# EXPERIMENTAL SIMULATION OF THE WAKE OF AN AXISYMMETRIC BODY NEAR A FREE SURFACE

by

Pinaki S. Mitra

thesis submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

Master of Science

in

Aerospace and Ocean Engineering

APPROVED:

Wayne L. Neu, Chairman

Joseph A. Schetz

Karl E. Sundkvist

May, 1985

Blacksburg, Virginia

# EXPERIMENTAL SIMULATION OF THE WAKE OF AN AXISYMMETRIC BODY NEAR A FREE SURFACE

by

Pinaki S. Mitra

(ABSTRACT)

Turbulent flow measurements were performed in the wake of a slender axisymmetric body in the presence of a flat plate strut and an image plane representing the "rigid lid" approximation to a free-surface. The tests were performed in a wind tunnel at a nominal Reynolds number of $6.0 \times 10^5$. All turbulent flow parameters were measured at three streamwise stations. A Yawhead probe was used for the mean flow measurements, and a Constant Temperature Anemometer System with a 'x'-wire probe was used to obtain the turbulent flow characteristics. The presence of the image plane was found to increase the velocity defect and the static pressure as the image plane was approached. A redistribution among the various components of velocity fluctuations was noted near the "rigid lid" plane. The transverse component was enhanced at the expense of the normal component. The image plane also was found to influence the magnitudes and radial spread of turbulence intensities and Reynolds stresses. Some interactions between the wake of the axisymmetric body and that of the plate strut were observed. Overall, the mean velocities and the turbulence quantities indicated symmetry about the image plane throughout the wake.

ACKNOWLEDGEMENTS

The author wishes to express his appreciation for the guidance provided by Dr. W.L.Neu and Dr. J.A.Schetz during the course of this work .Thanks are also due to the staff of the AOE Dept. for their help.

TABLE OF CONTENTS

LIST OF FIGURES

# NOMENCLATURE

| | |
|---|---|
| $R = \sqrt{Y^2 + Z^2}$ | radial distance in the x-plane |
| D | diameter of the axisymmetric bodies |
| L | length of the axisymmetric bodies |
| UF | tunnel free-stream velocity |
| U | mean axial (x-axis) velocity |
| V | mean velocity in y-direction |
| W | mean velocity in z-direction |
| P | local static pressure |
| $P_{fs}$ | free-stream static pressure |
| $Q_{fs}$ | tunnel free-stream dynamic pressure |
| $CP = \frac{P-P_{fs}}{Q_{fs}}$ | static pressure coefficient (non-dimensional) |
| u' | turbulence intensity in x-direction (r.m.s.) |
| v' | turbulence intensity in y-direction (r.m.s.) |
| w' | turbulence intensity in z-direction (r.m.s.) |
| $\overline{u'v'}, \overline{u'w'}, \overline{v'w'}$ | Reynolds stress components in the cartesian coordinate system |

# 1. INTRODUCTION

The study of turbulent flow has an important role in the analysis of the motion of bodies in a fluid medium. The state of understanding of the phenomenon of turbulence remains incomplete, so various means of mathematical modelling of the turbulent transport of momentum have been proposed (see e.g. Schetz (1984)), but none has achieved unanimous approval. Hence, considerable reliance continues to be placed on experimental observation of the physical phenomenon, both for a better basic understanding of the flow and as a means to check the adequacy of the various models. Also, the experimental data base forms the foundation of the derivation of the models.

In this study, it was intended to document a three-dimensional flow field in the wake of a configuration of engineering interest. The configuration tested was that of a SWATH or SWASH type ocean vehicle. Of particular interest in this case is the influence of a free surface on the wake.

If one were to attempt a numerical solution of this problem with the aim of evaluating a turbulent transport model, one has to deal with the uncertainties involved in imposing the proper free surface boundary conditions on the turbulence model. For a discussion of proposed free surface boundary conditions, see Naot and Rodi (1982). One alternative is to impose the simpler symmetry conditions of the "rigid lid" approximation. This was done by Swean and Peltzer (1984)

for the case of a flat plate moving near a free surface. The discrepancies between their numerical and experimental results, especially near the free surface, may be due to either the rigid lid conditions being applied to a case with a real free surface or the inadequacy of the turbulence model or both. The verification of the turbulence model under the simpler rigid lid conditions can be accomplished independent of the complete free surface boundary conditions. The rigid lid case can be modelled in the laboratory by the use of an "image body" such that a plane of symmetry exists between the bodies. This is true for the mean flow, but some questions about the behavior of the fluctuating flow remain.

