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CHARACTERISTICS OF THE TURBULENT  
BOUNDARY LAYER WITH HEAT AND MASS  
TRANSFER: DATA TABULATION

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Aerodynamics Research Report No. 280

**CHARACTERISTICS OF THE TURBULENT BOUNDARY LAYER WITH HEAT  
AND MASS TRANSFER: DATA TABULATION**

by

**James E. Danberg**

**ABSTRACT:** A tabulation of turbulent boundary layer data obtained under conditions of heat and mass transfer at a Mach number of 6.7 is presented. The report supplements the treatise given in NOLTR 64-99. A brief description of the model and test procedure is included.

**U. S. NAVAL ORDNANCE LABORATORY  
White Oak, Silver Spring, Maryland**

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**Characteristics of the Turbulent Boundary Layer with Heat and Mass Transfer: Data Tabulation**

This report presents the measured and deduced data obtained during an extensive investigation of hypersonic turbulent boundary layers with heat and mass transfer. The work was sponsored by the Bureau of Naval Weapons under Task No. RMGA-42-034/212-1/F009-10-001. It resulted in a Ph.D. thesis by the author submitted to the Catholic University of America. Only summary data were included in the thesis, which was also published as NOLTR 64-99. The present report was compiled after numerous requests for detailed data from other researchers in this field.

The author wishes to acknowledge the efforts of the Aerophysics Division of the U. S. Naval Ordnance Laboratory in preparing the material for publication.

E. F. SCHREITER  
Captain, USN  
Commander



E. L. HARRIS  
By direction

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LIST OF SYMBOLS

|               |                                                                          |
|---------------|--------------------------------------------------------------------------|
| $C_f$         | skin friction coefficient, $\tau_w / \frac{1}{2} \rho_\infty u_\infty^2$ |
| $C_{f0}$      | skin friction coefficient for zero mass transfer                         |
| $C_q$         | mass transfer coefficient, $\rho_w v_w / \rho_\infty u_\infty$           |
| $M$           | local Mach number                                                        |
| $M_\delta$    | Mach number at outer edge of boundary layer                              |
| $P_\infty$    | supply air pressure                                                      |
| $Re_x$        | Reynolds number, $\rho_\infty u_\infty x / \mu_\infty$                   |
| $Re_\delta$   | Reynolds number, $\rho_\infty u_\infty \delta / \mu_\infty$              |
| $St$          | Stanton number                                                           |
| $St_0$        | Stanton number for zero mass transfer                                    |
| $T_\infty$    | supply air temperature                                                   |
| $T_w$         | wall surface temperature                                                 |
| $T_\delta$    | temperature at outer edge of boundary layer                              |
| $u$           | local velocity                                                           |
| $u_\delta$    | velocity at outer edge of boundary layer                                 |
| $v_w$         | velocity component perpendicular to wall at wall surface                 |
| $x$           | distance from leading edge of plate in direction of free-stream velocity |
| $\delta$      | total boundary layer thickness                                           |
| $\delta^*$    | displacement thickness                                                   |
| $\theta$      | momentum thickness                                                       |
| $\theta$      | energy thickness                                                         |
| $\mu_\infty$  | viscosity at outer edge of boundary layer                                |
| $\rho_w$      | density at wall condition                                                |
| $\rho_\infty$ | density at outer edge of boundary layer                                  |
| $\tau_w$      | wall shear stress                                                        |

## INTRODUCTION

NOLTR 64-99 (ref. (1)) summarized an extensive program of turbulent boundary layer measurements under conditions of heat and mass transfer at a Mach number of 6.7. That report contained some typical velocity and temperature profiles as well as the correlation of the boundary layer profiles in terms of a number of parameters related to the heat and mass transfer, etc. In order to make that report more generally useful, it has been decided to publish in the present report the tabulated boundary layer data obtained during the course of that project.

The experiments were performed in the U. S. Naval Ordnance Laboratory's Hypersonic Research Tunnel using a Mach number 6.7 uniform flow two-dimensional nozzle with an exit area of about  $25 \times 25 \text{ cm}^2$ . The supply pressure and temperature were held constant during each test at a fixed pressure value between 15 and 38 atmospheres and at a constant supply temperature of  $550^\circ\text{K}$ . The control of these conditions limited the average deviation in nozzle temperature to  $\pm 1^\circ\text{C}$  and in supply pressure to  $\pm 0.1$  atmosphere.

The boundary layer measurements were made on a porous flat plate (see figure 1) which spanned the wind tunnel test section with the testing surface in the plane of symmetry of the two-dimensional nozzle. The plate had a sharp leading edge (radius of about .015 mm) and it had a smooth (about 11 microinches) continuous surface. Inserted in the testing surface of the model was a porous plate about 49 cm long, 18 cm wide, and 1.0 cm thick. The porous plate was made of 316 stainless steel powder sintered into compact material with a density of about 43 percent of solid stainless steel. Further details are given in the original report.

In order to make this tabulation of the experimental data more useful and complete, the instrumentation employed and the data reduction techniques are summarized in the following sections.

## INSTRUMENTATION AND DATA REDUCTION

### Pitot Pressure Probes

The majority of boundary layer Pitot pressure surveys were made using circular stainless steel tubing .559 mm in outside diameter and with an inlet diameter of .254 mm. A few surveys were made using rectangular cross section probes made from crushed tubing. Circular probes were preferred because of the greater ease in determining their position and orientation with respect to the model.

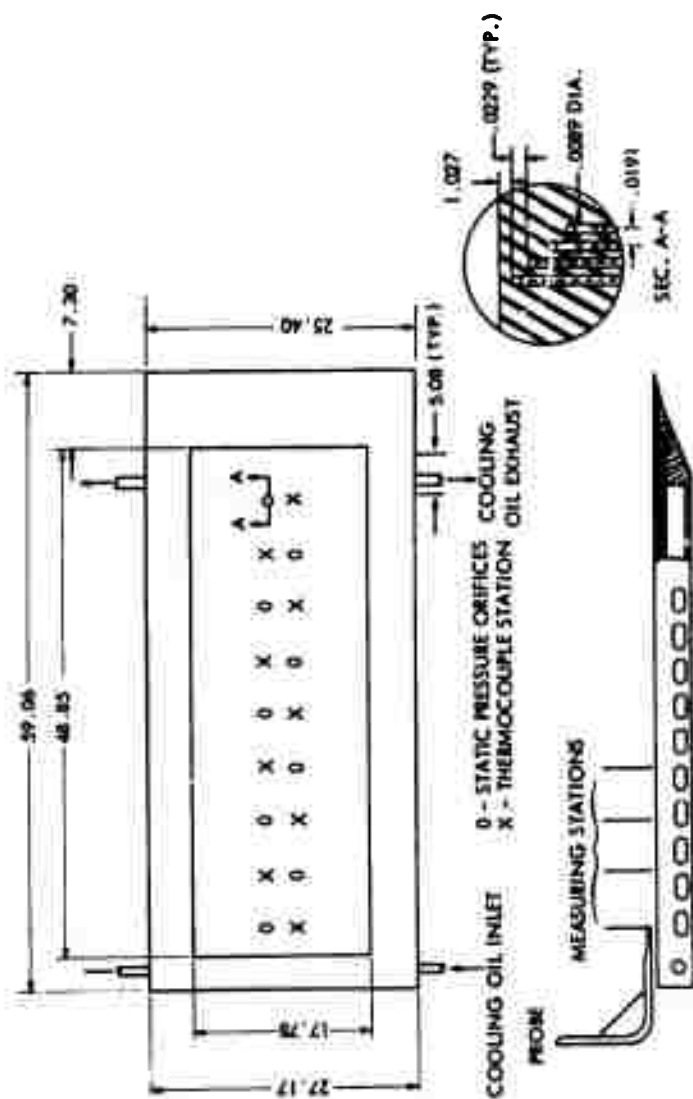


FIG. 1 SKETCH OF MODEL ( ALL DIMENSIONS IN CM )

Pressures were measured with transducers with ranges of 0-1 atmosphere or 0-300 mmHg. Transducers and recording systems were calibrated, before and after each survey, against a mercury manometer with  $\pm 1$  mm measuring accuracy.

The probes were held in the tunnel by a micrometer-traversing mechanism which allowed positioning of the probe with an accuracy of .025 mm. Each traverse was made from the free stream toward the plate. Wall contact, used to evaluate absolute distances from the wall, was indicated by the completion of an electric circuit.

#### Pressure Data Reduction

The NACA tables (ref. (2)) were used to compute the Mach number from the measured Pitot pressure and the static pressure which was assumed constant across the boundary layer and equal to the measured wall static pressure. Wall static pressures were measured by orifices in the porous plate surface through which stainless steel tubing (0.635 mm I.D.) was inserted flush with the testing surface. An oil manometer was used to measure the static pressure with an accuracy of  $\pm 1$  percent.

The surface shear stress was calculated by taking the slope of the Mach number distribution at the wall and multiplying this by the velocity of sound and viscosity of air evaluated at the measured wall temperature. The wall temperature and heat flux were obtained from temperature measurements made with iron-constantan thermocouples imbedded in the porous material at each test station. Four thermocouples were located at each station at various depths from the surface. The thermocouple nearest the surface was 1.27 mm beneath the surface. Together with the known location of the others, extrapolation of the temperature distribution to a surface value was felt to give reliable results.

#### Temperature Measurements

The equilibrium temperature probe (ref. (3)) was developed to measure the boundary layer temperature profiles for these experiments. It consists of a 10 degree angle cone of platinum supported by a good thermal insulator. The cone is mounted on the traversing mechanism with its axis parallel to the flow direction. A thermocouple measured the temperature of the cone which ideally should equal the adiabatic wall temperature. Sufficient run time was available in the NOL Hypersonic Tunnel to allow the probe to come into thermal equilibrium before each measurement was made. A second thermocouple in the ceramic insulator allowed the measured cone temperature to be corrected for conduction losses. The data were recorded on strip chart recorders which made continuous monitoring of the temperatures possible.

#### Temperature Probe Data Reduction

A recovery factor for the probe was computed for each survey while the probe was in the free stream where the flow and temperature



conditions were accurately known. It was assumed that the recovery factor remained constant thereafter for that survey. Thus it was possible to calculate the local total temperature in the boundary layer from the cone adiabatic wall temperature measurement, the assumed recovery factor and measured Mach number. Since temperatures were not always measured at the same location as the pressures, an interpolation was made between temperature data points to obtain the temperatures corresponding to the Mach number data points.

Heat transfer rates to the model surface were calculated from the slope of the total temperature distribution interpolated to the surface temperature and the thermal conductivity of air. This procedure supplements the heat transfer obtained from the temperature distribution within the model wall.

In calculating Stanton numbers, the adiabatic wall temperatures are required to obtain the latter for the zero mass transfer cases. It was assumed that the recovery factor equals the Prandtl number raised to the one third power where wall temperature was used to evaluate the Prandtl number. In the mass transfer cases the recovery factor ratios (i.e., recovery factor with mass transfer divided by the zero mass transfer recovery factor) obtained by Leadon and Bartle (ref. (4)) were used.

#### TEST CONDITIONS

As indicated earlier, the tests were run using a nominal Mach number 6.7 nozzle. However, local Mach numbers at the boundary layer edge were somewhat less because of leading edge shock wave losses and boundary layer flow field interaction; the latter was a significant effect in the mass transfer cases. The supply temperature was held constant at 550°K, while the supply pressure was varied between 15 and 38 atmospheres. Thus, the unit Reynolds number varied from 8 to  $19 \times 10^6$  per meter.

Four locations on the model were investigated: 37.78, 42.86, 47.94, and 53.02 cm from the leading edge. Natural transition was believed to have been completed because a local maximum in the wall temperature was observed at or before 32.7 cm from the leading edge. (Reynolds number =  $2.6 \times 10^6$ ). Three wall temperature ratios ( $T_w/T_\infty$ ) were investigated which had numerical values that averaged to 4.1, 5.2, and 7.6. The boundary layers were surveyed at zero air injection and at three mass transfer rates which were approximately equal to 0.09, 0.17, and 0.25 percent of free-stream mass flow per unit area except in the high supply pressure cases where the maximum injection rate was about 0.11 percent of the free-stream mass flow.

#### ARRANGEMENT OF TABLES

The measured and deduced boundary layer data are presented as summary tables containing the detailed profile data. Two summary

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tables precede each set of profile data obtained for specific test conditions, i.e.,  $P_O$ , and  $T_W/T_O$ , and various values of  $C_q$ , as shown in the following tabulation.

| Table No. | $P_O^*$<br>atm | $T_W/T_O^*$ | $C_q^*$                                                                      | Profile Data<br>Table Nos. |
|-----------|----------------|-------------|------------------------------------------------------------------------------|----------------------------|
| 1 & 2     | 15             | 4.1         | 0<br>$9.09 \times 10^{-4}$<br>$17.0 \times 10^{-4}$<br>$25.0 \times 10^{-4}$ | 3<br>through<br>23         |
| 24 & 25   | 15             | 5.2         | 0<br>$8.77 \times 10^{-4}$<br>$17.2 \times 10^{-4}$<br>$24.6 \times 10^{-4}$ | 26<br>through<br>42        |
| 43 & 44   | 15             | 7.6         | 0<br>$8.68 \times 10^{-4}$<br>$16.2 \times 10^{-4}$<br>$24.4 \times 10^{-4}$ | 45<br>through<br>52        |
| 53 & 54   | 38             | 7.6         | 0<br>$3.7 \times 10^{-4}$<br>$7.25 \times 10^{-4}$<br>$10.13 \times 10^{-4}$ | 55<br>through<br>58        |
| 59 & 60   | 38             | 4.1         | 0<br>$4.12 \times 10^{-4}$<br>$8.17 \times 10^{-4}$<br>$12.1 \times 10^{-4}$ | 61<br>through<br>67        |

\*The values of  $P_O$ ,  $T_W/T_O$ , and  $C_q$  are average or nominal values for these quantities for the purpose of identifying the tables--the precise values are listed in the tables for each of the surveys carried out.

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TABLE 1 SUMMARY OF SKIN FRICTION AND HEAT TRANSFER DATA,  $T_e/T_g = 4.1$  $T_e/T_g = 4.1$ 

| RUN                           | X<br>mm | NO   | P <sub>o</sub><br>atm | Re <sub>x</sub> × 10 <sup>-6</sup> | Re <sub>θ</sub> | T <sub>e</sub> /T <sub>g</sub> | C <sub>f</sub> × 10 <sup>4</sup> | C <sub>h</sub> × 10 <sup>4</sup> | C <sub>f</sub> /C <sub>h</sub> | 2C <sub>h</sub> /C <sub>f</sub> | St × 10 <sup>6</sup> | St <sub>o</sub> |
|-------------------------------|---------|------|-----------------------|------------------------------------|-----------------|--------------------------------|----------------------------------|----------------------------------|--------------------------------|---------------------------------|----------------------|-----------------|
| $C_q = 0$                     |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| $T_e/T_g = 4.48$              |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| 1                             | 377.8   | 6.60 | 15.18                 | 3.255                              | 1947            | 4.475                          | 0                                | 14.58                            | 1.000                          | 0                               | 4.97                 | 1.000           |
| 2                             | 428.6   | 6.55 | 15.15                 | 3.533                              | 2374            | 4.480                          | 0                                | 13.85                            | 1.000                          | 0                               | 4.97                 | 1.000           |
| 3                             | 479.4   | 6.54 | 15.15                 | 3.880                              | 2527            | 4.479                          | 0                                | 14.46                            | 1.000                          | 0                               | 5.27                 | 1.000           |
| 4                             | 530.2   | 6.49 | 15.20                 | 4.220                              | 3037            | 4.490                          | 0                                | 13.36                            | 1.000                          | 0                               | 4.29                 | 1.000           |
| $C_q = 9.09 \times 10^{-4}$   |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| $T_e/T_g = 4.17$              |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| 5                             | 377.8   | 6.38 | 15.15                 | 2.925                              | 3206            | 4.102                          | 9.23                             | 12.53                            | .859                           | 1.266                           | 4.23                 | .537            |
| 6                             | 428.6   | 6.49 | 15.22                 | 3.446                              | 4028            | 4.132                          | 9.07                             | 11.45                            | .827                           | 1.310                           | 4.09                 | .551            |
| 7                             | 479.4   | 6.60 | 15.15                 | 4.160                              | 4898            | 4.263                          | 8.85                             | 9.60                             | .664                           | 1.223                           | 3.60                 | .482            |
| 8                             | 530.2   | 6.48 | 15.22                 | 4.261                              | 5288            | 4.167                          | 9.21                             | 8.39                             | .628                           | 1.379                           | 3.17                 | .501            |
| $C_q = 17.0 \times 10^{-4}$   |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| $T_e/T_g = 3.94$              |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| 9                             | 377.8   | 6.39 | 15.17                 | 3.249                              | 4919            | 4.102                          | 16.86                            | 5.36                             | .368                           | 2.312                           | 2.65                 | .337            |
| 10                            | 479.4   | 6.42 | 15.12                 | 3.950                              | 6081            | 3.991                          | 16.24                            | 5.37                             | .371                           | 2.246                           | 2.57                 | .344            |
| 11                            | 530.2   | 6.37 | 15.18                 | 4.264                              | 7511            | 3.808                          | 17.81                            | 5.17                             | .387                           | 2.670                           | 1.90                 | .300            |
| $C_q = 25.0 \times 10^{-4}$   |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| $T_e/T_g = 3.73$              |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| 12                            | 377.8   | 6.28 | 15.15                 | 3.185                              | 6517            | 3.864                          | 24.91                            | 3.50                             | .260                           | 3.416                           | 1.96                 | .249            |
| 13                            | 428.6   | 6.20 | 15.15                 | 3.619                              | 8156            | 3.640                          | 24.52                            | 3.07                             | .222                           | 3.540                           | 1.32                 | .178            |
| 14                            | 479.4   | 6.22 | 15.15                 | 3.945                              | 8450            | 3.759                          | 24.90                            | 3.36                             | .232                           | 3.440                           | 1.68                 | .225            |
| 15                            | 530.2   | 6.22 | 15.22                 | 4.298                              | 10166           | 3.662                          | 25.80                            | 3.40                             | .254                           | 3.860                           | 1.29                 | .204            |
| $C_q = 0$                     |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| $T_e/T_g = 4.31$ (Repeat Run) |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| 16                            | 377.8   | 6.52 | 15.15                 | 3.057                              | 1716            | 4.418                          | 0                                | 14.29                            | 1.000                          | 0                               | 7.87                 | 1.000           |
| 17                            | 428.6   | 6.32 | 15.15                 | 3.163                              | 1993            | 4.171                          | 0                                | 15.30                            | 1.000                          | 0                               | 7.42                 | 1.000           |
| 18                            | 479.4   | 6.44 | 15.18                 | 3.679                              | 2347            | 4.346                          | 0                                | 15.47                            | 1.000                          | 0                               | 7.46                 | 1.000           |
| 19                            | 530.2   | 6.45 | 15.15                 | 4.260                              | 3023            | 4.297                          | 0                                | 12.54                            | 1.000                          | 0                               | 6.33                 | 1.000           |
| $C_q = 0$                     |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| $T_e/T_g = 4.12$              |         |      |                       |                                    |                 |                                |                                  |                                  |                                |                                 |                      |                 |
| 20                            | 479.2   | 6.68 | 20.05                 | 5.356                              | 3296            | 4.361                          | 0                                | 11.86                            | 1.000                          | 0                               | 6.16                 | 1.000           |
| 21                            | 479.4   | 6.41 | 24.95                 | 5.997                              | 3891            | 4.116                          | 0                                | 9.46                             | 1.000                          | 0                               | 5.30                 | 1.000           |

