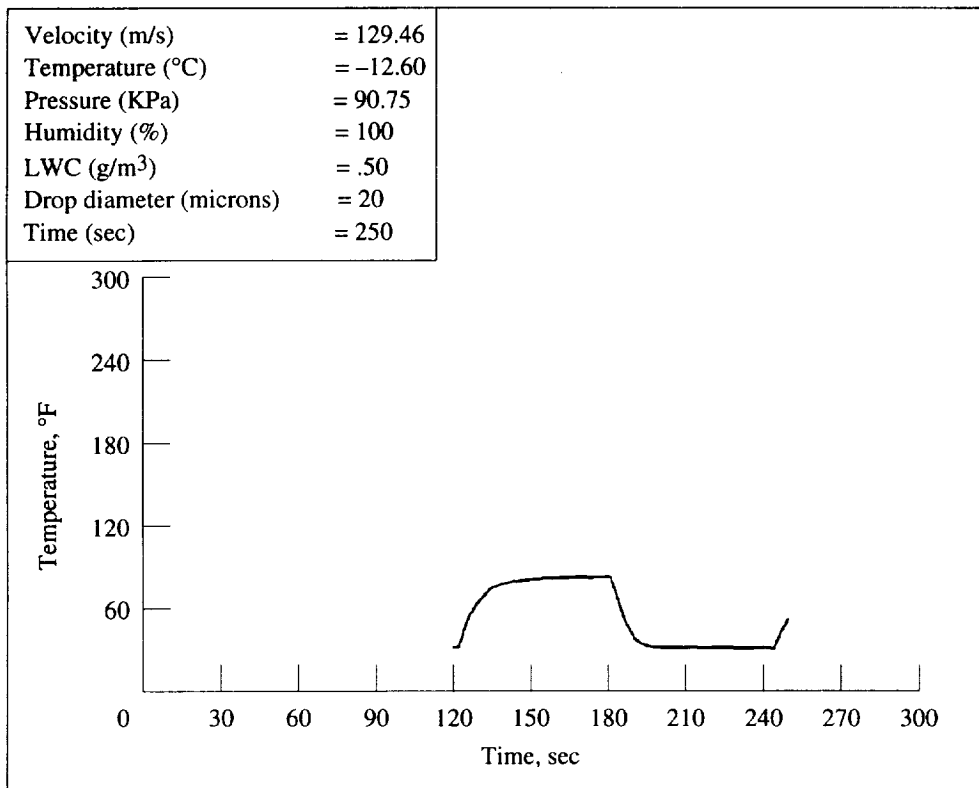


Figure 29.—Heater temperature for position 5.

| Velocity (m/s) | = 129.46 |
| Temperature (°C) | = –12.60 |
| Pressure (KPa) | = 90.75 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = .50 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 250 |
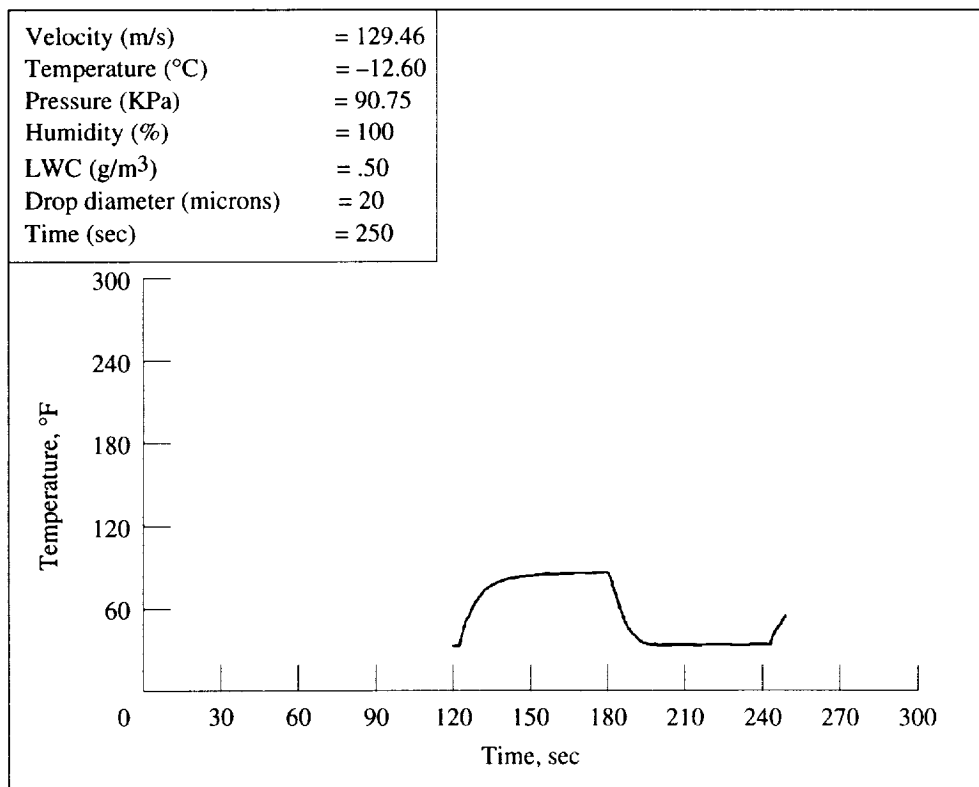


Figure 30.—Heater temperature for position 7.

| | |
|---|---|
| Velocity (m/s) | = 129.46 |
| Temperature (°C) | = −12.60 |
| Pressure (KPa) | = 90.75 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = .50 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 250 |
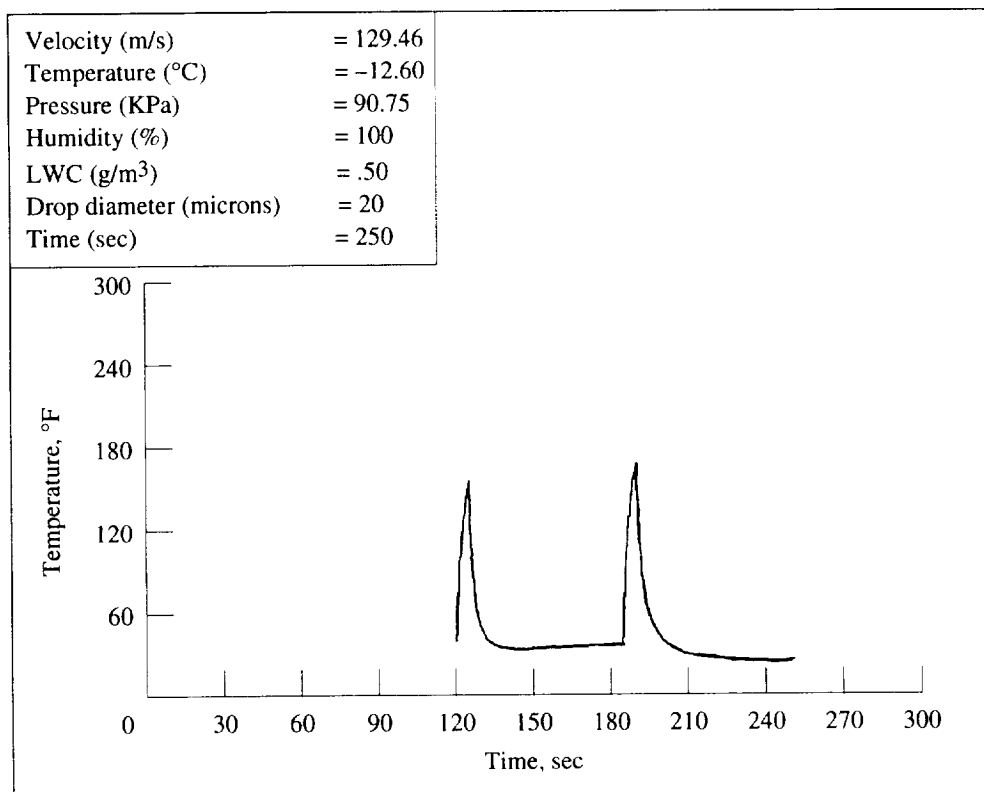


Figure 31.—Heater temperature for position 6.

| | |
|---|---|
| Velocity (m/s) | = 129.46 |
| Temperature (°C) | = −12.60 |
| Pressure (KPa) | = 90.75 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = .50 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 250 |
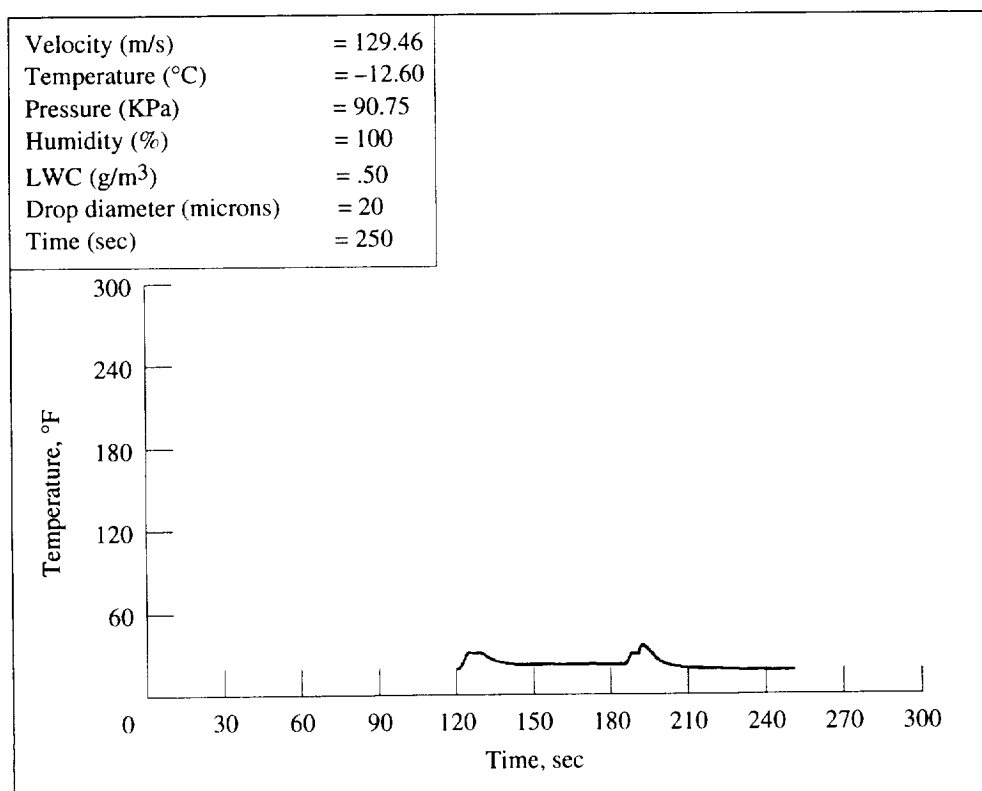


Figure 32.—Abrasion shield temperature for position 6.

| Velocity (m/s) | = 129.46 |
|---|---|
| Temperature (°C) | = –12.60 |
| Pressure (KPa) | = 90.75 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = .50 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 250 |
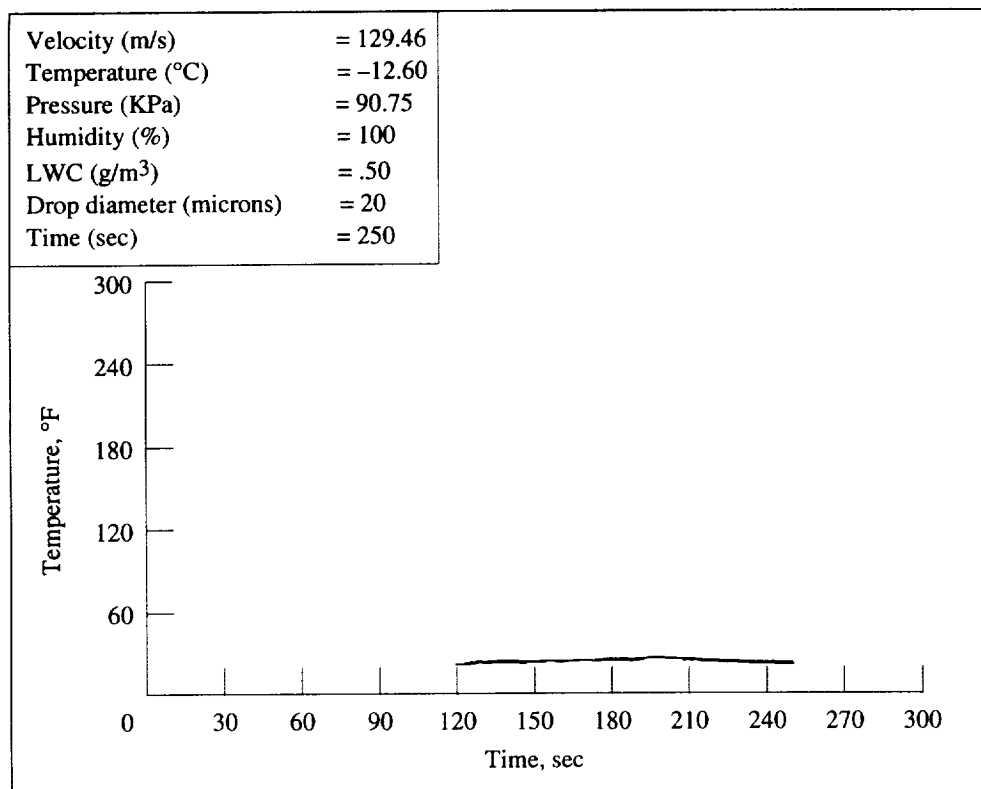
Figure 33.—Abrasion shield temperature for position 5.



| Velocity (m/s) | = 129.46 |
|---|---|
| Temperature (°C) | = –12.60 |
| Pressure (KPa) | = 90.75 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = .50 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 250 |
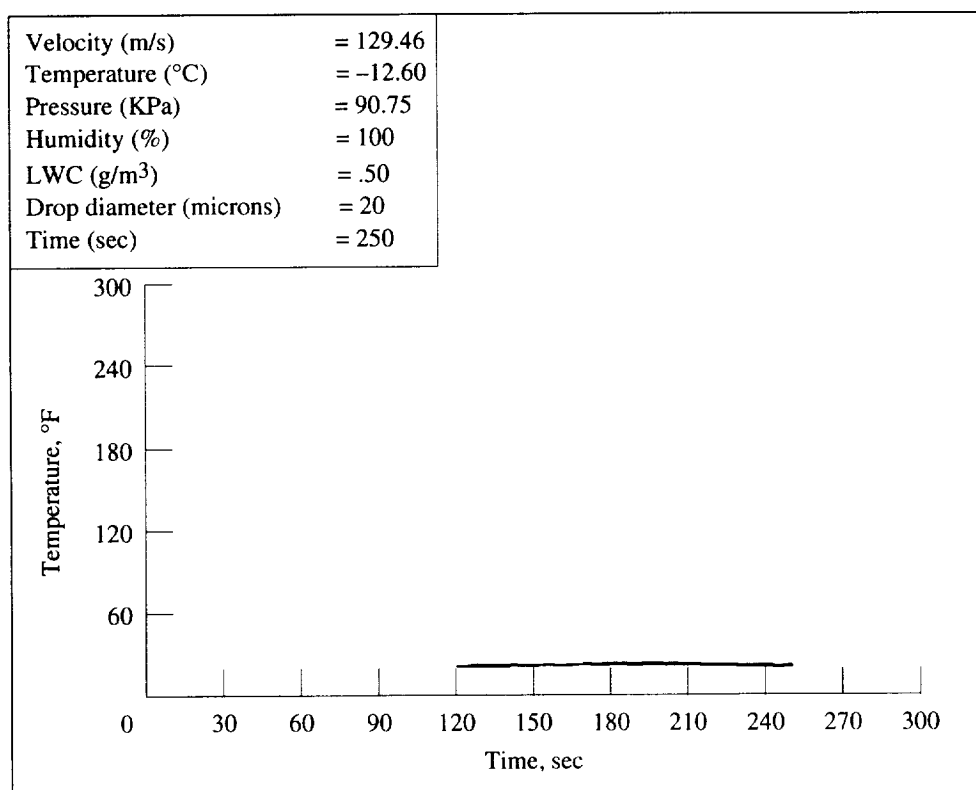
Figure 34.—Abrasion shield temperature for position 7.

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| Velocity (m/s) | = 129.46 |
| Temperature (°C) | = –12.60 |
| Pressure (KPa) | = 90.75 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = 0.5 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 250 |
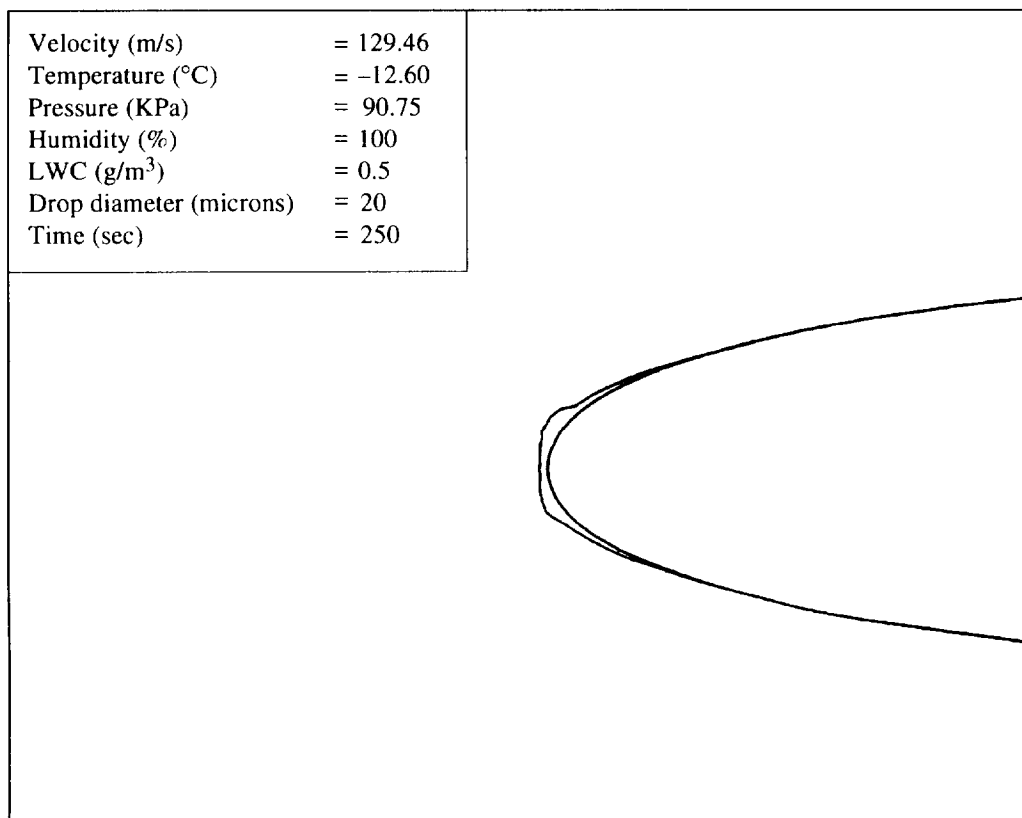
Figure 35.—Ice shape for example case.

| Velocity (m/s) | = 129.46 |
| Temperature (°C) | = -12.60 |
| Pressure (KPa) | = 90.75 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = .50 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 250 |
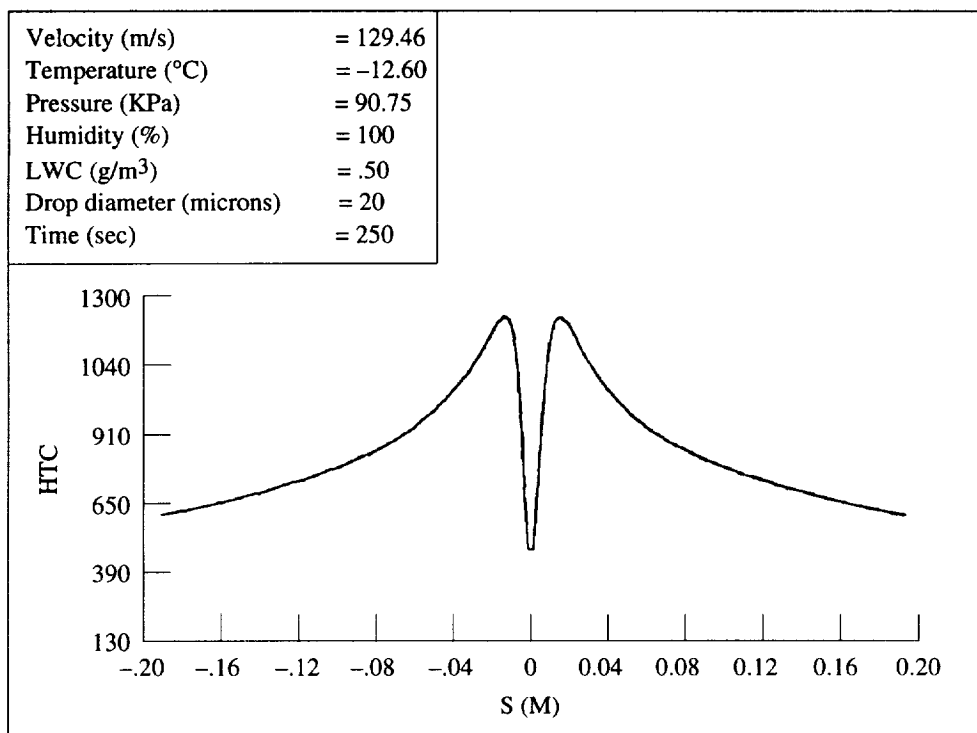
Figure 36.—Heat transfer coefficient for example case.



| Velocity (m/s) | = 129.46 |
| Temperature (°C) | = -12.60 |
| Pressure (KPa) | = 90.75 |
| Humidity (%) | = 100 |
| LWC (g/m$^3$) | = .50 |
| Drop diameter (microns) | = 20 |
| Time (sec) | = 250 |
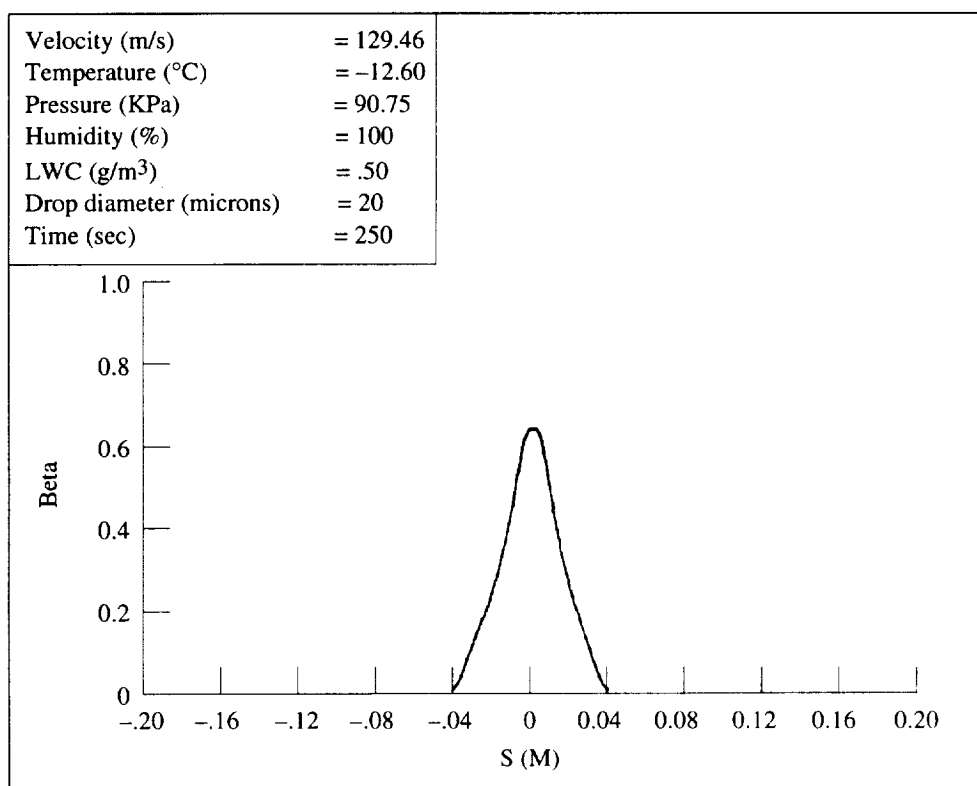
Figure 37.—Collection efficiency for example case.

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**FILE: MASS    DATA    A             VM/SP CONVERSATIONAL MONITOR SYSTEM**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | -0.21419E+02 | -0.24654E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 3 | -0.19188E+02 | -0.15423E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 4 | -0.16958E+02 | -0.14972E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 5 | -0.14727E+02 | -0.14966E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 6 | -0.12497E+02 | -0.14979E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 7 | -0.10266E+02 | -0.14624E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 8 | -0.80355E+01 | -0.13145E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 9 | -0.58050E+01 | -0.93198E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 10 | -0.54717E+01 | -0.43924E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 11 | -0.51383E+01 | 0.14209E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 12 | -0.48050E+01 | 0.75586E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 13 | -0.47745E+01 | 0.11848E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 14 | -0.47440E+01 | 0.16325E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 15 | -0.44107E+01 | 0.23889E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 16 | -0.40773E+01 | 0.30123E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 17 | -0.37440E+01 | 0.36054E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 18 | -0.37135E+01 | 0.40387E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 19 | -0.36830E+01 | 0.45148E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 20 | -0.35401E+01 | 0.51101E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 21 | -0.33973E+01 | 0.56500E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 22 | -0.32544E+01 | 0.61633E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 23 | -0.31116E+01 | 0.66521E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 24 | -0.29687E+01 | 0.71134E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 25 | -0.28259E+01 | 0.75403E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 26 | -0.26830E+01 | 0.79224E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 27 | -0.26525E+01 | 0.82157E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 28 | -0.26220E+01 | 0.85861E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 29 | -0.25451E+01 | 0.90303E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 30 | -0.24682E+01 | 0.94073E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 31 | -0.23912E+01 | 0.97561E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 32 | -0.23143E+01 | 0.10073E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 33 | -0.22374E+01 | 0.10342E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 34 | -0.21605E+01 | 0.10544E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 35 | -0.20835E+01 | 0.10652E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 36 | -0.20066E+01 | 0.10623E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 37 | -0.19297E+01 | 0.10376E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 38 | -0.18528E+01 | 0.97413E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 39 | -0.17758E+01 | 0.84164E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 40 | -0.16989E+01 | 0.58715E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 41 | -0.16220E+01 | 0.11539E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 42 | -0.15915E+01 | -0.72402E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 43 | -0.15610E+01 | -0.16552E+00 | 0.00000E+00 | 0.00000E+00 | 0.62661E-07 | 0.00000E+00 | |
| 44 | -0.15210E+01 | -0.25345E+00 | 0.00000E+00 | 0.00000E+00 | 0.33178E-06 | 0.00000E+00 | |
| 45 | -0.14810E+01 | 0.91577E+00 | 0.68631E-06 | 0.00000E+00 | 0.68631E-06 | 0.68631E-06 | |
| 46 | -0.14410E+01 | 0.85582E+00 | 0.11507E-05 | 0.00000E+00 | 0.10948E-05 | 0.11507E-05 | |
| 47 | -0.14010E+01 | 0.73281E+00 | 0.17299E-05 | 0.00000E+00 | 0.10903E-05 | 0.17299E-05 | |
| 48 | -0.13610E+01 | 0.63353E+00 | 0.24289E-05 | 0.00000E+00 | 0.10992E-05 | 0.24289E-05 | |
| 49 | -0.13210E+01 | 0.55388E+00 | 0.32419E-05 | 0.00000E+00 | 0.11188E-05 | 0.32419E-05 | |
| 50 | -0.12810E+01 | 0.49207E+00 | 0.41217E-05 | 0.00000E+00 | 0.11462E-05 | 0.41217E-05 | |
| 51 | -0.12410E+01 | 0.44917E+00 | 0.50111E-05 | 0.00000E+00 | 0.11791E-05 | 0.50111E-05 | |
| 52 | -0.12010E+01 | 0.41856E+00 | 0.58759E-05 | 0.00000E+00 | 0.12167E-05 | 0.58759E-05 | |
| 53 | -0.11610E+01 | 0.27615E+00 | 0.67263E-05 | 0.00000E+00 | 0.12555E-05 | 0.67263E-05 | |
| 54 | -0.11210E+01 | 0.34679E+00 | 0.75770E-05 | 0.00000E+00 | 0.12839E-05 | 0.75770E-05 | |
| 55 | -0.10810E+01 | 0.36184E+00 | 0.84354E-05 | 0.00000E+00 | 0.13261E-05 | 0.84354E-05 | |
| 56 | -0.10410E+01 | 0.37527E-00 | 0.93002E-05 | 0.00000E+00 | 0.13720E-05 | 0.93002E-05 | |