In a SWATH type configuration the axisymmetric bodies stay underwater and the struts pierce the free-surface to support the deck. It was intended to explore the wake of the submerged portion of the configuration by modelling the free surface with a rigid lid. The wake of the axisymmetric bodies in this configuration will be affected by both the rigid lid and the wake of the plate strut. It was intended to evaluate both these effects.

The image plane concept was utilized in the configuration tested here, where two axisymmetric slender bodies were connected by a long, thin flat plate strut along the centerline. See Figures 1 and 2 for the details of the arrangement. The testing was performed in the Virginia Tech Stability Wind Tunnel at a nominal Reynolds number (based on body diameter) of $6 \times 10^5$. All relevant flow field

parameters of the turbulent wake were measured at three streamwise stations, X/D=0.042, 1.0 and 33.0. A Constant Temperature Anemometer System was used with hot-wire probes to measure the turbulent quantities and a Yawhead probe was used to measure the mean flow quantities.

Although this data will probably find its principal application in the refinement of turbulence models and existing codes for flow field computations, it also should help to improve understanding of the flow phenomenon behind such a configuration, especially the effect of the rigid lid and the interference between the wake of the plate strut and that of the axisymmetric body. Also, this kind of experimental simulation provides some physical insight into the flow-field being modelled by the rigid lid approach.

The interested reader may wish to compare these results with similar work in an infinite region. A few recent studies of this nature have been tabulated in Table 1.

Table 1

Experimental Investigation of Turbulent Wake of Bodies

| Authors | Year | Ref. | Fluid Medium | Model Configuration | Propulsion | $Re_D$ |
|---|---|---|---|---|---|---|
| Chevray | 1967 | 2 | Air | Prolate spheroid | Drag | $2.75 \times 10^6$ ($Re_L$) |
| Lin et al | 1973 | 4 | Water | Slender body | Self-propelled | $4.0 \times 10^4$ |
| Schetz, Daffan et al | 1976 | 8 | Air | Slender body with sail | Self-propelled | $4.4 \times 10^5$ |
| Swean and Schetz | 1977 | 11 | Air | Slender body with sail | Self-propelled | $2.0 \times 10^5$ |
| Schetz and Stott-meister | 1978 | 6 | Air | Slender body with sail and deck | Drag and self-propelled | $4.5 \times 10^5$ |
| Schetz, Lee and Kong | 1983 | 7 | Air | Slender body with sail, deck and control surfaces | Self-propelled | $4.5 \times 10^5$ |
| Swean and Peltzer | 1984 | 10 | Water | Flat plate | Drag | $5.81 \times 10^5$ ($Re_L$) |
| Present | 1985 | - | Air | Slender body flat plate strut and "image body" | Drag | $6 \times 10^5$ |

## 2. MODEL AND INSTRUMENTATION

### 2.1 Model

The model consisted of two slender axisymmetric bodies connected by a flat plate strut in the vertical plane of symmetry as shown in Figure 1. The axisymmetric bodies had a slenderness (L/D) ratio of 15; each was 90 in. (2.28 m) long with a diameter of 6 in. (15.2 cm) and had a streamlined nose and pointed tail (see Figure 2). The flat plate strut was 60 in. (1.52 m) long, 6 in. (15.2 cm) wide and 3/8 in. (9.5 mm) thick with a streamlined leading edge and a sharp trailing edge. Thus, the image plane or the plane of the rigid lid was one diameter from the centerline of the lower axisymmetric body.

The lower axisymmetric body of the model housed a strain gage balance which measured all six components of forces and moments acting on the lower body alone. The strain gage strut was the only connection between the lower body and the flat plate. A gap of 1/16 in. (1.6 mm) was maintained between the bottom of the flat plate and the lower body to allow freedom in pitch. The strain gage, in addition to providing helpful data about the lift and the drag coefficients of the lower body, also proved helpful in the process of alignment of the model with the flow in the tunnel.

The model was suspended from the ceiling of the tunnel test-section with a streamlined strut which also housed the cables for the strain gage balance. All grooves and channels needed for the

mechanical assembly were flush and were smoothed with putty to avoid any protrusion or indentation.

## 2.2 Wind Tunnel

The wind tunnel at Virginia Tech used for this study is a single return facility with a closed 6 ft. (1.83 m) by 6 ft. (1.83 m) test-section 24 ft. (7.32 m) long. The tunnel was run at a dynamic pressure of 9 in. (22.9 cm) of water which corresponds to a nominal speed of 210 ft./sec. (64 m/sec.). The tunnel dynamic pressure, the ambient pressure and temperature were monitored and recorded routinely during the experiment. This tunnel is especially suitable for this kind of work because of the low level of free-stream turbulence. Previous studies have indicated a turbulence factor of 1.08.