TABLE 2 SUMMARY OF BOUNDARY LAYER PARAMETERS,  $T_e/T_A = 4.1$

| RUN | X     | $R_0 \times 10^{-6}$ | $T_e/T_B$ | $T_e/T_B = 4.1$             |          |            |          |          | $R\theta$ | $\frac{\delta^*}{\theta}$ |
|-----|-------|----------------------|-----------|-----------------------------|----------|------------|----------|----------|-----------|---------------------------|
|     |       |                      |           | $C_q \times 10^{-4}$        | $\theta$ | $\delta^*$ | $\delta$ | $\theta$ |           |                           |
|     |       |                      |           |                             | mm       | mm         | mm       | mm       |           |                           |
|     |       |                      |           | $C_q = 0$                   |          |            |          |          |           |                           |
|     |       |                      |           | $T_e/T_B = 4.48$            |          |            |          |          |           |                           |
| 1   | 377.8 | 3.255                | 4.475     | 0                           | .226     | 3.18       | 5.4      | .238     | 1947      | 14.07                     |
| 2   | 428.6 | 3.533                | 4.480     | 0                           | .288     | 3.66       | 7.45     | .460     | 2374      | 12.71                     |
| 3   | 479.4 | 3.880                | 4.479     | 0                           | .312     | 4.10       | 8.0      | .464     | 2527      | 13.12                     |
| 4   | 530.2 | 4.220                | 4.490     | 0                           | .382     | 4.84       | 9.2      | .644     | 3037      | 12.67                     |
|     |       |                      |           | $C_q = 9.09 \times 10^{-4}$ |          |            |          |          |           |                           |
|     |       |                      |           | $T_e/T_B = 4.17$            |          |            |          |          |           |                           |
| 5   | 377.8 | 2.925                | 4.102     | 9.23                        | .414     | 4.82       | 8.8      | .686     | 3206      | 11.64                     |
| 6   | 428.6 | 3.446                | 4.132     | 9.07                        | .501     | 5.72       | 10.8     | .848     | 4028      | 11.42                     |
| 7   | 479.4 | 4.160                | 4.263     | 8.85                        | .541     | 6.81       | 12.0     | .753     | 4698      | 12.59                     |
| 8   | 530.2 | 4.261                | 4.167     | 9.21                        | .658     | 7.86       | 14.1     | 1.070    | 5288      | 11.94                     |
|     |       |                      |           | $C_q = 17.5 \times 10^{-4}$ |          |            |          |          |           |                           |
|     |       |                      |           | $T_e/T_B = 3.94$            |          |            |          |          |           |                           |
| 9   | 377.8 | 3.249                | 4.102     | 16.86                       | .572     | 7.68       | 12.1     | .792     | 4919      | 13.43                     |
| 10  | 479.4 | 3.950                | 3.991     | 16.24                       | .738     | 9.62       | 15.5     | 1.070    | 6081      | 13.04                     |
| 11  | 530.2 | 4.264                | 3.808     | 17.81                       | .934     | 10.70      | 18.0     | 1.580    | 7511      | 11.46                     |
|     |       |                      |           | $C_q = 25.0 \times 10^{-4}$ |          |            |          |          |           |                           |
|     |       |                      |           | $T_e/T_B = 3.73$            |          |            |          |          |           |                           |
| 12  | 377.8 | 3.185                | 3.864     | 24.91                       | .773     | 9.96       | 14.8     | 1.216    | 6517      | 12.88                     |
| 13  | 428.6 | 3.619                | 3.640     | 24.52                       | .966     | 11.20      | 17.3     | 1.640    | 8156      | 11.59                     |
| 14  | 479.4 | 3.945                | 3.759     | 24.90                       | 1.027    | 12.90      | 19.7     | 1.650    | 8450      | 12.56                     |
| 15  | 530.2 | 4.298                | 3.662     | 25.80                       | 1.250    | 14.20      | 22.7     | 2.250    | 10166     | 11.36                     |
|     |       |                      |           | $C_q = 0$                   |          |            |          |          |           |                           |
|     |       |                      |           | $T_e/T_B = 4.31$            |          |            |          |          |           |                           |
| 16  | 377.8 | 3.057                | 4.418     | 0                           | .212     | 3.14       | 5.3      | .256     | 1716      | 14.81                     |
| 17  | 428.6 | 3.163                | 4.171     | 0                           | .270     | 3.64       | 6.7      | .272     | 1993      | 13.48                     |
| 18  | 479.4 | 3.679                | 4.346     | 0                           | .306     | 4.42       | 8.1      | .316     | 2349      | 14.44                     |
| 19  | 530.2 | 4.260                | 4.297     | 0                           | .376     | 5.68       | 10.0     | .384     | 3023      | 15.11                     |
|     |       |                      |           | $C_q = 0$                   |          |            |          |          |           |                           |
|     |       |                      |           | $T_e/T_B = 4.12$            |          |            |          |          |           |                           |
| 20  | 479.4 |                      | 4.381     | 0                           | .295     | 4.34       | 7.9      | .352     | 3296      | 14.71                     |
| 21  | 479.4 |                      | 4.116     | 0                           | .311     | 4.30       | 7.9      | NC       | 3891      | 13.83                     |

TABLE 3 - Run 1

$M_0 = 6.60$   
 $Re_0 = 1,947$   
 $\frac{P_0}{T_0} = 4.475$   
 $C_q = 0$

$P_0 = 15.18 \text{ atm}$   
 $T_0 = 546^\circ \text{K}$   
 $T_0 = 56.4^\circ \text{K}$   
 $U_0 = 994.31 \text{ m/sec}$

| Y<br>(mm) | M     | $T/T_0$ | $U/U_0$ |
|-----------|-------|---------|---------|
| 14.60     | 6.60  | 1.000   | 1.000   |
| 13.33     | 6.60  | 1.000   | 1.000   |
| 12.06     | 6.60  | 1.000   | 1.000   |
| 10.79     | 6.57  | 1.007   | .999    |
| 9.52      | 6.55  | 1.015   | .999    |
| 8.25      | 6.47  | 1.039   | .999    |
| 7.06      | 6.40  | 1.043   | .999    |
| 6.42      | 6.28  | 1.097   | .997    |
| 5.79      | 6.11  | 1.151   | .993    |
| 5.15      | 5.88  | 1.228   | .986    |
| 4.52      | 5.55  | 1.346   | .975    |
| 3.88      | 5.15  | 1.515   | .960    |
| 3.25      | 4.73  | 1.727   | .940    |
| 2.61      | 4.29  | 1.990   | .917    |
| 2.36      | 4.16  | 2.091   | .907    |
| 2.11      | 3.98  | 2.117   | .876    |
| 1.85      | 3.83  | 2.316   | .882    |
| 1.60      | 3.67  | 2.407   | .863    |
| 1.34      | 3.53  | 2.438   | .834    |
| 1.09      | 3.30  | 2.487   | .787    |
| .838      | 2.99  | 2.541   | .721    |
| .582      | 2.35  | 2.972   | .614    |
| .328      | 1.46  | 3.813   | .433    |
| .270      | 1.395 | 3.830   | .414    |

TABLE 4 - Run 2

$M_0 = 6.55$   
 $Re_0 = 2,374$   
 $\frac{P_0}{T_0} = 4.480$   
 $C_q = 0$

$P_0 = 15.150 \text{ atm}$   
 $T_0 = 546^\circ \text{K}$   
 $T_0 = 57.2^\circ \text{K}$   
 $U_0 = 992 \text{ m/sec}$

| Y<br>(mm) | M    | $T/T_0$ | $U/U_0$ |
|-----------|------|---------|---------|
| 14.94     | 6.55 | 1.000   | 1.000   |
| 12.40     | 6.55 | 1.000   | 1.000   |
| 9.86      | 6.49 | 1.017   | 1.000   |
| 9.23      | 6.45 | 1.031   | 1.000   |
| 8.59      | 6.37 | 1.052   | .998    |
| 7.96      | 6.25 | 1.086   | .995    |
| 7.32      | 6.11 | 1.130   | .991    |
| 6.69      | 5.91 | 1.188   | .977    |
| 6.05      | 5.70 | 1.263   | .967    |
| 5.42      | 5.44 | 1.355   | .955    |
| 4.78      | 5.15 | 1.472   | .940    |
| 4.15      | 4.85 | 1.608   | .923    |
| 3.51      | 4.55 | 1.766   | .905    |
| 2.88      | 4.25 | 1.942   | .884    |
| 2.24      | 3.96 | 2.140   | .854    |
| 1.61      | 3.62 | 2.382   | .764    |
| .927      | 3.12 | 2.430   | .655    |
| .660      | 2.90 | 2.526   | .577    |
| .533      | 2.12 | 3.178   | .477    |
| .406      | 1.63 | 3.664   | .430    |
| .317      | 1.44 | 3.854   | .409    |
| .279      | 1.37 | 3.829   |         |

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TABLE 5 - Run 3

$M_0 = 6.54$   
 $Re_0 = 2527$   
 $T_0 = 4.579$   
 $C_1 = 0$   
 $P_0 = 15.15 \text{ atm}$   
 $T_c = 546^\circ \text{K}$   
 $T_0 = 57.3^\circ \text{K}$   
 $U_0 = 992 \text{ m/sec}$

| Y<br>(mm) | M    | $T/T_0$ | $W/W_0$ |
|-----------|------|---------|---------|
| 16.13     | 6.54 | 1.000   | 1.000   |
| 13.59     | 6.52 | 1.004   | 1.000   |
| 12.32     | 6.50 | 1.012   | 1.000   |
| 11.05     | 6.46 | 1.025   | 1.000   |
| 9.78      | 6.38 | 1.047   | .999    |
| 8.14      | 6.31 | 1.069   | .998    |
| 6.00      | 6.11 | 1.128   | .992    |
| 4.98      | 5.81 | 1.224   | .985    |
| 3.48      | 5.63 | 1.286   | .977    |
| 2.97      | 5.43 | 1.360   | .968    |
| 2.46      | 5.22 | 1.440   | .959    |
| 1.95      | 5.01 | 1.534   | .949    |
| 1.44      | 4.77 | 1.645   | .937    |
| 1.34      | 4.54 | 1.765   | .923    |
| 1.22      | 4.44 | 1.823   | .917    |
| 1.10      | 4.09 | 2.069   | .895    |
| 1.00      | 3.87 | 2.201   | .879    |
| 1.00      | 3.63 | 2.389   | .858    |
| 1.00      | 3.48 | 2.498   | .842    |
| 1.14      | 3.18 | 2.546   | .822    |
| 1.02      | 3.01 | 2.621   | .808    |
| .889      | 2.91 | 2.630   | .792    |
| .762      | 2.64 | 2.791   | .777    |
| .635      | 2.36 | 2.981   | .767    |
| .508      | 1.98 | 3.323   | .754    |
| .381      | 1.36 | 4.034   | .744    |
| .279      | 1.12 | 4.210   | .733    |

TABLE 6 - Run 4

$M_0 = 6.49$   
 $Re_0 = 3037$   
 $T_0 = 4.490$   
 $U_0 = 990 \text{ m/sec}$   
 $P_0 = 15.20 \text{ atm}$   
 $T_c = 546^\circ \text{K}$   
 $T_0 = 57.9^\circ \text{K}$

| Y<br>(mm) | M    | $T/T_0$ | $W/W_0$ |
|-----------|------|---------|---------|
| 16.26     | 6.49 | 1.000   | 1.000   |
| 14.99     | 6.47 | 1.005   | 1.000   |
| 13.72     | 6.42 | 1.021   | 1.000   |
| 12.45     | 6.36 | 1.040   | .999    |
| 11.18     | 6.25 | 1.074   | .998    |
| 9.91      | 6.07 | 1.130   | .994    |
| 8.64      | 5.81 | 1.211   | .986    |
| 7.37      | 5.46 | 1.333   | .972    |
| 6.10      | 5.03 | 1.506   | .950    |
| 4.83      | 4.56 | 1.727   | .923    |
| 3.56      | 4.07 | 2.012   | .890    |
| 2.29      | 3.57 | 2.377   | .848    |
| 2.03      | 3.47 | 2.458   | .838    |
| 1.78      | 3.34 | 2.553   | .822    |
| 1.27      | 3.16 | 2.560   | .778    |
| 1.02      | 2.92 | 2.584   | .724    |
| .762      | 2.61 | 2.712   | .661    |
| .508      | 1.97 | 3.242   | .546    |
| .279      | 1.17 | 4.074   | .363    |

TABLE 7 - Run 5

$$\begin{aligned}
 M_B &= 6.36 \\
 Re_B &= 3206 \\
 \frac{D_V}{B} &= 4.102 \\
 P_0 &= 15.15 \text{ atm} \\
 T_c &= 548 \text{ }^\circ\text{K} \\
 T_B &= 60.4 \text{ }^\circ\text{K} \\
 U_B &= 994 \text{ m/sec}
 \end{aligned}$$

| Y<br>(cm) | M    | $T/T_B$ | $U/U_B$ |
|-----------|------|---------|---------|
| 10.83     | 6.38 | 1.000   | 1.000   |
| 10.19     | 6.31 | 1.020   | .999    |
| 9.56      | 6.18 | 1.059   | .997    |
| 8.92      | 6.01 | 1.109   | .992    |
| 8.29      | 5.80 | 1.175   | .986    |
| 7.65      | 5.54 | 1.262   | .976    |
| 7.02      | 5.23 | 1.370   | .963    |
| 6.38      | 4.93 | 1.495   | .947    |
| 5.75      | 4.63 | 1.639   | .920    |
| 5.11      | 4.33 | 1.800   | .910    |
| 4.48      | 4.01 | 1.984   | .886    |
| 3.84      | 3.76 | 2.156   | .865    |
| 3.21      | 3.50 | 2.351   | .841    |
| 2.57      | 3.27 | 2.536   | .816    |
| 1.94      | 3.02 | 2.754   | .786    |
| 1.30      | 2.71 | 2.879   | .722    |
| .668      | 2.14 | 2.994   | .581    |
| .414      | 1.58 | 3.427   | .459    |
| .279      | 1.13 | 3.574   | .334    |

TABLE 8 - Run 6

$$\begin{aligned}
 M_B &= 6.49 \\
 Re_B &= 4,028 \\
 \frac{D_V}{B} &= 4.132 \\
 P_0 &= 15.22 \text{ atm} \\
 T_c &= 548 \text{ }^\circ\text{K} \\
 T_B &= 58.1 \text{ }^\circ\text{K} \\
 U_B &= 992 \text{ m/sec}
 \end{aligned}$$

| Y<br>(cm) | M    | $T/T_B$ | $U/U_B$ |
|-----------|------|---------|---------|
| 19.94     | 6.49 | 1.000   | 1.000   |
| 13.59     | 6.45 | 1.011   | .999    |
| 12.95     | 6.42 | 1.022   | .999    |
| 12.32     | 6.36 | 1.038   | .998    |
| 11.68     | 6.27 | 1.064   | .996    |
| 11.05     | 6.15 | 1.099   | .993    |
| 10.41     | 6.02 | 1.138   | .986    |
| 9.78      | 5.83 | 1.197   | .982    |
| 9.14      | 5.63 | 1.261   | .974    |
| 8.51      | 5.41 | 1.342   | .965    |
| 7.87      | 5.10 | 1.430   | .953    |
| 7.24      | 4.93 | 1.537   | .941    |
| 6.60      | 4.68 | 1.652   | .926    |
| 5.97      | 4.42 | 1.781   | .909    |
| 5.33      | 4.20 | 1.907   | .892    |
| 4.70      | 3.96 | 2.051   | .873    |
| 4.06      | 3.74 | 2.196   | .853    |
| 3.43      | 3.49 | 2.381   | .829    |
| 2.79      | 3.27 | 2.551   | .804    |
| 2.16      | 3.06 | 2.698   | .778    |
| 1.52      | 2.76 | 2.835   | .727    |
| 1.27      | 2.63 | 2.976   | .699    |
| 1.02      | 2.42 | 3.039   | .649    |
| .762      | 2.15 | 3.055   | .579    |
| .508      | 1.71 | 3.286   | .476    |
| .361      | 1.41 | 3.538   | .408    |
| .279      | 1.15 | 3.737   | .341    |



TABLE 10 - Run 8

$M = 6.48$   
 $Re = 5,288$   
 $\frac{D}{T} = 4.167$   
 $C = 9.21 \cdot 10^{-4}$   
 $P = 15.22 \text{ atm}$   
 $T = 548 \text{ K}$   
 $T = 58.3 \text{ K}$   
 $U = 992 \text{ m/sec}$

| $Y$<br>(mm) | $M$ | $T/T_0$ | $U/U_0$ |
|-------------|-----|---------|---------|
|-------------|-----|---------|---------|

|       |       |       |       |
|-------|-------|-------|-------|
| 20.09 | 6.48  | 1.000 | 1.000 |
| 18.52 | 6.47  | 1.001 | 1.000 |
| 17.35 | 6.40  | 1.022 | 999   |
| 16.28 | 6.29  | 1.055 | 997   |
| 15.01 | 6.14  | 1.100 | 994   |
| 13.76 | 5.93  | 1.167 | 988   |
| 12.47 | 5.63  | 1.267 | 978   |
| 11.20 | 5.31  | 1.380 | 963   |
| 9.91  | 4.95  | 1.529 | 945   |
| 8.64  | 4.58  | 1.703 | 922   |
| 7.39  | 4.25  | 1.873 | 897   |
| 6.12  | 3.84  | 2.120 | 864   |
| 4.83  | 3.46  | 2.394 | 826   |
| 3.51  | 3.07  | 2.708 | 780   |
| 2.21  | 2.61  | 3.059 | 721   |
| 1.676 | 2.49  | 3.165 | 684   |
| 1.295 | 2.29  | 3.212 | 644   |
| 1.041 | 2.14  | 3.185 | 591   |
| .787  | 1.88  | 3.229 | 527   |
| .533  | 1.60  | 3.706 | 417   |
| .406  | 1.093 | 3.966 | 337   |
| .279  | .916  | 4.012 | .283  |