| | | | | | |
|---|---|---|---|---|---|
| 57 | -0.10010E+01 | 0.39760E+00 | 0.10170E-04 | 0.00000E+00 | 0.14209E-05 | 0.10170E-04 |
| 58 | -0.96100E+00 | 0.43178E+00 | 0.11039E-04 | 0.00000E+00 | 0.14734E-05 | 0.11039E-04 |
| 59 | -0.92100E+00 | 0.47510E+00 | 0.11899E-04 | 0.00000E+00 | 0.15312E-05 | 0.11899E-04 |
| 60 | -0.88100E+00 | 0.48901E+00 | 0.12748E-04 | 0.00000E+00 | 0.15777E-05 | 0.12748E-04 |
| 61 | -0.84100E+00 | 0.57232E+00 | 0.13609E-04 | 0.00000E+00 | 0.16388E-05 | 0.13609E-04 |
| 62 | -0.80100E+00 | 0.67093E+00 | 0.14517E-04 | 0.00000E+00 | 0.17097E-05 | 0.14517E-04 |
| 63 | -0.76100E+00 | 0.78851E+00 | 0.15506E-04 | 0.00000E+00 | 0.17895E-05 | 0.15506E-04 |
| 64 | -0.72100E+00 | 0.92785E+00 | 0.16599E-04 | 0.00000E+00 | 0.18802E-05 | 0.16599E-04 |
| 65 | -0.68100E+00 | 0.10834E+01 | 0.17816E-04 | 0.00000E+00 | 0.19857E-05 | 0.17816E-04 |
| 66 | -0.64100E+00 | 0.12246E+01 | 0.19157E-04 | 0.00000E+00 | 0.20409E-05 | 0.19157E-04 |
| 67 | -0.60100E+00 | 0.14248E+01 | 0.20534E-04 | 0.00000E+00 | 0.21812E-05 | 0.20534E-04 |
| 68 | -0.56100E+00 | 0.17725E+01 | 0.21841E-04 | 0.00000E+00 | 0.23257E-05 | 0.21841E-04 |
| 69 | -0.53050E+00 | 0.28107E+01 | 0.17346E-04 | 0.00000E+00 | 0.18888E-05 | 0.17346E-04 |
| 70 | -0.50000E+00 | 0.13586E+02 | 0.18033E-04 | 0.00000E+00 | 0.18657E-05 | 0.18033E-04 |
| 71 | -0.47500E+00 | 0.74369E+01 | 0.15283E-04 | 0.00000E+00 | 0.16083E-05 | 0.15283E-04 |
| 72 | -0.45000E+00 | 0.88954E+01 | 0.15857E-04 | 0.00000E+00 | 0.16431E-05 | 0.15857E-04 |
| 73 | -0.42500E+00 | 0.10350E+02 | 0.16537E-04 | 0.00000E+00 | 0.16590E-05 | 0.16537E-04 |
| 74 | -0.40000E+00 | 0.11289E+02 | 0.17317E-04 | 0.00000E+00 | 0.16695E-05 | 0.17317E-04 |
| 75 | -0.37500E+00 | 0.11935E+02 | 0.18123E-04 | 0.00000E+00 | 0.15913E-05 | 0.18123E-04 |
| 76 | -0.35000E+00 | 0.12365E+02 | 0.18874E-04 | 0.00000E+00 | 0.16614E-05 | 0.18874E-04 |
| 77 | -0.32500E+00 | 0.12597E+02 | 0.19591E-04 | 0.87211E-05 | 0.17376E-05 | 0.28312E-04 |
| 78 | -0.30000E+00 | 0.12725E+02 | 0.20393E-04 | 0.26962E-04 | 0.19120E-05 | 0.47355E-04 |
| 79 | -0.27500E+00 | 0.12930E+02 | 0.21399E-04 | 0.36308E-04 | 0.18157E-05 | 0.57707E-04 |
| 80 | -0.25000E+00 | 0.13218E+02 | 0.22448E-04 | 0.38600E-04 | 0.17053E-05 | 0.61047E-04 |
| 81 | -0.22500E+00 | 0.13464E+02 | 0.23076E-04 | 0.39946E-04 | 0.16401E-05 | 0.63022E-04 |
| 82 | -0.20000E+00 | 0.12198E+02 | 0.23546E-04 | 0.45405E-04 | 0.15796E-05 | 0.68952E-04 |
| 83 | -0.17500E+00 | 0.10067E+02 | 0.24475E-04 | 0.42699E-04 | 0.14408E-05 | 0.67174E-04 |
| 84 | -0.15000E+00 | 0.89549E+01 | 0.25328E-04 | 0.41664E-04 | 0.13063E-05 | 0.66992E-04 |
| 85 | -0.12500E+00 | 0.87703E+01 | 0.25634E-04 | 0.34868E-04 | 0.11685E-05 | 0.60502E-04 |
| 86 | -0.10000E+00 | 0.88701E+01 | 0.25965E-04 | 0.28391E-04 | 0.10469E-05 | 0.54357E-04 |
| 87 | -0.75000E-01 | 0.90751E+01 | 0.26439E-04 | 0.18158E-04 | 0.91558E-06 | 0.44598E-04 |
| 88 | -0.50000E-01 | 0.93930E+01 | 0.26479E-04 | 0.64299E-05 | 0.80811E-06 | 0.32909E-04 |
| 89 | -0.25000E-01 | 0.96650E+01 | 0.26491E-04 | 0.00000E+00 | 0.81166E-06 | 0.26491E-04 |
| 90 | 0.00000E+00 | 0.94287E+01 | 0.26463E-04 | 0.64299E-05 | 0.80623E-06 | 0.32892E-04 |
| 91 | 0.25000E-01 | 0.90473E+01 | 0.26438E-04 | 0.18537E-04 | 0.79480E-06 | 0.44975E-04 |
| 92 | 0.50000E-01 | 0.87957E+01 | 0.26396E-04 | 0.31274E-04 | 0.85985E-06 | 0.57670E-04 |
| 93 | 0.75000E-01 | 0.86461E+01 | 0.26157E-04 | 0.42330E-04 | 0.96683E-06 | 0.68486E-04 |
| 94 | 0.10000E+00 | 0.85783E+01 | 0.25824E-04 | 0.52756E-04 | 0.10947E-05 | 0.78580E-04 |
| 95 | 0.12500E+00 | 0.87124E+01 | 0.25429E-04 | 0.56854E-04 | 0.12477E-05 | 0.82282E-04 |
| 96 | 0.15000E+00 | 0.94885E+01 | 0.24915E-04 | 0.58821E-04 | 0.13773E-05 | 0.83736E-04 |
| 97 | 0.17500E+00 | 0.12137E+02 | 0.24059E-04 | 0.62605E-04 | 0.15036E-05 | 0.86665E-04 |
| 98 | 0.20000E+00 | 0.13632E+02 | 0.22013E-04 | 0.58585E-04 | 0.17693E-05 | 0.80597E-04 |
| 99 | 0.22500E+00 | 0.13384E+02 | 0.21359E-04 | 0.43136E-04 | 0.18455E-05 | 0.64495E-04 |
| 100 | 0.25000E+00 | 0.13147E+02 | 0.20717E-04 | 0.38637E-04 | 0.18824E-05 | 0.59354E-04 |
| 101 | 0.27500E+00 | 0.13245E+02 | 0.19268E-04 | 0.29891E-04 | 0.17568E-05 | 0.49159E-04 |
| 102 | 0.30000E+00 | 0.13237E+02 | 0.18025E-04 | 0.00000E+00 | 0.14772E-05 | 0.18025E-04 |
| 103 | 0.32500E+00 | 0.13092E+02 | 0.17298E-04 | 0.00000E+00 | 0.15990E-05 | 0.17298E-04 |
| 104 | 0.35000E+00 | 0.12827E+02 | 0.16738E-04 | 0.00000E+00 | 0.16697E-05 | 0.16738E-04 |
| 105 | 0.37500E+00 | 0.12432E+02 | 0.15990E-04 | 0.00000E+00 | 0.16383E-05 | 0.15990E-04 |
| 106 | 0.40000E+00 | 0.11835E+02 | 0.14989E-04 | 0.00000E+00 | 0.15794E-05 | 0.14989E-04 |
| 107 | 0.42500E+00 | 0.10917E+02 | 0.13956E-04 | 0.00000E+00 | 0.16906E-05 | 0.13956E-04 |
| 108 | 0.45000E+00 | 0.94804E+01 | 0.13103E-04 | 0.00000E+00 | 0.16690E-05 | 0.13103E-04 |
| 109 | 0.47500E+00 | 0.78319E+01 | 0.12465E-04 | 0.00000E+00 | 0.16356E-05 | 0.12465E-04 |
| 110 | 0.50000E+00 | 0.24394E+02 | 0.11983E-04 | 0.00000E+00 | 0.15665E-05 | 0.11983E-04 |
| 111 | 0.53050E+00 | 0.45384E+01 | 0.14051E-04 | 0.00000E+00 | 0.18204E-05 | 0.14051E-04 |

| 112 | 0.56100E+00 | 0.27150E+01 | 0.13519E-04 | 0.00000E+00 | 0.16902E-05 | 0.13519E-04 | 0. |
|-----|-------------|-------------|-------------|-------------|-------------|-------------|----|
| 113 | 0.60100E+00 | 0.20780E+01 | 0.16682E-04 | 0.00000E+00 | 0.21653E-05 | 0.16682E-04 | 0. |
| 114 | 0.64100E+00 | 0.16782E+01 | 0.15549E-04 | 0.00000E+00 | 0.20066E-05 | 0.15549E-04 | 0. |
| 115 | 0.68100E+00 | 0.13742E+01 | 0.14466E-04 | 0.00000E+00 | 0.18746E-05 | 0.14466E-04 | 0. |
| 116 | 0.72100E+00 | 0.11311E+01 | 0.13531E-04 | 0.00000E+00 | 0.17638E-05 | 0.13531E-04 | 0. |
| 117 | 0.76100E+00 | 0.94147E+00 | 0.12705E-04 | 0.00000E+00 | 0.16699E-05 | 0.12705E-04 | 0. |
| 118 | 0.80100E+00 | 0.85457E+00 | 0.11906E-04 | 0.00000E+00 | 0,16186E-05 | 0.11906E-04 | 0. |
| 119 | 0.84100E+00 | 0.73161E+00 | 0.11075E-04 | 0.00000E+00 | 0.15405E-05 | 0.11075E-04 | 0. |
| 120 | 0.88100E+00 | 0.63400E+00 | 0.10218E-04 | 0.00000E+00 | 0.14731E-05 | 0.10218E-04 | 0. |
| 121 | 0.92100E+00 | 0.56146E+00 | 0.93586E-05 | 0.00000E+00 | 0.14134E-05 | 0.93586E-05 | 0. |
| 122 | 0.96100E+00 | 0.50032E+00 | 0.85100E-05 | 0.00000E+00 | 0.13602E-05 | 0.85100E-05 | 0. |
| 123 | 0.10010E+01 | 0.40254E+00 | 0.76665E-05 | 0.00000E+00 | 0.13214E-05 | 0.76665E-05 | 0. |
| 124 | 0.10410E+01 | 0.50558E+00 | 0.68189E-05 | 0.00000E+00 | 0.12801E-05 | 0.68189E-05 | 0. |
| 125 | 0.10810E+01 | 0.50090E+00 | 0.59666E-05 | 0.00000E+00 | 0.12349E-05 | 0.59666E-05 | 0. |
| 126 | 0.11210E+01 | 0.50632E+00 | 0.51220E-05 | 0.00000E+00 | 0.11953E-05 | 0.51220E-05 | 0 |
| 127 | 0.11610E+01 | 0.52795E+00 | 0.42972E-05 | 0.00000E+00 | 0.11610E-05 | 0.42972E-05 | 0 |
| 128 | 0.12010E+01 | 0.57027E+00 | 0.34740E-05 | 0.00000E+00 | 0.11319E-05 | 0.34740E-05 | 0 |
| 129 | 0.12410E+01 | 0.64320E+00 | 0.26055E-05 | 0.00000E+00 | 0.11079E-05 | 0.26055E-05 | 0 |
| 130 | 0.12810E+01 | 0.75760E+00 | 0.16590E-05 | 0.00000E+00 | 0.10897E-05 | 0.16590E-05 | 0 |
| 131 | 0.13210E+01 | 0.90888E+00 | 0.73517E-06 | 0.00000E+00 | 0.73517E-06 | 0.73517E-06 | 0 |
| 132 | 0.13610E+01 | 0.10171E+01 | 0.42900E-08 | 0.00000E+00 | 0.42900E-08 | 0.42900E-08 | 0 |
| 133 | 0.14010E+01 | -0.13366E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 134 | 0.14410E+01 | -0.12440E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 135 | 0.14810E+01 | -0.63182E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 136 | 0.15210E+01 | -0.14955E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 137 | 0.15610E+01 | 0.33317E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 138 | 0.15915E+01 | 0.42719E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 139 | 0.16220E+01 | 0.69190E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 140 | 0.16989E+01 | 0.95464E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 141 | 0.17758E+01 | 0.10878E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 142 | 0.18528E+01 | 0.11507E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 143 | 0.19297E+01 | 0.11739E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 144 | 0.20066E+01 | 0.11746E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 145 | 0.20835E+01 | 0.11623E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 146 | 0.21605E+01 | 0.11420E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 147 | 0.22374E+01 | 0.11161E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 148 | 0.23143E+01 | 0.10861E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 149 | 0.23912E+01 | 0.10530E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 150 | 0.24682E+01 | 0.10176E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 151 | 0.25451E+01 | 0.98000E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 152 | 0.26220E+01 | 0.94013E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | ( |
| 153 | 0.26525E+01 | 0.89693E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | ( |
| 154 | 0.26830E+01 | 0.86194E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | ( |
| 155 | 0.28259E+01 | 0.82766E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | ( |
| 156 | 0.29687E+01 | 0.78550E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | ( |
| 157 | 0.31116E+01 | 0.74045E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | ' |
| 158 | 0.32544E+01 | 0.69301E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 159 | 0.33973E+01 | 0.64349E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 160 | 0.35401E+01 | 0.59207E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 161 | 0.36830E+01 | 0.53878E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 162 | 0.37135E+01 | 0.49380E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 163 | 0.37440E+01 | 0.45317E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 164 | 0.40773E+01 | 0.38557E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 165 | 0.44107E+01 | 0.32456E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 166 | 0.47440E+01 | 0.26165E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |

C-2

| | | | | | | |
|---|---|---|---|---|---|---|
| 167 | 0.47745E+01 | 0.21938E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 168 | 0.48050E+01 | 0.17876E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 169 | 0.51383E+01 | 0.10716E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 170 | 0.54717E+01 | 0.52964E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 171 | 0.58050E+01 | 0.23320E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 172 | 0.80355E+01 | -0.96367E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 173 | 0.10266E+02 | -0.13300E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 174 | 0.12497E+02 | -0.14425E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 175 | 0.14727E+02 | -0.14548E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 176 | 0.16958E+02 | -0.14329E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 177 | 0.19188E+02 | -0.14361E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 178 | 0.21419E+02 | -0.28086E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |

FILE: DICE    DATA    A                VM/SP  CONVERSATIONAL MONITOR SYSTEM

| | |
|---|---|
| 0.000000000000E+00 | 0.000000000000E+00 |
| 0.213658763380E+00 | 0.000000000000E+00 |
| 0.426801559342E+00 | 0.000000000000E+00 |
| 0.639564639659E+00 | 0.000000000000E+00 |
| 0.106430232933E+01 | 0.000000000000E+00 |
| 0.159427463898E+01 | 0.000000000000E+00 |
| 0.212357888963E+01 | 0.000000000000E+00 |
| 0.265245839848E+01 | 0.000000000000E+00 |
| 0.318106364380E+01 | 0.000000000000E+00 |
| 0.370946839810E+01 | 0.000000000000E+00 |
| 0.423769466110E+01 | 0.000000000000E+00 |
| 0.476576076594E+01 | 0.000000000000E+00 |
| 0.529366627263E+01 | 0.000000000000E+00 |
| 0.582140267458E+01 | 0.000000000000E+00 |
| 0.634897319844E+01 | 0.000000000000E+00 |
| 0.687637447091E+01 | 0.000000000000E+00 |
| 0.740359886540E+01 | 0.000000000000E+00 |
| 0.793064579526E+01 | 0.000000000000E+00 |
| 0.845751027388E+01 | 0.000000000000E+00 |
| 0.898419288792E+01 | 0.000000000000E+00 |
| 0.951068586414E+01 | 0.000000000000E+00 |
| 0.100369952158E+02 | 0.000000000000E+00 |
| 0.105631205029E+02 | 0.000000000000E+00 |
| 0.110890642187E+02 | 0.000000000000E+00 |
| 0.116148320833E+02 | 0.000000000000E+00 |
| 0.121404282031E+02 | 0.000000000000E+00 |
| 0.126658660714E+02 | 0.000000000000E+00 |
| 0.131911536081E+02 | 0.000000000000E+00 |
| 0.137163131063E+02 | 0.000000000000E+00 |
| 0.142413756589E+02 | 0.000000000000E+00 |
| 0.147663826255E+02 | 0.000000000000E+00 |
| 0.152913939920E-02 | 0.000000000000E+00 |
| 0.158164839710E+02 | 0.000000000000E+00 |
| 0.163417646144E+02 | 0.000000000000E+00 |
| 0.168673931472E+02 | 0.000000000000E+00 |
| 0.173935923535E+02 | 0.000000000000E+00 |
| 0.179207030826E+02 | 0.000000000000E+00 |
| 0.184492327955E+02 | 0.000000000000E+00 |
| 0.189800355223E+02 | 0.000000000000E+00 |
| 0.191933226366E+02 | 0.000000000000E+00 |
| 0.194073829687E+02 | 0.000000000000E+00 |
| 0.196224680490E+02 | 0.100524566000E-07 |
| 0.198389463001E+02 | 0.453962514000E-06 |
| 0.200573718221E+02 | 0.887504721000E-04 |
| 0.201675656894E+02 | 0.215322201000E-03 |
| 0.202786047320E+02 | 0.337043544000E-03 |
| 0.203906784961E+02 | 0.464335317000E-03 |
| 0.205040340112E+02 | 0.600579893000E-03 |
| 0.206190210186E+02 | 0.746608945000E-03 |
| 0.207364521062E+02 | 0.939490972000E-03 |
| 0.208581417033E+02 | 0.119158090000E-02 |
| 0.209869034585E+02 | 0.142938644000E-02 |
| 0.210564222489E+02 | 0.160364690000E-02 |
| 0.211335722384E+02 | 0.289047882000E-02 |
| 0.211776646186E+02 | 0.232472713000E-02 |

| | |
|---|---|
| 0.212286073720E+02 | 0.235507265000E-02 |
| 0.212400472133E+02 | 0.221005408000E-02 |
| 0.212520313467E+02 | 0.210260693000E-02 |
| 0.212646802300E+02 | 0.203932263000E-02 |
| 0.212781366324E+02 | 0.196106965000E-02 |
| 0.212925265299E+02 | 0.185003551000E-02 |
| 0.213081556640E+02 | 0.172521011000E-02 |
| 0.213165563599E+02 | 0.166754425000E-02 |
| 0.213254170814E+02 | 0.161967170000E-02 |
| 0.213348612133E+02 | 0.157313119000E-02 |
| 0.213450540448E+02 | 0.150693906000E-02 |
| 0.213562238575E+02 | 0.140628195000E-02 |
| 0.213688683317E+02 | 0.130496640000E-02 |
| 0.213842972681E+02 | 0.126235583000E-02 |
| 0.214186696557E+02 | 0.129296002000E-02 |
| 0.214530420432E+02 | 0.134247215000E-02 |
| 0.214684709796E+02 | 0.143570313000E-02 |
| 0.214811154538E+02 | 0.150468177000E-02 |
| 0.214922852665E+02 | 0.156887877000E-02 |
| 0.215024780980E+02 | 0.164282508000E-02 |
| 0.215119222299E+02 | 0.172157097000E-02 |
| 0.215207829514E+02 | 0.179782789000E-02 |
| 0.215291836473E+02 | 0.186827569000E-02 |
| 0.215448127815E+02 | 0.199275836000E-02 |
| 0.215592026790E+02 | 0.208739378000E-02 |
| 0.215726590813E+02 | 0.211706711000E-02 |
| 0.215853079646E+02 | 0.216788147000E-02 |
| 0.215972920980E+02 | 0.247450126000E-02 |
| 0.216087319394E+02 | 0.297235418000E-02 |
| 0.216596746927E+02 | 0.232414692000E-02 |
| 0.217037670729E+02 | 0.354407728000E-02 |
| 0.217809170625E+02 | 0.145220268000E-02 |
| 0.218504358528E+02 | 0.118785352000E-02 |
| 0.219791976080E+02 | 0.996353570000E-03 |
| 0.221008872051E+02 | 0.752129825000E-03 |
| 0.222183182928E+02 | 0.600256957000E-03 |
| 0.223333053001E+02 | 0.456815818000E-03 |
| 0.224466608153E+02 | 0.320933061000E-03 |
| 0.225587345793E+02 | 0.189257669000E-03 |
| 0.226697736219E+02 | 0.590182026000E-04 |
| 0.227799674892E+02 | 0.000000000000E+00 |
| 0.229983930112E+02 | 0.281359007000E-05 |
| 0.232148712623E+02 | 0.470211532000E-07 |
| 0.234299563426E+02 | 0.000000000000E+00 |
| 0.236440166748E+02 | 0.000000000000E+00 |
| 0.238573037891E+02 | 0.000000000000E+00 |
| 0.243881065159E+02 | 0.000000000000E+00 |
| 0.249166362287E+02 | 0.000000000000E+00 |
| 0.254437469578E+02 | 0.000000000000E+00 |
| 0.259699461641E+02 | 0.000000000000E+00 |
| 0.264955746969E+02 | 0.000000000000E+00 |
| 0.270208553403E+02 | 0.000000000000E+00 |
| 0.275459453193E+02 | 0.000000000000E+00 |
| 0.280709566858E+02 | 0.000000000000E+00 |
| 0.285959636524E+02 | 0.000000000000E+00 |

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0.291210262050E+02    0.000000000000E+00
0.296461857032E+02    0.000000000000E+00
0.301714732399E+02    0.000000000000E+00
0.306969111082E+02    0.000000000000E+00
0.312225072281E+02    0.000000000000E+00
0.317482750926E+02    0.000000000000E+00
0.322742188084E+02    0.000000000000E+00
0.328003440955E+02    0.000000000000E+00
0.333266534472E+02    0.000000000000E+00
0.338531464234E+02    0.000000000000E+00
0.343798290374E+02    0.000000000000E+00
0.349066935161E+02    0.000000000000E+00
0.354337404459E+02    0.000000000000E+00
0.359609648404E+02    0.000000000000E+00
0.364883661129E+02    0.000000000000E+00
0.370159366367E+02    0.000000000000E+00
0.375436730387E+02    0.000000000000E+00
0.380715785454E+02    0.000000000000E+00
0.385996446502E+02    0.000000000000E+00
0.391278709132E+02    0.000000000000E+00
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0.401848809128E+02    0.000000000000E+00
0.407137604217E+02    0.000000000000E+00
0.412430646723E+02    0.000000000000E+00
0.417730369820E+02    0.000000000000E+00
0.421977746717E+02    0.000000000000E+00
0.424105377520E+02    0.000000000000E+00
0.426236805479E+02    0.000000000000E+00
```

| | | | | |
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| 0.53340E+00 | 0.00000E+00 | 0.00000E+00 | 0.94528E+05 | 0.00000E+00 |
| 0.52807E+00 | -0.99959E-03 | 0.00000E+00 | 0.93085E+05 | 0.33257E+03 |
| 0.52273E+00 | -0.19261E-02 | 0.00000E+00 | 0.92501E+05 | 0.35195E+03 |
| 0.51740E+00 | -0.27945E-02 | 0.00000E+00 | 0.91961E+05 | 0.36999E+03 |
| 0.50673E+00 | -0.44011E-02 | 0.00000E+00 | 0.91466E+05 | 0.38681E+03 |
| 0.49339E+00 | -0.62408E-02 | 0.00000E+00 | 0.91115E+05 | 0.39923E+03 |
| 0.48006E+00 | -0.79519E-02 | 0.00000E+00 | 0.90863E+05 | 0.40860E+03 |
| 0.46672E+00 | -0.95761E-02 | 0.00000E+00 | 0.90654E+05 | 0.41668E+03 |
| 0.45339E+00 | -0.11142E-01 | 0.00000E+00 | 0.90463E+05 | 0.42434E+03 |
| 0.44005E+00 | -0.12662E-01 | 0.00000E+00 | 0.90281E+05 | 0.43181E+03 |
| 0.42672E+00 | -0.14143E-01 | 0.00000E+00 | 0.90105E+05 | 0.43925E+03 |
| 0.41338E+00 | -0.15586E-01 | 0.00000E+00 | 0.89932E+05 | 0.44674E+03 |
| 0.40005E+00 | -0.16991E-01 | 0.00000E+00 | 0.89763E+05 | 0.45424E+03 |
| 0.38671E+00 | -0.18355E-01 | 0.00000E+00 | 0.89599E+05 | 0.46175E+03 |
| 0.37338E+00 | -0.19676E-01 | 0.00000E+00 | 0.89437E+05 | 0.46942E+03 |
| 0.36004E+00 | -0.20952E-01 | 0.00000E+00 | 0.89276E+05 | 0.47725E+03 |
| 0.34671E+00 | -0.22181E-01 | 0.00000E+00 | 0.89117E+05 | 0.48524E+03 |
| 0.33337E+00 | -0.23360E-01 | 0.00000E+00 | 0.88959E+05 | 0.49344E+03 |
| 0.32004E+00 | -0.24485E-01 | 0.00000E+00 | 0.88802E+05 | 0.50188E+03 |
| 0.30670E+00 | -0.25553E-01 | 0.00000E+00 | 0.88646E+05 | 0.51060E+03 |
| 0.29337E+00 | -0.26560E-01 | 0.00000E+00 | 0.88491E+05 | 0.51962E+03 |
| 0.28003E+00 | -0.27502E-01 | 0.00000E+00 | 0.88335E+05 | 0.52908E+03 |
| 0.26670E+00 | -0.28376E-01 | 0.00000E+00 | 0.88178E+05 | 0.53896E+03 |
| 0.25336E+00 | -0.29176E-01 | 0.00000E+00 | 0.88019E+05 | 0.54941E+03 |
| 0.24003E+00 | -0.29898E-01 | 0.00000E+00 | 0.87859E+05 | 0.56048E+03 |
| 0.22670E+00 | -0.30533E-01 | 0.00000E+00 | 0.87697E+05 | 0.57223E+03 |
| 0.21336E+00 | -0.31077E-01 | 0.00000E+00 | 0.87532E+05 | 0.58482E+03 |
| 0.20002E+00 | -0.31519E-01 | 0.00000E+00 | 0.87370E+05 | 0.59823E+03 |
| 0.18669E+00 | -0.31848E-01 | 0.00000E+00 | 0.87208E+05 | 0.61262E+03 |
| 0.17335E+00 | -0.32054E-01 | 0.00000E+00 | 0.87049E+05 | 0.62818E+03 |
| 0.16002E+00 | -0.32125E-01 | 0.00000E+00 | 0.86893E+05 | 0.64508E+03 |
| 0.14668E+00 | -0.32045E-01 | 0.00000E+00 | 0.86742E+05 | 0.66365E+03 |
| 0.13335E+00 | -0.31797E-01 | 0.00000E+00 | 0.86597E+05 | 0.68429E+03 |
| 0.12001E+00 | -0.31361E-01 | 0.00000E+00 | 0.86463E+05 | 0.70739E+03 |
| 0.10668E+00 | -0.30708E-01 | 0.00000E+00 | 0.86346E+05 | 0.73363E+03 |
| 0.93345E-01 | -0.29806E-01 | 0.00000E+00 | 0.86256E+05 | 0.76394E+03 |
| 0.80010E-01 | -0.28609E-01 | 0.00000E+00 | 0.86207E+05 | 0.79977E+03 |
| 0.66675E-01 | -0.27060E-01 | 0.00000E+00 | 0.86222E+05 | 0.84362E+03 |
| 0.53340E-01 | -0.25072E-01 | 0.00000E+00 | 0.86289E+05 | 0.88156E+03 |
| 0.48006E-01 | -0.24125E-01 | 0.00000E+00 | 0.86350E+05 | 0.90769E+03 |
| 0.42672E-01 | -0.23071E-01 | 0.00000E+00 | 0.86451E+05 | 0.93724E+03 |
| 0.37338E-01 | -0.21890E-01 | 0.00000E+00 | 0.86617E+05 | 0.97066E+03 |
| 0.32004E-01 | -0.20555E-01 | 0.00000E+00 | 0.86890E+05 | 0.10080E+04 |
| 0.26670E-01 | -0.19029E-01 | 0.36846E-01 | 0.87197E+05 | 0.10389E+04 |
| 0.24003E-01 | -0.18179E-01 | 0.72813E-01 | 0.87462E+05 | 0.10614E+04 |
| 0.21336E-01 | -0.17262E-01 | 0.10903E+00 | 0.87792E+05 | 0.10855E+04 |
| 0.18669E-01 | -0.16267E-01 | 0.14571E+00 | 0.88194E+05 | 0.11122E+04 |
| 0.16002E-01 | -0.15182E-01 | 0.18299E+00 | 0.88677E+05 | 0.11436E+04 |
| 0.13335E-01 | -0.13991E-01 | 0.22123E+00 | 0.89290E+05 | 0.11801E+04 |
| 0.10668E-01 | -0.12655E-01 | 0.27031E+00 | 0.90202E+05 | 0.12137E+04 |
| 0.80010E-02 | -0.11093E-01 | 0.33232E+00 | 0.91577E+05 | 0.12363E+04 |
| 0.53340E-02 | -0.92001E-02 | 0.39755E+00 | 0.93134E+05 | 0.12260E+04 |
| 0.40005E-02 | -0.80426E-02 | 0.45049E+00 | 0.94644E+05 | 0.11809E+04 |
| 0.26670E-02 | -0.66067E-02 | 0.51003E+00 | 0.96128E+05 | 0.10989E+04 |
| 0.20002E-02 | -0.57068E-02 | 0.55315E+00 | 0.97340E+05 | 0.10040E+04 |

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0.13335E-02  -0.45979E-02   0.58051E+00   0.98116E+05   0.92716E+03
0.12001E-02  -0.43397E-02   0.59210E+00   0.98429E+05   0.88705E+03
0.10668E-02  -0.40661E-02   0.60299E+00   0.98714E+05   0.85121E+03
0.93345E-03  -0.37738E-02   0.61453E+00   0.99002E+05   0.81178E+03
0.80010E-03  -0.34591E-02   0.61789E+00   0.99292E+05   0.76835E+03
0.66675E-03  -0.31188E-02   0.62325E+00   0.99578E+05   0.72199E+03
0.53340E-03  -0.27449E-02   0.62761E+00   0.99793E+05   0.68355E+03
0.46672E-03  -0.25422E-02   0.63085E+00   0.99942E+05   0.65425E+03
0.40005E-03  -0.23272E-02   0.63420E+00   0.10008E+06   0.62528E+03
0.33337E-03  -0.20968E-02   0.63780E+00   0.10023E+06   0.59510E+03
0.26670E-03  -0.18466E-02   0.64381E+00   0.10036E+06   0.56432E+03
0.20003E-03  -0.15709E-02   0.64399E+00   0.10050E+06   0.53413E+03
0.13335E-03  -0.12567E-02   0.64421E+00   0.10064E+06   0.50297E+03
0.66675E-04  -0.87051E-03   0.64460E+00   0.10080E+06   0.50297E+03
0.00000E+00   0.00000E+00   0.64380E+00   0.10080E+06   0.50297E+03
0.66675E-04   0.87051E-03   0.64278E+00   0.10064E+06   0.50297E+03
0.13335E-03   0.12567E-02   0.64218E+00   0.10050E+06   0.53413E+03
0.20003E-03   0.15709E-02   0.64173E+00   0.10036E+06   0.56432E+03
0.26670E-03   0.18466E-02   0.63692E+00   0.10023E+06   0.59510E+03
0.33337E-03   0.20968E-02   0.63356E+00   0.10008E+06   0.62528E+03
0.40005E-03   0.23272E-02   0.63045E+00   0.99942E+05   0.65425E+03
0.46672E-03   0.25422E-02   0.62744E+00   0.99793E+05   0.68355E+03
0.53340E-03   0.27449E-02   0.62338E+00   0.99578E+05   0.72199E+03
0.66675E-03   0.31188E-02   0.61839E+00   0.99292E+05   0.76826E+03
0.80010E-03   0.34591E-02   0.61371E+00   0.99002E+05   0.81179E+03
0.93345E-03   0.37738E-02   0.60237E+00   0.98713E+05   0.85130E+03
0.10668E-02   0.40661E-02   0.59167E+00   0.98429E+05   0.88705E+03
0.12001E-02   0.43397E-02   0.58029E+00   0.98116E+05   0.92716E+03
0.13335E-02   0.45979E-02   0.55340E+00   0.97340E+05   0.10040E+04
0.20002E-02   0.57068E-02   0.51257E+00   0.96128E+05   0.10989E+04
0.26670E-02   0.66067E-02   0.45467E+00   0.94644E+05   0.11809E+04
0.40005E-02   0.80426E-02   0.39931E+00   0.93134E+05   0.12260E+04
0.53340E-02   0.92001E-02   0.33332E+00   0.91577E+05   0.12362E+04
0.80010E-02   0.11093E-01   0.26976E+00   0.90202E+05   0.12137E+04
0.10668E-01   0.12655E-01   0.21949E+00   0.89291E+05   0.11801E+04
0.13335E-01   0.13991E-01   0.18146E+00   0.88677E+05   0.11436E+04
0.16002E-01   0.15182E-01   0.14437E+00   0.88195E+05   0.11122E+04
0.18669E-01   0.16267E-01   0.10789E+00   0.87792E+05   0.10855E+04
0.21336E-01   0.17262E-01   0.71863E-01   0.87462E+05   0.10614E+04
0.24003E-01   0.18179E-01   0.36087E-01   0.87197E+05   0.10389E+04
0.26670E-01   0.19029E-01   0.00000E+00   0.86890E+05   0.10080E+04
0.32004E-01   0.20555E-01   0.00000E+00   0.86617E+05   0.97065E+03
0.37338E-01   0.21890E-01   0.00000E+00   0.86451E+05   0.93725E+03
0.42672E-01   0.23071E-01   0.00000E+00   0.86350E+05   0.90768E+03
0.48006E-01   0.24125E-01   0.00000E+00   0.86289E+05   0.88157E+03
0.53340E-01   0.25072E-01   0.00000E+00   0.86222E+05   0.84362E+03
0.66675E-01   0.27060E-01   0.00000E+00   0.86207E+05   0.79977E+03
0.80010E-01   0.28609E-01   0.00000E+00   0.86256E+05   0.76394E+03
0.93345E-01   0.29806E-01   0.00000E+00   0.86346E+05   0.73364E+03
0.10668E+00   0.30708E-01   0.00000E+00   0.86463E+05   0.70739E+03
0.12001E+00   0.31361E-01   0.00000E+00   0.86597E+05   0.68429E+03
0.13335E+00   0.31797E-01   0.00000E+00   0.86742E+05   0.66365E+03
0.14668E+00   0.32045E-01   0.00000E+00   0.86893E+05   0.64508E+03
0.16002E+00   0.32125E-01   0.00000E+00   0.87049E+05   0.62818E+03
0.17335E-00   0.32054E-01   0.00000E+00   0.87208E+05   0.61263E+03
```