## 2.3 Instrumentation

### 2.3.1 Mean Flow Measurements

The mean flow parameters - the three components of velocity and the static pressure - were measured by a 1/8 in. (3.2 mm) diameter three-dimensional Yawhead probe (United Sensor DC 125). The probe has a blunt conical nose with five pressure ports arranged on and around the nose. The pressures from the five ports were fed to a Scanivalve system (Model J Scanivalve Corp.) and were measured with a Barocel differential manometer (Type 1023 Datametrics, CGS Corp.). Special care was taken to minimize the tubing length to improve the time-response of the system.

### 2.3.2 Turbulent Flow Measurements

Constant Temperature Anemometers (TSI Model 1050) with Signal Linearizer Modules (TSI Model 1052) were used with 'x'-wire probes (TSI 1241-T2) to measure the turbulent quantities. The platinum coated tungsten wires were $2 \times 10^{-4}$ in. ($5.08 \times 10^{-4}$ cm) in diameter. The signals from the Linearizers were fed through a Signal Correlator (TSI 1015 C) to obtain the different combinations of signals needed for data reduction. The mean voltage measurements were done with a DVM (HP 3455A) which is a part of the Data Acquisition System. The r.m.s. quantities were measured with a r.m.s. voltmeter (DISA 55D35).

### 2.3.3 Traverse Mechanism

A remote-controlled traverse mechanism was used to position the different probes. The probe-holder could be moved vertically or horizontally in an axial plane. The error in positioning is estimated to be less than 0.04 in. (1 mm).

### 2.3.4 Data Acquisition System

A Hewlett Packard Data Acquisition System (HP 3052A) was driven by a HP9836 Microcomputer. All data acquisition and storage was automated. The Scanivalve system used with the Yawhead probe was controlled by a Relay Actuator Mechanism (HP 59309A) in a pre-programmed sequence.

# 3. TEST AND DATA REDUCTION PROCEDURES

## 3.1 Alignment of the Model

The model was aligned with the flow in the tunnel with the help of the strain gage balance in the lower body. It was intended to minimize the side force and yaw-moment components acting on the lower body. Also, two Pitot probes were mounted on the flat plate strut in an effort to balance the total pressures on the two sides of the plate.

Vertical and horizontal scans of the very near wake of the lower body indicated symmetry about the vertical center plane and the absence of separation bubbles.

## 3.2 Test Stations and Grids

Three stations at X/D=0.042, 1 and 33 were decided upon as representative of the broad features of the wake, from immediately behind the body to the far wake. See Figures 2 and 3 for the coordinate system used for this study. The natural symmetry of the configuration was exploited, and only one half of the wake behind the lower body was investigated in detail. Some mirror-image points were included as checks.

Measurements were concentrated in the upper quadrant, which is bounded by the image plane, since the wake in this region was of primary interest. For the third station (X/D=33), the grid was

expanded in keeping with the expected expansion of the wake. See Figures 3, 4 and 5 for details of the grids used. The point numbers are printed at the point locations.

The center of the grid for the third station (X/D=33) was obtained by scanning for the largest velocity defect in the wake. Hence, those measurements are about the true center of the wake, rather than simply the "center" obtained from the geometric considerations of the tunnel test-section.

### 3.3 Mean Flow Measurements

The three components of mean velocity, the flow angularities (pitch and yaw) and static pressures were obtained with the Yawhead probe. The Yawhead probe provides accurate measurements of the above quantities even in the presence of high angularity and turbulence in the flow field. The calibration and data reduction procedures can be found in Lee (1983).

A Pitot-static probe mounted near the front end of the test-section was used to obtain the free-stream velocity. All pressure measurements from the five ports of the Yawhead probe were referenced to the control room static pressure which showed little variations. The velocities presented are non-dimensionalized with the free-stream velocity.

The static pressure coefficients are obtained by non-dimensionalizing the difference of the local static pressure in the wake and the free-stream static pressure by the free-stream dynamic

pressure. It should be noted that the free-stream static pressure was measured at each station with the help of the Yawhead probe.

## 3.4 Turbulent Flow Measurements

Constant Temperature Anemometers were used to measure the turbulence quantities. Turbulence intensities u', v' and w', which are the r.m.s. values of the fluctuating components of the velocity vectors represented in a cartesian coordinate system, and the Reynolds stress quantities $\overline{u'w'}$, $\overline{u'v'}$ and $\overline{v'w'}$, which are correlations of the fluctuating components of velocity, were measured. Thus, all the variables usually treated in the Reynolds averaged Navier-Stokes equation and k-$\varepsilon$ formulations of turbulent flows were documented at the three stations.

An 'x' wire probe was placed in the horizontal, vertical and diagonal planes to obtain the turbulent quantities. The turbulence intensities and the shear quantities for a particular plane were obtained by placing the wires in that plane. The $\overline{v'w'}$ component was obtained by a coordinate transformation of the variables from the y-z axes to one obtained by turning the y-z axes by 45 degrees about the x-axis.