TABLE 9 - Run 7

$M_0 = 6.60$   
 $Re_0 = 4698$   
 $\frac{D}{T_0} = 4.263$   
 $C = 5.85 \cdot 10^{-4}$   
 $P_0 = 15.15 \text{ atm}$   
 $T_0 = 547 \text{ K}$   
 $T_0 = 56.1 \text{ K}$   
 $U_0 = 997 \text{ m/sec}$

| $Y$<br>(mm) | $M$ | $T/T_0$ | $U/U_0$ |
|-------------|-----|---------|---------|
|-------------|-----|---------|---------|

|       |      |       |       |
|-------|------|-------|-------|
| 18.69 | 6.60 | 1.000 | 1.000 |
| 16.15 | 6.55 | 1.013 | 1.000 |
| 14.85 | 6.48 | 1.015 | 1.000 |
| 13.61 | 6.36 | 1.070 | 997   |
| 12.34 | 6.15 | 1.135 | 993   |
| 11.71 | 6.01 | 1.179 | 989   |
| 11.07 | 5.84 | 1.238 | 984   |
| 10.44 | 5.64 | 1.306 | 978   |
| 9.804 | 5.47 | 1.368 | 969   |
| 8.534 | 5.25 | 1.459 | 961   |
| 7.899 | 5.03 | 1.553 | 949   |
| 7.264 | 4.81 | 1.653 | 925   |
| 6.639 | 4.59 | 1.768 | 898   |
| 5.984 | 4.38 | 1.881 | 864   |
| 5.359 | 4.15 | 2.017 | 826   |
| 4.724 | 3.94 | 2.157 | 780   |
| 4.089 | 3.72 | 2.314 | 721   |
| 3.454 | 3.51 | 2.472 | 684   |
| 2.819 | 3.28 | 2.643 | 644   |
| 2.184 | 3.07 | 2.861 | 591   |
| 1.549 | 2.82 | 3.120 | 527   |
| .914  | 2.58 | 3.289 | 417   |
| .640  | 2.13 | 3.381 | 337   |
| .406  | 1.77 | 3.586 | .508  |
| .279  | 1.29 | 3.815 | .287  |
|       | 1.10 | 3.967 | .333  |

TABLE 12 - Run 10

$M = 6.422$   
 $P_0 = 15.12 \text{ atm}$   
 $R_{\theta} = 6.081$   
 $T_c = 547 \text{ }^\circ\text{K}$   
 $T_g = 59.1 \text{ }^\circ\text{K}$   
 $U_g = 990 \text{ m/sec}$   
 $C_q = 16.24 \times 10^{-4}$

| Y<br>(cm) | M    | T/T <sub>g</sub> | V/U <sub>g</sub> |
|-----------|------|------------------|------------------|
| 21.23     | 6.42 | 1.000            | 1.000            |
| 19.96     | 6.38 | 1.010            | .999             |
| 18.69     | 6.32 | 1.032            | .999             |
| 17.42     | 6.20 | 1.070            | .998             |
| 16.79     | 6.12 | 1.095            | .997             |
| 16.15     | 6.02 | 1.126            | .993             |
| 15.52     | 5.89 | 1.166            | .990             |
| 14.88     | 5.75 | 1.212            | .986             |
| 14.25     | 5.50 | 1.264            | .979             |
| 13.61     | 5.41 | 1.331            | .972             |
| 12.98     | 5.22 | 1.404            | .964             |
| 12.34     | 5.04 | 1.482            | .955             |
| 11.71     | 4.84 | 1.570            | .944             |
| 11.07     | 4.63 | 1.666            | .930             |
| 10.44     | 4.43 | 1.765            | .916             |
| 9.804     | 4.23 | 1.873            | .901             |
| 9.169     | 4.03 | 1.996            | .886             |
| 8.534     | 3.82 | 2.132            | .869             |
| 7.899     | 3.64 | 2.281            | .849             |
| 7.264     | 3.44 | 2.395            | .829             |
| 6.629     | 3.27 | 2.522            | .808             |
| 5.994     | 3.05 | 2.714            | .782             |
| 5.359     | 2.87 | 2.880            | .757             |
| 4.724     | 2.71 | 3.023            | .734             |
| 4.089     | 2.49 | 3.255            | .699             |
| 3.454     | 2.37 | 3.333            | .673             |
| 2.815     | 2.15 | 3.587            | .634             |
| 2.184     | 1.92 | 3.848            | .588             |
| 1.930     | 1.86 | 3.897            | .570             |
| 1.676     | 1.77 | 3.934            | .546             |
| 1.422     | 1.65 | 3.954            | .513             |
| 1.168     | 1.50 | 4.004            | .468             |
| .914      | 1.34 | 3.980            | .424             |
| .660      | 1.10 | 4.091            | .348             |
| .406      | .716 | 4.266            | .279             |
| .279      | .534 | 4.216            | .171             |

TABLE 11 - Run 9

$M_g = 6.39$   
 $P_0 = 15.17 \text{ atm}$   
 $R_{\theta} = 4.919$   
 $T_c = 546 \text{ }^\circ\text{K}$   
 $T_g = 59.5 \text{ }^\circ\text{K}$   
 $U_g = 989 \text{ m/sec}$   
 $C_q = 16.86 \times 10^{-4}$

| Y<br>(cm) | M    | T/T <sub>g</sub> | V/U <sub>g</sub> |
|-----------|------|------------------|------------------|
| 20.55     | 6.39 | 1.000            | 1.000            |
| 14.20     | 6.29 | 1.030            | .998             |
| 12.93     | 6.06 | 1.099            | .994             |
| 11.66     | 5.72 | 1.216            | .987             |
| 10.39     | 5.26 | 1.397            | .973             |
| 9.75      | 5.01 | 1.505            | .962             |
| 9.12      | 4.93 | 1.526            | .952             |
| 8.48      | 4.48 | 1.749            | .928             |
| 7.85      | 4.22 | 1.898            | .909             |
| 7.21      | 3.95 | 2.067            | .887             |
| 6.58      | 3.71 | 2.228            | .865             |
| 5.94      | 3.46 | 2.412            | .839             |
| 5.31      | 3.22 | 2.599            | .813             |
| 4.67      | 2.99 | 2.814            | .783             |
| 4.037     | 2.76 | 3.027            | .751             |
| 3.402     | 2.57 | 3.216            | .721             |
| 2.767     | 2.36 | 3.436            | .685             |
| 2.132     | 2.13 | 3.650            | .644             |
| 1.497     | 1.86 | 3.847            | .572             |
| .862      | 1.43 | 3.882            | .440             |
| .227      | .723 | 4.033            | .227             |

TABLE 14 - Run 12

$M_0 = 6.287$   $P_0 = 15.15 \text{ atm}$   
 $Re_0 = 6.517$   $T_c = 547 \text{ K}$   
 $\frac{N}{T_0} = 3.864$   $T_0 = 619 \text{ K}$   
 $C_0 = 24.91 \times 10^{-4}$   $U_0 = 990 \text{ m/sec}$

| Y<br>(m) | N    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|----------|------|------------------|------------------|
| 18.74    | 6.28 | 1.000            | 1.000            |
| 18.11    | 6.24 | 1.011            | 1.000            |
| 16.84    | 6.14 | 1.044            | .999             |
| 15.57    | 5.92 | 1.110            | .994             |
| 14.30    | 5.54 | 1.222            | .984             |
| 13.03    | 5.13 | 1.390            | .964             |
| 11.76    | 4.67 | 1.589            | .937             |
| 10.49    | 4.17 | 1.819            | .901             |
| 9.218    | 3.69 | 2.139            | .860             |
| 7.948    | 3.24 | 2.455            | .809             |
| 6.678    | 2.82 | 2.801            | .753             |
| 5.408    | 2.43 | 3.169            | .689             |
| 4.138    | 2.08 | 3.528            | .623             |
| 2.868    | 1.74 | 3.872            | .547             |
| 1.598    | 1.37 | 4.010            | .489             |
| .963     | 1.38 | 4.074            | .443             |
| .328     | .971 | 4.212            | .317             |
| .279     | .685 | 4.397            | .215             |
|          | .491 | 4.010            | .156             |

TABLE 13 - Run 11

$M_0 = 6.37$   $P_0 = 15.16 \text{ atm}$   
 $Re_0 = 7.511$   $T_c = 547 \text{ K}$   
 $\frac{N}{T_0} = 3.808$   $T_0 = 60.0 \text{ K}$   
 $C_0 = 17.81 \times 10^{-4}$   $U_0 = 989 \text{ m/sec}$

| Y<br>(m) | N     | T/T <sub>0</sub> | U/U <sub>0</sub> |
|----------|-------|------------------|------------------|
| 22.561   | 6.37  | 1.000            | 1.000            |
| 21.311   | 6.31  | 1.017            | .999             |
| 20.041   | 6.21  | 1.046            | .997             |
| 18.771   | 6.055 | 1.093            | .994             |
| 17.501   | 5.842 | 1.158            | .977             |
| 16.231   | 5.57  | 1.248            | .962             |
| 14.961   | 5.229 | 1.372            | .945             |
| 13.691   | 4.932 | 1.491            | .923             |
| 12.421   | 4.562 | 1.660            | .896             |
| 11.151   | 4.195 | 1.851            | .867             |
| 9.881    | 3.872 | 2.034            | .835             |
| 8.611    | 3.551 | 2.263            | .787             |
| 7.341    | 3.228 | 2.473            | .752             |
| 6.071    | 2.903 | 2.724            | .700             |
| 4.801    | 2.581 | 2.982            | .640             |
| 3.531    | 2.26  | 3.256            | .576             |
| 2.261    | 1.965 | 3.484            | .436             |
| .991     | 1.493 | 3.458            | .309             |
| .483     | 1.037 | 3.593            | .279             |
| .279     | .571  | 3.848            | .176             |

TABLE 15 - Run 13

$M_\delta = 6.204$   
 $Re_\delta = 8.156$   
 $\frac{D}{T_\delta} = 3.640$   
 $Cq = 24.52 \times 10^{-4}$   
 $P_0 = 15.15 \text{ atm}$   
 $T_c = 547^\circ K$   
 $T_\delta = 62.9^\circ K$   
 $U_\delta = 987 \text{ m/sec}$

| Y<br>(cm) | M    | T/T <sub>δ</sub> | u/u <sub>δ</sub> |
|-----------|------|------------------|------------------|
| 26.24     | 6.20 | 1.000            | 1.000            |
| 19.89     | 6.11 | 1.029            | .999             |
| 18.62     | 5.98 | 1.069            | .997             |
| 17.15     | 5.77 | 1.130            | .988             |
| 16.08     | 5.69 | 1.220            | .977             |
| 14.81     | 5.06 | 1.376            | .957             |
| 13.54     | 4.66 | 1.562            | .932             |
| 12.27     | 4.15 | 1.797            | .897             |
| 11.63     | 4.02 | 1.862            | .883             |
| 11.00     | 3.75 | 2.026            | .861             |
| 10.36     | 3.54 | 2.162            | .839             |
| 9.728     | 3.35 | 2.293            | .818             |
| 9.093     | 3.16 | 2.430            | .794             |
| 8.458     | 2.91 | 2.577            | .770             |
| 7.823     | 2.79 | 2.734            | .743             |
| 7.188     | 2.60 | 2.893            | .713             |
| 6.553     | 2.44 | 3.032            | .685             |
| 5.918     | 2.30 | 3.162            | .657             |
| 5.283     | 2.16 | 3.292            | .625             |
| 4.648     | 2.03 | 3.355            | .599             |
| 4.013     | 1.82 | 3.562            | .555             |
| 3.378     | 1.68 | 3.682            | .520             |
| 2.763     | 1.56 | 3.709            | .486             |
| 2.108     | 1.39 | 3.772            | .436             |
| 1.473     | 1.25 | 3.740            | .388             |
| .838      | .980 | 3.734            | .305             |
| .279      | .516 | 3.734            | .161             |

TABLE 16 - Run 14

$M_\delta = 6.22$   
 $Re_\delta = 8450$   
 $\frac{D}{T_\delta} = 3.759$   
 $Cq = 24.90 \times 10^{-4}$   
 $P_0 = 15.15 \text{ atm}$   
 $T_c = 547^\circ K$   
 $T_\delta = 62.5^\circ K$   
 $U_\delta = 987 \text{ m/sec}$

| Y<br>(cm) | M    | T/T <sub>δ</sub> | u/u <sub>δ</sub> |
|-----------|------|------------------|------------------|
| 27.61     | 6.22 | 1.000            | 1.000            |
| 26.34     | 6.21 | 1.005            | 1.000            |
| 25.07     | 6.19 | 1.011            | 1.000            |
| 21.89     | 6.15 | 1.064            | .998             |
| 20.62     | 5.89 | 1.105            | .995             |
| 18.72     | 5.52 | 1.225            | .982             |
| 18.08     | 5.37 | 1.279            | .975             |
| 16.82     | 5.05 | 1.398            | .956             |
| 15.54     | 4.68 | 1.555            | .938             |
| 14.91     | 4.49 | 1.642            | .926             |
| 13.64     | 4.12 | 1.836            | .898             |
| 13.01     | 3.94 | 1.944            | .883             |
| 12.37     | 3.76 | 2.080            | .867             |
| 11.74     | 3.58 | 2.177            | .849             |
| 11.10     | 3.40 | 2.310            | .831             |
| 10.46     | 3.24 | 2.426            | .812             |
| 9.830     | 3.10 | 2.536            | .793             |
| 9.195     | 2.93 | 2.674            | .770             |
| 8.560     | 2.74 | 2.845            | .744             |
| 7.925     | 2.59 | 2.990            | .719             |
| 7.290     | 2.44 | 3.112            | .693             |
| 6.655     | 2.31 | 3.226            | .668             |
| 6.020     | 2.15 | 3.387            | .637             |
| 5.395     | 2.03 | 3.501            | .610             |
| 4.750     | 1.89 | 3.637            | .579             |
| 4.115     | 1.77 | 3.741            | .550             |
| 3.480     | 1.64 | 3.853            | .518             |
| 2.845     | 1.52 | 3.945            | .486             |
| 2.210     | 1.38 | 4.041            | .440             |
| 1.575     | 1.19 | 4.132            | .388             |
| .840      | .977 | 4.132            | .313             |
| .486      | .815 | 3.946            | .260             |
| .432      | .551 | 3.965            | .176             |
| .279      | .443 | 3.893            | .140             |

TABLE 17 - Run 15

$H_g = 6.22$   
 $H_{g0} = 10.166$   
 $T_g = 3.663$   
 $C_q = 25.80 \times 10^{-4}$   
 $P_0 = 15.22 \text{ atm}$   
 $T_c = 547 \text{ K}$   
 $T_g = 62.5 \text{ K}$   
 $U_g = 987 \text{ m/sec}$

| $Y$<br>(cm) | M    | $T/T_g$ | $U/U_g$ |
|-------------|------|---------|---------|
| 30.23       | 6.22 | 1.000   | 1.000   |
| 27.69       | 6.22 | 1.002   | 1.000   |
| 25.15       | 6.11 | 1.033   | 1.000   |
| 22.61       | 5.84 | 1.116   | .998    |
| 20.07       | 5.35 | 1.278   | .992    |
| 17.53       | 4.69 | 1.560   | .971    |
| 14.99       | 4.06 | 1.851   | .936    |
| 12.45       | 3.40 | 2.262   | .888    |
| 9.906       | 2.85 | 2.664   | .821    |
| 7.366       | 2.32 | 3.097   | .747    |
| 4.826       | 1.86 | 3.423   | .656    |
| 2.286       | 1.40 | 3.708   | .553    |
| 1.016       | 1.04 | 3.528   | .432    |
| .279        | .593 | 3.512   | .313    |
|             |      |         | .179    |

TABLE 18 - Run 16

$H_g = 6.52$   
 $H_{g0} = 1716$   
 $T_g = 4.418$   
 $C_q = 0$   
 $P_0 = 15.2 \text{ atm}$   
 $T_c = 548 \text{ K}$   
 $T_g = 57.6 \text{ K}$   
 $U_g = 992 \text{ m/sec}$

| $Y$<br>(cm) | M     | $T/T_g$ | $U/U_g$ |
|-------------|-------|---------|---------|
| 16.28       | 6.52  | 1.000   | 1.000   |
| 13.74       | 6.52  | 1.000   | 1.000   |
| 11.20       | 6.49  | 1.000   | 1.000   |
| 8.661       | 6.48  | 1.012   | 1.000   |
| 6.121       | 6.47  | 1.015   | 1.000   |
| 3.581       | 6.39  | 1.040   | .999    |
| 1.041       | 6.10  | 1.097   | .984    |
| .279        | 4.851 | 1.250   | .971    |
|             | 4.216 | 1.386   | .942    |
|             | 3.835 | 1.470   | .932    |
|             | 3.581 | 1.593   | .922    |
|             | 3.327 | 1.687   | .942    |
|             | 3.073 | 1.792   | .931    |
|             | 2.819 | 1.913   | .920    |
|             | 2.565 | 2.023   | .909    |
|             | 2.311 | 2.141   | .896    |
|             | 2.057 | 2.298   | .883    |
|             | 1.803 | 2.326   | .877    |
|             | 1.549 | 2.397   | .869    |
|             | 1.292 | 2.535   | .853    |
|             | 1.041 | 2.667   | .833    |
|             | .777  | 2.830   | .800    |
|             | .533  | 3.155   | .733    |
|             | .279  | 3.714   | .606    |
|             |       | 3.576   | .507    |

TABLE 19 - Run 17

$M_0 = 6.32$   
 $R_{E0} = 1993$   
 $\frac{Z_0}{T_0} = 4.171$   
 $C_0 = 0$

$P_0 = 15.2 \text{ atm}$   
 $T_c = 548 \text{ K}$   
 $T_0 = 61.0 \text{ K}$   
 $U_0 = 990 \text{ m/sec}$

| $\gamma$<br>(m) | M    | $T/T_0$ | $U/U_0$ |
|-----------------|------|---------|---------|
| 12.47           | 6.32 | 1.000   | 1.000   |
| 9.931           | 6.28 | 1.011   | 1.000   |
| 8.661           | 6.20 | 1.039   | .999    |
| 7.391           | 5.97 | 1.108   | .995    |
| 6.121           | 5.60 | 1.234   | .984    |
| 4.851           | 5.03 | 1.429   | .950    |
| 3.581           | 4.39 | 1.779   | .927    |
| 2.946           | 4.02 | 2.015   | .903    |
| 2.545           | 3.87 | 2.111   | .889    |
| 2.311           | 3.72 | 2.234   | .879    |
| 2.057           | 3.61 | 2.317   | .869    |
| 1.803           | 3.49 | 2.410   | .858    |
| 1.549           | 3.36 | 2.516   | .843    |
| 1.295           | 3.23 | 2.613   | .826    |
| 1.041           | 3.04 | 2.713   | .792    |
| .787            | 2.76 | 2.832   | .734    |
| .533            | 2.17 | 3.221   | .616    |
| .279            | 1.24 | 4.010   | .392    |

