**Measurement in a Wind Tunnel
of the Modification of Mean Wind
and Turbulence Characteristics
Due to Induction Effects Near
Wind Turbine Rotors**

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TO INDUCTION EFFECTS NEAR WIND
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PREFACE

Almost universally, the aerodynamic components in computational models of wind turbine response are formulated to modify the available free-stream wind characteristics to account for rotor-induced changes in the wind as the wind approaches the turbine blades. The problem is finding accurate corrections to all features of the wind that change and that determine the aerodynamic forces on the rotor. In the past, the axial and radial distributions of induced mean wind speed changes, computed from simple momentum theory and using a frozen wake assumption, have been the typical free-stream wind adjustments used. Turbulence has not been included as a factor in estimating aerodynamic forces on wind turbine rotors. More recently, however, fluctuating aerodynamic forces on wind turbine rotors have been shown by the Pacific Northwest Laboratory (PNL) to depend strongly upon the properties of both the mean wind and the fluctuating part of the 3-dimensional wind field. In addition, research at PNL has shown that the strong effects of turbulence on the aerodynamics depend not only upon the energy, or magnitude, of the turbulence but also upon the shape, size, and distribution of turbulent eddies in the inflow.

Within the Department of Energy's wind energy research program, PNL is responsible for developing and evaluating the models of the turbulent wind field that are the input to wind turbine aerodynamic models. There is no tested model of the effect of the rotor on the mean and important turbulence characteristics of the airflow from the free stream to the rotor airfoils. Because wind models must result in accurate aerodynamic calculations, PNL has begun research to determine the nature and importance of modifications of wind flowing into the induction, or flow distortion, zone near the rotor.

Developing the new induction model requires data and relations not previously obtained by measurement. First, and best known, is the mean wind speed induction relation. Second, the relations showing the induction effects on the energy, shape, and size of eddies are needed. Third, the relation between these mean and turbulence properties and the distinctly different characteristics of the wind seen by a rotating blade (the rotationally sampled wind) are important. Thus, the measurements of induction effect reported

herein provide the beginnings of an observational basis for developing a suitable model of the changes in characteristics of wind from the free stream to the vicinity of the rotor.

The first step in our measurement program has been to design a set of wind-tunnel studies based upon a working, scale-model wind turbine. In this program, the 3-dimensional field of turbulent airflow surrounding the rotor is measured from 3 rotor diameters upwind to 0.5 diameter downwind. The first four single-point statistical moments of the turbulent wind are to be calculated from the measurements, along with turbulent spectra and integral length scales of turbulence. A pilot study has been initiated using a wind turbine model lent to PNL by Cornell University, Department of Aerodynamics and Astronautics, and refurbished and modified by PNL. The measurements of the distorted flow have been made in a large wind tunnel under contract by staff of the Fluid Mechanics and Wind Engineering program at Colorado State University (CSU).

The following report was drafted by CSU; it provides the measured, computed, tabulated, and in some instances plotted basic wind parameters for the four cases composing the pilot study measurements. In follow-on work, a second report will present a PNL analysis and interpretation of these basic data for the purpose of advancing our understanding of effects of flow distortion on the turbulence properties of inflow wind to the rotor. A new wind turbine model has been constructed that will allow more precise and complete measurements in the fuller study that will follow this study. A full-scale field study of rotor induction effects on the turbulent airflow is to be undertaken at a wind turbine using the guiding information from the wind tunnel studies and recent theoretical advances.

We publish this report of primarily uninterpreted data for intermediate Reynolds number flows from the pilot wind tunnel study to provide early opportunities for other researchers to incorporate the information into their own work. We hope that this will expand an active exchange between PNL and other researchers on the flow distortion effects on wind near wind turbine rotors.

SUMMARY

The pilot measurement program described in this report produced data that will be useful in developing more accurate models of the turbulent wind that flows from the free stream into the turning blades of a wind turbine rotor. The flow distortion caused by the interaction of the rotor blades with the wind alters the character of the mean wind velocity and the turbulence properties.

The measurements were taken in a wind tunnel, by a single, nonmoving, 3-dimensional hot-film anemometer, from 3 rotor diameters upwind to 0.5 rotor diameter downwind of a scale model wind turbine. The rotor diameter was 0.53 m, and the rotor spun at about 26 revolutions per second for these tests. The wind tunnel cross section's width and height were both 1.83 m. The model rotor was 7 m downwind of a grid of dowels that generated the turbulence. The dowels were 1.27 cm in diameter and the grid spacing was 12 cm, which increased the turbulence intensity from background of 0.1% to a value of 1.5% at the mean wind speeds of 6 and 7.6 m/s. A rough estimate of the mass flow through the 0.27-m² spinning rotor area indicated that the effective blockage caused by the wind tunnel with a 3.34-m² cross section area was 4%. One can think of the spinning model rotor disk as having acted as though approximately half of its area were open to airflow. The mean speed measurement errors were about 3% and the wind direction measurement errors were about 2% for angles less than 15°. Errors in the measurement of the power out of the rotor shaft were ± 0.5 to ± 1.1 W for tip speed ratios from 4.0 to 7.6 respectively. Maximum power coefficients were in the range 0.28 to 0.35.

Some very preliminary tracer studies, using He-inflated soap bubbles, of the flow changes near the rotor disk showed: 1) Flow passing downwind through the rotor establishes counter-rotational swirl. 2) About 80% of the inflow at the 0.75 radius approached the rotor disk parallel to the axis of the rotor, and the other 20% experienced a single abrupt angular deflection in the region from 0.25 to 0.5 rotor radius upwind of the rotor disk. 3) When the inflow at about tip radius was taken into the tip vortices, the tracer bubble made a complete rotation in a space about equal to the blade length. Using titanium tetrachloride smoke as a tracer resulted in a less detailed, more average,

picture of the inflow diverging outward in a manner expected from a model of the average axial induction of mean wind velocity change.

The first, second, third and fourth single-point moments of the turbulent flow are computable for four different approach flow conditions (0.1 and 1.5% turbulence intensity and 6 and 7.6 m/s wind speed). Some representative samples of data are plotted to show mean wind and turbulence parameter variation as a function of both axial distance from the rotor and radial distance from the axis of rotation. The induction effects within and beyond the radius of the rotor are resolved with great detail and show maximum magnitudes in the 10% to 15% range. A variety of other data are plotted and tabulated. All data are summarized in computer printouts and computer program listings are included. The data presented in this report are expected to be used in detailed analyses to begin to improve models of rotor effects on inflow wind characteristics and for the design of more complete experiments on flow distortion.

DEFINITION OF SYMBOLS

<u>Symbol</u>	<u>Pages of Appearance</u>	<u>Definition</u>
$\bar{U}$	ix, 52-54	Wind speed in wind tunnel centerline of working section
T.I.	ix, 52-54	$\sigma_u/\bar{U}$ of wind tunnel flow
g_c	4	Gravitational conversion constant
ΔP	4	Stagnation pressure: static pressure at pitot static probe in tunnel
ρ	4	Air density in tunnel, computed from ideal gas law
E	5	Voltage output of hotfilm anemometer
A, B, C	5	Coefficients and exponents in single hotfilm calibration equation
U	5	Instantaneous longitudinal wind speed in tunnel measured by single hotfilms
E ₁ , E ₂	6	Voltage output of anemometer electronics for each of two films of crossfilm probe
i	6	Subscript (index) denoting a member of a set of calibration wind tunnel wind speeds at the sensor
j	6	Subscript (index) denoting a member of a set of calibration wind tunnel wind speeds at the sensor
u	6	x-direction (along-tunnel) instantaneous longitudinal wind velocity measured with a hotfilm anemometer
v	6	y-direction (cross-tunnel, horizontal) instantaneous lateral wind velocity measured with a hotfilm anemometer
w	implied on 6	z-direction instantaneous vertical wind velocity measured with a hotfilm anemometer
UN1	6	Wind velocity component normal to cross-film #1
UN2	6	Wind velocity component normal to cross-film #2

<u>Symbol</u>	<u>Pages of Appearance</u>	<u>Definition</u>
ϕ_i	7	Yaw angle between velocity vectors and film i , $\phi_i = 0$ denotes wind perpendicular to the film axis
k	7	Yaw factor to account for noncosine-law heat flux relation
$V_{eff,i}$	8,9	Effective normal cooling velocity for film i
V	8,9	Total instantaneous velocity vector approaching the sensor array
$u_i, i=1,3$	9	u for $i=1$, v for $i=2$, w for $i=3$
U_x	9	Instantaneous longitudinal velocity; same as U
U_r	9	Instantaneous crosswind radial velocity (cylindrical coordinate system)
U	9	Instantaneous crosswind tangential velocity (cylindrical coordinate system)
x, r, θ	10	Cylindrical coordinates with x longitudinal to wind tunnel flow
$\bar{u}$	11	Mean value of longitudinal wind speed
u'	11	Deviation of u from $\bar{u}$, i.e., $u' = u - \bar{u}$
P	12	Power out of turbine rotor at prony brake
A	12	Rotor disk area

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1.0 INTRODUCTION

Aerodynamicists currently use wind field and turbulence information to calculate the character of dynamic loading that large wind-generator rotors receive (Hansen 1979; Kareem 1981; Cliff and Fichtl 1978; Fichtl 1983). Unfortunately, these turbulence scales and intensities may be distorted by the pressure of the rotor flow field before they actually interact with the rotor blades. Indeed, wind-generator induction effects and streamline divergence caused by the hub and tower may significantly distort free wind field values.

In recent years, a limited number of model and field-scale measurement studies have examined near- and far-field turbine rotor wakes (Riley et al. 1980; Eberle 1981; Baker and Walker 1982). These wake studies were made to evaluate the influence of upwind turbines on downwind installations; little information appears in the literature concerning possible induction effects.

It is the purpose of this report to provide experimental data on the wind field surrounding a single model wind turbine rotor disk. These data should provide an improved physical insight into the induction effects of the air flow as it approaches the wind turbine. This insight should in turn improve an analytical model's predictive capabilities. A tradeoff between a well-controlled experiment in a wind tunnel with $Re_{chord} \leq 150,000$ and a very difficult full-size turbine measurement was made in favor of the wind tunnel in the first round of experiments. The analysis of results and scale-up efforts to follow in later reports will consider the applicable differences in physics.

A scaled model of a horizontal-axis wind turbine (a two-bladed rotor of diameter 53 cm) was placed into the Meteorological Wind Tunnel (MWT) facility at Colorado State University (cross-section width of 183 cm). Four different approach flow conditions were studied: low and moderate turbulence levels (0.1% and 1.5% intensity) at both 6 and 7.6 m/s freestream air velocities. For each of these flow conditions the rotor power coefficient versus tip speed ratio was obtained, and the 3-dimensional velocity field from 3 rotor diameters upwind to 0.5 diameter downwind was tabulated.

The power output of the rotor was obtained via a simple prony brake friction device that imparts a torque (measured by the deflection of a spring) to the spinning shaft of the wind turbine. The rotor speed, measured by a strobe light, was observed to vary with load from 900 rpm up to 2100 rpm for the flow conditions described above.

The 3-dimensional velocity field was measured via a three-hot-film probe (TSI 1294^(a)) capable of measuring rapidly varying velocity vector direction and magnitude within a rectangular coordinate system octant. The transducer response was directed to an analog to digital converter connected to a minicomputer system for on-line data reduction. The statistical values computed from the u-v-w time series in axisymmetrical coordinates for each position are:

1. mean, rms, skewness, and flatness of the axial velocity component
2. mean, rms, skewness, and flatness of the radial velocity component
3. mean, rms, skewness, and flatness of the angular velocity component
4. mean velocity vector angles from the axial, radial, and angular coordinate directions
5. Reynolds stresses
6. mean, rms, skewness, and flatness of the angular deviations about the axial axis
7. mean, rms, skewness, and flatness of the angular deviations about the radial axis
8. mean, rms, skewness, and flatness of the angular deviations about the angular axis.

Details of the measurement techniques are provided in Section 2.0. The test program and data results are given in Section 3.0. A short discussion of the implications of this data set is included in Section 4.0.

(a) Manufactured by TSI, Inc., St. Paul, Minnesota.

2.0 DATA ACQUISITION AND ANALYSIS

Laboratory measurement techniques are discussed in this section. Some of the methods used are conventional and need little elaboration.

2.1 WIND TUNNEL FACILITY

The experiments were performed in the Meteorological Wind Tunnel (MWT) shown in Figure 2.1 (Plate and Cermak 1963). This wind tunnel has a wind speed range of 0.3 to 30 m/s. The approach flow turbulent intensity varies upward from 0.1%. The test section in which the model wind turbine was located had a cross-sectional area of 3.34 m^2 ($1.83 \text{ m} \times 1.83 \text{ m}$). The model was located 7 m downwind from the convergent entrance to the test section. For the grid turbulence tests (turbulent intensity of 1.5%), a dowel grid was mounted at the test section entrance. The dowels were 1.27 cm in diameter and spaced 12 cm apart. The wind turbine was placed in the spatially uniform velocity field downwind of the entrance.

2.2 WIND TURBINE MODEL

The wind turbine model (Figure 2.2-1) was built by Mr. Peter Bushnell of Cornell University (Bushnell 1983, 1984). Figure 2.2-2 displays the mounting arrangement of this horizontal-axis wind turbine. The rotor shaft was mounted on two support rods; each rod holds a low-friction roller bearing to ensure rotor shaft rotational freedom. At the downwind end of the rotor shaft was mounted a small DC generator. A calibration of the generator's voltage variation versus rotational speed (obtained through the use of a strobe light) yielded the conversion equation $\text{rpm} = 744 \times (\text{volts})$.

The prony brake consisted of a spring mounted next to a ruler, a leather friction belt, an aluminum brake drum mounted on the rotor shaft, and a weight bucket. To start the wind turbine spinning, one manually lifted the brake assembly away from the brake drum until the turbine reached a rotational speed above its resonant frequency of around 1000 rpm. Once above this speed the prony brake was set back in place on the brake drum. The amount of weight placed in the bucket determined the rotor speed.

The rotor diameter was 53.4 cm. The rotor blades were made of balsa wood covered with epoxy. The blade shape was that of a NACA 4415 airfoil section. A steel pin at the base of each blade was connected to the hub with a set screw, and the hub was also connected to the rotor shaft with set screws. The blade chord was constant (4.76 cm) over the entire radial length of the blade. The tips were cut square. Table 2.2-1 displays the blade twist angle versus radial distance. The wind turbine was designed to operate at 1400 rpm, with a tip speed ratio of 5 and a lift coefficient of 1.0.

As stated in Section 2.1, the wind tunnel cross-sectional area was 3.34 m², whereas the rotor disk area was 0.268 m². A rough estimate of the mass flow through the spinning rotor disk indicates that approximately one-half of the rotor disk acted as open area. Thus the blocking area presented by the spinning rotor disk was 4% of the wind tunnel cross-sectional area.

2.3 FLOW VISUALIZATION TECHNIQUES

Video movies (VHS) were taken of helium soap bubbles produced by a bubble generator as they floated through or by the spinning rotor blades. Video movies were also taken of a smoke plume produced by titanium tetrachloride as it flowed past the rotor blades.

2.4 VELOCITY MEASUREMENTS

Velocity measurements were made with pitot probes, single hot films, cross films and 3-dimensional hot-film systems. Each of these instruments will be described in the following sections.

2.4.1 Pitot-Static Probe Measurements

Pitot-static probes were used as a velocity standard during the calibration of the different hot-film systems and to provide the reference upwind velocity measurement. The principles of operation of pitot-static probes are described in any fundamental text on fluid mechanics and will not be discussed in detail here. The operational relationship for these probes is $U = (2g_c \Delta P / \rho)^{1/2}$, where U = velocity, g_c = gravitational conversion constant, ΔP = difference between static and stagnation pressures, and ρ = the air density. ρ was calculated from the ideal gas law and ΔP was measured using an

electronic differential pressure manometer. The pitot-static probe measurements were accurate to within $\pm 2\%$ of the actual velocity.

2.4.2 Single-Hot-Film Probe Measurements

Single-hot-film (TSI 1210 Sensor) measurements were used to document the longitudinal turbulence levels for the four different approach flow conditions and as an error estimator for the cross-film and 3-D film measurements. To calibrate the single-film probe, it was placed into the wind tunnel next to the pitot-static probe. The anemometer voltages were digitized for several velocities covering the range of interest. These voltage-velocity (E,U) pairs were then regressed to the equation $E^2 = A + BU^c$ via a least squares approach to assumed values of exponent c. Convergence to the minimum square was accelerated by using the secant method to find the best new estimate of c. To take measurements with this calibrated single-film probe, the anemometer voltage was digitized and stored on a disk file within a minicomputer system. This voltage time series was converted to a velocity time series using the inverse of the calibration equation:

$$U = [(E^2 - A)/B]^{1/c}$$

This velocity time series was then analyzed for pertinent statistical quantities, such as mean, mean square, etc., and tabulated at the terminal.

The calibration curve yielded hot-film anemometer velocities that were always within $\pm 1\%$ of the velocities calculated from the pitot-static probe. The accuracy of a single hot-film during the measurement of turbulent flow quantities is dependent upon the flow regime being measured. During the present study the single-film probe was used only in conditions of no mean wind shear and low turbulent intensity (less than 1.5%). For these conditions the velocity time series should be accurate to within $\pm 2\%$.

2.4.3 Cross-Film Probe Measurements

Cross-film (TSI 1241) measurements were used to document the lateral and vertical turbulent level for one approach flow condition and as an error estimator for the 3-D hot-film measurements. To calibrate the cross-film probe, it was placed next to the pitot-static probe. Each of the two films

were yawed 45 degrees from the direction of the mean velocity vector. The anemometer voltages were digitized for several velocities covering the range of interest. These voltage-velocity pairs (E_1, U ; E_2, U) were fitted to the equation

$$(E_{i,j})^2 = A_i + B_i [(U_j \cos (45^\circ))]^{c_i}$$

via a least square approach with the secant method used to find the best new estimate of exponent, c_i . Strict cosine dependence of the heat flux from the film versus yaw angle was assumed; and thus, no yaw angle calibration was necessary. During measurements made with this calibrated cross film probe it was placed so that the mean velocity vector was at 45° to each film, while both films were located in the x-y plane. The voltage output from each anemometer was digitized, and the resulting voltage time series were converted to velocity time series via the equations

$$u = (U_{N1} + U_{N2})/1.414 \quad v = (U_{N1} - U_{N2})/1.414$$

where $U_{Ni} = [(E_i^2 - A_i)/B_i]^{c_i}$
 $= u \sin \phi_i + v \cos \phi_i; \quad \phi_1 = 45^\circ, \phi_2 = 135^\circ$
 U_{Ni} = velocity component normal to film i
 u = longitudinal velocity component
 v = lateral velocity component

To measure vertical velocity components the probe was rotated 90° so that both films were in the x-z plane. The reduction equations are similar to those above.

The calibration curve yielded hot-film anemometer velocities that were always within $\pm 1\%$ of the velocities calculated from the pitot-static probe. Since no yaw calibrations were performed, no estimate can be made of inaccuracies introduced by the cosine law assumption. From past experiences it is felt that this cross-film reduction method should be accurate to within $\pm 10\%$ for a low-intensity, nearly isotropic flow.

2.4.4 3-Dimensional Hot-Film Probe Measurements

A TSI model 1294-20 probe was used for all measurements behind and to the side of the wind turbine. Note that if wind direction is outside the probe's primary octant, the probe does not detect the difference. An estimate of the percent of time the wind was ambiguous is given in Column 4 of Table 3.3-3. A specially made probe, similar to the TSI 1294-20 but with a 90° bend in the probe shaft 3.8 cm back from the sensors, was used for all measurements upwind of the wind turbine. The data reduction scheme used was similar to that described in TSI Technical Bulletin 8. The TSI model 1294-20 probe has three orthogonally mounted, cylindrical hot films (dia = 0.051 mm), each doubly supported (Figure 2.4.4-1). The probe can measure total vector velocities that are contained within the single octant defined by the three film positions.

To calibrate the 1294 3-D probe, it was placed in the wind tunnel (the probe support axis parallel to air flow) next to the pitot-static probe. In this position the angle between each sensor and the flow vector is 54.74°; thus, the yaw angles for each sensor are 35.26° (Figure 2.4.4-1). The voltages from each anemometer channel (3 total) were digitized for several velocities covering the range of interest. These voltage-velocity pairs (E_{ij} , U_j ; $i = 1,3$), at a fixed angle, were fit to the equation

$$E_{i,j}^2 = A_i + B_i'(U_j)^{c_i}; \quad i = 1,3; \quad j = 1,n$$

where $B_i' = B_i(\cos^2\phi_i + k^2\sin^2\phi_i)^{c_i/2}$

ϕ_i = yaw angle between velocity vector and film i

k = yaw factor

n = no. of calibration points

via a least-squares fit with the secant method to find the best new estimate of the exponent c_i . Note that if the yaw factor, k , equals zero then a simple cosine law dependence of heat flux exists. To determine the yaw factor, k , the air velocity was set at a constant value, and the probe was rotated about its y axis and then its x axis so that voltage samples could be taken for a

wide range of yaw angle variations on all three films. Table 2.4.4-1 lists the yaw angles on the different films for the y-x axis rotations that were used. These voltage-yaw angles ($E_i, \phi_i; i = 1,3$) were regressed to the equation

$$B_i^2 = (E_{i,j}^2 - A_i) / U^{c_i} = B_i (\cos^2 \phi_{i,j} + k_i^2 \sin^2 \phi_{i,j})^{c_i/2}$$

where $i = 1,3$ and $j = 1,n$, via a least squares approach with the secant method to find the best new estimate for the yaw factor, k_i . A_i, B_i, c_i and k_i for all three films are thus obtained, but for the reduction algorithm used k_i must be equal for all films and not a function of velocity. Providing that all three films have a similar aspect ratio, then all three k_i values should be of similar magnitude and forcing them equal does not introduce large errors. Once a value for k is specified then a least-squares fit will determine the optimal values for B_i . Once the value of k was determined for a specific probe, it was no longer necessary to do angle calibrations.

Given the calibration constants A_i, B_i, c_i and the equations

$$E_i^2 = A_i + B_i (V_{\text{eff},i})^{c_i}; \quad i = 1,3$$

where $V_{\text{eff},i} = V(\cos^2 \phi_i + k^2 \sin^2 \phi_i)^{1/2}; i = 1,3$

$V_{\text{eff},i}$ = effective cooling velocity for film i

V = total velocity vector approaching sensor array

and using the trigonometric relationships that exist between the three yaw angles

$$\sum_{i=1}^3 \sin^2 \phi_i = 1 \text{ and } \sum_{i=1}^3 \cos^2 \phi_i = 2$$

one finds that the total velocity approaching the sensor array, V , is calculated from

$$V = \left[\sum_{i=1}^3 V_{\text{eff},i}^2 / (2 + k^2) \right]^{1/2} ;$$

the yaw angles, ϕ_i , are

$$\phi_i = \arcsin [(1 - V_{\text{eff},i}^2 / V^2) / (1 - k^2)]^{1/2} ;$$

the angles, ϕ_i , between a sensor coordinate axis and the velocity vector are

$$\phi_i = 90^\circ - \phi_i;$$

and the u_i velocity components (in the sensor coordinate system of x_i respectively) of the total velocity, V , are

$$u_i = V \sin \phi_i = [(V^2 - V_{\text{eff},i}^2) / (1 - k^2)]^{1/2} .$$

In the above equations $V_{\text{eff},i}$ is given by

$$V_{\text{eff},i} = [(E_i^2 - A_i) / B_i]^{1/c_i} .$$

The algorithm finds the velocity components, u_i , that are along the sensor coordinate directions. Thus it is necessary to transform the u_i values from sensor coordinates to u_i values in wind tunnel coordinates. The details of this transformation are given in Appendix A ($u_1 \equiv u$, $u_2 \equiv v$, $u_3 \equiv w$).

The computer programs (listed in Appendix B), used to calibrate and take data with the 3-D probes, were:

1. CAL3D - This program finds the calibration constants, A_i , B_i , c_i , k ($i = 1,3$) and writes them to a disk file for later retrieval by a reduction program.

2. DAT3D - This program creates a digital voltage time series for each of the 3 channels, converts the voltage values into U_x , U_r , U_θ velocity time series files (in tunnel coordinates) and calculates each time series minimum, maximum, mean, rms, skewness, and flatness.
3. DAT1 - This program creates a digital voltage time series for each of the 3 channels and stores it on the computer's disk. It was used to acquire data in a rapid sequence, as opposed to waiting for files to be reduced into velocity values.
4. DAT2 - This program picks up the digital voltage time series created by DAT1 and converts them into U_x , U_r , U_θ velocity time series. Then it calculates each time series minimum, maximum, mean, rms, skewness, and flatness.
5. ANGTM - This program creates the time series of the angular deviations about the tunnels x , r , θ coordinates and computes the minimum, maximum, mean, rms, skewness, and flatness. It is scheduled from inside DAT2.
6. PRT3 - This program prints out the reduced data that were calculated in program DAT2 in the format seen later in this report.

The accuracy of 3-D velocity measurements and associated reduction algorithms can be estimated by directing different known mean velocity vectors at the probe. Table 2.4.4-2 summarizes such tests. Table 2.4.4-2 shows that the mean velocity magnitude is generally within $\pm 3\%$ of the actual value. The error in angle calculations is seen to be approximately $\pm 2^\circ$ for angular deviations of 15° or less and somewhat larger than this for greater deviations.

Another test of the accuracy of the 3-D probe is to compare the measurements of different turbulent statistics to those obtained from more conventional probes, such as single-film and cross-film probes. Table 2.4.4-3 displays the mean and rms turbulence magnitudes calculated from a single film, a cross film, a TSI 1294-60 3-D probe, (a) and a TSI 1294-20 probe for two different turbulence conditions. The mean and rms velocity comparisons between

(a) The 1294-60 probe has larger diameter sensors and the sensors are separated by greater distances than the 1294-20 probe.

the single-film and the cross-film are within the bounds specified earlier in Section 2.4.3, that is ~2% and ~10% respectively. The 3-D probes compare to these $\bar{u}$ and u' measurements within ~3.5% and ~10% respectively. The v' and w' magnitude comparisons to the cross film results suggest errors of ~15% (except for v' in grid turb where 29% error was observed). Figure 2.4.4-3 displays the spectral responses of these four different probes. The single-film, cross-film, and TSI 1294-20 3-D probes all provide equivalent frequency response out to 800 Hz. The TSI 1294-60 3-D probe has a large sensing volume; hence, its response rolls off rapidly above 100 Hz. The large-sensor-volume TSI 1294-60 3-D probe was not used for any data acquisition during the remainder of the study.

2.5 POWER MEASUREMENTS

The power output from the wind turbine was calculated in the following manner (see Figure 2.5-1):

1. The spring force constant was calculated to be 54.2 N/m by measuring the deflection of the spring for loads varying between 0 and 453 g.
2. Z_0 , the spring zero deflection point as mounted in the prony brake system, was calculated from the equation (see upper part of Figure 2.5-1)

$$W = (Z_s - Z_0) K \text{ or } Z_0 = Z_s - W/K$$

for several different weights up to 453 g. The average of these Z_0 values was used as the spring zero deflection point.

3. The rotor was started for the specific approach flow conditions being tested. Over a range of weights placed in the bucket the rotor speed, Ω , and the spring deflection under dynamic conditions were recorded.
4. The frictional force, F , applied by the prony brake against the brake drum is $F = W - T_d$. The torque, τ , applied to the rotor shaft is then $\tau = F \times R$ and the power is $P = \tau \times \Omega$.

5. The power coefficient, C_p , is $C_p = P/(1/2\rho AU^3)$ where $\rho = 1.0 \text{ kg/m}^3$ is the density of air in the tunnel, A is the rotor disk area, and U is the approach flow mean wind speed. The tip speed ratio, λ , is given by $\Omega R/U$.

A calculation of the drag force on the wire connecting the weight to the prony brake assembly was determined to be small (equivalent deflection in spring of 0.3 mm) compared to the hysteresis errors accompanied with the estimate of the springs zero deflection point ($\pm 5 \text{ mm}$). This error in the estimation of Z_0 overshadows all other errors in the procedure to calculate the power, P . This error in P varies from $\pm 1.1 \text{ W}$ for the highest tip speed ratios down to $\pm 0.5 \text{ W}$ for the lowest tip speed ratios.

3.0 TEST PROGRAM AND DATA

The test program consisted of documenting the different approach flow characteristics, measurement of the performance (power coefficient versus tip speed ratio) of the model wind turbine, and the tabulation of the flow field near the spinning rotor. These topics are discussed in the following sections.

3.1 APPROACH WIND CHARACTERISTICS

Four different approach flow characteristics were studied: two different mean wind speeds and two different turbulent intensities. They were:

1. low turbulence ($\sim 0.1\%$) and mean wind speed = 6.0 m/s,
2. low turbulence ($\sim 0.1\%$) and mean wind speed = 7.6 m/s,
3. moderate turbulence ($\sim 1.5\%$) and mean wind speed = 6.0 m/s,
4. moderate turbulence ($\sim 1.5\%$) and mean wind speed = 7.6 m/s.

The approach flow was uniform and steady (within $\pm 2\%$) over the center portion of the wind tunnel. The moderate turbulence cases were produced by the placement of a grid, described in Section 2.1, at the entrance of the test section. Measurements of the approach flow character were made by a single-film probe and the TSI 1294-20 3-D hot-film probe. The turbulent statistics describing these approach flows are summarized in Table 3.1-1. The longitudinal and vertical velocity component power spectrums for Flows 3 and 4 are shown in Figure 3.1-1.

3.2 POWER COEFFICIENT RESULTS

The power output of the model wind turbine was measured for three different conditions:

	<u>Case</u>		
	<u>I</u>	<u>II</u>	<u>III</u>
mean velocity	6.0	7.6	7.6
turbulent intensity	0.1%	0.1%	1.5%

Tables 3.2-1 to 3.2-3 list the numerical values obtained from the Cases I, II, and III respectively. Figure 3.2-1 displays the power coefficient versus tip speed ratio.

3.3 WIND CHARACTERISTIC NEAR THE ROTOR

Figure 3.3-1 indicates the 58 spatial grid points at which velocity measurements were taken with a TSI 1294-20 3-dimensional hot-film probe. Table 3.3-1 lists the coordinates of each spatial location. Note that the right-most digit of the three-digit position number always represents the radial distance in 0.125 rotor diameters and the left two digits represent the axial distance. Four different approach flow conditions were tested, as described in Section 3.1. These were:

<u>Case No.</u>	<u>Mass Velocity (m/s)</u>	<u>Turb. Intensity (%)</u>
1	6.0	0.1
2	7.6	0.1
3	6.0	1.5
4	7.6	1.5

The nomenclature used for test designations was case number followed by position number. Thus run number 3062 would be for approach flow case number 3 ($U = 6.0$ m/s, T.I. = 1.5%) at position 62 which from Table 3.3-1 was at $x = -0.134$ m, $r = 0.134$ m, $\theta = 180^\circ$.

For Cases 1 and 3 a mass of 454 grams was placed into the prony brake systems bucket. For Cases 2 and 4 a mass of 906 grams was used. Unfortunately, the amount of friction between the prony brake's leather belt and the aluminum brake drum varied as the brake heated up and as aluminum oxide coated both belt and drum. Thus, the speed and power output of the wind turbine varied substantially during the test period. Table 3.3-2 documents the approximate rotor speed for each velocity measurement. The variation in rotor speed during the data-acquisition period for a single case was as large as ± 150 rpm.

Table 3.3-3 summarizes the pertinent turbulent statistics for all measurements of the 3-dimensional velocity field near the rotor. All measurements

were made with a digital sampling rate of 1563 Hz for a total of 32,384 samples. Thus, given a rotor speed of approximately 1400 rpm, the velocity time series included 967 passes of a rotor blade (rotor has 2 blades). Again, with a rotor speed of ~1400 rpm at a 1563 Hz sample rate, 67 samples were taken for every revolution of the rotor, or a sample was taken every 5.37° of rotation. These time series records were of sufficient length to insure an accuracy of $\pm 5\%$ in the computation of the mean, rms, and flatness.

The following is a description of the column headers that appear in Table 3.3-3.

1. FILE NAME - The component velocity time series at each measurement location were saved on digital tape by these names. The last four characters are equivalent to the run number described above. The first two characters define the velocity component.
 - UU is for the axial component.
 - VV is for the radial component.
 - WW is for the angular component.
2. AXIS - 1 designates the axial coordinate.
 - 2 designates the radial coordinate.
 - 3 designates the angular coordinate.
3. POSITION - Measurement position in meters for the axial and radial coordinates, and in degrees for the angular coordinate. See Figure 3.3-1 for further guidance.
4. LIMITS EXCEEDED - This was the number of times a velocity vector came within 10° of leaving the measurement octant of the sensor coordinate system. In many of these excursions the velocity vector will have left the measurement octant resulting in a calculational error. In this case the velocity component (in sensor coordinates) is set to zero before conversion to tunnel coordinates. In some cases the velocity vector may pass out of the measurement octant but not result in calculation errors; thus the approach places erroneous values into the time series. Records that have a significant number of these errors should not be trusted, and those that

only have a few have dubious accuracy, particularly in the higher moments, such as skewness and flatness.

5. VELOCITY (MEAN) - Mean velocity component in m/s.
6. VELOCITY (ANGLE) - Angle (degrees) from the specified AXIS to the mean velocity vector.
7. VELOCITY (MIN) - Minimum velocity in m/s.
8. VELOCITY (MAX) - Maximum velocity in m/s.
9. VELOCITY (RMS) - Root mean square of the velocity fluctuations in m/s.
10. VELOCITY (SKEWNESS) - Third moment of the velocity fluctuations normalized by the RMS. It is zero for a sine wave and a random signal.
11. VELOCITY (FLATNESS) - Fourth moment of the velocity fluctuations normalized by the RMS. It is 1.5 for a sine wave and 3.0 for a random signal.
12. VELOCITY (REYNOLDS STRESS) - This is not in the units of stress. It is simply the mean product of the indicated velocity components.
 - U for the axial component.
 - V for the radial component.
 - W for the angular component.Units are m/s^2 .
13. ANGLE (MEAN) - Mean value of the angular deviations about the indicated axis. The units are degrees.
14. ANGLE (MIN) - Minimum of the angular deviations (degrees).
15. ANGLE (MAX) - Maximum of the angular deviations (degrees).
16. ANGLE (RMS) - Root mean square of the angular deviation fluctuations (degrees).
17. ANGLE (SKEWNESS) - Third moment of the angular deviation fluctuations normalized by the RMS.

18. ANGLE (FLATNESS) - Fourth moment of the angular deviation fluctuations normalized by the RMS.

At the base of some of these tables is a note stating the magnitude of calibration errors that consistently occurred in the data reduction of all velocity values on that page. In some cases this repeatable error is hypothesized and the word probably has been included; in others the error is definitely correctable. In any case the stated values are always within $\pm 3\%$ of the suggested values.

4.0 DISCUSSION

4.1 VISUALIZATION RESULTS

When helium soap bubbles were introduced into flow upwind of the spinning rotor three different phenomena were observed. These were:

1. Most bubbles passed through the spinning rotor and were then caught up in the counterswirling flow downwind of the rotor. That is, the rotor was spinning in a counterclockwise sense and the flow downwind of the rotor swirled in a clockwise sense. This result was expected due to the conservation of angular momentum for this system.
2. When the bubble source was placed at approximately three-fourths of a radius from the hub, most bubbles seemed to have a straight-line approach to the spinning rotor but approximately 20% of them were deflected angularly upwind of the rotor. This deflection appeared to be fairly abrupt and occurred around a quarter to half of a rotor radius upwind.
3. When bubbles were caught up into the tip vortices these vortices appear to be quite tight with a bubble making a full revolution in the equivalent distance of approximately one blade length.

The visual result from introducing a smoke source upwind of the rotor was not able to reproduce the detailed flow tagging of helium soap bubbles but it did display the curving of streamlines radially outward around the spinning rotor blades. This is a demonstration of the existence of axial induction effects.

4.2 WIND FIELD RESULTS

Figure 4.2-1 displays the mean axial velocities for approach flow case I ($U = 6.0$ m/s, T.I. = 0.1%). The upwind data were obtained at a different time than the downwind data and thus the rotor speeds and calibration biasing may affect precise matching of these data sets. Figure 4.2-1 shows that the axial component of flow approaching the rotor disk was decelerated in the core region, defined by a tube containing the rotor disk, and accelerated outside this region. This deceleration was reasonably uniform with radial position

up to the measurement location just upwind of the rotor (0.125 rotor diameter). Then it radically departed from this trend as the flow passed through the rotor. An axial induction factor based on mean velocity measurements at 0.125 rotor diameter upwind would be 0.125 but depending on how one extrapolated the data through the rotor section, a radially depended axial induction factor may vary from 0.125 to 0.42. The flow outside of the rotor tube accelerated as was expected from mass continuity. The ordering of velocity magnitudes with radial distance took an unexplained reversal as the flow passed outside of the rotor blades.

The estimation of axial induction factors based on mean velocity values, as done above, may be in error due to the transient nature of velocity values as the rotor blade passes. The axial velocity just upwind of the rotor varied in a roughly sinusoidal form about its mean value (Figure 4.2-2). For approach flow Case I the periodic variation of axial flow velocity was as large as $\pm 7.5\%$ of the mean value at 0.125 rotor diameters upwind. If the minimum velocity value were used rather than the mean (File name UU1043, Table 3.3-3) the computed axial induction factor would be 0.2 instead of 0.133. Thus the transient nature of the flow has a significant influence on values important to the aerodynamic performance of the wind turbine.

Figures 4.2-3a to 4.2-3d display the normalized mean axial velocity change $100 \times (\bar{u} - \bar{u}_\infty) / \bar{u}_\infty$ versus axial distance in rotor diameters for each of the four approach flow conditions. Comparison between plots with similar approach velocities but different turbulence levels (Figures 4.2-3a and 4.2-3c, Figures 4.2-3b and 4.2-3d) do not show any major flow differences in this format. Comparison between plots with similar turbulence levels but different approach velocities (Figures 4.2-3a and 4.2-3b, Figures 4.2-3c and 4.2-3d) displays a difference in the magnitude of the range of mean axial velocities in the wake region of the turbine only. The range of axial velocity variation was greatest in the lower approach wind speed cases.

Figure 4.2-4 displays the normalized mean radial velocity ($100 \times \bar{u}_r / \bar{u}_x$) versus axial distance in rotor diameters for approach flow Case II. It shows that the flow was divergent approaching the wind turbine and in the wake region out to at least half a rotor diameter downwind. The maximum divergence was at the rotor disk where the mean velocity vector deviated by 10° from that of

the approach flow. The radial velocities were greatest (14 to 20% of the approach velocity value) near the tip region. The radial velocity transient variation just upwind of the disk and downwind outside of the rotor wake was nearly sinusoidal in form as observed by a flatness factor near to 1.5.

Figure 4.2-5 displays the normalized mean angular velocity ($100 \times \bar{\omega}/(\bar{u}_x)_\infty$) versus axial distance in rotor diameters. Within the wake region large negative angular velocities exist (the rotor was spinning in the positive sense). The magnitude of these angular velocities was greatest ($\approx 25\%$ of the approach flow velocity) at the innermost radial measurement position of one-eighth rotor diameter. The flow immediately upwind of the rotor and the flow downwind of the rotor but outside of its wake have negative mean angular velocities but their magnitude ($\approx 2-3\%$ of the approach flow velocity) is much less than that in the wake region.

Classical vortex/strip theory assumes that the angular velocity at the rotor disk is half of the angular velocity imparted to the slip stream (Wilson et al. 1976). This assumption leads to the use of an angular induction factor, a' , to correct the blade section angle of attack for induced rotational motions. These corrections usually presume a rotating activator disk with an infinite number of blades.