| | | | | |
|---|---|---|---|---|
| 0.18669E+00 | 0.31848E-01 | 0.00000E+00 | 0.87370E+05 | 0.59823E+03 |
| 0.20002E+00 | 0.31519E-01 | 0.00000E+00 | 0.87532E+05 | 0.58482E+03 |
| 0.21336E+00 | 0.31077E-01 | 0.00000E+00 | 0.87697E+05 | 0.57223E+03 |
| 0.22670E+00 | 0.30533E-01 | 0.00000E+00 | 0.87859E+05 | 0.56048E+03 |
| 0.24003E+00 | 0.29898E-01 | 0.00000E+00 | 0.88019E+05 | 0.54941E+03 |
| 0.25336E+00 | 0.29176E-01 | 0.00000E+00 | 0.88178E+05 | 0.53896E+03 |
| 0.26670E+00 | 0.28376E-01 | 0.00000E+00 | 0.88335E+05 | 0.52908E+03 |
| 0.28003E+00 | 0.27502E-01 | 0.00000E+00 | 0.88491E+05 | 0.51962E+03 |
| 0.29337E+00 | 0.26560E-01 | 0.00000E+00 | 0.88646E+05 | 0.51060E+03 |
| 0.30670E+00 | 0.25553E-01 | 0.00000E+00 | 0.88802E+05 | 0.50188E+03 |
| 0.32004E+00 | 0.24485E-01 | 0.00000E+00 | 0.88959E+05 | 0.49344E+03 |
| 0.33337E+00 | 0.23360E-01 | 0.00000E+00 | 0.89117E+05 | 0.48524E+03 |
| 0.34671E+00 | 0.22181E-01 | 0.00000E+00 | 0.89276E+05 | 0.47725E+03 |
| 0.36004E+00 | 0.20952E-01 | 0.00000E+00 | 0.89437E+05 | 0.46942E+03 |
| 0.37338E+00 | 0.19676E-01 | 0.00000E+00 | 0.89599E+05 | 0.46175E+03 |
| 0.38671E+00 | 0.18355E-01 | 0.00000E+00 | 0.89763E+05 | 0.45424E+03 |
| 0.40005E+00 | 0.16991E-01 | 0.00000E+00 | 0.89932E+05 | 0.44673E+03 |
| 0.41338E+00 | 0.15586E-01 | 0.00000E+00 | 0.90105E+05 | 0.43924E+03 |
| 0.42672E+00 | 0.14143E-01 | 0.00000E+00 | 0.90281E+05 | 0.43180E+03 |
| 0.44005E+00 | 0.12662E-01 | 0.00000E+00 | 0.90463E+05 | 0.42433E+03 |
| 0.45339E+00 | 0.11142E-01 | 0.00000E+00 | 0.90654E+05 | 0.41667E+03 |
| 0.46672E+00 | 0.95761E-02 | 0.00000E+00 | 0.90863E+05 | 0.40859E+03 |
| 0.48006E+00 | 0.79519E-02 | 0.00000E+00 | 0.91115E+05 | 0.39922E+03 |
| 0.49339E+00 | 0.62408E-02 | 0.00000E+00 | 0.91466E+05 | 0.38681E+03 |
| 0.50673E+00 | 0.44011E-02 | 0.00000E+00 | 0.91961E+05 | 0.36999E+03 |
| 0.51740E+00 | 0.27945E-02 | 0.00000E+00 | 0.92501E+05 | 0.35195E+03 |
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| 0.52807E+00 | 0.99959E-03 | 0.00000E+00 | 0.94528E+05 | 0.28421E+03 |
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| X(in) | Y(in) |
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| 9.91154523 | -1.15226143 |
| 7.68307923 | -1.24616059 |
| 5.45276231 | -1.25644559 |
| 5.11952640 | -1.24831620 |
| 4.78638001 | -1.23710023 |
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  0.01681608    0.48865483
  0.09936224    0.44208001
  0.14008078    0.43756448
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  0.21441341    0.47491618
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| | |
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| 0.27214938 | 0.50526031 |
| 0.31027840 | 0.52302332 |
| 0.34908695 | 0.53945352 |
| 0.38796796 | 0.55507079 |
| 0.42664827 | 0.57033986 |
| 0.46517276 | 0.58518940 |
| 0.50369177 | 0.59939996 |
| 0.54233606 | 0.61282514 |
| 0.58110596 | 0.62556844 |
| 0.61995177 | 0.63777907 |
| 0.65884703 | 0.64956275 |
| 0.69780618 | 0.66091599 |
| 0.73683978 | 0.67181460 |
| 0.77594207 | 0.68227062 |
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| 187.900000 | 0.195424 | 17.447711 | 6.116200 |
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| 188.300000 | 0.012090 | 16.821574 | 5.906171 |
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| 188.700000 | 0.000024 | 17.194825 | 6.095805 |
| 188.900000 | 0.000023 | 17.556795 | 6.329532 |
| 189.100000 | 0.000022 | 17.653754 | 6.232344 |
| 189.300000 | 0.000021 | 17.773119 | 6.112398 |
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| 123.20000000 | 21.62 | 21.63 | 131.85 | 28.32 | 141.59 | 34.31 | 131.69 |
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| 126.60000000 | 21.93 | 21.65 | 85.62 | 32.00 | 176.69 | 53.60 | 86.05 |
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| 136.60000000 | 23.01 | 21.95 | 33.72 | 24.90 | 215.34 | 76.31 | 35.34 |
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| 140.00000000 | 23.14 | 21.99 | 32.20 | 23.93 | 220.00 | 78.92 | 33.96 |
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| 143.00000000 | 23.24 | 22.01 | 31.77 | 23.55 | 222.65 | 80.35 | 33.62 |
| 143.20000000 | 23.25 | 22.01 | 31.76 | 23.54 | 222.79 | 80.43 | 33.61 |
| 143.40000000 | 23.26 | 22.01 | 31.75 | 23.53 | 222.93 | 80.50 | 33.60 |
| 143.60000000 | 23.26 | 22.01 | 31.74 | 23.51 | 223.07 | 80.57 | 33.60 |
| 143.80000000 | 23.27 | 22.01 | 31.74 | 23.50 | 223.20 | 80.64 | 33.60 |
| 144.00000000 | 23.28 | 22.02 | 31.73 | 23.49 | 223.33 | 80.71 | 33.59 |
| 144.20000000 | 23.28 | 22.02 | 31.73 | 23.48 | 223.45 | 80.78 | 33.59 |
| 144.40000000 | 23.29 | 22.02 | 31.73 | 23.47 | 223.58 | 80.84 | 33.59 |
| 144.60000000 | 23.30 | 22.02 | 31.72 | 23.46 | 223.70 | 80.90 | 33.60 |
| 144.80000000 | 23.30 | 22.02 | 31.72 | 23.45 | 223.82 | 80.96 | 33.60 |
| 145.00000000 | 23.31 | 22.02 | 31.73 | 23.44 | 223.93 | 81.02 | 33.60 |
| 145.20000000 | 23.32 | 22.02 | 31.73 | 23.43 | 224.04 | 81.08 | 33.61 |
| 145.40000000 | 23.32 | 22.03 | 31.73 | 23.43 | 224.15 | 81.14 | 33.62 |
| 145.60000000 | 23.33 | 22.03 | 31.73 | 23.42 | 224.26 | 81.19 | 33.62 |
| 145.80000000 | 23.34 | 22.03 | 31.74 | 23.41 | 224.36 | 81.24 | 33.63 |
| 146.00000000 | 23.35 | 22.03 | 31.74 | 23.41 | 224.47 | 81.30 | 33.64 |
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| 146.40000000 | 23.36 | 22.03 | 31.76 | 23.40 | 224.67 | 81.40 | 33.66 |
| 146.60000000 | 23.37 | 22.03 | 31.76 | 23.39 | 224.76 | 81.44 | 33.67 |
| 146.80000000 | 23.38 | 22.03 | 31.77 | 23.39 | 224.85 | 81.49 | 33.68 |
| 147.00000000 | 23.38 | 22.04 | 31.78 | 23.39 | 224.94 | 81.54 | 33.69 |
| 147.20000000 | 23.39 | 22.04 | 31.79 | 23.38 | 225.04 | 81.58 | 33.70 |
| 147.40000000 | 23.40 | 22.04 | 31.80 | 23.38 | 225.12 | 81.62 | 33.71 |
| 147.60000000 | 23.40 | 22.04 | 31.81 | 23.38 | 225.21 | 81.67 | 33.73 |
| 147.80000000 | 23.41 | 22.04 | 31.82 | 23.38 | 225.29 | 81.71 | 33.74 |
| 148.00000000 | 23.42 | 22.04 | 31.83 | 23.38 | 225.37 | 81.75 | 33.76 |
| 148.20000000 | 23.43 | 22.05 | 31.85 | 23.37 | 225.45 | 81.79 | 33.77 |
| 148.40000000 | 23.44 | 22.05 | 31.86 | 23.37 | 225.53 | 81.82 | 33.78 |
| 148.60000000 | 23.44 | 22.05 | 31.87 | 23.37 | 225.61 | 81.86 | 33.80 |
| 148.80000000 | 23.45 | 22.05 | 31.88 | 23.37 | 225.69 | 81.90 | 33.82 |
| 149.00000000 | 23.46 | 22.05 | 31.90 | 23.37 | 225.76 | 81.93 | 33.83 |
| 149.20000000 | 23.47 | 22.05 | 31.91 | 23.37 | 225.83 | 81.97 | 33.85 |
| 149.40000000 | 23.47 | 22.05 | 31.93 | 23.37 | 225.90 | 82.00 | 33.86 |
| 149.60000000 | 23.48 | 22.06 | 31.94 | 23.37 | 225.97 | 82.03 | 33.88 |
| 149.80000000 | 23.49 | 22.06 | 31.96 | 23.37 | 226.04 | 82.07 | 33.90 |
| 150.00000000 | 23.50 | 22.06 | 31.97 | 23.37 | 226.11 | 82.10 | 33.91 |
| 150.20000000 | 23.51 | 22.06 | 31.99 | 23.37 | 226.17 | 82.13 | 33.93 |
| 150.40000000 | 23.52 | 22.06 | 32.00 | 23.38 | 226.24 | 82.16 | 33.95 |
| 150.60000000 | 23.52 | 22.06 | 32.02 | 23.38 | 226.30 | 82.19 | 33.97 |
| 150.80000000 | 23.53 | 22.07 | 32.03 | 23.38 | 226.36 | 82.22 | 33.98 |
| 151.00000000 | 23.54 | 22.07 | 32.05 | 23.38 | 226.42 | 82.24 | 34.00 |
| 151.20000000 | 23.55 | 22.07 | 32.06 | 23.38 | 226.48 | 82.27 | 34.02 |
| 151.40000000 | 23.56 | 22.07 | 32.08 | 23.38 | 226.54 | 82.30 | 34.04 |
| 151.60000000 | 23.56 | 22.07 | 32.10 | 23.39 | 226.60 | 82.32 | 34.06 |
| 151.80000000 | 23.57 | 22.07 | 32.11 | 23.39 | 226.65 | 82.35 | 34.07 |
| 152.00000000 | 23.58 | 22.08 | 32.13 | 23.39 | 226.71 | 82.38 | 34.09 |

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| 152.20000000 | 23.59 | 22.08 | 32.15 | 23.39 | 226.76 | 82.40 | 34.11 |
| 152.40000000 | 23.60 | 22.08 | 32.16 | 23.39 | 226.82 | 82.42 | 34.13 |
| 152.60000000 | 23.61 | 22.08 | 32.18 | 23.40 | 226.87 | 82.45 | 34.15 |
| 152.80000000 | 23.61 | 22.08 | 32.20 | 23.40 | 226.92 | 82.47 | 34.17 |
| 153.00000000 | 23.62 | 22.09 | 32.21 | 23.40 | 226.97 | 82.49 | 34.18 |
| 153.20000000 | 23.63 | 22.09 | 32.23 | 23.40 | 227.02 | 82.52 | 34.20 |
| 153.40000000 | 23.64 | 22.09 | 32.25 | 23.41 | 227.07 | 82.54 | 34.22 |
| 153.60000000 | 23.65 | 22.09 | 32.27 | 23.41 | 227.12 | 82.56 | 34.24 |
| 153.80000000 | 23.66 | 22.09 | 32.28 | 23.41 | 227.16 | 82.58 | 34.26 |
| 154.00000000 | 23.67 | 22.10 | 32.30 | 23.42 | 227.21 | 82.60 | 34.28 |
| 154.20000000 | 23.67 | 22.10 | 32.32 | 23.42 | 227.25 | 82.62 | 34.30 |
| 154.40000000 | 23.68 | 22.10 | 32.34 | 23.42 | 227.30 | 82.64 | 34.31 |
| 154.60000000 | 23.69 | 22.10 | 32.35 | 23.42 | 227.34 | 82.66 | 34.33 |
| 154.80000000 | 23.70 | 22.10 | 32.37 | 23.43 | 227.39 | 82.68 | 34.35 |
| 155.00000000 | 23.71 | 22.10 | 32.39 | 23.43 | 227.43 | 82.69 | 34.37 |
| 155.20000000 | 23.72 | 22.11 | 32.40 | 23.43 | 227.47 | 82.71 | 34.39 |
| 155.40000000 | 23.73 | 22.11 | 32.42 | 23.44 | 227.51 | 82.73 | 34.41 |
| 155.60000000 | 23.73 | 22.11 | 32.44 | 23.44 | 227.55 | 82.75 | 34.42 |
| 155.80000000 | 23.74 | 22.11 | 32.46 | 23.44 | 227.59 | 82.76 | 34.44 |
| 156.00000000 | 23.75 | 22.11 | 32.47 | 23.45 | 227.63 | 82.78 | 34.46 |
| 156.20000000 | 23.76 | 22.12 | 32.49 | 23.45 | 227.67 | 82.80 | 34.48 |
| 156.40000000 | 23.77 | 22.12 | 32.51 | 23.45 | 227.71 | 82.81 | 34.50 |
| 156.60000000 | 23.78 | 22.12 | 32.52 | 23.46 | 227.75 | 82.83 | 34.52 |
| 156.80000000 | 23.79 | 22.12 | 32.54 | 23.46 | 227.79 | 82.85 | 34.53 |
| 157.00000000 | 23.79 | 22.12 | 32.56 | 23.46 | 227.82 | 82.86 | 34.55 |
| 157.20000000 | 23.80 | 22.13 | 32.58 | 23.47 | 227.86 | 82.88 | 34.57 |
| 157.40000000 | 23.81 | 22.13 | 32.59 | 23.47 | 227.89 | 82.89 | 34.59 |
| 157.60000000 | 23.82 | 22.13 | 32.61 | 23.47 | 227.93 | 82.90 | 34.61 |
| 157.80000000 | 23.83 | 22.13 | 32.63 | 23.48 | 227.96 | 82.92 | 34.62 |
| 158.00000000 | 23.84 | 22.13 | 32.64 | 23.48 | 228.00 | 82.93 | 34.64 |
| 158.20000000 | 23.85 | 22.14 | 32.66 | 23.49 | 228.03 | 82.95 | 34.66 |
| 158.40000000 | 23.85 | 22.14 | 32.68 | 23.49 | 228.06 | 82.96 | 34.68 |
| 158.60000000 | 23.86 | 22.14 | 32.69 | 23.49 | 228.09 | 82.97 | 34.69 |
| 158.80000000 | 23.87 | 22.14 | 32.71 | 23.50 | 228.13 | 82.99 | 34.71 |
| 159.00000000 | 23.88 | 22.15 | 32.73 | 23.50 | 228.16 | 83.00 | 34.73 |
| 159.20000000 | 23.89 | 22.15 | 32.74 | 23.50 | 228.19 | 83.01 | 34.74 |
| 159.40000000 | 23.90 | 22.15 | 32.76 | 23.51 | 228.22 | 83.02 | 34.76 |
| 159.60000000 | 23.91 | 22.15 | 32.78 | 23.51 | 228.25 | 83.04 | 34.78 |
| 159.80000000 | 23.91 | 22.15 | 32.79 | 23.52 | 228.28 | 83.05 | 34.80 |
| 160.00000000 | 23.92 | 22.16 | 32.81 | 23.52 | 228.31 | 83.06 | 34.81 |
| 160.20000000 | 23.93 | 22.16 | 32.82 | 23.52 | 228.34 | 83.07 | 34.83 |
| 160.40000000 | 23.94 | 22.16 | 32.84 | 23.53 | 228.37 | 83.08 | 34.85 |
| 160.60000000 | 23.95 | 22.16 | 32.85 | 23.53 | 228.40 | 83.09 | 34.86 |
| 160.80000000 | 23.96 | 22.16 | 32.87 | 23.53 | 228.43 | 83.11 | 34.88 |
| 161.00000000 | 23.97 | 22.17 | 32.88 | 23.53 | 228.45 | 83.12 | 34.90 |
| 161.20000000 | 23.97 | 22.17 | 32.90 | 23.54 | 228.48 | 83.13 | 34.91 |
| 161.40000000 | 23.98 | 22.17 | 32.91 | 23.54 | 228.51 | 83.14 | 34.93 |
| 161.60000000 | 23.99 | 22.17 | 32.93 | 23.54 | 228.54 | 83.15 | 34.94 |
| 161.80000000 | 24.00 | 22.17 | 32.94 | 23.54 | 228.56 | 83.16 | 34.96 |
| 162.00000000 | 24.01 | 22.18 | 32.96 | 23.55 | 228.59 | 83.17 | 34.98 |
| 162.20000000 | 24.02 | 22.18 | 32.97 | 23.55 | 228.61 | 83.18 | 34.99 |
| 162.40000000 | 24.02 | 22.18 | 32.99 | 23.55 | 228.64 | 83.19 | 35.01 |
| 162.60000000 | 24.03 | 22.18 | 33.00 | 23.56 | 228.66 | 83.20 | 35.02 |
| 162.80000000 | 24.04 | 22.18 | 33.02 | 23.56 | 228.69 | 83.21 | 35.04 |
| 163.00000000 | 24.05 | 22.19 | 33.03 | 23.56 | 228.71 | 83.22 | 35.05 |

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| 163.20000000 | 24.06 | 22.19 | 33.05 | 23.57 | 228.74 | 83.23 | 35.07 |
| 163.40000000 | 24.07 | 22.19 | 33.06 | 23.57 | 228.76 | 83.24 | 35.08 |
| 163.60000000 | 24.07 | 22.19 | 33.08 | 23.57 | 228.79 | 83.24 | 35.10 |
| 163.80000000 | 24.08 | 22.19 | 33.09 | 23.58 | 228.81 | 83.25 | 35.11 |
| 164.00000000 | 24.09 | 22.20 | 33.11 | 23.58 | 228.84 | 83.26 | 35.13 |
| 164.20000000 | 24.10 | 22.20 | 33.12 | 23.58 | 228.86 | 83.27 | 35.14 |
| 164.40000000 | 24.11 | 22.20 | 33.14 | 23.59 | 228.88 | 83.28 | 35.16 |
| 164.60000000 | 24.11 | 22.20 | 33.15 | 23.59 | 228.90 | 83.29 | 35.17 |
| 164.80000000 | 24.12 | 22.20 | 33.16 | 23.59 | 228.93 | 83.30 | 35.19 |
| 165.00000000 | 24.13 | 22.21 | 33.18 | 23.60 | 228.95 | 83.30 | 35.20 |
| 165.20000000 | 24.14 | 22.21 | 33.19 | 23.60 | 228.97 | 83.31 | 35.22 |
| 165.40000000 | 24.15 | 22.21 | 33.21 | 23.60 | 228.99 | 83.32 | 35.23 |
| 165.60000000 | 24.15 | 22.21 | 33.22 | 23.61 | 229.01 | 83.33 | 35.25 |
| 165.80000000 | 24.16 | 22.21 | 33.24 | 23.61 | 229.03 | 83.34 | 35.26 |
| 166.00000000 | 24.17 | 22.22 | 33.25 | 23.61 | 229.05 | 83.34 | 35.27 |
| 166.20000000 | 24.18 | 22.22 | 33.26 | 23.62 | 229.07 | 83.35 | 35.29 |
| 166.40000000 | 24.19 | 22.22 | 33.28 | 23.62 | 229.10 | 83.36 | 35.30 |
| 166.60000000 | 24.19 | 22.22 | 33.29 | 23.62 | 229.11 | 83.37 | 35.31 |
| 166.80000000 | 24.20 | 22.22 | 33.30 | 23.63 | 229.14 | 83.37 | 35.33 |
| 167.00000000 | 24.21 | 22.23 | 33.32 | 23.63 | 229.15 | 83.38 | 35.34 |
| 167.20000000 | 24.22 | 22.23 | 33.33 | 23.63 | 229.18 | 83.39 | 35.35 |
| 167.40000000 | 24.23 | 22.23 | 33.34 | 23.64 | 229.19 | 83.40 | 35.36 |
| 167.60000000 | 24.23 | 22.23 | 33.36 | 23.64 | 229.21 | 83.40 | 35.37 |
| 167.80000000 | 24.24 | 22.23 | 33.37 | 23.64 | 229.23 | 83.41 | 35.38 |
| 168.00000000 | 24.25 | 22.24 | 33.38 | 23.65 | 229.25 | 83.42 | 35.40 |
| 168.20000000 | 24.26 | 22.24 | 33.40 | 23.65 | 229.27 | 83.42 | 35.41 |
| 168.40000000 | 24.26 | 22.24 | 33.41 | 23.65 | 229.29 | 83.43 | 35.42 |
| 168.60000000 | 24.27 | 22.24 | 33.42 | 23.66 | 229.31 | 83.44 | 35.43 |
| 168.80000000 | 24.28 | 22.24 | 33.43 | 23.66 | 229.33 | 83.44 | 35.44 |
| 169.00000000 | 24.29 | 22.25 | 33.45 | 23.66 | 229.34 | 83.45 | 35.45 |
| 169.20000000 | 24.29 | 22.25 | 33.46 | 23.67 | 229.36 | 83.46 | 35.46 |
| 169.40000000 | 24.30 | 22.25 | 33.47 | 23.67 | 229.38 | 83.46 | 35.47 |
| 169.60000000 | 24.31 | 22.25 | 33.48 | 23.67 | 229.40 | 83.47 | 35.48 |
| 169.80000000 | 24.32 | 22.25 | 33.50 | 23.67 | 229.41 | 83.48 | 35.50 |
| 170.00000000 | 24.32 | 22.26 | 33.51 | 23.68 | 229.43 | 83.48 | 35.51 |
| 170.20000000 | 24.33 | 22.26 | 33.52 | 23.68 | 229.45 | 83.49 | 35.52 |
| 170.40000000 | 24.34 | 22.26 | 33.53 | 23.68 | 229.46 | 83.49 | 35.53 |
| 170.60000000 | 24.35 | 22.26 | 33.54 | 23.69 | 229.48 | 83.50 | 35.54 |
| 170.80000000 | 24.35 | 22.26 | 33.56 | 23.69 | 229.50 | 83.51 | 35.55 |
| 171.00000000 | 24.36 | 22.27 | 33.57 | 23.69 | 229.51 | 83.51 | 35.56 |
| 171.20000000 | 24.37 | 22.27 | 33.58 | 23.69 | 229.53 | 83.52 | 35.57 |
| 171.40000000 | 24.37 | 22.27 | 33.59 | 23.70 | 229.54 | 83.52 | 35.5E |
| 171.60000000 | 24.38 | 22.27 | 33.60 | 23.70 | 229.56 | 83.53 | 35.6C |
| 171.80000000 | 24.39 | 22.27 | 33.61 | 23.70 | 229.58 | 83.53 | 35.61 |
| 172.00000000 | 24.40 | 22.27 | 33.63 | 23.71 | 229.59 | 83.54 | 35.62 |
| 172.20000000 | 24.40 | 22.28 | 33.64 | 23.71 | 229.61 | 83.55 | 35.63 |
| 172.40000000 | 24.41 | 22.28 | 33.65 | 23.71 | 229.62 | 83.55 | 35.64 |
| 172.60000000 | 24.42 | 22.28 | 33.66 | 23.71 | 229.64 | 83.56 | 35.65 |
| 172.80000000 | 24.42 | 22.28 | 33.67 | 23.72 | 229.66 | 83.56 | 35.63 |
| 173.00000000 | 24.43 | 22.28 | 33.68 | 23.72 | 229.67 | 83.57 | 35.68 |
| 173.20000000 | 24.44 | 22.29 | 33.69 | 23.72 | 229.68 | 83.57 | 35.69 |
| 173.40000000 | 24.44 | 22.29 | 33.70 | 23.72 | 229.70 | 83.58 | 35.70 |
| 173.60000000 | 24.45 | 22.29 | 33.71 | 23.73 | 229.71 | 83.58 | 35.7 |
| 173.80000000 | 24.46 | 22.29 | 33.73 | 23.73 | 229.73 | 83.59 | 35.7 |
| 174.00000000 | 24.47 | 22.29 | 33.74 | 23.73 | 229.74 | 83.59 | 35.7 |