TABLE 20 - Run 18

$M_0 = 6.44$   
 $R_{E0} = 2349$   
 $\frac{Z_0}{T_0} = 4.346$   
 $C_0 = 0$

$P_0 = 15.2 \text{ atm}$   
 $T_c = 547 \text{ K}$   
 $T_0 = 59.0 \text{ K}$   
 $U_0 = 991 \text{ m/sec}$

| $\gamma$<br>(m) | M    | $T/T_0$ | $U/U_0$ |
|-----------------|------|---------|---------|
| 15.29           | 6.44 | 1.000   | 1.000   |
| 12.75           | 6.43 | 1.002   | .999    |
| 10.21           | 6.30 | 1.042   | .999    |
| 7.671           | 5.79 | 1.206   | .989    |
| 6.401           | 5.36 | 1.366   | .974    |
| 5.131           | 4.86 | 1.583   | .950    |
| 3.861           | 4.30 | 1.889   | .918    |
| 2.591           | 3.76 | 2.261   | .878    |
| 1.956           | 3.48 | 2.490   | .834    |
| 1.321           | 3.16 | 2.763   | .815    |
| .686            | 2.48 | 3.172   | .685    |
| .432            | 1.78 | 3.778   | .538    |
| .279            | 1.40 | 3.988   | .435    |

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TABLE 21 - Run 19

|               |                          |               |                           |
|---------------|--------------------------|---------------|---------------------------|
| $M_0 = 6.45$  | $P_0 = 15.2 \text{ atm}$ | $M_0 = 6.68$  | $P_0 = 20.05 \text{ atm}$ |
| $Re_0 = 3023$ | $T_c = 547 \text{ K}$    | $Re_0 = 3296$ | $T_c = 550 \text{ K}$     |
| $T_0 = 4.297$ | $T_0 = 58.6 \text{ K}$   | $T_0 = 4.381$ | $T_0 = 55.5 \text{ K}$    |
| $T_0$         | $U = 991 \text{ m/sec}$  | $T_0$         | $U = 998 \text{ m/sec}$   |
| $C_q = 0$     |                          | $C_q = 0$     |                           |

| Y<br>(m) | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|----------|------|------------------|------------------|
| 27.20    | 6.45 | 1.000            | 1.000            |
| 24.66    | 6.45 | 1.007            | 1.000            |
| 22.12    | 6.44 | 1.004            | 1.000            |
| 19.58    | 6.41 | 1.012            | .999             |
| 17.04    | 6.38 | 1.020            | .999             |
| 14.50    | 6.34 | 1.034            | .998             |
| 13.23    | 6.28 | 1.051            | .998             |
| 11.96    | 6.18 | 1.081            | .996             |
| 10.69    | 6.03 | 1.132            | .994             |
| 9.423    | 5.81 | 1.208            | .989             |
| 8.153    | 5.47 | 1.333            | .979             |
| 6.883    | 5.04 | 1.514            | .942             |
| 5.613    | 4.58 | 1.782            | .938             |
| 4.343    | 4.13 | 2.004            | .907             |
| 3.708    | 3.91 | 2.150            | .889             |
| 3.073    | 3.65 | 2.350            | .867             |
| 2.819    | 3.56 | 2.422            | .859             |
| 2.565    | 3.54 | 2.436            | .855             |
| 2.311    | 3.37 | 2.594            | .840             |
| 2.057    | 3.26 | 2.693            | .829             |
| 1.803    | 3.14 | 2.806            | .816             |
| 1.549    | 3.04 | 2.901            | .803             |
| 1.295    | 2.91 | 3.017            | .783             |
| 1.041    | 2.71 | 3.145            | .746             |
| .787     | 2.42 | 3.313            | .681             |
| .533     | 2.08 | 3.750            | .665             |
| .406     | 1.54 | 4.042            | .479             |
| .279     | 1.07 | 4.459            | .349             |

TABLE 22 - Run 20

|               |                           |
|---------------|---------------------------|
| $M_0 = 6.68$  | $P_0 = 20.05 \text{ atm}$ |
| $Re_0 = 3296$ | $T_c = 550 \text{ K}$     |
| $T_0 = 4.381$ | $T_0 = 55.5 \text{ K}$    |
| $T_0$         | $U = 998 \text{ m/sec}$   |
| $C_q = 0$     |                           |

| Y<br>(m) | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|----------|------|------------------|------------------|
| 19.20    | 6.68 | 1.000            | 1.000            |
| 12.85    | 6.65 | 1.009            | 1.000            |
| 11.58    | 6.63 | 1.016            | 1.000            |
| 10.31    | 6.55 | 1.039            | 1.000            |
| 9.042    | 6.48 | 1.060            | .999             |
| 8.407    | 6.37 | 1.093            | .997             |
| 7.772    | 6.24 | 1.135            | .995             |
| 7.137    | 6.06 | 1.193            | .990             |
| 6.502    | 5.84 | 1.266            | .984             |
| 5.867    | 5.60 | 1.356            | .976             |
| 5.232    | 5.32 | 1.468            | .965             |
| 4.597    | 5.05 | 1.586            | .952             |
| 3.962    | 4.77 | 1.719            | .937             |
| 3.327    | 4.46 | 1.883            | .920             |
| 2.692    | 4.19 | 2.058            | .901             |
| 2.438    | 3.90 | 2.266            | .875             |
| 2.184    | 3.77 | 2.365            | .867             |
| 1.930    | 3.64 | 2.464            | .857             |
| 1.676    | 3.50 | 2.591            | .843             |
| 1.422    | 3.39 | 2.683            | .831             |
| 1.168    | 3.25 | 2.829            | .818             |
| .914     | 3.09 | 2.970            | .798             |
| .787     | 2.93 | 3.063            | .767             |
| .660     | 2.80 | 3.120            | .741             |
| .533     | 2.58 | 3.289            | .701             |
| .406     | 2.33 | 3.459            | .646             |
| .279     | 1.93 | 3.703            | .557             |
|          | 1.45 | 4.085            | .439             |

TABLE 23 - Run 21

$M_\delta = 6.41$   
 $Re_\delta = 3891$   
 $\frac{T_w}{T_\delta} = 4.116$   
 $Cq = 0$   
 $P_o = 24.95 \text{ atm}$   
 $T_c = 550 \text{ K}$   
 $T_\delta = 60.0 \text{ K}$   
 $U_\delta = 994 \text{ m/sec}$

| $Y$<br>(mm) | $M$  | $T/T_\delta$ | $U/U_\delta$ |
|-------------|------|--------------|--------------|
| 21.82       | 6.41 | 1.000        | 1.000        |
| 15.47       | 6.41 | 1.000        | 1.000        |
| 11.66       | 6.34 | 1.019        | .999         |
| 10.39       | 6.30 | 1.032        | .998         |
| 9.119       | 6.16 | 1.076        | .998         |
| 7.849       | 5.87 | 1.171        | .991         |
| 6.579       | 5.46 | 1.317        | .977         |
| 5.309       | 4.94 | 1.530        | .954         |
| 4.039       | 4.38 | 1.812        | .920         |
| 2.769       | 3.75 | 2.223        | .873         |
| 1.499       | 3.12 | 2.749        | .808         |
| .864        | 2.73 | 3.059        | .746         |
| .737        | 2.60 | 3.053        | .709         |
| .610        | 2.40 | 3.259        | .675         |
| .483        | 2.09 | 3.472        | .607         |
| .356        | 1.65 | 3.837        | .505         |
| .279        | 1.36 | 4.032        | .427         |



TABLE 24 SUMMARY OF SKIN FRICTION AND HEAT TRANSFER DATA,  $T_w/T_b = 5.2$ 

$$T_w/T_b = 5.2$$

| ROW                                              | X     | $M_B$ | $P_o$ | $Re_x \times 10^{-6}$ | $Re_\theta$ | $T_w/T_b$ | $C_q \times 10^6$ | $C_f \times 10^6$ | $C_f/C_{fo}$ | $2C_q/C_{fo}$ | $St \times 10^4$ | $\frac{St}{St_o}$ |
|--------------------------------------------------|-------|-------|-------|-----------------------|-------------|-----------|-------------------|-------------------|--------------|---------------|------------------|-------------------|
| $C_q = 0 \quad T_w/T_b = 5.44$                   |       |       |       |                       |             |           |                   |                   |              |               |                  |                   |
| 22                                               | 377.8 | 6.46  | 15.22 | 3.028                 | 1619        | 5.45      | 0                 | 15.6              |              |               | 6.77             |                   |
| 23                                               | 428.6 | 6.46  | 15.25 | 3.323                 | 1853        | 5.116     | 0                 | 11.85             | 1.000        | 0             | 6.42             | 1.000             |
| 24                                               | 479.4 | 6.62  | 15.08 | 4.210                 | 2520        | 5.722     | 0                 | 14.74             | 1.000        | 0             | 6.69             | 1.000             |
| 25                                               | 530.2 | 6.45  | 15.12 | 4.285                 | 2667        | 5.427     | 0                 | 12.10             | 1.000        | 0             | 5.18             | 1.000             |
| $C_q = 8.77 \times 10^{-4} \quad T_w/T_b = 5.45$ |       |       |       |                       |             |           |                   |                   |              |               |                  |                   |
| 26                                               | 377.8 | 6.45  | 15.01 | 3.468                 | 2994        | 5.210     | 8.944             | 10.91             | .656         | 1.076         | 5.45             | .754              |
| 27                                               | 428.6 | 6.50  | 15.15 | 3.552                 | 3448        | 5.502     | 8.932             | 9.11              | .738         | 1.508         | 4.66             | .726              |
| 28                                               | 479.4 | 6.64  | 15.08 | 4.438                 | 4554        | 5.741     | 8.432             | 10.83             | .735         | 1.144         | 4.26             | .637              |
| 29                                               | 530.2 | 6.55  | 15.05 | 4.701                 | 5281        | 5.348     | 8.756             | 7.82              | .646         | 1.439         | 3.97             | .765              |
| $C_q = 17.2 \times 10^{-4} \quad T_w/T_b = 5.07$ |       |       |       |                       |             |           |                   |                   |              |               |                  |                   |
| 30                                               | 377.8 | 6.21  | 15.22 | 2.894                 | 4519        | 4.752     | 17.57             | 6.22              | .374         | 2.114         | 3.19             | .441              |
| 31                                               | 428.6 | 6.30  | 15.15 | 3.495                 | 5365        | 4.954     | 17.14             | 5.76              | .486         | 2.892         | 3.28             | .511              |
| 32                                               | 479.4 | 6.39  | 15.20 | 3.885                 | 6223        | 5.119     | 17.45             | 6.75              | .458         | 2.368         | 2.68             | .401              |
| 33                                               | 530.2 | 6.62  | 15.05 | 5.050                 | 8048        | 5.468     | 16.46             | 8.14              | .673         | 2.721         | 2.58             | .498              |
| $C_q = 24.6 \times 10^{-4} \quad T_w/T_b = 4.85$ |       |       |       |                       |             |           |                   |                   |              |               |                  |                   |
| 34                                               | 377.8 | 6.27  | 15.08 | 3.264                 | 6826        | 4.800     | 24.42             | 6.26              | .377         | 2.938         | 2.26             | .312              |
| 35                                               | 428.6 | 6.33  | 15.12 | 4.045                 | 8651        | 4.872     | 22.96             | 3.98              | .336         | 3.875         | 1.85             | .288              |
| 36                                               | 479.4 | 6.27  | 15.15 | 3.940                 | 8969        | 4.838     | 26.47             | 2.58              | .184         | 3.592         | 1.98             | .276              |
| 37                                               | 530.2 | 6.37  | 15.12 | 4.773                 | 10640       | 4.887     | 24.44             | 5.34              | .441         | 4.040         | 1.88             | --                |
| $C_q = 0 \quad T_w/T_b = 5.58$                   |       |       |       |                       |             |           |                   |                   |              |               |                  |                   |
| 38                                               | 377.8 | 6.53  | 15.05 | 3.161                 | 1713        | 5.582     | 0                 | 16.62             | 1.000        | 0             | 7.23             | 1.000             |

TABLE 25 SUMMARY OF BOUNDARY LAYER PARAMETERS,  $T_w/T_g = 5.2$  $T_w/T_g = 5.2$ 

| RUN                                          | X<br>— | $Re_x \times 10^{-6}$ | $T_w/T_g$ | $C_q \times 10^{-4}$ | $\theta$<br>— | $\delta^*$<br>— | $\delta$<br>— | $\theta$<br>— | $Re_\theta$ | $\theta^*$<br>$\theta$ |
|----------------------------------------------|--------|-----------------------|-----------|----------------------|---------------|-----------------|---------------|---------------|-------------|------------------------|
| $C_q = 0$ $T_w/T_g = 5.44$                   |        |                       |           |                      |               |                 |               |               |             |                        |
| 22                                           | 377.8  | 3.028                 | 5.45      | 0                    | .202          | 3.22            | 5.65          | NC            | 1619        |                        |
| 23                                           | 428.6  | 3.323                 | 5.116     | 0                    | .239          | 3.54            | 6.70          | NC            | 1853        | 14.81                  |
| 24                                           | 479.4  | 4.210                 | 5.722     | 0                    | .287          | 4.77            | 8.30          | .300          | 2520        | 16.62                  |
| 25                                           | 530.2  | 4.285                 | 5.427     | 0                    | .330          | 5.62            | 9.15          | NC            | 2667        | 15.21                  |
| $C_q = 8.77 \times 10^{-4}$ $T_w/T_g = 5.45$ |        |                       |           |                      |               |                 |               |               |             |                        |
| 26                                           | 377.8  | 3.468                 | 5.210     | 8.944                | .370          | 5.25            | 9.00          | .328          | 2994        | 14.19                  |
| 27                                           | 428.6  | 3.552                 | 5.502     | 8.932                | .416          | 5.94            | 10.70         | NC            | 3448        | 14.29                  |
| 28                                           | 479.4  | 4.438                 | 5.741     | 8.482                | .492          | 8.04            | 12.70         | .604          | 4554        | 16.34                  |
| 29                                           | 530.2  | 4.701                 | 5.348     | 8.756                | .596          | 8.58            | 14.20         | 1.016         | 5281        | 14.33                  |
| $C_q = 17.2 \times 10^{-4}$ $T_w/T_g = 5.07$ |        |                       |           |                      |               |                 |               |               |             |                        |
| 30                                           | 377.8  | 2.894                 | 4.752     | 17.570               | .590          | 7.42            | 12.00         | .880          | 4519        | 12.58                  |
| 31                                           | 428.6  | 3.495                 | 4.954     | 17.140               | .658          | 8.65            | 14.20         | NC            | 5365        | 13.14                  |
| 32                                           | 479.4  | 3.885                 | 5.119     | 17.450               | .964          | 11.06           | 16.50         | 1.285         | 6223        | 11.47                  |
| 33                                           | 530.2  | 5.050                 | 5.468     | 16.460               | .845          | 12.74           | 19.4          | 1.620         | 8048        | 15.08                  |
| $C_q = 24.6 \times 10^{-4}$ $T_w/T_g = 4.85$ |        |                       |           |                      |               |                 |               |               |             |                        |
| 34                                           | 377.8  | 3.264                 | 4.800     | 24.420               | .790          | 11.24           | 16.50         | 1.28          | 6826        | 14.23                  |
| 35                                           | 428.6  | 4.045                 | 4.872     | 22.960               | .917          | 14.00           | 21.00         | 1.39          | 8651        | 15.28                  |
| 36                                           | 479.4  | 3.948                 | 4.838     | 26.470               | 1.090         | 14.26           | 19.70         | 1.86          | 8969        | 13.07                  |
| 37                                           | 530.2  | 4.773                 | 4.887     | 24.440               | 1.182         | 16.56           | 24.00         | 2.14          | 10640       | 14.01                  |
| $C_q = 0$ $T_w/T_g = 5.58$                   |        |                       |           |                      |               |                 |               |               |             |                        |
| 38                                           | 377.8  | 3.141                 | 5.582     | 0                    | .206          | 3.47            | 5.90          | .214          | 1713        | 16.85                  |

TABLE 27 - Run 23

$M_0 = 6.46$   $P_0 = 15.25 \text{ atm}$   
 $Re_0 = 1853$   $T_t = 550^\circ K$   
 $T_u/T_0 = 5.116$   $T_0 = 58.8^\circ K$   
 $C_q = 0$   $U_0 = 993 \text{ m/sec}$

| Y<br>mm | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|---------|------|------------------|------------------|
| 10.29   | 6.46 | 1.000            | 1.000            |
| 7.747   | 6.24 | 1.065            | .996             |
| 6.477   | 5.90 | 1.170            | .988             |
| 5.207   | 5.39 | 1.356            | .971             |
| 3.937   | 4.78 | 1.628            | .944             |
| 2.667   | 4.18 | 1.984            | .911             |
| 1.397   | 3.37 | 2.559            | .836             |
| 1.143   | 2.93 | 2.909            | .773             |
| .889    | 2.34 | 3.515            | .679             |
| .635    | 1.60 | 4.459            | .522             |
| .508    | 1.22 | 4.733            | .420             |
| .381    | .991 | 5.093            | .346             |
| .330    | .941 | 5.069            | .328             |

TABLE 26 - Run 22

$M_0 = 6.46$   $P_0 = 15.22 \text{ atm}$   
 $Re_0 = 1619$   $T_t = 546^\circ K$   
 $T_u/T_0 = 5.45$   $T_0 = 58.7^\circ K$   
 $C_q = 0$   $U_0 = 992 \text{ m/sec}$

| Y<br>mm | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|---------|------|------------------|------------------|
| 12.66   | 6.45 | 1.000            | 1.000            |
| 11.39   | 6.46 | 1.000            | 1.000            |
| 10.12   | 6.44 | 1.008            | 1.000            |
| 8.217   | 6.41 | 1.015            | 1.000            |
| 7.982   | 6.37 | 1.027            | .999             |
| 6.947   | 6.30 | 1.051            | .999             |
| 6.312   | 6.17 | 1.087            | .996             |
| 5.677   | 5.98 | 1.147            | .991             |
| 5.042   | 5.68 | 1.249            | .983             |
| 4.407   | 5.30 | 1.399            | .971             |
| 3.772   | 4.85 | 1.610            | .953             |
| 3.137   | 4.03 | 1.869            | .933             |
| 2.502   | 3.68 | 2.131            | .910             |
| 1.967   | 3.51 | 2.420            | .885             |
| 1.613   | 3.27 | 2.552            | .869             |
| 1.359   | 2.93 | 2.722            | .834             |
| 1.105   | 2.46 | 2.940            | .778             |
| .851    | 2.18 | 3.331            | .695             |
| .597    | 1.84 | 4.029            | .573             |
| .343    | 1.01 | 4.843            | .403             |
| .165    |      | 4.828            | .343             |