To compute the instantaneous angular induction factor for the model wind turbine, a correlation between the rotor blade positions and the angular velocity components' magnitude must be known. Unfortunately, a blade position time series was not measured during this study. Examination of the axial and angular velocity time series (Run No. 1043) presented in Figures 4.2-2 and 4.2-6 can give a qualitative estimate as to the sign of the angular induction factor. The sharp drop seen in the axial velocity time series is undoubtedly due to the pressure field surrounding a passing rotor blade. This fall in axial velocity occurs at the same time as a sharp maximum in the angular velocity time series. This would indicate that the rotor blade sees an angular velocity component that is in the opposite direction as the rotor blade travel.

Figures 4.2-2 and 4.2-6 also show that each rotor blade has a different periodic magnitude. This was due to slight misalignments of the rotor blades in their plane of motion. One rotor blade was 3 mm closer to the measurement

probe than the other. Since the probe was 67 mm from the rotor plane the flow characteristics must be changing rapidly in the immediate region in front of the rotor disk.

Figures 4.2-7a and 4.2-7b display the axial turbulent intensity relative to the free stream wind speed ($100 \times u'_{rms}/\bar{u}_{\infty}$) versus axial distance in rotor diameters for approach flow Cases II and IV respectively. They show that the axial turbulence energy increases dramatically in the region approaching the rotor disk and then initially decreases sharply in the rotor wake. The sharp increase in turbulent intensity for the spatial location of $X = 1/2$, $R = 1/8$ is due to the influence of the growing wake caused by the wind turbine hub and support mechanism. Figure 4.2-8 of the axial flatness factor versus axial distance shows that most of this turbulent intensity in the non-wake region is due to an organized periodic structure of slowly varying amplitudes, approaching that of a sine wave.

The velocity time series for the axial velocity component (Figure 4.2-2) and the angular velocity component (Figure 4.2-6) help estimate the angle of attack(a) during a rotor cycle. The rotor rotational velocity, 25.81 rps, was estimated by measuring the time period between blade passages on these figures. At a radius of 0.201 m the velocity of this rotor blade section was 32.6 m/s. This information was used to plot the angle of attack time series shown in Figure 4.2-9. This figure shows that the periodic nature of axial induction is the primary cause for variations in the angle of attack for this approach flow and position. The actual variation of angle of attack that occurs at the rotor disk will be larger than that shown here at 6.7 cm upwind of the rotor disk.

(a) No account has been made for rotor blade twist angle.

5.0 REFERENCES

- Baker, R. W., and S. N. Walker. 1982. Wake Studies at the Goodnoe Hills Mod-2 Site. DOE/BP-182, Bonneville Power Administration, Portland, Oregon.
- Bushnell, P. 1984. Design of Rotor Blades for a Model Horizontal Axis Wind Turbine. Cornell University, Ithaca, New York.
- Bushnell, P. 1983. Experimental Study of the Vortex Wake Formed by a Model Wind Turbine. Cornell University, Ithaca, New York.
- Cliff, W. C., and G. H. Fichtl. 1978. Wind Velocity-Change (Gust Rise) Criteria for Wind Turbine Design. PNL-2526, Pacific Northwest Laboratory, Richland, Washington.
- Eberle, W. R. 1981. Wind Flow Characteristics in the Wakes of Large Wind Turbines, pp. 1-211. DOE/NASA0029-1, Lockheed Missiles and Space Company, Inc., Sunnyvale, California.
- Fichtl, G. 1983. Covariance Statistics of Turbulence Velocity Components for Wind Energy Conversion System Design-Homogeneous, Isotropic Case. PNL-3499, Pacific Northwest Laboratory, Richland, Washington.
- Hansen, A. C. 1979. "Effects of Turbulence on Wind Turbine Performance." ASCE Preprint 3537, pp. 1-17.
- Kareem, A. 1981. "Wind-Loading Definition for the Structural Design of Wind-Turbine Generators." Journal of Energy 5(2):89-93.
- Plate, E. J., and J. E. Cermak. 1963. Micrometeorological Wind Tunnel Facility: Description and Characteristics. CER63-EJP-JEC-9, Colorado State University, Fort Collins, Colorado.
- Riley, J. J., E. W. Geller, M. D. Coon and J. C. Schedvin. 1980. A Review of Wind Turbine Wake Effects. DOE/ET/23160-80/1. Available from National Technical Information Service, Springfield, Virginia.
- TSI Technical Bulletin No. 8. No Date. "Data Reduction Method for Model 1294 3-D Probes, Orthogonal Sensors." TSI, Inc., St. Paul, Minnesota.
- Wilson, R. E., P. B. S. Lissaman and S. N. Walker. 1976. Aerodynamic Performance of Wind Turbines, p. 164. Oregon State University, Corvallis, Oregon.

FIGURES

FIGURE 2.1-1. Meteorological Wind Tunnel

FIGURE 2.2-1. Wind Turbine Model

FIGURE 2.2-2. Wind Turbine Mounting Diagram

FIGURE 2.4.4-1. TSI Model 1294-20 3-D Probe

Single Film

Cross Film

1294-20

1294-60

FIGURE 2.4.4-2. Spectral Response of Different Anemometer Probes

FIGURE 2.5-1. Prony Brake System

U Component
Flow No. 3

U Component
Flow No. 4

W Component
Flow No. 3

W Component
Flow No. 4

FIGURE 3.1-1. Velocity Fluctuation Power Spectrums for Approach Flows 3 and 4

FIGURE 3.2-1. Power Coefficient Versus Tip Speed Ratio

FIGURE 3.3-1. Measurement Locations. Note that measurements downwind were taken only away from the tip vortex region where flow might pass through other directions than the one for which the velocity probe is oriented. See Column 4, Table 3.3-3 for estimate of this end.

FIGURE 4.2-1. Mean Axial Velocities for Approach Flow Case I

FIGURE 4.2-2. Axial Velocity Time Series for Run No. 1043,
Just Upwind of Rotor Plane

FIGURE 4.2-3a. Normalized Mean Axial Velocity Change Versus Axial Distance for Approach Flow Case I

FIGURE 4.2-3b. Normalized Mean Axial Velocity Change Versus Axial Distance for Approach Flow Case II

FIGURE 4.2-3c. Normalized Mean Axial Velocity Change Versus Axial Distance for Approach Flow Case III

FIGURE 4.2-3d. Normalized Mean Axial Velocity Change Versus Axial Distance for Approach Flow Case IV

FIGURE 4.2-4. Normalized Mean Radial Velocity Change Versus Axial Distance for Approach Flow Case II

FIGURE 4.2-5. Normalized Mean Angular Velocity Change Versus Axial Distance for Approach Flow Case II

FIGURE 4.2-6. Angular Velocity Time Series for Run No. 1043

FIGURE 4.2-7a. Axial Turbulent Intensity Versus Axial Distance for Approach Flow Case II

FIGURE 4.2-7b. Axial Turbulent Intensity Versus Axial Distance for Approach Flow Case IV

FIGURE 4.2-8. Axial Flatness Factor Versus Axial Distance for Approach Flow Case IV

FIGURE 4.2-9. Angle of Attack Time Series for Run No. 1043

TABLES

TABLE 2.2-1. Blade Twist Angles Versus Rotor Radius

<u>r</u> <u>(m)</u>	<u>r/R</u>	<u>Twist Angle</u> <u>(degree)</u>
0.021	0.08	37.9
0.031	0.12	31.8
0.052	0.20	22.5
0.062	0.24	19.0
0.094	0.36	11.8
0.125	0.48	7.5
0.156	0.60	4.7
0.187	0.72	2.8
0.219	0.84	1.4
0.250	0.96	0.3
0.260	1.00	0.0

Note: Blade begins at $r = 0.016$ m ($r/R = 0.061$)

TABLE 2.4.4-1. Yaw Angle Calibration Points

1st Rotation ^(a) About y Axis	2nd Rotation ^(a) About x Axis	Yaw Angles ^(a)		
		ϕ_1	ϕ_2	ϕ_3
0	-30	17.2	17.2	65.3
	-15	26.9	26.9	50.3
	0	35.3	35.3	35.3
	10	39.8	39.8	25.3
	20	43.0	43.0	15.3
-120	-30	17.2	65.3	17.2
	-15	26.9	50.3	26.9
	0	35.3	35.3	35.3
120	-30	65.3	17.2	17.2
	-15	50.3	26.9	26.9
	0	35.3	35.3	35.3

(a) All angles in degrees, positive rotations about probe coordinate system are clockwise (looking from positive axis to negative axis).

TABLE 2.4.4-2. Comparison of Actual and Calculated Velocity Vectors for 3-D Probe

Velocity m/s	Actual Angle From Axis (Deg.)			Velocity m/s	Calculated ^(a) From Axis (Deg.)		
	X	Y	Z		X	Y	Z
4.0	40	90	50	4.2	41.2	88.0	48.9
	30	90	60	4.1	31.9	89.1	58.2
	15	90	75	4.0	16.9	89.9	73.1
	0	90	90	4.0	0.3	90.0	89.7
	30	120	90	4.1	26.4	116.3	93.1
	15	105	90	4.0	15.0	105.0	90.5
	15	75	90	4.0	15.4	74.6	90.1
	30	60	90	4.1	26.2	63.9	92.5
	15	90	105	4.0	14.5	89.9	104.5
	30	90	120	4.0	22.8	89.4	112.8
6.0	40	90	50	6.2	43.4	88.0	46.7
	30	90	60	6.2	32.8	89.7	57.2
	15	90	75	6.1	17.1	90.1	72.5
	0	90	90	6.0	0.5	90.2	89.5
	30	120	90	6.1	27.0	116.9	92.9
	15	105	90	6.0	15.4	105.4	90.4
	15	75	90	6.0	15.3	74.7	90.0
	30	60	90	6.2	26.8	63.3	92.3
	15	90	105	6.0	14.6	89.7	104.6
	30	90	120	6.0	23.9	89.0	113.8
8.0	40	90	50	8.2	44.8	87.3	45.4
	30	90	60	8.1	33.0	89.4	57.0
	15	90	75	8.0	16.9	90.1	73.1
	0	90	90	8.0	0.4	89.7	89.7
	30	120	90	8.1	27.0	116.8	93.2
	15	105	90	8.0	15.0	105.0	90.6
	15	75	90	8.1	15.2	74.8	90.1
	30	60	90	8.3	26.7	63.5	92.5
	15	90	105	8.0	14.8	89.9	104.8
	30	90	120	8.1	24.3	89.4	114.3

(a) Velocity calibration on $\theta_x = 0^\circ$, $\theta_y = 90^\circ$, $\theta_z = 0^\circ$. Angle calibration performed at 6.0 m/s.

TABLE 2.4.4-3. Comparative Response of Anemometer Probes

Probe	Grid Turbulence				Cylinder Wake Turbulence			
	<u>u</u>	<u>'</u>	<u>v'</u>	<u>w'</u>	<u>u</u>	<u>'</u>	<u>v'</u>	<u>w'</u>
Single Wire	5.99 m/s	0.106			5.7	0.407		
Crosswire	5.982	0.106	0.0763		5.827	0.374		0.368
	5.983	0.109		0.0813	5.776	0.411	0.383	
3-D Probe (1294-60)	5.86	0.097	0.108	0.099	5.51	0.386	0.433	0.418
3-D Probe (1294-20)	5.90	0.096	0.100	0.096				

TABLE 3.1-1. Approach Flow Characteristics

Approach Flow No.	Measurement Probe	Velocity Component	Minimum (m/s)	Mean (m/s)	Maximum (m/s)	RMS (m/s)	Skewness	Flatness	Integral Scale (m)
1	single film	u	5.878	5.900	5.924	0.007	0.162	2.934	
2	single film	u	7.500	7.538	7.588	0.009	0.188	3.106	
3	single film	u	5.491	5.928	6.330	0.107	-0.045	2.952	0.0463
4	single film	u	6.980	7.516	8.033	0.131	0.0414	2.900	0.0425
1	3-D Probe	u	5.877	5.90	5.918	0.007	-0.0346	2.441	
2	3-D Probe	u	7.581	7.60	7.622	0.007	1.092	2.858	
3	3-D Probe	u	5.580	5.96	6.325	0.100	-0.120	2.963	0.0517
4	3-D Probe	u	7.060	7.59	8.057	0.120	-0.039	2.912	0.0504
1	3-D Probe	v	-0.014	0.01	0.045	0.008	0.072	3.167	
2	3-D Probe	v	-0.142	-0.08	-0.028	0.016	0.086	2.671	
3	3-D Probe	v	-0.581	-0.08	0.392	0.106	-0.003	3.006	0.0147
4	3-D Probe	v	-0.758	-0.11	0.478	0.139	-0.039	3.177	0.0152
1	3-D Probe	w	-0.004	0.02	0.052	0.008	-0.018	2.966	
2	3-D Probe	w	0.036	0.08	0.116	0.011	-0.116	2.744	
3	3-D Probe	w	-0.429	0.07	0.482	0.101	-0.090	3.104	0.0171
4	3-D Probe	w	-0.618	0.12	0.622	0.128	-0.040	3.156	0.0164

TABLE 3.2-1. Power Measurement Test for $\bar{U} = 6.0$ m/s, T.I. = 0.1%

Mass (kg)	Spring Deflection Z_d (a) (cm)	Ω (rpm)	Tip Speed Ratio	Power (watts)	Power Coefficient
0.091	8.5	1640	7.4	1.13	0.050
0.227	10.0	1545	7.01	2.79	0.124
0.318	11.1	1460	6.62	3.57	0.158
0.408	12.3	1370	6.22	4.19	0.186
0.454	12.7	1330	6.03	4.58	0.203
0.499	13.2	1300	5.90	4.95	0.219
0.545	13.8	1230	5.58	5.01	0.222
0.635	14.7	1180	5.35	5.8	0.757
0.681	15.1	1135	5.15	6.16	0.273
0.726	15.7	1080	4.9	6.13	0.272
0.771	16.3	980	4.45	5.8	0.257

(a) $Z_d = 7.45$ cm.

TABLE 3.2-2. Power Measurement Test for $\bar{U} = 7.6$ m/s, T.I. = 0.1%

<u>Mass</u> <u>(kg)</u>	<u>Spring</u> <u>Deflection</u> <u>Z_d (a) (cm)</u>	<u>Ω</u> <u>(rpm)</u>	<u>Tip Speed</u> <u>Ratio</u>	<u>Power</u> <u>(watts)</u>	<u>Power</u> <u>Coefficient</u>
0.453	12.6	1925	6.89	6.81	0.148
0.544	13.6	1900	6.80	8.15	0.178
0.680	15.0	1805	6.46	9.97	0.217
0.770	16.1	1760	6.30	10.80	0.235
0.906	17.6	1645	5.89	11.93	0.260
0.997	18.7	1575	5.64	12.40	0.271
1.088	19.2	1460	5.23	13.46	0.293

(a) $Z_d = 7.45$ cm.

TABLE 3.2-3. Power Measurement Test for $\bar{U} = 7.6$ m/s, T.I. = 1.5%

Mass (kg)	Spring Deflection $Z_d(a)$ (cm)	Ω (rpm)	Tip Speed Ratio	Power (watts)	Power Coefficient
0.453	13.0	2080	7.45	6.39	0.139
0.544	13.8	1980	7.09	8.03	0.175
0.680	15.2	1860	6.66	9.83	0.214
0.771	16.2	1840	6.59	11.11	0.242
0.861	17.1	1770	6.34	12.19	0.266
0.906	17.4	1700	6.09	12.72	0.277
0.996	18.1	1640	5.87	14.00	0.306
1.087	18.6	1510	5.41	14.90	0.326
1.132	18.7	1380	4.94	14.70	0.322
1.222	18.6	1240	4.44	15.80	0.344
1.313	18.7	1080	3.87	15.68	0.342

(a) $Z_d = 7.45$ cm.

TABLE 3.3-1. Measurement Locations

Position	x/D	r/D	x (m)	r (m)	θ (deg.)
001	1/2	1/8	0.267	0.067	180
002	1/2	2/8	0.267	0.134	180
003	1/2	3/8	0.267	0.201	180
005	1/2	5/8	0.267	0.334	180
006	1/2	6/8	0.267	0.401	180
008	1/2	8/8	0.267	0.535	180
011	1/4	1/8	0.134	0.067	180
012	1	2/8	0.134	0.134	180
013	1/4	3/8	0.134	0.201	180
015	1/4	5/8	0.134	0.334	180
016	1/4	6/8	0.134	0.401	180
018	1/4	8/8	0.134	0.535	180
021	1/8	1/8	0.067	0.067	180
022	1/8	2/8	0.067	0.134	180
023	1/8	3/8	0.067	0.201	180
025	1/8	5/8	0.067	0.334	180
026	1/8	6/8	0.067	0.401	180
028	1/8	8/8	0.067	0.535	180
035	0	5/8	0	0.334	180
036	1	6/8	0	0.401	180
038	0	8/8	0	0.535	180
041	-1/8	1/8	-0.067	0.067	180
042	-1/8	2/8	-0.067	0.134	180
043	-1/8	3/8	-0.067	0.201	180
044	-1/8	4/8	-0.067	0.267	180
045	-1/8	5/8	-0.067	0.334	180
046	-1/8	6/8	-0.067	0.401	180
048	-1/8	8/8	-0.067	0.535	180
060	-1/4	0	-0.134	0	0
061	-1/4	1/8	-0.134	0.067	180
062	-1/4	2/8	-0.134	0.134	180
063	-1/4	3/8	-0.134	0.201	180
064	-1/4	4/8	-0.134	0.267	180
065	-1/4	5/8	-0.134	0.334	180
066	-1/4	6/8	-0.134	0.401	180
068	-1/4	8/8	-0.134	0.535	180
070	-1/2	0	-0.267	0	0
071	-1/2	1/8	-0.267	0.067	180
072	-1/2	2/8	-0.267	0.134	180
073	-1/2	3/8	-0.267	0.201	180
074	-1/2	4/8	-0.267	0.267	180
075	-1/2	5/8	-0.267	0.334	180
076	-1/2	6/8	-0.267	0.401	180
078	-1/2	8/8	-0.267	0.535	180

TABLE 3.3-1. (contd)

<u>Position</u>	<u>x/D</u>	<u>r/D</u>	<u>x</u> <u>(m)</u>	<u>r</u> <u>(m)</u>	<u>θ</u> <u>(deg.)</u>
080	1	0	-0.535	0	0
082	1	1/4	-0.535	0.134	180
084	1	2/4	-0.535	0.267	180
086	1	3/4	-0.535	0.401	180
088	1	4/4	-0.535	0.535	180
090	3/2	0	-0.802	0	0
094	3/2	1/2	-0.802	0.267	180
098	3/2	2/2	-0.802	0.535	180
100	2	0	-1.070	0	0
104	2	1/2	-1.070	0.267	180
108	2	2/2	-1.070	0.535	180
110	3	0	-1.605	0	0
114	3	1/2	-1.605	0.267	180
118	3	2/2	-1.605	0.535	180

TABLE 3.3-2. Rotor Speed During Data Acquisition

Position No.	Case No.			
	1	2	3	4
(Data Obtained with TSI 1294-20 Probe)				
001	1340	1600	1470	1360
002	1340	1600	1470	1370
003	1340	1580	1440	1350
005	1340	1560	1440	1340
006	1300	1525	1440	1330
008	1340	1525	1440	1320
011	1360	1500	1420	1320
012	1360	1500	1420	1350
013	1360	1500	1420	1350
015	1360	1500	1420	1370
016	1360	1510	1440	1360
018	1340	1510	1440	1350
021	1380	1500	1400	1350
022	1380	1450	1420	1370
023	1380	1450	1420	1370
025	1380	1450	1420	1370
026	1430	1465	1420	1500
028	1430	1465	1420	1560
035	1430	1390	1380	1550
036	1430	1390	1400	1520
038	1430	1390	1400	1520
045	1420	1400	1400	1580
046	1406	1400	1400	1580
048	1490	1420	1400	1600

(Data Obtained with Modified TSI 1294-20 Probe, 90° Bend)

041	1550	1540	1354	1360
042	1550	1540	1354	1360
043	1550	1530	1354	1360
044	1550	1420	1354	1360
045	1550	1380	1354	1360
046	1550	1420	1354	1320
048	1540	1380	1354	1320
060	1500	1380	1300	1370
061	1500	1400	1320	1370
062	1520	1430	1320	1370
063	1530	1400	1320	1430
064	1530	1340	1320	1430
065	1530	1340	1320	1430
066	1530	1460	1320	1350
068	1540	1460	1320	1350

TABLE 3.3-2. (contd)

Position No.	Case No.			
	1	2	3	4
(Data Obtained with TSI 1294-20 Probe, 90°)				
070	1490	1450	1310	1430
071	1465	1410	1310	1430
072	1465	1420	1310	1430
073	1465	1460	1330	1430
074	1465	1340	1330	1430
075	1465	1370	1330	1430
076	1465	1370	1330	1390
078	1440	1430	1330	1310
080	1320	1413	1330	1310
082	1320	1450	1330	1310
084	1320	1465	1330	1310
086	1320	1413	1330	1310
088	1300	1450	1330	1310
090	1350	1460	1350	1310
094	1350	1420	1350	1310
098	1350	1420	1350	1310
100	1420	1550	1400	1310
104	1400	1465	1400	1310
108	1400	1525	1400	1310
110	1500	1600	1465	1310
114	1500	1600	1443	1310
118	1465	1600	1400	1310

TABLE 3.3-3. Near-Field Velocity Information

FILE NAME	NO. OF POSITION	DEPTH	TIME	MEAN VEL.	ANGLE FROM	VELOCITY INFORMATION	FLATNESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	ANGLE INFORMATION	FLATNESS
						AIR. VEL.	RAY. VEL.	RMS. VEL.	SLIP LOSS				
UU1001	1	.267	1.422	5.44	11.0	1.57	1.00	1.10	10.10	UV	.0055	11.0	1.33
UU1001	2	.267	1.422	5.44	11.0	1.57	1.00	1.10	10.10	UV	.0055	11.0	1.33
UU1001	3	100.000	1.570	1.11	101.0	4.42	1.00	1.10	10.10	UV	.0055	101.0	1.11
UU1002	1	.267	0.000	4.31	11.0	2.05	5.07	1.01	10.10	UV	.0055	11.0	1.33
UU1002	2	.267	0.000	4.31	11.0	2.05	5.07	1.01	10.10	UV	.0055	11.0	1.33
UU1002	3	100.000	1.000	1.04	101.0	2.47	2.00	1.01	10.10	UV	.0055	101.0	1.04
UU1003	1	.267	0.000	2.73	11.0	1.00	3.20	1.10	10.10	UV	.0055	11.0	1.33
UU1003	2	.267	0.000	2.73	11.0	1.00	3.20	1.10	10.10	UV	.0055	11.0	1.33
UU1003	3	100.000	1.010	1.00	102.0	1.00	1.43	1.10	10.10	UV	.0055	102.0	1.00
UU1005	1	.267	0.000	6.31	11.0	6.55	7.00	1.00	10.10	UV	.0055	11.0	1.33
UU1005	2	.267	0.000	6.31	11.0	6.55	7.00	1.00	10.10	UV	.0055	11.0	1.33
UU1005	3	100.000	0.000	1.19	101.0	1.01	1.00	1.00	10.10	UV	.0055	101.0	1.19
UU1006	1	.267	0.000	6.60	11.0	6.54	6.72	1.00	10.10	UV	.0055	11.0	1.33
UU1006	2	.267	0.000	6.60	11.0	6.54	6.72	1.00	10.10	UV	.0055	11.0	1.33
UU1006	3	100.000	0.000	1.01	101.0	1.00	1.00	1.00	10.10	UV	.0055	101.0	1.01
UU1008	1	.267	0.000	6.55	11.0	6.52	6.60	1.00	10.10	UV	.0055	11.0	1.33
UU1008	2	.267	0.000	6.55	11.0	6.52	6.60	1.00	10.10	UV	.0055	11.0	1.33
UU1008	3	100.000	0.000	1.24	101.0	1.00	1.00	1.00	10.10	UV	.0055	101.0	1.24
UU1011	1	.134	0.025	6.76	11.1	6.72	6.72	1.00	10.10	UV	.0055	11.1	1.33
UU1011	2	.134	0.025	6.76	11.1	6.72	6.72	1.00	10.10	UV	.0055	11.1	1.33
UU1011	3	100.000	0.000	1.12	101.0	1.00	1.00	1.00	10.10	UV	.0055	101.0	1.12
UU1012	1	.134	0.015	6.60	10.2	6.72	6.72	1.00	10.10	UV	.0055	10.2	1.33
UU1012	2	.134	0.015	6.60	10.2	6.72	6.72	1.00	10.10	UV	.0055	10.2	1.33
UU1012	3	100.000	0.020	1.00	101.0	1.00	1.00	1.00	10.10	UV	.0055	101.0	1.00
UU1013	1	.134	0.005	6.07	11.0	6.72	6.72	1.00	10.10	UV	.0055	11.0	1.33
UU1013	2	.134	0.005	6.07	11.0	6.72	6.72	1.00	10.10	UV	.0055	11.0	1.33
UU1013	3	100.000	0.750	1.00	101.0	1.00	1.00	1.00	10.10	UV	.0055	101.0	1.00
UU1015	1	.134	0.000	6.73	11.0	6.61	6.60	1.00	10.10	UV	.0055	11.0	1.33
UU1015	2	.134	0.000	6.73	11.0	6.61	6.60	1.00	10.10	UV	.0055	11.0	1.33
UU1015	3	100.000	0.000	1.19	101.0	1.00	1.00	1.00	10.10	UV	.0055	101.0	1.19
UU1016	1	.134	0.000	6.56	11.0	6.51	6.50	1.00	10.10	UV	.0055	11.0	1.33
UU1016	2	.134	0.000	6.56	11.0	6.51	6.50	1.00	10.10	UV	.0055	11.0	1.33
UU1016	3	100.000	0.000	1.00	101.0	1.00	1.00	1.00	10.10	UV	.0055	101.0	1.00
UU1018	1	.134	0.000	6.41	11.0	6.37	6.44	1.00	10.10	UV	.0055	11.0	1.33
UU1018	2	.134	0.000	6.41	11.0	6.37	6.44	1.00	10.10	UV	.0055	11.0	1.33
UU1018	3	100.000	0.000	1.21	101.0	1.00	1.00	1.00	10.10	UV	.0055	101.0	1.21
UU1021	1	.067	0.003	5.00	11.7	5.03	7.11	1.04	10.10	UV	.0055	11.7	1.33
UU1021	2	.067	0.003	5.00	11.7	5.03	7.11	1.04	10.10	UV	.0055	11.7	1.33
UU1021	3	100.000	1.157	1.13	101.0	1.10	1.40	1.10	10.10	UV	.0055	101.0	1.13
UU1022	1	.067	0.172	4.57	10.4	2.87	6.41	1.40	10.10	UV	.0055	10.4	1.33
UU1022	2	.067	0.172	4.57	10.4	2.87	6.41	1.40	10.10	UV	.0055	10.4	1.33
UU1022	3	100.000	3.045	1.73	101.0	1.01	1.00	1.00	10.10	UV	.0055	101.0	1.73
UU1023	1	.067	0.324	3.24	11.3	1.40	5.00	1.00	10.10	UV	.0055	11.3	1.33
UU1023	2	.067	0.324	3.24	11.3	1.40	5.00	1.00	10.10	UV	.0055	11.3	1.33
UU1023	3	100.000	1.774	1.63	100.0	1.00	1.00	1.00	10.10	UV	.0055	100.0	1.63

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (%) TIME	VELOCITY INFORMATION								ANGLE INFORMATION							
			MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKEW NESS	FLAT NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKEW NESS	FLAT NESS		
UU1025	1	.037	0.000	6.54	0.3	6.44	6.55	.054	.06	1.50	UV	.0000	0.3	7.0	10.3	.2	.67	2.03
VV1025	2	.334	0.000	.94	01.0	.80	1.10	.102	.67	2.01	UV	.0030	01.0	22.9	03.0	.8	.69	2.06
WW1025	3	100.000	0.000	.15	21.3	.20	.09	.040	1.41	4.00	UV	.0022	21.3	20.0	92.4	.3	1.40	3.99
UU1026	1	.067	0.000	6.42	5.4	6.30	6.47	.013	.25	2.72	UV	.0000	5.4	5.0	6.3	.2	.06	3.12
VV1026	2	.401	0.000	.60	04.7	.53	.60	.024	.23	2.13	UV	.0001	04.7	03.9	08.3	.2	.03	3.10
WW1026	3	100.000	0.000	.10	21.3	.23	.14	.014	.51	3.00	UV	.0001	21.3	21.3	92.1	.1	.70	3.07
UU1028	1	.067	0.000	6.33	3.1	6.30	6.36	.010	.14	2.45	UV	.0000	3.1	3.7	3.5	.1	-.10	3.92
VV1028	2	.535	0.000	.23	07.4	.23	.23	.011	.10	2.22	UV	.0000	07.4	07.0	07.9	.1	.31	3.98
WW1028	3	100.000	0.000	.20	21.0	.23	.17	.000	.01	2.21	UV	.0000	21.0	21.5	92.0	.1	-.10	3.90
UU1035	1	0.000	0.000	6.21	2.9	6.06	6.37	.007	.01	1.56	UV	.0003	2.9	3.3	10.7	.5	-1.21	3.44
VV1035	2	.334	0.000	1.07	00.7	.80	1.10	.053	1.20	3.23	UV	.0010	00.7	29.4	01.2	.8	1.23	3.40
WW1035	3	100.000	0.000	.14	21.3	.25	.09	.024	1.20	3.23	UV	.0002	21.3	20.0	92.3	.2	1.25	3.10
UU1036	1	0.000	0.000	6.25	6.1	6.20	6.21	.002	.03	2.00	UV	.0001	6.1	5.5	6.6	.2	.27	3.61
VV1036	2	.101	0.000	.65	04.1	.50	.70	.010	.47	2.20	UV	.0002	04.1	03.0	04.7	.2	.31	3.56
WW1036	3	100.000	0.000	.15	21.5	.21	.12	.012	.22	3.04	UV	.0000	21.5	21.1	91.9	.1	.40	3.09
UU1038	1	0.000	0.000	6.26	7.2	6.21	6.22	.010	.16	2.42	UV	.0000	7.2	7.0	6.7	.1	.22	3.43
VV1038	2	.535	0.000	.20	07.2	.21	.20	.011	.17	2.07	UV	.0000	07.2	07.0	07.0	.1	.24	3.38
WW1038	3	100.000	0.000	.10	21.4	.21	.15	.007	.06	3.05	UV	.0000	21.4	21.4	91.9	.1	-.15	3.25
UU1040	1	.067	0.000	6.22	7.0	6.20	6.01	.026	.70	2.40	UV	.0001	7.0	6.9	6.9	.4	-.15	1.94
VV1040	2	.134	0.000	.22	07.0	.21	.22	.015	.10	2.07	UV	.0000	07.0	07.1	07.2	.4	.12	1.93
WW1040	3	100.000	0.000	.12	21.2	.16	.09	.012	.22	2.73	UV	.0001	21.2	20.7	91.5	.1	-.20	2.92
UU1041	1	.067	0.000	6.10	5.5	6.02	6.15	.017	.25	2.51	UV	.0000	5.5	4.0	6.0	.1	.02	2.97
VV1041	2	.401	0.000	.57	04.7	.40	.60	.014	.23	2.23	UV	.0001	04.7	04.0	05.5	.1	.07	2.93
WW1041	3	100.000	0.000	.15	21.1	.10	.11	.010	.01	2.51	UV	.0000	21.1	21.0	91.9	.1	.40	2.85
UU1042	1	.067	0.000	6.10	5.2	6.10	6.22	.017	.16	2.24	UV	.0000	5.2	5.0	6.6	.1	.07	2.98
VV1042	2	.535	0.000	.20	07.2	.21	.22	.012	.03	2.24	UV	.0000	07.2	07.0	07.0	.1	.12	2.91
WW1042	3	100.000	0.000	.15	21.0	.16	.12	.007	.00	2.24	UV	.0000	21.0	21.0	91.0	.1	1.02	2.91

TABLE 3.3-3. (contd)

FILE NAME	ANIS POSITION	LIMITS EXCEEDED (%) TIME	MEAN VEL.	ANGLE FROM	VELOCITY INFORMATION					FLATNESS			ANGLE INFORMATION					FLATNESS		
					MIN. VEL.	MAX. VEL.	RMS VEL.	SKEWNESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKEWNESS	FLATNESS					
UU1041	1	-0.067	0.000	5.37	1.1	5.26	5.53	.001	.26	1.72	VW	.0011	1.7	.4	3.4	.4	.64	3.14		
VV1041	2	-0.067	0.000	.07	87.3	.12	.25	.005	.17	2.35	UV	.0054	87.4	21.3	.9	.23	2.35			
WW1041	3	180.000	0.000	.06	90.5	.31	.15	.070	1.01	2.70	UV	.0013	90.5	80.4	93.3	1.0	1.03	2.81		
UU1042	1	-0.067	0.000	5.25	2.0	4.96	5.53	.147	.15	2.31	VW	.0007	2.4	.2	4.1	.8	.62	2.32		
VV1042	2	.134	0.000	.17	88.1	.01	.33	.002	.01	1.63	UV	.0028	88.1	84.4	87.2	.9	.04	1.63		
WW1042	3	180.000	0.000	-1.06	90.7	.23	.25	.121	.71	2.70	UV	.0023	90.7	87.2	92.5	1.3	-.91	2.89		
UU1043	1	-0.067	0.000	5.20	3.0	4.81	5.56	.202	.06	1.81	VW	.0013	3.1	4.9	7.4	.6	.22	1.81		
VV1043	2	-0.201	0.000	.55	84.0	.45	.44	.042	-.16	1.57	UV	.0021	84.0	82.6	85.1	.6	-.30	2.11		
WW1043	3	180.000	0.000	-1.01	90.2	.15	.22	.114	.82	2.54	UV	.0015	90.1	83.9	91.6	1.2	-.86	2.51		
UU1044	1	-0.067	0.000	5.54	2.0	5.51	5.80	.075	.28	1.85	VW	.0007	2.1	6.2	11.5	1.2	.11	1.68		
VV1044	2	.267	0.000	.90	81.0	.69	1.13	.113	.13	1.62	UV	.0070	81.0	78.5	83.1	1.2	-.11	1.68		
WW1044	3	180.000	0.000	.03	87.7	.06	.16	.054	.32	2.00	UV	.0024	87.7	88.2	90.6	.5	-.63	2.08		
UU1045	1	-0.067	0.000	6.12	2.8	6.08	6.20	.026	.66	2.40	VW	.0001	2.8	5.8	7.7	.4	-.12	1.93		
VV1045	2	.334	0.000	.73	83.2	.62	.83	.044	.11	1.88	UV	.0000	83.2	82.5	84.2	.4	.11	1.93		
WW1045	3	180.000	0.000	.01	87.9	.03	.06	.013	.25	2.67	UV	.0002	87.9	89.5	90.3	.1	-.32	2.69		
UU1046	1	-0.067	0.000	6.31	4.4	6.27	6.36	.015	.21	2.12	VW	.0000	4.4	4.0	4.9	.1	-.02	2.93		
VV1046	2	.401	0.000	.42	85.6	.44	.54	.014	.04	2.87	UV	.0001	85.6	85.1	87.0	.1	.21	2.92		
WW1046	3	180.000	0.000	.03	90.3	.06	.01	.002	.23	2.82	UV	.0000	90.3	87.9	90.5	.1	-.98	3.04		
UU1048	1	-0.067	0.000	6.41	2.0	6.36	6.45	.012	.24	2.71	VW	.0000	2.0	1.5	2.3	.1	-.02	3.10		
VV1048	2	.535	0.000	.21	88.1	.16	.26	.012	.07	3.03	UV	.0000	88.1	87.7	88.5	.1	-.31	2.99		
WW1048	3	180.000	0.000	-1.06	90.5	.09	.83	.007	.07	2.77	UV	.0000	90.5	90.2	90.8	.1	1.14	2.87		
UU1060	1	.134	0.000	5.54	2.6	5.51	5.58	.002	.17	2.76	VW	.0000	2.6	1.7	3.4	.3	-.06	1.80		
VV1060	2	0.000	0.000	.19	88.1	.10	.26	.033	.02	1.80	UV	.0001	88.0	87.3	88.2	.3	-.03	1.80		
WW1060	3	0.000	0.000	.16	88.3	.09	.22	.027	.03	1.72	UV	.0001	88.3	87.7	87.0	.3	.03	1.72		
UU1061	1	-0.134	0.000	5.54	1.8	5.42	5.62	.033	.10	2.22	VW	.0000	1.8	.6	6.4	.4	-.60	3.26		
VV1061	2	.067	0.000	.00	90.8	-.19	.14	.036	-.06	2.41	UV	.0011	90.8	88.6	91.9	.4	.12	2.41		
WW1061	3	180.000	0.000	-1.15	91.6	.61	.04	.038	.70	3.23	UV	.0002	91.6	90.4	92.2	.4	-.69	3.19		
UU1062	1	-0.134	0.000	5.57	1.4	5.44	5.70	.062	.16	2.26	VW	.0001	1.5	.3	2.3	.4	-.62	2.45		
VV1062	2	.134	0.000	.07	89.2	.01	.15	.032	.00	1.85	UV	.0016	89.2	88.5	90.1	.2	.03	1.86		
WW1062	3	180.000	0.000	-1.12	91.2	-.21	.01	.048	.63	2.38	UV	.0003	91.2	89.9	92.1	.5	-.62	2.37		
UU1063	1	-0.134	0.000	5.70	2.2	5.55	5.84	.072	.05	1.93	VW	.0004	2.2	1.4	2.9	.2	-.46	3.03		
VV1063	2	.201	0.000	.18	88.2	.00	.27	.032	.45	2.12	UV	.0006	88.2	87.3	87.2	.4	.39	2.13		
WW1063	3	180.000	0.000	-1.12	91.2	.23	-.00	.045	.44	2.38	UV	.0000	91.2	90.0	92.3	.5	-.44	2.38		
UU1064	1	-0.134	0.000	5.85	4.4	5.77	5.94	.037	.00	1.72	VW	.0001	4.4	3.6	5.3	.3	.11	2.08		
VV1064	2	.267	0.000	.45	85.4	.37	.54	.031	.11	2.12	UV	.0011	85.4	84.7	86.4	.3	-.16	2.08		
WW1064	3	180.000	0.000	-1.02	90.1	.07	.06	.025	.44	2.13	UV	.0002	90.1	87.4	90.7	.2	-.53	2.18		
UU1065	1	-0.134	0.000	6.00	4.1	6.04	6.12	.011	.04	2.74	VW	.0000	4.1	3.4	4.7	.2	-.01	2.10		
VV1065	2	.334	0.000	.43	85.9	.36	.50	.025	.01	2.09	UV	.0002	85.9	85.3	86.6	.2	.04	2.10		
WW1065	3	180.000	0.000	-1.02	90.2	.06	.02	.012	.17	2.71	UV	.0001	90.2	87.8	90.6	.1	-.47	2.77		
UU1066	1	-0.134	0.000	6.23	3.2	6.20	6.26	.000	.24	2.07	VW	.0000	3.2	2.6	3.7	.1	-.10	2.92		
VV1066	2	.401	0.000	.35	86.8	.29	.40	.015	.14	2.70	UV	.0000	86.8	85.3	87.4	.1	.05	2.91		
WW1066	3	180.000	0.000	.04	90.3	-.07	-.01	.008	.03	3.02	UV	.0000	90.4	90.1	90.6	.1	-.97	2.97		
UU1068	1	-0.134	0.000	6.34	1.7	6.31	6.38	.000	.04	2.89	VW	.0000	1.7	1.3	2.1	.1	.07	2.99		
VV1068	2	.535	0.000	.18	88.4	.13	.23	.013	.00	2.98	UV	.0000	88.4	87.9	88.8	.1	.13	2.98		
WW1068	3	180.000	0.000	-1.04	90.4	-.07	.02	.008	.14	3.09	UV	.0000	90.4	90.1	90.6	.1	-.28	3.11		