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| 174.20000000 | 24.47 | 22.29 | 33.75 | 23.74 | 229.76 | 83.60 | 35.75 |
| 174.40000000 | 24.48 | 22.30 | 33.76 | 23.74 | 229.77 | 83.60 | 35.76 |
| 174.60000000 | 24.49 | 22.30 | 33.77 | 23.74 | 229.78 | 83.61 | 35.78 |
| 174.80000000 | 24.49 | 22.30 | 33.78 | 23.74 | 229.80 | 83.61 | 35.79 |
| 175.00000000 | 24.50 | 22.30 | 33.79 | 23.74 | 229.81 | 83.62 | 35.80 |
| 175.20000000 | 24.51 | 22.30 | 33.80 | 23.75 | 229.83 | 83.62 | 35.81 |
| 175.40000000 | 24.51 | 22.30 | 33.81 | 23.75 | 229.84 | 83.63 | 35.82 |
| 175.60000000 | 24.52 | 22.31 | 33.82 | 23.75 | 229.85 | 83.63 | 35.83 |
| 175.80000000 | 24.53 | 22.31 | 33.83 | 23.75 | 229.87 | 83.64 | 35.85 |
| 176.00000000 | 24.53 | 22.31 | 33.84 | 23.75 | 229.88 | 83.64 | 35.86 |
| 176.20000000 | 24.54 | 22.31 | 33.85 | 23.76 | 229.89 | 83.64 | 35.87 |
| 176.40000000 | 24.54 | 22.31 | 33.86 | 23.76 | 229.91 | 83.65 | 35.88 |
| 176.60000000 | 24.55 | 22.32 | 33.86 | 23.76 | 229.92 | 83.65 | 35.89 |
| 176.80000000 | 24.56 | 22.32 | 33.87 | 23.76 | 229.93 | 83.66 | 35.90 |
| 177.00000000 | 24.56 | 22.32 | 33.88 | 23.76 | 229.94 | 83.66 | 35.91 |
| 177.20000000 | 24.57 | 22.32 | 33.89 | 23.77 | 229.96 | 83.67 | 35.92 |
| 177.40000000 | 24.58 | 22.32 | 33.90 | 23.77 | 229.97 | 83.67 | 35.93 |
| 177.60000000 | 24.58 | 22.32 | 33.91 | 23.77 | 229.98 | 83.68 | 35.94 |
| 177.80000000 | 24.59 | 22.33 | 33.92 | 23.77 | 229.99 | 83.68 | 35.95 |
| 178.00000000 | 24.60 | 22.33 | 33.93 | 23.78 | 230.01 | 83.68 | 35.96 |
| 178.20000000 | 24.60 | 22.33 | 33.94 | 23.78 | 230.02 | 83.69 | 35.97 |
| 178.40000000 | 24.61 | 22.33 | 33.95 | 23.78 | 230.03 | 83.69 | 35.98 |
| 178.60000000 | 24.61 | 22.33 | 33.96 | 23.78 | 230.04 | 83.70 | 35.99 |
| 178.80000000 | 24.62 | 22.33 | 33.97 | 23.79 | 230.06 | 83.70 | 36.00 |
| 179.00000000 | 24.63 | 22.33 | 33.98 | 23.79 | 230.07 | 83.70 | 36.01 |
| 179.20000000 | 24.63 | 22.34 | 33.99 | 23.79 | 230.08 | 83.71 | 36.02 |
| 179.40000000 | 24.64 | 22.34 | 34.00 | 23.79 | 230.09 | 83.71 | 36.03 |
| 179.60000000 | 24.64 | 22.34 | 34.01 | 23.79 | 230.10 | 83.72 | 36.04 |
| 179.80000000 | 24.65 | 22.34 | 34.02 | 23.80 | 230.11 | 83.72 | 36.05 |
| 180.00000000 | 24.66 | 22.34 | 34.02 | 23.80 | 230.12 | 83.72 | 36.06 |
| 180.20000000 | 24.66 | 22.34 | 34.03 | 23.80 | 210.94 | 83.72 | 36.07 |
| 180.40000000 | 24.67 | 22.35 | 34.04 | 23.80 | 197.96 | 83.69 | 36.08 |
| 180.60000000 | 24.67 | 22.35 | 34.05 | 23.81 | 186.48 | 83.58 | 36.09 |
| 180.80000000 | 24.68 | 22.35 | 34.06 | 23.81 | 176.70 | 83.33 | 36.09 |
| 181.00000000 | 24.69 | 22.35 | 34.07 | 23.81 | 167.73 | 82.93 | 36.10 |
| 181.20000000 | 24.69 | 22.35 | 34.07 | 23.81 | 159.75 | 82.37 | 36.10 |
| 181.40000000 | 24.70 | 22.35 | 34.08 | 23.81 | 152.49 | 81.66 | 36.10 |
| 181.60000000 | 24.70 | 22.35 | 34.08 | 23.82 | 145.90 | 80.84 | 36.10 |
| 181.80000000 | 24.71 | 22.36 | 34.08 | 23.82 | 139.87 | 79.90 | 36.09 |
| 182.00000000 | 24.71 | 22.36 | 34.08 | 23.82 | 134.33 | 78.87 | 36.08 |
| 182.20000000 | 24.72 | 22.36 | 34.07 | 23.82 | 129.25 | 77.76 | 36.06 |
| 182.40000000 | 24.73 | 22.36 | 34.06 | 23.82 | 124.53 | 76.59 | 36.04 |
| 182.60000000 | 24.73 | 22.36 | 34.05 | 23.82 | 120.18 | 75.37 | 36.01 |
| 182.80000000 | 24.74 | 22.36 | 34.03 | 23.83 | 116.13 | 74.12 | 35.97 |
| 183.00000000 | 24.74 | 22.37 | 34.01 | 23.83 | 112.36 | 72.84 | 35.94 |
| 183.20000000 | 24.75 | 22.37 | 33.99 | 23.83 | 108.83 | 71.55 | 35.89 |
| 183.40000000 | 24.75 | 22.37 | 33.97 | 23.83 | 105.54 | 70.25 | 35.85 |
| 183.60000000 | 24.76 | 22.37 | 33.94 | 23.83 | 102.44 | 68.95 | 35.80 |
| 183.80000000 | 24.76 | 22.37 | 33.91 | 23.83 | 99.54 | 67.66 | 35.74 |
| 184.00000000 | 24.77 | 22.37 | 33.87 | 23.83 | 96.79 | 66.38 | 35.68 |
| 184.20000000 | 24.77 | 22.37 | 33.83 | 23.83 | 94.20 | 65.12 | 35.62 |
| 184.40000000 | 24.78 | 22.38 | 33.79 | 23.82 | 91.75 | 63.87 | 35.56 |
| 184.60000000 | 24.78 | 22.38 | 33.75 | 23.82 | 89.42 | 62.65 | 35.49 |
| 184.80000000 | 24.79 | 22.38 | 33.71 | 23.82 | 87.21 | 61.45 | 35.42 |
| 185.00000000 | 24.79 | 22.38 | 33.66 | 23.82 | 85.11 | 60.28 | 35.34 |

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| 185.20000000 | 24.80 | 22.38 | 52.67 | 23.82 | 83.11 | 59.13 | 54.32 |
| 185.40000000 | 24.80 | 22.38 | 65.23 | 23.84 | 81.20 | 58.02 | 66.83 |
| 185.60000000 | 24.81 | 22.38 | 75.83 | 23.93 | 79.38 | 56.94 | 77.39 |
| 185.80000000 | 24.81 | 22.38 | 84.50 | 24.12 | 77.64 | 55.88 | 86.01 |
| 186.00000000 | 24.82 | 22.39 | 92.24 | 24.45 | 75.97 | 54.86 | 93.70 |
| 186.20000000 | 24.82 | 22.39 | 99.07 | 24.88 | 74.37 | 53.87 | 100.47 |
| 186.40000000 | 24.83 | 22.39 | 105.31 | 25.42 | 72.85 | 52.91 | 106.66 |
| 186.60000000 | 24.83 | 22.39 | 110.99 | 26.04 | 71.39 | 51.98 | 112.29 |
| 186.80000000 | 24.84 | 22.39 | 116.23 | 26.72 | 69.99 | 51.07 | 117.49 |
| 187.00000000 | 24.85 | 22.39 | 121.06 | 27.47 | 68.65 | 50.20 | 122.28 |
| 187.20000000 | 24.85 | 22.39 | 125.56 | 28.25 | 67.36 | 49.36 | 126.74 |
| 187.40000000 | 24.86 | 22.40 | 129.74 | 29.07 | 66.13 | 48.55 | 130.88 |
| 187.60000000 | 24.87 | 22.40 | 133.64 | 29.91 | 64.95 | 47.76 | 134.75 |
| 187.80000000 | 24.87 | 22.40 | 137.29 | 30.73 | 63.83 | 47.00 | 138.37 |
| 188.00000000 | 24.88 | 22.40 | 140.72 | 31.63 | 62.75 | 46.27 | 141.77 |
| 188.20000000 | 24.89 | 22.40 | 143.94 | 32.00 | 61.72 | 45.56 | 144.96 |
| 188.40000000 | 24.91 | 22.40 | 146.98 | 32.00 | 60.73 | 44.88 | 147.96 |
| 188.60000000 | 24.92 | 22.40 | 149.83 | 32.00 | 59.79 | 44.23 | 150.78 |
| 188.80000000 | 24.93 | 22.41 | 152.50 | 32.00 | 58.88 | 43.60 | 153.43 |
| 189.00000000 | 24.95 | 22.41 | 155.02 | 32.00 | 58.02 | 42.99 | 155.92 |
| 189.20000000 | 24.96 | 22.41 | 157.38 | 32.00 | 57.20 | 42.40 | 158.25 |
| 189.40000000 | 24.98 | 22.41 | 159.59 | 32.00 | 56.41 | 41.84 | 160.44 |
| 189.60000000 | 25.00 | 22.41 | 161.67 | 32.00 | 55.66 | 41.30 | 162.50 |
| 189.80000000 | 25.02 | 22.42 | 163.63 | 32.00 | 54.95 | 40.78 | 164.44 |
| 190.00000000 | 25.04 | 22.42 | 165.47 | 32.00 | 54.26 | 40.28 | 166.28 |
| 190.20000000 | 25.07 | 22.42 | 148.03 | 32.00 | 53.61 | 39.80 | 148.84 |
| 190.40000000 | 25.09 | 22.43 | 136.73 | 32.00 | 52.99 | 39.33 | 137.55 |
| 190.60000000 | 25.12 | 22.43 | 126.97 | 32.00 | 52.40 | 38.89 | 127.81 |
| 190.80000000 | 25.14 | 22.43 | 118.87 | 32.00 | 51.84 | 38.47 | 119.74 |
| 191.00000000 | 25.17 | 22.44 | 111.62 | 32.00 | 51.30 | 38.06 | 112.53 |
| 191.20000000 | 25.20 | 22.44 | 105.25 | 33.50 | 50.79 | 37.67 | 106.20 |
| 191.40000000 | 25.23 | 22.45 | 99.59 | 34.38 | 50.30 | 37.29 | 100.59 |
| 191.60000000 | 25.26 | 22.45 | 94.51 | 35.16 | 49.83 | 36.94 | 95.58 |
| 191.80000000 | 25.29 | 22.46 | 90.01 | 35.74 | 49.38 | 36.59 | 91.14 |
| 192.00000000 | 25.31 | 22.46 | 85.93 | 36.15 | 48.95 | 36.26 | 87.10 |
| 192.20000000 | 25.34 | 22.47 | 82.31 | 36.42 | 48.54 | 35.95 | 83.52 |
| 192.40000000 | 25.37 | 22.48 | 79.00 | 36.56 | 48.14 | 35.65 | 80.23 |
| 192.60000000 | 25.40 | 22.48 | 76.05 | 36.59 | 47.75 | 35.37 | 77.30 |
| 192.80000000 | 25.43 | 22.49 | 73.32 | 36.55 | 47.38 | 35.09 | 74.58 |
| 193.00000000 | 25.46 | 22.50 | 70.89 | 36.43 | 47.03 | 34.83 | 72.15 |
| 193.20000000 | 25.49 | 22.51 | 68.61 | 36.26 | 46.68 | 34.58 | 69.87 |
| 193.40000000 | 25.51 | 22.51 | 66.57 | 36.03 | 46.35 | 34.35 | 67.82 |
| 193.60000000 | 25.54 | 22.52 | 64.65 | 35.78 | 46.03 | 34.12 | 65.89 |
| 193.80000000 | 25.56 | 22.53 | 62.91 | 35.49 | 45.72 | 33.91 | 64.14 |
| 194.00000000 | 25.59 | 22.54 | 61.27 | 35.19 | 45.42 | 33.71 | 62.48 |
| 194.20000000 | 25.61 | 22.55 | 59.77 | 34.87 | 45.13 | 33.51 | 60.97 |
| 194.40000000 | 25.63 | 22.55 | 58.35 | 34.54 | 44.85 | 33.33 | 59.53 |
| 194.60000000 | 25.65 | 22.56 | 57.04 | 34.20 | 44.58 | 33.16 | 58.21 |
| 194.80000000 | 25.67 | 22.57 | 55.80 | 33.87 | 44.32 | 33.00 | 56.95 |
| 195.00000000 | 25.69 | 22.58 | 54.65 | 33.53 | 44.06 | 32.85 | 55.79 |
| 195.20000000 | 25.71 | 22.58 | 53.55 | 33.20 | 43.82 | 32.71 | 54.67 |
| 195.40000000 | 25.73 | 22.59 | 52.53 | 32.86 | 43.58 | 32.58 | 53.63 |
| 195.60000000 | 25.75 | 22.60 | 51.55 | 32.54 | 43.35 | 32.46 | 52.63 |
| 195.80000000 | 25.76 | 22.61 | 50.65 | 32.22 | 43.12 | 32.34 | 51.71 |
| 196.00000000 | 25.78 | 22.61 | 49.77 | 31.92 | 42.91 | 32.24 | 50.83 |

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|---|---|---|---|---|---|---|---|
| 196.20000000 | 25.79 | 22.62 | 48.95 | 31.59 | 42.70 | 32.15 | 49.98 |
| 196.40000000 | 25.81 | 22.63 | 48.16 | 30.76 | 42.49 | 32.08 | 49.17 |
| 196.60000000 | 25.82 | 22.63 | 47.43 | 30.47 | 42.30 | 32.01 | 48.41 |
| 196.80000000 | 25.83 | 22.64 | 46.70 | 29.80 | 42.10 | 31.97 | 47.68 |
| 197.00000000 | 25.84 | 22.64 | 46.02 | 29.48 | 41.92 | 32.00 | 46.98 |
| 197.20000000 | 25.85 | 22.65 | 45.34 | 28.96 | 41.74 | 32.00 | 46.30 |
| 197.40000000 | 25.86 | 22.65 | 44.69 | 28.64 | 41.57 | 32.00 | 45.64 |
| 197.60000000 | 25.86 | 22.66 | 44.06 | 28.21 | 41.40 | 32.00 | 45.00 |
| 197.80000000 | 25.87 | 22.66 | 43.46 | 27.92 | 41.23 | 32.00 | 44.39 |
| 198.00000000 | 25.88 | 22.67 | 42.87 | 27.56 | 41.08 | 32.00 | 43.79 |
| 198.20000000 | 25.88 | 22.67 | 42.31 | 27.29 | 40.92 | 32.00 | 43.21 |
| 198.40000000 | 25.88 | 22.68 | 41.76 | 26.99 | 40.77 | 32.00 | 42.65 |
| 198.60000000 | 25.89 | 22.68 | 41.24 | 26.75 | 40.62 | 32.00 | 42.12 |
| 198.80000000 | 25.89 | 22.68 | 40.73 | 26.48 | 40.48 | 32.00 | 41.60 |
| 199.00000000 | 25.89 | 22.68 | 40.25 | 26.26 | 40.33 | 32.00 | 41.11 |
| 199.20000000 | 25.89 | 22.69 | 39.78 | 26.03 | 40.20 | 32.00 | 40.63 |
| 199.40000000 | 25.89 | 22.69 | 39.34 | 25.84 | 40.06 | 32.00 | 40.17 |
| 199.60000000 | 25.89 | 22.69 | 38.90 | 25.63 | 39.92 | 32.00 | 39.73 |
| 199.80000000 | 25.89 | 22.69 | 38.49 | 25.46 | 39.79 | 32.00 | 39.31 |
| 200.00000000 | 25.89 | 22.70 | 38.09 | 25.28 | 39.66 | 32.00 | 38.89 |
| 200.20000000 | 25.88 | 22.70 | 37.71 | 25.13 | 39.53 | 32.00 | 38.50 |
| 200.40000000 | 25.88 | 22.70 | 37.34 | 24.97 | 39.40 | 32.00 | 38.12 |
| 200.60000000 | 25.87 | 22.70 | 36.98 | 24.83 | 39.28 | 32.00 | 37.76 |
| 200.80000000 | 25.87 | 22.70 | 36.64 | 24.68 | 39.15 | 32.00 | 37.41 |
| 201.00000000 | 25.86 | 22.70 | 36.31 | 24.56 | 39.02 | 32.00 | 37.07 |
| 201.20000000 | 25.85 | 22.70 | 35.99 | 24.43 | 38.90 | 32.00 | 36.74 |
| 201.40000000 | 25.85 | 22.70 | 35.69 | 24.32 | 38.77 | 32.00 | 36.43 |
| 201.60000000 | 25.84 | 22.70 | 35.40 | 24.20 | 38.65 | 32.00 | 36.12 |
| 201.80000000 | 25.83 | 22.70 | 35.11 | 24.10 | 38.52 | 32.00 | 35.83 |
| 202.00000000 | 25.82 | 22.70 | 34.84 | 23.99 | 38.40 | 32.00 | 35.55 |
| 202.20000000 | 25.81 | 22.70 | 34.58 | 23.90 | 38.27 | 32.00 | 35.27 |
| 202.40000000 | 25.80 | 22.70 | 34.32 | 23.81 | 38.15 | 32.00 | 35.01 |
| 202.60000000 | 25.79 | 22.70 | 34.08 | 23.72 | 38.03 | 32.00 | 34.75 |
| 202.80000000 | 25.78 | 22.69 | 33.84 | 23.64 | 37.91 | 32.00 | 34.50 |
| 203.00000000 | 25.77 | 22.69 | 33.61 | 23.56 | 37.79 | 32.00 | 34.26 |
| 203.20000000 | 25.76 | 22.69 | 33.39 | 23.48 | 37.67 | 32.00 | 34.02 |
| 203.40000000 | 25.75 | 22.69 | 33.17 | 23.41 | 37.55 | 32.00 | 33.80 |
| 203.60000000 | 25.74 | 22.69 | 32.96 | 23.34 | 37.43 | 32.00 | 33.58 |
| 203.80000000 | 25.72 | 22.69 | 32.77 | 23.27 | 37.32 | 32.00 | 33.36 |
| 204.00000000 | 25.71 | 22.68 | 32.57 | 23.21 | 37.20 | 32.00 | 33.16 |
| 204.20000000 | 25.70 | 22.68 | 32.38 | 23.15 | 37.09 | 32.00 | 32.96 |
| 204.40000000 | 25.68 | 22.68 | 32.20 | 23.09 | 36.98 | 32.00 | 32.76 |
| 204.60000000 | 25.67 | 22.68 | 32.03 | 23.04 | 36.87 | 32.00 | 32.57 |
| 204.80000000 | 25.66 | 22.67 | 31.85 | 22.98 | 36.76 | 32.00 | 32.39 |
| 205.00000000 | 25.64 | 22.67 | 31.69 | 22.93 | 36.65 | 32.00 | 32.21 |
| 205.20000000 | 25.63 | 22.67 | 31.53 | 22.88 | 36.54 | 32.00 | 32.03 |
| 205.40000000 | 25.61 | 22.66 | 31.37 | 22.83 | 36.44 | 32.00 | 31.86 |
| 205.60000000 | 25.60 | 22.66 | 31.22 | 22.79 | 36.33 | 32.00 | 31.70 |
| 205.80000000 | 25.59 | 22.66 | 31.07 | 22.74 | 36.23 | 32.00 | 31.54 |
| 206.00000000 | 25.57 | 22.66 | 30.93 | 22.70 | 36.13 | 32.00 | 31.38 |
| 206.20000000 | 25.56 | 22.65 | 30.79 | 22.66 | 36.03 | 32.00 | 31.23 |
| 206.40000000 | 25.54 | 22.65 | 30.66 | 22.62 | 35.93 | 32.00 | 31.09 |
| 206.60000000 | 25.52 | 22.64 | 30.53 | 22.58 | 35.83 | 32.00 | 30.94 |
| 206.80000000 | 25.51 | 22.64 | 30.40 | 22.55 | 35.73 | 32.00 | 30.81 |
| 207.00000000 | 25.49 | 22.64 | 30.28 | 22.51 | 35.64 | 32.00 | 30.67 |

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|---|---|---|---|---|---|---|---|
| 207.20000000 | 25.48 | 22.63 | 30.16 | 22.48 | 35.55 | 32.00 | 30.54 |
| 207.40000000 | 25.46 | 22.63 | 30.04 | 22.44 | 35.46 | 32.00 | 30.41 |
| 207.60000000 | 25.45 | 22.63 | 29.93 | 22.41 | 35.36 | 32.00 | 30.29 |
| 207.80000000 | 25.43 | 22.62 | 29.81 | 22.38 | 35.28 | 32.00 | 30.16 |
| 208.00000000 | 25.41 | 22.62 | 29.71 | 22.35 | 35.19 | 32.00 | 30.04 |
| 208.20000000 | 25.40 | 22.62 | 29.60 | 22.32 | 35.10 | 32.00 | 29.93 |
| 208.40000000 | 25.38 | 22.61 | 29.50 | 22.30 | 35.01 | 32.00 | 29.82 |
| 208.60000000 | 25.36 | 22.61 | 29.40 | 22.27 | 34.93 | 32.00 | 29.71 |
| 208.80000000 | 25.35 | 22.60 | 29.30 | 22.24 | 34.85 | 32.00 | 29.60 |
| 209.00000000 | 25.33 | 22.60 | 29.20 | 22.22 | 34.76 | 32.00 | 29.49 |
| 209.20000000 | 25.31 | 22.60 | 29.11 | 22.19 | 34.68 | 32.00 | 29.39 |
| 209.40000000 | 25.30 | 22.59 | 29.02 | 22.17 | 34.60 | 32.00 | 29.29 |
| 209.60000000 | 25.28 | 22.59 | 28.93 | 22.15 | 34.53 | 32.00 | 29.19 |
| 209.80000000 | 25.27 | 22.58 | 28.84 | 22.12 | 34.45 | 32.00 | 29.10 |
| 210.00000000 | 25.25 | 22.58 | 28.76 | 22.10 | 34.37 | 32.00 | 29.01 |
| 210.20000000 | 25.23 | 22.58 | 28.67 | 22.08 | 34.30 | 32.00 | 28.91 |
| 210.40000000 | 25.22 | 22.57 | 28.59 | 22.06 | 34.22 | 32.00 | 28.83 |
| 210.60000000 | 25.20 | 22.57 | 28.51 | 22.04 | 34.15 | 32.00 | 28.74 |
| 210.80000000 | 25.18 | 22.56 | 28.43 | 22.02 | 34.08 | 32.00 | 28.65 |
| 211.00000000 | 25.16 | 22.56 | 28.36 | 22.00 | 34.01 | 32.00 | 28.57 |
| 211.20000000 | 25.15 | 22.55 | 28.28 | 21.98 | 33.94 | 32.00 | 28.49 |
| 211.40000000 | 25.13 | 22.55 | 28.21 | 21.96 | 33.87 | 32.00 | 28.41 |
| 211.60000000 | 25.11 | 22.55 | 28.14 | 21.95 | 33.80 | 32.00 | 28.33 |
| 211.80000000 | 25.10 | 22.54 | 28.07 | 21.93 | 33.73 | 32.00 | 28.25 |
| 212.00000000 | 25.08 | 22.54 | 28.00 | 21.91 | 33.67 | 32.00 | 28.18 |
| 212.20000000 | 25.06 | 22.53 | 27.93 | 21.90 | 33.60 | 32.00 | 28.10 |
| 212.40000000 | 25.05 | 22.53 | 27.87 | 21.88 | 33.54 | 32.00 | 28.03 |
| 212.60000000 | 25.03 | 22.53 | 27.80 | 21.87 | 33.47 | 32.00 | 27.96 |
| 212.80000000 | 25.01 | 22.52 | 27.74 | 21.85 | 33.41 | 32.00 | 27.89 |
| 213.00000000 | 25.00 | 22.52 | 27.68 | 21.84 | 33.35 | 32.00 | 27.82 |
| 213.20000000 | 24.98 | 22.51 | 27.61 | 21.82 | 33.29 | 32.00 | 27.76 |
| 213.40000000 | 24.96 | 22.51 | 27.55 | 21.81 | 33.22 | 32.00 | 27.69 |
| 213.60000000 | 24.95 | 22.50 | 27.50 | 21.79 | 33.16 | 32.00 | 27.63 |
| 213.80000000 | 24.93 | 22.50 | 27.44 | 21.78 | 33.11 | 32.00 | 27.56 |
| 214.00000000 | 24.92 | 22.50 | 27.38 | 21.77 | 33.05 | 32.00 | 27.50 |
| 214.20000000 | 24.90 | 22.49 | 27.32 | 21.75 | 32.99 | 32.00 | 27.44 |
| 214.40000000 | 24.88 | 22.49 | 27.27 | 21.74 | 32.93 | 32.00 | 27.38 |
| 214.60000000 | 24.87 | 22.48 | 27.22 | 21.73 | 32.87 | 32.00 | 27.32 |
| 214.80000000 | 24.85 | 22.48 | 27.16 | 21.72 | 32.82 | 32.00 | 27.26 |
| 215.00000000 | 24.83 | 22.47 | 27.11 | 21.71 | 32.76 | 32.00 | 27.21 |
| 215.20000000 | 24.82 | 22.47 | 27.06 | 21.69 | 32.71 | 32.00 | 27.15 |
| 215.40000000 | 24.80 | 22.47 | 27.01 | 21.68 | 32.66 | 32.00 | 27.10 |
| 215.60000000 | 24.78 | 22.46 | 26.96 | 21.67 | 32.60 | 32.00 | 27.04 |
| 215.80000000 | 24.77 | 22.46 | 26.91 | 21.66 | 32.55 | 32.00 | 26.99 |
| 216.00000000 | 24.75 | 22.45 | 26.86 | 21.65 | 32.50 | 32.00 | 26.94 |
| 216.20000000 | 24.74 | 22.45 | 26.81 | 21.64 | 32.45 | 32.00 | 26.83 |
| 216.40000000 | 24.72 | 22.45 | 26.77 | 21.63 | 32.39 | 32.00 | 26.8 |
| 216.60000000 | 24.70 | 22.44 | 26.72 | 21.62 | 32.34 | 32.00 | 26.7 |
| 216.80000000 | 24.69 | 22.44 | 26.67 | 21.61 | 32.29 | 32.00 | 26.7 |
| 217.00000000 | 24.67 | 22.43 | 26.63 | 21.60 | 32.25 | 32.00 | 26.6 |
| 217.20000000 | 24.66 | 22.43 | 26.59 | 21.59 | 32.20 | 32.00 | 26.6 |
| 217.40000000 | 24.64 | 22.43 | 26.54 | 21.58 | 32.15 | 32.00 | 26.5 |
| 217.60000000 | 24.63 | 22.42 | 26.50 | 21.57 | 32.10 | 32.00 | 26.5 |
| 217.80000000 | 24.61 | 22.42 | 26.46 | 21.56 | 32.06 | 32.00 | 26.5 |
| 218.00000000 | 24.59 | 22.41 | 26.42 | 21.55 | 32.01 | 32.00 | 26.4 |