TABLE 28 Run 24

$M_0 = 6.62$   
 $M_{0.9} = 2520$   
 $T_c = 5.722$   
 $T_0 = 56.0^\circ\text{K}$   
 $C_q = 0$   
 $P_c = 15.08 \text{ atm}$   
 $T_c = 546^\circ\text{K}$   
 $T_0 = 56.0^\circ\text{K}$   
 $U_0 = 993 \text{ m/sec}$

| Y     | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|-------|------|------------------|------------------|
| 13.27 | 6.62 | 1.000            | 1.000            |
| 12.00 | 6.55 | 1.021            | 1.000            |
| 10.73 | 6.43 | 1.059            | 1.000            |
| 10.10 | 6.35 | 1.084            | .999             |
| 9.462 | 6.24 | 1.117            | .997             |
| 8.827 | 6.09 | 1.168            | .994             |
| 8.192 | 5.92 | 1.227            | .991             |
| 7.557 | 5.70 | 1.309            | .984             |
| 6.922 | 5.47 | 1.397            | .977             |
| 6.287 | 5.22 | 1.502            | .966             |
| 5.652 | 4.96 | 1.627            | .955             |
| 5.017 | 4.69 | 1.769            | .941             |
| 4.382 | 4.43 | 1.919            | .928             |
| 3.747 | 4.16 | 2.101            | .912             |
| 3.112 | 3.91 | 2.298            | .895             |
| 2.478 | 3.67 | 2.522            | .877             |
| 1.842 | 3.45 | 2.766            | .858             |
| 1.206 | 3.24 | 3.038            | .836             |
| 0.568 | 3.03 | 3.341            | .813             |
| 0.000 | 2.82 | 3.666            | .786             |
|       | 2.63 | 4.011            | .759             |
|       | 2.45 | 4.374            | .731             |
|       | 2.28 | 4.750            | .704             |
|       | 2.11 | 5.142            | .677             |
|       | 1.94 | 5.542            | .650             |
|       | 1.77 | 5.950            | .623             |
|       | 1.60 | 6.366            | .596             |
|       | 1.43 | 6.790            | .569             |
|       | 1.26 | 7.222            | .542             |
|       | 1.09 | 7.662            | .515             |
|       | 0.92 | 8.109            | .488             |
|       | 0.75 | 8.562            | .461             |
|       | 0.58 | 9.020            | .434             |
|       | 0.41 | 9.477            | .407             |
|       | 0.24 | 9.940            | .380             |
|       | 0.07 | 10.407           | .353             |
|       |      | 10.878           | .326             |
|       |      | 11.352           | .299             |
|       |      | 11.828           | .272             |
|       |      | 12.305           | .245             |
|       |      | 12.783           | .218             |
|       |      | 13.261           | .191             |
|       |      | 13.739           | .164             |
|       |      | 14.217           | .137             |
|       |      | 14.695           | .110             |
|       |      | 15.173           | .083             |
|       |      | 15.651           | .056             |
|       |      | 16.129           | .029             |
|       |      | 16.607           | .002             |

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TABLE 29 - Run 25

$M_0 = 6.45$   
 $M_{0.9} = 2667$   
 $T_c = 5.427$   
 $T_0 = 58.6^\circ\text{K}$   
 $C_q = 0$   
 $P_c = 15.12 \text{ atm}$   
 $T_c = 546^\circ\text{K}$   
 $T_0 = 58.6^\circ\text{K}$   
 $U_0 = 990 \text{ m/sec}$

| Y     | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|-------|------|------------------|------------------|
| 15.29 | 6.45 | 1.000            | 1.000            |
| 14.02 | 6.43 | 1.006            | 1.000            |
| 13.39 | 6.41 | 1.010            | .998             |
| 12.75 | 6.38 | 1.020            | .999             |
| 12.12 | 6.33 | 1.036            | 1.000            |
| 11.48 | 6.28 | 1.051            | .999             |
| 10.85 | 6.20 | 1.076            | .998             |
| 10.21 | 6.10 | 1.109            | .996             |
| 9.576 | 5.98 | 1.150            | .995             |
| 8.941 | 5.84 | 1.199            | .991             |
| 8.306 | 5.66 | 1.259            | .985             |
| 7.671 | 5.46 | 1.334            | .978             |
| 7.036 | 5.25 | 1.416            | .969             |
| 6.401 | 5.21 | 1.423            | .965             |
| 5.766 | 4.79 | 1.620            | .946             |
| 5.131 | 4.55 | 1.747            | .931             |
| 4.496 | 4.31 | 1.888            | .918             |
| 3.861 | 4.06 | 2.057            | .903             |
| 3.226 | 3.80 | 2.247            | .883             |
| 2.591 | 3.54 | 2.467            | .862             |
| 1.956 | 3.29 | 2.699            | .838             |
| 1.321 | 3.19 | 2.806            | .829             |
| 0.686 | 3.06 | 2.900            | .808             |
|       | 2.96 | 2.961            | .778             |
|       | 2.59 | 3.146            | .712             |
|       | 2.20 | 3.496            | .638             |
|       | 1.89 | 3.861            | .577             |
|       | 1.56 | 4.206            | .502             |
|       | 1.38 | 4.488            | .452             |

TABLE 30 - Run 26

$M_0 = 6.45$   
 $R_{\theta} = 2994$   
 $T_0/T_8 = 5.210$   
 $C_q = 8.94 \times 10^{-4}$   
 $P_c = 15.01 \text{ atm}$   
 $T_c = 546^\circ\text{K}$   
 $T_8 = 59.2^\circ\text{K}$   
 $U_8 = 995 \text{ m/sec}$

| Y     | M    | T/T <sub>8</sub> | U/U <sub>8</sub> |
|-------|------|------------------|------------------|
| 13.75 | 6.45 | 1.000            | 1.000            |
| 12.48 | 6.44 | 1.003            | 1.000            |
| 11.21 | 6.39 | 1.000            | 1.000            |
| 9.944 | 6.23 | 1.047            | .999             |
| 8.674 | 5.88 | 1.152            | .988             |
| 7.404 | 5.32 | 1.353            | .970             |
| 6.134 | 4.67 | 1.644            | .937             |
| 4.864 | 4.03 | 2.010            | .895             |
| 3.594 | 3.47 | 2.449            | .851             |
| 2.324 | 3.00 | 2.892            | .800             |
| 1.689 | 2.74 | 3.167            | .760             |
| 1.054 | 2.25 | 3.517            | .659             |
| .419  | 1.15 | 4.720            | .392             |
| .165  | .795 | 4.814            | .273             |

TABLE 31 - Run 27

$M_0 = 6.50$   
 $R_{\theta} = 3448$   
 $T_0/T_8 = 5.502$   
 $C_q = 8.93 \times 10^{-4}$   
 $P_c = 15.15 \text{ atm}$   
 $T_c = 548^\circ\text{K}$   
 $T_8 = 58.0^\circ\text{K}$   
 $U_8 = 992 \text{ m/sec}$

| Y     | M     | T/T <sub>8</sub> | U/U <sub>8</sub> |
|-------|-------|------------------|------------------|
| 17.56 | 6.50  | 1.000            | 1.000            |
| 15.02 | 6.50  | 1.000            | 1.000            |
| 12.48 | 6.49  | 1.035            | 1.000            |
| 11.21 | 6.40  | 1.091            | .996             |
| 9.940 | 5.87  | 1.196            | .987             |
| 8.672 | 5.42  | 1.356            | .971             |
| 7.402 | 4.82  | 1.572            | .948             |
| 6.132 | 4.27  | 1.820            | .920             |
| 4.862 | 3.81  | 2.121            | .886             |
| 3.592 | 3.30  | 2.467            | .846             |
| 2.322 | 3.06  | 2.899            | .800             |
| 1.687 | 2.723 | 3.237            | .754             |
| 1.052 | 1.986 | 3.984            | .613             |
| .417  | .851  | 5.371            | .303             |
| .165  | .673  |                  |                  |

TABLE 31 - Run 29

$M_B = 6.55$   
 $P_O = 15.05 \text{ atm}$   
 $R_{Og} = 5281$   
 $T_t = 548^\circ K$   
 $T_B = 57.3^\circ K$   
 $\frac{T_B}{T_t} = 5.348$   
 $C_q = 8.76 \times 10^{-4}$   
 $U_B = 993 \text{ m/sec}$

| Y     | M    | T/T <sub>B</sub> | U/U <sub>B</sub> |
|-------|------|------------------|------------------|
| 16.31 | 6.55 | 1.000            | 1.000            |
| 17.04 | 6.42 | 1.036            | .999             |
| 15.77 | 6.22 | 1.098            | .996             |
| 14.50 | 5.95 | 1.185            | .990             |
| 13.23 | 5.63 | 1.298            | .980             |
| 11.96 | 5.29 | 1.437            | .969             |
| 10.69 | 4.92 | 1.601            | .952             |
| 9.423 | 4.56 | 1.786            | .931             |
| 8.153 | 4.17 | 2.021            | .905             |
| 6.883 | 3.80 | 2.268            | .875             |
| 5.613 | 3.46 | 2.540            | .843             |
| 4.343 | 3.26 | 2.712            | .821             |
| 3.073 | 3.11 | 2.861            | .803             |
| 1.803 | 2.92 | 3.054            | .780             |
| 0.533 | 2.73 | 3.279            | .755             |
|       | 2.53 | 3.525            | .725             |
|       | 2.31 | 3.771            | .686             |
|       | 2.20 | 3.898            | .660             |
|       | 2.08 | 4.021            | .639             |
|       | 1.96 | 4.103            | .576             |
|       | 1.82 | 4.172            | .493             |
|       | 1.52 | 4.482            | .421             |
|       | 1.28 | 4.812            | .355             |
|       | 1.03 | 5.084            | .293             |
|       | .844 | 5.224            | .265             |
|       | .614 | 5.583            | .149             |

TABLE 32 - Run 28

$M_B = 6.64$   
 $P_O = 15.08 \text{ atm}$   
 $R_{Og} = 4554$   
 $T_t = 546^\circ K$   
 $T_B = 55.7^\circ K$   
 $\frac{T_B}{T_t} = 5.76$   
 $C_q = 8.432 \times 10^{-4}$   
 $U_B = 996 \text{ m/sec}$

| Y     | M    | T/T <sub>B</sub> | U/U <sub>B</sub> |
|-------|------|------------------|------------------|
| 19.58 | 6.64 | 1.000            | 1.000            |
| 17.04 | 6.54 | 1.032            | 1.000            |
| 15.77 | 6.43 | 1.068            | 1.000            |
| 14.50 | 6.24 | 1.126            | .998             |
| 13.23 | 6.01 | 1.205            | .994             |
| 11.96 | 5.70 | 1.314            | .985             |
| 10.69 | 5.30 | 1.479            | .972             |
| 9.423 | 4.89 | 1.674            | .952             |
| 8.153 | 4.46 | 1.907            | .929             |
| 6.883 | 4.05 | 2.169            | .899             |
| 6.248 | 3.81 | 2.365            | .882             |
| 5.613 | 3.62 | 2.505            | .864             |
| 4.978 | 3.42 | 2.675            | .843             |
| 4.343 | 3.24 | 2.853            | .824             |
| 4.089 | 3.14 | 2.949            | .814             |
| 3.835 | 3.08 | 3.005            | .805             |
| 3.581 | 2.99 | 3.109            | .795             |
| 3.327 | 2.91 | 3.205            | .786             |
| 3.073 | 2.84 | 3.289            | .777             |
| 2.819 | 2.78 | 3.356            | .768             |
| 2.565 | 2.70 | 3.444            | .756             |
| 2.311 | 2.59 | 3.612            | .742             |
| 2.057 | 2.50 | 3.718            | .727             |
| 1.803 | 2.43 | 3.783            | .712             |
| 1.549 | 2.30 | 3.909            | .685             |
| 1.295 | 2.13 | 4.054            | .646             |
| 1.041 | 1.92 | 4.247            | .595             |
| .787  | 1.62 | 4.573            | .522             |
| .533  | 1.21 | 5.085            | .418             |
| .406  | 1.02 | 5.268            | .353             |
| .279  | .834 | 5.418            | .292             |

TABLE 34 -- Run 30

$M_B = 6.21$        $P_0 = 15.22 \text{ atm}$   
 $B_{0H} = 4519$        $T_c = 547^\circ \text{K}$   
 $\frac{P_0}{T_0} = 4.752$        $T_0 = 63.6^\circ \text{K}$   
 $C_q = 17.6 \times 10^{-4}$        $U_0 = 993 \text{ m/sec}$

| $\frac{Y}{M}$ | M    | $T/T_0$ | $U/U_0$ |
|---------------|------|---------|---------|
| 14.00         | 6.21 | 1.000   | 1.000   |
| 12.72         | 5.97 | 1.071   | .995    |
| 11.46         | 5.63 | 1.178   | .984    |
| 10.18         | 5.11 | 1.367   | .962    |
| 9.550         | 4.79 | 1.506   | .946    |
| 8.915         | 4.50 | 1.644   | .930    |
| 8.280         | 4.24 | 1.779   | .912    |
| 7.645         | 3.97 | 1.913   | .891    |
| 7.010         | 3.73 | 2.095   | .869    |
| 6.375         | 3.48 | 2.274   | .844    |
| 5.740         | 3.25 | 2.444   | .820    |
| 5.105         | 3.03 | 2.613   | .793    |
| 4.470         | 2.83 | 2.777   | .766    |
| 3.835         | 2.62 | 3.045   | .735    |
| 3.200         | 2.44 | 3.289   | .707    |
| 2.565         | 2.24 | 3.491   | .674    |
| 1.930         | 2.01 | 3.731   | .626    |
| 1.295         | 1.66 | 4.016   | .535    |
| 1.041         | 1.42 | 4.151   | .469    |
| .787          | 1.14 | 4.469   | .390    |
| .533          | .802 | 4.761   | .251    |
| .406          | .689 | 4.750   | .242    |
| .330          | .631 | 4.744   | .221    |

TABLE 35 Run 31

$M_B = 6.30$        $P_0 = 15.15 \text{ atm}$   
 $B_{0H} = 5365$        $T_c = 547^\circ \text{K}$   
 $\frac{P_0}{T_0} = 4.954$        $T_0 = 61.6^\circ \text{K}$   
 $C_q = 17.14 \times 10^{-4}$        $U_0 = 991 \text{ m/sec}$

| $\frac{Y}{M}$ | M    | $T/T_0$ | $U/U_0$ |
|---------------|------|---------|---------|
| 17.71         | 6.30 | 1.000   | 1.000   |
| 16.99         | 6.03 | 1.050   | .995    |
| 13.92         | 5.76 | 1.168   | .989    |
| 12.65         | 5.40 | 1.292   | .975    |
| 11.36         | 4.96 | 1.470   | .955    |
| 10.11         | 4.49 | 1.698   | .929    |
| 8.839         | 4.11 | 1.908   | .901    |
| 7.569         | 3.68 | 2.189   | .865    |
| 6.299         | 3.28 | 2.503   | .824    |
| 5.029         | 2.89 | 2.968   | .777    |
| 3.759         | 2.54 | 3.238   | .725    |
| 3.124         | 2.35 | 3.468   | .695    |
| 2.489         | 2.18 | 3.668   | .662    |
| 1.854         | 1.94 | 3.923   | .611    |
| 1.219         | 1.60 | 4.163   | .519    |
| .584          | .924 | 4.778   | .321    |
| .330          | .673 | 4.851   | .237    |

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TABLE 37 - Run 33

$M_0 = 6.42$   
 $R_{00} = 804.0$   
 $T_0 = 5.448$   
 $T_0 = 15.05 \text{ atm}$   
 $T_0 = 546.0^\circ\text{K}$   
 $T_0 = 56.0^\circ\text{K}$   
 $C_0 = 16.46 \times 10^{-4}$   
 $U_0 = 993 \text{ m/sec}$

| Y     | M    | T/T <sub>0</sub> | W/W <sub>0</sub> |
|-------|------|------------------|------------------|
| 24.46 | 6.42 | 1.000            | 1.000            |
| 22.12 | 6.41 | 1.063            | .998             |
| 19.58 | 6.04 | 1.180            | .992             |
| 17.04 | 5.45 | 1.394            | .973             |
| 14.50 | 4.72 | 1.737            | .939             |
| 11.96 | 4.03 | 2.168            | .892             |
| 9.423 | 3.37 | 2.662            | .831             |
| 6.883 | 2.76 | 3.272            | .754             |
| 4.343 | 2.22 | 3.908            | .664             |
| 3.073 | 1.97 | 4.229            | .612             |
| 2.438 | 1.81 | 4.457            | .578             |
| 1.803 | 1.67 | 4.558            | .540             |
| 1.549 | 1.53 | 4.727            | .502             |
| 1.295 | 1.43 | 4.761            | .473             |
| 1.041 | 1.29 | 4.871            | .431             |
| .787  | 1.09 | 5.054            | .370             |
| .660  | .991 | 5.123            | .339             |
| .533  | .922 | 5.132            | .316             |
| .406  | .799 | 5.213            | .276             |
| .279  | .612 | 5.353            | .214             |

TABLE 36 - Run 32

$M_0 = 6.39$   
 $R_{00} = 6223$   
 $T_0 = 5.119$   
 $T_0 = 17.45 \times 10^{-4}$   
 $P_0 = 15.20 \text{ atm}$   
 $T_0 = 546.0^\circ\text{K}$   
 $T_0 = 59.7^\circ\text{K}$   
 $U_0 = 989 \text{ m/sec}$

| Y     | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|-------|------|------------------|------------------|
| 24.97 | 6.39 | 1.000            | 1.000            |
| 22.43 | 6.35 | 1.011            | 1.000            |
| 19.89 | 6.23 | 1.051            | 1.000            |
| 18.62 | 6.09 | 1.098            | .999             |
| 17.98 | 6.00 | 1.127            | .998             |
| 17.35 | 5.89 | 1.166            | .995             |
| 16.71 | 5.73 | 1.222            | .992             |
| 16.08 | 5.58 | 1.274            | .986             |
| 15.44 | 5.36 | 1.358            | .979             |
| 14.81 | 5.19 | 1.427            | .971             |
| 14.17 | 5.04 | 1.490            | .963             |
| 13.54 | 4.86 | 1.569            | .954             |
| 12.90 | 4.69 | 1.653            | .944             |
| 12.27 | 4.47 | 1.773            | .931             |
| 11.63 | 4.28 | 1.882            | .918             |
| 11.00 | 4.09 | 1.995            | .904             |
| 10.36 | 3.91 | 2.111            | .889             |
| 9.728 | 3.72 | 2.241            | .873             |
| 9.093 | 3.55 | 2.376            | .856             |
| 8.458 | 3.38 | 2.510            | .837             |
| 7.823 | 3.21 | 2.653            | .818             |
| 7.188 | 3.05 | 2.791            | .798             |
| 6.553 | 2.90 | 2.943            | .778             |
| 5.918 | 2.74 | 3.094            | .755             |
| 5.283 | 2.59 | 3.261            | .731             |
| 4.648 | 2.44 | 3.424            | .706             |
| 4.013 | 2.27 | 3.611            | .677             |
| 3.378 | 2.13 | 3.781            | .649             |
| 2.743 | 1.99 | 3.957            | .619             |
| 2.108 | 1.85 | 4.075            | .585             |
| 1.473 | 1.63 | 4.265            | .527             |
| .838  | 1.23 | 4.539            | .411             |
| .511  | 1.03 | 4.645            | .348             |