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION		LIMITS EXCEEDED (2) TIME	VELOCITY INFORMATION						ANGLE INFORMATION						FLAT-NESS		
				MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKEW NESS	FLAT-NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE		SKEW NESS	
UU1070	1	-.267	0.000	5.03	2.3	5.00	5.05	.009	-1.05	2.27	VW	.0000	2.3	1.0	2.8	.1	.08	2.92
VU1070	2	0.000	0.000	.20	88.1	.14	.25	.014	.06	2.74	UV	.0000	88.1	87.5	88.6	.1	-.43	2.99
WW1070	3	0.000	0.000	.13	88.7	.09	.17	.010	.10	2.72	UV	.0000	88.7	88.5	89.1	.1	.47	2.80
UU1071	1	-.267	0.000	5.05	1.8	5.01	5.00	.011	.03	2.47	VW	.0000	1.0	1.3	2.3	.1	-.04	2.89
VU1071	2	.067	0.000	-.13	91.3	-.17	.07	.013	.04	3.01	UV	.0000	91.3	90.7	91.7	.1	-.31	3.00
WW1071	3	180.000	0.000	-.13	91.3	-.17	.07	.011	.20	2.04	UV	.0000	91.3	90.9	91.6	.1	-.28	2.84
UU1072	1	-.267	0.000	5.00	1.1	5.03	5.02	.015	.11	2.57	VW	.0000	1.1	.7	1.5	.1	-.13	2.85
VU1072	2	.134	0.000	-.03	90.3	-.07	.01	.012	.01	2.97	UV	.0000	90.3	89.9	90.7	.1	-.32	2.95
WW1072	3	180.000	0.000	-.11	91.0	-.14	.07	.011	.23	2.01	UV	.0000	91.0	90.7	91.4	.1	-.20	2.70
UU1073	1	-.267	0.000	5.04	1.0	5.00	5.00	.014	.01	2.60	VW	.0000	1.0	.7	1.4	.1	-.05	2.77
VU1073	2	.201	0.000	.02	89.0	.03	.02	.010	.20	3.13	UV	.0000	89.0	89.5	90.3	.1	-.35	3.01
WW1073	3	130.000	0.000	-.10	91.0	-.15	.07	.011	.10	2.80	UV	.0000	91.0	90.7	91.4	.1	.38	2.77
UU1074	1	-.267	0.000	6.03	.2	5.99	6.07	.013	.17	2.45	VW	.0000	.2	.7	1.3	.1	-.10	3.01
VU1074	2	.257	0.000	.05	89.5	.01	.10	.011	.05	3.13	UV	.0000	89.5	89.0	89.9	.1	-.09	3.12
WW1074	3	180.000	0.000	-.08	90.0	.11	.04	.009	.08	2.03	UV	.0000	90.0	90.4	91.1	.1	-.07	2.89
UU1075	1	-.267	0.000	6.11	1.0	6.07	6.14	.007	.13	2.78	VW	.0000	1.0	.7	1.3	.1	-.10	2.84
VU1075	2	.334	0.000	.01	89.5	.00	.10	.012	.12	3.03	UV	.0000	89.5	89.0	90.0	.1	-.39	2.94
WW1075	3	130.000	0.000	-.09	90.0	.13	.03	.009	.02	3.00	UV	.0000	90.0	90.5	91.2	.1	-.32	2.99
UU1076	1	-.267	0.000	6.10	1.0	6.15	6.20	.000	.54	2.79	VW	.0000	1.0	.7	1.3	.1	.27	3.47
VU1076	2	.401	0.000	.04	89.6	.01	.02	.012	.11	3.13	UV	.0000	89.6	89.2	90.1	.1	.50	3.16
WW1076	3	180.000	0.000	-.07	90.7	.14	.02	.007	.00	3.20	UV	.0000	90.7	90.5	91.3	.1	.19	3.21
UU1078	1	-.267	0.000	6.26	.9	6.23	6.29	.000	.30	2.52	VW	.0000	.9	.5	1.2	.1	.04	3.16
VU1078	2	.535	0.000	-.03	90.2	.07	.02	.012	.01	3.23	UV	.0000	90.2	89.0	90.7	.1	-.57	3.17
WW1078	3	180.000	0.000	.07	90.6	.12	.02	.008	.25	3.24	UV	.0000	90.0	90.5	91.1	.1	.78	3.34

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (%)	TIME	MEAN VEL.	--VELOCITY INFORMATION--							--ANGLE INFORMATION--						
					ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKEW-NESS	FLAT-NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKEW-NESS	FLAT-NESS	
UU1080	1	.535	0.000	5.73	70.4	5.71	5.75	.006	.79	3.05	VW	.0000	70.4	70.4	70.4	.1	.23	3.25
VV1080	2	0.000	0.000	.00	70.0	.04	.04	.010	.15	3.14	UV	.0000	70.0	70.0	70.4	.1	.30	3.04
WW1080	3	0.000	0.000	-.04	70.4	.07	.00	.008	.32	3.42	UV	.0000	70.4	70.0	70.7	.1	.42	3.17
UU1082	1	.535	0.000	5.77	70.4	5.75	5.79	.007	.55	3.50	VW	.0000	70.6	70.2	70.9	.1	.03	3.23
VV1082	2	.134	0.000	.04	70.4	.00	.02	.002	.18	3.01	UV	.0000	70.6	70.3	70.6	.1	.73	3.02
WW1082	3	180.000	0.000	.04	70.4	.01	.07	.002	.02	3.07	UV	.0000	70.5	70.3	70.9	.1	.71	3.94
UU1084	1	.535	0.000	5.80	70.6	5.77	5.82	.008	.16	3.67	VW	.0000	70.8	70.4	71.3	.1	.05	3.20
VV1084	2	.267	0.000	.05	70.5	.01	.02	.010	.15	3.04	UV	.0000	70.8	70.1	70.9	.1	.14	3.01
WW1084	3	180.000	0.000	.06	70.4	.03	.07	.007	.27	3.15	UV	.0000	70.5	70.1	70.9	.1	-.17	3.10
UU1086	1	.535	0.000	5.84	70.7	5.81	5.86	.008	.75	3.74	VW	.0000	70.7	70.2	71.1	.1	.06	3.18
VV1086	2	.401	0.000	.05	70.5	.00	.02	.010	.07	3.25	UV	.0000	70.5	70.1	70.9	.1	.38	3.03
WW1086	3	180.000	0.000	.04	70.5	.01	.00	.008	.22	3.22	UV	.0000	70.5	70.2	70.9	.1	.68	3.03
UU1088	1	.535	0.000	5.87	70.6	5.83	5.90	.007	.40	3.82	VW	.0000	70.6	70.1	71.1	.1	.12	3.18
VV1088	2	.535	0.000	.03	70.7	.01	.02	.012	.03	3.13	UV	.0000	70.6	70.1	70.1	.1	.13	3.13
WW1088	3	180.000	0.000	.05	70.5	.03	.09	.007	.02	3.10	UV	.0000	70.5	70.2	70.7	.1	.64	3.01
UU1090	1	.302	0.000	5.84	70.7	5.82	5.87	.008	1.18	4.00	VW	.0000	70.8	70.5	71.0	.1	-.08	3.23
VV1090	2	0.000	0.000	.01	70.2	.04	.05	.018	.02	3.11	UV	.0000	70.8	70.4	70.4	.1	.72	3.06
WW1090	3	0.000	0.000	.03	70.7	.10	.05	.003	.12	3.07	UV	.0000	70.8	70.5	71.0	.1	1.07	3.94
UU1094	1	-.602	0.000	5.82	70.7	5.79	5.84	.010	.70	3.07	VW	.0000	70.8	70.6	71.3	.1	.25	3.24
VV1094	2	.267	0.000	.00	70.0	.05	.04	.011	.17	3.40	UV	.0000	70.0	70.6	70.8	.1	.36	3.13
WW1094	3	180.000	0.000	.09	70.1	.02	.12	.007	.17	3.25	UV	.0000	70.1	70.8	70.4	.1	.59	3.02
UU1098	1	.802	0.000	5.84	70.8	5.81	5.86	.007	.22	3.41	VW	.0000	70.8	70.5	71.2	.1	.10	3.22
VV1098	2	.535	0.000	.00	70.0	.05	.04	.011	.18	3.22	UV	.0000	70.0	70.6	70.8	.1	.21	3.01
WW1098	3	180.000	0.000	.08	70.2	.05	.12	.003	.02	3.02	UV	.0000	70.1	70.8	70.5	.1	.87	3.21
UU1100	1	1.070	0.000	5.81	71.0	5.79	5.84	.007	.01	3.74	VW	.0000	71.0	70.7	71.3	.1	.03	3.26
VV1100	2	0.000	0.000	.00	70.0	.05	.04	.007	.04	3.17	UV	.0000	70.0	70.7	70.5	.1	.45	3.15
WW1100	3	0.000	0.000	-.10	71.0	.12	.07	.003	.02	3.07	UV	.0000	70.7	70.7	71.3	.1	1.01	3.05
UU1104	1	1.070	0.000	5.82	71.0	5.80	5.85	.008	.01	3.43	VW	.0000	71.1	70.8	71.4	.1	.01	3.22
VV1104	2	.267	0.000	.00	70.0	.05	.04	.011	.05	3.12	UV	.0000	70.0	70.6	70.5	.1	.13	3.10
WW1104	3	180.000	0.000	.11	70.0	.05	.14	.007	.09	3.23	UV	.0000	70.0	70.6	70.2	.1	.89	3.15
UU1108	1	1.070	0.000	5.85	71.0	5.82	5.88	.008	.41	3.50	VW	.0000	71.0	70.5	71.3	.1	.07	3.21
VV1108	2	.535	0.000	.01	70.1	.05	.05	.010	.02	3.12	UV	.0000	70.1	70.7	70.8	.1	.51	3.21
WW1108	3	180.000	0.000	.10	70.0	.05	.13	.003	.03	3.02	UV	.0000	70.0	70.7	70.5	.1	.24	3.01
UU1110	1	1.305	0.000	5.84	71.1	5.81	5.87	.011	.00	3.32	VW	.0000	71.1	70.8	71.4	.1	.11	3.21
VV1110	2	0.000	0.000	-.00	70.0	.04	.04	.007	.08	3.20	UV	.0000	70.0	70.6	70.3	.1	.17	3.21
WW1110	3	0.000	0.000	.11	71.1	.14	.07	.007	.21	3.20	UV	.0000	71.1	70.8	71.3	.1	.07	3.03
UU1114	1	1.305	0.000	5.87	71.2	5.85	5.90	.008	.43	3.06	VW	.0000	71.2	70.9	71.5	.1	.00	3.02
VV1114	2	.267	0.000	.00	70.0	.04	.05	.010	.04	3.31	UV	.0000	70.0	70.6	70.4	.1	.13	3.11
WW1114	3	180.000	0.000	.12	70.0	.09	.15	.003	.10	3.02	UV	.0000	70.7	70.5	70.1	.1	.95	3.04
UU1118	1	1.305	0.000	5.84	71.2	5.84	5.87	.007	.73	3.63	VW	.0000	71.2	71.0	71.5	.1	.03	3.27
VV1118	2	.535	0.000	.01	70.1	.02	.04	.011	.04	3.26	UV	.0000	70.1	70.6	70.8	.1	.43	3.22
WW1118	3	180.000	0.000	.13	70.0	.10	.14	.003	.07	3.06	UV	.0000	70.7	70.5	70.0	.1	.72	3.06

Note: $\bar{u}$ values are 2.5% low.

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (%)	TIME	VELOCITY INFORMATION										ANGLE INFORMATION				
				MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKEW NESS	FLAT- NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKEW NESS	FLAT- NESS	
UU2001	1	.267	1.927	4.84	12.5	2.13	2.44	.611	2.30	10.43	UV	.0067	14.6	.3	55.0	7.0	2.23	8.61
UU2001	2	.967	2.642	.02	20.3	5.00	5.01	.012	.10	12.31	UV	.0020	20.1	45.8	130.4	7.0	.33	7.78
WW2001	3	100.000	.500	1.52	102.5	2.50	4.31	.715	.11	12.35	UV	.1490	102.4	59.7	144.3	6.4	.22	12.22
UU2002	1	.267	0.000	5.47	11.0	3.82	6.63	.332	.00	9.61	UV	.0221	12.7	.1	32.5	3.6	.23	8.72
UU2002	2	.134	.306	.30	87.0	1.62	3.20	.353	.73	9.51	UV	.0672	88.2	57.4	107.6	3.9	.01	7.63
WW2002	3	180.000	.003	1.11	101.5	2.75	2.67	.350	2.26	9.83	UV	.0222	101.5	59.7	117.9	4.2	-2.01	9.02
UU2003	1	.267	.015	4.00	13.0	2.78	4.27	.226	.30	4.01	UV	.0038	13.7	.1	10.0	2.0	.19	8.73
UU2003	2	.201	.331	.26	86.4	1.50	2.35	.286	.52	4.61	UV	.0134	86.4	57.1	116.9	4.1	.58	8.14
WW2003	3	180.000	.015	.00	102.4	2.31	2.20	.288	2.01	9.22	UV	.0159	102.4	59.8	119.2	4.1	-1.90	9.28
UU2005	1	.267	0.000	8.54	2.3	0.26	0.43	.175	.15	1.61	UV	.0015	2.7	.1	5.3	1.1	.20	1.59
UU2005	2	.334	0.000	.25	87.7	.00	.71	.285	.03	1.53	UV	.0050	87.7	55.1	20.9	1.4	.02	1.58
WW2005	3	180.000	0.000	.24	91.8	.33	.12	.022	.32	3.35	UV	.0018	91.8	50.8	22.9	.2	.50	3.19
UU2006	1	.267	0.000	8.37	2.6	0.32	0.41	.014	.32	3.33	UV	.0001	2.6	.3	3.1	.1	.18	3.25
UU2006	2	.301	0.000	.26	89.2	.29	.33	.017	.03	3.02	UV	.0000	89.2	57.7	88.6	.1	.13	3.88
WW2006	3	180.000	0.000	.28	91.9	.34	.33	.015	.15	3.26	UV	.0000	91.9	51.6	92.3	.1	.47	3.02
UU2008	1	.267	0.000	8.18	2.3	0.14	0.23	.012	.11	3.82	UV	.0000	2.3	1.9	2.7	.1	.05	3.11
UU2008	2	.535	0.000	.13	83.1	.08	.19	.014	.07	3.02	UV	.0000	82.1	88.7	82.9	.1	.56	3.11
WW2008	3	180.000	0.000	.30	92.1	.35	.23	.012	.26	3.63	UV	.0000	92.2	91.6	92.9	.1	-1.01	3.73
UU2011	1	.134	.145	7.07	14.5	4.22	8.20	.254	.73	8.16	UV	.0315	15.4	.1	41.9	5.0	1.52	16.70
UU2011	2	.067	.442	.33	87.4	3.21	4.63	.663	.43	5.53	UV	.0632	87.4	57.2	122.3	3.6	.47	5.81
WW2011	3	180.000	.006	-1.01	104.3	4.22	2.72	.350	1.80	17.37	UV	.0721	104.2	67.5	123.3	2.6	1.55	16.32
UU2012	1	.134	.019	5.71	13.3	3.55	8.41	.362	.01	7.37	UV	.0404	13.0	.1	42.3	5.1	2.23	11.16
UU2012	2	.134	2.365	.47	85.4	2.70	5.10	.632	1.62	9.13	UV	.0585	85.4	51.3	118.9	6.1	-1.60	8.29
WW2012	3	180.000	.161	-1.16	101.4	4.04	2.01	.478	2.27	14.85	UV	.0532	101.4	59.7	125.1	4.9	-2.19	13.99
UU2013	1	.134	.034	4.40	13.7	2.74	5.22	.357	.24	3.18	UV	.0067	15.3	.2	41.0	5.3	1.29	7.09
UU2013	2	.201	2.097	.40	83.7	2.54	3.05	.450	.66	16.10	UV	.0017	83.7	51.4	124.1	6.0	-1.87	6.67
WW2013	3	180.000	.420	-1.26	102.2	2.45	2.53	.462	2.57	13.27	UV	.0400	102.0	59.7	122.1	6.1	-2.52	13.86
UU2015	1	.134	0.000	8.43	5.5	0.21	0.54	.125	.03	1.60	UV	.0027	5.5	4.2	6.8	.6	.00	1.75
UU2015	2	.334	0.000	.72	84.7	.60	.58	.073	.04	1.74	UV	.0002	84.7	83.3	85.9	.6	-1.10	1.73
WW2015	3	180.000	0.000	.20	91.4	.30	.13	.030	.07	3.13	UV	.0000	91.4	90.9	92.0	.2	.73	3.08
UU2016	1	.134	0.000	8.20	4.0	0.14	0.23	.013	.74	4.06	UV	.0000	4.0	3.5	4.6	.2	-.04	2.30
UU2016	2	.401	0.000	.52	86.3	.45	.60	.025	.14	2.33	UV	.0000	86.3	85.0	86.9	.2	.15	2.34
WW2016	3	180.000	0.000	-1.25	91.5	.31	.21	.017	.45	2.72	UV	.0000	91.7	91.4	92.1	.1	.23	2.59
UU2018	1	.134	0.000	8.05	2.6	0.01	0.07	.012	.03	2.76	UV	.0000	2.6	2.2	3.0	.1	.02	2.94
UU2018	2	.535	0.000	.26	88.2	.19	.31	.015	.14	2.71	UV	.0000	88.2	87.0	88.6	.1	-.07	2.87
WW2018	3	180.000	0.000	.26	91.9	.32	.22	.012	.05	3.07	UV	.0000	91.8	91.5	92.3	.1	.92	3.03
UU2021	1	.067	.204	7.05	14.6	4.22	8.77	.461	.63	3.70	UV	.0463	15.1	.3	42.3	5.2	.68	5.56
UU2021	2	.067	1.572	.54	85.7	4.62	4.93	1.035	.16	2.82	UV	.3376	85.5	50.6	120.3	8.6	-1.14	3.86
WW2021	3	180.000	.262	1.75	103.9	4.39	4.18	.731	2.03	12.36	UV	.0930	103.7	59.7	127.3	5.9	-2.02	12.81
UU2022	1	.067	.311	5.89	12.4	3.26	8.82	.733	.02	1.83	UV	.0002	12.4	.3	45.1	7.2	.77	3.54
UU2022	2	.134	2.066	.54	84.2	3.85	6.27	.860	1.28	6.44	UV	.3718	84.5	47.0	127.6	8.4	-.94	4.77
WW2022	3	180.000	2.514	1.19	101.3	4.85	4.82	1.044	1.05	7.53	UV	.0715	101.1	59.7	130.5	9.8	-1.76	8.62
UU2023	1	.067	.090	4.78	13.4	2.71	6.51	.293	.67	2.10	UV	.0776	17.2	.5	44.1	7.3	1.05	3.74
UU2023	2	.201	3.841	.74	81.3	3.92	3.92	.577	1.46	8.00	UV	.0623	81.3	47.6	124.5	7.1	-1.45	7.59
WW2023	3	180.000	3.693	-1.06	100.1	3.23	3.40	.950	1.40	7.48	UV	.0761	100.0	59.7	122.2	10.9	-1.58	7.45

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (%)	TIME	VELOCITY INFORMATION						ANGLE INFORMATION						FLAT-NESS					
				MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKW NESS	FLAT-NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKW NESS	FLAT-NESS				
UU20235	1	.067	0.000	8.20	7.0	7.98	8.42	.127	.04	1.53	VM	.0052	7.0	4.6	7.2	1.4	-.10	1.45			
VU20235	2	.334	0.000	.99	83.1	.64	1.50	.200	.15	1.46	UM	.0020	83.1	80.9	85.5	1.4	.08	1.45			
WU20235	3	180.000	0.000	.19	91.3	.37	.10	.053	1.31	3.90	UV	-.0022	91.3	90.7	92.6	.4	1.34	3.91			
UU20236	1	.067	0.000	8.07	4.8	8.01	8.13	.022	.02	2.32	VM	.0002	4.8	4.1	5.5	.3	-.07	1.90			
VU20236	2	.401	0.000	.64	85.5	.51	.74	.030	.13	1.92	UM	.0004	85.5	84.0	86.2	.3	.13	1.90			
WU20236	3	180.000	0.000	-.22	91.6	-.22	.17	.018	.37	2.96	UV	.0001	91.6	91.2	92.0	.1	.29	2.89			
UU20238	1	.067	0.000	7.95	2.7	7.82	8.00	.016	.03	3.40	VM	.0000	2.7	2.4	3.1	.1	-.01	2.91			
VU20238	2	.535	0.000	.29	87.2	.24	.35	.014	.21	3.06	UM	.0000	87.2	87.5	88.3	.1	.84	3.22			
WU20238	3	180.000	0.000	-.24	91.0	.29	.20	.012	.02	2.09	UV	.0000	91.7	91.4	92.1	.1	-.08	2.90			
UU20235	1	0.000	0.000	7.90	7.5	7.70	8.14	.133	.16	1.53	VM	.0016	7.5	5.0	8.5	.6	-.71	2.68			
VU20235	2	.334	0.000	1.02	82.7	.72	1.16	.083	.50	2.36	UM	.0016	82.7	81.6	84.4	.6	.71	2.65			
WU20235	3	180.000	0.000	-.19	91.4	-.30	.12	.027	.77	4.05	UV	.0007	91.4	90.9	92.2	.2	.63	3.58			
UU20236	1	0.000	0.000	7.84	5.0	7.77	7.92	.021	.04	1.92	VM	.0001	5.0	4.4	5.5	.1	-.26	2.82			
VU20236	2	.401	0.000	.65	85.3	.57	.72	.020	.23	2.73	UM	.0001	85.3	84.7	85.8	.2	.43	2.83			
WU20236	3	180.000	0.000	-.21	91.6	-.26	.16	.013	.10	3.05	UV	.0000	91.6	91.2	91.9	.1	-.27	3.03			
UU2045	1	-.067	0.000	7.81	6.3	7.55	7.71	.035	.57	2.25	VM	.0005	6.3	5.2	7.2	.5	-.13	1.73			
VU2045	2	.334	0.000	.82	83.9	.67	.75	.047	-.08	1.92	UM	.0012	83.9	82.9	85.0	.5	.09	1.71			
WU2045	3	180.000	0.000	-.17	91.3	-.23	.10	.019	.20	2.47	UV	.0003	91.3	90.7	91.7	.1	-.13	2.41			
UU2046	1	-.067	0.000	7.74	4.5	7.67	7.77	.021	.21	2.15	VM	.0001	4.5	4.1	5.1	.2	.12	2.71			
VU2046	2	.401	0.000	.50	85.3	.51	.66	.023	.03	2.57	UM	.0002	85.3	85.1	86.2	.2	-.13	2.63			
WU2046	3	180.000	0.000	-.20	91.5	-.25	.14	.015	.10	2.61	UV	.0000	91.5	91.1	91.8	.1	.36	2.59			
UU2048	1	-.067	0.000	7.60	2.7	7.75	7.85	.015	.66	3.10	VM	.0000	2.7	2.3	3.2	.1	.14	3.33			
VU2048	2	.535	0.000	.31	87.7	.25	.36	.015	.08	2.09	UM	.0000	87.7	87.4	88.2	.1	-.02	2.86			
WU2048	3	180.000	0.000	-.21	91.5	.26	.16	.012	.08	3.12	UV	.0000	91.5	91.2	91.9	.1	.41	3.15			

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (2) TIME	VELOCITY INFORMATION							FLATNESS	REYNOLDS STRESS	ANGLE INFORMATION					SKEWNESS	FLATNESS
			MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKEWNESS	MEAN ANGLE			MIN. ANGLE	MAX. ANGLE	RMS ANGLE				
UU2041	1	.067	0.000	6.05	1.5	6.57	7.09	.131	.04	2.07	VW	.0010	2.2	.3	3.0	.0	-.44	2.17
VU2041	2	.067	0.000	-7.01	90.1	.31	.20	.142	.04	1.80	UW	.0175	70.1	67.0	92.7	1.2	.10	1.89
WW2041	3	180.000	0.000	-7.10	91.5	.41	.10	.157	.42	2.29	UV	.0051	91.5	88.4	93.4	1.3	-.62	2.30
UU2042	1	-.067	0.000	6.76	1.2	6.27	7.21	.254	.13	1.73	VW	.0000	2.6	.0	3.6	.0	-1.28	3.59
VU2042	2	.134	0.000	.17	88.6	.02	.90	.121	.02	1.66	UW	.0277	88.6	86.8	90.5	1.0	.05	1.66
WW2042	3	180.000	0.000	-1.15	91.3	.40	.30	.205	.70	2.36	UV	.0049	91.3	87.0	93.4	1.5	-.77	2.37
UU2043	1	.067	0.000	6.83	4.7	6.27	7.33	.309	.13	1.71	VW	.0065	4.2	3.6	6.5	.6	.23	2.15
VU2043	2	.201	0.000	.56	85.4	.42	.60	.052	.15	2.19	UW	.0096	85.4	84.6	86.3	.6	-.33	2.37
WW2043	3	180.000	0.000	-1.09	90.7	.40	.30	.170	.92	2.61	UV	.0040	90.7	86.7	93.2	1.5	-.90	2.63
UU2045	1	.067	0.000	7.89	3.9	7.82	8.00	.037	.53	2.20	VW	.0007	4.0	2.9	5.0	.5	-.07	1.72
VU2045	2	.334	0.000	.54	86.1	.37	.70	.073	.04	1.70	UW	.0014	86.1	85.0	87.2	.5	-.05	1.71
WW2045	3	180.000	0.000	-1.10	90.7	-1.10	.03	.025	.14	2.32	UV	.0010	90.7	90.2	91.5	.2	-.05	2.29
UU2046	1	-.067	0.000	8.03	2.3	7.26	8.10	.023	.17	2.21	VW	.0001	2.3	1.8	2.8	.1	-.02	2.63
VU2046	2	.401	0.000	.22	87.7	.21	.22	.023	.13	2.21	UW	.0002	87.7	87.4	88.5	.2	.04	2.64
WW2046	3	180.000	0.000	-1.14	91.0	.19	.09	.013	.20	3.22	UV	.0001	91.0	90.2	91.5	.1	.47	3.06
UU2048	1	.067	0.000	8.07	1.2	8.04	8.11	.011	.05	2.77	VW	.0000	1.2	.9	1.6	.1	.28	3.48
VU2048	2	.535	0.000	.03	89.8	.05	.02	.017	.01	2.81	UW	.0000	89.8	89.3	90.3	.1	.23	3.87
WW2048	3	180.000	0.000	-1.17	91.2	.22	.12	.010	.05	3.20	UV	.0000	91.2	90.9	91.6	.1	-1.06	3.11
UU2060	1	-.134	0.000	7.00	1.7	6.77	7.15	.010	.46	3.83	VW	.0000	1.7	.1	2.4	.2	-.04	2.19
VU2060	2	0.000	0.000	.14	88.8	.00	.23	.027	.10	2.23	UW	.0000	88.8	88.1	90.0	.2	-.10	2.23
WW2060	3	0.000	0.000	.15	88.8	.01	.22	.024	.06	2.11	UV	.0000	88.8	88.2	90.1	.2	-.10	2.10
UU2061	1	-.134	0.000	7.04	1.2	6.94	7.15	.044	.12	2.16	VW	.0001	1.3	.1	2.2	.4	-.57	2.37
VU2061	2	.067	0.000	-7.01	90.1	.15	.13	.055	.06	1.76	UW	.0022	70.1	68.9	91.6	.4	-.06	1.96
WW2061	3	180.000	0.000	-1.15	91.2	.27	.00	.055	.40	2.09	UV	.0002	91.2	90.0	92.2	.5	-.40	2.09
UU2062	1	-.134	0.000	7.10	1.8	6.70	7.20	.025	.13	1.84	VW	.0004	1.7	.5	2.5	.4	-.55	2.05
VU2062	2	.134	0.000	.15	88.8	.04	.26	.048	.02	1.75	UW	.0041	88.8	87.9	89.6	.4	-.04	1.77
WW2062	3	180.000	0.000	-1.12	91.0	.25	.06	.076	.42	1.91	UV	.0003	91.0	89.5	92.0	.6	-.45	1.93
UU2063	1	-.134	0.000	7.25	2.5	7.03	7.44	.102	.08	1.67	VW	.0000	2.5	1.9	3.2	.2	.09	2.56
VU2063	2	.201	0.000	.22	87.7	.21	.36	.019	.10	2.70	UW	.0006	87.7	87.1	88.3	.3	.04	2.87
WW2063	3	180.000	0.000	-1.11	90.9	-.23	.04	.066	.55	1.96	UV	.0006	90.9	89.6	91.8	.5	-.52	1.94
UU2064	1	-.134	0.000	7.54	2.6	7.44	7.73	.025	.04	1.60	VW	.0004	2.7	1.5	3.6	.3	.12	1.91
VU2064	2	.257	0.000	.34	87.5	.04	.46	.040	.17	1.77	UW	.0020	87.4	86.5	87.7	.4	-.17	1.94
WW2064	3	180.000	0.000	-1.07	90.7	.20	.02	.040	.52	2.07	UV	.0000	90.7	89.8	91.5	.3	-.46	2.03
UU2065	1	-.134	0.000	7.77	2.3	7.72	7.82	.012	.19	2.33	VW	.0000	2.3	1.6	3.1	.3	.00	2.04
VU2065	2	.334	0.000	.29	87.2	.17	.40	.032	.01	2.02	UW	.0005	87.2	87.1	88.0	.3	-.00	2.01
WW2065	3	180.000	0.000	-1.12	90.9	.20	.05	.022	.02	2.60	UV	.0003	90.9	90.3	91.4	.2	-.04	2.59
UU2066	1	-.134	0.000	7.91	1.7	7.80	7.96	.011	.02	2.80	VW	.0000	1.7	1.2	2.2	.1	-.09	2.73
VU2066	2	.401	0.000	.20	88.6	.11	.20	.025	.15	2.66	UW	.0000	88.6	88.0	89.2	.2	.23	2.68
WW2066	3	180.000	0.000	-1.14	91.0	.20	.10	.013	.22	3.14	UV	.0001	91.0	90.7	91.4	.1	.64	3.35
UU2068	1	-.134	0.000	8.01	1.1	7.96	8.05	.011	.03	2.70	VW	.0000	1.1	.8	1.4	.1	-.25	3.49
VU2068	2	.535	0.000	.01	89.9	-.06	.07	.017	.10	2.83	UW	.0000	89.9	89.5	90.4	.1	-.18	2.80
WW2068	3	180.000	0.000	-1.15	91.1	.19	.11	.010	.20	3.33	UV	.0001	91.0	90.8	91.3	.1	.72	2.95

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (%)	TIME	VELOCITY INFORMATION							ANGLE INFORMATION						
				MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKEW NESS	FLAT NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKEW NESS	FLAT NESS
UU2070	1	.267	0.000	7.42	1.7	7.39	7.46	.010	.15	2.20 VM	.0000	1.7	1.2	2.2	.1	.03	3.08
VV2070	2	0.000	0.000	.17	88.7	.11	.23	.012	.07	2.00 UM	.0000	88.7	88.2	89.2	.1	.15	3.01
WW2070	3	0.000	0.000	.14	88.9	.07	.20	.014	.12	2.02 UV	.0000	88.9	88.5	89.3	.1	.01	2.80
UU2071	1	.267	0.000	7.45	1.3	7.41	7.40	.011	.14	2.31 VM	.0000	1.3	.8	1.0	.1	.06	2.88
VV2071	2	.057	0.000	.10	20.8	.12	.03	.013	.02	2.22 UM	.0000	20.8	20.2	21.2	.1	.13	2.92
WW2071	3	180.000	0.000	.11	21.0	.19	.07	.015	.07	2.92 UV	.0001	21.0	20.2	21.4	.1	.23	2.94
UU2072	1	.267	0.000	7.50	1.0	7.45	7.55	.013	.17	2.56 VM	.0000	1.0	.5	1.4	.1	.16	2.72
VV2072	2	.134	0.000	.02	20.2	.08	.03	.015	.02	2.93 UM	.0001	20.2	19.7	20.6	.1	.17	2.93
WW2072	3	180.000	0.000	.13	21.0	.10	.07	.015	.23	2.71 UV	.0000	21.0	20.5	21.4	.1	.18	2.61
UU2073	1	.267	0.000	7.55	1.0	7.50	7.61	.020	.17	2.26 VM	.0000	1.0	.6	1.3	.1	.16	2.52
VV2073	2	.201	0.000	.03	22.7	.02	.10	.014	.07	3.17 UM	.0000	22.7	22.2	20.2	.1	.24	3.17
WW2073	3	180.000	0.000	.12	20.2	.18	.02	.012	.22	2.74 UV	.0001	20.2	20.4	21.3	.1	.04	2.66
UU2074	1	.267	0.000	7.60	.0	7.63	7.74	.017	.06	2.40 VM	.0001	.2	.5	1.2	.1	.12	2.94
VV2074	2	.267	0.000	.07	22.5	.00	.13	.014	.02	3.22 UM	.0001	22.5	22.0	20.0	.1	.11	3.23
WW2074	3	180.000	0.000	.09	20.7	.15	.03	.015	.05	2.74 UV	.0000	20.7	20.2	21.1	.1	.49	2.96
UU2075	1	.267	0.000	7.72	.2	7.72	7.80	.012	.02	2.57 VM	.0000	.2	.5	1.4	.1	.07	3.20
VV2075	2	.324	0.000	.07	22.5	.00	.14	.012	.13	3.02 UM	.0001	22.5	22.0	20.0	.1	.00	3.00
WW2075	3	180.000	0.000	.10	20.0	.18	.04	.015	.18	3.47 UV	.0000	20.0	20.3	21.3	.1	.38	3.28
UU2078	1	.267	0.000	7.90	.0	7.86	7.94	.014	.41	2.63 VM	.0000	.8	.4	1.1	.1	.07	3.04
VV2078	2	.555	0.000	.02	20.2	.08	.04	.015	.01	3.10 UM	.0000	20.1	19.7	20.6	.1	.57	3.12
WW2078	3	180.000	0.000	.11	20.8	.15	.02	.010	.12	3.21 UV	.0001	20.8	20.4	21.0	.1	-1.20	3.22

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (%)	TIME	MEAN VEL.	ANGLE FROM	VELOCITY INFORMATION			SKIN RESS	FLAT- RESS	REYNOLDS STRESS	ANGLE INFORMATION					
						MIN. VEL.	MAX. VEL.	RMS VEL.				MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKEW NESS	FLAT- NESS
UU2080	1	.535	0.000	7.30	87.5	7.27	7.35	.010	.53	3.34	VW	.0000	87.5	87.2	1.0	.1	.00
VV2080	2	0.000	0.000	.04	87.7	.02	.12	.014	.26	3.34	UV	.0000	87.7	87.0	20.2	.1	.03
WW2080	3	0.000	0.000	.05	70.4	.16	.00	.012	.08	3.03	UV	.0000	70.4	70.0	20.2	.1	.15
UU2082	1	.535	0.000	7.31	87.4	7.28	7.33	.009	.43	3.23	VW	.0000	87.4	87.1	20.7	.1	.04
VV2082	2	.134	0.000	.03	87.2	.00	.02	.011	.61	3.23	UV	.0000	87.2	87.0	20.6	.1	.03
WW2082	3	130.000	0.000	.05	87.0	.01	.00	.013	.08	3.27	UV	.0001	87.0	87.3	20.6	.1	.21
UU2084	1	-.535	0.000	7.33	87.3	7.30	7.36	.007	.14	3.02	VW	.0000	87.3	87.1	20.4	.1	.05
VV2084	2	.267	0.000	.01	70.1	.03	.01	.013	.17	3.02	UV	.0000	70.1	70.4	20.4	.1	.33
WW2084	3	160.000	0.000	.04	87.7	.00	.00	.010	.10	3.00	UV	.0000	87.0	87.0	20.0	.1	1.10
UU2086	1	.535	0.000	7.30	87.5	7.34	7.42	.013	.15	3.70	VW	.0000	87.5	87.2	20.0	.1	.23
VV2086	2	.401	0.000	.00	70.0	.03	.04	.012	.19	3.10	UV	.0000	70.0	70.2	20.0	.1	.00
WW2086	3	130.000	0.000	.07	87.5	.03	.11	.011	.09	3.02	UV	.0000	87.5	87.0	20.0	.1	.51
UU2088	1	-.535	0.000	7.41	87.6	7.36	7.44	.011	.10	3.15	VW	.0000	87.6	87.3	20.0	.1	.00
VV2088	2	.535	0.000	.00	70.0	.04	.05	.011	.00	3.10	UV	.0000	70.0	70.0	20.0	.1	.40
WW2088	3	100.000	0.000	.00	87.4	.04	.13	.011	.05	3.00	UV	.0000	87.4	87.0	20.0	.1	.40
UU2090	1	.802	0.000	7.34	1.5	7.30	7.37	.012	.28	3.20	VW	.0001	1.5	1.1	1.0	.1	.40
VV2090	2	0.000	0.000	.12	87.1	.01	.17	.013	.34	3.27	UV	.0000	87.1	88.7	20.2	.1	.00
WW2090	3	0.000	0.000	.12	71.2	.20	.11	.013	.17	3.00	UV	.0000	71.2	70.7	21.0	.1	.00
UU2094	1	-.802	0.000	7.34	1.7	7.30	7.38	.015	.06	3.14	VW	.0000	1.7	1.3	2.0	.1	.14
VV2094	2	.267	0.000	.15	71.0	.20	.10	.013	.07	3.25	UV	.0000	71.0	70.0	21.0	.1	.15
WW2094	3	100.000	0.000	.10	88.0	.11	.19	.010	.11	3.43	UV	.0000	88.0	88.5	20.1	.1	.21
UU2098	1	.802	0.000	7.22	3.2	7.07	7.36	.035	.60	3.00	VW	.0016	3.2	2.0	2.0	.1	.56
VV2098	2	.535	0.000	.30	87.3	.72	.10	.080	.51	3.27	UV	.0025	87.3	87.0	23.0	.1	.55
WW2098	3	130.000	0.000	.29	87.0	.10	.58	.050	.47	3.70	UV	.0039	87.0	85.0	20.6	.4	.50
UU2100	1	-1.070	0.000	7.36	1.6	7.33	7.39	.011	.41	3.26	VW	.0000	1.6	1.3	1.0	.1	.46
VV2100	2	0.000	0.000	.07	87.3	.01	.15	.013	.12	3.15	UV	.0000	87.3	88.7	20.7	.1	.00
WW2100	3	0.000	0.000	.10	71.4	.22	.13	.013	.31	3.05	UV	.0000	71.4	71.0	21.0	.1	.00
UU2104	1	-1.070	0.000	7.30	1.5	7.34	7.42	.013	.24	3.30	VW	.0000	1.5	1.1	1.0	.1	.11
VV2104	2	.267	0.000	.07	70.0	.13	.01	.013	.24	3.03	UV	.0001	70.0	70.1	21.0	.1	.30
WW2104	3	180.000	0.000	.10	88.0	.13	.22	.011	.00	3.00	UV	.0000	88.0	88.5	20.0	.1	.34
UU2108	1	-1.070	0.000	7.41	1.5	7.37	7.44	.011	.32	3.63	VW	.0000	1.5	1.2	1.0	.1	.10
VV2108	2	.535	0.000	.03	70.7	.13	.02	.014	.07	3.07	UV	.0000	70.7	70.0	21.0	.1	.54
WW2108	3	160.000	0.000	.17	88.7	.13	.22	.010	.10	3.25	UV	.0000	88.0	88.0	20.0	.1	.50
UU2110	1	-1.605	0.000	7.41	1.5	7.30	7.44	.008	.02	3.61	VW	.0000	1.5	1.1	1.0	.1	.26
VV2110	2	0.000	0.000	.09	87.3	.03	.15	.014	.07	3.30	UV	.0000	87.3	88.0	20.0	.1	.37
WW2110	3	0.000	0.000	.17	71.3	.22	.12	.013	.07	3.07	UV	.0000	71.3	70.7	21.7	.1	.21
UU2114	1	-1.605	0.000	7.41	1.7	7.30	7.45	.011	.71	3.57	VW	.0000	1.7	1.5	2.0	.1	.01
VV2114	2	.267	0.000	.09	70.7	.15	.04	.014	.05	3.20	UV	.0000	70.7	70.3	21.1	.1	.61
WW2114	3	100.000	0.000	.20	88.5	.15	.24	.012	.00	3.24	UV	.0001	88.5	88.1	20.0	.1	.20
UU2118	1	1.605	0.000	7.42	1.8	7.22	7.56	.011	.73	4.31	VW	.0000	1.8	1.4	2.0	.1	.00
VV2118	2	.535	0.000	.10	70.0	.25	.04	.016	.22	4.20	UV	.0000	70.0	67.0	20.0	.1	.40
WW2118	3	130.000	0.000	.20	88.4	.09	.30	.013	.22	4.21	UV	.0000	88.4	87.0	20.0	.1	.30

Note: $\bar{u}$ values are 2.5% low.