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|---|---|---|---|---|---|---|
| 218.20000000 | 24.58 | 22.41 | 26.37 | 21.55 | 31.96 | 32.00 | 26.41 |
| 218.40000000 | 24.56 | 22.41 | 26.33 | 21.54 | 31.92 | 32.00 | 26.37 |
| 218.60000000 | 24.55 | 22.40 | 26.29 | 21.53 | 31.87 | 32.00 | 26.32 |
| 218.80000000 | 24.53 | 22.40 | 26.25 | 21.52 | 31.83 | 32.00 | 26.28 |
| 219.00000000 | 24.52 | 22.39 | 26.22 | 21.51 | 31.79 | 32.00 | 26.24 |
| 219.20000000 | 24.50 | 22.39 | 26.18 | 21.50 | 31.74 | 32.00 | 26.20 |
| 219.40000000 | 24.49 | 22.39 | 26.14 | 21.50 | 31.70 | 32.00 | 26.16 |
| 219.60000000 | 24.47 | 22.38 | 26.10 | 21.49 | 31.66 | 32.00 | 26.12 |
| 219.80000000 | 24.46 | 22.38 | 26.06 | 21.48 | 31.62 | 32.00 | 26.08 |
| 220.00000000 | 24.44 | 22.37 | 26.03 | 21.47 | 31.58 | 32.00 | 26.04 |
| 220.20000000 | 24.43 | 22.37 | 25.99 | 21.47 | 31.53 | 32.00 | 26.00 |
| 220.40000000 | 24.41 | 22.37 | 25.96 | 21.46 | 31.49 | 32.00 | 25.96 |
| 220.60000000 | 24.40 | 22.36 | 25.92 | 21.45 | 31.45 | 32.00 | 25.92 |
| 220.80000000 | 24.38 | 22.36 | 25.89 | 21.45 | 31.41 | 32.00 | 25.89 |
| 221.00000000 | 24.37 | 22.35 | 25.85 | 21.44 | 31.38 | 32.00 | 25.85 |
| 221.20000000 | 24.35 | 22.35 | 25.82 | 21.43 | 31.34 | 32.00 | 25.81 |
| 221.40000000 | 24.34 | 22.35 | 25.78 | 21.43 | 31.30 | 32.00 | 25.78 |
| 221.60000000 | 24.32 | 22.34 | 25.75 | 21.42 | 31.26 | 32.00 | 25.74 |
| 221.80000000 | 24.31 | 22.34 | 25.72 | 21.41 | 31.22 | 32.00 | 25.71 |
| 222.00000000 | 24.30 | 22.34 | 25.69 | 21.41 | 31.19 | 32.00 | 25.67 |
| 222.20000000 | 24.28 | 22.33 | 25.65 | 21.40 | 31.15 | 32.00 | 25.64 |
| 222.40000000 | 24.27 | 22.33 | 25.62 | 21.39 | 31.11 | 32.00 | 25.61 |
| 222.60000000 | 24.25 | 22.32 | 25.59 | 21.39 | 31.08 | 32.00 | 25.57 |
| 222.80000000 | 24.24 | 22.32 | 25.56 | 21.38 | 31.04 | 32.00 | 25.54 |
| 223.00000000 | 24.22 | 22.32 | 25.53 | 21.38 | 31.01 | 32.00 | 25.51 |
| 223.20000000 | 24.21 | 22.31 | 25.50 | 21.37 | 30.97 | 32.00 | 25.47 |
| 223.40000000 | 24.20 | 22.31 | 25.47 | 21.36 | 30.94 | 32.00 | 25.44 |
| 223.60000000 | 24.18 | 22.31 | 25.44 | 21.36 | 30.90 | 32.00 | 25.41 |
| 223.80000000 | 24.17 | 22.30 | 25.41 | 21.35 | 30.87 | 32.00 | 25.38 |
| 224.00000000 | 24.15 | 22.30 | 25.38 | 21.35 | 30.84 | 32.00 | 25.35 |
| 224.20000000 | 24.14 | 22.29 | 25.35 | 21.34 | 30.80 | 32.00 | 25.32 |
| 224.40000000 | 24.13 | 22.29 | 25.32 | 21.34 | 30.77 | 32.00 | 25.29 |
| 224.60000000 | 24.11 | 22.29 | 25.30 | 21.33 | 30.74 | 32.00 | 25.26 |
| 224.80000000 | 24.10 | 22.28 | 25.27 | 21.33 | 30.71 | 32.00 | 25.23 |
| 225.00000000 | 24.09 | 22.28 | 25.24 | 21.32 | 30.67 | 32.00 | 25.20 |
| 225.20000000 | 24.07 | 22.28 | 25.21 | 21.32 | 30.64 | 32.00 | 25.17 |
| 225.40000000 | 24.06 | 22.27 | 25.19 | 21.31 | 30.61 | 32.00 | 25.14 |
| 225.60000000 | 24.05 | 22.27 | 25.16 | 21.31 | 30.58 | 32.00 | 25.11 |
| 225.80000000 | 24.03 | 22.27 | 25.13 | 21.30 | 30.55 | 32.00 | 25.09 |
| 226.00000000 | 24.02 | 22.26 | 25.11 | 21.30 | 30.52 | 32.00 | 25.06 |
| 226.20000000 | 24.01 | 22.26 | 25.08 | 21.29 | 30.49 | 32.00 | 25.03 |
| 226.40000000 | 23.99 | 22.26 | 25.06 | 21.29 | 30.46 | 32.00 | 25.00 |
| 226.60000000 | 23.98 | 22.25 | 25.03 | 21.29 | 30.43 | 32.00 | 24.98 |
| 226.80000000 | 23.97 | 22.25 | 25.01 | 21.28 | 30.40 | 32.00 | 24.95 |
| 227.00000000 | 23.96 | 22.25 | 24.98 | 21.28 | 30.37 | 32.00 | 24.92 |
| 227.20000000 | 23.94 | 22.24 | 24.96 | 21.27 | 30.34 | 32.00 | 24.90 |
| 227.40000000 | 23.93 | 22.24 | 24.93 | 21.27 | 30.31 | 32.00 | 24.87 |
| 227.60000000 | 23.92 | 22.24 | 24.91 | 21.26 | 30.29 | 32.00 | 24.85 |
| 227.80000000 | 23.90 | 22.23 | 24.88 | 21.26 | 30.26 | 32.00 | 24.82 |
| 228.00000000 | 23.89 | 22.23 | 24.86 | 21.26 | 30.23 | 32.00 | 24.80 |
| 228.20000000 | 23.88 | 22.23 | 24.84 | 21.25 | 30.20 | 32.00 | 24.77 |
| 228.40000000 | 23.87 | 22.22 | 24.81 | 21.25 | 30.17 | 32.00 | 24.75 |
| 228.60000000 | 23.85 | 22.22 | 24.79 | 21.25 | 30.15 | 32.00 | 24.7 |
| 228.80000000 | 23.84 | 22.22 | 24.77 | 21.24 | 30.12 | 32.00 | 24.7 |
| 229.00000000 | 23.83 | 22.21 | 24.75 | 21.24 | 30.09 | 32.00 | 24.6 |

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|---|---|---|---|---|---|---|---|
| 229.20000000 | 23.82 | 22.21 | 24.72 | 21.23 | 30.07 | 32.00 | 24.65 |
| 229.40000000 | 23.81 | 22.21 | 24.70 | 21.23 | 30.04 | 32.00 | 24.63 |
| 229.60000000 | 23.79 | 22.20 | 24.68 | 21.23 | 30.01 | 32.00 | 24.60 |
| 229.80000000 | 23.78 | 22.20 | 24.66 | 21.22 | 29.99 | 32.00 | 24.58 |
| 230.00000000 | 23.77 | 22.20 | 24.64 | 21.22 | 29.96 | 32.00 | 24.56 |
| 230.20000000 | 23.76 | 22.19 | 24.61 | 21.22 | 29.94 | 32.00 | 24.53 |
| 230.40000000 | 23.75 | 22.19 | 24.59 | 21.21 | 29.91 | 32.00 | 24.51 |
| 230.60000000 | 23.73 | 22.19 | 24.57 | 21.21 | 29.89 | 32.00 | 24.49 |
| 230.80000000 | 23.72 | 22.18 | 24.55 | 21.21 | 29.86 | 32.00 | 24.47 |
| 231.00000000 | 23.71 | 22.18 | 24.53 | 21.21 | 29.84 | 32.00 | 24.45 |
| 231.20000000 | 23.70 | 22.18 | 24.51 | 21.20 | 29.81 | 32.00 | 24.42 |
| 231.40000000 | 23.69 | 22.18 | 24.49 | 21.20 | 29.79 | 32.00 | 24.40 |
| 231.60000000 | 23.68 | 22.17 | 24.47 | 21.20 | 29.76 | 32.00 | 24.38 |
| 231.80000000 | 23.67 | 22.17 | 24.45 | 21.19 | 29.74 | 32.00 | 24.36 |
| 232.00000000 | 23.65 | 22.17 | 24.43 | 21.19 | 29.72 | 32.00 | 24.34 |
| 232.20000000 | 23.64 | 22.16 | 24.41 | 21.19 | 29.69 | 32.00 | 24.32 |
| 232.40000000 | 23.63 | 22.16 | 24.39 | 21.18 | 29.67 | 32.00 | 24.30 |
| 232.60000000 | 23.62 | 22.16 | 24.37 | 21.18 | 29.65 | 32.00 | 24.28 |
| 232.80000000 | 23.61 | 22.15 | 24.35 | 21.18 | 29.62 | 32.00 | 24.26 |
| 233.00000000 | 23.60 | 22.15 | 24.33 | 21.17 | 29.60 | 32.00 | 24.24 |
| 233.20000000 | 23.59 | 22.15 | 24.31 | 21.17 | 29.58 | 32.00 | 24.22 |
| 233.40000000 | 23.58 | 22.15 | 24.30 | 21.17 | 29.56 | 32.00 | 24.20 |
| 233.60000000 | 23.56 | 22.14 | 24.28 | 21.16 | 29.54 | 32.00 | 24.18 |
| 233.80000000 | 23.55 | 22.14 | 24.26 | 21.16 | 29.51 | 32.00 | 24.16 |
| 234.00000000 | 23.54 | 22.14 | 24.24 | 21.16 | 29.49 | 32.00 | 24.14 |
| 234.20000000 | 23.53 | 22.13 | 24.22 | 21.16 | 29.47 | 32.00 | 24.12 |
| 234.40000000 | 23.52 | 22.13 | 24.20 | 21.16 | 29.45 | 32.00 | 24.10 |
| 234.60000000 | 23.51 | 22.13 | 24.19 | 21.16 | 29.43 | 32.00 | 24.08 |
| 234.80000000 | 23.50 | 22.13 | 24.17 | 21.16 | 29.41 | 32.00 | 24.06 |
| 235.00000000 | 23.49 | 22.12 | 24.15 | 21.16 | 29.38 | 32.00 | 24.05 |
| 235.20000000 | 23.48 | 22.12 | 24.13 | 21.15 | 29.36 | 32.00 | 24.03 |
| 235.40000000 | 23.47 | 22.12 | 24.12 | 21.15 | 29.34 | 32.00 | 24.01 |
| 235.60000000 | 23.46 | 22.11 | 24.10 | 21.15 | 29.32 | 32.00 | 23.99 |
| 235.80000000 | 23.45 | 22.11 | 24.08 | 21.15 | 29.30 | 32.00 | 23.97 |
| 236.00000000 | 23.44 | 22.11 | 24.07 | 21.14 | 29.28 | 32.00 | 23.96 |
| 236.20000000 | 23.43 | 22.11 | 24.05 | 21.14 | 29.26 | 32.00 | 23.94 |
| 236.40000000 | 23.42 | 22.10 | 24.03 | 21.14 | 29.24 | 32.00 | 23.92 |
| 236.60000000 | 23.41 | 22.10 | 24.02 | 21.13 | 29.22 | 32.00 | 23.90 |
| 236.80000000 | 23.40 | 22.10 | 24.00 | 21.13 | 29.21 | 32.00 | 23.8 |
| 237.00000000 | 23.39 | 22.10 | 23.98 | 21.13 | 29.19 | 32.00 | 23.8 |
| 237.20000000 | 23.38 | 22.09 | 23.97 | 21.13 | 29.17 | 32.00 | 23.8 |
| 237.40000000 | 23.37 | 22.09 | 23.95 | 21.12 | 29.15 | 32.00 | 23.8 |
| 237.60000000 | 23.36 | 22.09 | 23.93 | 21.12 | 29.13 | 32.00 | 23.8 |
| 237.80000000 | 23.35 | 22.09 | 23.92 | 21.12 | 29.11 | 32.00 | 23.8 |
| 238.00000000 | 23.34 | 22.08 | 23.90 | 21.11 | 29.09 | 32.00 | 23.7 |
| 238.20000000 | 23.33 | 22.08 | 23.89 | 21.11 | 29.08 | 32.00 | 23.7 |
| 238.40000000 | 23.32 | 22.08 | 23.87 | 21.13 | 29.06 | 32.00 | 23.7 |
| 238.60000000 | 23.31 | 22.08 | 23.86 | 21.13 | 29.04 | 32.00 | 23.7 |
| 238.80000000 | 23.30 | 22.07 | 23.84 | 21.13 | 29.02 | 32.00 | 23.7 |
| 239.00000000 | 23.29 | 22.07 | 23.83 | 21.13 | 29.00 | 32.00 | 23.7 |
| 239.20000000 | 23.28 | 22.07 | 23.81 | 21.12 | 28.99 | 32.00 | 23.6 |
| 239.40000000 | 23.27 | 22.06 | 23.80 | 21.12 | 28.97 | 32.00 | 23.6 |
| 239.60000000 | 23.26 | 22.06 | 23.78 | 21.12 | 28.95 | 32.00 | 23.6 |
| 239.80000000 | 23.25 | 22.06 | 23.77 | 21.12 | 28.94 | 32.00 | 23.6 |
| 240.00000000 | 23.24 | 22.06 | 23.75 | 21.12 | 28.92 | 32.00 | 23.6 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 240.20000000 | 23.23 | 22.06 | 23.74 | 21.11 | 47.97 | 32.00 | 23.62 |
| 240.40000000 | 23.23 | 22.05 | 23.72 | 21.11 | 60.56 | 32.00 | 23.60 |
| 240.60000000 | 23.22 | 22.05 | 23.71 | 21.11 | 71.21 | 32.00 | 23.59 |
| 240.80000000 | 23.21 | 22.05 | 23.70 | 21.11 | 79.94 | 32.00 | 23.57 |
| 241.00000000 | 23.20 | 22.05 | 23.68 | 21.10 | 87.75 | 32.00 | 23.56 |
| 241.20000000 | 23.19 | 22.04 | 23.67 | 21.10 | 94.63 | 32.00 | 23.55 |
| 241.40000000 | 23.18 | 22.04 | 23.66 | 21.10 | 100.94 | 32.00 | 23.53 |
| 241.60000000 | 23.17 | 22.04 | 23.64 | 21.10 | 106.67 | 32.00 | 23.52 |
| 241.80000000 | 23.16 | 22.04 | 23.63 | 21.10 | 111.96 | 32.00 | 23.51 |
| 242.00000000 | 23.15 | 22.03 | 23.62 | 21.09 | 116.82 | 32.00 | 23.51 |
| 242.20000000 | 23.14 | 22.03 | 23.61 | 21.09 | 121.33 | 32.00 | 23.50 |
| 242.40000000 | 23.14 | 22.03 | 23.61 | 21.09 | 125.51 | 32.00 | 23.50 |
| 242.60000000 | 23.13 | 22.03 | 23.60 | 21.09 | 129.39 | 32.00 | 23.50 |
| 242.80000000 | 23.12 | 22.02 | 23.60 | 21.08 | 133.00 | 32.00 | 23.50 |
| 243.00000000 | 23.11 | 22.02 | 23.59 | 21.08 | 136.37 | 32.00 | 23.51 |
| 243.20000000 | 23.10 | 22.02 | 23.59 | 21.08 | 139.51 | 32.00 | 23.52 |
| 243.40000000 | 23.09 | 22.02 | 23.59 | 21.08 | 142.45 | 32.00 | 23.53 |
| 243.60000000 | 23.09 | 22.02 | 23.60 | 21.08 | 145.20 | 32.00 | 23.54 |
| 243.80000000 | 23.08 | 22.01 | 23.60 | 21.07 | 147.78 | 32.00 | 23.56 |
| 244.00000000 | 23.07 | 22.01 | 23.61 | 21.07 | 150.21 | 32.00 | 23.59 |
| 244.20000000 | 23.06 | 22.01 | 23.62 | 21.07 | 152.48 | 32.00 | 23.61 |
| 244.40000000 | 23.05 | 22.01 | 23.63 | 21.07 | 154.63 | 32.00 | 23.64 |
| 244.60000000 | 23.04 | 22.00 | 23.65 | 21.07 | 156.65 | 33.54 | 23.67 |
| 244.80000000 | 23.04 | 22.00 | 23.67 | 21.07 | 158.55 | 34.64 | 23.71 |
| 245.00000000 | 23.03 | 22.00 | 23.69 | 21.07 | 160.38 | 35.65 | 23.74 |
| 245.20000000 | 23.02 | 22.00 | 23.71 | 21.07 | 162.12 | 36.50 | 23.78 |
| 245.40000000 | 23.01 | 22.00 | 23.73 | 21.07 | 163.78 | 37.40 | 23.83 |
| 245.60000000 | 23.00 | 21.99 | 23.76 | 21.07 | 165.38 | 38.21 | 23.87 |
| 245.80000000 | 23.00 | 21.99 | 23.78 | 21.07 | 166.93 | 39.02 | 23.92 |
| 246.00000000 | 22.99 | 21.99 | 23.81 | 21.08 | 168.44 | 39.74 | 23.97 |
| 246.20000000 | 22.98 | 21.99 | 23.85 | 21.08 | 169.89 | 40.44 | 24.03 |
| 246.40000000 | 22.97 | 21.99 | 23.88 | 21.08 | 171.30 | 41.09 | 24.08 |
| 246.60000000 | 22.97 | 21.98 | 23.91 | 21.09 | 172.66 | 41.71 | 24.14 |
| 246.80000000 | 22.96 | 21.98 | 23.95 | 21.09 | 173.98 | 42.29 | 24.20 |
| 247.00000000 | 22.95 | 21.98 | 23.99 | 21.09 | 175.25 | 42.86 | 24.26 |
| 247.20000000 | 22.94 | 21.98 | 24.03 | 21.10 | 176.48 | 43.40 | 24.32 |
| 247.40000000 | 22.94 | 21.98 | 24.07 | 21.10 | 177.66 | 43.94 | 24.38 |
| 247.60000000 | 22.93 | 21.97 | 24.11 | 21.11 | 178.80 | 44.49 | 24.45 |
| 247.80000000 | 22.92 | 21.97 | 24.16 | 21.11 | 179.91 | 45.02 | 24.51 |
| 248.00000000 | 22.91 | 21.97 | 24.20 | 21.12 | 180.97 | 45.56 | 24.58 |
| 248.20000000 | 22.91 | 21.97 | 24.25 | 21.13 | 182.00 | 46.10 | 24.65 |
| 248.40000000 | 22.90 | 21.97 | 24.29 | 21.13 | 183.00 | 46.65 | 24.71 |
| 248.60000000 | 22.89 | 21.96 | 24.34 | 21.14 | 183.96 | 47.31 | 24.78 |
| 248.80000000 | 22.89 | 21.96 | 24.39 | 21.15 | 184.90 | 48.07 | 24.85 |
| 249.00000000 | 22.88 | 21.96 | 24.44 | 21.16 | 185.81 | 48.84 | 24.92 |
| 249.20000000 | 22.88 | 21.96 | 24.49 | 21.16 | 186.69 | 49.61 | 25.00 |
| 249.40000000 | 22.87 | 21.96 | 24.54 | 21.17 | 187.55 | 50.43 | 25.0 |
| 249.60000000 | 22.86 | 21.95 | 24.59 | 21.18 | 188.40 | 51.21 | 25.1 |
| 249.80000000 | 22.86 | 21.95 | 24.65 | 21.19 | 189.22 | 51.96 | 25.2 |
| 250.00000000 | 22.85 | 21.95 | 24.70 | 21.20 | 190.03 | 52.67 | 25.2 |

```
TOTAL NUMBER OF SLABS                              L= 14
NUMBER OF LAYERS IN HEATER                         NX= 23
TOTAL NUMBER OF NODES IN THE Y-DIRECTION           M= 60
TOTAL NUMBER OF NODES IN THE X-DIRECTION           N=177
TOTAL LENGTH OF COMPOSITE SLAB IN THE Y-DIRECTION  TLEN1=    0.511900INCHES
TOTAL LENGTH OF THE GRID IN THE X-DIRECTION        TLEN2=   24.610000INCHES
```

| # OF | LENGTH | CONDUCTIVITY | DIFFUSIVITY |
|---|---|---|---|
| 5 | 0.07500 | 102.000000 | 2.830000 |
| 3 | 0.01000 | 0.100000 | 0.005800 |
| 5 | 0.05000 | 102.000000 | 2.830000 |
| 3 | 0.01000 | 0.100000 | 0.005800 |
| 4 | 0.02000 | 8.700000 | 0.150000 |
| 2 | 0.00820 | 0.100000 | 0.005800 |
| 4 | 0.01380 | 0.220000 | 0.008700 |
| 4 | 0.00820 | 0.100000 | 0.005800 |
| 4 | 0.00650 | 60.000000 | 1.150000 |
| 4 | 0.00820 | 0.100000 | 0.005800 |
| 4 | 0.01380 | 0.220000 | 0.008700 |
| 4 | 0.00820 | 0.100000 | 0.005800 |
| 6 | 0.03000 | 8.700000 | 0.150000 |
| 21 | 0.25000 | 1.290000 | 0.044600 |

```
                  DATA   FOR   THE    HEATER
```

| | | | |
|---|---|---|---|
| 8 | 15.61367 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 8 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 14 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 26 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 41 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 26 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 14 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 8 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 3 | 0.06100 | 0.100000 | 0.005800 |
| 4 | 1.00000 | 60.000000 | 1.150000 |
| 8 | 15.61367 | 0.100000 | 0.005800 |

```
INTERNAL HEAT GENERATION IN SLAB NUMBER         IJ=  9
                            BETWEEN NODE    NO1= 24
                            AND NODE        NO2= 27

     1         30.00000        5.00000       60.00000      120.00000

HEATER  1 STARTS AT NODE IN X-DIRECTION      NODEG =  43
```

HEATER  1 ENDS AT NODE IN X-DIRECTION        NODG =  67

      2         30.00000         60.00000         60.00000      120.00000

HEATER  2 STARTS AT NODE IN X-DIRECTION      NODEG =  70
HEATER  2 ENDS AT NODE IN X-DIRECTION        NODG = 109

      3         30.00000          5.00000         60.00000      120.00000

HEATER  3 STARTS AT NODE IN X-DIRECTION      NODEG = 112
HEATER  3 ENDS AT NODE IN X-DIRECTION        NODG = 136

STEP FUNCTION HEAT INPUT IN WATTS/IN*IN


CONVECTION OCCURS       AT  J=1
          AMBIENT TEMPERAT URE    TG1=    9.400000DEG.F
          HEAT TRANSFER COEFF.    H1 =    1.000000B.T.U/HR.FT.FT.DEG.F
INSULATED BOUNDARY CONDITION ON LEFT SIDE.

INSULATED BOUNDARY CONDITION ON RIGHT SIDE.


FULL ACCRETION BALANCE IS USED AT TOP SURFACE


 X-COORDINATE Y-COORDINATE  BETA        PRESSURE      HTC

COMPOSITE BODY TEMPERATURES ARE INITIALIZED TO THE ACCRETION BALANCE TEMPERATURE PROFILE


CONDUCTION INTO THE BLADE IS NOT CONSIDERED BEFORE THE HEATER(S) TURN ON.

SHEDDING OF ICE IS CONSIDERED




THE PHASE CHANGE IN THE ICE LAYER IS CONSIDERED

LATENT HEAT OF ICE                    HLAM =    143.400000B.T.U./LB
THERMAL CONDUCTIVITY OF WATER         AKL  =      0.320000B.T.U./HR.FT.DEG.F
DENSITY OF WATER                      DEL  =     62.400000LB/CU.FT
SPECIFIC HEAT * DENSITY OF WATER      CPL  =     62.212800B.T.U./CU.FT.DEG.F
DENSITY OF ICE                        DES  =     57.400000LB/CU.FT.
THE MELTING TEMPERATURE               TMP  =     32.000000DEG.F

ICE MELTING RANGE                     TR   =      0.000010DEG.F
HEAT OF VAPORIZATION                  HVAP =   1075.160000 BTU/LB
HEAT CAPACITY OF AIR                  CPAIR =     0.250000 BTU/LB*DEG F
NUMBER OF POINTS IN ICE SHAPE APPROXIMATION  NP =  2
        X-COORDINATE XP =   0.00000    Y-COORDINATE YP =   0.00000
        X-COORDINATE XP =  24.61000    Y-COORDINATE YP =   0.00000
AMBIENT TEMPERATURE,TINF =   9.320 DEG. F
LIQUID WATER CONTENT,LWC =    0.5000 G/M**3
AMBIENT VELOCITY,VINF =  424.737591 FT/S

```
DROPLET DIAMETER,DROP =   20.0000 MICRONS
AMBIENT PRESSURE,PINF =   13.161907 PSI
ANGLE OF ATTACK,ALPHA =   0.000 DEG

INITIAL TIME STEP                              DTAUI =    0.100000SECS
                               FOR TIME STEPS NISP   = 10
INTERMIDIATE TIME STEP                         DTAUM =    0.100000SECS
                               FOR TIME STEPS NMSP   =100
FINAL TIME STEP                                DTAUF =    0.100000SECS
NUMBER OF SECONDS IN THE SIMULATION     TIMEOUT =       250.0000 SEC
MAXIMUM NUMBER OF ITERATIONS FOR PHASE ROUTINE  JCOUNT =  20


X-Y COORDINATES OF THE ICE SHAPE WILL BE PRINTED OUT AT THE FOLLOWING TIME STEPS
           1200
           1800
           2400
           2500
X-LAYER   WHERE(L-M-R)   Y-LAYER   WHERE(B-M-T)

    8        M             9          T
    8        M            13          T
   10        M             9          T
   10        M            13          T
   12        M             9          T
   12        M            13          T
   14        M             9          T
   14        M            13          T
   16        M             9          T
   16        M            13          T

ICE LAYER MATRIX.  CHANGE FORMAT 780 SO THAT BOTTOM ROW IS ALL NINES.
THIS REPRESENTS THE ICE SHAPE IN RECTANGULAR COORDINATES
0 = AIR, 1 = INTERIOR ICE NODE, 2-8 = ICE-AIR BOUNDARY NODE
9 = ICE-METAL (OR AIR-METAL) BOUNDARY NODE

99999999999999999999999999999999999999999999999999999999999999999999999999999999
99999999999999999999999999999999999999999999999999999999999999999999999999999999
999999999999999999999
MASS OF ICE/UNIT SPAN COMING IN EACH TIME STEP =   8.764176601 *10**(-5) LB/FT
  3 ITERATIONS WERE REQUIRED AT TIME =  122.300
  3 ITERATIONS WERE REQUIRED AT TIME =  123.900
  3 ITERATIONS WERE REQUIRED AT TIME =  184.700
  3 ITERATIONS WERE REQUIRED AT TIME =  245.200
  3 ITERATIONS WERE REQUIRED AT TIME =  245.400
  3 ITERATIONS WERE REQUIRED AT TIME =  245.600
  3 ITERATIONS WERE REQUIRED AT TIME =  249.100
-------------------------------------------------------------
00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
00000000000000000000008000000000000000000000000000000000000000000000000000000000000000000
000000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000000000000000000800
000000000000000008007000000000000000000000000000000000000000000000000000000000000000000000
00000000000000000000000
00000000000000000CC00000000000000000000000000000000000000000000000000000000000000005400
```

```
000000000000000000700700000000000000000000000000000000000000000000000000000000000
0000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000003160
0000000000000000070516000000000000000000000000000000000000000000000000000000000000
0000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000003112
2600000000000000051211400000000000000000000000000000000000000000000C00000000000000
0000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000003111
112600000000000521111140000000000000000000000000000000000000000000000000000000000000
0000000000000000000
000000000000000000000000000000000000000000000000000000000000000000000000521111
11111260000000051111111160000000000000000000000000000000000000000000000000000000000
0000000000000000000
0000000000000000000000000000000000000000000000000000000000000000000052222111111
1111112222222111111111122600000000000000000000000000000000000000000000000000000000
0000000000000000000
000000000000000000000000000000000000000000000000000000000000000052221111111111111
111111111111111111111111122222600000000000000000000000000000000000000000000000000
0000000000000000000
00000000000000000000000000000000000000000000000000000000000000052222211111111111111
1111111111111111111111111111111122226000000000000000000000000000000000000000000000
0000000000000000000
000000000000000000000000000000000000000000000000000000000000005222222111111111111111111
1111111111111111111111111111111111111112222260000000000000000000000000000000000000
0000000000000000000
0000000000000000000000000000000000000000000000000005222222211111111111111111111111111
1111111111111111111111111111111111111111111111122222222222226000000000000000000000000
0000000000000000000
999999999999999999999999999999999999999999999999999999999999999999999999999999999
999999999999999999999999999999999999999999999999999999999999999999999999999999999
999999999999999999
```

Example1 Output

**FILE: EXAMPLE1    OUTPUT    A          VM/SP CONVERSATIONAL MONITOR SYSTEM**

1
0               UNTRANSFORMED COORDINATE DATA FOR BODY ID =   1,

| I | X(I) | Y(I) | I | X(I) |
|---|---|---|---|---|
| 1 | 1.0000000 | 0.0000000 | 51 | 0.0150000 |
| 2 | 0.9899999 | -0.0018740 | 52 | 0.0100000 |
| 3 | 0.9800000 | -0.0036110 | 53 | 0.0075000 |
| 4 | 0.9700000 | -0.0052390 | 54 | 0.0050000 |
| 5 | 0.9500000 | -0.0082510 | 55 | 0.0037500 |
| 6 | 0.9250000 | -0.0117000 | 56 | 0.0025000 |
| 7 | 0.9000000 | -0.0149080 | 57 | 0.0022500 |
| 8 | 0.8750000 | -0.0179530 | 58 | 0.0020000 |
| 9 | 0.8500000 | -0.0208880 | 59 | 0.0017500 |
| 10 | 0.8250000 | -0.0237390 | 60 | 0.0015000 |
| 11 | 0.8000000 | -0.0265150 | 61 | 0.0012500 |
| 12 | 0.7750000 | -0.0292210 | 62 | 0.0010000 |
| 13 | 0.7500000 | -0.0318550 | 63 | 0.0008750 |
| 14 | 0.7250000 | -0.0344110 | 64 | 0.0007500 |
| 15 | 0.7000000 | -0.0368870 | 65 | 0.0006250 |
| 16 | 0.6750000 | -0.0392810 | 66 | 0.0005000 |
| 17 | 0.6500000 | -0.0415850 | 67 | 0.0003750 |
| 18 | 0.6250000 | -0.0437950 | 68 | 0.0002500 |
| 19 | 0.6000000 | -0.0459040 | 69 | 0.0001250 |
| 20 | 0.5750000 | -0.0479060 | 70 | 0.0000000 |
| 21 | 0.5500000 | -0.0497930 | 71 | 0.0001250 |
| 22 | 0.5250000 | -0.0515600 | 72 | 0.0002500 |
| 23 | 0.5000000 | -0.0531980 | 73 | 0.0003750 |
| 24 | 0.4750000 | -0.0546980 | 74 | 0.0005000 |
| 25 | 0.4500000 | -0.0560510 | 75 | 0.0006250 |
| 26 | 0.4250000 | -0.0572430 | 76 | 0.0007500 |
| 27 | 0.4000000 | -0.0582620 | 77 | 0.0008750 |
| 28 | 0.3750000 | -0.0590900 | 78 | 0.0010000 |
| 29 | 0.3500000 | -0.0597070 | 79 | 0.0012500 |
| 30 | 0.3250000 | -0.0600940 | 80 | 0.0015000 |
| 31 | 0.3000000 | -0.0602260 | 81 | 0.0017500 |
| 32 | 0.2750000 | -0.0600760 | 82 | 0.0020000 |
| 33 | 0.2500000 | -0.0596120 | 83 | 0.0022500 |
| 34 | 0.2250000 | -0.0587940 | 84 | 0.0025000 |
| 35 | 0.2000000 | -0.0575700 | 85 | 0.0037500 |
| 36 | 0.1750000 | -0.0558790 | 86 | 0.0050000 |
| 37 | 0.1500000 | -0.0536360 | 87 | 0.0075000 |
| 38 | 0.1250000 | -0.0507320 | 88 | 0.0100000 |
| 39 | 0.1000000 | -0.0470040 | 89 | 0.0150000 |
| 40 | 0.0900000 | -0.0452280 | 90 | 0.0200000 |
| 41 | 0.0800000 | -0.0432520 | 91 | 0.0250000 |
| 42 | 0.0700000 | -0.0410380 | 92 | 0.0300000 |
| 43 | 0.0600000 | -0.0385350 | 93 | 0.0350000 |
| 44 | 0.0500000 | -0.0356740 | 94 | 0.0400000 |
| 45 | 0.0450000 | -0.0340820 | 95 | 0.0450000 |
| 46 | 0.0400000 | -0.0323620 | 96 | 0.0500000 |
| 47 | 0.0350000 | -0.0304960 | 97 | 0.0600000 |
| 48 | 0.0300000 | -0.0284620 | 98 | 0.0700000 |
| 49 | 0.0250000 | -0.0262300 | 99 | 0.0800000 |
| 50 | 0.0200000 | -0.0237260 | 100 | 0.0900000 |