TABLE 39 - Run 35

$M_0 = 6.33$   
 $Re_0 = 8651$   
 $\frac{D_V}{T_0} = 4.872$   
 $C_q = 22.96 \times 10^{-4}$   
 $P_0 = 15.12 \text{ atm}$   
 $T_c = 547^\circ \text{K}$   
 $T_0 = 60.6^\circ \text{K}$   
 $U_0 = 988 \text{ m/sec}$

| Y     | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|-------|------|------------------|------------------|
| 25.20 | 6.13 | 1.000            | 1.000            |
| 22.65 | 6.10 | 1.072            | .998             |
| 20.11 | 5.79 | 1.179            | .992             |
| 17.57 | 5.12 | 1.437            | .968             |
| 15.03 | 4.30 | 1.847            | .923             |
| 12.49 | 3.53 | 2.371            | .858             |
| 9.947 | 2.85 | 2.968            | .775             |
| 7.407 | 2.12 | 3.826            | .655             |
| 4.867 | 1.65 | 4.377            | .545             |
| 3.597 | 1.42 | 4.645            | .482             |
| 2.327 | 1.17 | 4.884            | .408             |
| 1.692 | 1.03 | 4.954            | .363             |
| 1.057 | .792 | 5.011            | .280             |
| .279  | .334 | 4.966            | .118             |

TABLE 38 - Run 34

$M_0 = 6.27$   
 $Re_0 = 6826$   
 $\frac{D_V}{T_0} = 4.800$   
 $C_q = 24.42 \times 10^{-4}$   
 $P_0 = 15.08 \text{ atm}$   
 $T_c = 546^\circ \text{K}$   
 $T_0 = 61.9^\circ \text{K}$   
 $U_0 = 988 \text{ m/sec}$

| Y     | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|-------|------|------------------|------------------|
| 23.52 | 6.27 | 1.000            | 1.000            |
| 20.98 | 6.17 | 1.000            | 1.000            |
| 18.44 | 6.12 | 1.044            | .998             |
| 15.90 | 5.58 | 1.223            | .984             |
| 13.36 | 4.70 | 1.591            | .946             |
| 10.82 | 3.75 | 2.149            | .877             |
| 8.280 | 2.92 | 2.838            | .785             |
| 5.740 | 2.19 | 3.635            | .665             |
| 3.200 | 1.63 | 4.300            | .539             |
| 2.565 | 1.47 | 4.510            | .498             |
| 1.930 | 1.35 | 4.591            | .463             |
| 1.676 | 1.30 | 4.597            | .446             |
| 1.422 | 1.28 | 4.546            | .435             |
| 1.168 | 1.07 | 4.757            | .373             |
| .914  | .932 | 4.771            | .325             |
| .660  | .773 | 4.808            | .271             |
| .406  | .603 | 4.806            | .211             |
| .279  | .428 | 4.865            | .151             |

TABLE 40 - Run 36

$M_0 = 6.27$   
 $R_{00} = 8969$   
 $T_0 = 4.838$   
 $C_1 = 26.47 \times 10^{-4}$   
 $P_0 = 15.15 \text{ atm}$   
 $T_c = 546^\circ \text{K}$   
 $T_0 = 62.0^\circ \text{K}$   
 $U_0 = 986 \text{ m/sec}$

| Y     | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|-------|------|------------------|------------------|
| 25.49 | 6.27 | 1.000            | 1.000            |
| 22.86 | 5.94 | 1.000            | 1.000            |
| 20.32 | 5.34 | 1.196            | .993             |
| 17.76 | 4.60 | 1.495            | .947             |
| 15.24 | 3.85 | 1.918            | .897             |
| 12.70 | 3.18 | 2.379            | .825             |
| 10.16 | 2.56 | 2.942            | .739             |
| 7.620 | 2.08 | 3.410            | .647             |
| 5.080 | 1.62 | 3.921            | .538             |
| 3.210 | 1.43 | 4.068            | .487             |
| 2.540 | 1.19 | 4.323            | .413             |
| 1.905 | 1.08 | 4.399            | .381             |
| 1.270 | .876 | 4.505            | .313             |
| 1.016 | .720 | 4.562            | .259             |
| .762  | .515 | 4.622            | .186             |
| .635  | .428 | 4.621            | .155             |
| .279  | .313 | 4.472            | .111             |

TABLE 41 - Run 37

$M_0 = 6.37$   
 $R_{00} = 10640$   
 $T_0 = 4.887$   
 $C_1 = 24.64 \times 10^{-4}$   
 $P_0 = 15.12 \text{ atm}$   
 $T_c = 547^\circ \text{K}$   
 $T_0 = 60.0^\circ \text{K}$   
 $U_0 = 990 \text{ m/sec}$

| Y     | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|-------|------|------------------|------------------|
| 32.31 | 6.37 | 1.000            | 1.000            |
| 29.77 | 6.32 | 1.016            | .999             |
| 27.23 | 6.16 | 1.062            | .996             |
| 24.69 | 5.86 | 1.151            | .991             |
| 22.15 | 5.37 | 1.339            | .974             |
| 19.61 | 4.69 | 1.642            | .942             |
| 17.07 | 4.08 | 1.978            | .899             |
| 14.53 | 3.30 | 2.367            | .846             |
| 11.99 | 2.90 | 2.895            | .775             |
| 9.449 | 2.45 | 3.340            | .702             |
| 6.909 | 2.00 | 3.830            | .615             |
| 4.369 | 1.61 | 4.277            | .522             |
| 3.099 | 1.41 | 4.489            | .468             |
| 2.444 | 1.25 | 4.682            | .423             |
| 1.829 | 1.18 | 4.667            | .398             |
| 1.575 | 1.14 | 4.647            | .385             |
| 1.321 | .979 | 4.829            | .316             |
| 1.067 | .904 | 4.839            | .312             |
| .813  | .803 | 4.851            | .278             |
| .559  | .598 | 4.942            | .209             |
| .432  | .554 | 4.904            | .182             |
| .305  | .476 | 4.883            | .165             |
| .279  |      |                  |                  |

TABLE 42 - Run 38

$M_\infty = 6.53$   
 $Re_\theta = 1713$   
 $T_w = 5.582$   
 $C_q = 0$   
 $P_\infty = 15.05 \text{ atm}$   
 $T_t = 546^\circ K$   
 $T_\infty = 57.3^\circ K$   
 $U_\infty = 991 \text{ m/sec}$

| Y<br>(mm) | M    | $T/T_\infty$ | $U/U_\infty$ |
|-----------|------|--------------|--------------|
| 19.36     | 6.53 | 1.000        | 1.000        |
| 18.09     | 6.53 | 1.000        | 1.000        |
| 16.82     | 6.53 | 1.000        | 1.000        |
| 15.54     | 6.53 | 1.000        | 1.000        |
| 14.28     | 6.54 | .998         | 1.000        |
| 13.00     | 6.54 | .998         | 1.000        |
| 11.74     | 6.54 | 1.000        | 1.000        |
| 10.46     | 6.53 | 1.004        | 1.001        |
| 9.195     | 6.50 | 1.013        | 1.002        |
| 7.925     | 6.41 | 1.041        | 1.001        |
| 6.655     | 6.19 | 1.110        | .998         |
| 5.385     | 5.73 | 1.261        | .986         |
| 4.750     | 5.43 | 1.379        | .976         |
| 4.115     | 4.97 | 1.586        | .959         |
| 3.480     | 4.52 | 1.839        | .936         |
| 2.845     | 4.09 | 2.126        | .914         |
| 2.210     | 3.71 | 2.474        | .889         |
| 1.575     | 3.34 | 2.781        | .853         |
| 1.321     | 3.16 | 2.891        | .824         |
| 1.067     | 2.94 | 3.001        | .779         |
| .813      | 2.63 | 3.206        | .720         |
| .559      | 2.08 | 3.766        | .618         |
| .432      | 1.66 | 4.337        | .528         |
| .305      | 1.24 | 4.886        | .419         |
| .279      | 1.01 | 5.240        | .355         |

TABLE 43 SUMMARY OF SKIN FRICTION AND HEAT TRANSFER DATA,  $T_w/T_s = 7.6$ 

| $T_w/T_s = 7.6$                                  |         |       |              |                       |             |           |       |           |                   |              |               |                  |                   |
|--------------------------------------------------|---------|-------|--------------|-----------------------|-------------|-----------|-------|-----------|-------------------|--------------|---------------|------------------|-------------------|
| RUN                                              | X<br>mm | $M_s$ | $P_o$<br>atm | $Re_x \times 10^{-6}$ | $Re_\theta$ | $T_w/T_s$ | $C_q$ | $T_w/T_s$ | $C_f \times 10^4$ | $C_f/C_{fo}$ | $2C_q/C_{fo}$ | $St \times 10^4$ | $\frac{St}{St_o}$ |
| $C_q = 0 \quad T_w/T_s = 7.87$                   |         |       |              |                       |             |           |       |           |                   |              |               |                  |                   |
| 39                                               | 277.3   | 6.31  | 15.12        | 2.840                 | 1223        | 7.614     | 0     | 19.54     | 1.000             | 0            | 28.2          | 1.000            |                   |
| 40                                               | 428.6   | 6.45  | 15.05        | 3.429                 | 1720        | 7.780     | 0     | 17.70     | 1.000             | 0            | 29.4          | 1.000            |                   |
| 41                                               | 479.4   | 6.61  | 15.12        | 4.252                 | 2200        | 8.080     | 0     | 15.74     | 1.000             | 0            | 23.3          | 1.000            |                   |
| 42                                               | 530.2   | 6.62  | 15.08        | 4.803                 | 2844        | 8.018     | 0     | 14.50     | 1.000             | 0            | 20.6          | 1.000            |                   |
| $C_q = 8.68 \times 10^{-4} \quad T_w/T_s = 7.65$ |         |       |              |                       |             |           |       |           |                   |              |               |                  |                   |
| 43                                               | 479.4   | 6.51  | 15.08        | 4.099                 | 4541        | 7.650     | 8.68  | 11.20     | .712              | 1.103        | 10.71         | .440             |                   |
| $C_q = 16.2 \times 10^{-4} \quad T_w/T_s = 7.65$ |         |       |              |                       |             |           |       |           |                   |              |               |                  |                   |
| 44                                               | 479.4   | 6.57  | 15.08        | 4.514                 | 6365        | 7.649     | 16.17 | 8.41      | .534              | 2.055        | 5.18          | .222             |                   |
| $C_q = 24.4 \times 10^{-4} \quad T_w/T_s = 7.26$ |         |       |              |                       |             |           |       |           |                   |              |               |                  |                   |
| 45                                               | 479.4   | 6.49  | 15.01        | 4.632                 | 8928        | 7.259     | 24.42 | 6.06      | .385              | 3.103        | 2.82          | .121             |                   |
| $C_q = 0 \quad T_w/T_s = 7.81$                   |         |       |              |                       |             |           |       |           |                   |              |               |                  |                   |
| 46                                               | 479.4   | 6.43  | 20.01        | 4.897                 | 2360        | 7.805     | 0     | 14.56     | 1.000             | 0            | 23.08         | 1.000            |                   |

TABLE 44 SUMMARY OF BOUNDARY LAYER PARAMETERS,  $T_w/T_\infty = 7.6$   
 $T_w/T_\infty = 7.6$

| RUN | X     | Pe $\times 10^{-6}$ | $T_w/T_\infty$ | $C_q \times 10^4$           | $\theta$ | $\theta^*$            | $\theta$ | Re $\theta$ | $\theta^*$ |
|-----|-------|---------------------|----------------|-----------------------------|----------|-----------------------|----------|-------------|------------|
|     |       |                     |                |                             | mm       | mm                    | mm       |             | mm         |
|     |       |                     |                | $C_q = 0$                   |          | $T_w/T_\infty = 7.87$ |          |             |            |
| 39  | 477.2 | 2.840               | 7.614          | 0                           | .176     | 3.78                  | 6.2      | 132.7       | 21.48      |
| 40  | 472.6 | 3.429               | 7.780          | 0                           | .215     | 4.72                  | 7.5      | 172.0       | 21.95      |
| 41  | 479.4 | 4.252               | 8.080          | 0                           | .248     | 5.56                  | 8.5      | 220.0       | 22.42      |
| 42  | 510.2 | 4.803               | 8.012          | 0                           | .314     | 6.57                  | 10.2     | 286.4       | 20.92      |
|     |       |                     |                | $C_q = 8.6 \times 10^{-4}$  |          | $T_w/T_\infty = 7.65$ |          |             |            |
| 43  | 479.4 | 4.099               | 7.650          | 2.68                        | .531     | 8.45                  | 15.0     | 454.1       | 15.91      |
|     |       |                     |                | $C_q = 16.2 \times 10^{-4}$ |          | $T_w/T_\infty = 7.65$ |          |             |            |
| 44  | 479.4 | 4.514               | 7.649          | 16.17                       | .676     | 12.90                 | 17.5     | 536.6       | 19.02      |
|     |       |                     |                | $C_q = 24.4 \times 10^{-4}$ |          | $T_w/T_\infty = 7.26$ |          |             |            |
| 45  | 479.4 | 4.632               | 7.259          | 24.42                       | .924     | 17.42                 | 23.0     | 892.8       | 12.35      |
|     |       |                     |                | $C_q = 0$                   |          | $T_w/T_\infty = 7.81$ |          |             |            |
| 46  | 479.4 | 4.297               | 7.805          | 0                           | .280     | 5.24                  | 8.7      | 286.0       | 12.72      |

TABLE 45 - Run 39

$M = 6.31$   
 $P_0 = 15.12 \text{ atm}$   
 $P_{0g} = 1323$   
 $T_c = 549^\circ K$   
 $T_g = 7.614$   
 $T_g = 61.3^\circ K$   
 $C_q = 0$   
 $U_g = 991. \text{ m/sec}$

| $Y$<br>(mm) | $M$  | $T/T_g$ | $U/U_g$ |
|-------------|------|---------|---------|
| 24.10       | 6.29 | 1.000   | 1.000   |
| 17.76       | 6.34 | 1.000   | 1.000   |
| 13.94       | 6.34 | 1.000   | 1.000   |
| 11.41       | 6.34 | 1.000   | 1.000   |
| 10.14       | 6.31 | 1.000   | 1.000   |
| 8.865       | 6.25 | 1.021   | 1.000   |
| 7.595       | 6.07 | 1.077   | .998    |
| 6.325       | 5.75 | 1.191   | .993    |
| 5.035       | 5.18 | 1.423   | .978    |
| 4.420       | 4.83 | 1.600   | .967    |
| 3.785       | 4.41 | 1.867   | .950    |
| 2.515       | 3.66 | 2.452   | .909    |
| 1.880       | 3.33 | 2.809   | .886    |
| 1.499       | 3.05 | 3.143   | .856    |
| 1.265       | 2.79 | 3.496   | .826    |
| .991        | 2.42 | 4.037   | .771    |
| .737        | 1.89 | 4.967   | .668    |
| .610        | 1.60 | 5.555   | .596    |
| .483        | 1.32 | 6.081   | .515    |
| .279        | .827 | 6.942   | .345    |

TABLE 46 - Run 40

$M = 6.45$   
 $P_0 = 15.05 \text{ atm}$   
 $Re = 1720$   
 $T_c = 550^\circ K$   
 $T_g = 7.780$   
 $T_g = 59.2^\circ K$   
 $C_q = 0$   
 $U = 995 \text{ m/sec}$

| $Y$<br>(mm) | $M$  | $T/T$ | $U/U$ |
|-------------|------|-------|-------|
| 12.89       | 6.45 | 1.000 | 1.000 |
| 12.26       | 6.44 | 1.005 | 1.000 |
| 11.62       | 6.42 | 1.011 | 1.000 |
| 10.99       | 6.38 | 1.025 | 1.000 |
| 10.35       | 6.33 | 1.042 | 1.000 |
| 9.716       | 6.25 | 1.068 | 1.000 |
| 9.081       | 6.14 | 1.103 | .999  |
| 8.446       | 5.98 | 1.156 | .997  |
| 7.811       | 5.80 | 1.222 | .994  |
| 7.176       | 5.58 | 1.308 | .988  |
| 6.541       | 5.32 | 1.418 | .981  |
| 5.906       | 5.04 | 1.551 | .972  |
| 5.271       | 4.74 | 1.709 | .961  |
| 4.636       | 4.44 | 1.892 | .947  |
| 4.001       | 4.18 | 2.079 | .933  |
| 3.366       | 3.90 | 2.307 | .918  |
| 2.731       | 3.61 | 2.592 | .900  |
| 2.096       | 3.32 | 2.911 | .879  |
| 1.461       | 2.93 | 3.412 | .849  |
| 1.207       | 2.66 | 3.807 | .803  |
| .953        | 2.28 | 4.398 | .740  |
| .699        | 1.71 | 5.457 | .619  |
| .572        | 1.42 | 6.036 | .542  |
| .445        | 1.21 | 6.462 | .475  |
| .318        | .961 | 6.905 | .391  |
| .279        | .761 | 7.285 | .318  |

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TABLE 47 - Run 41

$M_0 = 6.61$   
 $Re_0 = 2200$   
 $T_u/T = 8.080$   
 $C_q = 0$

$P_0 = 15.12 \text{ atm}$   
 $T_t = 548^\circ K$   
 $T = 56.4^\circ K$   
 $U = 995 \text{ m/sec}$

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 19.41     | 6.61 | 1.000 | 1.000 |
| 18.14     | 6.61 | 1.000 | 1.000 |
| 16.74     | 6.61 | 1.000 | 1.000 |
| 14.33     | 6.58 | 1.010 | 1.000 |
| 11.79     | 6.42 | 1.062 | 1.000 |
| 10.52     | 6.24 | 1.119 | .999  |
| 9.246     | 5.95 | 1.221 | .995  |
| 7.976     | 5.55 | 1.378 | .985  |
| 6.706     | 5.06 | 1.601 | .969  |
| 5.436     | 4.57 | 1.883 | .948  |
| 4.166     | 4.06 | 2.244 | .921  |
| 2.896     | 3.57 | 2.720 | .891  |
| 2.261     | 3.29 | 3.048 | .869  |
| 1.626     | 2.92 | 3.551 | .833  |
| 1.372     | 2.71 | 3.843 | .803  |
| 1.118     | 2.38 | 4.392 | .754  |
| .864      | 1.91 | 5.259 | .663  |
| .737      | 1.66 | 5.775 | .604  |
| .610      | 1.38 | 6.395 | .527  |
| .483      | 1.09 | 7.007 | .436  |
| .356      | .972 | 7.307 | .398  |
| .279      | .774 | 7.512 | .321  |