TABLE 3.3-3. (contd)

PILE NAME	PILE NO.	DEPTH (ft)	LIGATE EXCEEDED (%)	TIME	VELOCITY INFORMATION					FLAT- NESS	REYNOLDS STRESS	ANGLE INFORMATION					FLAT- NESS	
					MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.			MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE			
DU3001	1	.247	.655	5.56	10.0	1.04	7.00	.422	2.00	17.25	VW	.0070	11.7	.1	54.2	5.7	2.23	12.93
DU3001	2	.067	1.025	1.13	100.0	4.03	1.41	.502	1.00	18.33	UV	.0507	80.2	10.6	131.1	6.3	1.28	11.01
DU3001	3	180.000	.534	-1.90	100.0	-4.40	3.25	.402	1.42	19.80	UV	.0414	90.2	59.5	143.0	5.0	1.30	23.00
DU3002	1	.015	.006	4.22	10.0	2.01	5.11	.122	.10	2.70	VW	.0120	11.0	.1	32.3	4.1	.23	9.15
DU3002	2	.123	.445	1.23	60.0	2.00	2.51	.222	1.21	2.51	UV	.0206	80.2	56.2	122.3	4.0	1.25	2.91
DU3002	3	180.000	.074	.74	99.9	2.19	2.52	.353	1.22	2.77	UV	.0207	90.2	59.7	119.3	5.0	-1.79	8.74
DU3003	1	.247	.012	2.42	10.0	1.70	3.45	.224	.20	2.92	VW	.0035	14.5	.2	41.2	5.0	1.12	1.31
DU3003	2	.001	1.123	1.12	100.0	1.12	1.21	.223	1.11	6.12	UV	.0151	81.2	53.1	114.2	6.1	1.18	6.33
DU3003	3	180.000	.077	-1.53	100.0	1.74	1.53	.223	1.27	6.35	UV	.0172	101.2	59.7	123.2	5.7	1.25	6.62
DU3005	1	.247	0.000	4.01	3.7	4.32	7.27	.131	.12	2.17	VW	.0000	3.0	.1	10.2	1.3	.22	2.43
DU3005	2	.000	0.000	.25	99.9	.15	1.12	.120	.15	2.12	UV	.0034	80.2	81.1	21.2	1.3	1.12	3.20
DU3005	3	180.000	0.000	.25	99.9	.22	.12	.075	.01	2.05	UV	.0042	90.2	80.9	95.1	.6	-1.02	4.02
DU3006	1	.247	0.000	4.45	3.4	4.30	6.22	.060	.01	2.70	VW	.0000	3.1	.0	4.3	.6	.03	3.00
DU3006	2	.001	0.000	.25	99.9	.12	.12	.075	.03	2.13	UV	.0000	80.2	81.5	21.0	.7	.02	3.17
DU3006	3	180.000	0.000	.25	99.9	.22	.12	.068	.02	2.02	UV	.0001	90.2	80.6	94.0	.6	.01	3.02
DU3008	1	.247	0.000	4.42	3.1	4.17	4.32	.067	.04	2.05	VW	.0001	3.1	.5	5.7	.7	.01	2.97
DU3008	2	.000	0.000	.25	99.9	.12	.12	.075	.00	2.12	UV	.0000	80.2	80.6	21.1	.7	.01	3.03
DU3008	3	180.000	0.000	.25	99.9	.22	.12	.070	.07	2.02	UV	.0005	90.2	89.0	95.2	.6	-1.06	2.99
DU3011	1	.131	.015	5.81	10.0	4.05	6.20	.200	1.00	7.31	VW	.0206	11.0	.2	32.1	2.8	1.22	11.77
DU3011	2	.007	.212	1.20	60.0	2.01	2.51	.200	1.00	7.31	UV	.0520	80.0	56.2	118.6	5.1	1.52	1.64
DU3011	3	180.000	.015	1.01	99.0	2.01	2.01	.513	1.00	12.70	UV	.0742	90.0	59.0	110.0	3.1	1.52	12.60
DU3012	1	.131	.012	4.34	10.2	2.70	5.45	.361	1.42	2.72	VW	.0020	13.0	.2	10.3	3.9	1.60	7.73
DU3012	2	.134	2.773	.22	85.2	2.14	2.50	.350	1.42	2.72	UV	.1221	80.0	45.1	120.0	7.0	1.05	6.46
DU3012	3	180.000	.326	.22	99.5	2.51	2.50	.554	2.12	9.11	UV	.0468	90.4	59.7	120.3	7.3	-2.16	9.56
DU3013	1	.134	.130	2.91	10.0	1.52	3.25	.260	.34	3.22	VW	.0050	16.5	.2	41.2	6.5	1.22	6.05
DU3013	2	.001	1.720	.30	99.9	1.32	1.32	.408	.34	3.12	UV	.0175	80.3	50.3	124.4	9.0	-1.69	4.89
DU3013	3	180.000	.721	.31	101.8	1.32	1.32	.302	2.32	11.14	UV	.0208	101.6	59.7	125.5	7.3	-2.32	11.19
DU3015	1	.174	0.000	5.62	6.0	4.32	7.01	.102	.10	2.55	VW	.0014	6.0	.2	11.5	1.2	-1.03	2.41
DU3015	2	.234	0.000	.72	83.5	.22	1.22	.115	.05	2.22	UV	.0022	80.5	70.2	87.7	1.2	.03	2.32
DU3015	3	180.000	0.000	.22	91.9	.22	.07	.072	.01	2.22	UV	.0012	91.9	89.4	94.8	.6	.02	2.95
DU3016	1	.134	0.000	4.50	5.3	4.22	4.71	.070	.00	2.22	VW	.0004	5.3	.2	8.6	.7	.06	3.06
DU3016	2	.001	0.000	.25	85.1	.22	.02	.060	.00	2.22	UV	.0002	85.1	82.1	87.9	.7	-1.02	2.94
DU3016	3	180.000	0.000	.25	92.0	.22	.05	.062	.04	2.24	UV	.0004	92.0	89.6	94.5	.6	-1.03	2.92
DU3018	1	.134	0.000	4.30	3.6	4.06	4.60	.067	.04	3.02	VW	.0001	3.7	.4	6.5	.7	-1.05	3.07
DU3018	2	.535	0.000	.21	87.2	.22	.02	.074	.11	3.02	UV	.0002	87.2	84.5	90.2	.7	-1.10	3.02
DU3018	3	180.000	0.000	.25	92.3	.22	.10	.071	.10	3.11	UV	.0007	92.3	89.1	94.7	.6	-1.10	3.11
DU3021	1	.067	.031	5.75	11.6	3.72	7.10	.208	.17	4.66	UV	.0248	13.7	.7	32.2	3.9	1.54	12.30
DU3021	2	.052	.724	1.46	85.5	3.22	3.22	.692	.07	3.22	UV	.1293	85.4	53.2	122.7	6.8	-1.13	10.44
DU3021	3	180.000	.235	-1.08	100.0	3.04	3.50	.473	2.61	13.04	UV	.0009	100.6	59.7	119.8	4.7	-2.74	19.02
DU3022	1	.067	.207	4.44	10.2	2.00	4.32	.432	.78	3.74	VW	.0036	15.6	.3	41.7	5.9	1.43	7.35
DU3022	2	.134	2.772	.41	84.8	3.20	4.07	.600	.52	3.58	UV	.1201	84.6	48.2	120.1	6.2	-1.26	5.22
DU3022	3	180.000	2.301	.73	99.6	3.22	3.73	.771	2.17	9.36	UV	.0506	99.4	59.7	123.9	9.4	-2.21	9.16
DU3023	1	.067	.528	3.13	15.4	1.43	5.22	.324	.44	3.71	VW	.0451	18.4	.4	52.3	7.1	1.22	4.62
DU3023	2	.010	6.051	.55	80.3	3.31	3.06	.551	.40	1.18	UV	.0077	80.7	42.5	126.8	9.4	-1.12	3.90
DU3023	3	180.000	1.445	-1.67	101.8	2.75	2.51	.463	2.37	14.53	UV	.0072	101.0	59.7	141.2	8.0	-2.17	12.84

Note: velocity values are possibly 3% low.

TABLE 3.3-3. (contd)

FILE NAME	ACT'G POSITION	LIMITS EXCEEDED (%)	-VELOCITY INFORMATION-								-ANGLE INFORMATION-						
			MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKEW-NESS	FLAT-NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKEW-NESS	FLAT-NESS	
UU3025	1	.067	0.000	6.50	2.1	6.16	6.00	.004	.07	2.70 VM	.0002	2.1	5.2	13.1	1.1	.35	3.70
UU3025	2	.554	0.000	1.01	81.1	.53	1.42	.104	.38	2.26 UM	.0005	81.1	73.3	85.2	1.0	-.34	3.80
UU3025	3	180.000	0.000	-.21	91.9	-1.50	1.00	.072	.12	3.03 UV	.0005	21.9	67.3	94.4	.7	.12	3.04
UU3025	1	.067	0.000	6.35	2.3	6.07	6.33	.071	.05	2.82 VM	.0000	6.3	3.4	9.0	.7	.05	3.93
UU3025	2	.181	0.000	.62	84.0	.35	.92	.072	.01	2.21 UM	.0005	84.0	81.3	86.0	.7	.01	3.91
UU3025	3	100.000	0.000	.22	92.0	.49	.67	.072	.02	2.98 UV	.0004	22.0	89.4	94.5	.6	-.01	3.98
UU3026	1	.067	0.000	6.22	3.2	5.95	6.50	.070	-.03	2.72 VM	.0002	3.2	1.0	6.2	.7	.04	3.06
UU3026	2	.535	0.000	-.25	85.0	-.92	.63	.072	.12	3.10 UM	.0003	86.8	81.2	89.8	.7	.11	3.10
UU3026	3	180.000	0.000	-.24	92.2	-1.50	.14	.072	.05	3.07 UV	.0002	22.2	88.6	95.3	.7	-.05	3.07
UU3035	1	0.000	0.000	6.17	10.1	5.00	6.55	.116	.00	2.43 VM	.0003	10.2	2.3	13.8	.9	-.20	3.06
UU3035	2	.274	0.000	1.08	80.0	.67	1.42	.075	.20	2.09 UM	.0002	80.0	76.6	83.7	.7	.10	3.07
UU3035	3	180.000	0.000	.20	91.8	.52	.69	.075	.03	3.05 UV	.0005	21.8	89.2	94.7	.7	.04	3.05
UU3076	1	0.000	0.000	6.18	6.6	5.21	6.16	.074	-.03	2.84 VM	.0002	6.7	3.6	9.2	.7	.01	3.06
UU3076	2	.191	0.000	.67	83.7	-.33	1.03	.074	.03	2.91 UM	.0002	83.6	80.3	86.7	.7	.01	3.04
UU3076	3	180.000	0.000	-.21	91.9	-1.49	.16	.073	.01	3.02 UV	.0001	21.9	88.5	94.5	.7	.02	3.01
UU3078	1	0.000	0.000	6.11	4.0	5.98	6.37	.072	.01	2.80 VM	.0001	4.0	1.0	7.4	.7	-.01	3.05
UU3078	2	.525	0.000	.36	84.6	-.07	.62	.072	.12	3.15 UM	.0005	86.6	83.6	90.6	.7	.10	3.15
UU3078	3	100.000	0.000	.22	92.1	.52	.60	.073	.05	3.04 UV	.0002	22.1	89.3	95.0	.7	-.04	3.03
UU3045	1	.067	0.000	5.87	8.5	5.57	6.16	.075	.01	2.86 VM	.0002	8.5	5.3	11.7	.9	-.00	3.97
UU3045	2	.334	0.000	-.06	81.7	.52	1.20	.089	.01	2.74 UM	.0001	81.7	78.4	84.9	.8	.02	3.96
UU3045	3	180.000	0.000	-.17	91.7	-1.46	.17	.074	.03	2.79 UV	.0005	21.7	88.4	94.5	.7	-.01	3.96
UU3046	1	.067	0.000	5.05	6.2	5.24	6.31	.073	-.07	3.02 VM	.0000	6.3	3.1	9.8	.7	.05	3.06
UU3046	2	.181	0.000	.63	84.0	.31	.98	.072	.01	2.27 UM	.0000	84.0	80.7	87.0	.7	.02	3.99
UU3046	3	180.000	0.000	.17	91.8	-.52	.13	.073	.02	3.01 UV	.0002	21.8	88.8	94.9	.7	-.01	3.01
UU3048	1	.067	0.000	6.03	4.0	5.78	6.32	.072	.05	2.95 VM	.0001	4.1	1.2	7.1	.7	-.00	3.02
UU3048	2	.535	0.000	.20	85.5	-.91	.63	.072	.10	3.11 UM	.0004	86.4	83.6	90.1	.7	.08	3.12
UU3048	3	180.000	0.000	-.20	91.9	-1.40	.12	.074	.07	3.01 UV	.0003	21.9	88.7	94.5	.7	-.06	3.01

Note: $\bar{u}$ values are possibly 3% low.

TABLE 3.3-3. (contd)

SITE POSITION			ORBIT		TELESCOPE INFORMATION										ANGLE INFORMATION		
NAME	UT	COORD	PERIOD (S)	MEAN VEL.	SHELL FROM	MIN VEL.	MAX VEL.	RMS VEL.	SKIN NESS	FLAT NESS	REYNOLD'S	HEAD ANGLE	HTP ANGLE	HA ANGLE	RMS ANGLE	SKIN NESS	FLAT NESS
UU30411	1	.007	0.000	5.10	30.1.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.1.0	30.1.0	30.1.0	.10	.00
UU30411	1	.007	0.000	.00	30.1.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.1.0	30.1.0	30.1.0	.10	.00
UU30411	100.000	0.000	.11	.11	30.1.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.1.0	30.1.0	30.1.0	.10	.00
UU30412	1	.007	0.000	5.10	30.2.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.2.0	30.2.0	30.2.0	.10	.00
UU30412	1	.121	0.000	.10	30.2.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.2.0	30.2.0	30.2.0	.10	.00
UU30412	100.000	0.000	.12	.12	30.2.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.2.0	30.2.0	30.2.0	.10	.00
UU30413	1	.007	0.000	5.10	30.3.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.3.0	30.3.0	30.3.0	.10	.00
UU30413	1	.201	0.000	.10	30.3.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.3.0	30.3.0	30.3.0	.10	.00
UU30413	100.000	0.000	.00	.00	30.3.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.3.0	30.3.0	30.3.0	.10	.00
UU30414	1	.007	0.000	5.10	30.4.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.4.0	30.4.0	30.4.0	.10	.00
UU30414	1	.207	0.000	.04	30.4.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.4.0	30.4.0	30.4.0	.10	.00
UU30414	100.000	0.000	.02	.02	30.4.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.4.0	30.4.0	30.4.0	.10	.00
UU30415	1	.007	0.000	5.11	30.5.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.5.0	30.5.0	30.5.0	.10	.00
UU30415	1	.207	0.000	.04	30.5.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.5.0	30.5.0	30.5.0	.10	.00
UU30415	100.000	0.000	.05	.05	30.5.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.5.0	30.5.0	30.5.0	.10	.00
UU30416	1	.007	0.000	5.12	30.6.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.6.0	30.6.0	30.6.0	.10	.00
UU30416	1	.101	0.000	.00	30.6.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.6.0	30.6.0	30.6.0	.10	.00
UU30416	100.000	0.000	.00	.00	30.6.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.6.0	30.6.0	30.6.0	.10	.00
UU30417	1	.007	0.000	5.12	30.7.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.7.0	30.7.0	30.7.0	.10	.00
UU30417	1	.101	0.000	.00	30.7.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.7.0	30.7.0	30.7.0	.10	.00
UU30417	100.000	0.000	.11	.11	30.7.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.7.0	30.7.0	30.7.0	.10	.00
UU30418	1	.007	0.000	5.11	30.8.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.8.0	30.8.0	30.8.0	.10	.00
UU30418	1	.101	0.000	.00	30.8.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.8.0	30.8.0	30.8.0	.10	.00
UU30418	100.000	0.000	.11	.11	30.8.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.8.0	30.8.0	30.8.0	.10	.00
UU30419	1	.131	0.000	5.11	30.9.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.9.0	30.9.0	30.9.0	.10	.00
UU30419	1	.000	0.000	.04	30.9.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.9.0	30.9.0	30.9.0	.10	.00
UU30419	100.000	0.000	.10	.10	30.9.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.9.0	30.9.0	30.9.0	.10	.00
UU30421	1	.131	0.000	5.12	30.1.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.1.0	30.1.0	30.1.0	.10	.00
UU30421	1	.007	0.000	.11	30.1.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.1.0	30.1.0	30.1.0	.10	.00
UU30421	100.000	0.000	.10	.10	30.1.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.1.0	30.1.0	30.1.0	.10	.00
UU30422	1	.131	0.000	5.12	30.2.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.2.0	30.2.0	30.2.0	.10	.00
UU30422	1	.131	0.000	.07	30.2.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.2.0	30.2.0	30.2.0	.10	.00
UU30422	100.000	0.000	.09	.09	30.2.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.2.0	30.2.0	30.2.0	.10	.00
UU30423	1	.131	0.000	5.12	30.3.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.3.0	30.3.0	30.3.0	.10	.00
UU30423	1	.101	0.000	.11	30.3.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.3.0	30.3.0	30.3.0	.10	.00
UU30423	100.000	0.000	.00	.00	30.3.0	5.10	5.10	1.10	.01	.000	UU	.0010	30.3.0	30.3.0	30.3.0	.10	.00
UU30424	1	.131	0.000	5.10	30.4.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.4.0	30.4.0	30.4.0	.10	.00
UU30424	1	.207	0.000	.00	30.4.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.4.0	30.4.0	30.4.0	.10	.00
UU30424	100.000	0.000	.00	.00	30.4.0	5.11	5.11	1.11	.01	.000	UU	.0010	30.4.0	30.4.0	30.4.0	.10	.00
UU30425	1	.131	0.000	5.12	30.5.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.5.0	30.5.0	30.5.0	.10	.00
UU30425	1	.131	0.000	.02	30.5.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.5.0	30.5.0	30.5.0	.10	.00
UU30425	100.000	0.000	.00	.00	30.5.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.5.0	30.5.0	30.5.0	.10	.00
UU30426	1	.131	0.000	5.14	30.6.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.6.0	30.6.0	30.6.0	.10	.00
UU30426	1	.401	0.000	.00	30.6.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.6.0	30.6.0	30.6.0	.10	.00
UU30426	100.000	0.000	.00	.00	30.6.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.6.0	30.6.0	30.6.0	.10	.00
UU30427	1	.131	0.000	5.12	30.7.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.7.0	30.7.0	30.7.0	.10	.00
UU30427	1	.131	0.000	.00	30.7.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.7.0	30.7.0	30.7.0	.10	.00
UU30427	100.000	0.000	.00	.00	30.7.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.7.0	30.7.0	30.7.0	.10	.00
UU30428	1	.131	0.000	5.12	30.8.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.8.0	30.8.0	30.8.0	.10	.00
UU30428	1	.131	0.000	.00	30.8.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.8.0	30.8.0	30.8.0	.10	.00
UU30428	100.000	0.000	.00	.00	30.8.0	5.12	5.12	1.12	.01	.000	UU	.0010	30.8.0	30.8.0	30.8.0	.10	.00

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (%) TIME	VELOCITY INFORMATION										ANGLE INFORMATION					
			MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SREW NESS	FLAT NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SREW NESS	FLAT NESS		
UU3070	1	.267	0.000	5.74	20.5	5.12	6.05	.077	.02	22.22 VM	.0000	1.0	1.0	1.5	.05	2.00		
UU3070	2	0.000	0.000	.05	20.5	.41	.06	.071	.01	22.11 UM	.0000	0.0	1.1	1.5	.05	2.00		
WW3070	3	0.000	0.000	.07	20.5	.29	.04	.050	.00	22.05 UV	.0000	0.0	2.0	1.5	.05	2.00		
UU3071	1	.267	0.000	5.75	1.3	5.12	6.05	.078	.02	22.03 VM	.0000	1.0	1.0	1.5	.05	2.00		
UU3071	2	.067	0.000	.11	20.5	.20	.05	.071	.02	22.03 UM	.0000	0.0	1.1	1.5	.05	2.00		
WW3071	3	180.000	0.000	.07	20.5	.36	.21	.070	.01	22.02 UV	.0000	0.0	2.0	1.5	.01	2.00		
UU3072	1	.267	0.000	5.72	1.2	5.12	6.10	.079	.02	22.01 VM	.0001	1.0	1.0	1.5	.05	2.00		
UU3072	2	.131	0.000	.17	20.5	.16	.04	.072	.05	22.07 UM	.0001	0.0	1.0	1.5	.04	2.00		
WW3072	3	180.000	0.000	.02	20.5	.33	.27	.071	.00	22.01 UV	.0000	0.0	2.0	1.5	.01	2.00		
UU3073	1	.267	0.000	5.85	2.2	5.56	6.14	.081	.10	22.00 VM	.0001	1.0	1.0	1.5	.08	2.00		
UU3073	2	.267	0.000	.23	20.5	.07	.03	.072	.05	22.00 UM	.0000	0.0	1.0	1.5	.05	2.00		
WW3073	3	100.000	0.000	.05	20.5	.14	.20	.072	.07	22.00 UV	.0000	0.0	2.0	1.5	.06	2.00		
UU3074	1	.267	0.000	5.86	2.1	5.65	6.19	.082	.10	22.00 VM	.0000	1.0	1.0	1.5	.08	2.00		
UU3074	2	.267	0.000	.25	20.5	.04	.03	.071	.01	22.01 UM	.0000	0.0	1.0	1.5	.03	2.00		
WW3074	3	180.000	0.000	.04	20.1	.31	.26	.071	.02	22.05 UV	.0000	0.0	2.1	1.5	.03	2.00		
UU3075	1	.267	0.000	6.03	2.4	5.71	6.33	.077	.05	22.02 VM	.0005	1.0	1.0	1.5	.05	2.00		
UU3075	2	.314	0.000	.23	20.5	.02	.03	.077	.01	22.04 UM	.0000	0.0	1.0	1.5	.03	2.00		
WW3075	3	180.000	0.000	.04	20.4	.33	.23	.070	.05	22.04 UV	.0000	0.0	2.4	1.5	.05	2.00		
UU3076	1	.267	0.000	6.07	2.2	5.72	6.34	.078	.05	22.08 VM	.0004	1.1	1.1	1.5	.05	2.00		
UU3076	2	.401	0.000	.24	20.5	.03	.03	.077	.02	22.05 UM	.0000	0.0	1.0	1.5	.03	2.00		
WW3076	3	180.000	0.000	.05	20.5	.33	.24	.072	.01	22.05 UV	.0001	0.0	2.4	1.5	.01	2.00		
UU3078	1	.267	0.000	6.11	1.7	5.81	6.43	.070	.03	22.20 VM	.0003	1.2	1.0	1.5	.07	2.00		
UU3078	2	.335	0.000	.10	20.3	.21	.17	.072	.02	22.00 UM	.0001	0.0	1.0	1.5	.01	2.00		
WW3078	3	180.000	0.000	.05	20.5	.41	.25	.073	.05	22.00 UV	.0004	0.0	2.7	1.5	.05	2.00		

TABLE 3.3-3. (contd)

FILE NAME	AMC POSITION	LIMITS EXCEEDED (%)	TIME	MEAN VEL.	ANGLE FROM	VELOCITY INFORMATION					FLAT-NESS	REYNOLDS STRESS	ANGLE INFORMATION					FLAT-NESS
						MIN. VEL.	MAX. VEL.	RMS VEL.	SPW-NESS				MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKEW-NESS	
UU3070	1	.267	0.000	5.50	1.0	5.12	5.78	.075	.00	0.92	VM	.0001	1.3	.0	4.3	.6	.13	.05
UU3070	2	0.000	0.000	.02	20.2	.32	.32	.070	.01	0.92	UM	.0002	20.2	07.0	23.2	.56	.03	.04
WW3070	3	0.000	0.000	.04	09.2	.32	.32	.070	.02	0.92	UV	.0001	09.2	06.3	22.2	.56	.03	.05
UU3071	1	.267	0.000	5.52	1.5	5.32	6.02	.072	.10	0.93	VM	.0001	1.2	.0	4.4	.54	.20	.05
UU3071	2	.067	0.000	.15	08.5	.20	.41	.071	.00	0.95	UM	.0002	08.5	06.2	22.0	.54	.01	.04
WW3071	3	100.000	0.000	.04	20.4	.30	.20	.030	.02	0.97	UV	.0004	20.4	07.1	23.0	.54	.02	.00
UU3072	1	.267	0.000	5.24	2.1	5.12	6.15	.076	.03	0.95	VM	.0001	1.2	.1	4.0	.54	.10	.04
UU3072	2	.134	0.000	.21	07.2	.11	.51	.070	.03	0.91	UM	.0005	07.2	01.0	21.1	.54	.04	.04
WW3072	3	100.000	0.000	.04	20.4	.33	.20	.070	.00	1.14	UV	.0001	20.4	07.1	20.2	.54	.00	.13
UU3073	1	.267	0.000	5.00	2.5	5.53	6.02	.075	.02	0.97	VM	.0001	2.6	.1	5.4	.54	.04	.07
UU3073	2	.204	0.000	.25	07.2	.03	.54	.071	.01	0.91	UM	.0002	07.2	01.3	20.2	.54	.00	.01
WW3073	3	100.000	0.000	.04	20.4	.31	.22	.071	.01	0.91	UV	.0005	20.4	07.1	23.0	.54	.01	.02
UU3074	1	.267	0.000	5.07	3.2	5.50	6.15	.077	.07	0.92	VM	.0001	3.2	.5	6.5	.54	.07	.07
UU3074	2	.267	0.000	.33	06.0	.04	.56	.069	.05	0.92	UM	.0001	06.0	03.5	22.5	.54	.06	.04
WW3074	3	100.000	0.000	.00	20.0	.26	.20	.071	.05	0.92	UV	.0004	20.0	07.1	22.5	.54	.05	.01
UU3075	1	.267	0.000	5.23	3.3	5.67	6.23	.075	.01	0.93	VM	.0002	3.3	.5	6.6	.54	.03	.01
UU3075	2	.334	0.000	.34	06.7	.07	.56	.070	.00	0.93	UM	.0003	06.7	02.8	22.4	.54	.02	.00
WW3075	3	100.000	0.000	.01	09.2	.30	.22	.071	.00	0.97	UV	.0005	09.2	07.2	22.2	.54	.00	.00
UU3076	1	.267	0.000	5.28	3.1	5.70	6.22	.074	.04	0.96	VM	.0004	3.2	.2	6.1	.54	.02	.00
UU3076	2	.401	0.000	.33	06.7	.07	.54	.071	.01	0.93	UM	.0005	06.7	03.2	22.3	.54	.02	.04
WW3076	3	100.000	0.000	.00	20.0	.27	.25	.071	.00	0.90	UV	.0007	20.0	07.6	22.6	.54	.02	.01
UU3078	1	.267	0.000	6.02	2.6	5.76	6.33	.078	.06	0.95	VM	.0003	2.7	.1	5.9	.54	.02	.10
UU3078	2	.535	0.000	.20	07.4	.09	.61	.074	.10	0.91	UM	.0003	07.4	01.1	20.3	.54	.03	.11
WW3078	3	100.000	0.000	.02	09.0	.24	.33	.073	.12	0.90	UV	.0005	09.0	06.0	22.0	.54	.12	.07
UU3080	1	.535	0.000	5.27	3.0	5.58	6.24	.074	.05	0.92	VM	.0002	1.1	.0	3.4	.54	.52	.06
UU3080	2	0.000	0.000	.00	20.2	.34	.20	.073	.00	0.92	UM	.0001	20.2	00.1	23.3	.54	.02	.00
WW3080	3	0.000	0.000	.01	20.1	.35	.20	.069	.01	0.91	UV	.0002	20.1	07.3	23.2	.54	.01	.00
UU3082	1	.535	0.000	5.28	1.0	5.62	6.22	.080	.06	0.93	VM	.0002	1.2	.0	4.4	.54	.40	.08
UU3082	2	.134	0.000	.10	09.0	.22	.42	.073	.03	0.94	UM	.0001	09.0	03.3	22.1	.54	.03	.00
WW3082	3	100.000	0.000	.00	20.0	.26	.34	.071	.03	0.97	UV	.0001	20.0	06.7	22.7	.54	.03	.00
UU3084	1	.535	0.000	6.02	1.1	5.70	6.22	.072	.07	0.91	VM	.0002	1.4	.0	4.4	.54	.34	.03
UU3084	2	.267	0.000	.12	09.2	.16	.46	.073	.04	0.91	UM	.0003	09.2	06.6	22.3	.54	.04	.00
WW3084	3	100.000	0.000	.01	09.9	.31	.36	.072	.02	0.92	UV	.0004	09.9	06.6	22.9	.54	.02	.01
UU3086	1	.535	0.000	6.03	1.2	5.71	6.35	.077	.03	0.91	VM	.0004	1.4	.0	4.5	.54	.21	.03
UU3086	2	.401	0.000	.12	09.0	.12	.47	.074	.01	0.90	UM	.0002	09.0	05.9	21.0	.54	.01	.00
WW3086	3	100.000	0.000	.02	09.0	.32	.34	.073	.05	0.90	UV	.0003	09.0	06.8	23.0	.54	.05	.04
UU3088	1	.535	0.000	6.02	1.1	5.72	6.30	.080	.07	0.93	VM	.0004	1.4	.0	4.6	.54	.22	.05
UU3088	2	.535	0.000	.12	09.2	.42	.47	.082	.24	0.51	UM	.0000	09.2	06.6	24.1	.54	.00	.00
WW3088	3	100.000	0.000	.02	09.7	.22	.37	.072	.11	0.10	UV	.0000	09.7	06.2	22.5	.54	.11	.00
UU3090	1	.802	0.000	6.01	.7	5.67	6.33	.072	.01	0.92	VM	.0000	1.1	.0	5.0	.54	.56	.17
UU3090	2	0.000	0.000	.07	20.2	.41	.27	.072	.01	0.90	UM	.0001	20.2	02.5	23.3	.54	.01	.00
WW3090	3	0.000	0.000	.02	20.2	.51	.27	.074	.07	0.97	UV	.0001	20.2	07.4	24.3	.54	.07	.09
UU3094	1	.802	0.000	6.03	.2	5.72	6.32	.081	.05	0.90	VM	.0005	1.2	.0	4.1	.54	.13	.06
UU3094	2	.267	0.000	.02	09.1	.20	.42	.076	.01	0.90	UM	.0000	09.1	06.0	21.9	.54	.04	.01
WW3094	3	100.000	0.000	.04	09.7	.27	.34	.075	.03	0.90	UV	.0005	09.7	06.7	22.5	.54	.04	.00

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (%) TIME	VELOCITY INFORMATION								ANGLE INFORMATION					
			MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	CHW NESS	FLAT NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	STEW NESS	FLAT NESS
UU3098	1	-1.002	0.000	6.00	1.1	5.71	6.23	.003	.01	2.80 VW	.0005	1.1	0.0	5.9	.00	1.01
UU3098	2	.535	0.000	.10	89.0	.00	.40	.003	.10	3.23 UW	.0000	89.0	89.0	92.0	.10	1.04
WW3098	3	180.000	0.000	.05	89.5	.43	.60	.003	.00	3.21 UW	.0007	89.5	89.0	94.0	.10	1.11
UU3100	1	-1.070	0.000	6.04	.7	5.75	6.15	.002	.01	2.01 VW	.0002	1.1	0.0	4.7	.00	1.07
UU3100	2	0.000	0.000	.00	90.0	.14	.00	.000	.00	2.02 UW	.0000	90.0	89.0	91.0	.00	1.00
WW3100	3	0.000	0.000	.05	90.4	.42	.00	.005	.01	2.10 UW	.0003	90.4	89.4	94.0	.05	1.10
UU3104	1	-1.070	0.000	6.03	1.0	5.75	6.33	.002	.11	2.05 VW	.0003	1.1	0.0	4.5	.00	1.00
UU3104	2	.567	0.000	.00	89.0	.01	.40	.001	.01	2.05 UW	.0002	89.0	89.0	92.0	.01	1.00
WW3104	3	180.000	0.000	.05	89.0	.01	.10	.002	.00	2.05 UW	.0005	89.0	89.0	92.0	.00	1.00
UU3108	1	-1.070	0.000	6.01	1.0	5.51	6.30	.002	.11	2.01 VW	.0006	1.1	0.0	4.0	.00	1.09
UU3108	2	.535	0.000	.00	89.0	.40	.40	.000	.01	2.00 UW	.0002	89.0	89.0	91.0	.01	1.11
WW3108	3	180.000	0.000	.07	89.3	.29	.40	.003	.00	2.00 UW	.0006	89.3	89.0	92.0	.00	1.08
UU3110	1	-1.605	0.000	6.06	1.0	5.71	6.50	.002	.00	2.05 VW	.0003	1.1	0.0	4.0	.00	1.05
UU3110	2	0.000	0.000	.00	90.0	.40	.20	.002	.00	2.03 UW	.0007	90.0	89.0	94.0	.00	1.05
WW3110	3	0.000	0.000	.00	90.0	.40	.20	.001	.00	2.00 UW	.0003	90.0	89.0	94.0	.00	1.01
UU3114	1	1.605	0.000	6.07	1.1	5.60	6.42	.000	.00	2.24 VW	.0002	1.1	0.0	4.0	.00	1.03
UU3114	2	.567	0.000	.00	89.0	.40	.40	.000	.00	2.23 UW	.0002	89.0	89.0	91.0	.00	1.04
WW3114	3	180.000	0.000	.00	89.0	.20	.40	.000	.00	2.22 UW	.0007	89.0	89.0	92.0	.00	1.01
UU3118	1	-1.605	0.000	6.02	1.2	5.65	6.30	.002	.05	2.01 VW	.0000	1.1	0.0	5.5	.00	1.00
UU3118	2	.535	0.000	.00	89.1	.40	.50	.004	.10	2.43 UW	.0001	89.1	89.0	91.0	.10	1.05
WW3118	3	180.000	0.000	.00	89.2	.20	.40	.000	.02	2.10 UW	.0000	89.2	89.0	92.0	.00	1.00

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (%)	TIME	MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKEW-NESS	FLAT-NESS	REYNOLDS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKEW-NESS	FLAT-NESS	
UU4001	1	.267	1.768	6.18	16.4	1.98	2.70	.894	-.82	4.28	VM	.1302	17.5	.1	54.8	7.0	1.11	3.80
UU4001	2	.267	1.572	.01	80.7	0.49	5.67	1.211	.03	1.52	UM	-.2041	89.7	45.0	134.2	11.2	-.07	4.39
UU4001	3	180.000	.049	-1.82	102.4	-5.93	4.07	.702	.59	7.21	UV	-.2521	102.2	52.7	144.3	8.6	-.46	7.70
UU4002	1	.267	.000	5.25	15.2	3.50	4.52	.402	.27	2.82	VM	.0463	15.9	.3	41.6	4.3	-.45	6.80
UU4002	2	.131	.684	.42	85.6	3.02	3.22	.419	.60	6.63	UM	-.0657	85.5	54.0	116.7	4.5	-.66	6.37
UU4002	3	100.000	0.000	-1.35	104.5	3.50	1.80	.327	1.74	9.35	UV	-.0509	104.6	70.4	123.7	3.8	-1.19	7.10
UU4003	1	.267	.031	4.18	14.6	2.84	5.12	.202	-.40	5.38	VM	.0052	15.3	.3	41.1	4.0	-.20	7.29
UU4003	2	.261	.795	-.33	85.6	-2.03	3.40	.242	-.52	6.15	UM	-.0073	85.6	52.5	120.0	4.7	-.47	6.76
UU4003	3	180.000	.003	-1.64	103.9	-2.36	2.22	.292	1.68	7.48	UV	-.0350	103.0	52.7	122.6	3.9	1.24	7.65
UU4005	1	.267	0.000	0.14	3.8	7.86	2.03	.225	.11	1.23	VM	-.0006	4.0	.3	8.4	1.3	.21	2.22
UU4005	2	.234	0.000	.42	87.6	-.22	1.14	.248	.04	2.03	UM	.0041	87.6	82.3	91.6	1.7	.05	2.03
UU4005	3	100.000	0.000	-.38	92.5	-.82	.04	.072	.01	3.13	UV	-.0045	92.5	89.7	95.6	.6	.01	3.12
UU4006	1	.267	0.000	0.31	3.7	8.00	8.00	.003	.02	2.84	VM	.0001	3.7	.1	6.4	.6	.03	2.94
UU4006	2	.101	0.000	.32	87.5	-.09	.74	.025	-.02	3.03	UM	-.0010	87.5	84.9	90.6	.7	-.00	3.03
UU4006	3	180.000	0.000	-1.35	92.7	-.74	.01	.087	.10	2.26	UV	-.0004	92.7	90.1	95.1	.6	-.09	2.92
UU4008	1	.267	0.000	8.14	3.5	7.02	3.46	.082	-.07	2.98	VM	-.0001	3.5	.7	6.2	.7	-.04	3.03
UU4008	2	.275	0.000	-.25	88.2	-.12	.64	.024	-.06	3.07	UM	.0003	88.2	85.6	91.2	.7	.05	3.07
UU4008	3	130.000	0.000	-.43	93.0	-.90	-.05	.089	.06	3.02	UV	-.0008	93.0	90.3	95.7	.6	-.05	3.02
UU4011	1	.134	.096	6.82	16.6	4.70	8.20	.223	-.60	5.73	VM	-.0383	17.4	.1	41.4	3.0	-.92	11.45
UU4011	2	.067	.725	.15	86.4	-4.23	4.26	.387	-.18	5.64	UM	-.0970	86.3	56.4	125.2	5.6	-.23	5.81
UU4011	3	180.000	0.000	-1.97	106.1	-4.42	1.20	.394	1.75	13.92	UV	-.1302	106.0	73.9	123.6	3.3	-1.76	12.65
UU4012	1	.134	.013	5.56	11.2	3.13	8.13	.405	.31	5.98	VM	.0321	15.5	.3	42.4	5.4	1.68	8.12
UU4012	2	.134	.603	.54	84.6	-2.78	5.01	.624	1.34	7.58	UM	-.0771	84.6	51.3	123.2	6.3	-1.18	6.81
UU4012	3	180.000	.108	-1.30	103.1	-3.84	3.79	.486	2.45	15.62	UV	.0905	103.0	59.7	125.4	5.1	-2.34	15.76
UU4013	1	.134	.031	4.42	15.0	2.81	5.55	.346	-.50	2.22	VM	.0032	16.3	.2	41.6	5.5	.84	5.81
UU4013	2	.201	.031	.54	83.2	-2.31	3.25	.140	-.20	6.52	UM	-.0816	83.1	52.3	121.9	5.8	-.78	6.64
UU4013	3	180.000	.303	-1.05	103.3	-2.68	2.58	.467	2.46	12.31	UV	-.0585	103.1	57.7	123.6	6.0	-2.40	12.79
UU4015	1	.134	0.000	0.34	6.1	7.05	8.82	.165	.02	2.12	VM	-.0026	6.1	.2	10.1	1.1	.12	2.55
UU4015	2	.224	0.000	.82	83.8	-.75	1.45	.157	.12	3.48	UM	-.0006	84.3	80.4	87.6	1.1	-.14	2.40
UU4015	3	130.000	0.000	-.34	92.3	-.72	.10	.071	.10	3.08	UV	-.0020	92.3	89.3	94.8	.6	-.11	3.09
UU4017	1	.134	0.000	6.17	5.1	7.84	8.18	.004	-.02	2.23	VM	.0001	5.1	.2	7.2	.7	.00	3.01
UU4017	2	.101	0.000	.54	85.6	-.22	1.02	.026	.00	3.00	UM	.0010	85.6	82.7	88.4	.7	-.03	3.00
UU4017	3	180.000	0.000	-.35	92.4	-.71	.10	.021	.06	2.99	UV	-.0007	92.4	89.3	94.9	.6	-.05	2.99
UU4018	1	.134	0.000	7.77	3.8	7.34	8.27	.085	.11	2.70	VM	-.0002	3.9	.1	6.8	.7	-.03	3.02
UU4018	2	.535	0.000	.38	87.3	-.06	.74	.056	.10	3.02	UM	.0002	87.3	84.5	90.4	.7	.00	3.11
UU4018	3	130.000	0.000	-.38	92.7	-.76	.01	.020	.07	3.14	UV	-.0011	92.7	89.9	95.4	.6	-.09	3.15
UU4021	1	.067	.070	6.91	16.7	4.46	8.62	.417	-.16	3.30	VM	.0451	18.7	.1	42.4	4.7	.28	6.43
UU4021	2	.067	1.751	.75	81.0	3.98	4.90	1.045	-.05	3.51	UM	-.3172	83.8	50.0	125.5	8.4	-.05	2.56
UU4021	3	180.000	.062	-1.93	105.8	-4.40	4.11	.579	2.26	13.52	UV	.0701	105.3	52.7	125.3	4.7	-2.21	13.50
UU4022	1	.067	.080	5.71	14.0	3.47	8.33	.595	.30	2.21	VM	-.0038	17.1	.3	44.5	5.7	.69	5.22
UU4022	2	.134	2.158	.61	84.1	-3.25	5.16	.778	.70	5.36	UM	-.2673	83.0	48.5	122.1	7.6	-.48	4.34
UU4022	3	100.000	1.478	1.28	102.5	-4.04	4.93	.859	2.38	12.28	UV	.0591	102.4	59.7	129.6	8.3	-2.36	11.61
UU4023	1	.067	.018	4.64	15.2	2.25	6.50	.562	.25	2.80	VM	.0344	17.7	.2	43.0	5.7	1.21	6.14
UU4023	2	.201	1.520	.77	89.0	-2.49	4.07	.542	1.15	7.27	UM	-.0274	80.9	47.5	123.0	6.5	-1.56	7.40
UU4023	3	180.000	1.800	-1.00	102.0	-3.32	3.37	.748	2.19	10.77	UV	.0387	101.7	52.7	123.9	8.6	-2.42	11.22

Note: velocity values are possibly 2.5% low.