0                 UNTRANSFORMED COORDINATE DATA FOR BODY ID =  1,

| I | X(I) | Y(I) | | I | X(I) |
|---|---|---|---|---|---|
| 101 | 0.1000000 | 0.0470040 | | 121 | 0.6000000 |
| 102 | 0.1250000 | 0.0507320 | | 122 | 0.6250000 |
| 103 | 0.1500000 | 0.0536360 | | 123 | 0.6500000 |
| 104 | 0.1750000 | 0.0558790 | | 124 | 0.6750000 |
| 105 | 0.2000000 | 0.0575700 | | 125 | 0.7000000 |
| 106 | 0.2250000 | 0.0587940 | | 126 | 0.7250000 |
| 107 | 0.2500000 | 0.0596120 | | 127 | 0.7500000 |
| 108 | 0.2750000 | 0.0600760 | | 128 | 0.7750000 |
| 109 | 0.3000000 | 0.0602260 | | 129 | 0.8000000 |
| 110 | 0.3250000 | 0.0600940 | | 130 | 0.8250000 |
| 111 | 0.3500000 | 0.0597070 | | 131 | 0.8500000 |
| 112 | 0.3750000 | 0.0590900 | | 132 | 0.8750000 |
| 113 | 0.4000000 | 0.0582620 | | 133 | 0.9000000 |
| 114 | 0.4250000 | 0.0572430 | | 134 | 0.9250000 |
| 115 | 0.4500000 | 0.0560510 | | 135 | 0.9500000 |
| 116 | 0.4750000 | 0.0546980 | | 136 | 0.9700000 |
| 117 | 0.5000000 | 0.0531980 | | 137 | 0.9800000 |
| 118 | 0.5250000 | 0.0515600 | | 138 | 0.9899999 |
| 119 | 0.5500000 | 0.0497930 | | 139 | 1.0000000 |
| 120 | 0.5750000 | 0.0479060 | | | |

1   DOUGLAS  AIRCRAFT  COMPANY  TWO-DIMENSIONAL  POTENTIAL  FLOW  PROGRAM
0COMBINED  FLOW
0ALPHA =   0.000000         ALPHA 0 =  -0.000010          NO.  OF  BODIES    1
0  CL  =  -0.000001           CHORD =   1.000000          TOTAL  ELEMENTS   138
0BODY ID =  1                 NO. OF ELEMENTS   138

| 0  I | X | Y | S | VT | CP |
|---|---|---|---|---|---|
| 1 | 0.9950030 | -0.0009536 | 0.0024939 | -0.8268568 | 0.3163079 |
| 2 | 0.9850022 | -0.0027573 | 0.0074755 | -0.8886779 | 0.2102516 |
| 3 | 0.9750018 | -0.0044365 | 0.0124468 | -0.9189485 | 0.1555337 |
| 4 | 0.9600045 | -0.0067781 | 0.0198878 | -0.9451057 | 0.1067752 |
| 5 | 0.9375049 | -0.0100112 | 0.0310313 | -0.9680865 | 0.0628085 |
| 6 | 0.9125030 | -0.0133284 | 0.0433953 | -0.9839662 | 0.0318105 |
| 7 | 0.8875018 | -0.0164470 | 0.0557466 | -0.9951778 | 0.0096211 |
| 8 | 0.8625011 | -0.0194324 | 0.0680896 | -1.0043850 | -0.0087891 |
| 9 | 0.8375007 | -0.0223233 | 0.0804271 | -1.0128345 | -0.0258331 |
| 10 | 0.8125010 | -0.0251359 | 0.0927601 | -1.0208492 | -0.0421324 |
| 11 | 0.7875008 | -0.0278768 | 0.1050892 | -1.0285645 | -0.0579443 |
| 12 | 0.7625008 | -0.0305473 | 0.1174145 | -1.0361195 | -0.0735426 |
| 13 | 0.7375007 | -0.0331427 | 0.1297361 | -1.0434093 | -0.0887022 |
| 14 | 0.7125006 | -0.0356590 | 0.1420537 | -1.0504131 | -0.1033669 |
| 15 | 0.6875010 | -0.0380946 | 0.1543673 | -1.0573273 | -0.1179409 |
| 16 | 0.6625009 | -0.0404444 | 0.1666770 | -1.0641356 | -0.1323843 |
| 17 | 0.6375008 | -0.0427021 | 0.1789826 | -1.0707989 | -0.1466093 |
| 18 | 0.6125008 | -0.0448624 | 0.1912839 | -1.0773830 | -0.1607542 |
| 19 | 0.5875007 | -0.0469188 | 0.2035809 | -1.0838785 | -0.1747923 |
| 20 | 0.5625011 | -0.0488641 | 0.2158736 | -1.0902729 | -0.1886950 |
| 21 | 0.5375010 | -0.0506920 | 0.2281620 | -1.0966110 | -0.2025557 |
| 22 | 0.5125009 | -0.0523956 | 0.2404461 | -1.1029644 | -0.2165298 |
| 23 | 0.4875010 | -0.0539657 | 0.2527259 | -1.1092901 | -0.2305241 |
| 24 | 0.4625010 | -0.0553936 | 0.2650015 | -1.1156693 | -0.2447176 |
| 25 | 0.4375010 | -0.0566678 | 0.2772731 | -1.1220808 | -0.2590647 |
| 26 | 0.4125009 | -0.0577762 | 0.2895408 | -1.1285248 | -0.2735682 |

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| | | | | |
|---|---|---|---|---|
| 27 | 0.3875008 | -0.0587010 | 0.3018049 | -1.1350374 | -0.2883091 |
| 28 | 0.3625007 | -0.0594260 | 0.3140658 | -1.1414566 | -0.3029222 |
| 29 | 0.3375004 | -0.0599308 | 0.3263240 | -1.1477957 | -0.3174343 |
| 30 | 0.3125001 | -0.0601935 | 0.3385806 | -1.1540527 | -0.3318377 |
| 31 | 0.2874997 | -0.0601882 | 0.3508365 | -1.1601448 | -0.3459358 |
| 32 | 0.2624992 | -0.0598856 | 0.3630934 | -1.1660824 | -0.3597479 |
| 33 | 0.2374985 | -0.0592503 | 0.3753535 | -1.1718359 | -0.3731985 |
| 34 | 0.2124973 | -0.0582363 | 0.3876199 | -1.1771927 | -0.3857822 |
| 35 | 0.1874957 | -0.0567876 | 0.3998970 | -1.1819983 | -0.3971195 |
| 36 | 0.1624932 | -0.0548323 | 0.4121915 | -1.1859293 | -0.4064274 |
| 37 | 0.1374894 | -0.0522749 | 0.4245133 | -1.1885767 | -0.4127140 |
| 38 | 0.1124833 | -0.0489800 | 0.4368784 | -1.1891909 | -0.4141741 |
| 39 | 0.0949960 | -0.0461379 | 0.4455639 | -1.1883068 | -0.4120722 |
| 40 | 0.0849948 | -0.0442662 | 0.4505519 | -1.1872902 | -0.4096575 |
| 41 | 0.0749931 | -0.0421762 | 0.4555610 | -1.1851130 | -0.4044924 |

1    DOUGLAS  AIRCRAFT    COMPANY   TWO-DIMENSIONAL POTENTIAL   FLOW    PROGRAM
OCOMBINED  FLOW

OALPHA =   0.000000          ALPHA O =  -0.000010            NO.  OF  BODIES    1
0 CL  =  -0.000001              CHORD =   1.000000            TOTAL  ELEMENTS   138
OBODY ID =  1                  NO. OF ELEMENTS   138

| 0  I | X | Y | S | VT | CP |
|---|---|---|---|---|---|
| 42 | 0.0649905 | -0.0398243 | 0.4605984 | -1.1808882 | -0.3944960 |
| 43 | 0.0549870 | -0.0371499 | 0.4656748 | -1.1729183 | -0.3757372 |
| 44 | 0.0474957 | -0.0348913 | 0.4695106 | -1.1636896 | -0.3541727 |
| 45 | 0.0424947 | -0.0332373 | 0.4720929 | -1.1553192 | -0.3347616 |
| 46 | 0.0374936 | -0.0314462 | 0.4746971 | -1.1443930 | -0.3096352 |
| 47 | 0.0324921 | -0.0294985 | 0.4773283 | -1.1306772 | -0.2784309 |
| 48 | 0.0274893 | -0.0273701 | 0.4799936 | -1.1155014 | -0.2443428 |
| 49 | 0.0224832 | -0.0250116 | 0.4827065 | -1.0984278 | -0.2065430 |
| 50 | 0.0174724 | -0.0223086 | 0.4854980 | -1.0677691 | -0.1401300 |
| 51 | 0.0124526 | -0.0190892 | 0.4884223 | -1.0151653 | -0.0305605 |
| 52 | 0.0087273 | -0.0161891 | 0.4907375 | -0.9530599 | 0.0916770 |
| 53 | 0.0062075 | -0.0137715 | 0.4924502 | -0.8769054 | 0.2310369 |
| 54 | 0.0043571 | -0.0115558 | 0.4938660 | -0.7800955 | 0.3914510 |
| 55 | 0.0030979 | -0.0096758 | 0.4949756 | -0.6789739 | 0.5389946 |
| 56 | 0.0023736 | -0.0083787 | 0.4957039 | -0.6001760 | 0.6397888 |
| 57 | 0.0021234 | -0.0078803 | 0.4959773 | -0.5699757 | 0.6751277 |
| 58 | 0.0018732 | -0.0073498 | 0.4962648 | -0.5368442 | 0.7117984 |
| 59 | 0.0016230 | -0.0067808 | 0.4965695 | -0.4998917 | 0.7501083 |
| 60 | 0.0013727 | -0.0061669 | 0.4968945 | -0.4601265 | 0.7882836 |
| 61 | 0.0011222 | -0.0054975 | 0.4972448 | -0.4157826 | 0.8271249 |
| 62 | 0.0009367 | -0.0049563 | 0.4975253 | -0.3790886 | 0.8562919 |
| 63 | 0 0008116 | -0.0045648 | 0.4977267 | -0.3526645 | 0.8756278 |
| 64 | 0.0006864 | -0.0041473 | 0.4979404 | -0.3240116 | 0.8950166 |
| 65 | 0.0005612 | -0.0036968 | 0.4981695 | -0.2925074 | 0.9144395 |
| 66 | 0.0004359 | -0.0032039 | 0.4984189 | -0.2576435 | 0.9336199 |
| 67 | 0.0003101 | -0.0026510 | 0.4986968 | -0.2174374 | 0.9527210 |
| 68 | 0.0001830 | -0.0019948 | 0.4990245 | -0.1691893 | 0.9713750 |
| 69 | 0.0000337 | -0.0008182 | 0.4996060 | -0.0722345 | 0.9947822 |
| 70 | 0.0000337 | 0.0008182 | 0.5004090 | 0.0722346 | 0.9947822 |
| 71 | 0.0001830 | 0.0019948 | 0.5009906 | 0.1691884 | 0.9713753 |
| 72 | 0.0003101 | 0.0026510 | 0.5013182 | 0.2174363 | 0.9527215 |
| 73 | 0.0004359 | 0.0032039 | 0.5015962 | 0.2576425 | 0.9336204 |
| 74 | 0.0005612 | 0.0036968 | 0.5018455 | 0.2925056 | 0.9144405 |
| 75 | 0.0006864 | 0.0041473 | 0.5020747 | 0.3240096 | 0.8950178 |

| | | | | |
|---|---|---|---|---|
| 76 | 0.0008116 | 0.0045648 | 0.5022883 | 0.3526618 | 0.8756297 |
| 77 | 0.0009367 | 0.0049563 | 0.5024897 | 0.3790872 | 0.8562930 |
| 78 | 0.0011222 | 0.0054975 | 0.5027702 | 0.4157806 | 0.8271265 |
| 79 | 0.0013727 | 0.0061669 | 0.5031205 | 0.4601249 | 0.7882851 |
| 80 | 0.0016230 | 0.0067808 | 0.5034456 | 0.4998900 | 0.7501100 |
| 81 | 0.0018732 | 0.0073498 | 0.5037503 | 0.5368431 | 0.7117995 |
| 82 | 0.0021234 | 0.0078803 | 0.5040377 | 0.5699748 | 0.6751287 |

1  DOUGLAS  AIRCRAFT  COMPANY  TWO-DIMENSIONAL  POTENTIAL  FLOW  PROGRAM
0COMBINED  FLOW
0ALPHA =  0.000000         ALPHA 0 =  -0.000010         NO.  OF  BODIES   1
0  CL  =  -0.000001          CHORD =   1.000000         TOTAL  ELEMENTS  138
0BODY ID = 1                NO. OF ELEMENTS  138

| 0  I | X | Y | S | VT | CP |
|---|---|---|---|---|---|
| 83 | 0.0023736 | 0.0083787 | 0.5043111 | 0.6001753 | 0.6397897 |
| 84 | 0.0030979 | 0.0096758 | 0.5050395 | 0.6789737 | 0.5389948 |
| 85 | 0.0043571 | 0.0115558 | 0.5061491 | 0.7800954 | 0.3914512 |
| 86 | 0.0062075 | 0.0137715 | 0.5075648 | 0.8769064 | 0.2310352 |
| 87 | 0.0087273 | 0.0161891 | 0.5092775 | 0.9530599 | 0.0916770 |
| 88 | 0.0124526 | 0.0190892 | 0.5115927 | 1.0151653 | -0.0305605 |
| 89 | 0.0174724 | 0.0223086 | 0.5145170 | 1.0677700 | -0.1401320 |
| 90 | 0.0224832 | 0.0250116 | 0.5173085 | 1.0984278 | -0.2065430 |
| 91 | 0.0274893 | 0.0273701 | 0.5200214 | 1.1155024 | -0.2443447 |
| 92 | 0.0324921 | 0.0294985 | 0.5226867 | 1.1306782 | -0.2784328 |
| 93 | 0.0374936 | 0.0314462 | 0.5253180 | 1.1443930 | -0.3096352 |
| 94 | 0.0424947 | 0.0332373 | 0.5279222 | 1.1553192 | -0.3347616 |
| 95 | 0.0474957 | 0.0348913 | 0.5305044 | 1.1636896 | -0.3541727 |
| 96 | 0.0549870 | 0.0371499 | 0.5343402 | 1.1729183 | -0.3757372 |
| 97 | 0.0649905 | 0.0398243 | 0.5394166 | 1.1808882 | -0.3944960 |
| 98 | 0.0749931 | 0.0421762 | 0.5444540 | 1.1851130 | -0.4044924 |
| 99 | 0.0849948 | 0.0442662 | 0.5494631 | 1.1872892 | -0.4096556 |
| 100 | 0.0949960 | 0.0461379 | 0.5544512 | 1.1883059 | -0.4120703 |
| 101 | 0.1124833 | 0.0489800 | 0.5631366 | 1.1891890 | -0.4141703 |
| 102 | 0.1374894 | 0.0522749 | 0.5755017 | 1.1885757 | -0.4127121 |
| 103 | 0.1624932 | 0.0548323 | 0.5878236 | 1.1859283 | -0.4064255 |
| 104 | 0.1874957 | 0.0567876 | 0.6001180 | 1.1819973 | -0.3971176 |
| 105 | 0.2124973 | 0.0582363 | 0.6123952 | 1.1771927 | -0.3857822 |
| 106 | 0.2374985 | 0.0592503 | 0.6246616 | 1.1718359 | -0.3731985 |
| 107 | 0.2624992 | 0.0598856 | 0.6369216 | 1.1660814 | -0.3597450 |
| 108 | 0.2874997 | 0.0601882 | 0.6491785 | 1.1601439 | -0.3459330 |
| 109 | 0.3125001 | 0.0601935 | 0.6614344 | 1.1540527 | -0.3318377 |
| 110 | 0.3375004 | 0.0599308 | 0.6736910 | 1.1477957 | -0.3174343 |
| 111 | 0.3625007 | 0.0594260 | 0.6859493 | 1.1414576 | -0.3029251 |
| 112 | 0.3875008 | 0.0587010 | 0.6982101 | 1.1350374 | -0.2883091 |
| 113 | 0.4125009 | 0.0577752 | 0.7104742 | 1.1285248 | -0.2735682 |
| 114 | 0.4375010 | 0.0566678 | 0.7227419 | 1.1220808 | -0.2590647 |
| 115 | 0.4625010 | 0.0553936 | 0.7350135 | 1.1156702 | -0.2447195 |
| 116 | 0.4875010 | 0.0539657 | 0.7472891 | 1.1092901 | -0.2305241 |
| 117 | 0.5125009 | 0.0523956 | 0.7595669 | 1.1029644 | -0.2165298 |
| 118 | 0.5375010 | 0.0506920 | 0.7718530 | 1.0966110 | -0.2025557 |
| 119 | 0.5625011 | 0.0488641 | 0.7841414 | 1.0902729 | -0.1886950 |
| 120 | 0.5875007 | 0.0469188 | 0.7964341 | 1.0838785 | -0.1747923 |
| 121 | 0.6125008 | 0.0448624 | 0.8087311 | 1.0773830 | -0.1607542 |
| 122 | 0.6375008 | 0.0427021 | 0.8210325 | 1.0707989 | -0.1466093 |
| 123 | 0.6625009 | 0.0404444 | 0.8333380 | 1.0641346 | -0.1323824 |

1  DOUGLAS  AIRCRAFT  COMPANY  TWO-DIMENSIONAL  POTENTIAL  FLOW  PROGRAM

```
0COMBINED  FLOW
0ALPHA =   0.000000        ALPHA 0 =  -0.000010       NO.  OF  BODIES    1
0 CL  =  -0.000001          CHORD =   1.000000        TOTAL  ELEMENTS  138
0BODY ID =  1               NO. OF ELEMENTS  138
0 I          X              Y              S              VT             CP
 124      0.6875010      0.0380946      0.8456477      1.0573263      -0.1179380
 125      0.7125006      0.0356590      0.8579614      1.0504122      -0.1033649
 126      0.7375007      0.0331427      0.8702790      1.0434084      -0.0887003
 127      0.7625008      0.0305473      0.8826005      1.0361185      -0.0735407
 128      0.7875008      0.0278768      0.8949258      1.0285645      -0.0579443
 129      0.8125010      0.0251359      0.9072549      1.0208492      -0.0421324
 130      0.8375007      0.0223233      0.9195880      1.0128345      -0.0258331
 131      0.8625011      0.0194324      0.9319254      1.0043850      -0.0087891
 132      0.8875018      0.0164470      0.9442685      0.9951773       0.0096221
 133      0.9125030      0.0133284      0.9566197      0.9839657       0.0318115
 134      0.9375049      0.0100112      0.9689837      0.9680861       0.0628093
 135      0.9600045      0.0067781      0.9801271      0.9451054       0.1067759
 136      0.9750018      0.0044365      0.9875680      0.9189482       0.1555341
 137      0.9850022      0.0027573      0.9925392      0.8886767       0.2102538
 138      0.9950030      0.0009536      0.9975207      0.8268554       0.3163102
0INTEGRATED VALUES
0CY =    0.00000    CX =     0.00010
0CL =    0.00000    CD =     0.00010    CM =     0.00000
0PARABOLIC INTEGRATION
0INTEGRATED VALUES
0CY =    0.00000    CX =     0.00014
0CL =    0.00000    CD =     0.00014    CM =     0.00000
0TOTAL CM =    0.00000
0TOTAL CM =    0.00000    (PARABOLIC)
1
```

THE PARTICLES ARE RELEASED FROM X = -2.23860E+00
WHICH IS OBTAINED AT THE    1 LOOP OF   50 LOOPS

GEOMETRY CHARACTERISTICS:

| | | |
|---|---|---|
| LEADING EDGE (X,Y) | -2.0000E-03 | 0.0000E+00 |
| TRAILING EDGE (X,Y) | 5.3540E-01 | 0.0000E+00 |
| THICKNESS | 6.8249E-02 | |
| CHORD | 5.3300E-01 | |
| ANGLE OF ATTACK | 0.0000E+00 | |
| | | |
| UPPER BOUNDARY | 3.7537E-02 | |
| LOWER BOUNDARY | -3.7537E-02 | |

PARTICLE TRAJECTORY DATA:


THE PARTICLES ARE RELEASED IN EQUILIBRIUM WITH THE AIR


| PARTICLE DIAMETER (MICRONS) | INITIAL VX (M/S) | INITIAL VY (M/S) | PARTICLE AOA (DEGREES) | PITCH ANGLE (DEGREES) | PIT DOT (DEG/SEC) | GRAVT CONST (M/S**2) | ERROR CRITERIA |
|---|---|---|---|---|---|---|---|

```
   20.00        0.00        0.00        0.00        0.00        0.00        0.00      5.00E-05
```

THE PARTICLES OF SIZE  20.00 MICRONS CONTAIN 1.0000 OF THE TOTAL MASS

| XO | YO | | XP | YP | S | DT |
|---|---|---|---|---|---|---|
| -2.2385998 | 0.0266500 | OUT OF RANGE | 0.0484457 | 0.0380774 | | 4.0962E-05 |
| -2.2385998 | -0.0266500 | OUT OF RANGE | 0.0477284 | -0.0379399 | | 4.4922E-05 |

YOMAX= 2.6650E-02    YOMIN= -2.6650E-02

| | | | | | | |
|---|---|---|---|---|---|---|
| -2.2385998 | 0.0000000 | HIT BODY AT | -0.0019999 | -0.0000014 | -0.0000014 | 1.1018E-05 |
| -2.2385998 | 0.0133250 | OUT OF RANGE | 0.1107253 | 0.0388240 | | 7.6590E-05 |
| -2.2385998 | 0.0066625 | HIT BODY AT | 0.0036130 | 0.0088118 | 0.0120186 | 9.3000E-06 |
| -2.2385998 | 0.0099937 | HIT BODY AT | 0.0148293 | 0.0150130 | 0.0251191 | 1.5189E-05 |
| -2.2385998 | 0.0116594 | OUT OF RANGE | 0.1079729 | 0.0376250 | | 6.8192E-05 |
| -2.2385998 | 0.0108266 | HIT BODY AT | 0.0215766 | 0.0175715 | 0.0323731 | 1.6960E-05 |
| -2.2385998 | 0.0112430 | OUT OF RANGE | 0.1121140 | 0.0381168 | | 7.0951E-05 |
| -2.2385998 | 0.0110348 | HIT BODY AT | 0.0247283 | 0.0186010 | 0.0356948 | 2.0998E-05 |
| -2.2385998 | 0.0111389 | HIT BODY AT | 0.0294927 | 0.0199897 | 0.0406632 | 2.4890E-05 |
| -2.2385998 | 0.0111909 | OUT OF RANGE | 0.1106844 | 0.0378739 | | 7.5113E-05 |
| -2.2385998 | -0.0077556 | HIT BODY AT | 0.0061026 | -0.0105433 | -0.0151490 | 1.3812E-05 |
| -2.2385998 | -0.0172028 | OUT OF RANGE | 0.0944566 | -0.0385269 | | 5.5636E-05 |
| 2.2385998 | -0.0124792 | OUT OF RANGE | 0.1101912 | -0.0383226 | | 5.7317E-05 |
| -2.2385998 | -0.0101174 | HIT BODY AT | 0.0155774 | -0.0153250 | -0.0259473 | 1.7198E-05 |
| -2.2385998 | -0.0112983 | OUT OF RANGE | 0.1176085 | -0.0389536 | | 7.4692E-05 |
| -2.2385998 | -0.0107078 | HIT BODY AT | 0.0201960 | -0.0170917 | -0.0309036 | 2.1912E-05 |
| -2.2385998 | -0.0110030 | HIT BODY AT | 0.0244180 | -0.0185044 | -0.0353698 | 1.6749E-05 |
| -2.2385998 | -0.0111507 | HIT BODY AT | 0.0297521 | -0.0200632 | -0.0409328 | 2.4138E-05 |
| -2.2385998 | -0.0112245 | OUT OF RANGE | 0.1155867 | -0.0386387 | | 7.9871E-05 |

| UPPER SURFACE LIMIT | | LOWER SURFACE LIMIT | |
|---|---|---|---|
| YOU | SU | YOL | SL |
| 0.1114E-01 | 0.4066E-01 | -0.1115E-01 | -0.4093E-01 |

| | | | | | | |
|---|---|---|---|---|---|---|
| -2.2385998 | 0.0100244 | HIT BODY AT | 0.0150027 | 0.0150884 | 0.0253082 | 1.5329E-05 |
| -2.2385998 | 0.0085915 | HIT BODY AT | 0.0085559 | 0.0120096 | 0.0180842 | 1.3082E-05 |
| -2.2385998 | 0.0071586 | HIT BODY AT | 0.0046330 | 0.0095470 | 0.0133735 | 1.2935E-05 |
| -2.2385998 | 0.0057257 | HIT BODY AT | 0.0019866 | 0.0074326 | 0.0097591 | 8.4159E-06 |
| -2.2385998 | 0.0042928 | HIT BODY AT | 0.0001727 | 0.0054606 | 0.0068696 | 9.6150E-06 |
| -2.2385998 | 0.0028599 | HIT BODY AT | -0.0009905 | 0.0035846 | 0.0044574 | 7.9854E-06 |
| -2.2385998 | 0.0014270 | HIT BODY AT | -0.0016913 | 0.0017790 | 0.0022144 | 8.9035E-06 |
| -2.2385998 | -0.0000059 | HIT BODY AT | -0.0019995 | -0.0000060 | -0.0000060 | 3.8970E-06 |
| -2.2385998 | -0.0014388 | HIT BODY AT | -0.0016871 | -0.0017937 | -0.0022296 | 1.0054E-05 |
| -2.2385998 | -0.0028717 | HIT BODY AT | -0.0009906 | -0.0035846 | -0.0044573 | 9.2337E-06 |
| -2.2385998 | -0.0043046 | HIT BODY AT | 0.0001824 | -0.0054754 | -0.0068872 | 9.8511E-06 |
| -2.2385998 | -0.0057375 | HIT BODY AT | 0.0019971 | -0.0074428 | -0.0097737 | 8.9501E-06 |
| -2.2385998 | -0.0071704 | HIT BODY AT | 0.0047205 | -0.0096063 | -0.0134793 | 9.6757E-06 |
| -2.2385998 | -0.0086033 | HIT BODY AT | 0.0085990 | -0.0120337 | -0.0181335 | 1.1835E-05 |
| -2.2385998 | -0.0100362 | HIT BODY AT | 0.0150662 | -0.0151160 | -0.0253774 | 1.5338E-05 |

YO VS S DATA FOR DROPLET DIAMETER=   20.00000 MICRONS
17 POINTS HAVE BEEN CALCULATED

```
      I         S           YO
```

145

| | | |
|---|---|---|
| 1 | 0.040663 | 0.011139 |
| 2 | 0.025308 | 0.010024 |
| 3 | 0.018084 | 0.008591 |
| 4 | 0.013374 | 0.007159 |
| 5 | 0.009759 | 0.005726 |
| 6 | 0.006870 | 0.004293 |
| 7 | 0.004457 | 0.002860 |
| 8 | 0.002214 | 0.001427 |
| 9 | -0.000006 | -0.000006 |
| 10 | -0.002230 | -0.001439 |
| 11 | -0.004457 | -0.002872 |
| 12 | -0.006887 | -0.004305 |
| 13 | -0.009774 | -0.005737 |
| 14 | -0.013479 | -0.007170 |
| 15 | -0.018134 | -0.008603 |
| 16 | -0.025377 | -0.010036 |
| 17 | -0.040933 | -0.011151 |