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TABLE 48 - Run 42

$M_0 = 6.62$   
 $Re_0 = 2844$   
 $T_u/T = 8.018$   
 $C_q = 0$

$P_0 = 15.08 \text{ atm}$   
 $T_t = 548^\circ K$   
 $T_g = 56.2^\circ K$   
 $U_g = 995 \text{ m/sec}$

| Y<br>(mm) | M    | T/T <sub>0</sub> | U/U <sub>0</sub> |
|-----------|------|------------------|------------------|
| 23.90     | 6.62 | 1.000            | 1.000            |
| 17.55     | 6.53 | 1.024            | .999             |
| 13.74     | 6.36 | 1.077            | .998             |
| 12.47     | 6.24 | 1.119            | .996             |
| 11.20     | 6.03 | 1.191            | .995             |
| 9.931     | 5.75 | 1.298            | .989             |
| 8.661     | 5.39 | 1.449            | .980             |
| 7.391     | 4.98 | 1.647            | .966             |
| 6.121     | 4.55 | 1.891            | .944             |
| 4.851     | 4.11 | 2.196            | .921             |
| 4.216     | 3.91 | 2.369            | .908             |
| 3.581     | 3.67 | 2.590            | .892             |
| 2.946     | 3.43 | 2.843            | .874             |
| 2.311     | 3.19 | 3.136            | .854             |
| 1.676     | 2.85 | 3.631            | .820             |
| 1.041     | 2.20 | 4.686            | .721             |
| .787      | 1.71 | 5.662            | .615             |
| .660      | 1.46 | 6.187            | .548             |
| .533      | 1.09 | 7.002            | .436             |
| .406      | .975 | 7.151            | .394             |
| .279      | .763 | 7.488            | .315             |

TABLE 50 - Run 44

$M_0 = 6.37$   
 $M_{00} = 6365$   
 $\Sigma \tau = 7.649$   
 $C_q = 16.17 \times 10^{-4}$   
 $P_0 = 15.08 \text{ atm}$   
 $T_c = 549^\circ \text{K}$   
 $T_B = 57.0^\circ \text{K}$   
 $U_B = 994 \text{ m/sec}$

| Y<br>(mm) | H    | $T/T_B$ | $U/U_B$ |
|-----------|------|---------|---------|
| 27.94     | 6.57 | 1.000   | 1.000   |
| 25.40     | 6.53 | 1.012   | 1.000   |
| 22.86     | 6.44 | 1.040   | 1.000   |
| 20.32     | 6.19 | 1.127   | 1.000   |
| 17.78     | 5.68 | 1.315   | .991    |
| 16.51     | 5.32 | 1.465   | .980    |
| 15.24     | 4.94 | 1.618   | .957    |
| 13.70     | 4.17 | 2.116   | .923    |
| 12.43     | 3.80 | 2.409   | .896    |
| 11.16     | 3.42 | 2.761   | .864    |
| 8.890     | 3.08 | 3.129   | .829    |
| 7.620     | 2.81 | 3.454   | .795    |
| 6.350     | 2.53 | 3.846   | .754    |
| 5.080     | 2.25 | 4.267   | .708    |
| 3.810     | 1.94 | 4.824   | .649    |
| 2.540     | 1.64 | 5.411   | .580    |
| 1.305     | 1.46 | 5.767   | .534    |
| 1.170     | 1.16 | 6.359   | .444    |
| 1.016     | 1.00 | 6.384   | .407    |
| .745      | .903 | 6.787   | .359    |
| .506      | .635 | 7.187   | .275    |
| .381      | .548 | 7.317   | .234    |
| .279      | .428 | 7.485   | .176    |

TABLE 49 - Run 43

$M_0 = 6.51$   
 $M_{00} = 6541$   
 $\Sigma \tau = 7.650$   
 $C_q = 8.68 \times 10^{-4}$   
 $P_0 = 15.08 \text{ atm}$   
 $T_c = 551^\circ \text{K}$   
 $T_B = 58.4^\circ \text{K}$   
 $U_B = 1007 \text{ m/sec}$

| Y<br>(mm) | H    | $T/T_B$ | $U/U_B$ |
|-----------|------|---------|---------|
| 25.42     | 6.62 | 1.000   | 1.000   |
| 22.88     | 6.63 | 1.000   | 1.000   |
| 20.34     | 6.62 | 1.000   | 1.000   |
| 17.81     | 6.57 | 1.000   | 1.000   |
| 15.26     | 6.20 | 1.098   | .990    |
| 12.72     | 5.58 | 1.322   | .977    |
| 11.46     | 5.18 | 1.494   | .964    |
| 10.18     | 4.78 | 1.696   | .947    |
| 8.915     | 4.38 | 1.937   | .927    |
| 7.645     | 3.98 | 2.214   | .901    |
| 6.375     | 3.60 | 2.534   | .872    |
| 5.105     | 3.22 | 2.915   | .838    |
| 4.470     | 3.05 | 3.111   | .820    |
| 3.835     | 2.87 | 3.337   | .789    |
| 3.200     | 2.68 | 3.614   | .775    |
| 2.565     | 2.48 | 3.951   | .745    |
| 1.930     | 2.18 | 4.430   | .700    |
| 1.295     | 1.79 | 5.156   | .618    |
| .860      | 1.11 | 6.511   | .430    |
| .533      | .950 | 6.797   | .377    |
| .408      | .748 | 7.140   | .304    |
| .279      | .628 | 7.280   | .258    |



TABLE 51 - Run 45

$M_0 = 6.49$   
 $R_{\theta} = 0928$   
 $T_c = 7.259$   
 $T_B = 58.2^\circ\text{K}$   
 $C_q = 24.42 \times 10^{-4}$   
 $P_0 = 15.01 \text{ atm}$   
 $T_c = 54.0^\circ\text{K}$   
 $T_B = 58.2^\circ\text{K}$   
 $U_B = 992 \text{ m/sec}$

| $\gamma$<br>(mm) | M    | $x/T_B$ | $U/U_B$ |
|------------------|------|---------|---------|
| 35.54            | 6.49 | 1.000   | 1.000   |
| 33.00            | 6.49 | 1.000   | 1.000   |
| 30.46            | 6.45 | 1.010   | .999    |
| 27.92            | 6.35 | 1.041   | .999    |
| 25.38            | 6.12 | 1.119   | .998    |
| 22.84            | 5.58 | 1.315   | .987    |
| 20.30            | 4.92 | 1.618   | .964    |
| 17.76            | 4.14 | 2.087   | .921    |
| 15.22            | 3.41 | 2.697   | .862    |
| 12.68            | 2.83 | 3.332   | .795    |
| 10.14            | 2.37 | 3.933   | .724    |
| 7.595            | 1.92 | 4.633   | .637    |
| 5.055            | 1.43 | 5.519   | .519    |
| 3.785            | 1.34 | 5.656   | .489    |
| 2.515            | 1.11 | 6.072   | .421    |
| 1.800            | .963 | 6.331   | .376    |
| 1.245            | .796 | 6.612   | .316    |
| .991             | .632 | 6.881   | .256    |
| .483             | .520 | 7.016   | .212    |
| .279             | .329 | 7.216   | .136    |

TABLE 52 - Run 46

$M_0 = 6.43$   
 $R_{\theta} = 2860$   
 $T_c = 54.8^\circ\text{K}$   
 $T_B = 59.1^\circ\text{K}$   
 $C_q = 0$   
 $P_0 = 20.01 \text{ atm}$   
 $T_c = 54.8^\circ\text{K}$   
 $T_B = 59.1^\circ\text{K}$   
 $U_B = 992 \text{ m/sec}$

| $\gamma$<br>(mm) | M    | $x/T_B$ | $U/U_B$ |
|------------------|------|---------|---------|
| 23.39            | 6.42 | 1.000   | 1.000   |
| 17.04            | 6.43 | 1.000   | 1.000   |
| 15.77            | 6.43 | 1.000   | 1.000   |
| 13.23            | 6.40 | 1.009   | .999    |
| 11.96            | 6.30 | 1.030   | .999    |
| 10.49            | 6.14 | 1.073   | .997    |
| 9.423            | 5.93 | 1.156   | .995    |
| 8.153            | 5.59 | 1.288   | .986    |
| 6.883            | 5.14 | 1.481   | .971    |
| 5.613            | 4.66 | 1.727   | .951    |
| 4.343            | 4.16 | 2.043   | .923    |
| 3.073            | 3.63 | 2.477   | .889    |
| 1.803            | 3.04 | 3.159   | .841    |
| 1.168            | 2.62 | 3.784   | .792    |
| 1.041            | 2.49 | 3.993   | .772    |
| .916             | 2.30 | 4.290   | .742    |
| .787             | 2.06 | 4.725   | .695    |
| .660             | 1.76 | 5.310   | .629    |
| .533             | 1.40 | 6.045   | .536    |
| .406             | 1.09 | 6.877   | .439    |
| .279             | .868 | 7.061   | .358    |

TABLE 53 SUMMARY OF SKIN FRICTION AND HEAT TRANSFER DATA,  $T_w/T_\infty = 7.6$  $\tau_w/\tau_\infty = 7.6$ 

| RUN | X<br>mm | H <sub>0</sub> | P <sub>0</sub><br>atm | Re <sub>x</sub> 10 <sup>-6</sup> | Re <sub>θ</sub> | $T_w/T_\infty$ | $c_{q2}10^4$ | $c_{q2}10^4$ | $c_g/c_{g0}$ | $2C_q/C_{q0}$ | St10 <sup>4</sup> | $\frac{SE}{SC}$ |
|-----|---------|----------------|-----------------------|----------------------------------|-----------------|----------------|--------------|--------------|--------------|---------------|-------------------|-----------------|
| 47  | 530.2   | 6.34           | 38.07                 | 9.70                             | 4897            | 7.06           | 0            | 9.92         | 1.000        | 0             | 8.3               | 1.000           |
| 48  | 530.2   | 6.46           | 38.07                 | 10.76                            | 6824            | 7.19           | 3.70         | 8.35         | .861         | .746          | 5.83              | .702            |
| 49  | 530.2   | 6.47           | 38.07                 | 10.84                            | 8753            | 7.01           | 7.25         | 7.6          | .767         | 1.464         | 4.49              | .541            |
| 50  | 530.2   | 6.52           | 38.07                 | 11.03                            | 11737           | 6.87           | 10.13        | 6.25         | .630         | 2.040         | 3.64              | .439            |

TABLE 54. SUMMARY OF BOUNDARY LAYER PARAMETERS,  $T_u/T_8 = 7.6$

$T_u/T_8 = 7.6$

| RUN | X     | $R_{\theta} \times 10^{-6}$ | $T_u/T_8$ | $c_q \times 10^4$ | $\theta$ | $\beta^*$ | $\delta$ | $\delta$ | Re $\theta$ | $\beta^*$<br>$\frac{\theta}{\delta}$ |
|-----|-------|-----------------------------|-----------|-------------------|----------|-----------|----------|----------|-------------|--------------------------------------|
| 47  | 530.2 | 9.70                        | 7.06      | 0                 | .265     | 4.66      | 8.0      | .150     | 4897        | 17.6                                 |
| 48  | 530.2 | 10.76                       | 7.19      | 3.70              | .336     | 6.26      | 9.5      | .640     | 6824        | 16.91                                |
| 49  | 532.0 | 10.84                       | 7.01      | 7.25              | .428     | 7.80      | 11.0     | 1.36     | 8753        | 18.22                                |
| 50  | 530.2 | 11.03                       | 6.87      | 10.13             | .564     | 9.80      | 14.2     | 2.74     | 11737       | 17.38                                |

TABLE 56 - Run 48

$N = 6.46$   
 $Re = 6824$   
 $\frac{T_w}{T} = 7.19$   
 $C_q = 3.70 \times 10^{-4}$   
 $P = 38.07 \text{ atm}$   
 $T_t = 508 \text{ K}$   
 $T = 58.7 \text{ K}$   
 $U = 992 \text{ m/sec}$

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 26.25     | 6.46 | 1.000 | 1.000 |
| 23.71     | 6.45 | 1.003 | 1.000 |
| 21.17     | 6.43 | 1.007 | 1.000 |
| 18.63     | 6.42 | 1.010 | 1.000 |
| 16.09     | 6.42 | 1.014 | 1.000 |
| 13.55     | 6.40 | 1.034 | 1.000 |
| 11.01     | 6.41 | 1.112 | 1.000 |
| 10.38     | 5.98 | 1.162 | .998  |
| 9.741     | 5.80 | 1.226 | .994  |
| 9.106     | 5.58 | 1.305 | .988  |
| 8.471     | 5.34 | 1.402 | .980  |
| 7.836     | 5.07 | 1.521 | .969  |
| 7.201     | 4.81 | 1.649 | .957  |
| 6.566     | 4.55 | 1.797 | .944  |
| 5.931     | 4.25 | 1.978 | .926  |
| 5.296     | 3.97 | 2.176 | .908  |
| 4.661     | 3.68 | 2.409 | .885  |
| 4.026     | 3.35 | 2.716 | .856  |
| 3.391     | 3.08 | 3.015 | .827  |
| 2.756     | 2.85 | 3.285 | .800  |
| 2.121     | 2.62 | 3.600 | .770  |
| 1.486     | 2.34 | 4.070 | .730  |
| .851      | 1.84 | 4.951 | .634  |
| .597      | 1.51 | 5.436 | .549  |
| .470      | 1.31 | 5.848 | .492  |
| .343      | 1.04 | 6.302 | .406  |
| .292      | .959 | 6.641 | .377  |
| .191      | .911 | 6.410 | .357  |

TABLE 55 - Run 47

$M = 6.34$   
 $Re = 4897$   
 $T_w/T = 7.06$   
 $C_q = 0$   
 $P_0 = 33.07 \text{ atm}$   
 $T_t = 550^\circ K$   
 $T = 61.0^\circ K$   
 $U = 992.0 \text{ m/sec}$

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 21.22     | 6.34 | 1.000 | 1.000 |
| 18.68     | 6.33 | 1.003 | 1.000 |
| 16.14     | 6.32 | 1.006 | 1.000 |
| 13.60     | 6.32 | 1.025 | .999  |
| 11.06     | 6.25 | 1.054 | .999  |
| 9.792     | 6.17 | 1.123 | .997  |
| 8.522     | 5.96 | 1.242 | .988  |
| 7.252     | 5.57 | 1.371 | .980  |
| 6.617     | 5.30 | 1.497 | .968  |
| 5.932     | 5.01 | 1.610 | .939  |
| 4.712     | 4.42 | 1.999 | .920  |
| 4.077     | 4.12 | 2.240 | .898  |
| 3.442     | 3.80 | 2.486 | .875  |
| 2.807     | 3.52 | 2.777 | .850  |
| 2.172     | 3.23 | 3.131 | .822  |
| 1.537     | 2.94 | 4.028 | .742  |
| .648      | 1.94 | 4.660 | .662  |
| .521      | 1.70 | 5.066 | .603  |
| .394      | 1.38 | 5.607 | .517  |
| .267      | 1.08 | 6.114 | .421  |
| .191      | 1.04 | 6.103 | .403  |

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TABLE 57 - Run 49

|                             |                         |                              |                         |
|-----------------------------|-------------------------|------------------------------|-------------------------|
| $M = 6.47$                  | $P = 38.77 \text{ atm}$ | $M = 6.52$                   | $P = 38.77 \text{ atm}$ |
| $T_0 = 8753$                | $T_c = 549 \text{ K}$   | $T_0 = 11,737$               | $T_c = 553 \text{ K}$   |
| $T_{10} = 7.01$             | $T = 58.6 \text{ K}$    | $T_{10} = 6.87$              | $T = 58.2 \text{ K}$    |
| $C_q = 7.25 \times 10^{-6}$ | $U = 993 \text{ m/sec}$ | $C_q = 1.013 \times 10^{-6}$ | $U = 997 \text{ m/sec}$ |

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 28.79     | 6.47 | 1.000 | 1.000 |
| 26.25     | 6.46 | 1.003 | 1.000 |
| 23.71     | 6.45 | 1.008 | 1.000 |
| 21.17     | 6.44 | 1.010 | 1.000 |
| 18.63     | 6.44 | 1.032 | 1.002 |
| 16.09     | 6.38 | 1.095 | 1.003 |
| 13.55     | 6.20 | 1.167 | .999  |
| 12.28     | 5.94 | 1.335 | .989  |
| 11.01     | 5.54 | 1.620 | .979  |
| 9.74      | 5.28 | 1.938 | .970  |
| 8.41      | 5.06 | 1.679 | .957  |
| 7.07      | 4.78 | 1.799 | .945  |
| 5.71      | 4.56 | 2.117 | .913  |
| 4.31      | 4.06 | 2.507 | .873  |
| 2.91      | 3.57 | 2.981 | .826  |
| 1.51      | 3.10 | 3.688 | .771  |
| 0.11      | 2.67 | 3.780 | .740  |
|           | 2.46 | 4.122 | .706  |
|           | 2.25 | 4.559 | .669  |
|           | 2.00 | 5.236 | .609  |
|           | 1.77 | 5.869 | .562  |
|           | 1.57 | 6.305 | .514  |
|           | .943 | 6.389 | .463  |
|           | .287 | 6.463 | .417  |
|           | .191 | 6.482 | .302  |

TABLE 58 - Run 50

|                              |                         |                              |                         |
|------------------------------|-------------------------|------------------------------|-------------------------|
| $M = 6.52$                   | $P = 38.77 \text{ atm}$ | $M = 6.52$                   | $P = 38.77 \text{ atm}$ |
| $T_0 = 11,737$               | $T_c = 553 \text{ K}$   | $T_0 = 11,737$               | $T_c = 553 \text{ K}$   |
| $T_{10} = 6.87$              | $T = 58.2 \text{ K}$    | $T_{10} = 6.87$              | $T = 58.2 \text{ K}$    |
| $C_q = 1.013 \times 10^{-6}$ | $U = 997 \text{ m/sec}$ | $C_q = 1.013 \times 10^{-6}$ | $U = 997 \text{ m/sec}$ |

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 28.77     | 6.52 | 1.000 | 1.000 |
| 23.69     | 6.49 | 1.009 | 1.000 |
| 18.61     | 6.43 | 1.031 | 1.000 |
| 16.07     | 6.24 | 1.090 | 1.000 |
| 13.53     | 5.64 | 1.299 | .985  |
| 12.26     | 5.16 | 1.639 | .977  |
| 10.99     | 4.69 | 1.741 | .948  |
| 9.716     | 4.22 | 2.015 | .920  |
| 8.446     | 3.84 | 2.289 | .892  |
| 7.176     | 3.27 | 2.818 | .843  |
| 5.906     | 2.89 | 3.234 | .797  |
| 4.636     | 2.52 | 3.676 | .741  |
| 3.366     | 2.17 | 4.193 | .682  |
| 2.731     | 2.01 | 4.459 | .652  |
| 2.096     | 1.83 | 4.786 | .615  |
| 1.461     | 1.62 | 5.186 | .566  |
| .826      | 1.34 | 5.617 | .488  |
| .572      | 1.15 | 5.907 | .428  |
| .445      | .966 | 6.181 | .368  |
| .318      | .832 | 6.337 | .317  |
| .191      | .693 | 6.457 | .270  |