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMIT LYCEEDLD (%) TIME	VELOCITY INFORMATION							ANGLE INFORMATION						
			MEAN VEL	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKEW- NESS	FLAT- NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE	SKEW- NESS	FLAT- NESS
UU4025	1	.067	0.000	8.16	2.4	7.66	0.02	.155	.07	2.35 VW	.0042	2.3	3.5	12.2	.14	3.01
UU4025	2	.067	0.000	1.02	82.7	1.12	1.57	.231	.12	1.24 UU	.0030	82.7	78.3	87.1	1.6	3.01
UU4025	3	180.000	0.000	.22	92.0	.72	.13	.100	.07	3.01 UV	.0057	92.0	87.0	95.2	.3	3.03
UU4026	1	.067	0.000	0.04	5.7	7.67	0.37	.007	.02	2.36 VW	.0001	5.8	3.0	8.8	.7	3.05
UU4026	2	.401	0.000	.75	81.7	.32	1.10	.100	.00	3.06 UW	.0010	81.7	81.6	87.6	.2	3.03
UU4026	3	180.000	0.000	.76	92.0	.68	.00	.090	.10	3.05 UV	.0004	92.1	89.3	94.7	.6	3.05
UU4028	1	.067	0.000	7.90	3.0	7.57	0.22	.007	.07	3.03 VW	.0000	3.0	.4	7.5	.7	3.13
UU4028	2	.535	0.000	.11	82.1	.06	.05	.027	.10	3.15 UW	.0002	82.1	83.7	70.4	.7	3.16
UU4028	3	180.000	0.000	-.34	92.5	-.71	.05	.021	.07	3.04 UV	.0010	92.4	87.6	95.1	.7	3.05
UU4035	1	0.000	0.000	7.01	2.4	7.35	0.20	.152	.04	2.35 VW	.0017	2.4	5.9	13.2	.9	3.02
UU4035	2	.734	0.000	1.27	89.8	.74	1.45	.124	.10	2.35 UW	.0077	89.8	83.0	84.6	.5	3.00
UU4035	3	180.000	0.000	.27	92.0	-.68	.10	.074	.05	2.99 UV	.0005	92.0	89.3	94.9	.7	3.08
UU4036	1	0.000	0.000	7.86	2.3	7.48	0.17	.021	.07	2.36 VW	.0001	2.3	2.7	7.7	.7	3.07
UU4036	2	.401	0.000	.31	84.1	.34	1.22	.076	.01	3.05 UW	.0011	84.1	81.1	87.5	.7	3.06
UU4036	3	180.000	0.000	-.29	92.1	-.65	.12	.020	.05	3.06 UV	.0004	92.1	89.1	94.7	.7	3.04
UU4038	1	0.000	0.000	7.01	3.9	7.45	0.13	.006	-.03	2.87 VW	.0000	4.0	.8	7.1	.7	3.07
UU4038	2	.535	0.000	.43	84.8	.00	.84	.026	.06	3.02 UW	.0001	84.8	83.0	70.0	.7	3.00
UU4038	3	180.000	0.000	-.32	92.3	.72	.06	.023	.04	3.02 UV	.0010	92.3	89.5	95.3	.7	3.02
UU4045	1	-.067	0.000	7.47	8.0	7.10	7.82	.025	-.04	2.20 VW	.0004	8.0	4.0	12.2	.7	3.00
UU4045	2	.734	0.000	1.02	92.2	.60	1.51	.110	.02	2.93 UW	.0001	92.2	78.4	85.5	.9	3.06
UU4045	3	180.000	0.000	-.23	91.8	-.65	.20	.074	.06	3.12 UV	.0005	91.8	89.5	95.1	.7	3.12
UU4046	1	.067	0.000	7.66	6.0	7.32	0.01	.021	.00	2.36 VW	.0004	6.0	3.1	9.9	.7	3.03
UU4046	2	.401	0.000	.25	81.4	.22	1.22	.026	.05	3.02 UW	.0010	81.4	80.0	87.1	.7	3.03
UU4046	3	120.000	0.000	.27	92.0	.62	.10	.022	.04	3.04 UV	.0004	92.0	88.7	94.6	.7	3.04
UU4048	1	.067	0.000	7.70	4.0	7.40	0.01	.007	.02	2.01 VW	.0002	4.1	.5	6.0	.7	3.14
UU4048	2	.535	0.000	.42	86.6	.01	.85	.077	.00	3.11 UW	.0000	86.6	83.7	70.1	.7	3.12
UU4048	3	180.000	0.000	-.28	92.1	-.66	.17	.023	.05	3.07 UV	.0000	92.1	88.6	94.9	.7	3.03

Note: velocity values are possibly 2.5% low.

TABLE 3.3-3. (contd)

FILE NAME	AXIS	POSITION	LIMITS EXCEEDED (%)	TIME	VELOCITY INFORMATION							ANGLE INFORMATION					FLATNESS
					MEAN	ANGLE	MIN.	MAX.	RMS	SKEW	FLATNESS	REYNOLDS	MEAN	MIN.	MAX.	RMS	
					VLL.	FROM	VEL.	VEL.	VLL.	NESS	STRESS	ANGLE	ANGLE	ANGLE	ANGLE	NESS	NESS
UU4041	1	.057	0.000		6.23	2.4	6.02	7.24	.101	.02	.0030	WM	33.1	31.0	35.7	1.30	2.444
UU4041	2	.057	0.000		.24	80.0	.32	.91	.100	.02	.0031	UU	33.0	31.3	35.5	1.00	2.444
UU4041	3	130.000	0.000		.14	91.2	.55	.50	.210	.34	.0051	UV	21.2	35.0	25.6	1.00	2.444
UU4042	1	-.067	0.000		6.66	2.4	5.00	7.38	.305	.10	.0013	WM	4.6	31.1	27.2	1.40	2.444
UU4042	2	.134	0.000		.30	86.7	.13	.87	.151	.01	.0346	UU	35.0	31.0	27.2	1.12	2.444
UU4042	3	180.000	0.000		-.11	90.9	-.92	.92	.251	.24	.0030	UV	30.9	35.0	27.2	1.04	2.444
UU4043	1	.057	0.000		6.74	3.3	5.86	7.57	.350	.14	.0000	WM	36.6	32.2	10.6	1.0	2.48
UU4043	2	.201	0.000		.34	83.3	.64	1.14	.070	.05	.0110	UU	35.4	31.0	27.2	1.2	2.48
UU4043	3	180.000	0.000		.04	90.3	.94	.72	.210	.00	.0032	UV	30.3	35.9	24.3	1.9	2.48
UU4044	1	-.067	0.000		7.30	2.7	6.83	7.82	.150	.07	.0028	WM	7.0	31.7	12.6	1.6	2.48
UU4044	2	.257	0.000		.92	83.4	.43	1.50	.125	.12	.0175	UU	35.0	31.4	26.4	1.4	2.48
UU4044	3	180.000	0.000		.02	90.2	.45	.50	.125	.21	.0001	UV	30.2	35.5	26.0	1.0	2.48
UU4045	1	.067	0.000		7.23	5.6	7.30	0.13	.100	.01	.0002	WM	5.6	31.3	8.7	.0	2.48
UU4045	2	.334	0.000		.26	81.1	.23	1.17	.115	.00	.0000	UU	34.1	31.3	27.2	.0	2.48
UU4045	3	130.000	0.000		.04	90.3	.42	.32	.009	.03	.0011	UV	30.3	37.0	23.1	.7	2.48
UU4046	1	-.067	0.000		7.87	6.2	7.52	8.21	.021	.03	.0001	WM	3.3	31.2	6.6	.07	2.48
UU4046	2	.401	0.000		.53	86.2	.12	.88	.000	.01	.0005	UU	35.0	31.6	26.4	.6	2.48
UU4046	3	180.000	0.000		-.10	90.9	.13	.22	.005	.11	.0002	UV	30.9	35.4	23.0	.6	2.48
UU4048	1	.067	0.000		7.82	2.3	7.80	0.22	.020	.01	.0002	WM	3.4	31.1	5.1	.2	2.48
UU4048	2	.535	0.000		.28	82.3	.13	.96	.020	.12	.0002	UU	35.4	31.7	21.4	.7	2.48
UU4048	3	130.000	0.000		.13	91.0	.39	.23	.000	.01	.0000	UV	21.0	35.3	23.5	.6	2.48
UU4060	1	-.134	0.000		6.61	1.2	6.46	7.18	.020	.00	.0005	WM	1.5	31.0	5.0	.0	2.48
UU4060	2	.000	0.000		.07	90.7	.53	.13	.020	.01	.0001	UU	29.1	31.3	24.9	.0	2.48
UU4060	3	0.000	0.000		.13	85.0	-.25	.45	.000	.01	.0002	UV	35.0	35.0	22.1	.0	2.48
UU4061	1	.134	0.000		6.70	2.0	6.50	7.22	.100	.03	.0005	WM	3.2	31.2	5.4	.0	2.48
UU4061	2	.067	0.000		.21	80.9	.23	.61	.103	.03	.0015	UU	33.2	31.0	21.8	.0	2.48
UU4061	3	180.000	0.000		.11	90.9	.40	.43	.106	.11	.0002	UV	30.9	35.4	24.0	.9	2.48
UU4062	1	-.134	0.000		6.26	3.0	6.12	7.17	.142	.03	.0005	WM	3.3	31.1	6.7	.0	2.48
UU4062	2	.134	0.000		.16	87.1	.10	.75	.020	.05	.0040	UU	37.1	31.7	20.3	.8	2.48
UU4062	3	100.000	0.000		.03	90.7	.50	.36	.112	.17	.0001	UV	30.7	37.0	24.1	1.0	2.48
UU4063	1	-.134	0.000		7.10	4.3	6.65	7.61	.146	.03	.0011	WM	4.4	31.4	7.4	.7	2.48
UU4063	2	.201	0.000		.53	85.9	.15	.92	.082	.05	.0011	UU	35.7	31.6	20.0	.0	2.48
UU4063	3	180.000	0.000		.07	90.6	.45	.35	.113	.15	.0003	UV	30.5	35.6	23.5	.0	2.48
UU4064	1	-.134	0.000		7.37	4.0	6.98	7.80	.112	.03	.0005	WM	4.3	31.1	8.4	.0	2.48
UU4064	2	.267	0.000		.62	85.8	.15	1.01	.100	.02	.0030	UU	35.3	31.0	20.9	.0	2.48
UU4064	3	180.000	0.000		-.04	90.8	-.49	.31	.027	.03	.0001	UV	30.8	35.6	23.0	.0	2.48
UU4065	1	.134	0.000		7.63	4.2	7.23	7.92	.027	.01	.0005	WM	4.2	31.5	8.7	.7	2.48
UU4065	2	.334	0.000		.56	85.0	.16	.95	.027	.01	.0011	UU	35.3	31.5	20.0	.0	2.48
UU4065	3	180.000	0.000		.04	90.4	.41	.34	.020	.02	.0005	UV	30.3	35.5	23.1	.7	2.48
UU4066	1	-.134	0.000		7.78	3.3	7.43	8.10	.023	.05	.0001	WM	3.3	31.6	6.0	.7	2.48
UU4066	2	.401	0.000		.43	83.8	.02	.90	.023	.04	.0004	UU	35.0	31.4	20.5	.7	2.48
UU4066	3	180.000	0.000		-.02	90.9	.43	.35	.027	.05	.0002	UV	30.9	35.1	23.5	.6	2.48
UU4068	1	.134	0.000		7.93	2.2	7.36	8.21	.024	.02	.0006	WM	3.3	31.0	5.2	.7	2.48
UU4068	2	.535	0.000		.28	82.9	.12	.92	.025	.12	.0002	UU	35.3	31.7	22.0	.7	2.48
UU4068	3	180.000	0.000		.12	90.8	.50	.25	.021	.00	.0004	UV	20.6	35.2	24.3	.7	2.48

TABLE 3.3-3. (contd)

FILE NAME	AXIS POSITION	LIMITS EXCEEDED (%)	TIME	VELOCITY INFORMATION						ANGLE INFORMATION					
				MEAN VEL.	ANGLE FROM	MIN. VEL.	MAX. VEL.	RMS VEL.	SKEW NESS	FLAT NESS	REYNOLDS STRESS	MEAN ANGLE	MIN. ANGLE	MAX. ANGLE	RMS ANGLE
UU1070	1	.257	0.000	7.25	1.0	6.85	7.65	.026	.00	2.74	UU	.0000	1.3	.0	4.2
UU1070	U	0.000	0.000	.08	90.0	.44	.44	.000	.01	3.03	UU	.0000	20.2	0.7	22.7
UU1070	U	0.000	0.000	.10	90.0	.31	.47	.007	.03	3.05	UU	.0000	22.2	32.1	22.5
UU4071	1	.257	0.000	7.30	1.0	6.94	7.70	.026	.00	2.80	UU	.0000	1.5	.0	4.5
UU4071	U	.000	0.000	.11	90.0	.23	.50	.023	.01	3.01	UU	.0000	20.2	0.6	21.8
UU4071	U	100.000	0.000	.09	90.0	.45	.50	.003	.00	3.03	UU	.0000	20.7	0.6	23.4
UU1072	1	.257	0.000	7.35	1.0	6.95	7.66	.022	.04	2.78	UU	.0001	1.3	.0	5.0
UU1072	U	.131	0.000	.21	90.0	.12	.29	.020	.00	3.20	UU	.0005	20.2	0.5	21.9
UU1072	U	130.000	0.000	.09	90.0	.40	.52	.021	.07	3.20	UU	.0001	20.7	0.5	23.5
UU4073	1	.257	0.000	7.35	1.0	6.98	7.70	.026	.05	2.79	UU	.0000	1.3	.1	5.7
UU1073	U	.201	0.000	.20	90.0	.10	.29	.020	.00	3.04	UU	.0005	20.2	0.5	21.4
UU4073	U	100.000	0.000	.07	90.0	.50	.50	.021	.00	3.00	UU	.0000	20.7	0.5	23.0
UU1074	1	.257	0.000	7.43	1.0	7.12	7.63	.026	.00	2.77	UU	.0005	2.4	.1	6.1
UU1074	U	.257	0.000	.30	90.0	.21	.30	.021	.01	3.01	UU	.0003	21.1	0.5	20.7
UU1074	U	100.000	0.000	.07	90.0	.44	.54	.020	.07	3.03	UU	.0003	20.5	0.3	23.3
UU4075	1	.257	0.000	7.50	1.0	7.21	7.72	.025	.00	2.85	UU	.0001	2.4	.0	5.0
UU4075	U	.334	0.000	.30	90.0	.02	.30	.020	.00	3.26	UU	.0000	23.7	0.5	20.7
UU4075	U	100.000	0.000	.07	90.0	.42	.56	.020	.00	3.00	UU	.0001	20.7	0.3	20.7
UU1076	1	.257	0.000	7.65	1.0	7.26	7.77	.021	.04	2.70	UU	.0001	2.3	.1	6.0
UU4076	U	.401	0.000	.25	90.0	.14	.35	.020	.00	3.00	UU	.0005	23.3	0.5	21.0
UU4076	U	100.000	0.000	.09	90.0	.43	.50	.020	.03	3.02	UU	.0000	20.6	0.3	23.1
UU4078	1	.257	0.000	7.65	1.0	7.26	7.66	.020	.00	3.02	UU	.0005	1.3	.0	4.7
UU1078	U	.535	0.000	.20	90.0	.13	.33	.020	.11	3.12	UU	.0005	20.5	0.5	21.7
UU4078	U	100.000	0.000	.09	90.0	.44	.50	.020	.04	3.07	UU	.0000	20.6	0.5	23.7

APPENDIX A

COORDINATE TRANSFORMATIONS

APPENDIX A

COORDINATE TRANSFORMATIONS

The reduction algorithm for the TSI model 1294 probe calculates the velocity components along the sensor coordinate system. To find the values of the velocity components in the tunnel coordinate system, several intermediate transformations must be made. Figure A.1 details the different coordinate systems that will be discussed here.

Consider the general derivation of the transformation tensor that relates the magnitudes of vector quantities (u_j) in the "unprimed" Cartesian coordinate system to the magnitudes (u_j''') resolved in a "triple-primed" system. To transform from the unprimed system to the triple-primed system, three intermediate transformations must be made. The first transformation is a rotation of α_1 degrees about the x_1 axis. The second transformation is a rotation of α_2 degrees about the new x_2' axis. The third transformation is a rotation of α_3 degrees about the x_3'' axis.^(a) These transformations can be stated mathematically as

(1) For α_1 rotation

$$u_k' = c_{km} u_m, \text{ where } c_{km} =$$

k =	m =		
	1	2	3
1	1	0	0
2	0	$\cos \alpha_1$	$\sin \alpha_1$
3	0	$-\sin \alpha_1$	$\cos \alpha_1$

(2) For α_2 rotation

$$u_j'' = b_{jk} u_k', \text{ where } b_{jk} =$$

j =	k =		
	1	2	3
1	$\cos \alpha_2$	0	$-\sin \alpha_2$
2	0	1	0
3	$\sin \alpha_2$	0	$\cos \alpha_2$

-
- (a) The sense of the angular rotations is defined as follows: looking from the positive to negative direction along the axis in question a positive angle requires the counterclockwise rotation of the other two axes.

FIGURE A.1. Sensor, Probe, and Tunnel Coordinate Systems

(3) For α_3 rotation

$$u_k''' = a_{ij}u_j'', \text{ where } a_{ij} = \begin{array}{c|ccc} & j = 1 & 2 & 3 \\ \hline i = 1 & \cos\alpha_3 & \sin\alpha_3 & 0 \\ 2 & -\sin\alpha_3 & \cos\alpha_3 & 0 \\ 3 & 0 & 0 & 1 \end{array}$$

The components of the intermediate transformation tensors (c_{km} , b_{jk} , and a_{ij}) may be obtained from inspection. For example, c_{km} is the cosine of the angle between the k th primed and the m th unprimed coordinate axis, i.e., $c_{km} = \cos(x_k', x_m)$.

Grouping the three transformations into one completes the general derivation of the vector component relationships between the unprimed and the triple-primed systems.

$$u_i''' = a_{ij}b_{jk}c_{km}u_m = A_{im}u_m$$

$$\text{where } A_{im} = \begin{bmatrix} \cos\alpha_2\cos\alpha_3 & \cos\alpha_1\sin\alpha_3 + \sin\alpha_1\sin\alpha_2\cos\alpha_3 & \sin\alpha_1\sin\alpha_3 - \cos\alpha_1\sin\alpha_2\cos\alpha_3 \\ -\cos\alpha_2\sin\alpha_3 & \cos\alpha_1\cos\alpha_3 - \sin\alpha_1\sin\alpha_2\sin\alpha_3 & \sin\alpha_1\cos\alpha_3 + \cos\alpha_1\sin\alpha_2\sin\alpha_3 \\ \sin\alpha_2 & -\sin\alpha_1\cos\alpha_2 & \cos\alpha_1\cos\alpha_2 \end{bmatrix}$$

It should be noted that the transpose of $A_{im} = A_{im}^T = A_{mi}$ can be used to transform vector components in the triple-primed system to those in the unprimed system, i.e., $u_j = A_{mi}u_i'''$.

The geometric relationship between the sensor coordinates and the probe coordinates is always fixed, but the relationship between the probe coordinates and the wind-tunnel coordinate also needs to be formalized before an overall transformation from sensor coordinates to wind-tunnel coordinates can be stipulated. During physical placement of the probe within the wind tunnel, one starts with the probe coordinates aligned with the wind-tunnel coordinates. The probe and thus the probe coordinate system is first rotated γ_3 degrees about the x_3^{**} axis, then γ_2 degrees about the new x_2^{**} axis, and then γ_1

degrees about the new x_1^* axis. After these rotations of the probe by its supporting mechanism are completed, the probe is in position to take data.(a)

To find the coordinate transformations that are necessary to convert vector components in the sensor system (unprimed) coordinates to the probe system (triple-primed) coordinates, consider the reverse transform, i.e., probe system to sensors. It is seen in Figure A.1 that a rotation sequence of $\alpha_1 = 0$, $\alpha_2 = 35.26$, and $\alpha_3 = -45.0$ will achieve the desired orientation. This transform can be written as

$$u_i = A_{ij}u_j'''$$

where A_{ij} is calculated from the general derivation given previously. We are more interested in the reverse transform, i.e., sensor to probe. This is found by taking the transpose of tensor A_{ij} above, i.e.,

$$u_i''' = A_{ij}^T u_j = A_{ji} u_j$$

Inserting $\alpha_1 = 0$, $\alpha_2 = 35.26$, and $\alpha_3 = -45.0$ into the equations for the components of A_{ji} , one finds that the transformation tensor for conversion of velocity components in the sensor system to velocity components in the probe system is

$$A_{ji} = \begin{bmatrix} 1/\sqrt{3} & 1/\sqrt{3} & 1/\sqrt{3} \\ -1/\sqrt{2} & 1/\sqrt{2} & 0 \\ -1/\sqrt{6} & -1/\sqrt{6} & 2/\sqrt{6} \end{bmatrix}$$

-
- (a) The reason for aligning the probe away from the tunnel coordinates is that the probe's x_1 axis should be in approximate alignment with the expected mean velocity vector. This will increase the accuracy of the measurement. For low-to-moderate turbulence levels it insures that the velocity vector never leaves the sensor coordinate system octant in which measurements are possible.

To convert the velocity components resolved in the probe coordinate system to those of the wind-tunnel system one must reverse the rotational order that was used during the physical placement of the probe.

$$u_k^* = c_{km} u_m^{''' } \quad \text{then} \quad u_j^{**} = b_{jk} u_k^* \quad \text{then} \\ u_i^{***} = a_{ij} u_j^{**} \quad \Rightarrow \quad u_i^{***} = B_{im} u_m^{''' }$$

where the angles α_1 , α_2 , α_3 that make up the general transformation tensor are now defined as $-\gamma_1$, $-\gamma_2$, and $-\gamma_3$, respectively.

Combining the two transformation tensors derived above, one for sensor to probe conversion and the other for probe to tunnel conversion, into one overall transformation tensor for sensor to tunnel system conversion yields (note that the indices have been changed for convenience)

$$u_j^{''' } = A_{ji} u_i \quad \text{and} \quad u_k^{***} = B_{kj} u_j^{''' } \\ u_k^{***} = B_{kj} A_{ji} u_i = C_{ki} u_i$$

where

$u_k^{***} \equiv$ velocity components in the tunnel coordinate system

$u_i \equiv$ velocity components in the sensor coordinate system

$B_{kj} \equiv$ general transformation tensor with $\alpha_1 = -\gamma_1$, $\alpha_2 = -\gamma_2$, $\alpha_3 = -\gamma_3$

$A_{ji} \equiv$ transpose of the general transformation tensor with $\alpha_1 = 0$,
 $\alpha_2 = 35.26$, $\alpha_3 = -45$.

Since the elements of C_{ki} are the cosine of the angle between the i th sensor coordinate and the k th tunnel coordinate, the yaw angles in calibration mode are easily calculated as

$$\phi_i = 90.0 - \arccos C_{1i} = \arcsin C_{1i}.$$

To convert from the rectangular tunnel coordinates to an axisymmetric tunnel coordinate system it is only necessary to rotate the rectangular system

about the x_1 axis so that the measurement location is contained within the $x_1 - x_2$ plane. This angle of rotation is given by the following conditional statements:

1. if $x_2 = 0$ and $x_3 = 0$ then $\beta = 0$
2. if $x_2 = 0$ and $x_3 > 0$ then $\beta = 90.0$
3. if $x_2 = 0$ and $x_3 < 0$ then $\beta = -90.0$
4. if $x_2 < 0$ then $\beta = \arctan (x_3/x_2) + 180.0$
5. if $x_2 > 0$ then $\beta = \arctan (x_3/x_2).$

The transformation can be summarized as

$$u_m^o = d_{mk} u_k^{***} = d_{mk} C_{ki} u_i = O_{mi} u_i$$

where

$u_k^o \equiv$ velocity components in the axisymmetric tunnel system, and
 $d_{mk} \equiv$ general transformation tensor with $a_1 = \beta$, $a_2 = 0$, $a_3 = 0$.

APPENDIX B

COMPUTER PROGRAMS

```

0001 FTN1=L
0002 PROGRAM CALIB(Z=70)
0003 C++CALIBRATED TSI 1200 2D PROBE
0004 COMMON A(3),B(3),C(3),FK(3),TEMP,PRES,UMIN,UMAX,ANCRN(3),ANCMX(3),
0005 : SUP(3),AMP(3)
0006 DIMENSION IPAR(5)=ICH(3),ANG(3)
0007 CALL RMPAR(IPAR)
0008 LU=IPAR(1)
0009 IF(LU.LT.1)LU=1
0010 CALL LIBER(LU)
0011 WRITE(LU,100)
0012 READ(LU,*)ICH(1),TEMP,PRES
0013 ICH(2)=ICH(1)+1
0014 ICH(3)=ICH(1)+2
0015 WRITE(LU,102)(ICH(I),I=1,3)
0016 READ(LU,*)(SUP(I),I=1,3)
0017 WRITE(LU,104)(ICH(I),I=1,3)
0018 READ(LU,*)(AMP(I),I=1,3)
0019 WRITE(LU,110)
0020 IF(NOYES(LU))2,1,3
0021 1 CONTINUE
0022 WRITE(LU,120)(ICH(I),I=1,3)
0023 READ(LU,*)(FK(I),I=1,3)
0024 WRITE(LU,130)
0025 READ(LU,*)(ANG(I),I=1,3)
0026 CALL CLVEL(0,ICH,ANG,LU)
0027 GO TO 3
0028 2 CONTINUE
0029 CALL CLVEL(1,ICH,ANG,LU)
0030 WRITE(LU,140)
0031 READ(LU,*)DEL F
0032 U=1.75*SQRT((TEMP-273.)*DEL F/PRES)
0033 CALL CLANG(ICH,U,LU)
0034 CONTINUE
0035 WRITE(LU,150)
0036 IF(NOYES(LU))0,0,7
0037 1 CONTINUE
0038 CALL WRCAL(LU)
0039 CONTINUE
0040 WRITE(LU,100)
0041 100 FORMAT('ENTER CHAN. 1, TEMP,(C), PRESSURE(IN HG) ')
0042 102 FORMAT('ENTER SUPPRESSION FOR CHANG. *I2*,*I2*,*I2* ')
0043 104 FORMAT('ENTER AMPLIFICATION FOR CHANG. *I2*,*I2*,*I2* ')
0044 110 FORMAT('DETERMINE YAW FACTOR F ')
0045 120 FORMAT('ENTER YAW FACTOR K FOR CHANG. *I2*,*I2*,*I2* ')
0046 130 FORMAT('ENTER ANGLES OF ROTATION ABOUT X,Y,Z AXIS ')
0047 140 FORMAT('ENTER PRESSURE FOR ANGLE CALIBRATION ')
0048 150 FORMAT('WICH TO WRITE TO CAL. FILE ')
0049 160 FORMAT('RUN COMPLETE')
0050 END

```

```

0051 C*****
0052 SUBROUTINE CLVEL(IOP,ICH,ANG,LU)
0053 COMMON A(3),B(3),C(3),FK(3),TEMP,PRES,UMIN,UMAX,ANGMN(3),ANGMX(3),
0054 SUP(3),AMP(3)
0055 DIMENSION ICH(3),ANG(3),VANG(3),U(25),E(25,3),EMN(3),ERMS(3)
0056 CALL FANG(ANG,VANG)
0057 WRITE(LU,100)(ICH(I),I=1,3)
0058 N=0
0059 UMIN=1.0E10
0060 UMAX=-1.0E10
0061 10 CONTINUE
0062 N=N+1
0063 WRITE(LU,110)
0064 READ(LU,*)DEL P
0065 IF(DEL P.EQ.0.0)GO TO 20
0066 N=N-2
0067 GO TO 10
0068 20 CONTINUE
0069 IF(N.EQ.1)GO TO 25
0070 UMIN=AMIN1(UMIN,U(N-1))
0071 UMAX=AMAX1(UMAX,U(N-1))
0072 25 CONTINUE
0073 IF(DEL P.EQ.0.0)GO TO 40
0074 U(N)=4.75*SQRT((TEMP+273.)*DEL P/PRES)
0075 CALL DATIN(ICH,EMN,ERMS,LU)
0076 DO 30 I=1,3
0077 E(N,I)=EMN(I)/AMP(I)*SUP(I)
0078 30 CONTINUE
0079 WRITE(LU,120)(EMN(I),ERMS(I),I=1,3),U(N)
0080 GO TO 10
0081 40 CONTINUE
0082 N=N-1
0083 DO 50 I=1,3
0084 Z=VANG(I)*3.14159/180.
0085 WRITE(LU,130)ICH(I),VANG(I)
0086 READ(LU,*)C(I)
0087 WRITE(LU,140)
0088 AFAC=1.0
0089 IF(IOP.EQ.0)AFAC=SQRT(COS(Z)**2*(FK(I)*SIN(Z))**2)
0090 CALL FTVEL(LU,E(1,I),U,N,AFAC,A(I),B(I),C(I))
0091 CALL OUTVL(LU,E(1,I),U,N,AFAC,A(I),B(I),C(I))
0092 50 CONTINUE
0093 RETURN
0094 100 FORMAT('ZERO PRESSURE WILL EXIT LOOP.')
0095 'NEG. PRESSURE WILL DELETE PREVIOUS ENTRY.'
0096 'CHANNEL NO. =15X,12,2(12X,12)/
0097 24X,3('MEAN RMS'X)'SPEED (M/S)')
0098 110 FORMAT('PRESSURE (MM HG)-? -')
0099 120 FORMAT(24X,6(F5.3,2X)F6.3)
0100 130 FORMAT('*****VELOCITY CURVE FIT RESULTS FOR CHANNEL *12* YAW='
0101 F5.1' *****'ENTER ESTIMATE FOR VEL. EXP. C -')
0102 140 FORMAT(7X'C'12X'A'12X'B'11X'F(C)'10X'E RMS'10X'U RMS')
0103 END

```



```

0104 C*****
0105 SUBROUTINE FTVEL(LU,E,U,N,AFAC,A,B,C)
0106 DIMENSION E(N),U(N)
0107 DELT=0.05
0108 SVDEL=DELT
0109 1 CONTINUE
0110 DO 30 I=1,N
0111 ZEST=F OF C(E,U,N,AFAC,C,A,B)
0112 SUM1=0.0
0113 SUM2=0.0
0114 SUM3=0.0
0115 DO 10 K=1,N
0116 SUM1=SUM1+(E(K)*E(K)-A-B*(AFAC*U(K))**C)**2
0117 ROOT=A+B*(AFAC*U(K))**C
0118 IF(ROOT.LT.0.)ROOT=1.E30
0119 SUM2=SUM2+(E(K)-SQRT(ROOT))**2
0120 ROOT=(E(K)*E(K)-A)/B
0121 IF(ROOT.LT.0.)ROOT=1.E30
0122 SUM3=SUM3+(U(K)-ROOT**((1./C)/AFAC))**2
0123 10 CONTINUE
0124 DEV1=SQRT(SUM1/FLOAT(N))
0125 DEV2=SQRT(SUM2/FLOAT(N))
0126 DEV3=SQRT(SUM3/FLOAT(N))
0127 WRITE(LU,110)C,A,B,ZEST,DEV2,DEV3
0128 IF(I.EQ.1)GO TO 20
0129 DELT=-ZEST*SBELT/(ZEST-SZEST)
0130 ADEL=ABS(DELT)
0131 IF(ADDEL.LT.0.001)GO TO 40
0132 IF(ADDEL.GT.SVDEL)DELT=SVDEL*DELT/ADDEL
0133 20 CONTINUE
0134 C=C+DELT
0135 SZEST=ZEST
0136 SBELT=DELT
0137 30 CONTINUE
0138 40 CONTINUE
0139 WRITE(LU,120)
0140 IF(NDYES(LU))60,40,50
0141 50 CONTINUE
0142 WRITE(LU,130)
0143 READ(LU,*)C
0144 GO TO 1
0145 60 CONTINUE
0146 RETURN
0147 110 FORMAT(2(X,F10.5))
0148 120 FORMAT('WISH TO ENTER NEW ESTIMATE FOR C ? -')
0149 130 FORMAT('ENTER ESTIMATE FOR VEL. EXP. C -')
0150 END

0151 C*****
0152 FUNCTION F OF C(E,U,N,AFAC,C,A,B)
0153 DIMENSION E(N),U(N)
0154 FN=FLOAT(N)
0155 T1=0.0
0156 T2=0.0
0157 T3=0.0
0158 T4=0.0
0159 DO 1 I=1,N
0160 U1=(U(I)*AFAC)**C
0161 T1=T1+E(I)*E(I)
0162 T2=T2+U1
0163 T3=T3+E(I)*E(I)*U1
0164 T4=T4+U1**U1
0165 1 CONTINUE
0166 B=(T1*T2/FN-T3)/(T2*T2/FN-T4)
0167 A=(T1-B*T2)/FN
0168 T5=0.0
0169 DO 2 I=1,N
0170 U1=U(I)*AFAC
0171 T5=T5+(U1**C)*ALOG(U1)*(E(I)*E(I)-A-B*U1**C)
0172 2 CONTINUE
0173 F OF C=T5
0174 RETURN
0175 END

```

```

0176 C*****
0177 SUBROUTINE OUTVL(LU,E,U,N,AFAC,A,B,C)
0178 DIMENSION E(N),U(N)
0179 WRITE(LU,100)
0180 DO 10 I=1,N
0181     UCAL=((E(I)*E(I)-A)/B)**(1.0/C)/AFAC
0182     ERR=(UCAL-U(I))*100.0/U(I)
0183     WRITE(LU,110)E(I),U(I),UCAL,ERR
0184 10 CONTINUE
0185 RETURN
0186 100 FORMAT('VOLTAGE VELOCITY VELOCITY ERROR'/
0187 + 11X'ACTUAL CALCULATED (%)'/' )
0188 110 FORMAT(F7.3,3X,F7.2,5X,F7.2,2X,F5.1)
0189 END

```

```

0190 C*****
0191 SUBROUTINE CLANG(ICH,U,LU)
0192 COMMON A(3),B(3),C(3),FK(3),TEMP,PRES,UMIN,UMAX,ANGMN(3),ANGMX(3),
0193 + SUP(3),AMP(3)
0194 DIMENSION ICH(3),VANG(25,3),E(25,3),ERMS(3),EMN(3),ANG(3),VANG1(3)
0195 WRITE(LU,100)(ICH(I),I=1,3)
0196 N=0
0197 DO 10 I=1,3
0198     ANGMN(I)=360.0
0199     ANGMX(I)=-360.0
0200 10 CONTINUE
0201 20 CONTINUE
0202     N=N+1
0203     WRITE(LU,110)
0204     READ(LU,*) (ANG(I),I=1,3)
0205     IF(ANG(1).LE.360.0) GO TO 30
0206     N=N-2
0207     GO TO 20
0208 30 CONTINUE
0209     IF(N.EQ.1) GO TO 45
0210     DO 40 I=1,3
0211         ANGMN(I)=AMIN1(ANGMN(I),VANG(N,1,I))
0212         ANGMX(I)=AMAX1(ANGMX(I),VANG(N,1,I))
0213 40 CONTINUE
0214 45 CONTINUE
0215     IF(ANG(1).EQ.360.0) GO TO 70
0216     CALL FANG(ANG,VANG1)
0217     DO 50 I=1,3
0218         VANG(N,I)=VANG1(I)
0219 50 CONTINUE
0220     CALL DATIN(ICH,EMN,ERMS,LU)
0221     DO 60 I=1,3
0222         E(N,I)=EMN(I)/AMP(I)+SUP(I)
0223 60 CONTINUE
0224     WRITE(LU,120)(VANG1(I),I=1,3),(EMN(I),ERMS(I),I=1,3)
0225     GO TO 20
0226 70 CONTINUE
0227     N=N-1
0228     DO 80 I=1,3
0229         WRITE(LU,130) ICH(I),U
0230         READ(LU,*) FK(I)
0231         WRITE(LU,140)
0232         CALL FTANG(LU,E(1,I),VANG(1,I),N,U,A(I),C(I),B(I),FK(I))
0233         CALL OUTAG(LU,E(1,I),VANG(1,I),N,U,A(I),B(I),C(I),FK(I))
0234 80 CONTINUE
0235 81 WRITE(LU,150)
0236     IF(NYES(LU)) 90,81,82
0237 82 CONTINUE
0238     WRITE(LU,160)
0239     READ(LU,*) FK(1)
0240     WRITE(LU,170)
0241     DO 85 I=1,3
0242         FK(I)=FK(1)
0243         ZEST=F OF K(E(1,I),VANG(1,I),N,U,A(I),C(I),FK(I),B(I))
0244         WRITE(LU,180) A(I),B(I),C(I),FK(I),ZEST
0245 85 CONTINUE
0246 86 WRITE(LU,190)
0247     IF(NYES(LU)) 82,86,90
0248 90 CONTINUE
0249     RETURN
0250 100 FORMAT(/'ANGLE = 360.0 WILL EXIT LOOP'//
0251 + 'ANGLE > 360.0 WILL DELETE PREVIOUS ENTRY'//
0252 + 'CHANNEL NO. = '25X,I2,2(12X,I2)//
0253 + '34X,3('MEAN RMS'1X))
0254 110 FORMAT('ROT. ANGLES(3)-? ')
0255 120 FORMAT('YAW='3(F5.1',',12X,4(F5.3,2X))
0256 130 FORMAT(/'*****ANGLE CURVE FIT RESULTS FOR CHANNEL 'I2
0257 + ' VELOCITY= 'F6.2' *****'//
0258 + 'ENTER ESTIMATE FOR YAW FACTOR K - ')
0259 140 FORMAT(7X'K'12X'B'11X'F(C)'11X'RMS'10X'E RMS'6X'(' RMS')
0260 150 FORMAT('WISH TO FORCE EQUALITY OF 'K' FOR ALL 3 CHANG. ')
0261 160 FORMAT('ENTER DESIRED 'K' ')
0262 170 FORMAT(/4X'A'9X'B'9X'C'9X'K'7X'F(C)')
0263 180 FORMAT(4(F8.3,2X),F8.5)
0264 190 FORMAT('ARE VALUES OK - ')
0265 END