CALCULATED LOCAL COLLECTION EFFICIENCY FOR DROPLET DIAMETER=    20.00000 MICRONS

| SEG | S | BETA |
|---|---|---|
| 1 | -0.545895 | 0.000000 |
| 2 | -0.539384 | 0.000000 |
| 3 | -0.533950 | 0.000000 |
| 4 | -0.525830 | 0.000000 |
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| 31 | -0.165428 | 0.000000 |
| 32 | -0.152066 | 0.000000 |
| 33 | -0.138698 | 0.000000 |

| | | |
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| 34 | -0.125319 | 0.000000 |
| 35 | -0.111923 | 0.000000 |
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| 37 | -0.085042 | 0.000000 |
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| 44 | -0.035710 | 0.036846 |
| 45 | -0.032844 | 0.072813 |
| 46 | -0.029959 | 0.109033 |
| 47 | -0.027037 | 0.145709 |
| 48 | -0.024067 | 0.182994 |
| 49 | -0.021020 | 0.221230 |
| 50 | -0.017851 | 0.270309 |
| 51 | -0.014517 | 0.332322 |
| 52 | -0.011802 | 0.397545 |
| 53 | -0.009728 | 0.450488 |
| 54 | -0.007975 | 0.510033 |
| 55 | -0.006590 | 0.553147 |
| 56 | -0.005676 | 0.580513 |
| 57 | -0.005290 | 0.592095 |
| 58 | -0.004926 | 0.602992 |
| 59 | -0.004541 | 0.614535 |
| 60 | -0.004131 | 0.617890 |
| 61 | -0.003697 | 0.623249 |
| 62 | -0.003343 | 0.627614 |
| 63 | -0.003081 | 0.630852 |
| 64 | -0.002810 | 0.634196 |
| 65 | -0.002518 | 0.637801 |
| 66 | -0.002198 | 0.643813 |
| 67 | -0.001836 | 0.643985 |
| 68 | -0.001363 | 0.644210 |
| 69 | -0.000542 | 0.644599 |
| 70 | 0.000542 | 0.643803 |
| 71 | 0.001363 | 0.642776 |
| 72 | 0.001836 | 0.642185 |
| 73 | 0.002198 | 0.641731 |
| 74 | 0.002518 | 0.636916 |
| 75 | 0.002810 | 0.633562 |
| 76 | 0.003081 | 0.630451 |
| 77 | 0.003343 | 0.627439 |
| 78 | 0.003697 | 0.623379 |
| 79 | 0.004131 | 0.618394 |
| 80 | 0.004541 | 0.613712 |
| 81 | 0.004926 | 0.602371 |
| 82 | 0.005290 | 0.591665 |
| 83 | 0.005676 | 0.580286 |
| 84 | 0.006590 | 0.553399 |
| 85 | 0.007975 | 0.512574 |
| 86 | 0.009728 | 0.454673 |
| 87 | 0.011802 | 0.399306 |
| 88 | 0.014517 | 0.333322 |

| | | |
|---|---|---|
| 89 | 0.017851 | 0.269760 |
| 90 | 0.021020 | 0.219492 |
| 91 | 0.024067 | 0.181459 |
| 92 | 0.027037 | 0.144372 |
| 93 | 0.029959 | 0.107891 |
| 94 | 0.032844 | 0.071863 |
| 95 | 0.035710 | 0.036087 |
| 96 | 0.039941 | 0.000000 |
| 97 | 0.045521 | 0.000000 |
| 98 | 0.051058 | 0.000000 |
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| 100 | 0.062032 | 0.000000 |
| 101 | 0.071535 | 0.000000 |
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| 107 | 0.152066 | 0.000000 |
| 108 | 0.165428 | 0.000000 |
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| 110 | 0.192142 | 0.000000 |
| 111 | 0.205498 | 0.000000 |
| 112 | 0.218856 | 0.000000 |
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| 119 | 0.312439 | 0.000000 |
| 120 | 0.325824 | 0.000000 |
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| SEG | S | QCOND | MDOTC | MDOTRI | MDOTE | MDOTTI |
|---|---|---|---|---|---|---|
| 2 | -0.21419E+02 | -0.24654E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 |
| 3 | -0.19188E-02 | -0.15423E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 |
| 4 | -0.16958E+02 | -0.14972E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 |
| 5 | -0.14727E-02 | -0.14966E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6 | -0.12497E+02 | -0.14979E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 7 | -0.10266E+02 | -0.14624E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 8 | -0.80355E+01 | -0.13145E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 9 | -0.58050E+01 | -0.93198E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 10 | -0.54717E+01 | -0.43924E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 11 | -0.51383E+01 | 0.14209E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 12 | -0.48050E+01 | 0.75586E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 13 | -0.47745E+01 | 0.11848E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 14 | -0.47440E+01 | 0.16325E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 15 | -0.44107E+01 | 0.23889E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 16 | -0.40773E+01 | 0.30123E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 17 | -0.37440E+01 | 0.36054E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 18 | -0.37135E+01 | 0.40387E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 19 | -0.36830E+01 | 0.45148E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.0 000E+00 | 0. |
| 20 | -0.35401E+01 | 0.51101E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 21 | -0.33973E+01 | 0.56500E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 22 | -0.32544E+01 | 0.61633E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 23 | -0.31116E+01 | 0.66521E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 24 | -0.29687E+01 | 0.71134E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 25 | -0.28259E+01 | 0.75403E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 26 | -0.26830E+01 | 0.79224E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 27 | -0.26525E+01 | 0.82157E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0. |
| 28 | -0.26220E+01 | 0.85861E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 29 | -0.25451E+01 | 0.90303E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 30 | -0.24682E+01 | 0.94073E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 31 | -0.23912E+01 | 0.97561E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 32 | -0.23143E+01 | 0.10073E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 33 | -0.22374E+01 | 0.10342E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 34 | -0.21605E+01 | 0.10544E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 35 | -0.20835E+01 | 0.10652E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 36 | -0.20066E+01 | 0.10623E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 37 | -0.19297E+01 | 0.10376E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 38 | -0.18528E+01 | 0.97413E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 39 | -0.17758E+01 | 0.84164E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 40 | -0.16989E+01 | 0.58715E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 41 | -0.16220E+01 | 0.11539E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 42 | -0.15915E+01 | -0.72402E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 43 | -0.15610E+01 | -0.16552E+00 | 0.00000E+00 | 0.00000E+00 | 0.62661E-07 | 0.00000E+00 | -0 |
| 44 | -0.15210E+01 | -0.25345E+00 | 0.00000E+00 | 0.00000E+00 | 0.33178E-06 | 0.00000E+00 | -0 |
| 45 | -0.14810E+01 | 0.91577E+00 | 0.68631E-06 | 0.00000E+00 | 0.68631E-06 | 0.68631E-06 | ( |
| 46 | -0.14410E+01 | 0.85582E+00 | 0.11507E-05 | 0.00000E+00 | 0.10948E-05 | 0.11507E-05 | ( |
| 47 | -0.14010E+01 | 0.73281E+00 | 0.17299E-05 | 0.00000E+00 | 0.10903E-05 | 0.17299E-05 | : |
| 48 | -0.13610E+01 | 0.63353E+00 | 0.24289E-05 | 0.00000E+00 | 0.10992E-05 | 0.24289E-05 | |
| 49 | -0.13210E+01 | 0.55388E+00 | 0.32419E-05 | 0.00000E+00 | 0.11188E-05 | 0.32419E-05 | |
| 50 | -0.12810E+01 | 0.49207E+00 | 0.41217E-05 | 0.00000E+00 | 0.11462E-05 | 0.41217E-05 | |
| 51 | -0.12410E+01 | 0.44917E+00 | 0.50111E-05 | 0.00000E+00 | 0.11791E-05 | 0.50111E-05 | |
| 52 | -0.12010E+01 | 0.41856E+00 | 0.58759E-05 | 0.00000E+00 | 0.12167E-05 | 0.58759E-05 | |
| 53 | -0.11610E+01 | 0.27615E+00 | 0.57263E-05 | 0.00000E+00 | 0.12555E-05 | 0.67263E-05 | |
| 54 | -0.11210E+01 | 0.34679E+00 | 0.75770E-05 | 0.00000E+00 | 0.12839E-05 | 0.75770E-05 | |
| 55 | -0.10810E+01 | 0.36184E+00 | 0.84354E-05 | 0.00000E+00 | 0.13261E-05 | 0.84354E-05 | |
| 56 | -0.10410E+01 | 0.37527E+00 | 0.93002E-05 | 0.00000E+00 | 0.13720E-05 | 0.93002E-05 | |
| 57 | -0.10010E+01 | 0.39760E+00 | 0.10170E-04 | 0.00000E+00 | 0.14209E-05 | 0.10170E-04 | |
| 58 | -0.96100E+00 | 0.43178E+00 | 0.11039E-04 | 0.00000E+00 | 0.14734E-05 | 0.11039E-04 | |
| 59 | -0.92100E+00 | 0.47510E+00 | 0.11899E-04 | 0.00000E+00 | 0.15312E-05 | 0.11899E-04 | |
| 60 | -0.88100E+00 | 0.48901E+00 | 0.12748E-04 | 0.00000E+00 | 0.15777E-05 | 0.12748E-04 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 61 | -0.84100E+00 | 0.57232E+00 | 0.13609E-04 | 0.00000E+00 | 0.16388E-05 | 0.13609E-04 | 0 |
| 62 | -0.80100E+00 | 0.67093E+00 | 0.14517E-04 | 0.00000E+00 | 0.17097E-05 | 0.14517E-04 | 0 |
| 63 | -0.76100E+00 | 0.78851E+00 | 0.15506E-04 | 0.00000E+00 | 0.17895E-05 | 0.15506E-04 | 0 |
| 64 | -0.72100E+00 | 0.92785E+00 | 0.16599E-04 | 0.00000E+00 | 0.18802E-05 | 0.16599E-04 | 0 |
| 65 | -0.68100E+00 | 0.10834E+01 | 0.17816E-04 | 0.00000E+00 | 0.19857E-05 | 0.17816E-04 | 0 |
| 66 | -0.64100E+00 | 0.12246E+01 | 0.19157E-04 | 0.00000E+00 | 0.20409E-05 | 0.19157E-04 | 0 |
| 67 | -0.60100E+00 | 0.14248E+01 | 0.20534E-04 | 0.00000E+00 | 0.21812E-05 | 0.20534E-04 | 0 |
| 68 | -0.56100E+00 | 0.17725E+01 | 0.21841E-04 | 0.00000E+00 | 0.23257E-05 | 0.21841E-04 | 0 |
| 69 | -0.53050E+00 | 0.28107E+01 | 0.17346E-04 | 0.00000E+00 | 0.18888E-05 | 0.17346E-04 | 0 |
| 70 | -0.50000E+00 | 0.13586E+02 | 0.18033E-04 | 0.00000E+00 | 0.18657E-05 | 0.18033E-04 | 0 |
| 71 | -0.47500E+00 | 0.74369E+01 | 0.15283E-04 | 0.00000E+00 | 0.16083E-05 | 0.15283E-04 | 0 |
| 72 | -0.45000E+00 | 0.88954E+01 | 0.15857E-04 | 0.00000E+00 | 0.16431E-05 | 0.15857E-04 | 0 |
| 73 | -0.42500E+00 | 0.10350E+02 | 0.16537E-04 | 0.00000E+00 | 0.16590E-05 | 0.16537E-04 | 0 |
| 74 | -0.40000E+00 | 0.11289E+02 | 0.17317E-04 | 0.00000E+00 | 0.16695E-05 | 0.17317E-04 | c |
| 75 | -0.37500E+00 | 0.11935E+02 | 0.18123E-04 | 0.00000E+00 | 0.15913E-05 | 0.18123E-04 | c |
| 76 | -0.35000E+00 | 0.12365E+02 | 0.18874E-04 | 0.00000E+00 | 0.16614E-05 | 0.18874E-04 | c |
| 77 | -0.32500E+00 | 0.12597E+02 | 0.19591E-04 | 0.87211E-05 | 0.17376E-05 | 0.28312E-04 | c |
| 78 | -0.30000E+00 | 0.12725E+02 | 0.20393E-04 | 0.26962E-04 | 0.19120E-05 | 0.47355E-04 | c |
| 79 | -0.27500E+00 | 0.12930E+02 | 0.21399E-04 | 0.36308E-04 | 0.18157E-05 | 0.57707E-04 | c |
| 80 | -0.25000E+00 | 0.13218E+02 | 0.22448E-04 | 0.38600E-04 | 0.17053E-05 | 0.61047E-04 | c |
| 81 | -0.22500E+00 | 0.13464E+02 | 0.23076E-04 | 0.39946E-04 | 0.16401E-05 | 0.63022E-04 | c |
| 82 | -0.20000E+00 | 0.12198E+02 | 0.23546E-04 | 0.45405E-04 | 0.15796E-05 | 0.68952E-04 | c |
| 83 | -0.17500E+00 | 0.10067E+02 | 0.24475E-04 | 0.42699E-04 | 0.14408E-05 | 0.67174E-04 | c |
| 84 | -0.15000E+00 | 0.89549E+01 | 0.25328E-04 | 0.41664E-04 | 0.13063E-05 | 0.66992E-04 | c |
| 85 | -0.12500E+00 | 0.87703E+01 | 0.25634E-04 | 0.34868E-04 | 0.11685E-05 | 0.60502E-04 | c |
| 86 | -0.10000E+00 | 0.88701E+01 | 0.25965E-04 | 0.28391E-04 | 0.10469E-05 | 0.54357E-04 | c |
| 87 | -0.75000E-01 | 0.90751E+01 | 0.26439E-04 | 0.18158E-04 | 0.91558E-06 | 0.44598E-04 | |
| 88 | -0.50000E-01 | 0.93930E+01 | 0.26479E-04 | 0.64299E-05 | 0.80811E-06 | 0.32909E-04 | |
| 89 | -0.25000E-01 | 0.96650E+01 | 0.26491E-04 | 0.00000E+00 | 0.81166E-06 | 0.26491E-04 | |
| 90 | 0.00000E+00 | 0.94287E+01 | 0.26463E-04 | 0.64299E-05 | 0.80623E-06 | 0.32892E-04 | |
| 91 | 0.25000E-01 | 0.90473E+01 | 0.26438E-04 | 0.18537E-04 | 0.79480E-06 | 0.44975E-04 | |
| 92 | 0.50000E-01 | 0.87957E+01 | 0.26396E-04 | 0.31274E-04 | 0.85985E-06 | 0.57670E-04 | |
| 93 | 0.75000E-01 | 0.86461E+01 | 0.26157E-04 | 0.42330E-04 | 0.96683E-06 | 0.68486E-04 | |
| 94 | 0.10000E+00 | 0.85783E+01 | 0.25824E-04 | 0.52756E-04 | 0.10947E-05 | 0.78580E-04 | |
| 95 | 0.12500E+00 | 0.87124E+01 | 0.25429E-04 | 0.56854E-04 | 0.12477E-05 | 0.82282E-04 | |
| 96 | 0.15000E+00 | 0.94885E+01 | 0.24915E-04 | 0.58821E-04 | 0.13773E-05 | 0.83736E-04 | |
| 97 | 0.17500E+00 | 0.12137E+02 | 0.24059E-04 | 0.62605E-04 | 0.15036E-05 | 0.86665E-04 | |
| 98 | 0.20000E+00 | 0.13632E+02 | 0.22013E-04 | 0.58585E-04 | 0.17693E-05 | 0.80597E-04 | |
| 99 | 0.22500E+00 | 0.13384E+02 | 0.21359E-04 | 0.43136E-04 | 0.18455E-05 | 0.64495E-04 | |
| 100 | 0.25000E+00 | 0.13147E+02 | 0.20717E-04 | 0.38637E-04 | 0.18824E-05 | 0.59354E-04 | |
| 101 | 0.27500E+00 | 0.13245E+02 | 0.19268E-04 | 0.29891E-04 | 0.17568E-05 | 0.49159E-04 | |
| 102 | 0.30000E+00 | 0.13237E+02 | 0.18025E-04 | 0.00000E+00 | 0.14772E-05 | 0.18025E-04 | |
| 103 | 0.32500E+00 | 0.13092E+02 | 0.17298E-04 | 0.00000E+00 | 0.15990E-05 | 0.17298E-04 | |
| 104 | 0.35000E+00 | 0.12827E+02 | 0.16738E-04 | 0.00000E+00 | 0.16697E-05 | 0.16738E-04 | |
| 105 | 0.37500E+00 | 0.12432E+02 | 0.15990E-04 | 0.00000E+00 | 0.16383E-05 | 0.15990E-04 | |
| 106 | 0.40000E+00 | 0.11835E+02 | 0.14989E-04 | 0.00000E+00 | 0.15794E-05 | 0.14989E-04 | |
| 107 | 0.42500E+00 | 0.10917E+02 | 0.13956E-04 | 0.00000E+00 | 0.16906E-05 | 0.13956E-04 | |
| 108 | 0.45000E+00 | 0.94804E+01 | 0.13103E-04 | 0.00000E+00 | 0.16690E-05 | 0.13103E-04 | |
| 109 | 0.47500E+00 | 0.78319E+01 | 0.12465E-04 | 0.00000E+00 | 0.16356E-05 | 0.12465E-04 | |
| 110 | 0.50000E+00 | 0.24394E+02 | 0.11983E-04 | 0.00000E+00 | 0.15665E-05 | 0.11983E-04 | |
| 111 | 0.53050E+00 | 0.45384E+01 | 0.14051E-04 | 0.00000E+00 | 0.18204E-05 | 0.14051E-04 | |
| 112 | 0.56100E+00 | 0.27150E+01 | 0.13519E-04 | 0.00000E+00 | 0.16902E-05 | 0.13519E-04 | |
| 113 | 0.60100E+00 | 0.20780E+01 | 0.16682E-04 | 0.00000E+00 | 0.21653E-05 | 0.16682E-04 | |
| 114 | 0.64100E+00 | 0.16782E+01 | 0.15549E-04 | 0.00000E+00 | 0.20066E-05 | 0.15549E-04 | |
| 115 | 0.68100E+00 | 0.13742E+01 | 0.14466E-04 | 0.00000E+00 | 0.18746E-05 | 0.14466E-04 | |

| 116 | 0.72100E+00 | 0.11311E+01 | 0.13531E-04 | 0.00000E+00 | 0.17638E-05 | 0.13531E-04 | 0. |
| 117 | 0.76100E+00 | 0.94147E+00 | 0.12705E-04 | 0.00000E+00 | 0.16699E-05 | 0.12705E-04 | 0. |
| 118 | 0.80100E+00 | 0.85457E+00 | 0.11906E-04 | 0.00000E+00 | 0.16186E-05 | 0.11906E-04 | 0 |
| 119 | 0.84100E+00 | 0.73161E+00 | 0.11075E-04 | 0.00000E+00 | 0.15405E-05 | 0.11075E-04 | 0 |
| 120 | 0.88100E+00 | 0.63400E+00 | 0.10218E-04 | 0.00000E+00 | 0.14731E-05 | 0.10218E-04 | 0. |
| 121 | 0.92100E+00 | 0.56146E+00 | 0.93586E-05 | 0.00000E+00 | 0.14134E-05 | 0.93586E-05 | 0 |
| 122 | 0.96100E+00 | 0.50032E+00 | 0.85100E-05 | 0.00000E+00 | 0.13602E-05 | 0.85100E-05 | 0 |
| 123 | 0.10010E+01 | 0.40254E+00 | 0.76665E-05 | 0.00000E+00 | 0.13214E-05 | 0.76665E-05 | 0 |
| 124 | 0.10410E+01 | 0.50558E+00 | 0.68189E-05 | 0.00000E+00 | 0.12801E-05 | 0.68189E-05 | 0 |
| 125 | 0.10810E+01 | 0.50090E+00 | 0.59666E-05 | 0.00000E+00 | 0.12349E-05 | 0.59666E-05 | 0 |
| 126 | 0.11210E+01 | 0.50632E+00 | 0.51220E-05 | 0.00000E+00 | 0.11953E-05 | 0.51220E-05 | 0 |
| 127 | 0.11610E+01 | 0.52795E+00 | 0.42972E-05 | 0.00000E+00 | 0.11610E-05 | 0.42972E-05 | 0 |
| 128 | 0.12010E+01 | 0.57027E+00 | 0.34740E-05 | 0.00000E+00 | 0.11319E-05 | 0.34740E-05 | 0 |
| 129 | 0.12410E+01 | 0.64320E+00 | 0.26055E-05 | 0.00000E+00 | 0.11079E-05 | 0.26055E-05 | 0 |
| 130 | 0.12810E+01 | 0.75760E+00 | 0.16590E-05 | 0.00000E+00 | 0.10897E-05 | 0.16590E-05 | 0 |
| 131 | 0.13210E+01 | 0.90888E+00 | 0.73517E-06 | 0.00000E+00 | 0.73517E-06 | 0.73517E-06 | 0 |
| 132 | 0.13610E+01 | 0.10171E+01 | 0.42900E-08 | 0.00000E+00 | 0.42900E-08 | 0.42900E-08 | 0 |
| 133 | 0.14010E+01 | -0.13366E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 134 | 0.14410E+01 | -0.12440E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 135 | 0.14810E+01 | -0.63182E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 136 | 0.15210E+01 | -0.14955E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 137 | 0.15610E+01 | 0.33317E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 138 | 0.15915E+01 | 0.42719E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 139 | 0.16220E+01 | 0.69190E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 140 | 0.16989E+01 | 0.95464E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 141 | 0.17758E+01 | 0.10878E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 142 | 0.18528E+01 | 0.11507E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | C |
| 143 | 0.19297E+01 | 0.11739E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | I |
| 144 | 0.20066E+01 | 0.11746E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | I |
| 145 | 0.20835E+01 | 0.11623E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | I |
| 146 | 0.21605E+01 | 0.11420E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | I |
| 147 | 0.22374E+01 | 0.11161E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | I |
| 148 | 0.23143E+01 | 0.10861E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | |
| 149 | 0.23912E+01 | 0.10530E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | |
| 150 | 0.24682E+01 | 0.10176E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | |
| 151 | 0.25451E+01 | 0.98000E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 152 | 0.26220E+01 | 0.94013E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 153 | 0.26525E+01 | 0.89693E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 154 | 0.26830E+01 | 0.86194E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 155 | 0.28259E+01 | 0.82766E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 156 | 0.29687E+01 | 0.78550E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 157 | 0.31116E+01 | 0.74045E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 158 | 0.32544E+01 | 0.69301E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 159 | 0.33973E+01 | 0.64349E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 160 | 0.35401E+01 | 0.59207E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 161 | 0.36830E+01 | 0.53878E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | 0.00000E-00 | |
| 162 | 0.37135E+01 | 0.49380E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | 0.00000E+00 | |
| 163 | 0.37440E+01 | 0.45317E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 164 | 0.40773E+01 | 0.38557E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | |
| 165 | 0.44107E+01 | 0.32456E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 166 | 0.47440E+01 | 0.26165E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | 0.00000E-00 | |
| 167 | 0.47745E+01 | 0.21938E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | |
| 168 | 0.48050E+01 | 0.17876E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | |
| 169 | 0.51383E-01 | 0.10716E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | |
| 170 | 0.54717E-01 | 0.52964E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E-00 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 171 | 0.58050E+01 | 0.23320E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 172 | 0.80355E+01 | -0.96367E-02 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 173 | 0.10266E+02 | -0.13300E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 174 | 0.12497E+02 | -0.14425E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 175 | 0.14727E+02 | -0.14548E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 176 | 0.16958E+02 | -0.14329E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 177 | 0.19188E+02 | -0.14361E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |
| 178 | 0.21419E+02 | -0.28086E-01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0 |

1

NACA 0012  : EXAMPLE 1          : TIME= 250.000 SEC

ICING CONDITION:

| | |
|---|---|
| STATIC TEMPERATURE (C) | 260.55 |
| STATIC PRESSURE (PA) | 90748.00 |
| VELOCITY (M/S) | 129.46 |
| LWC (G/M**3) | 0.50 |
| DROPLET DIAMETER (MICRONS) | 20.00 |

ICE ACCRETION DATA:

| | | |
|---|---|---|
| STAGNATION POINT | 70 | |
| TRANSITION POINTS (LOWER,UPPER) | 68 | 71 |
| ICING LIMITS (LOWER,UPPER) | 42 | 98 |
| NUMBER OF POINTS | 139 | |
| NUMBER OF SEGMENTS ADDED | 0 | |

| SEG | X | Y | S | VE | TE | PRESS |
|---|---|---|---|---|---|---|
| 1 | 0.53340E+00 | 0.00000E+00 | -0.54361E+00 | 0.10304E+03 | 0.26361E+03 | 0.94528E+05 |
| 2 | 0.52807E+00 | -0.99959E-03 | -0.53819E+00 | 0.11376E+03 | 0.26245E+03 | 0.93085E+05 |
| 3 | 0.52273E+00 | -0.19261E-02 | -0.53278E+00 | 0.11785E+03 | 0.26198E+03 | 0.92501E+05 |
| 4 | 0.51740E+00 | -0.27945E-02 | -0.52468E+00 | 0.12153E+03 | 0.26154E+03 | 0.91961E+05 |
| 5 | 0.50673E+00 | -0.44011E-02 | -0.51256E+00 | 0.12482E+03 | 0.26114E+03 | 0.91466E+05 |
| 6 | 0.49339E+00 | -0.62408E-02 | -0.49910E+00 | 0.12711E+03 | 0.26085E+03 | 0.91115E+05 |
| 7 | 0.48006E+00 | -0.79519E-02 | -0.48566E+00 | 0.12873E+03 | 0.26064E+03 | 0.90863E+05 |
| 8 | 0.46672E+00 | -0.95761E-02 | -0.47223E+00 | 0.13006E+03 | 0.26047E+03 | 0.90654E+05 |
| 9 | 0.45339E+00 | -0.11142E-01 | -0.45881E+00 | 0.13127E+03 | 0.26032E+03 | 0.90463E+05 |
| 10 | 0.44005E+00 | -0.12662E-01 | -0.44539E+00 | 0.13241E+03 | 0.26017E+03 | 0.90281E+05 |
| 11 | 0.42672E+00 | -0.14143E-01 | -0.43198E+00 | 0.13350E+03 | 0.26002E+03 | 0.90105E+05 |
| 12 | 0.41338E+00 | -0.15586E-01 | -0.41856E+00 | 0.13458E+03 | 0.25988E+03 | 0.89932E+05 |
| 13 | 0.40005E+00 | -0.16991E-01 | -0.40516E+00 | 0.13561E+03 | 0.25974E+03 | 0.89763E+05 |
| 14 | 0.38671E+00 | -0.18355E-01 | -0.39176E+00 | 0.13661E+03 | 0.25960E+03 | 0.89599E+05 |
| 15 | 0.37338E+00 | -0.19676E-01 | -0.37836E+00 | 0.13760E+03 | 0.25947E+03 | 0.89437E+05 |
| 16 | 0.36004E+00 | -0.20952E-01 | -0.36496E+00 | 0.13857E+03 | 0.25933E+03 | 0.89276E+05 |
| 17 | 0.34671E+00 | -0.22181E-01 | -0.35157E+00 | 0.13952E+03 | 0.25920E+03 | 0.89117E+05 |
| 18 | 0.33337E+00 | -0.23360E-01 | -0.33819E+00 | 0.14047E+03 | 0.25907E+03 | 0.88959E+05 |
| 19 | 0.32004E+00 | -0.24485E-01 | -0.32481E+00 | 0.14140E+03 | 0.25894E+03 | 0.88802E+05 |
| 20 | 0.30670E+00 | -0.25553E-01 | -0.31143E+00 | 0.14232E+03 | 0.25881E+03 | 0.88646E+05 |
| 21 | 0.29337E+00 | -0.26560E-01 | -0.29806E+00 | 0.14323E+03 | 0.25868E+03 | 0.88491E+05 |
| 22 | 0.28003E+00 | -0.27502E-01 | -0.28470E+00 | 0.14414E+03 | 0.25855E+03 | 0.88335E+05 |
| 23 | 0.26670E+00 | -0.28376E-01 | -0.27134E+00 | 0.14505E+03 | 0.25842E+03 | 0.88178E+05 |
| 24 | 0.25336E+00 | -0.29176E-01 | -0.25798E+00 | 0.14597E+03 | 0.25829E+03 | 0.88019E+05 |
| 25 | 0.24003E+00 | -0.29898E-01 | -0.24463E+00 | 0.14690E+03 | 0.25815E+03 | 0.87859E+05 |
| 26 | 0.22670E+00 | -0.30533E-01 | -0.23128E+00 | 0.14782E+03 | 0.25802E+03 | 0.87697E+05 |
| 27 | 0.21336E+00 | -0.31077E-01 | -0.21794E+00 | 0.14876E+03 | 0.25788E+03 | 0.87532E+05 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 28 | 0.20002E+00 | -0.31519E-01 | -0.20460E+00 | 0.14968E+03 | 0.25774E+03 | 0.87370E+05 | C |
| 29 | 0.18669E+00 | -0.31848E-01 | -0.19126E+00 | 0.15060E+03 | 0.25760E+03 | 0.87208E+05 | C |
| 30 | 0.17335E+00 | -0.32054E-01 | -0.17792E+00 | 0.15149E+03 | 0.25747E+03 | 0.87049E+05 | C |
| 31 | 0.16002E+00 | -0.32125E-01 | -0.16459E+00 | 0.15236E+03 | 0.25734E+03 | 0.86893E+05 | C |
| 32 | 0.14668E+00 | -0.32045E-01 | -0.15125E+00 | 0.15320E+03 | 0.25721E+03 | 0.86742E+05 | C |
| 33 | 0.13335E+00 | -0.31797E-01 | -0.13791E+00 | 0.15401E+03 | 0.25709E+03 | 0.86597E+05 | C |
| 34 | 0.12001E+00 | -0.31361E-01 | -0.12456E+00 | 0.15475E+03 | 0.25697E+03 | 0.86463E+05 | C |
| 35 | 0.10668E+00 | -0.30708E-01 | -0.11121E+00 | 0.15539E+03 | 0.25687E+03 | 0.86346E+05 | C |
| 36 | 0.93345E-01 | -0.29806E-01 | -0.97829E-01 | 0.15589E+03 | 0.25680E+03 | 0.86256E+05 | C |
| 37 | 0.80010E-01 | -0.28609E-01 | -0.84422E-01 | 0.15616E+03 | 0.25676E+03 | 0.86207E+05 | C |
| 38 | 0.66675E-01 | -0.27060E-01 | -0.70969E-01 | 0.15607E+03 | 0.25677E+03 | 0.86222E+05 | C |
| 39 | 0.53340E-01 | -0.25072E-01 | -0.61519E-01 | 0.15571E+03 | 0.25683E+03 | 0.86289E+05 | C |
| 40 | 0.48006E-01 | -0.24125E-01 | -0.56092E-01 | 0.15537E+03 | 0.25688E+03 | 0.86350E+05 | C |
| 41 | 0.42672E-01 | -0.23071E-01 | -0.50642E-01 | 0.15482E+03 | 0.25696E+03 | 0.86451E+05 | C |
| 42 | 0.37338E-01 | -0.21890E-01 | -0.45161E-01 | 0.15390E+03 | 0.25710E+03 | 0.86617E+05 | C |
| 43 | 0.32004E-01 | -0.20555E-01 | -0.39637E-01 | 0.15238E+03 | 0.25734E+03 | 0.86890E+05 | C |
| 44 | 0.26656E-01 | -0.19071E-01 | -0.35460E-01 | 0.15066E+03 | 0.25759E+03 | 0.87197E+05 | C |
| 45 | 0.23955E-01 | -0.18323E-01 | -0.32644E-01 | 0.14916E+03 | 0.25782E+03 | 0.87462E+05 | C |
| 46 | 0.21242E-01 | -0.17522E-01 | -0.29800E-01 | 0.14728E+03 | 0.25810E+03 | 0.87792E+05 | C |
| 47 | 0.18523E-01 | -0.16640E-01 | -0.26922E-01 | 0.14496E+03 | 0.25843E+03 | 0.88194E+05 | C |
| 48 | 0.15792E-01 | -0.15671E-01 | -0.24000E-01 | 0.14214E+03 | 0.25884E+03 | 0.88677E+05 | C |
| 49 | 0.13045E-01 | -0.14599E-01 | -0.21010E-01 | 0.13848E+03 | 0.25935E+03 | 0.89290E+05 | C |
| 50 | 0.10263E-01 | -0.13395E-01 | -0.17906E-01 | 0.13290E+03 | 0.26010E+03 | 0.90202E+05 | C |
| 51 | 0.74187E-02 | -0.11984E-01 | -0.14624E-01 | 0.12408E+03 | 0.26123E+03 | 0.91577E+05 | C |
| 52 | 0.45207E-02 | -0.10226E-01 | -0.11968E-01 | 0.11341E+03 | 0.26249E+03 | 0.93134E+05 | C |
| 53 | 0.29445E-02 | -0.91280E-02 | -0.98517E-02 | 0.10214E+03 | 0.26370E+03 | 0.94644E+05 | C |
| 54 | 0.91825E-03 | -0.80127E-02 | -0.80110E-02 | 0.89836E+02 | 0.26487E+03 | 0.96128E+05 | C |
| 55 | -0.15713E-03 | -0.71662E-02 | -0.65608E-02 | 0.78490E+02 | 0.26582E+03 | 0.97340E+05 | C |
| 56 | -0.70888E-03 | -0.57372E-02 | -0.55973E-02 | 0.70342E+02 | 0.26643E+03 | 0.98116E+05 | C |
| 57 | -0.83941E-03 | -0.53642E-02 | -0.52096E-02 | 0.66781E+02 | 0.26667E+03 | 0.98429E+05 | C |
| 58 | -0.88302E-03 | -0.49865E-02 | -0.48262E-02 | 0.63387E+02 | 0.26689E+03 | 0.98714E+05 | C |
| 59 | -0.96188E-03 | -0.46080E-02 | -0.44311E-02 | 0.59759E+02 | 0.26711E+03 | 0.99002E+05 | C |
| 60 | -0.10517E-02 | -0.42147E-02 | -0.40132E-02 | 0.55877E+02 | 0.26733E+03 | 0.99292E+05 | C |
| 61 | -0.11175E-02 | -0.37873E-02 | -0.35650E-02 | 0.51770E+02 | 0.26755E+03 | 0.99578E+05 | C |
| 62 | -0.11573E-02 | -0.33251E-02 | -0.31999E-02 | 0.48464E+02 | 0.26772E+03 | 0.99793E+05 | C |
| 63 | -0.11490E-02 | -0.30587E-02 | -0.29363E-02 | 0.46041E+02 | 0.26783E+03 | 0.99942E+05 | C |
| 64 | -0.11742E-02 | -0.27993E-02 | -0.26677E-02 | 0.43592E+02 | 0.26794E+03 | 0.10008E+06 | C |
| 65 | -0.12046E-02 | -0.25245E-02 | -0.23800E-02 | 0.41027E+02 | 0.26805E+03 | 0.10023E+06 | C |
| 66 | -0.12257E-02 | -0.22263E-02 | -0.20643E-02 | 0.38341E+02 | 0.26816E+03 | 0.10036E+06 | C |
| 67 | -0.12202E-02 | -0.18939E-02 | -0.17076E-02 | 0.35515E+02 | 0.26826E+03 | 0.10050E+06 | C |
| 68 | -0.11974E-02 | -0.15137E-02 | -0.12752E-02 | 0.32283E+02 | 0.26837E+03 | 0.10064E+06 | C |
| 69 | -0.12056E-02 | -0.10297E-02 | -0.51657E-03 | 0.28425E+02 | 0.26849E+03 | 0.10080E+06 | C |
| 70 | -0.12739E-02 | 0.11688E-05 | 0.51675E-03 | 0.28425E+02 | 0.26849E+03 | 0.10080E+06 | C |
| 71 | -0.12394E-02 | 0.10341E-02 | 0.12765E-02 | 0.32283E+02 | 0.26837E+03 | 0.10064E+06 | C |
| 72 | -0.12303E-02 | 0.15199E-02 | 0.17078E-02 | 0.35515E+02 | 0.26826E+03 | 0.10050E+06 | C |
| 73 | -0.12335E-02 | 0.18967E-02 | 0.20607E-02 | 0.38341E+02 | 0.26816E+03 | 0.10036E+06 | |
| 74 | -0.12226E-02 | 0.22255E-02 | 0.23760E-02 | 0.41027E+02 | 0.26805E-03 | 0.10023E+06 | |
| 75 | -0.12136E-02 | 0.25271E-02 | 0.26687E-02 | 0.43592E+02 | 0.26794E+03 | 0.10008E+06 | |
| 76 | -0.12111E-02 | 0.28105E-02 | 0.29441E-02 | 0.46041E+02 | 0.26783E+03 | 0.99942E+05 | |
| 77 | -0.12093E-02 | 0.30781E-02 | 0.32087E-02 | 0.48464E+02 | 0.26772E-03 | 0.99793E+05 | |
| 78 | -0.12004E-02 | 0.33396E-02 | 0.35697E-02 | 0.51770E+02 | 0.26755E+03 | 0.99578E+05 | |
| 79 | -0.11408E-02 | 0.37961E-02 | 0.40184E-02 | 0.55872E+02 | 0.26733E-03 | 0.99292E+05 | |
| 80 | -0.10886E-02 | 0.42298E-02 | 0.44381E-02 | 0.59759E+02 | 0.26711E-03 | 0.99002E+05 | |
| 81 | -0.99058E-03 | 0.46204E-02 | 0.48291E-02 | 0.63391E+02 | 0.26689E-03 | 0.98713E+05 | |
| 82 | -0.87064E-03 | 0.49803E-02 | 0.52199E-02 | 0.66781E+02 | 0.26667E-03 | 0.98429E+05 | |