TABLE 59 SUMMARY OF SKIN FRICTION AND HEAT TRANSFER DATA,  $T_w/T_s = 4.1$  $T_w/T_s = 4.1$ 

| RUN                                          | X<br>mm | M <sub>s</sub> | P <sub>o</sub> | Re <sub>x</sub> 10 <sup>-6</sup> | Re    | $T_w/T_s$ | $C_q$ 10 <sup>4</sup> | $C_f$ 10 <sup>4</sup> | $C_f/C_{fo}$ | $2C_q/C_{fo}$ | $St$ 10 <sup>4</sup> | $\frac{St}{St_o}$ |
|----------------------------------------------|---------|----------------|----------------|----------------------------------|-------|-----------|-----------------------|-----------------------|--------------|---------------|----------------------|-------------------|
| $C_q = 0$ $T_w/T_s = 4.70$                   |         |                |                |                                  |       |           |                       |                       |              |               |                      |                   |
| 51                                           | 428.6   | 6.50           | 38.07          | 8.529                            | 3841  | 4.665     | 0                     | 6.26                  | 1.000        | 0             | 4.61                 | 1.000             |
| 52                                           | 479.4   | 6.49           | 38.07          | 9.260                            | 4557  | 4.735     | 0                     | 6.97                  | 1.000        | 0             | 4.47                 | 1.000             |
| 53                                           | 530.2   | 6.37           | 38.01          | 10.13                            | 5997  | 4.700     | 0                     | 6.81                  | 1.000        | 0             | 4.00                 | 1.000             |
| $C_q = 0$ $T_w/T_s = 4.32$                   |         |                |                |                                  |       |           |                       |                       |              |               |                      |                   |
| 54                                           | 530.2   | 6.34           | 35.01          | 8.98                             | 5218  | 4.32      | 0                     | 7.73                  | 1.000        | 0             | 4.64                 | 1.000             |
| $C_q = 4.12 \times 10^{-4}$ $T_w/T_s = 4.41$ |         |                |                |                                  |       |           |                       |                       |              |               |                      |                   |
| 55                                           | 530.2   | 6.50           | 35.01          | 9.57                             | 7816  | 4.41      | 4.12                  | 6.41                  | .83          | 1.066         | 2.95                 | .636              |
| $C_q = 8.17 \times 10^{-4}$ $T_w/T_s = 4.37$ |         |                |                |                                  |       |           |                       |                       |              |               |                      |                   |
| 56                                           | 530.2   | 6.45           | 35.01          | 9.41                             | 10011 | 4.37      | 8.17                  | 5.30                  | .686         | 2.114         | 2.44                 | .525              |
| $C_q = 12.1 \times 10^{-4}$ $T_w/T_s = 4.35$ |         |                |                |                                  |       |           |                       |                       |              |               |                      |                   |
| 57                                           | 530.2   | 6.47           | 35.01          | 9.89                             | 12775 | 4.35      | 12.1                  | 4.23                  | .547         | 3.123         | 2.14                 | .461              |

TABLE 60 SUMMARY OF BOUNDARY LAYER PARAMETERS,  $T_w/T_g = 4.1$  $T_w/T_g = 4.1$ 

| RUN                                          | X     | $R_{e_x} \times 10$ | $T_w/T_g$ | $C_q \times 10^{-4}$ | $\theta$ | $\delta^*$ | $\delta$ | $\theta$ | Re $\theta$ | $\frac{\delta}{\theta}$ |
|----------------------------------------------|-------|---------------------|-----------|----------------------|----------|------------|----------|----------|-------------|-------------------------|
| $C_q = 0$ $T_w/T_g = 4.32$                   |       |                     |           |                      |          |            |          |          |             |                         |
| 51                                           | 428.6 | 8.529               | 4.665     | 0                    | .193     | 2.78       | 5.20     | .248     | 3841        | 14.40                   |
| 52                                           | 479.4 | 9.26                | 4.735     | 0                    | .236     | 3.51       | 5.85     | .284     | 4557        | 14.88                   |
| 53                                           | 530.2 | 10.13               | 4.700     | 0                    | .313     | 4.70       | 7.70     | .408     | 5997        | 15.01                   |
| $C_q = 0$ $T_w/T_g = 4.32$                   |       |                     |           |                      |          |            |          |          |             |                         |
| 54                                           | 530.2 | 8.98                | 4.32      | 0                    | .308     | 4.63       | 7.8      |          | 5218        | 15.02                   |
| $C_q = 4.12 \times 10^{-4}$ $T_w/T_g = 4.41$ |       |                     |           |                      |          |            |          |          |             |                         |
| 55                                           | 530.2 | 9.57                | 4.41      | 4.12                 | .433     | 6.52       | 10.7     |          | 7816        | 15.06                   |
| $C_q = 8.17 \times 10^{-4}$ $T_w/T_g = 4.37$ |       |                     |           |                      |          |            |          |          |             |                         |
| 56                                           | 530.2 | 9.41                | 4.37      | 8.17                 | .564     | 7.64       |          |          | 10011       | 13.55                   |
| $C_q = 12.1 \times 10^{-4}$ $T_w/T_g = 4.35$ |       |                     |           |                      |          |            |          |          |             |                         |
| 57                                           | 530.2 | 9.89                | 4.35      | 12.1                 | .685     | 9.22       | 14.8     |          | 12775       | 13.46                   |

TABLE 61 - Run 51

$M = 6.50$   
 $Re = 3861$   
 $T_u/T = 4.665$   
 $C_q = 0$   
 $P = 38.07 \text{ atm}$   
 $T_t = 550 \text{ K}$   
 $T = 58.1 \text{ K}$   
 $U = 996 \text{ m/sec}$

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 10.77     | 6.50 | 1.000 | 1.000 |
| 9.499     | 6.50 | 1.002 | 1.000 |
| 8.864     | 6.49 | 1.004 | 1.000 |
| 8.229     | 6.49 | 1.005 | 1.000 |
| 7.584     | 6.47 | 1.009 | .999  |
| 6.959     | 6.43 | 1.020 | .998  |
| 6.324     | 6.34 | 1.044 | .996  |
| 5.689     | 6.21 | 1.085 | .994  |
| 5.054     | 5.94 | 1.176 | .991  |
| 4.419     | 5.66 | 1.276 | .983  |
| 3.784     | 5.21 | 1.464 | .969  |
| 3.149     | 4.72 | 1.695 | .944  |
| 2.631     | 4.29 | 1.945 | .920  |
| 2.133     | 3.89 | 2.221 | .891  |
| 1.879     | 3.69 | 2.377 | .875  |
| 1.625     | 3.51 | 2.539 | .858  |
| 1.371     | 3.33 | 2.705 | .841  |
| 1.117     | 3.14 | 2.875 | .819  |
| .863      | 2.95 | 3.063 | .793  |
| .706      | 2.82 | 3.159 | .771  |
| .609      | 2.53 | 3.495 | .726  |
| .482      | 2.06 | 4.040 | .635  |
| .431      | 1.85 | 4.296 | .589  |
| .406      | 1.78 | 4.339 | .553  |
| .304      | 1.74 | 4.128 | .542  |

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TABLE 62 - Run 52

$M = 6.49$   
 $Re = 4557$   
 $T_u/T = 4.735$   
 $C_q = 0$   
 $P_o = 38.07 \text{ atm}$   
 $T_t = 550^\circ K$   
 $T = 58.6^\circ K$   
 $U = 996 \text{ m/sec}$

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 23.62     | 6.49 | 1.000 | 1.000 |
| 21.08     | 6.49 | 1.000 | 1.000 |
| 18.34     | 6.48 | 1.003 | 1.000 |
| 16.00     | 6.48 | 1.002 | .999  |
| 13.46     | 6.48 | 1.002 | .999  |
| 10.92     | 6.47 | 1.005 | .999  |
| 9.650     | 6.45 | 1.013 | 1.000 |
| 8.380     | 6.40 | 1.027 | 1.000 |
| 7.745     | 6.35 | 1.042 | .999  |
| 7.110     | 6.26 | 1.071 | .997  |
| 6.475     | 6.09 | 1.124 | .994  |
| 5.840     | 5.86 | 1.199 | .989  |
| 5.205     | 5.56 | 1.307 | .979  |
| 4.570     | 5.18 | 1.462 | .965  |
| 3.935     | 4.78 | 1.638 | .943  |
| 3.554     | 4.52 | 1.778 | .929  |
| 3.300     | 4.38 | 1.856 | .918  |
| 2.919     | 4.14 | 1.997 | .901  |
| 2.665     | 4.01 | 2.082 | .891  |
| 2.284     | 3.76 | 2.258 | .871  |
| 2.030     | 3.58 | 2.399 | .855  |
| 1.776     | 3.64 | 2.321 | .855  |
| 1.552     | 3.25 | 2.707 | .823  |
| 1.268     | 3.09 | 2.882 | .807  |
| 1.014     | 2.93 | 3.047 | .787  |
| .760      | 2.74 | 3.194 | .753  |
| .557      | 2.37 | 3.496 | .682  |
| .532      | 2.30 | 3.570 | .669  |
| .506      | 2.24 | 3.656 | .652  |
| .430      | 1.90 | 4.037 | .588  |
| .379      | 1.72 | 4.232 | .546  |



TABLE 63 - Run 53

$M = 6.37$   
 $P_o = 38.01 \text{ atm}$   
 $Re = 5997$   
 $T_t = 549^\circ K$   
 $T = 60.2^\circ K$   
 $\frac{T_w}{T} = 4.700$   
 $U = 991 \text{ m/sec}$   
 $C_q = 0$

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 24.75     | 6.37 | 1.000 | 1.000 |
| 24.21     | 6.36 | 1.002 | .999  |
| 21.67     | 6.34 | 1.008 | .999  |
| 19.13     | 6.33 | 1.012 | .998  |
| 16.59     | 6.31 | 1.018 | .998  |
| 14.05     | 6.30 | 1.021 | .998  |
| 11.51     | 6.24 | 1.038 | .998  |
| 10.24     | 6.21 | 1.052 | .999  |
| 8.972     | 6.11 | 1.083 | .998  |
| 7.702     | 5.83 | 1.174 | .990  |
| 6.432     | 5.34 | 1.348 | .973  |
| 5.162     | 4.74 | 1.609 | .943  |
| 3.892     | 4.12 | 1.951 | .902  |
| 3.257     | 3.79 | 2.174 | .876  |
| 2.622     | 3.44 | 2.442 | .843  |
| 1.987     | 3.13 | 2.722 | .810  |
| 1.352     | 2.79 | 3.076 | .769  |
| 1.098     | 2.65 | 3.224 | .747  |
| .844      | 2.52 | 3.330 | .720  |
| .590      | 2.21 | 3.610 | .660  |
| .463      | 1.90 | 3.953 | .594  |
| .336      | 1.45 | 4.924 | .484  |

TABLE 64 - Run 54

$M = 6.34$   
 $P_o = 35.01 \text{ atm}$   
 $Re = 5218$   
 $T_t = 548.5^\circ K$   
 $T = 60.7^\circ K$   
 $\frac{T_w}{T} = 4.32$   
 $U = 990 \text{ m/sec}$   
 $C_q = 0$

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 29.74     | 6.34 | 1.000 | 1.000 |
| 27.20     | 6.34 | 1.000 | 1.000 |
| 24.66     | 6.34 | 1.000 | 1.000 |
| 22.12     | 6.33 | 1.003 | 1.000 |
| 19.58     | 6.33 | 1.005 | 1.000 |
| 17.04     | 6.31 | 1.011 | 1.000 |
| 14.50     | 6.31 | 1.011 | 1.000 |
| 11.96     | 6.25 | 1.030 | 1.000 |
| 10.69     | 6.20 | 1.044 | .999  |
| 9.423     | 6.12 | 1.070 | .998  |
| 8.153     | 5.89 | 1.148 | .995  |
| 6.883     | 5.45 | 1.30  | .981  |
| 6.248     | 5.20 | 1.42  | .977  |
| 5.613     | 4.92 | 1.52  | .958  |
| 4.978     | 4.62 | 1.67  | .942  |
| 4.343     | 4.31 | 1.84  | .922  |
| 3.708     | 4.02 | 2.01  | .899  |
| 3.073     | 3.70 | 2.23  | .872  |
| 2.438     | 3.38 | 2.48  | .841  |
| 1.803     | 3.06 | 2.78  | .804  |
| 1.549     | 2.92 | 2.91  | .786  |
| 1.295     | 2.79 | 3.06  | .769  |
| 1.041     | 2.65 | 3.20  | .747  |
| .787      | 2.51 | 3.29  | .718  |
| .660      | 2.38 | 3.37  | .688  |
| .533      | 2.17 | 3.50  | .641  |
| .406      | 1.80 | 3.88  | .558  |
| .279      | 1.27 | 4.42  | .422  |

TABLE 65 - Run 55

$M = 6.50$   
 $Re = 7816$   
 $\frac{T_w}{T} = 4.41$   
 $C_q = 4.12 \times 10^{-4}$   
 $P_o = 35.01 \text{ atm}$   
 $T_c = 549.5^\circ K$   
 $T = 58.0^\circ K$   
 $U = 994 \text{ m/sec}$

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 29.84     | 6.50 | 1.000 | 1.000 |
| 27.31     | 6.51 | 1.000 | 1.000 |
| 24.76     | 6.48 | 1.007 | 1.000 |
| 22.22     | 6.45 | 1.016 | 1.000 |
| 19.58     | 6.44 | 1.021 | 1.000 |
| 17.14     | 6.44 | 1.021 | 1.000 |
| 14.61     | 6.40 | 1.032 | 1.000 |
| 12.06     | 6.21 | 1.092 | .997  |
| 10.80     | 6.00 | 1.160 | .994  |
| 9.525     | 5.62 | 1.30  | .983  |
| 8.255     | 5.15 | 1.49  | .965  |
| 6.985     | 4.65 | 1.73  | .940  |
| 5.715     | 4.13 | 2.03  | .904  |
| 4.445     | 3.60 | 2.40  | .858  |
| 3.810     | 3.34 | 2.62  | .830  |
| 3.175     | 3.09 | 2.83  | .799  |
| 2.540     | 2.82 | 3.10  | .764  |
| 1.905     | 2.58 | 3.36  | .726  |
| 1.651     | 2.45 | 3.51  | .705  |
| 1.397     | 2.37 | 3.58  | .691  |
| 1.143     | 2.26 | 3.72  | .670  |
| .889      | 2.11 | 3.86  | .636  |
| .762      | 2.01 | 3.90  | .610  |
| .635      | 1.84 | 4.00  | .567  |
| .508      | 1.58 | 4.17  | .496  |
| .279      | 1.14 | 4.30  | .363  |

TABLE 66 - Run 56

$M = 6.45$   
 $Re = 10,011$   
 $\frac{T_w}{T} = 4.38$   
 $C_q = 8.17 \times 10^{-4}$   
 $P_o = 35.01 \text{ atm}$   
 $T_c = 548.5^\circ K$   
 $T = 59.2^\circ K$   
 $U = 995.0 \text{ m/sec}$

| Y<br>(mm) | M    | T/T   | U/U   |
|-----------|------|-------|-------|
| 29.74     | 6.45 | 1.000 | 1.000 |
| 27.20     | 6.44 | 1.004 | 1.000 |
| 24.66     | 6.43 | 1.005 | 1.000 |
| 22.12     | 6.42 | 1.007 | 1.000 |
| 19.58     | 6.41 | 1.011 | 1.000 |
| 17.04     | 6.40 | 1.015 | 1.000 |
| 14.50     | 6.23 | 1.065 | .997  |
| 13.23     | 6.06 | 1.12  | .995  |
| 11.96     | 5.76 | 1.22  | .987  |
| 10.69     | 5.37 | 1.37  | .974  |
| 9.423     | 4.92 | 1.56  | .953  |
| 8.153     | 4.48 | 1.78  | .926  |
| 6.883     | 4.02 | 2.04  | .891  |
| 5.613     | 3.56 | 2.35  | .847  |
| 4.978     | 3.33 | 2.52  | .822  |
| 4.343     | 3.12 | 2.70  | .795  |
| 3.708     | 2.92 | 2.87  | .768  |
| 3.073     | 2.67 | 3.12  | .730  |
| 2.438     | 2.48 | 3.28  | .698  |
| 1.803     | 2.26 | 3.51  | .656  |
| 1.549     | 2.18 | 3.60  | .642  |
| 1.295     | 2.09 | 3.69  | .623  |
| 1.041     | 2.01 | 3.72  | .602  |
| .914      | 1.93 | 3.77  | .582  |
| .787      | 1.85 | 3.77  | .558  |
| .660      | 1.76 | 3.77  | .529  |
| .533      | 1.63 | 3.79  | .493  |
| .432      | 1.43 | 3.94  | .441  |
| .279      | 1.12 | 4.10  | .351  |

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TABLE 67 - Run 57

$M = 6.47$   
 $Re = 12,775$   
 $\frac{Tw}{T} = 4.35$   
 $C_q = 12.1 \times 10^{-4}$

$P_o = 35.01 \text{ atm}$   
 $T_t = 549^\circ K$   
 $T = 58.6^\circ K$   
 $U = 993 \text{ m/sec}$

| $Y$<br>(mm) | $M$  | $T/T$ | $U/U$ |
|-------------|------|-------|-------|
| 29.95       | 6.47 | 1.000 | 1.000 |
| 27.41       | 6.46 | 1.003 | 1.000 |
| 24.87       | 6.44 | 1.009 | 1.000 |
| 22.33       | 6.43 | 1.009 | .999  |
| 19.79       | 6.42 | 1.012 | .999  |
| 17.25       | 6.32 | 1.044 | .998  |
| 15.98       | 6.18 | 1.085 | .996  |
| 14.71       | 5.95 | 1.162 | .991  |
| 13.44       | 5.63 | 1.277 | .983  |
| 12.17       | 5.31 | 1.394 | .970  |
| 10.90       | 4.81 | 1.613 | .945  |
| 9.627       | 4.34 | 1.862 | .915  |
| 8.357       | 3.91 | 2.12  | .880  |
| 7.087       | 3.48 | 2.43  | .837  |
| 5.817       | 3.06 | 2.77  | .787  |
| 4.547       | 2.67 | 3.12  | .729  |
| 3.277       | 2.30 | 3.48  | .663  |
| 2.642       | 2.13 | 3.64  | .628  |
| 2.007       | 1.92 | 3.86  | .581  |
| 1.753       | 1.85 | 3.93  | .568  |
| 1.499       | 1.76 | 4.02  | .546  |
| 1.245       | 1.70 | 4.05  | .529  |
| .991        | 1.60 | 4.13  | .501  |
| .864        | 1.52 | 4.17  | .479  |
| .737        | 1.43 | 4.20  | .452  |
| .610        | 1.33 | 4.21  | .424  |
| .483        | 1.18 | 4.29  | .377  |
| .279        | .908 | 4.33  | .292  |

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| 2. heat transfer            |        |    |        |    |        |    |
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