```

```

0266 C*****
0267 SUBROUTINE FTANG(LU,E,ANG,N,U,A,C,B,FK)
0268 DIMENSION E(N),ANG(N)
0269 CONST=3.14159/180.
0270 DELT=0.02
0271 SVDEL=DELT
0272 1 CONTINUE
0273 DO 30 I=1,35
0274 ZEST=F OF K(E,ANG,N,U,A,C,B,FK)
0275 SUM1=0.0
0276 SUM2=0.0
0277 SUM3=0.0
0278 DO 10 K=1,N
0279 Z=ANG(K)*CONST
0280 Y=(E(K)*E(K)-A)/U**C
0281 X=SQRT(COS(Z)**2+(FK*SIN(Z))**2)
0282 SUM1=SUM1+(Y-B**X**C)**2
0283 ROOT=B*(U*X)**C+A
0284 IF(ROOT.LT.0.)ROOT=1.E30
0285 SUM2=SUM2+(E(K)-SQRT(ROOT))**2
0286 ROOT=(E(K)*E(K)-A)/B
0287 IF(ROOT.LT.0.)GO TO 5
0288 UEFF=ROOT**(1./C)
0289 IF(UEFF.GT.U)GO TO 5
0290 ARG=SQRT((1.-(UEFF/U)**2)/(1.-FK*FK))
0291 ANGLE=ATAN(ARG/SQRT(1.-ARG*ARG))
0292 SUM3=SUM3+(Z-ANGLE)**2
0293 GO TO 10
0294 5 CONTINUE
0295 SUM3=1.E30
0296 10 CONTINUE
0297 DEV1=SQRT(SUM1/FLOAT(N))
0298 DEV2=SQRT(SUM2/FLOAT(N))
0299 DEV3=SQRT(SUM3/FLOAT(N))/CONST
0300 WRITE(LU,110)FK,B,ZEST,DEV1,DEV2,DEV3
0301 IF(I.EQ.1)GO TO 20
0302 DELT=-ZEST*SVDEL/(ZEST-SZEST)
0303 ADEL=ABS(DELT)
0304 IF(ADEL.LT.0.0002)GO TO 40
0305 IF(ADEL.GT.SVDEL)DELT=SVDEL*DELT/ADEL
0306 20 CONTINUE
0307 FK=FK+DELT
0308 SZEST=ZEST
0309 SVDEL=DELT
0310 30 CONTINUE
0311 40 CONTINUE
0312 WRITE(LU,120)
0313 IF(NOMES(LU))60,40,50
0314 50 CONTINUE
0315 WRITE(LU,130)
0316 READ(LU,*)FK
0317 GO TO 1
0318 40 CONTINUE
0319 RETURN
0320 110 FORMAT(6(3X,F10.5))
0321 120 FORMAT('WISH TO ENTER NEW ESTIMATE FOR K - ?')
0322 130 FORMAT('ENTER ESTIMATE FOR YAW FACTOR K - ?')
0323 END

```

```

0324 C*****
0325 FUNCTION F OF K(E,ANG,N,U,A,C,FK,B)
0326 DIMENSION E(N),ANG(N)
0327 T1=0.0
0328 T2=0.0
0329 T3=0.0
0330 T4=0.0
0331 DO 1 I=1,N
0332 Z=ANG(I)*3.14159/180.
0333 Y=(E(I)*E(I)-A)/U*C
0334 X=COS(Z)*COS(Z)+FK*FK*SIN(Z)*SIN(Z)
0335 T1=T1+Y*X**(C/2.0)
0336 T2=T2+X**C
0337 T3=T3+SIN(Z)*SIN(Z)*X**(C-1.0)
0338 T4=T4+Y*SIN(Z)*SIN(Z)*X**(C/2.0 1)
0339 1 CONTINUE
0340 B=T1/T2
0341 F OF K=B*T3-T4
0342 RETURN
0343 END

```

```

0344 C*****
0345 SUBROUTINE OUTAG(LU,E,VANG,N,U,A,B,C,FK)
0346 DIMENSION E(N),VANG(N)
0347 CONST=180.0/3.14159
0348 WRITE(LU,100)
0349 DO 10 I=1,N
0350   ROOT=(E(I)*E(I)-A)/B
0351   IF(ROOT.LT.0.)ROOT=1.E30
0352   UEFF=ROOT**(.10/C)
0353   IF(UEFF.LE.U)GO TO 1
0354   ANG=1.E30
0355   ERR=1.E30
0356   GO TO 5
0357 1   CONTINUE
0358   ARG=SQRT((1.0-(UEFF/U)**2)/(1.0-FK*FK))
0359   ANG=ATAN(ARG/SQRT(1.0-ARG*ARG))*CONST
0360   ERR=ANG-VANG(I)
0361 5   CONTINUE
0362   WRITE(LU,110)E(I),VANG(I),ANG,ERR
0363 10  CONTINUE
0364   RETURN
0365 100  FORMAT('VOLTAGE      ANGLE      ANGLE      ERROR'/
0366 +        '11X*ACTUAL    CALCULATED (DEG)')
0367 110  FORMAT(F7.3,3X,F7.2,5X,F7.2,2X,F5.1)
0368   END

0369 C*****
0370 SUBROUTINE FANG(ANG,VANG)
0371 DIMENSION ANG(3),VANG(3),A(3,3),B(3,3)
0372 CONST=3.14159/180.0
0373 X=0.0*CONST
0374 Y=35.26*CONST
0375 Z=-45.0*CONST
0376 CALL TRXYZ(A,X,Y,Z)
0377 X=ANG(1)*CONST
0378 Y=ANG(2)*CONST
0379 Z=ANG(3)*CONST
0380 CALL TRXYZ(B,X,Y,Z)
0381 C.....NOTE THAT THE TRANSPOSE OF 'A'
0382 C      IS USED IN THE FOLLOWING MATRICE
0383 C      MULT. TO CHANGE THE DIRECTION
0384 C      OF THE TRANSFORMATION THAT FORMED
0385 C      'A'.
0386
0387 DO 2 J=1,3
0388   SUM=0.0
0389   DO 1 I=1,3
0390     SUM=SUM+B(1,I)*A(J,I)
0391 1   CONTINUE
0392   VANG(J)=ATAN(SUM/SQRT(1.0-SUM*SUM))/CONST
0393 2   CONTINUE
0394   RETURN
0395   END

0395 C*****
0396 SUBROUTINE TRXYZ(A,X,Y,Z)
0397 DIMENSION A(3,3)
0398 A(1,1)=COS(Y)*COS(Z)
0399 A(1,2)=COS(X)*SIN(Z)+SIN(X)*SIN(Y)*COS(Z)
0400 A(1,3)=SIN(X)*SIN(Z)-COS(X)*SIN(Y)*COS(Z)
0401 A(2,1)=-COS(Y)*SIN(Z)
0402 A(2,2)=-SIN(X)*SIN(Y)*SIN(Z)+COS(X)*COS(Z)
0403 A(2,3)=SIN(X)*COS(Z)+COS(X)*SIN(Y)*SIN(Z)
0404 A(3,1)=SIN(Y)
0405 A(3,2)=-SIN(X)*COS(Y)
0406 A(3,3)=COS(X)*COS(Y)
0407 RETURN
0408 END

```

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0409 C*****
0410 SUBROUTINE DATIN(ICH,E,RMS,LU)
0411 DIMENSION NAMF(3),ISIZE(2),IPAR(5),IDCB(144),NAMF(5),ICH(3),
0412 + E(3),RMS(3)
0413 DATA NAMF,NAMF /2HDA,2HTA,2H ,2HSC,2HRA,2HTC,2HDX,16/
0414 IF(LU.NE.1.AND.LU.NE.26)CALL NAMIT(LU,NAMF)
0415 IRATE=100
0416 NSAM=256
0417 ISIZE(1)=(NSAM/128)*3+1
0418 CALL PURGE(IDCB,IERR,NAMF,NAMF(4),NAMF(5))
0419 CALL CREAT(IDCB,IERR,NAMF,ISIZE,1,NAMF(4),NAMF(5))
0420 IF(IERR.LT.0)GO TO 1000
0421 CALL CLOSE(IDCB)
0422 CALL OPEN(IDCB,IERR,NAMF,1,NAMF(4),NAMF(5))
0423 IF(IERR.LT.0)GO TO 1000
0424 CALL EXEC(23,NAMF,ICH(1),ICH(3),IRATE,NSAM,0,NAMF,5)
0425 CALL RMPAR(IPAR)
0426 IF(IPAR(1).LT.0)GO TO 1010
0427 WRITE(LU,100)
0428 CALL POSNT(IDCB,IERR,1,1)
0429 IF(IERR.LT.0)GO TO 1000
0430 CALL VOLTS(IDCB,E,RMS,LU)
0431 CALL CLOSE(IDCB)
0432 CALL PURGE(IDCB,IERR,NAMF,NAMF(4),NAMF(5))
0433 RETURN
0434 1000 CONTINUE
0435 WRITE(LU,110)IERR
0436 GO TO 1020
0437 1010 CONTINUE
0438 WRITE(LU,120)IPAR(1)
0439 1020 CONTINUE
0440 CALL CLOSE(IDCB)
0441 CALL PURGE(IDCB,IERR,NAMF,NAMF(4),NAMF(5))
0442 WRITE(LU,130)
0443 STOP
0444 100 FORMAT(' ')
0445 110 FORMAT('FILE MANAGER ERROR '13' IN SUBROUTINE DATIN')
0446 120 FORMAT('DATA PROGRAM ERROR NO. '13' SEE DATA PROGRAM ERROR CODE')
0447 130 FORMAT('RUN COMPLETE')
0448 END

0449 C*****
0450 SUBROUTINE VOLTS(IDCB,E,RMS,LU)
0451 DIMENSION IDCB(144),IBUF(768),E(3),RMS(3),SUM(3)
0452 CALL READF(IDCB,IERR,IBUF,768)
0453 IF(IERR.LT.0)GO TO 1000
0454 DO 1 I=1,3
0455 SUM(I)=0.0
0456 1 CONTINUE
0457 DO 3 I=1,768,3
0458 DO 2 J=1,3
0459 SUM(J)=SUM(J)+FLOAT(IBUF(I+J-1))
0460 2 CONTINUE
0461 3 CONTINUE
0462 DO 4 I=1,3
0463 E(I)=SUM(I)/256.0
0464 4 CONTINUE
0465 DO 5 I=1,3
0466 SUM(I)=0.0
0467 5 CONTINUE
0468 DO 7 I=1,768,3
0469 DO 6 J=1,3
0470 X=FLOAT(IBUF(I+J-1))
0471 SUM(J)=SUM(J)+(X-E(J))*(X-E(J))
0472 6 CONTINUE
0473 7 CONTINUE
0474 DO 8 I=1,3
0475 RMS(I)=SQRT(SUM(I)/256.0)/3275.2
0476 E(I)=E(I)/3275.2
0477 8 CONTINUE
0478 RETURN
0479 1000 CONTINUE
0480 WRITE(LU,100)IERR
0481 STOP
0482 100 FORMAT('FMGR ERROR '15' IN VOLTS')
0483 END

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0484 C*****
0485 SUBROUTINE WRCAL(LU)
0486 COMMON A(3),B(3),C(3),FK(3),TEMP,PRES,UMIN,UMAX,ANGHN(3),ANGHX(3),
0487 + SUP(3),AMP(3)
0488 DIMENSION IDCB(144),IBUF(18),CAL(9),NAM(5),ISIZ(2)
0489 EQUIVALENCE (IBUF(1),CAL(1))
0490 DATA NAM,ISIZ /2HVE,2HLC,2HAL,2HDN,16,1,18/
0491 CALL CREAT(IDCB,IERR,NAM,ISIZ,2,NAM(4),NAM(5))
0492 IF(IERR.GE.0)GO TO 1
0493 IF(IERR.NE.-2)GO TO 1000
0494 CALL OPEN(IDCB,IERR,NAM,0,NAM(4),NAM(5))
0495 IF(IERR.LT.0)GO TO 1000
0496 1 CONTINUE
0497 DO 2 I=1,3
0498 CAL(1)=A(I)
0499 CAL(2)=B(I)
0500 CAL(3)=C(I)
0501 CAL(4)=FK(I)
0502 CAL(5)=TEMP
0503 CAL(6)=UMIN
0504 CAL(7)=UMAX
0505 CAL(8)=SUP(I)
0506 CAL(9)=AMP(I)
0507 CALL WRITE(IDCB,IERR,IBUF,18)
0508 IF(IERR.LT.0)GO TO 1000
0509 2 CONTINUE
0510 CALL CLOSE(IDCB)
0511 RETURN
0512 1000 CONTINUE
0513 WRITE(LU,100)IERR
0514 STOP
0515 100 FORMAT('FMGR ERROR 'I5' IN WRCAL')
0516 END

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0001      FTN4,L
0002      PROGRAM DAT3D(3,00)
0003      C
0004      C**DESIGNED TO BE USED WITH THE TSI 1221 3D HOT FILM PROBE.
0005      C**IT USES THE REDUCTION TECHNIQUES DESCRIBED IN TSI TR C TO OBTAIN
0006      C**THE U,V,W TIME SERIES.
0007      C
0008      COMMON /WK/ IPAR(5)
0009      DIMENSION POS(4),A(3,3)
0010      CALL RMPAR(IPAR)
0011      LU=IPAR(1)
0012      IF(LU.LT.1)LU=1
0013      CALL LIBR(LU)
0014      CALL INPUT(IFST,IRATE,NSAM,NSEG,SL,IAXIS,LU)
0015      1      CONTINUE
0016      CALL FILES(NSAM,NSEG,LU)
0017      CALL SETUP(POS,A,IAXIS,LU)
0018      2      WRITE(LU,110)
0019      IF(NYES(LU))5,2,4
0020      4      CONTINUE
0021      CALL DATIN(IFST,IRATE,NSAM,NSEG,LU)
0022      IF(IFDRK(DM).LT.0)GO TO 5
0023      WRITE(LU,130)
0024      CALL CONV( NSAM,NSEG,POS,A,CL,LU)
0025      CALL REDUC(NSAM,NSEG,SL,LU)
0026      CALL SAVIT(IRATE,NSAM,NSEG,CL,POS,LU)
0027      CALL F INFO(NSAM,IRATE,NSEG,SL,LU)
0028      5      CONTINUE
0029      CALL PURG(NSAM,NSEG,LU)
0030      6      WRITE(LU,140)
0031      IF(NYES(LU))7,6,1
0032      7      CONTINUE
0033      WRITE(LU,150)
0034      110      FORMAT('READY-?')
0035      130      FORMAT('*****DATA RECORD OBTAINED*****')
0036      140      FORMAT('WANT TO RUN AGAIN-?')
0037      150      FORMAT('RUN COMPLETE')
0038      END

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0039 C*****
0040 BLOCK DATA
0041 COMMON /FIL/ IDCB(144),NAME(5),IDCB(144,3),NAMD(5,3)
0042 COMMON /CAL/ A(3),B(3),C(3),RK,T(2),F(2),UMIN,UMAX,SUF(3),AMP(3)
0043 COMMON /TAB/ CALIB(101,3),CSLPE(3),CICPT(3),NC PTS
0044 COMMON /VAL/ VMN(3),VMQMT(3,3),VSTRC(3),VMIN(3),VMAX(3),NCRR(3)
0045 COMMON /WK/ IDUH(1153)
0046 DATA NC PTS,NAME /101,2HCC,2HRA,2HTC,2HDH,16./
0047 DATA NAMD(1,2),NAMD(1,3) /2HVU,2HWV/
0048 END

0049 C*****
0050 SUBROUTINE INPUT(IFST,IRATE,NSAM,NSEG,SL,IAXIS,LU)
0051 1 CONTINUE
0052 WRITE(LU,100)
0053 READ(LU,*)IFST,IRATE,NSAM,NSEG,OPTEMP
0054 NSAM=((NSAM+127)/128)*128
0055 RATE=RATE1(IRATE)
0056 NCHAN=3
0057 ILST=IFST+NCHAN-1
0058 TIME=FLOAT(NSEG)*FLOAT(NSAM)/RATE
0059 WRITE(LU,110)NSAM,NSEG,RATE,TIME,IFST,NCHAN,OPTEMP
0060 2 CONTINUE
0061 WRITE(LU,120)
0062 IF(NYES(LU))1,2,3
0063 3 CONTINUE
0064 WRITE(LU,130)
0065 READ(LU,140)IAXIS
0066 CALL VELCL(IFST,OPTEMP,SL,LU)
0067 RETURN
0068 100 FORMAT('ENTER CHAN 1, RATE, SAMPLES, SEGMENTS, TEMP,- ')
0069 110 FORMAT('NO. OF SAMPLES= 'I5/
0070 + 'NO. OF SEGMENTS= 'I5/
0071 + 'SAMPLE RATE= 'F7.2/
0072 + 'TIME DURATION= 'F8.2/
0073 + 'FIRST CHANNEL= 'I2/
0074 + 'NO. CHANNELS= 'I2/
0075 + 'OPERATION TEMP.= 'F5.1/)
0076 120 FORMAT('ENTRIES OK-? 'I2)
0077 130 FORMAT('TYPE OF AXIS (RECT. OR CYLINDER) 'I2)
0078 140 FORMAT(A2)
0079 END

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0080 C*****
0081 SUBROUTINE VELCL(IFST,OPTEMP,SL,LU)
0082 COMMON /CAL/ A(3),B(3),C(3),RK,T(2),F(2),UMIN,UMAX,SUP(3),AMP(3)
0083 COMMON /FIL/ IDCB(144),IDUM(452)
0084 COMMON /WK/ IBUF(18)
0085 DIMENSION NAME(5)
0086 EQUIVALENCE (IBUF(1),A1),(IBUF(3),B1),(IBUF(5),C1),(IBUF(7),RK1),
0087 + (IBUF(9),CLTEMP1),(IBUF(11),UMIN1),(IBUF(13),UMAX1),
0088 + (IBUF(15),SUP1),(IBUF(17),AMP1)
0089 DATA NAME /2HVE,2HLC,2HAL,2HDN,10/
0090 CALL OPEN(IDCB,IERR,NAME,0,NAME(4),NAME(5))
0091 CALL ERROR(LU,IERR,2HVE,IDCB,0,1)
0092 DO 10 IC=1,3
0093 CALL READF(IDCB,IERR,IBUF)
0094 CALL ERROR(LU,IERR,2HVE,IDCB,0,1)
0095 A(IC)=A1
0096 B(IC)=B1
0097 C(IC)=C1
0098 RK=RK1
0099 CLTEMP=CLTEMP1
0100 UMIN=UMIN1
0101 UMAX=UMAX1
0102 SUP(IC)=SUP1
0103 AMP(IC)=AMP1
0104 10 CONTINUE
0105 20 WRITE(LU,100)
0106 IF(NYES(LU))80,20,30
0107 30 WRITE(LU,110)
0108 DO 40 IC=1,3
0109 ICH=IC+IFST-1
0110 WRITE(LU,120) ICH,A(IC),B(IC),C(IC),RK,CLTEMP,UMIN,UMAX
0111 + SUP(IC),AMP(IC)
0112 40 CONTINUE
0113 80 CONTINUE
0114 SL=UMAX/32752.0
0115 T(1)=CLTEMP
0116 T(2)=OPTEMP
0117 CALL TABLE
0118 CALL CLOSE(IDCB)
0119 RETURN
0120 100 FORMAT(/'WISH TO SEE CALIBRATION FILE-7
0121 110 FORMAT('CHANNEL A*6X*B*7X*C*7X*K *1X*CAL TEMP*2X*UMIN'
0122 + ' UMAX SUPPRES AMPLIFY')
0123 120 FORMAT(1X,12,4X,F6.3,2X,F6.4,2X,F6.4,2X,F5.3,2X,F4.1,2X,
0124 + F6.2,2X,F6.2,2X,F6.3,2X,F5.2)
0125 END

```

```

0126 C*****
0127 SUBROUTINE TABLE
0128 COMMON /CAL/ A(3),B(3),C(3),RK,T(2),F(2),UMIN,UMAX,SUP(3),AMP(3)
0129 COMMON /TAB/ CALIB(101,3),CSLPE(3),CICPT(3),NC PTS
0130 C DATA ALPHA /0.00392/
0131 DATA PI /3.14159/
0132 F(1)=2, +RK*RK
0133 F(2)=1, -RK*RK
0134 TFAC=1.0
0135 C TFAC=SQRT(1./(1.+ALPHA*(T(1)-T(2))/0.5))
0136 C AFACMN=SQRT(COS(PI/2.))**2+(RK*SIN(PI/2.))**2)
0137 AFACMN=RK
0138 C AFACMX=SQRT(COS(0.0)**2+(RK*SIN(0.0))**2)
0139 AFACMX=1.0
0140 DO 2 J=1,3
0141 ERMIN=SQRT(TFAC*(A(J)+B(J)*(UMIN*AFACMN)**C(J)))
0142 EMIN=(ERMIN-SUP(J))*AMP(J)
0143 IF(EMIN.LT.-10.0)EMIN=-10.0
0144 ERMAX=SQRT(TFAC*(A(J)+B(J)*(UMAX*AFACMX)**C(J)))
0145 EMAX=(ERMAX-SUP(J))*AMP(J)
0146 IF(EMAX.GT.10.0)EMAX=10.0
0147 DEL E=(EMAX-EMIN)/FLOAT(NC PTS-1)
0148 E=EMIN-DEL E
0149 POW=2.0/C(J)
0150 DO 1 I=1,NC PTS
0151 E=E+DEL E
0152 ER=E/AMP(J)+SUP(J)
0153 CALIB(I,J)=(ER*ER/TFAC-A(J))/B(J)**POW
0154 1 CONTINUE
0155 CMIN=EMIN*3275.2
0156 CMAX=EMAX*3275.2
0157 CSLPE(J)=FLOAT(NC PTS-1)/(CMAX-CMIN)
0158 CICPT(J)=-CSLPE*CMIN+1.0
0159 2 CONTINUE
0160 RETURN
0161 END

0162 C*****
0163 SUBROUTINE FILES(NSAM,NSEG,LU)
0164 COMMON /FIL/ IDCB(144),NAME(5),IDCRD(144,3),NAMD(5,3)
0165 COMMON /WK/ ISIZE(2)
0166 1 CONTINUE
0167 WRITE(LU,100)
0168 CALL GNAME(LU,NAMD(1,1),NAMD(4,1),NAMD(5,1),1)
0169 NAMD(1,1)=2HUU
0170 NAMD(2,2)=NAMD(2,1)
0171 NAMD(2,3)=NAMD(2,1)
0172 NAMD(3,2)=NAMD(3,1)
0173 NAMD(3,3)=NAMD(3,1)
0174 NAMD(4,2)=NAMD(4,1)
0175 NAMD(4,3)=NAMD(4,1)
0176 NAMD(5,2)=NAMD(5,1)
0177 NAMD(5,3)=NAMD(5,1)
0178 ISIZE(1)=(NSAM/128)*NSEG+1
0179 DO 2 I=1,3
0180 IF(I.EQ.3.AND.NSEG.LT.3)ISIZE(1)=(NSAM/128)*3+1
0181 CALL CREAT(IDCRD(1,I),IERR,NAMD(1,I),ISIZE,1,NAMD(4,I),
0182 + NAMD(5,I))
0183 IF(IERR.LT.0)GO TO 1000
0184 2 CONTINUE
0185 CALL CLOSE(IDCRD(1,3))
0186 CALL OPEN(IDCRD(1,3),IERR,NAMD(1,3),1,NAMD(4,3),NAMD(5,3))
0187 IF(IERR.LT.0)GO TO 1000
0188 ISIZE(1)=(NSAM/128)*3*NSEG+1
0189 CALL PURGE(IDCB,IERR,NAME,NAME(4),NAME(5))
0190 CALL CREAT(IDCB,IERR,NAME,ISIZE,1,NAME(4),NAME(5))
0191 IF(IERR.LT.0)GO TO 1000
0192 RETURN
0193 1000 CONTINUE
0194 CALL ERROR(LU,IERR,2HFI,IDCB,1,0)
0195 WRITE(LU,110)
0196 1010 IF(NYES(LU))1020,1010,1
0197 1020 CONTINUE
0198 STOP 1000
0199 100 FORMAT(/'ENTER DATA FILE NAMR-
0200 110 FORMAT(/'WISH TO RE-ENTER NAMR-
0201 END

```

```

0202 C*****
0203 SUBROUTINE SETUP(POS,C,IAXIS,LU)
0204 C
0205 C**CALCULATES THE DIRECTION COSINE TENSOR 'C(3,3)' FOR THE COORDINATE
0206 C TRANSFORMATION FROM 1294 3D PROBES SENSOR COORDINATES TO THOSE OF THE
0207 C DESIRED TUNNEL COORDINATES. 'IAXIS'=2HRE FOR RECTANGULAR SYSTEM,
0208 C 'IAXIS'=2HCY FOR CYLINDRICAL SYSTEM.
0209 C POS(1,2,3) ARE THE LOCATIONS OF THE PROBE IN THE TUNNEL COORDINATES
0210 C X, Y & Z RESPECTIVELY. WHEN A CONVERSION IS MADE FROM RECTANGULAR
0211 C TO CYLINDERICAL COORDINATES, X REMAINS THE SAME AND POS(2&3) ARE
0212 C CHANGED FROM THE INPUTED Y, Z VALUES TO R, THETA VALUES.
0213 C FOR THE CYLINDERICAL SYSTEM, WHEN LOOKING DOWN (+TO-) THE POSITIVE
0214 C X AXIS THE THETA COMPONENT IS POSITIVE IN THE COUNTERCLOCKWISE SENSE.
0215 C POS(4,5&6) ARE THE ROTATIONAL ANGLES ABOUT THE X, Y & Z AXIS OF THE
0216 C PROBE SUPPORT COORDINATES FROM AN INITIAL ALIGNMENT WITH THE TUNNEL
0217 C COORDINATES RESPECTIVELY. THE ROTATIONAL SEQUENCE MUST BE IN THE ORDER
0218 C ABOUT Z, THEN Y, THEN X SINCE PROBE COORDINATES WILL NO LONGER BE ALIGNED
0219 C WITH TUNNEL COORDINATES AFTER THE FIRST ROTATION. THE SENSE OF THE
0220 C ROTATION IS: LOOKING DOWN (+TO-) THE POSITIVE AXIS OF THE PROBE
0221 C COORDINATE SYSTEM THE OTHER TWO AXIS ARE ROTATED IN A CLOCKWISE
0222 C**DIRECTION RESULTS IN A POSITIVE ANGLE.
0223 C
0224 COMMON /WK/ A(3,3),B(3,3)
0225 DIMENSION POS(6),C(3,3)
0226 DATA PI /3.14159/
0227 CONST=PI/180.0
0228 C.....FIND TRANSFORMATION TENSOR 'A' FOR
0229 C PROBE TO SENSOR CONVERSION.
0230 ROT X=0.0*CONST
0231 ROT Y=35.26*CONST
0232 ROT Z=-45.0*CONST
0233 CALL TRXYZ(A,ROT X,ROT Y,ROT Z)
0234 C.....TAKE TRANSPOSE OF 'A' TO FIND
0235 C SENSOR TO PROBE CONVERSION.
0236 DO 20 I=1,3
0237 DO 10 J=I+1,3
0238 SAVE=A(I,J)
0239 A(I,J)=A(J,I)
0240 A(J,I)=SAVE
0241 10 CONTINUE
0242 20 CONTINUE
0243 C.....FIND TRANSFORMATION TENSOR 'B' FOR
0244 C PROBE TO TUNNEL CONVERSION.
0245 WRITE(LU,100)
0246 READ(LU,*)POS
0247 ROT X=POS(4)*CONST
0248 ROT Y=POS(5)*CONST
0249 ROT Z=POS(6)*CONST
0250 CALL TRXYZ(B,ROT X,ROT Y,ROT Z)
0251 C.....CALCULATE TOTAL TRANSFORMATION TENSOR
0252 C 'C' FOR SENSOR TO TUNNEL CONVERSION.
0253 CALL TMULT(A,B,C)
0254 IF(IAXIS.NE.2HCY)RETURN
0255 C.....CONVERT FROM RECT. COOR. TO CYL.
0256 C COOR. BY CALCULATING THE TRANS.

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0257 C                                TENSOR 'A' FOR THE ROTATION ABOUT
0258 C                                THE X AXIS (THETA=ATAN(Z/Y)) THAT
0259 C                                IS NECESSARY. THEN RECALCULATE
0260 C                                'C' TO INCLUDE THIS LAST TRANS.
0261 Y=POS(2)
0262 Z=POS(3)
0263 IF(Y.EQ.0.0.AND.Z.GE.0.0)GO TO 21
0264 GO TO 22
0265 21 CONTINUE
0266 THETA=PI/2.0
0267 GO TO 25
0268 22 CONTINUE
0269 IF(Y.EQ.0.0.AND.Z.LT.0.0)GO TO 23
0270 GO TO 24
0271 23 CONTINUE
0272 THETA=-PI/2.0
0273 GO TO 25
0274 24 CONTINUE
0275 THETA=ATAN(Z/Y)
0276 IF(Y.LT.0.0)THETA=THETA+PI
0277 25 CONTINUE
0278 POS(2)=SQRT(Y*Y+Z*Z)
0279 POS(3)=THETA/CONST
0280 DO 40 I=1,3
0281 DO 30 J=1,3
0282 A(I,J)=C(I,J)
0283 30 CONTINUE
0284 40 CONTINUE
0285 CALL TRXYZ(B,THETA,0.,0.)
0286 CALL TMULT(A,B,C)
0287 RETURN
0288 100 FORMAT('ENTER X, Y, Z, ROT X, ROT Y, ROT Z _')
0289 END

```

```

0290 C*****
0291 SUBROUTINE TRXYZ(A,X,Y,Z)
0292 C
0293 C FINDS THE CARTESIAN COORDINATE TRANSFORMATION TENSOR FOR ROTATIONS
0294 C ABOUT X AXIS, THEN Y AXIS, THEN Z AXIS. POSITIVE ROTATION IS
0295 C COUNTERCLOCKWISE WHEN LOOKING FROM + TO - ON THE AXIS.
0296 C
0297 DIMENSION A(3,3)
0298 A(1,1)=COS(Y)*COS(Z)
0299 A(1,2)=COS(X)*SIN(Z)+SIN(X)*SIN(Y)*COS(Z)
0300 A(1,3)=SIN(X)*SIN(Z)-COS(X)*SIN(Y)*COS(Z)
0301 A(2,1)=-COS(Y)*SIN(Z)
0302 A(2,2)=-SIN(X)*SIN(Y)*SIN(Z)+COS(X)*COS(Z)
0303 A(2,3)=SIN(X)*COS(Z)+COS(X)*SIN(Y)*SIN(Z)
0304 A(3,1)=SIN(Y)
0305 A(3,2)=-SIN(X)*COS(Y)
0306 A(3,3)=COS(X)*COS(Y)
0307 RETURN
0308 END

```

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0309 C*****
0310 SUBROUTINE TMULT(A,B,C)
0311 DIMENSION A(3,3),B(3,3),C(3,3)
0312 DO 30 I=1,3
0313 DO 20 J=1,3
0314 C(I,J)=0.0
0315 DO 10 K=1,3
0316 C(I,J)=C(I,J)+B(I,K)*A(K,J)
0317 10 CONTINUE
0318 20 CONTINUE
0319 30 CONTINUE
0320 RETURN
0321 END

```

```

0322 C*****
0323 SUBROUTINE DATIN(IFST,IRATE,NSAM,NSEG,LU)
0324 COMMON /FIL/ IDCB(144),NAME(5),IDCB(144,3),NAMD(5,3)
0325 COMMON /WK/ IPAR(5)
0326 DIMENSION NAMF(3)
0327 DATA NAMF /2HDA,2HTA,2H /
0328 IF(LU.NE.1.AND.LU.NE.26)CALL NAMIT(LU,NAMF)
0329 IF=0
0330 IF(IRATE.GT.3125)IF=1
0331 ILST=IFST+2
0332 DO 1 ISEG=1,NSEG
0333 CALL EXEC(23,NAMF,IFST,ILST,IRATE,NSAM,IF,NAMD(1,3),5)
0334 CALL RMPAR(IPAR)
0335 CALL ERROR(LU,IERR,2HDA,IDCB,1,1)
0336 CALL FILL(IDCB,IDCB(1,3),NSAM,ISEG,LU)
0337 1 CONTINUE
0338 CALL POSNT(IDCB,IERR,1,1)
0339 CALL POSNT(IDCB(1,3),IERR,1,1)
0340 RETURN
0341 END

```

```

0342 C*****
0343 SUBROUTINE FILL(IDCB,IDCBD,NSAM,ISEG,LU)
0344 COMMON /WK/ IBUF(128)
0345 DIMENSION IDCB(144),IDCBD(144)
0346 IBLKS=(NSAM/128)*3
0347 IPOS=(ISEG-1)*IBLKS
0348 DO 1 IREC=1,IBLKS
0349 CALL READF(IDCBD,IERR,IBUF,128,LEN,IREC)
0350 CALL ERROR(LU,IERR,2HFL,IDCB,1,1)
0351 JREC=IPOS+IREC
0352 CALL WRITF(IDCB,IERR,IBUF,128,JREC)
0353 CALL ERROR(LU,IERR,2HFL,IDCB,1,1)
0354 1 CONTINUE
0355 RETURN
0356 END

```

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0357 C*****
0358 SUBROUTINE CONV(TNSAM,NSEG,POS,A,SL,LU)
0359 COMMON /FIL/ IDC(144),NAME(5),IDCD(144,3),NAME(5,3)
0360 COMMON /VAL/ V(3),IDUM(36),NERR(3)
0361 COMMON /WK/ IBUF(384),IBUFD(128,3),SUM(3),JERR(3)
0362 DIMENSION POS(6),A(3,3)
0363 DO 10 I=1,3
0364     JERR(I)=0
0365     NERR(I)=0
0366     SUM(I)=0.0
0367 10 CONTINUE
0368 NBLKS=(NSAM/128)*NSEG
0369 DO 5 I=1,NBLKS
0370     CALL READF(IDC,IERR,IBUF,384)
0371     CALL ERROR(LU,IERR,2HCO,IDC,1,1)
0372     IPOS=-2
0373     DO 3 J=1,128
0374         IPOS=IPOS+3
0375         CALL UVW(IBUF(IPOS),V,VTOT,JERR,LU)
0376         CALL CHECK(V,VTOT,NERR)
0377         CALL TCOOR(V,A)
0378         DO 1 K=1,3
0379             IBUFD(J,K)=IFIX(V(K)/SL)
0380             SUM(K)=SUM(K)+V(K)
0381 1 CONTINUE
0382 3 CONTINUE
0383 DO 4 K=1,3
0384     CALL WRITF(IDCD(1,K),IERR,IBUFD(1,K),128)
0385     CALL ERROR(LU,IERR,2HCO,IDC,1,1)
0386 4 CONTINUE
0387 5 CONTINUE
0388 DO 6 K=1,3
0389     V(K)=SUM(K)/(128.0*FLOAT(NBLKS))
0390 6 CONTINUE
0391 CALL OUT1(NAME,POS,V,SL,JERR,NERR,LU)
0392 CALL PURGE(IDC,IERR,NAME,NAME(4),NAME(5))
0393 RETURN
0394 END

0395 C*****
0396 SUBROUTINE UVW(IAD,V,VTOT,JERR,LU)
0397 COMMON /CAL/ A(3),B(3),C(3),RK,T(2),F(2),UMIN,UMAX,SUF(3),AMP(3)
0398 COMMON /TAB/ CALIB(101,3),CSLPE(3),CICPT(3),NC PTS
0399 DIMENSION IAD(3),V(3),JERR(3),VEFF2(3)
0400 SUM=0.0
0401 DO 10 I=1,3
0402     BIN=FLOAT(IAD(I))*CSLPE(I)+CICPT(I)
0403     N=IFIX(BIN)
0404     IF(N.GE.1)GO TO 2
0405         JERR(1)=JERR(1)+1
0406         BIN=1.0
0407         N=1
0408         GO TO 4
0409 2 CONTINUE
0410     IF(N.LE.100)GO TO 4
0411         JERR(2)=JERR(2)+1
0412         BIN=101.0
0413         N=100
0414 4 CONTINUE
0415     DEL=(CALIB(N+1,I)-CALIB(N,I))*(BIN-FLOAT(N))
0416     VEFF2(I)=CALIB(N,I)+DEL
0417     SUM=SUM+VEFF2(I)
0418 10 CONTINUE
0419 VTOT2=SUM/F(1)
0420 DO 30 I=1,3
0421     TEMPX=VTOT2-VEFF2(I)
0422     IF(TEMPX.GE.0.0)GO TO 20
0423         TEMPX=0.0
0424         JERR(3)=JERR(3)+1
0425 20 CONTINUE
0426     V(I)=SQRT(TEMPX/F(2))
0427 30 CONTINUE
0428 VTOT=SQRT(VTOT2)
0429 RETURN
0430 END

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0431 C*****
0432 SUBROUTINE CHECK(V,VTOT,NERR)
0433 DIMENSION V(3),NERR(3)
0434 DATA SIN10,SIN80 /0.1736,0.9848/
0435 DO 1 I=1,3
0436 X=V(I)/VTOT
0437 IF(X.LT,SIN10.OR.X.GT,SIN80)NERR(I)=NERR(I)+1
0438 1 CONTINUE
0439 RETURN
0440 END

0441 C*****
0442 SUBROUTINE TCOOR(V,A)
0443 DIMENSION V(3),A(3,3),VTUN(3)
0444 DO 2 I=1,3
0445 VTUN(I)=0.0
0446 DO 1 J=1,3
0447 VTUN(I)=VTUN(I)+A(I,J)*V(J)
0448 1 CONTINUE
0449 2 CONTINUE
0450 DO 3 I=1,3
0451 V(I)=VTUN(I)
0452 3 CONTINUE
0453 RETURN
0454 END