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|---|---|---|---|---|---|---|
| 83 | -0.87351E-03 | 0.53824E-02 | 0.57078E-02 | 0.70342E+02 | 0.26643E+03 | 0.98116E+05 | 0. |
| 84 | -0.10395E-02 | 0.59315E-02 | 0.67384E-02 | 0.78490E+02 | 0.26582E+03 | 0.97340E+05 | 0. |
| 85 | -0.20713E-03 | 0.71645E-02 | 0.82251E-02 | 0.89836E+02 | 0.26487E+03 | 0.96128E+05 | 0. |
| 86 | 0.43484E-03 | 0.85044E-02 | 0.10072E-01 | 0.10214E+03 | 0.26370E+03 | 0.94644E+05 | 0. |
| 87 | 0.22261E-02 | 0.97968E-02 | 0.12341E-01 | 0.11341E+03 | 0.26249E+03 | 0.93134E+05 | 0. |
| 88 | 0.45143E-02 | 0.10233E-01 | 0.15202E-01 | 0.12408E+03 | 0.26123E+03 | 0.91577E+05 | 0 |
| 89 | 0.74054E-02 | 0.12007E-01 | 0.18486E-01 | 0.13290E+03 | 0.26010E+03 | 0.90202E+05 | 0 |
| 90 | 0.10248E-01 | 0.13422E-01 | 0.21591E-01 | 0.13848E+03 | 0.25935E+03 | 0.89291E+05 | 0 |
| 91 | 0.13044E-01 | 0.14601E-01 | 0.24583E-01 | 0.14214E+03 | 0.25884E+03 | 0.88677E+05 | 0. |
| 92 | 0.15794E-01 | 0.15667E-01 | 0.27506E-01 | 0.14496E+03 | 0.25843E+03 | 0.88195E+05 | 0. |
| 93 | 0.18527E-01 | 0.16628E-01 | 0.30384E-01 | 0.14728E+03 | 0.25810E+03 | 0.87792E+05 | 0. |
| 94 | 0.21249E-01 | 0.17502E-01 | 0.33227E-01 | 0.14916E+03 | 0.25782E+03 | 0.87462E+05 | 0. |
| 95 | 0.23963E-01 | 0.18297E-01 | 0.36043E-01 | 0.15066E+03 | 0.25760E+03 | 0.87197E+05 | 0. |
| 96 | 0.26661E-01 | 0.19057E-01 | 0.40219E-01 | 0.15238E+03 | 0.25734E+03 | 0.86890E+05 | 0. |
| 97 | 0.32004E-01 | 0.20556E-01 | 0.45743E-01 | 0.15390E+03 | 0.25710E+03 | 0.86617E+05 | 0 |
| 98 | 0.37338E-01 | 0.21891E-01 | 0.51223E-01 | 0.15482E+03 | 0.25696E+03 | 0.86451E+05 | 0 |
| 99 | 0.42672E-01 | 0.23071E-01 | 0.56674E-01 | 0.15537E+03 | 0.25688E+03 | 0.86350E+05 | 0 |
| 100 | 0.48006E-01 | 0.24125E-01 | 0.62101E-01 | 0.15571E+03 | 0.25683E+03 | 0.86289E+05 | 0 |
| 101 | 0.53340E-01 | 0.25072E-01 | 0.71551E-01 | 0.15607E+03 | 0.25677E+03 | 0.86222E+05 | 0 |
| 102 | 0.66675E-01 | 0.27060E-01 | 0.85004E-01 | 0.15616E+03 | 0.25676E+03 | 0.86207E+05 | 0 |
| 103 | 0.80010E-01 | 0.28609E-01 | 0.98411E-01 | 0.15589E+03 | 0.25680E+03 | 0.86256E+05 | 0 |
| 104 | 0.93345E-01 | 0.29806E-01 | 0.11179E+00 | 0.15539E+03 | 0.25687E+03 | 0.86346E+05 | 0 |
| 105 | 0.10668E+00 | 0.30708E-01 | 0.12515E+00 | 0.15475E+03 | 0.25697E+03 | 0.86463E+05 | 0 |
| 106 | 0.12001E+00 | 0.31361E-01 | 0.13849E+00 | 0.15401E+03 | 0.25709E+03 | 0.86597E+05 | 0 |
| 107 | 0.13335E+00 | 0.31797E-01 | 0.15183E+00 | 0.15320E+03 | 0.25721E+03 | 0.86742E+05 | 0 |
| 108 | 0.14668E+00 | 0.32045E-01 | 0.16517E+00 | 0.15236E+03 | 0.25734E+03 | 0.86893E+05 | 0 |
| 109 | 0.16002E+00 | 0.32125E-01 | 0.17850E+00 | 0.15149E+03 | 0.25747E+03 | 0.87049E+05 | 0 |
| 110 | 0.17335E+00 | 0.32054E-01 | 0.19184E+00 | 0.15060E+03 | 0.25760E+03 | 0.87208E+05 | 0 |
| 111 | 0.18669E+00 | 0.31848E-01 | 0.20518E+00 | 0.14968E+03 | 0.25774E+03 | 0.87370E+05 | 0 |
| 112 | 0.20002E+00 | 0.31519E-01 | 0.21852E+00 | 0.14876E+03 | 0.25788E+03 | 0.87532E+05 | 0 |
| 113 | 0.21336E+00 | 0.31077E-01 | 0.23186E+00 | 0.14782E+03 | 0.25802E+03 | 0.87697E+05 | 0 |
| 114 | 0.22670E+00 | 0.30533E-01 | 0.24521E+00 | 0.14690E+03 | 0.25815E+03 | 0.87859E+05 | 0 |
| 115 | 0.24003E-00 | 0.29898E-01 | 0.25856E+00 | 0.14597E+03 | 0.25829E+03 | 0.88019E+05 | 0 |
| 116 | 0.25336E-00 | 0.29176E-01 | 0.27192E+00 | 0.14505E+03 | 0.25842E+03 | 0.88178E+05 | 0 |
| 117 | 0.26670E+00 | 0.28376E-01 | 0.28528E+00 | 0.14414E+03 | 0.25855E+03 | 0.88335E+05 | 0 |
| 118 | 0.28003E+00 | 0.27502E-01 | 0.29865E+00 | 0.14323E+03 | 0.25868E+03 | 0.88491E+05 | 0 |
| 119 | 0.29337E+00 | 0.26560E-01 | 0.31202E+00 | 0.14232E+03 | 0.25881E+03 | 0.88646E+05 | 0 |
| 120 | 0.30670E-00 | 0.25553E-01 | 0.32539E+00 | 0.14140E+03 | 0.25894E+03 | 0.88802E+05 | C |
| 121 | 0.32004E+00 | 0.24485E-01 | 0.33877E+00 | 0.14047E+03 | 0.25907E+03 | 0.88959E+05 | C |
| 122 | 0.33337E+00 | 0.23360E-01 | 0.35216E+00 | 0.13952E+03 | 0.25920E+03 | 0.89117E+05 | C |
| 123 | 0.34671E+00 | 0.22181E-01 | 0.36555E+00 | 0.13857E+03 | 0.25933E+03 | 0.89276E+05 | C |
| 124 | 0.36004E+00 | 0.20952E-01 | 0.37894E+00 | 0.13760E+03 | 0.25947E+03 | 0.89437E+05 | C |
| 125 | 0.37338E+00 | 0.19676E-01 | 0.39234E+00 | 0.13661E+03 | 0.25960E+03 | 0.89599E+05 | C |
| 126 | 0.38671E+00 | 0.18355E-01 | 0.40574E+00 | 0.13561E+03 | 0.25974E+03 | 0.89763E+05 | C |
| 127 | 0.40005E-00 | 0.16991E-01 | 0.41915E+00 | 0.13457E+03 | 0.25988E+03 | 0.89932E+05 | C |
| 128 | 0.41338E+00 | 0.15586E-01 | 0.43256E+00 | 0.13350E+03 | 0.26002E+03 | 0.90105E+05 | C |
| 129 | 0.42672E+00 | 0.14143E-01 | 0.44597E+00 | 0.13240E+03 | 0.26017E+03 | 0.90281E+05 | C |
| 130 | 0.44005E+00 | 0.12662E-01 | 0.45939E+00 | 0.13126E+03 | 0.26032E+03 | 0.90463E+05 | C |
| 131 | 0.45339E+00 | 0.11142E-01 | 0.47282E+00 | 0.13005E+03 | 0.26047E+03 | 0.90654E+05 | C |
| 132 | 0.46672E+00 | 0.95761E-02 | 0.48625E+00 | 0.12873E+03 | 0.26064E+03 | 0.90863E+05 | : |
| 133 | 0.48006E+00 | 0.79519E-02 | 0.49968E+00 | 0.12710E+03 | 0.26085E+03 | 0.91115E+05 | |
| 134 | 0.49339E+00 | 0.62408E-02 | 0.51314E+00 | 0.12482E+03 | 0.26114E+03 | 0.91466E+05 | |
| 135 | 0.50673E+00 | 0.44011E-02 | 0.52526E+00 | 0.12153E+03 | 0.26154E+03 | 0.91961E+05 | |
| 136 | 0.51740E+00 | 0.27945E-02 | 0.53336E+00 | 0.11785E+03 | 0.26198E+03 | 0.92501E+05 | |
| 137 | 0.52273E+00 | 0.19261E-02 | 0.53877E+00 | 0.11376E+03 | 0.26245E+03 | 0.93085E+05 | |

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|---|---|---|---|---|---|---|---|
| 138 | 0.52807E+00 | 0.99959E-03 | 0.54419E+00 | 0.10304E+03 | 0.26361E+03 | 0.94528E+05 | 0 |
| 139 | 0.53340E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 | 0.90748E+05 | 0 |
| 1 SEG | S | HTC | XK | BETA | FFRAC | RI | |
| 1 | -0.54361E+00 | 0.00000E+00 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | 0 |
| 2 | -0.53819E+00 | 0.33257E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | 0 |
| 3 | -0.53278E+00 | 0.35195E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | 0 |
| 4 | -0.52468E+00 | 0.36999E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | C |
| 5 | -0.51256E+00 | 0.38681E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | 0 |
| 6 | -0.49910E+00 | 0.39923E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | C |
| 7 | -0.48566E+00 | 0.40860E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | C |
| 8 | -0.47223E+00 | 0.41668E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | C |
| 9 | -0.45881E+00 | 0.42434E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | C |
| 10 | -0.44539E+00 | 0.43181E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | C |
| 11 | -0.43198E+00 | 0.43925E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 12 | -0.41856E+00 | 0.44674E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 13 | -0.40516E+00 | 0.45424E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 14 | -0.39176E+00 | 0.46175E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 15 | -0.37836E+00 | 0.46942E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 16 | -0.36496E+00 | 0.47725E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 17 | -0.35157E+00 | 0.48524E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 18 | -0.33819E+00 | 0.49344E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 19 | -0.32481E+00 | 0.50188E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 20 | -0.31143E+00 | 0.51060E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 21 | -0.29806E+00 | 0.51962E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 22 | -0.28470E+00 | 0.52908E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 23 | -0.27134E+00 | 0.53896E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 24 | -0.25798E+00 | 0.54941E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 25 | -0.24463E+00 | 0.56048E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 26 | -0.23128E+00 | 0.57223E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 27 | -0.21794E+00 | 0.58482E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E-01 | |
| 28 | -0.20460E+00 | 0.59823E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 29 | -0.19126E+00 | 0.61262E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 30 | -0.17792E+00 | 0.62818E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 31 | -0.16459E+00 | 0.64508E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 32 | -0.15125E+00 | 0.66365E-03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 33 | -0.13791E+00 | 0.68429E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 34 | -0.12456E+00 | 0.70739E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 35 | -0.11121E+00 | 0.73363E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | ( |
| 36 | -0.97829E-01 | 0.76394E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 37 | -0.84422E-01 | 0.79977E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 38 | -0.70969E-01 | 0.84362E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 39 | -0.61519E-01 | 0.88156E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 40 | -0.56092E-01 | 0.90769E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 41 | -0.50642E-01 | 0.93724E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 42 | -0.45161E-01 | 0.97066E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 43 | -0.39637E-01 | 0.10080E+04 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 | |
| 44 | -0.35460E-01 | 0.10389E+04 | 0.35000E-03 | 0.36846E-01 | 0.10000E+01 | 0.10000E+01 | |
| 45 | -0.32644E-01 | 0.19514E+04 | 0.35000E-03 | 0.72813E-01 | 0.10000E+01 | 0.10000E+01 | |
| 46 | -0.29800E-01 | 0.10855E+04 | 0.35000E-03 | 0.10903E+00 | 0.10000E+01 | 0.10000E+01 | |
| 47 | -0.26922E-01 | 0.11122E+04 | 0.35000E-03 | 0.14571E+00 | 0.10000E+01 | 0.10000E+01 | |
| 48 | -0.24000E-01 | 0.11436E+04 | 0.35000E-03 | 0.18299E+00 | 0.10000E+01 | 0.10000E-01 | |
| 49 | -0.21010E-01 | 0.11801E+04 | 0.35000E-03 | 0.22123E+00 | 0.10000E+01 | 0.10000E-01 | |
| 50 | -0.17906E-01 | 0.12137E+04 | 0.35000E-03 | 0.27031E+00 | 0.10000E+01 | 0.10000E-01 | |
| 51 | -0.14624E-01 | 0.12363E+04 | 0.35000E-03 | 0.33232E+00 | 0.10000E+01 | 0.10000E+01 | |
| 52 | -0.11968E-01 | 0.12260E+04 | 0.35000E-03 | 0.39755E+00 | 0.10000E+01 | 0.10000E+01 | |

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|---|---|---|---|---|---|
| 53 | -0.98517E-02 | 0.11809E+04 | 0.35000E-03 | 0.45049E+00 | 0.99682E+00 | 0.10000E+01 |
| 54 | -0.80110E-02 | 0.10989E+04 | 0.35000E-03 | 0.51003E+00 | 0.63919E+00 | 0.10000E+01 |
| 55 | -0.65608E-02 | 0.10040E+04 | 0.35000E-03 | 0.55315E+00 | 0.38742E+00 | 0.10000E+01 |
| 56 | -0.55973E-02 | 0.92716E+03 | 0.35000E-03 | 0.58051E+00 | 0.38283E+00 | 0.10000E+01 |
| 57 | -0.52096E-02 | 0.88705E+03 | 0.35000E-03 | 0.59210E+00 | 0.33200E+00 | 0.10000E+01 |
| 58 | -0.48262E-02 | 0.85121E+03 | 0.35000E-03 | 0.60299E+00 | 0.32936E+00 | 0.10000E+01 |
| 59 | -0.44311E-02 | 0.81178E+03 | 0.35000E-03 | 0.61453E+00 | 0.35917E+00 | 0.10000E+01 |
| 60 | -0.40132E-02 | 0.76835E+03 | 0.35000E-03 | 0.61789E+00 | 0.34738E+00 | 0.10000E+01 |
| 61 | -0.35650E-02 | 0.72199E+03 | 0.35000E-03 | 0.62325E+00 | 0.31216E+00 | 0.10000E+01 |
| 62 | -0.31999E-02 | 0.68355E+03 | 0.35000E-03 | 0.62761E+00 | 0.33452E+00 | 0.10000E+01 |
| 63 | -0.29363E-02 | 0.65425E+03 | 0.35000E-03 | 0.63085E+00 | 0.35510E+00 | 0.10000E+01 |
| 64 | -0.26677E-02 | 0.62528E+03 | 0.35000E-03 | 0.63420E+00 | 0.36255E+00 | 0.10000E+01 |
| 65 | -0.23800E-02 | 0.59510E+03 | 0.35000E-03 | 0.63780E+00 | 0.35994E+00 | 0.10000E+01 |
| 66 | -0.20643E-02 | 0.56432E+03 | 0.35000E-03 | 0.64381E+00 | 0.36543E+00 | 0.10000E+01 |
| 67 | -0.17076E-02 | 0.53413E+03 | 0.35000E-03 | 0.64399E+00 | 0.39686E+00 | 0.10000E+01 |
| 68 | -0.12752E-02 | 0.50297E+03 | 0.35000E-03 | 0.64421E+00 | 0.44907E+00 | 0.10000E+01 |
| 69 | -0.51657E-03 | 0.50297E+03 | 0.35000E-03 | 0.64460E+00 | 0.50305E+00 | 0.10000E+01 |
| 70 | 0.51675E-03 | 0.50297E+03 | 0.35000E-03 | 0.64380E+00 | 0.43645E+00 | 0.10000E+01 |
| 71 | 0.12765E-02 | 0.50297E+03 | 0.35000E-03 | 0.64278E+00 | 0.28318E+00 | 0.10000E+01 |
| 72 | 0.17078E-02 | 0.53413E+03 | 0.35000E-03 | 0.64218E+00 | 0.26629E+00 | 0.10000E+01 |
| 73 | 0.20607E-02 | 0.56432E+03 | 0.35000E-03 | 0.64173E+00 | 0.24279E+00 | 0.10000E+01 |
| 74 | 0.23760E-02 | 0.59510E+03 | 0.35000E-03 | 0.63692E+00 | 0.22965E+00 | 0.10000E+01 |
| 75 | 0.26687E-02 | 0.62528E+03 | 0.35000E-03 | 0.63356E+00 | 0.23991E+00 | 0.10000E+01 |
| 76 | 0.29441E-02 | 0.65425E+03 | 0.35000E-03 | 0.63045E+00 | 0.26148E+00 | 0.10000E+01 |
| 77 | 0.32087E-02 | 0.68355E+03 | 0.35000E-03 | 0.62744E+00 | 0.28025E+00 | 0.10000E+01 |
| 78 | 0.35697E-02 | 0.72199E+03 | 0.35000E-03 | 0.62338E+00 | 0.28961E+00 | 0.10000E+01 |
| 79 | 0.40184E-02 | 0.76826E+03 | 0.35000E-03 | 0.61839E+00 | 0.28369E+00 | 0.10000E+01 |
| 80 | 0.44381E-02 | 0.81179E+03 | 0.35000E-03 | 0.61371E+00 | 0.26032E+00 | 0.10000E+01 |
| 81 | 0.48291E-02 | 0.85130E+03 | 0.35000E-03 | 0.60237E+00 | 0.25398E+00 | 0.10000E+01 |
| 82 | 0.52199E-02 | 0.88705E+03 | 0.35000E-03 | 0.59167E+00 | 0.28320E+00 | 0.10000E+01 |
| 83 | 0.57078E-02 | 0.92716E+03 | 0.35000E-03 | 0.58029E+00 | 0.34705E+00 | 0.10000E+01 |
| 84 | 0.67384E-02 | 0.10040E+04 | 0.35000E-03 | 0.55340E+00 | 0.42388E+00 | 0.10000E+01 |
| 85 | 0.82251E-02 | 0.10989E+04 | 0.35000E-03 | 0.51257E+00 | 0.40270E+00 | 0.10000E+01 |
| 86 | 0.10072E-01 | 0.11809E+04 | 0.35000E-03 | 0.45467E+00 | 0.10000E+01 | 0.10000E+01 |
| 87 | 0.12341E-01 | 0.12260E+04 | 0.35000E-03 | 0.39931E+00 | 0.99908E+00 | 0.10000E+01 |
| 88 | 0.15202E-01 | 0.12362E+04 | 0.35000E-03 | 0.33332E+00 | 0.10000E+01 | 0.10000E+01 |
| 89 | 0.18486E-01 | 0.12137E+04 | 0.35000E-03 | 0.26976E+00 | 0.10000E+01 | 0.10000E+01 |
| 90 | 0.21591E-01 | 0.11801E+04 | 0.35000E-03 | 0.21949E+00 | 0.10000E+01 | 0.10000E+01 |
| 91 | 0.24583E-01 | 0.11436E+04 | 0.35000E-03 | 0.18146E+00 | 0.10000E+01 | 0.10000E+01 |
| 92 | 0.27506E-01 | 0.11122E+04 | 0.35000E-03 | 0.14437E+00 | 0.10000E+01 | 0.10000E+01 |
| 93 | 0.30384E-01 | 0.10855E+04 | 0.35000E-03 | 0.10789E+00 | 0.10000E+01 | 0.10000E+01 |
| 94 | 0.33227E-01 | 0.10614E+04 | 0.35000E-03 | 0.71863E-01 | 0.10000E+01 | 0.10000E+01 |
| 95 | 0.36043E-01 | 0.10389E+04 | 0.35000E-03 | 0.36087E-01 | 0.10000E+01 | 0.10000E+01 |
| 96 | 0.40219E-01 | 0.10080E+04 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 97 | 0.45743E-01 | 0.97065E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |
| 98 | 0.51223E-01 | 0.93725E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |
| 99 | 0.56674E-01 | 0.90768E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |
| 100 | 0.62101E-01 | 0.88157E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |
| 101 | 0.71551E-01 | 0.84362E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |
| 102 | 0.85004E-01 | 0.79977E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |
| 103 | 0.98411E-01 | 0.76394E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |
| 104 | 0.11179E+00 | 0.73364E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |
| 105 | 0.12515E+00 | 0.70739E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |
| 106 | 0.13849E+00 | 0.68429E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |
| 107 | 0.15183E+00 | 0.66365E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+0 |

| 108 | 0.16517E+00 | 0.64508E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 109 | 0.17850E+00 | 0.62818E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 110 | 0.19184E+00 | 0.61263E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 111 | 0.20518E+00 | 0.59823E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 112 | 0.21852E+00 | 0.58482E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 113 | 0.23186E+00 | 0.57223E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 114 | 0.24521E+00 | 0.56048E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 115 | 0.25856E+00 | 0.54941E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 116 | 0.27192E+00 | 0.53896E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 117 | 0.28528E+00 | 0.52908E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 118 | 0.29865E+00 | 0.51962E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 119 | 0.31202E+00 | 0.51060E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 120 | 0.32539E+00 | 0.50188E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 121 | 0.33877E+00 | 0.49344E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 122 | 0.35216E+00 | 0.48524E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 123 | 0.36555E+00 | 0.47725E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 124 | 0.37894E+00 | 0.46942E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 125 | 0.39234E+00 | 0.46175E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 126 | 0.40574E+00 | 0.45424E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 127 | 0.41915E+00 | 0.44673E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 128 | 0.43256E+00 | 0.43924E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 129 | 0.44597E+00 | 0.43180E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
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| 134 | 0.51314E+00 | 0.38681E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 135 | 0.52526E+00 | 0.36999E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 136 | 0.53336E+00 | 0.35195E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 137 | 0.53877E+00 | 0.33258E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |
| 138 | 0.54419E+00 | 0.28421E+03 | 0.35000E-03 | 0.00000E+00 | 0.10000E+01 | 0.10000E+01 |

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**13. ABSTRACT (Maximum 200 words)**

A version of LEWICE has been developed that incorporates a recently developed electrothermal deicer code, developed at the University of Toledo by William B. Wright. This was accomplished, in essence, by replacing a subroutine in LEWICE, called EBAL, which balanced the energies at the ice surface, with a subroutine called UTICE. UTICE performs this same energy balance, as well as handles all the time-temperature transients below the ice surface, for all of the layers of a composite blade as well as the ice layer itself. This new addition is set up in such a fashion that a user may specify any number of heaters, any heater chordwise length, and any heater gap desired. The heaters may be fired in unison, or they may be cycled with periods independent of each other. The heater intensity may also be varied. In addition, the user may specify any number of layers and thicknesses depthwise into the blade. Thus, the new addition has maximum flexibility in modeling virtually any electrothermal deicer installed into any airfoil. It should be noted that the model simulates both shedding and runback. With the runback capability, it can simulate the anti-icing mode of heater performance, as well as detect icing downstream of the heaters due to runback in unprotected portions of the airfoil. This version of LEWICE can be run in three modes. In mode 1, no conduction heat transfer is modeled (which would be equivalent to the original version of LEWICE). In mode 2, all heat transfer is considered due to conduction, but no heaters are firing. In mode 3, conduction heat transfer where the heaters are engaged is modeled, with subsequent ice shedding. When run in the first mode, there is virtually identical agreement with the original version of LEWICE in the prediction of accreted ice shapes. The code may be run in the second mode to determine the effects of conduction on the ice accretion process.

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