0455 C*****
0456 SUBROUTINE OUT1(NAMD,POS,V,SL,JERR,NERR,LU)
0457 COMMON /WK/ ANGLE(3)
0458 DIMENSION NAMD(5,3),POS(6),V(3),JERR(3),NERR(3)
0459 WRITE(LU,100)
0460 DO 1 J=1,3
0461 1 WRITE(LU,110)(NAMD(I,J),I=1,3),(POS(I),I=1,6),V(J),SL
0462 VTOT=SQRT(V(1)*V(1)+V(2)*V(2)+V(3)*V(3))
0463 WRITE(LU,120)VTOT
0464 DO 2 I=1,3
0465 ANGLE(I)=ATAN(V(I)/SQRT((VTOT-V(I))*(VTOT+V(I))))
0466 ANGLE(I)=90.0-ANGLE(I)*180.0/3.14159
0467 2 CONTINUE
0468 WRITE(LU,130)(ANGLE(I),I=1,3)
0469 IF(JERR(1).NE.0)WRITE(LU,140)JERR(1)
0470 IF(JERR(2).NE.0)WRITE(LU,145)JERR(2)
0471 IF(JERR(3).NE.0)WRITE(LU,150)JERR(3)
0472 IF(NERR(1).NE.0.OR.NERR(2).NE.0.OR.NERR(3).NE.0)
0473 + WRITE(LU,160)(NERR(I),I=1,3)
0474 RETURN
0475 100 FORMAT(' FILE LINEAR POSITION ROTATIONAL POSITION(DEG)'
0476 + ' MEAN VEL. CONVERSION "/ NAME " CONSTANT')
0477 + ' X Y Z'
0478 110 FORMAT(3A2,5X,6(F7.2),4X,F7.2,3X,G11.4)
0479 120 FORMAT('/MEAN TOTAL VELOCITY =F7.1)
0480 130 FORMAT('MEAN COMP.ANGLES = F6.1 FROM X AXIS'
0481 + ' F6.1 FROM Y AXIS'
0482 + ' F6.1 FROM Z AXIS')
0483 140 FORMAT('/!!!! LOWER CAL. RANGE WAS EXCEEDED '15' TIMES !!!!!')
0484 145 FORMAT('/!!!! UPPER CAL. RANGE WAS EXCEEDED '15' TIMES !!!!!')
0485 150 FORMAT('/!!!! CALCULATIONAL ERROR OCCURED '15' TIMES !!!!!')
0486 160 FORMAT('/!!!! VELOCITY VECTOR 1 EXCEEDED DIR. LIMITS '15' TIMES'
0487 + ' VELOCITY VECTOR 2 EXCEEDED DIR. LIMITS '15' TIMES'
0488 + ' VELOCITY VECTOR 3 EXCEEDED DIR. LIMITS '15' TIMES')
0489 END

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0490 C*****
0491 SUBROUTINE REDUC(NSAM,NSEG,SL,LU)
0492 COMMON /FIL/ IDCBD(144),NAME(5),IDCB(144,3),NAMD(5,3)
0493 COMMON /VAL/ VMN(3),VMONT(3,3),VSTRS(3),VMIN(3),VMAX(3),NERR(3)
0494 COMMON /WK/ IBUFD(128,3),V(128,3),CVMN(3)
0495 DO 1 I=1,3
0496 CALL POSNT(IDCB(I),I,IERR,1,1)
0497 CALL ERROR(LU,IERR,2HRE,IDCB,1,1)
0498 CVMN(I)=VMN(I)/SL
0499 VMIN(I)=1.E30
0500 VMAX(I)=-1.E30
0501 1 CONTINUE
0502 NBLKS=(NSAM/128)*NSEG
0503 DO 4 I=1,NBLKS
0504 DO 3 J=1,3
0505 CALL READF(IDCB(I,J),IERR,IBUFD(I,J),128)
0506 CALL ERROR(LU,IERR,2HRE,IDCB,1,1)
0507 DO 2 K=1,128
0508 V(K,J)=FLOAT(IBUFD(K,J))
0509 VMIN(J)=AMIN1(VMIN(J),V(K,J))
0510 VMAX(J)=AMAX1(VMAX(J),V(K,J))
0511 2 CONTINUE
0512 CALL MOMET(V(1,J),CVMN(J),VMONT(1,J),I)
0513 3 CONTINUE
0514 CALL STRES(V,CVMN,VSTRS,I)
0515 4 CONTINUE
0516 DO 5 I=1,3
0517 VMONT(2,I)=VMONT(2,I)/(VMONT(1,I)**1.5)
0518 VMONT(3,I)=VMONT(3,I)/(VMONT(1,I)*VMONT(1,I))
0519 VMONT(1,I)=SL*SQR(VMONT(1,I))
0520 VSTRS(I)=VSTRS(I)*SL*SL
0521 VMIN(I)=VMIN(I)*SL
0522 VMAX(I)=VMAX(I)*SL
0523 5 CONTINUE
0524 CALL OUT2(VMONT,VSTRS,VMIN,VMAX,LU)
0525 RETURN
0526 END

```

```

0527 C*****
0528 SUBROUTINE MOMET(V,VMN,VMONT,N)
0529 DIMENSION V(128),VMONT(3)
0530 SUM1=0.0
0531 SUM2=0.0
0532 SUM3=0.0
0533 WIGHT=1.0/FLOAT(N)
0534 DO 1 I=1,128
0535 X=V(I)-VMN
0536 XX=X*X
0537 SUM1=SUM1+XX
0538 SUM2=SUM2+XX*X
0539 SUM3=SUM3+XX*XX
0540 1 CONTINUE
0541 VMONT(1)=VMONT(1)*(1.-WIGHT)+SUM1*WIGHT/128.0
0542 VMONT(2)=VMONT(2)*(1.-WIGHT)+SUM2*WIGHT/128.0
0543 VMONT(3)=VMONT(3)*(1.-WIGHT)+SUM3*WIGHT/128.0
0544 RETURN
0545 END

```

```

0546 C*****
0547 SUBROUTINE STRES(VEL,VHN,VSTRS,N)
0548 DIMENSION VEL(128,3),VHN(3),VSTRS(3)
0549 SUM1=0.0
0550 SUM2=0.0
0551 SUM3=0.0
0552 WIGHT=1.0/FLOAT(N)
0553 DO 1 I=1,128
0554   U=VEL(I,1)-VHN(1)
0555   V=VEL(I,2)-VHN(2)
0556   W=VEL(I,3)-VHN(3)
0557   SUM1=SUM1+U*W
0558   SUM2=SUM2+U*V
0559   SUM3=SUM3+V*W
0560 1 CONTINUE
0561 VSTRS(1)=VSTRS(1)*(1.-WIGHT)+SUM1*WIGHT/128.0
0562 VSTRS(2)=VSTRS(2)*(1.-WIGHT)+SUM2*WIGHT/128.0
0563 VSTRS(3)=VSTRS(3)*(1.-WIGHT)+SUM3*WIGHT/128.0
0564 RETURN
0565 END

0566 C*****
0567 SUBROUTINE OUT2(VMOHT,VSTRS,VHIN,VMAX,LU)
0568 DIMENSION VMOHT(3,3),VSTRS(3),VHIN(3),VMAX(3)
0569 WRITE(LU,100)
0570 WRITE(LU,102)(VHIN(I),I=1,3)
0571 WRITE(LU,104)(VMAX(I),I=1,3)
0572 WRITE(LU,110)(VMOHT(1,I),I=1,3)
0573 WRITE(LU,120)((VMOHT(I,J),J=1,3),I=2,3)
0574 WRITE(LU,130)(VSTRS(I),I=1,3)
0575 RETURN
0576 100 FORMAT(22X*U*9X*V*9X*W*)
0577 102 FORMAT(/2X*MIN. VELOCITY= *3(F8.3,2X))
0578 104 FORMAT(2X*MAX. VELOCITY= *3(F8.3,2X))
0579 110 FORMAT(2X*RMS VELOCITY = *3(F8.3,2X))
0580 120 FORMAT(2X*SKEWNESS = *3(F8.3,2X)/
0581 + 2X*FLATNESS = *3(F8.3,2X))
0582 130 FORMAT(/22X*UW*8X*UV*8X*VW*/
0583 + 2X*KEY. STRESS = *3(F8.5,2X))
0584 END

```

```

0585 C*****
0586 SUBROUTINE SAVIT(IRATE,NSAM,NSEG,SL,POS,LU)
0587 COMMON /FIL/ IDUM(581),NAM(5,3)
0588 COMMON /CAL/ A(3),B(3),C(3),RK,T(2),F(2),UHIN,UMAX,SUP(3),AMP(3)
0589 COMMON /VAL/ VMN(3),VMOMT(3,3),VSTRS(3),VMIN(3),VMAX(3),NERR(3)
0590 COMMON /WK/ IBUF(102),IB2(18),IB3(24)
0591 DIMENSION POS(6),POS1(6),A1(3),IB1(15),IB4(45),NAM(5)
0592 EQUIVALENCE (IB1(1),NAM(1,1)),(IB2(1),RATE),(IB2(3),NSAM1),
0593 + (IB2(4),NSEG1),(IB2(5),SL1),(IB2(7),POS1(1)),
0594 + (IB3(1),A1(1)),(IB4(1),VMN(1))
0595 DATA NAM /2HVA,2HLU,2HES,2HDN,16/
0596 WRITE(LU,100)
0597 10 IF(NOYES(LU))7,10,11
0598 11 CONTINUE
0599 RATE=RATE1(IRATE)
0600 NSAM1=NSAM
0601 NSEG1=NSEG
0602 SL1=SL
0603 DO 1 I=1,6
0604 POS1(I)=POS(I)
0605 1 CONTINUE
0606 DO 3 I=1,15
0607 IBUF(I)=IB1(I)
0608 3 CONTINUE
0609 DO 4 I=1,18
0610 J=I+15
0611 IBUF(J)=IB2(I)
0612 4 CONTINUE
0613 DO 5 I=1,24
0614 J=I+33
0615 IBUF(J)=IB3(I)
0616 5 CONTINUE
0617 DO 6 I=1,45
0618 J=I+57
0619 IBUF(J)=IB4(I)
0620 6 CONTINUE
0621 CALL WREC(IBUF,102,NAM,LU)
0622 7 CONTINUE
0623 RETURN
0624 100 FORMAT(/'WISH TO SAVE RESULTS ON FILE VALUES:DN:16 -? _')
0625 END

0626 C*****
0627 SUBROUTINE F INFO(NSAM,IRATE,NSEG,SL,LU)
0628 COMMON /FIL/ IDCB(144),NAME(5),IDCRD(144,3),NAM(5,3)
0629 COMMON /VAL/ VMN(3),VMOMT(3,3),VSTRS(3),VMIN(3),VMAX(3),NERR(3)
0630 COMMON /WK/ IBUF(128)
0631 EQUIVALENCE (IBUF(1),NSM),(IBUF(2),RATE),(IBUF(4),IBLOC),
0632 + (IBUF(5),RMN),(IBUF(7),RMS),(IBUF(9),SLPE)
0633 NSM=NSAM
0634 RATE=RATE1(IRATE)
0635 IBLOC=(NSAM/128)*NSEG
0636 SLPE=1.0/SL
0637 DO 10 I=1,3
0638 RMN=VMN(I)
0639 RMS=VMOMT(1,I)
0640 CALL WRITE(IDCRD(1,I),IERR,IBUF,128,(IBLOC+1))
0641 CALL ERROR(LU,IERR,2HF, IDCB,1,0)
0642 10 CONTINUE
0643 RETURN
0644 END

```

```

0645 C*****
0646 SUBROUTINE WREC(IB,N,NAM,LU)
0647 COMMON /WK/ ISAV(200),IDCB(144),ISIZ(2),IB1(10)
0648 DIMENSION IB(N),NAM(5)
0649 ISIZ(1)=24
0650 ISIZ(2)=N
0651 CALL OPEN(IDCB,IERR,NAM,2,NAM(4),NAM(5))
0652 IF(IERR.EQ.-6)CALL CREAT(IDCB,IERR,NAM,ISIZ,3,NAM(4),NAM(5))
0653 CALL ERROR(LU,IERR,2HWR,IDCB,1,1)
0654 10 CONTINUE
0655 CALL READF(IDCB,IERR,IB1,10,LEN)
0656 CALL ERROR(LU,IERR,2HWR,IDCB,1,1)
0657 IF(LEN.NE.-1)GO TO 10
0658 CALL FOSNT(IDCB,IERR,-1)
0659 CALL ERROR(LU,IERR,2HWR,IDCB,1,1)
0660 CALL WRITF(IDCB,IERR,IB,N)
0661 CALL ERROR(LU,IERR,2HWR,IDCB,1,1)
0662 CALL CLOSE(IDCB)
0663 RETURN
0664 END

0665 C*****
0666 SUBROUTINE PURG(NSAM,NSEG,LU)
0667 COMMON /FIL/ IDUM(149),IDCBD(144,3),NAMD(5,3)
0668 COMMON /WK/ IB(10)
0669 DIMENSION NAM(5)
0670 DATA NAM,N /2HTR,2HAN,2HSF,2HDN,16,10/
0671 ITRUN=0
0672 IF(NSEG.LT.3)ITRUN=(3-NSEG)*(NSAM/128)
0673 IANSW=2HND
0674 10 WRITE(LU,100)
0675 IF(NOYES(LU))30,10,20
0676 20 CONTINUE
0677 IANSW=2HYE
0678 30 CONTINUE
0679 DO 50 I=1,3
0680 CALL CLOSE(IDCBD(1,I))
0681 IF(IANSW.EQ.2HYE)GO TO 40
0682 CALL CODE
0683 WRITE(IB,110)(NAMD(J,I),J=1,5)
0684 CALL WREC(IB,N,NAM,LU)
0685 IF(I.NE.3)GO TO 50
0686 CALL OPEN(IDCBD,IERR,NAMD(1,3),0,NAMD(4,3),NAMD(5,3))
0687 CALL ERROR(LU,IERR,2HPU,IDCB,0,0)
0688 CALL CLOSE(IDCBD,IERR,ITRUN)
0689 CALL ERROR(LU,IERR,2HPU,IDCB,0,0)
0690 GO TO 50
0691 40 CONTINUE
0692 CALL PURGE(IDCBD(1,I),IERR,NAMD(1,I),NAMD(4,I),NAMD(5,I))
0693 50 CONTINUE
0694 IF(IANSW.EQ.2HYE)WRITE(LU,120)((NAMD(I,J),I=1,3),J=1,3)
0695 RETURN
0696 100 FORMAT('WISH TO PURGE DATA FILES-?')
0697 110 FORMAT(' :PU,'3A2':'I5':'I3')
0698 120 FORMAT('/PURGED FILES ARE '3(4X,3A2)/)
0699 END

```

```

0700 C*****
0701 SUBROUTINE ERROR(LU,IERR,LOC,IDCB,IPUR,ISTOP)
0702 DIMENSION IDCB(144)
0703 IF(IERR.GE.0)RETURN
0704 CALL CLOSE(IDCB)
0705 IF(LOC.NE.2HDA)WRITE(LU,100)IERR,LOC
0706 IF(LOC.EQ.2HDA)WRITE(LU,110)IERR,LOC
0707 IF(IPUR.EQ.1)CALL PURG(0,3,LU)
0708 IF(ISTOP.EQ.1)STOP 1111
0709 RETURN
0710 100 FORMAT(' FMGR ERROR 'I5' IN 'A2)
0711 110 FORMAT(' DATA PROGRAM ERROR 'I5' IN 'A2)
0712 END

0713 C*****
0714 FUNCTION RATE1(IRATE)
0715 IP=0
0716 IF(IRATE.GT.3125)IP=1
0717 RATE1=FLOAT(3125*(IP+1))/FLOAT(3125*(IP+1)/IRATE)
0718 RETURN
0719 END

```

```

0001 FTH4-L
0002 PROGRAM DAT1(3,00)
0003 C
0004 C**DESIGNED TO BE USED WITH THE TSI 1224 3D HOT FILM PROBE.
0005 C**ACQUIRES DATA ONLY
0006 C
0007 DIMENSION IPAR(5),POS(5)
0008 CALL RMPAR(IPAR)
0009 LU=IPAR(1)
0010 IF(LU.LT.1)LU=1
0011 CALL LIBER(LU)
0012 CALL INPUT(IFST,IRATE,NSAM,NSEG,OPTEMP,LU)
0013 1 CONTINUE
0014 CALL FILES(NSAM,NSEG,LU)
0015 WRITE(LU,100)
0016 READ(LU,*)POS
0017 2 WRITE(LU,110)
0018 IF(NYES(LU))5,2,4
0019 4 CONTINUE
0020 CALL DATIN(IFST,IRATE,NSAM,NSEG,LU)
0021 IF(IFERK(DM).LT.0)GO TO 5
0022 WRITE(LU,130)
0023 CALL F INFO(NSAM,IRATE,NSEG,POS,OPTEMP,LU)
0024 5 CONTINUE
0025 CALL PURG(LU)
0026 6 WRITE(LU,140)
0027 IF(NYES(LU))7,6,1
0028 7 CONTINUE
0029 WRITE(LU,150)
0030 100 FORMAT('ENTER X, Y, Z, ROT X, ROT Y, ROT Z -')
0031 110 FORMAT('READY-? -')
0032 130 FORMAT('*****DATA RECORD OBTAINED*****')
0033 140 FORMAT('WANT TO RUN AGAIN-? -')
0034 150 FORMAT('RUN COMPLETE')
0035 END

```

```

0041 C*****
0042 SUBROUTINE INPUT(IFST,IRATE,NSAM,NSEG,OPTEMP,LU)
0043 1 CONTINUE
0044 WRITE(LU,100)
0045 READ(LU,*)IFST,IRATE,NSAM,NSEG,OPTEMP
0046 NSAM=((NSAM+127)/128)*128
0047 RATE=RATE1(IRATE)
0048 NCHAN=3
0049 ILST=IFST+NCHAN-1
0050 TIME=FLOAT(NSEG)*FLOAT(NSAM)/RATE
0051 WRITE(LU,110)NSAM,NSEG,RATE,TIME,IFST,NCHAN,OPTEMP
0052 2 CONTINUE
0053 WRITE(LU,120)
0054 IF(NYES(LU))1,2,3
0055 3 CONTINUE
0056 RETURN
0057 100 FORMAT('ENTER CHAN 1, RATE, SAMPLES, SEGMENTS , TEMP. -')
0058 110 FORMAT('NO. OF SAMPLES= 'I5/
0059 'NO. OF SEGMENTS= 'I5/
0060 'SAMPLE RATE= 'F7.2/
0061 'TIME DURATION= 'F8.2/
0062 'FIRST CHANNEL= 'I2/
0063 'NO. CHANNELS= 'I2/
0064 'TEMPERATURE= 'F7.1/
0065 120 FORMAT('ENTRIES OK-? 'I1)
0066 END

0067 C*****
0068 SUBROUTINE FILES(NSAM,NSEG,LU)
0069 COMMON /FIL/ IDCBS(144),NAME(5),IDCBS(144),NAMS(5)
0070 DIMENSION ISIZE(2)
0071 1 CONTINUE
0072 WRITE(LU,100)
0073 CALL GNAME(LU,NAME,NAME(4),NAME(5),1)
0074 ISIZE(1)=(NSAM/128)*NSEG*3+1
0075 CALL CREAT(IDCBS,IERR,NAME,ISIZE,1,NAME(4),NAME(5))
0076 IF(IERR.LT.0)GO TO 1000
0077 ISIZE(1)=(NSAM/128)*3+1
0078 CALL PURGE(IDCBS,IERR,NAMS,NAMS(4),NAMS(5))
0079 CALL CREAT(IDCBS,IERR,NAMS,ISIZE,1,NAMS(4),NAMS(5))
0080 IF(IERR.LT.0)GO TO 1000
0081 CALL CLOSE(IDCBS)
0082 CALL OPEN(IDCBS,IERR,NAMS,1,NAMS(4),NAMS(5))
0083 IF(IERR.LT.0)GO TO 1000
0084 RETURN
0085 1000 CONTINUE
0086 CALL ERROR(LU,IERR,2HFI,IDCB,1,0)
0087 WRITE(LU,110)
0088 1010 IF(NYES(LU))1020,1010,1
0089 1020 CONTINUE
0090 STOP 1000
0091 100 FORMAT('ENTER DATA FILE NAME- 'I1)
0092 110 FORMAT('WISH TO RE-ENTER NAME- 'I1)
0093 END

```



```

0094 C*****
0095 SUBROUTINE DATIN(IFST,IRATE,NSAM,NSEG,LU)
0096 COMMON /FIL/ IDCB(144),NAME(5),IDCBS(144),NAMS(5)
0097 DIMENSION NAMP(3),IPAR(5)
0098 DATA NAMP /2HDA,2HTA,2H /
0099 IF(LU.NE.1.AND.LU.NE.26)CALL NAMIT(LU,NAMP)
0100 IF=0
0101 IF(IRATE.GT.3125)IF=1
0102 ILST=IFST+2
0103 DO 1 ISEG=1,NSEG
0104 CALL EXEC(23,NAMP,IFST,ILST,IRATE,NSAM,IP,NAMS,5)
0105 CALL RMPAR(IPAR)
0106 CALL ERROR(LU,IERR,2HDA,IDCB,1,1)
0107 CALL FILL(IDCB,IDCBS,NSAM,ISEG,LU)
0108 1 CONTINUE
0109 CALL PURGE(IDCBS,IERR,NAMS,NAMS(4),NAMS(5))
0110 RETURN
0111 END

0112 C*****
0113 SUBROUTINE FILL(IDCB,IDCBS,NSAM,ISEG,LU)
0114 DIMENSION IDCB(144),IDCBS(144),IBUF(128)
0115 IBLKS=(NSAM/128)*3
0116 IPOB=(ISEG-1)*IBLKS
0117 DO 1 IREC=1,IBLKS
0118 CALL READF(IDCBS,IERR,IBUF,128,LEN,IREC)
0119 CALL ERROR(LU,IERR,2HFL,IDCB,1,1)
0120 JREC=IPOB+IREC
0121 CALL WRITF(IDCB,IERR,IBUF,128,JREC)
0122 CALL ERROR(LU,IERR,2HFL,IDCB,1,1)
0123 1 CONTINUE
0124 RETURN
0125 END

0126 C*****
0127 SUBROUTINE F INFO(NSAM,IRATE,NSEG,POS,OPTEMP,LU)
0128 COMMON /FIL/ IDCB(144),NAME(5),IDCBS(144),NAMS(5)
0129 DIMENSION IBUF(128),POS(6),POS1(6)
0130 EQUIVALENCE (IBUF(1),NSM),(IBUF(2),RATE),(IBUF(4),IBLOC),
0131 + (IBUF(5),POS1(1)),(IBUF(17),OPTEM)
0132 NSM=NSAM
0133 RATE=RATE1(IRATE)
0134 IBLOC=(NSAM/128)*NSEG
0135 OPTEM=OPTEMP
0136 DO 5 I=1,6
0137 POS1(I)=POS(I)
0138 5 CONTINUE
0139 JBLOC=IBLOC*3
0140 CALL WRITF(IDCB,IERR,IBUF,128,(JBLOC+1))
0141 CALL ERROR(LU,IERR,2HF ,IDCB,1,0)
0142 10 CONTINUE
0143 RETURN
0144 END

```

```

0145 C*****
0146 SUBROUTINE WREC(IB,N,NAM,LU)
0147 DIMENSION IDCB(144),ISIZ(2),IB1(10),IB(N),NAM(5)
0148 ISIZ(1)=24
0149 ISIZ(2)=N
0150 CALL OPEN(IDCB,IERR,NAM,2,NAM(4),NAM(5))
0151 IF(IERR.EQ.-6)CALL CREAT(IDCB,IERR,NAM,ISIZ,3,NAM(4),NAM(5))
0152 CALL ERROR(LU,IERR,2HWR,IDCB,1,1)
0153 10 CONTINUE
0154 CALL READF(IDCB,IERR,IB1,10,LEN)
0155 CALL ERROR(LU,IERR,2HWR,IDCB,1,1)
0156 IF(LEN.NE.-1)GO TO 10
0157 CALL POSNT(IDCB,IERR,-1)
0158 CALL ERROR(LU,IERR,2HWR,IDCB,1,1)
0159 CALL WRITE(IDCB,IERR,IB,N)
0160 CALL ERROR(LU,IERR,2HWR,IDCB,1,1)
0161 CALL CLOSE(IDCB)
0162 RETURN
0163 END

```

```

0164 C*****
0165 SUBROUTINE PURG(LU)
0166 COMMON /FIL/ IDCB(144),NAME(5),IDCBS(144),NAMS(5)
0167 DIMENSION NAM(5),IB(10)
0168 DATA NAM,N /2HTR,2HAN,2HSF,2HDN,16,10/
0169 IANSW=2HND
0170 10 WRITE(LU,100)
0171 IF(NYES(LU))30,10,20
0172 20 CONTINUE
0173 IANSW=2HYE
0174 30 CONTINUE
0175 CALL CLOSE(IDCB)
0176 IF(IANSW.EQ.2HYE)GO TO 40
0177 CALL CODE
0178 WRITE(IB,110)(NAME(J),J=1,5)
0179 CALL WREC(IB,N,NAM,LU)
0180 GO TO 50
0181 40 CONTINUE
0182 CALL PURGE(IDCB,IERR,NAME,NAME(4),NAME(5))
0183 50 CONTINUE
0184 IF(IANSW.EQ.2HYE)WRITE(LU,120)(NAME(I),I=1,3)
0185 RETURN
0186 100 FORMAT('WISH TO PURGE DATA FILE -?')
0187 110 FORMAT('!PU,'3A2':!IS':!I3)
0188 120 FORMAT('/PURGED FILES ARE '3(4X,3A2)/)
0189 END

```

```

0190 C*****
0191 SUBROUTINE ERROR(LU,IERR,LOC,IDCB,IPUR,ISTOP)
0192 DIMENSION IDCB(144)
0193 IF(IERR.GE.0)RETURN
0194 CALL CLOSE(IDCB)
0195 IF(LOC.NE.2HDA)WRITE(LU,100)IERR,LOC
0196 IF(LOC.EQ.2HDA)WRITE(LU,110)IERR,LOC
0197 IF(IPUR.EQ.1)CALL PURG(LU)
0198 IF(ISTOP.EQ.1)STOP 1111
0199 RETURN
0200 100 FORMAT(' FMR ERROR 'I5' IN 'A2)
0201 110 FORMAT(' DATA PROGRAM ERROR 'I5' IN 'A2)
0202 END
0203 C*****
0204 FUNCTION RATE1(IRATE)
0205 IF=0
0206 IF(IRATE.GT.3125)IP=1
0207 RATE1=FLOAT(3125*(IP+1))/FLOAT(3125*(IP+1)/IRATE)
0208 RETURN
0209 END

```

FTN4 COMPILER: HP92060-16092 REV. 1901 (781201)

```

00000 FTN0-L
00001 PROGRAM DAT2(3,20)
00002
00003 C
00004 C**DESIGNED TO BE USED WITH THE TCI 1224 3D HOT FILM PROBE,
00005 C**IT USES THE REDUCTION TECHNIQUES DESCRIBED IN TCI TD 2 TO OBTAIN
00006 C**THE U,V,W TIME SERIES.
00007 C
00008 COMMON /WK/ IPAR(5)
00009 DIMENSION POS(5),A(3,3),NAMTR(5),NAMCL(5),NAMTR2(5),NAMVL(5)
00010 CALL RHPAR(IPAR)
00011 LU=IPAR(1)
00012 IF(LU.LT.1)LU=1
00013 CALL LIBER(LU)
00014 CALL INNAM(NAMTR,NAMCL,NAMTR2,NAMVL,IAXIS,ICR,IPUR,LU)
00015 CALL VELCL(NAMCL,SL,LU)
00016 NC=0
00017 1 CONTINUE
00018 NC=NC+1
00019 CALL TRFIL(NAMTR,NC,IEND,LU)
00020 IF(IEND.EQ.1)GO TO 7
00021 CALL INPUT(RATE,NSAM,NSEG,POS,LU)
00022 CALL FILES(NSAM,NSEG,ICR,LU)
00023 CALL SETUP(POS,A,IAXIS,LU)
00024 CALL CONUT(NSAM,NSEG,POS,A,SL,LU)
00025 CALL REDUC(NSAM,NSEG,SL,LU)
00026 CALL ANOTH(NSAM,NSEG,LU)
00027 CALL SAVIT(RATE,NSAM,NSEG,SL,POS,NAMVL,LU)
00028 CALL F INFO(NSAM,RATE,NSEG,SL,LU)
00029 CALL TRANS(NAMTR2,IPUR,LU)
00030 IF(IPUR.NE.0)CALL PURG(LU)
00031 GO TO 1
00032 7 CONTINUE
00033 NC=NC-1
00034 WRITE(LU,150)NC
00035 150 FORMAT(' RUN COMPLETE ON '15' RUNS')
00036 END

```

```

0037 C*****
0038 BLOCK DATA
0039 COMMON /FIL/ IDCBD(144),NAME(5),IDCBD(144,3),NAMD(5,3)
0040 COMMON /CAL/ A(3),B(3),C(3),RK,T(2),F(2),UMIN,UHAX,SUP(3),AMP(3)
0041 COMMON /TAB/ CALIP(101,3),CSLPE(3),CICPT(3),NC PTS
0042 COMMON /VAL/ UMN(3),UMONT(3,3),VSTRS(3),UMIN(3),UHAX(3),HERR(3)
0043 + ,AGMIN(3),AGHAX(3),AMN(3),AMONT(3,3)
0044 COMMON /WK/ IDUH(1158)
0045 DATA NC PTS,NAME /101,2HSC,2HRA,2HTC,2HBN,15/
0046 DATA NAMD(1,1),NAMD(1,2),NAMD(1,3) /2HUU,2HVV,2HWW/
0047 END

```

```

0019 C*****
0020 SUBROUTINE INNAM(NAMTR,NAMCL,NAMTR2,NAMVL,IAXIS,ICR,IPUR,LU)
0021 DIMENSION NAMTR(5),NAMCL(5),NAMTR2(5),NAMVL(5)
0022 WRITE(LU,100)
0023 READ(LU,110)IAXIS
0024 WRITE(LU,170)
0025 READ(LU,*)IPUR
0026 WRITE(LU,120)
0027 CALL GNAME(LU,NAMTR,NAMTR(4),NAMTR(5),1)
0028 IF(IPUR.NE.0)GO TO 10
0029 WRITE(LU,130)
0030 CALL GNAME(LU,NAMTR2,NAMTR2(4),NAMTR2(5),1)
0031 10 CONTINUE
0032 WRITE(LU,140)
0033 CALL GNAME(LU,NAMCL,NAMCL(4),NAMCL(5),1)
0034 WRITE(LU,150)
0035 CALL GNAME(LU,NAMVL,NAMVL(4),NAMVL(5),1)
0036 WRITE(LU,160)
0037 READ(LU,*)ICR
0038 RETURN
0039 100 FORMAT('TYPE OF AXIS (RECT. OR CYL.)-')
0040 110 FORMAT(A2)
0041 120 FORMAT('ENTER TRANSFER FILE NAMR-(IN)')
0042 130 FORMAT('ENTER TRANSFER FILE NAMR-(OUT)')
0043 140 FORMAT('ENTER CALIBRATION FILE NAMR-')
0044 150 FORMAT('ENTER VALUES FILE NAMR-')
0045 160 FORMAT('ENTER CART. NO. FOR U, V, W, FILES')
0046 170 FORMAT('ENTER '0' TO SAVE U, V, W, FILES')
0047 END

0077 C*****
0078 SUBROUTINE TRFIL(NAMTR,NC,IEND,LU)
0079 COMMON /FIL/ IDC8(144),NAME(5)
0080 COMMON /WK/ IBUF(36),ITEN(10)
0081 DIMENSION NAMTR(5)
0082 CALL OPEN(IDC8,IERR,NAMTR,0,NAMTR(4),NAMTR(5))
0083 CALL ERROR(LU,IERR,2HTR)
0084 CALL FOSNT(IDC8,IERR,NC,1)
0085 IEND=0
0086 ISCR=1
0087 CALL READF(IDC8,IERR,IBUF,36,LEN2)
0088 CALL ERROR(LU,IERR,2HTR)
0089 LEN=LEN2*2
0090 IF(IBUF(1).EQ.2H:.)GO TO 20
0091 IF(LEN.LT.1)GO TO 20
0092 CALL NAMR(ITEN,IBUF,LEN,ISCR)
0093 IF(NAMR(ITEN,IBUF,LEN,ISCR)>20,10)
0094 10 IF(IP1(0,ITEN(4)).NE.3)GO TO 20
0095 NAME(1)=ITEN(1)
0096 NAME(2)=ITEN(2)
0097 NAME(3)=ITEN(3)
0098 NAME(4)=0
0099 IF(IP1(1,ITEN(4)).NE.0)NAME(4)=ITEN(5)
0100 NAME(5)=0
0101 IF(IP1(2,ITEN(4)).EQ.1)NAME(5)=ITEN(6)
0102 CALL CLOSE(IDC8)
0103 CALL OPEN(IDC8,IERR,NAME,0,NAME(4),NAME(5))
0104 CALL ERROR(LU,IERR,2HTR)
0105 RETURN
0106 20 CONTINUE
0107 CALL PURGE(IDC8,IERR,NAMTR,NAMTR(4),NAMTR(5))
0108 IEND=1
0109 RETURN
0110 END

```

```

0111 C*****
0112 FUNCTION IP1(IPR,IWORD)
0113 JWORD=IWORD/(4*IPR)
0114 IP1=MOD(JWORD,4)
0115 RETURN
0116 END

0117 C*****
0118 SUBROUTINE INPUT(RATE,NSAM,NSEG,POS,LU)
0119 COMMON /FIL/ IDC(144),NAME(5),IDUM(447)
0120 COMMON /CAL/ DUM(10),T(2),DUM1(10)
0121 COMMON /WK/ IB(128)
0122 DIMENSION POS(6),POS1(6)
0123 EQUIVALENCE (IB(1),NSAM1),(IB(2),RATE1),(IB(4),IBLOC),
0124 + (IB(5),POS1(1)),(IB(17),OPTEMP)
0125 NBLOC=IDC(6)/2
0126 CALL READF(IDC,IERR,IB,128,LEN,NBLOC)
0127 CALL ERROR(LU,IERR,2HIF)
0128 CALL POSNT(IDC,IERR,1,1)
0129 DO 10 I=1,6
0130 POS(I)=POS1(I)
0131 10 CONTINUE
0132 T(2)=OPTEMP
0133 NSAM=NSAM1
0134 RATE=RATE1
0135 NSEG=IBLOC/(NSAM/128)
0136 TIME=FLOAT(NSEG)*FLOAT(NSAM)/RATE
0137 WRITE(LU,110)NSAM,NSEG,RATE,TIME,OPTEMP
0138 RETURN
0139 110 FORMAT(///"*****"
0140 + /"NO. OF SAMPLES=" 'I5/
0141 + "NO. OF SEGMENTS=" 'I5/
0142 + "SAMPLE RATE=" 'F7.2/
0143 + "TIME DURATION=" 'F8.2/
0144 + "OPERATION TEMP.=" 'F5.1/)
0145 END

```

```

0146 C*****
0147 SUBROUTINE VELCL(NAMCL,SL,LU)
0148 COMMON /CAL/ A(3),B(3),C(3),RK,T(2),F(2),UMIN,UMAX,SUP(3),AMP(3)
0149 COMMON /FIL/ IDC(144)
0150 COMMON /WK/ IBUF(18)
0151 DIMENSION NAMCL(5)
0152 EQUIVALENCE (IBUF(1),A1),(IBUF(3),B1),(IBUF(5),C1),(IBUF(7),RK1),
0153 + (IBUF(9),CLTEMP),(IBUF(11),UMIN1),(IBUF(13),UMAX1),
0154 + (IBUF(15),SUP1),(IBUF(17),AMP1)
0155 CALL OPEN(IDC,IERR,NAMCL,0,NAMCL(4),NAMCL(5))
0156 CALL ERROR(LU,IERR,2HVE)
0157 DO 10 IC=1,3
0158 CALL READF(IDC,IERR,IBUF)
0159 CALL ERROR(LU,IERR,2HVE)
0160 A(IC)=A1
0161 B(IC)=B1
0162 C(IC)=C1
0163 RK=RK1
0164 CLTEMP=CLTEMP1
0165 UMIN=UMIN1
0166 UMAX=UMAX1
0167 SUP(IC)=SUP1
0168 AMP(IC)=AMP1
0169 10 CONTINUE
0170 WRITE(LU,110)
0171 DO 30 IC=1,3
0172 WRITE(LU,120)IC,A(IC),B(IC),C(IC),RK,CLTEMP,UMIN,UMAX
0173 + ,SUP(IC),AMP(IC)
0174 30 CONTINUE
0175 90 CONTINUE
0176 SL=UMAX/32752.0
0177 T(1)=CLTEMP
0178 CALL TABLE
0179 CALL CLOSE(IDC)
0180 RETURN
0181 110 FORMAT('CHANNEL A*6X*B*7X*C*7X*K *1X*CAL TEMP*2X*UMIN*
0182 + UMAX SUPPRES AMPLIFY')
0183 120 FORMAT(1X,12,4X,F6.3,2X,F6.4,2X,F6.4,2X,F5.3,2X,F4.1,2X,
0184 + F6.2,2X,F6.2,2X,F6.3,2X,F5.2)
0185 END

```

```

0186 C*****
0187 SUBROUTINE TABLE
0188 COMMON /CAL/ A(3),B(3),C(3),RK,T(2),F(2),UMIN,UMAX,SUP(3),AMP(3)
0189 COMMON /TAB/ CALIB(101,3),CSLPE(3),CICPT(3),NC PTS
0190 C DATA ALPHA /0.00392/
0191 DATA PI /3.14159/
0192 F(1)=2.+RK*RK
0193 F(2)=1.-RK*RK
0194 TFAC=1.0
0195 C TFAC=SQRT(1./(1.+ALPHA*(T(1)-T(2))/0.5))
0196 C AFACHN=SQRT(COS(PI/2.))**2+(RK*SIN(PI/2.))**2)
0197 AFACHN=RK
0198 C AFACHX=SQRT(COS(0.0)**2+(RK*SIN(0.0))**2)
0199 AFACHX=1.0
0200 DO 2 J=1,3
0201 ERMIN=SQRT(TFAC*(A(J)+B(J))*(UMIN*AFACHN)**C(J))
0202 EMIN=(ERMIN-SUP(J))*AMP(J)
0203 IF (EMIN.LT.-10.0)EMIN=-10.0
0204 ERMAX=SQRT(TFAC*(A(J)+B(J))*(UMAX*AFACHX)**C(J))
0205 EMAX=(ERMAX-SUP(J))*AMP(J)
0206 IF (EMAX.GT.10.0)EMAX=10.0
0207 DEL E=(EMAX-EMIN)/FLOAT(NC PTS-1)
0208 E=EMIN-DEL E
0209 POW=2.0/C(J)
0210 DO 1 I=1,NC PTS
0211 E=E+DEL E
0212 ER=E/AMP(J)+SUP(J)
0213 CALIB(I,J)=(ER*ER/TFAC-A(J))/B(J)**POW
0214 1 CONTINUE
0215 CMIN=EMIN*3275.2
0216 CMAX=EMAX*3275.2
0217 CSLPE(J)=FLOAT(NC PTS-1)/(CMAX-CMIN)
0218 CICPT(J)=-CSLPE*CMIN+1.0
0219 2 CONTINUE
0220 RETURN
0221 END

0222 C*****
0223 SUBROUTINE FILES(NSAM,NSEG,ICR,LU)
0224 COMMON /FIL/ IDCB(144),NAME(5),IDCB(144,3),NAMD(5,3)
0225 COMMON /WK/ ISIZE(2)
0226 NAMD(2,1)=NAME(2)
0227 NAMD(2,2)=NAME(2)
0228 NAMD(2,3)=NAME(2)
0229 NAMD(3,1)=NAME(3)
0230 NAMD(3,2)=NAME(3)
0231 NAMD(3,3)=NAME(3)
0232 NAMD(4,1)=NAME(4)
0233 NAMD(4,2)=NAME(4)
0234 NAMD(4,3)=NAME(4)
0235 NAMD(5,1)=ICR
0236 NAMD(5,2)=ICR
0237 NAMD(5,3)=ICR
0238 ISIZE(1)=(NSAM/128)*NSEG+1
0239 DO 2 I=1,3
0240 CALL CREAT(IDCB(1,I),IERR,NAMD(1,I),ISIZE,1,NAMD(4,I),
0241 + NAMD(5,I))
0242 CALL ERROR(LU,IERR,2HFI)
0243 CALL CLOSE(IDCB(1,I))
0244 CALL OPEN(IDCB(1,I),IERR,NAMD(1,I),1,NAMD(4,I),NAMD(5,I))
0245 CALL ERROR(LU,IERR,2HFI)
0246 2 CONTINUE
0247 RETURN
0248 END

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0219 C*****
0250 SUBROUTINE SETUP(POS,C,IAXIS,LU)
0251 C
0252 C**CALCULATES THE DIRECTION COSINE TENSOR 'C(3,3)' FOR THE COORDINATE
0253 C TRANSFORMATION FROM 1294 3D PROBES SENSOR COORDINATES TO THOSE OF THE
0254 C DESIRED TUNNEL COORDINATES. 'IAXIS'=2HRE FOR RECTANGULAR SYSTEM,
0255 C 'IAXIS'=2HCY FOR CYLINDERICAL SYSTEM.
0256 C POS(1,2,3) ARE THE LOCATIONS OF THE PROBE IN THE TUNNEL COORDINATES
0257 C X, Y & Z RESPECTIVELY. WHEN A CONVERSION IS MADE FROM RECTANGULAR
0258 C TO CYLINDERICAL COORDINATES, X REMAINS THE SAME AND POS(2&3) ARE
0259 C CHANGED FROM THE INPUTED Y, Z VALUES TO R, THETA VALUES.
0260 C FOR THE CYLINDERICAL SYSTEM, WHEN LOOKING DOWN (+TO-) THE POSITIVE
0261 C X AXIS THE THETA COMPONENT IS POSITIVE IN THE COUNTERCLOCKWISE SENSE.
0262 C POS(4,5&6) ARE THE ROTATIONAL ANGLES ABOUT THE X, Y & Z AXIS OF THE
0263 C PROBE SUPPORT COORDINATES FROM AN INITIAL ALIGNMENT WITH THE TUNNEL
0264 C COORDINATES RESPECTIVELY. THE ROTATIONAL SEQUENCE MUST BE IN THE ORDER
0265 C ABOUT Z, THEN Y, THEN X SINCE PROBE COORDINATES WILL NO LONGER BE ALIGNED
0266 C WITH TUNNEL COORDINATES AFTER THE FIRST ROTATION. THE SENSE OF THE
0267 C ROTATION IS: LOOKING DOWN (+TO-) THE POSITIVE AXIS OF THE PROBE
0268 C COORDINATE SYSTEM THE OTHER TWO AXIS ARE ROTATED IN A CLOCKWISE
0269 C**DIRECTION RESULTS IN A POSITIVE ANGLE,
0270 C
0271 COMMON /WK/ A(3,3),B(3,3)
0272 DIMENSION POS(6)-C(3,3)
0273 DATA PI /3.14159/
0274 CONST=PI/180.0
0275 C .....FIND TRANSFORMATION TENSOR 'A' FOR
0276 C PROBE TO SENSOR CONVERSION.
0277 ROT X=0.0*CONST
0278 ROT Y=35.26*CONST
0279 ROT Z=-45.0*CONST
0280 CALL TRXYZ(A,ROT X,ROT Y,ROT Z)
0281 C .....TAKE TRANSPOSE OF 'A' TO FIND
0282 C SENSOR TO PROBE CONVERSION.
0283 DO 20 I=1,2
0284 DO 10 J=I+1,3
0285 SAVE=A(I,J)
0286 A(I,J)=A(J,I)
0287 A(J,I)=SAVE
0288 10 CONTINUE
0289 20 CONTINUE
0290 C .....FIND TRANSFORMATION TENSOR 'B' FOR
0291 C PROBE TO TUNNEL CONVERSION.
0292 ROT X=POS(4)*CONST
0293 ROT Y=POS(5)*CONST
0294 ROT Z=POS(6)*CONST
0295 CALL TRXYZ(B,ROT X,ROT Y,ROT Z)
0296 C .....CALCULATE TOTAL TRANSFORMATION TENSOR
0297 C 'C' FOR SENSOR TO TUNNEL CONVERSION.
0298 CALL TMULT(A,B,C)
0299 IF(IAXIS.NE.2HCY)RETURN
0300 C .....CONVERT FROM RECT. COOR. TO CYL.
0301 C COOR. BY CALCULATING THE TRANS.
0302 C TENSOR 'A' FOR THE ROTATION ABOUT
0303 C THE X AXIS (THETA=ATAN(Z/Y)) THAT

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0304 C                                     IS NECESSARY. THEN RECALCULATE
0305 C                                     'C' TO INCLUDE THIS LAST TRANS.
0306 Y=POS(2)
0307 Z=POS(3)
0308 IF(Y.EQ.0.0.AND.Z.EQ.0.0)GO TO 21
0309 GO TO 22
0310 21 CONTINUE
0311 THETA=0.0
0312 GO TO 27
0313 22 CONTINUE
0314 IF(Y.EQ.0.0.AND.Z.GT.0.0)GO TO 23
0315 GO TO 24
0316 23 CONTINUE
0317 THETA=PI/2.0
0318 GO TO 27
0319 24 CONTINUE
0320 IF(Y.EQ.0.0.AND.Z.LT.0.0)GO TO 25
0321 GO TO 26
0322 25 CONTINUE
0323 THETA=-PI/2.0
0324 GO TO 27
0325 26 CONTINUE
0326 THETA=ATAN(Z/Y)
0327 IF(Y.LT.0.0)THETA=THETA+PI
0328 27 CONTINUE
0329 POS(2)=SQRT(Y*Y+Z*Z)
0330 POS(3)=THETA/CONST
0331 DO 40 I=1,3
0332 DO 30 J=1,3
0333 A(I,J)=C(I,J)
0334 30 CONTINUE
0335 40 CONTINUE
0336 CALL TRXYZ(B,THETA,0.,0.)
0337 CALL TMULT(A,B,C)
0338 RETURN
0339 END

```

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0340 C*****
0341 SUBROUTINE TRXYZ(A,X,Y,Z)
0342 C
0343 C FINDS THE CARTESIAN COORDINATE TRANSFORMATION TENSOR FOR ROTATIONS
0344 C ABOUT X AXIS, THEN Y AXIS, THEN Z AXIS. POSITIVE ROTATION IS
0345 C COUNTERCLOCKWISE WHEN LOOKING FROM + TO - ON THE AXIS.
0346 C
0347 DIMENSION A(3,3)
0348 A(1,1)=COS(Y)*COS(Z)
0349 A(1,2)=COS(X)*SIN(Z)+SIN(X)*SIN(Y)*COS(Z)
0350 A(1,3)=SIN(X)*SIN(Z)-COS(X)*SIN(Y)*COS(Z)
0351 A(2,1)=-COS(Y)*SIN(Z)
0352 A(2,2)=-SIN(X)*SIN(Y)*SIN(Z)+COS(X)*COS(Z)
0353 A(2,3)=SIN(X)*COS(Z)+COS(X)*SIN(Y)*SIN(Z)
0354 A(3,1)=SIN(Y)
0355 A(3,2)=-SIN(X)*COS(Y)
0356 A(3,3)=COS(X)*COS(Y)
0357 RETURN
0358 END

```

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0359 C*****
0360 SUBROUTINE TMULT(A,B,C)
0361 DIMENSION A(3,3),B(3,3),C(3,3)
0362 DO 30 I=1,3
0363     DO 20 J=1,3
0364         C(I,J)=0.0
0365     DO 10 K=1,3
0366         C(I,J)=C(I,J)+B(I,K)*A(K,J)
0367 10 CONTINUE
0368 20 CONTINUE
0369 30 CONTINUE
0370 RETURN
0371 END

```

```

0372 C*****
0373 SUBROUTINE CONV(NSAM,NSEG,POS,A,SL,LU)
0374 COMMON /FIL/ IDCBD(144),NAME(5),IDCRD(144,3),NAMD(5,3)
0375 COMMON /VAL/ V(3),IDUM(36),NERR(3)
0376 COMMON /WK/ IBUF(384),IBUFD(128,3),SUM(3),JERR(3)
0377 DIMENSION POS(6),A(3,3)
0378 DO 10 I=1,3
0379     JERR(I)=0
0380     NERR(I)=0
0381     SUM(I)=0.0
0382 10 CONTINUE
0383 NBLKS=(NSAM/128)*NSEG
0384 DO 5 I=1,NBLKS
0385     CALL READF(IDCBD,IERR,IBUF,384)
0386     CALL ERROR(LU,IERR,2HCO)
0387     IPOS=-2
0388     DO 3 J=1,128
0389         IPOS=IPOS+3
0390         CALL UVW(IBUF(IPOS),V,VTOT,JERR,LU)
0391         CALL CHECK(V,VTOT,NERR)
0392         CALL TCOOR(V,A)
0393         DO 1 K=1,3
0394             IBUFD(J,K)=IFIX(V(K)/SL)
0395             SUM(K)=SUM(K)+V(K)
0396 1 CONTINUE
0397 3 CONTINUE
0398 DO 4 K=1,3
0399     CALL WRITF(IDCBD(1,K),IERR,IBUFD(1,K),12B)
0400     CALL ERROR(LU,IERR,2HCO)
0401 4 CONTINUE
0402 5 CONTINUE
0403 DO 6 K=1,3
0404     V(K)=SUM(K)/(128.0*FLOAT(NBLKS))
0405 6 CONTINUE
0406 CALL OUT1(NAMD,POS,V,SL,JERR,NERR,LU)
0407 CALL PURGE(IDCBD,IERR,NAME,NAME(4),NAME(5))
0408 RETURN
0409 END

```

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0410 C*****
0411 SUBROUTINE UVW(IAD,V,VTOT,JERR,LU)
0412 COMMON /CAL/ A(3),B(3),C(3),RK,T(2),F(2),UMIN,UMAX,SUP(3),AMP(3)
0413 COMMON /TAB/ CALIB(101,3),CSLPE(3),CICPT(3),NC PTS
0414 DIMENSION IAD(3),V(3),JERR(3),VEFF2(3)
0415 SUM=0.0
0416 DO 10 I=1,3
0417   BIN=FLOAT(IAD(I))*CSLPE(I)+CICPT(I)
0418   N=IFIX(BIN)
0419   IF(N,GE,1)GO TO 2
0420     JERR(1)=JERR(1)+1
0421     BIN=1.0
0422     N=1
0423     GO TO 4
0424 2   CONTINUE
0425   IF(N,LE,100)GO TO 4
0426     JERR(2)=JERR(2)+1
0427     BIN=101.0
0428     N=100
0429     GO TO 4
0430 4   CONTINUE
0431   DEL=(CALIB(N+1,I)-CALIB(N,I))*(BIN-FLOAT(N))
0432   VEFF2(I)=CALIB(N,I)+DEL
0433   SUM=SUM+VEFF2(I)
0434 10  CONTINUE
0435   VTOT2=SUM/F(1)
0436   DO 30 I=1,3
0437     TEMPX=VTOT2-VEFF2(I)
0438     IF(TEMPX,GE,0.0)GO TO 20
0439     TEMPX=0.0
0440     JERR(3)=JERR(3)+1
0441 20  CONTINUE
0442     V(I)=SQRT(TEMPX/F(2))
0443 30  CONTINUE
0444   VTOT=SQRT(VTOT2)
0445   RETURN
0446   END

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0446 C*****
0447 SUBROUTINE CHECK(V,VTOT,NERR)
0448 DIMENSION V(3),NERR(3)
0449 DATA SIN10,SIN80 /0.1736,0.9848/
0450 DO 1 I=1,3
0451   S=V(I)/VTOT
0452   IF(X,LT,SIN10,OR,X,GT,SIN80)NERR(I)=NERR(I)+1
0453 1   CONTINUE
0454   RETURN
0455   END

```

```

0456 C*****
0457 SUBROUTINE TCOOR(V,A)
0458 DIMENSION V(3),A(3,3),VTUN(3)
0459 DO 2 I=1,3
0460   VTUN(I)=0.0
0461   DO 1 J=1,3
0462     VTUN(I)=VTUN(I)+A(I,J)*V(J)
0463 1   CONTINUE
0464 2   CONTINUE
0465   DO 3 I=1,3
0466     V(I)=VTUN(I)
0467 3   CONTINUE
0468   RETURN
0469   END

```

```

0470 C*****
0471 SUBROUTINE OUT1(NAMD,POS,V,SL,JERR,NERR,LU)
0472 COMMON /WK/ ANGLE(3)
0473 DIMENSION NAMD(5,3),POS(6),V(3),JERR(3),NERR(3)
0474 WRITE(LU,100)
0475 DO 1 J=1,3
0476 1 WRITE(LU,110)(NAMD(I,J),I=1,3),(POS(I),I=1,6),V(J),SL
0477 VTOT=SQRT(V(1)*V(1)+V(2)*V(2)+V(3)*V(3))
0478 WRITE(LU,120)VTOT
0479 DO 2 I=1,3
0480 ANGLE(I)=ATAN(V(I)/SQRT((VTOT-V(I))*(VTOT+V(I))))
0481 ANGLE(I)=90.0-ANGLE(I)*180.0/3.14159
0482 2 CONTINUE
0483 WRITE(LU,130)(ANGLE(I),I=1,3)
0484 IF(JERR(1).NE.0)WRITE(LU,140)JERR(1)
0485 IF(JERR(2).NE.0)WRITE(LU,145)JERR(2)
0486 IF(JERR(3).NE.0)WRITE(LU,150)JERR(3)
0487 IF(NERR(1).NE.0.OR.NERR(2).NE.0.OR.NERR(3).NE.0)
0488 + WRITE(LU,160)(NERR(I),I=1,3)
0489 RETURN
0490 100 FORMAT(' FILE LINEAR POSITION ROTATIONAL POSITION(DEG)'
0491 + ' MEAN VEL. CONVERSION "/ NAME X Y 2 '
0492 + ' X Y Z CONSTANT')
0493 110 FORMAT(3A2,5X,6(F7.2),4X,F7.2,3X,G11.4)
0494 120 FORMAT('MEAN TOTAL VELOCITY ='F7.1)
0495 130 FORMAT('MEAN COMP. ANGLES = 'F6.1' FROM X AXIS'/
0496 + ' 'F6.1' FROM Y AXIS'/
0497 + ' 'F6.1' FROM Z AXIS'/)
0498 140 FORMAT('/***** LOWER CAL. RANGE WAS EXCEEDED *15* TIMES *****/)
0499 145 FORMAT('/***** UPPER CAL. RANGE WAS EXCEEDED *15* TIMES *****/)
0500 150 FORMAT('/***** CALCULATIONAL ERROR OCCURED *15* TIMES *****/)
0501 160 FORMAT('/*** VELOCITY VECTOR 1 EXCEEDED DIR. LIMITS *15* TIMES'
0502 + '/*** VELOCITY VECTOR 2 EXCEEDED DIR. LIMITS *15* TIMES'
0503 + '/*** VELOCITY VECTOR 3 EXCEEDED DIR. LIMITS *15* TIMES')
0504 END

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```

0505 C*****
0506 SUBROUTINE REDUC(NSAM,NSEG,SL,LU)
0507 COMMON /FIL/ IDCBD(144),NAME(5),IDCB(144,3),NAME(5,3)
0508 COMMON /VAL/ VMN(3),VMDMT(3,3),VSTRS(3),VMIN(3),VMAX(3),NERR(3)
0509 COMMON /WK/ IBUFD(128,3),V(128,3),CVMN(3)
0510 DO 1 I=1,3
0511   CALL POSNT(IDCB(1,I),IERR,1,1)
0512   CALL ERROR(LU,IERR,2HRE)
0513   CVMN(I)=VMN(I)/SL
0514   VMIN(I)=1.E30
0515   VMAX(I)=-1.E30
0516 1 CONTINUE
0517 NBLKS=(NSAM/128)*NSEG
0518 DO 4 I=1,NBLKS
0519   DO 3 J=1,3
0520     CALL READF(IDCB(1,J),IERR,IBUFD(1,J),128)
0521     CALL ERROR(LU,IERR,2HRE)
0522     DO 2 K=1,128
0523       V(K,J)=FLOAT(IBUFD(K,J))
0524       VMIN(J)=AMIN1(VMIN(J),V(K,J))
0525       VMAX(J)=AMAX1(VMAX(J),V(K,J))
0526     2 CONTINUE
0527     CALL MHMET(V(1,J),CVMN(J),VMDMT(1,J),I)
0528   3 CONTINUE
0529   CALL STRES(V,CVMN,VSTRS,I)
0530 4 CONTINUE
0531 DO 5 I=1,3
0532   VMDMT(2,I)=VMDMT(2,I)/(VMDMT(1,I)**1.5)
0533   VMDMT(3,I)=VMDMT(3,I)/(VMDMT(1,I)*VMDMT(1,I))
0534   VMDMT(1,I)=SL*SQRT(VMDMT(1,I))
0535   VSTRS(I)=VSTRS(I)*SL*SL
0536   VMIN(I)=VMIN(I)*SL
0537   VMAX(I)=VMAX(I)*SL
0538 5 CONTINUE
0539 CALL OUT2(VMDMT,VSTRS,VMIN,VMAX,LU)
0540 RETURN
0541 END

```

```

0542 C*****
0543 SUBROUTINE MHMET(V,VMN,VMDMT,N)
0544 DIMENSION V(128),VMDMT(3)
0545 SUM1=0.0
0546 SUM2=0.0
0547 SUM3=0.0
0548 WIGHT=1.0/FLOAT(N)
0549 DO 1 I=1,128
0550   X=V(I)-VMN
0551   XX=X*X
0552   SUM1=SUM1+XX
0553   SUM2=SUM2+XX*X
0554   SUM3=SUM3+XX*XX
0555 1 CONTINUE
0556 VMDMT(1)=VMDMT(1)*(1.-WIGHT)+SUM1*WIGHT/128.0
0557 VMDMT(2)=VMDMT(2)*(1.-WIGHT)+SUM2*WIGHT/128.0
0558 VMDMT(3)=VMDMT(3)*(1.-WIGHT)+SUM3*WIGHT/128.0
0559 RETURN
0560 END

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0561 C*****
0562 SUBROUTINE STRES(VEL,VHN,VSTRS,N)
0563 DIMENSION VEL(128,3),VHN(3),VSTRS(3)
0564 SUM1=0.0
0565 SUM2=0.0
0566 SUM3=0.0
0567 WIGHT=1.0/FLOAT(N)
0568 DO 1 I=1,128
0569   U=VEL(I,1)-VHN(1)
0570   V=VEL(I,2)-VHN(2)
0571   W=VEL(I,3)-VHN(3)
0572   SUM1=SUM1+U*W
0573   SUM2=SUM2+U*V
0574   SUM3=SUM3+V*W
0575 1 CONTINUE
0576 VSTRS(1)=VSTRS(1)*(1.-WIGHT)+SUM1*WIGHT/128.0
0577 VSTRS(2)=VSTRS(2)*(1.-WIGHT)+SUM2*WIGHT/128.0
0578 VSTRS(3)=VSTRS(3)*(1.-WIGHT)+SUM3*WIGHT/128.0
0579 RETURN
0580 END

```

```

0581 C*****
0582 SUBROUTINE OUT2(VMOMT,VSTRS,VMIN,VMAX,LU)
0583 DIMENSION VMOMT(3,3),VSTRS(3),VMIN(3),VMAX(3)
0584 WRITE(LU,100)
0585 WRITE(LU,102)(VMIN(I),I=1,3)
0586 WRITE(LU,104)(VMAX(I),I=1,3)
0587 WRITE(LU,110)(VMOMT(I,I),I=1,3)
0588 WRITE(LU,120)((VMOMT(I,J),J=1,3),I=2,3)
0589 WRITE(LU,130)(VSTRS(I),I=1,3)
0590 RETURN
0591 100 FORMAT(22X*U*8X*V*9X*W*)
0592 102 FORMAT(72X*MIN. VELOCITY= *3(F8.3,2X))
0593 104 FORMAT(2X*MAX. VELOCITY= *3(F8.3,2X))
0594 110 FORMAT(2X*RMS VELOCITY = *3(F8.3,2X))
0595 120 FORMAT(2X*SKEWNESS = *3(F8.3,2X)/
0596 + 2X*FLATNESS = *3(F8.3,2X))
0597 130 FORMAT(72X*UW*8X*UV*8X*VW*/
0598 + 2X*REY. STRESS = *3(F8.5,2X))
0599 END

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```

0600 C*****
0601 SUBROUTINE ANGTH(NSAM,NSEG,LU)
0602 COMMON /VAL/ IDUM(45),AGMIN(3),AGMAX(3),AMN(3),AMOMT(3,3)
0603 COMMON /FIL/ IDUM1(581),NAM(5,3)
0604 DIMENSION IB(36),NAMF(3)
0605 EQUIVALENCE (IB(1),AGMIN(1))
0606 DATA NAMF /2HAN,2HGT,2HM /
0607 CALL EXEC(23,NAMF,NSAM,NSEG,LU,ID,ID,NAMD,15)
0608 CALL EXEC(14,1,IB,36)
0609 RETURN
0610 END

```

```

0611 C*****
0612 SUBROUTINE SAVIT(RATE,NSAM,NSEG,SL,POS,NAMVL,LU)
0613 COMMON /FIL/ IDUM(S81),NAMD(5,3)
0614 COMMON /VAL/ VMN(3),VMONT(3,3),VSTRS(3),VMIN(3),VMAX(3),NERR(3)
0615 + ,AGMIN(3),AGMAX(3),AMN(3),AMONT(3,3)
0616 COMMON /WK/ IBUF(114),IB2(18)
0617 DIMENSION POS(6),POS1(6),IB1(15),IB4(81),NAMVL(5)
0618 EQUIVALENCE (IB1(1),NAMD(1,1)),(IB2(1),RATE1),(IB2(3),NSAM1),
0619 + (IB2(4),NSEG1),(IB2(5),SL1),(IB2(7),POS1(1)),
0620 + (IB4(1),VMN(1))
0621 RATE1=RATE
0622 NSAM1=NSAM
0623 NSEG1=NSEG
0624 SL1=SL
0625 DO 1 I=1,6
0626 POS1(I)=POS(I)
0627 1 CONTINUE
0628 DO 3 I=1,15
0629 IBUF(I)=IB1(I)
0630 3 CONTINUE
0631 DO 4 I=1,18
0632 J=I+15
0633 IBUF(J)=IB2(I)
0634 4 CONTINUE
0635 DO 6 I=1,81
0636 J=I+33
0637 IBUF(J)=IB4(I)
0638 6 CONTINUE
0639 CALL WREC(IBUF,114,NAMVL,LU)
0640 CONTINUE
0641 RETURN
0642 END

0643 C*****
0644 SUBROUTINE F INFO(NSAM,RATE,NSEG,SL,LU)
0645 COMMON /FIL/ IDCBD(144),NAME(5),IDCBD(144,3),NAMD(5,3)
0646 COMMON /VAL/ VMN(3),VMONT(3,3),VSTRS(3),VMIN(3),VMAX(3),NERR(3)
0647 COMMON /WK/ IBUF(128)
0648 EQUIVALENCE (IBUF(1),NSM),(IBUF(2),RATE1),(IBUF(4),IBLOC),
0649 + (IBUF(5),RMN),(IBUF(7),RMS),(IBUF(9),SLPE)
0650 NSM=NSAM
0651 RATE1=RATE
0652 IBLOC=(NSAM/128)*NSEG
0653 SLPE=1.0/SL
0654 DO 10 I=1,3
0655 RMN=VMN(I)
0656 RMS=VMONT(1,I)
0657 CALL WRITEF(IDCBD(1,I),IERR,IBUF,128,(IBLOC+1))
0658 CALL ERROR(LU,IERR,2HF)
0659 10 CONTINUE
0660 RETURN
0661 END

```

```

0662 C*****
0663 SUBROUTINE WREC(IB,N,NAM,LU)
0664 COMMON /WK/ ISAV(200),IDCB(144),ISIZ(2),IB1(10)
0665 DIMENSION IB(1),NAM(5)
0666 ISIZ(1)=24
0667 ISIZ(2)=N
0668 CALL OPEN(IDCB,IERR,NAM,2,NAM(4),NAM(5))
0669 IF(IERR.EQ.-6)CALL CREAT(IDCB,IERR,NAM,ISIZ,3,NAM(4),NAM(5))
0670 CALL ERROR(LU,IERR,2HWR)
0671 10 CONTINUE
0672 CALL READF(IDCB,IERR,IB1,10,LEN)
0673 CALL ERROR(LU,IERR,2HWR)
0674 IF(LEN.NE.-1)GO TO 10
0675 CALL POSNT(IDCB,IERR,-1)
0676 CALL ERROR(LU,IERR,2HWR)
0677 CALL WRITE(IDCB,IERR,IB,N)
0678 CALL ERROR(LU,IERR,2HWR)
0679 CALL CLOSE(IDCB)
0680 RETURN
0681 END

```

```

0682 C*****
0683 SUBROUTINE TRANS(NAMTR2,IPUR,LU)
0684 COMMON /FIL/ IDCB(144),NAME(5),IDCB(144,3),NAM(5,3)
0685 DIMENSION NAMTR2(5),IB(10)
0686 DO 10 I=1,3
0687 CALL CLOSE(IDCB(1,I))
0688 IF(IPUR.NE.0)GO TO 10
0689 CALL CODE
0690 WRITE(IB,100)(NAM(J,I),J=1,5)
0691 CALL WREC(IB,10,NAMTR2,LU)
0692 10 CONTINUE
0693 RETURN
0694 100 FORMAT(' :PU,"3A2":'I5':'I3)
0695 END

```

```

0704 C*****
0705 SUBROUTINE ERROR(LU,IERR,LOC)
0706 COMMON /FIL/ IDCB(144),NAME(5),IDCB(144,3),NAM(5,3)
0707 IF(IERR.GE.0)RETURN
0708 CALL CLOSE(IDCB)
0709 DO 10 I=1,3
0710 CALL CLOSE(IDCB(1,I))
0711 10 CONTINUE
0712 WRITE(LU,100)IERR,LOC
0713 STOP 1111
0714 100 FORMAT(' FMGR ERROR 'I5' IN 'A2)
0715 END

```



```

0001  FTH4,L
0002  PROGRAM ANGTN(3,95)
0003  DIMENSION ID(15),IB(36),IDCB(144,3),AMN(3),AMONT(3,3),AGMIN(3),
0004  +      AGMAX(3),IPAR(5),NAMD(5,3)
0005  EQUIVALENCE (ID(1),NAMD(1,1)),(IPAR(1),NSAM),
0006  +      (IPAR(2),NSEC),(IPAR(3),LU),
0007  +      (IB(1),AGMIN(1)),(IB(7),AGMAX(1)),(IB(13),AMN(1)),
0008  +      (IP(12),AMONT(1,1))
0009  CALL RMPAR(IPAR)
0010  CALL LIPER(LU)
0011  CALL EXEC(14,1,ID,15)
0012  DO 10 I=1,3
0013  +      CALL OPEN(IDCB(1,I),IERR,NAMD(1,I),1,NAMD(4,I),NAMD(5,I))
0014  +      CALL ERROR(LU,IERR,2HAN)
0015  10  CONTINUE
0016  CALL ANGLE(NSAM,NSEC,IDCB,AMN,AMONT,AGMIN,AGMAX,LU)
0017  DO 20 I=1,3
0018  +      CALL CLOSE(IDCB(1,I))
0019  20  CONTINUE
0020  CALL EXEC(14,2,IB,36)
0021  END

```

```

0022 C*****
0023 SUBROUTINE ANGLE(NSAM,NSEG,IDCB,AMN,AMONT,AGMIN,AGMAX,LU)
0024 DIMENSION AMN(3),AMONT(3,3),AGMIN(3),AGMAX(3),IDCB(144,3),
0025 + IB(128,3),V(128,3),SUM(3)
0026 DATA PI2,CON /1.5708,57.222/
0027 NBLKS=(NSAM/128)*NSEG
0028 DO 5 J=1,3
0029 SUM(J)=0.0
0030 AGMIN(J)=1.E30
0031 AGMAX(J)=-1.E30
0032 5 CONTINUE
0033 DO 35 I=1,NBLKS
0034 DO 15 J=1,3
0035 CALL READF(IDCB(1,J),IERR,IB(1,J),128,LEN,I)
0036 CALL ERROR(LU,IERR,2HAN)
0037 DO 10 K=1,128
0038 V(K,J)=FLOAT(IB(K,J))
0039 10 CONTINUE
0040 15 CONTINUE
0041 DO 30 K=1,128
0042 SUMT=0.0
0043 DO 20 J=1,3
0044 SUMT=SUMT+V(K,J)*V(K,J)
0045 20 CONTINUE
0046 VT=SQRT(SUMT)
0047 DO 25 J=1,3
0048 AGR=V(K,J)/SQRT((VT-V(K,J))*(VT+V(K,J)))
0049 ANG=PI2-ATAN(AGR)
0050 SUM(J)=SUM(J)+ANG
0051 AGMIN(J)=AMIN1(AGMIN(J),ANG)
0052 AGMAX(J)=AMAX1(AGMAX(J),ANG)
0053 IB(K,J)=IFIX(ANG*CON*100.0)
0054 25 CONTINUE
0055 30 CONTINUE
0056 35 CONTINUE
0057 DO 40 J=1,3
0058 AMN(J)=SUM(J)/(FLOAT(NBLKS)*128.0)
0059 40 CONTINUE
0060 DO 90 I=1,NBLKS
0061 DO 55 J=1,3
0062 CALL READF(IDCB(1,J),IERR,IB(1,J),128,LEN,I)
0063 CALL ERROR(LU,IERR,2HAN)
0064 DO 50 K=1,128
0065 V(K,J)=FLOAT(IB(K,J))
0066 50 CONTINUE
0067 55 CONTINUE
0068 DO 70 K=1,128
0069 SUMT=0.0
0070 DO 60 J=1,3
0071 SUMT=SUMT+V(K,J)*V(K,J)
0072 60 CONTINUE
0073 VT=SQRT(SUMT)
0074 DO 65 J=1,3
0075 AGR=V(K,J)/SQRT((VT-V(K,J))*(VT+V(K,J)))
0076 ANG=PI2-ATAN(AGR)

```

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0077 V(K,J)=ANG
0078 65 CONTINUE
0079 70 CONTINUE
0080 DO 75 J=1,3
0081 CALL MOMET(V(1,J),AMN(J),AMONT(1,J),I)
0082 75 CONTINUE
0083 80 CONTINUE
0084 DO 85 J=1,3
0085 AGMIN(J)=AGMIN(J)*CON
0086 AGMAX(J)=AGMAX(J)*CON
0087 AMN(J)=AMN(J)*CON
0088 AMONT(2,J)=AMONT(2,J)/(AMONT(1,J)**1.5)
0089 AMONT(3,J)=AMONT(3,J)/(AMONT(1,J)**2)
0090 AMONT(1,J)=SQRT(AMONT(1,J))*CON
0091 85 CONTINUE
0092 CALL OUT3(AGMIN,AGMAX,AMN,AMONT,LU)
0093 RETURN
0094 END

```

```

0095 C*****
0096 SUBROUTINE MOMET(V,VMN,VMOMT,N)
0097 DIMENSION V(128),VMOMT(3)
0098 SUM1=0.0
0099 SUM2=0.0
0100 SUM3=0.0
0101 WIGHT=1.0/FLOAT(N)
0102 DO 1 I=1,128
0103   X=V(I)-VMN
0104   XX=X*X
0105   SUM1=SUM1+XX
0106   SUM2=SUM2+XX*X
0107   SUM3=SUM3+XX*XX
0108 1 CONTINUE
0109 VMOMT(1)=VMOMT(1)*(1.-WIGHT)+SUM1*WIGHT/128.0
0110 VMOMT(2)=VMOMT(2)*(1.-WIGHT)+SUM2*WIGHT/128.0
0111 VMOMT(3)=VMOMT(3)*(1.-WIGHT)+SUM3*WIGHT/128.0
0112 RETURN
0113 END

0114 C*****
0115 SUBROUTINE OUT3(AGMIN,AGMAX,AMN,AMOMT,LU)
0116 DIMENSION AGMIN(3),AGMAX(3),AMN(3),AMOMT(3,3)
0117 WRITE(LU,100)
0118 WRITE(LU,110)(AGMIN(I),I=1,3)
0119 WRITE(LU,120)(AGMAX(I),I=1,3)
0120 WRITE(LU,130)(AMN(I),I=1,3)
0121 WRITE(LU,140)((AMOMT(I,J),J=1,3),I=1,3)
0122 RETURN
0123 100 FORMAT(/'ANGLES FROM AXIS'6X'1'9X'2'9X'3'/)
0124 110 FORMAT(2X'MIN, ANGLE='3(F8.3,2X))
0125 120 FORMAT(2X'MAX, ANGLE='3(F8.3,2X))
0126 130 FORMAT(2X'MEAN ANGLE='3(F8.3,2X))
0127 140 FORMAT(2X'RMS ANGLE='3(F8.3,2X)/
0128   + 2X'SKEWNESS = '3(F8.3,2X)/
0129   + 2X'FLATNESS = '3(F8.3,2X))
0130 END

0131 C*****
0132 SUBROUTINE ERROR(LU,IERR,LOC)
0133 IF(IERR,GE,0)RETURN
0134 WRITE(LU,100)IERR
0135 RETURN
0136 100 FORMAT('FMGR ERROR 'I5' IN SDN PROGRAM ANGTH')
0137 END

```

```

0001  FTN4.L
0002  C*****
0003  PROGRAM PRT3(3,00)
0004  C
0005  C WRITTEN BY DAVE NEFF TO OUTPUT RESULTS FROM U,V,W VELOCITY INFO.
0006  C OBTAINED FROM PROGRAM DAT2 ON THE LINE PRINTER IN REPORT FORMAT.
0007  C
0008  DIMENSION IDCB(144),IPAR(5),NAME(3),IORDER(200)
0009  CALL RMPAR(IPAR)
0010  LU=IPAR(1)
0011  IF(LU,LT,1)LU=1
0012  CALL LIBER(LU)
0013  WRITE(LU,1)
0014  CALL GNAME(LU,NAME,ISEC,ICR,1)
0015  CALL OPEN(IDCB,IERR,NAME,0,ISEC,ICR)
0016  IF(IERR,LT,0)CALL ERR(IERR,1)
0017  CALL SORT(IDCB,IORDER,LAST)
0018  CALL OUT(IDCB,IORDER,LAST,LU)
0019  CALL CLOSE(IDCB)
0020  WRITE(LU,5)
0021  1  FORMAT('ENTER RESULTS FILE NAME:SEC:CR- _')
0022  5  FORMAT('RUN COMPLETE')
0023  END

```

```

0024 C*****
0025 SUBROUTINE OUT(IDC, IORDER, LAST, LU)
0026 C**WRITES OUT THE RESULTS TO THE LINE PRINTER
0027 DIMENSION IDC(144), IB(114), NAMD(5,3), POS(6),
0028 + VMN(3), VMONT(3,3), VSTRS(3), ILAB1(3), ANG(3),
0029 + ILAB2(3), IORDER(200), AERR(3), NERR(3), VMIN(3), VMAX(3),
0030 + AGMIN(3), AGMAX(3), AMN(3), AMONT(3,3)
0031 EQUIVALENCE (IB(1), NAMD(1,1)), (IB(16), RATE), (IB(18), NSAM),
0032 + (IB(19), NSEG), (IB(20), CL), (IB(22), POS(1)),
0033 + (IB(34), VMN(1)), (IB(40), VMONT(1,1)), (IB(50), VSTRS(1)),
0034 + (IB(64), VMIN(1)), (IB(70), VMAX(1)), (IB(76), NERR(1)),
0035 + (IB(79), AGMIN(1)), (IB(85), AGMAX(1)), (IB(91), AMN(1)),
0036 + (IB(97), AMONT(1,1))
0037 DATA ILAB1, ILAB2 /2HUV, 2HUV, 2HUV, 2H1 , 2H2 , 2H3 /
0038 CALL POSNT(IDC, IERR, 1, 1)
0039 IF(IERR.LT.0) CALL ERR(IERR, 8)
0040 CALL LURQ(1, 27, 1)
0041 IK=0
0042 1 CONTINUE
0043 DO 3 K=1, 16
0044 IK=IK+1
0045 IF(IK.GT.LAST) GO TO 5
0046 IF(K.EQ.1) WRITE(27, 100)
0047 CALL POSNT(IDC, IERR, IORDER(IK), 1)
0048 IF(IERR.LT.0) CALL ERR(IERR, 10)
0049 CALL READF(IDC, IERR, IB, 114, LEN)
0050 IF(IERR.LT.0) CALL ERR(IERR, 9)
0051 VTMN=SQRT(VMN(1)*VMN(1)+VMN(2)*VMN(2)+VMN(3)*VMN(3))
0052 DO 2 I=1, 3
0053 AERR(I)=100.0*FLOAT(NERR(I))/(FLOAT(NSAM)*FLOAT(NSEG))
0054 ANG(I)=ATAN(VMN(I)/SQRT((VTMN-VMN(I))*((VTMN-VMN(I))))
0055 ANG(I)=90.0-ANG(I)*180.0/3.14159
0056 WRITE(27, 110) (NAMD(J, I), J=1, 3), ILAB2(I), POS(I), AERR(I),
0057 + VMN(I), ANG(I), VMIN(I), VMAX(I), (VMONT(J, I), J=1, 3),
0058 + ILAB1(I), VSTRS(I), AMN(I), AGMIN(I), AGMAX(I),
0059 + (AMONT(J, I), J=1, 3)
0060 2 CONTINUE
0061 WRITE(27, 120)
0062 3 CONTINUE
0063 GO TO 1
0064 5 CONTINUE
0065 WRITE(27, 130)
0066 CALL LURQ(0, 27, 1)
0067 RETURN
0068 100 FORMAT(' FILE AXIS POSITION LIMITS -----'
0069 + ' VELOCITY INFORMATION-----'
0070 + ' ANGLE INFORMATION-----'
0071 + ' NAME 16X EXCEEDED MEAN ANGLE MIN. MAX. RMS'
0072 + ' SKEW- FLAT- REYNOLDS MEAN MIN. MAX. '
0073 + ' RMS SKEW- FLAT '
0074 + ' 22X (Z) TIME VEL. FROM VEL. VEL. VEL. NESS'
0075 + ' NESS STRESS ANGLE ANGLE ANGLE ANGLE NECS'
0076 + ' NESS')
0077 110 FORMAT(1X, 3A2, 2X, A2, 2X, F8.3, 1X, F7.3, 1X, F6.2, 1X, F6.1, 1X, F6.2, 1X,
0078 + F6.2, 1X, F6.3, 1X, F5.2, 1X, F6.2, 1X, A2, 1X, F7.4, 1X, F6.1, 1X,

```

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0079 + F6.1, 1X, F6.1, 1X, F4.1, 2X, F5.2, 1X, F6.2)
0080 120 FORMAT(' ')
0081 130 FORMAT(' ')
0082 END

```

```

0083 C*****
0084 SUBROUTINE SORT(IDC8,IORDER,LAST)
0085 DIMENSION IDC8(144),IORDER(200),IB(3),NUM(200)
0086 I=0
0087 10 CONTINUE
0088 I=I+1
0089 CALL READF(IDC8,IERR,IB,3,LEN)
0090 IF(IERR.LT.0)CALL ERR(IERR,11)
0091 IF(LEN.EQ.-1)GO TO 20
0092 N1=(IB(3)*256)/256-48
0093 N2=IB(3)/256-48
0094 N3=(IB(2)*256)/256-48
0095 NUM(I)=N3*100+N2*10+N1
0096 GO TO 10
0097 20 CONTINUE
0098 N=I-1
0099 K=1
0100 DO 40 I=1,1000
0101 IFLAG=0
0102 DO 30 J=1,N
0103 IF(NUM(J).NE.(I-1))GO TO 30
0104 IORDER(K)=J
0105 IFLAG=1
0106 30 CONTINUE
0107 IF(IFLAG.NE.0)K=K+1
0108 40 CONTINUE
0109 LAST=K-1
0110 RETURN
0111 END

```

FTN4 COMPILER: HP92060-16092 REV. 1901 (781201)

** NO WARNINGS ** NO ERRORS ** PROGRAM = 00367 COMMON = 00000

PAGE 0005 FTN, 12:06 PM FRI., 25 OCT., 1985

```

0112 C*****
0113 SUBROUTINE ERR(IERR,LOC)
0114 WRITE(1,1)IERR,LOC
0115 STOP
0116 1 FORMAT('FMGR ERROR 'I3' AT LOCATION 'I3)
0117 END

```

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** NO WARNINGS ** NO ERRORS ** PROGRAM = 00037 COMMON = 00000

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