An overheat ratio of 1.8 was used to reduce probe sensitivity to fluctuations in temperature. An integrating time constant of 3 seconds was used for the r.m.s. measurements.

To correct for small variations in the tunnel temperature, the calibration was checked for a range of temperatures and a straight line fit was obtained. The calibration was modified by a factor

$$T_{cor} = \frac{1}{-7.151 \times 10^{-3} \times T + 1.6436}$$

where T is the tunnel temperature in degrees Fahrenheit. The factor was arrived at by taking the calibration for 90° F as the base. The correction for the variations in tunnel temperature was incorporated in the data reduction procedure. The turbulent quantities were non-dimensionalized by the free-stream velocity obtained by placing the hot-wire probe well outside the wake.

# 4. RESULTS AND DISCUSSION

## 4.1 Forces on the Model

The coefficients of drag and lift acting on the lower axisymmetric body alone (i.e. excluding the forces acting on the flat plate strut) were found to be 0.19 and 0.06, respectively. The coefficients were calculated using the cross-sectional area of the lower axisymmetric body. The drag coefficient is low, since the body has a high L/D. The coefficient of lift, arising from the influence of the flat plate strut and the image body on the pressure distribution on the upper surface of the axisymmetric body, is significant compared to the drag coefficient.

## 4.2 The Wake

The results have been organized in four sections - a) Mean Velocities, b) Static Pressures, c) Turbulence Intensities and d) Reynolds Stresses. In each section, the vertical, horizontal and radial profiles of the related quantities have been presented for the three streamwise stations. The numerical values of the above quantities have been tabulated in the appendices.

### 4.2.1 Mean Velocities

The vertical velocity profile at X/D=0.042 in Figure 6 shows that the maximum velocity defect behind the body is about 70% and the

defect in the wake of the strut is about 20%. The velocity variations in the horizontal direction (y-axis) are found to decrease with increasing Z/D as shown in Figure 7. Symmetry about the vertical center plane through the body tail (z-axis) is maintained. In the near wake, the effect of the wake of the plate strut is found to extend horizontally approximately a quarter diameter from the strut centerline. This should be kept in mind while evaluating the effects of the rigid lid on the flow-field.

The radial variation of velocity given in Figure 8 shows the effect of the image plane on the mean velocity in the wake. The angles used to denote a particular radial profile are measured counter-clockwise from the positive y-axis. The velocity defect increases as the image plane is approached going up from $\theta$ = 270 deg. to $\theta$ = 90 deg. The profile at $\theta$ = 135 deg. differs from those at 180 deg. and greater which are presumably less influenced by the rigid lid. In the wake of the plate strut ($\theta$ = 90 deg.) the influence of the image plane cannot be readily separated from the wake of the strut alone.

This phenomenon of increased velocity defect towards the rigid lid plane can be explained by the blockage caused by the presence of the image body. This behavior must be inherent in any wake near a rigid lid and should, of course, decay with increasing depth of submergence. A similar increase in velocity defect towards an actual free surface has been noted by Swean and Peltzer (1984) for the wake of a flat plate.

The vector plot of velocities in the cross-plane given in Figure 9 indicates the presence of an upward component of velocity in much of the wake. The presence of the plate strut and the image plane causes an upward displacement of the wake of the lower body. Although the effects of these factors are difficult to separate here, previous wake measurements in the vicinity of a free surface have shown a migration of the wake towards the free surface, see for example, Swean and Peltzer (1984). The existence of this vertical component of velocity seems to be corroborated by high values of $\overline{u'w'}$ on the y-axis to be presented below. Note, however, that as the image plane is approached, this vertical component of velocity approaches zero as it must.

At X/D=1, the velocity defect at the centerline of the lower body and that in the wake of the strut are found to have decayed to 50% and 15% respectively. This can be seen in Figure 10. The general features of the velocity profiles, in Figures 10-12, remain very much the same as for X/D=0.042. However, the upward velocity component first noted at that station has now become very small. The effects of the image plane on the radial profiles of axial velocity is still noticeable for $\theta$ = 135 deg. in Figure 12.

For the far field station, X/D=33, the defect at the center of the wake is only 7% while that in the wake of the strut is 4%. The velocity gradients are everywhere much reduced in magnitude. This can be seen in Figures 13-15. The effect of the image plane on the radial profiles of axial velocity is barely noticeable in Figure 15.

The rate of decay of the velocity defect is found to be much sharper for the wake of the axisymmetric body in comparison to that of the strut. This can be seen in Figure 16. It is to be mentioned though that the very near wake of the flat plate (corresponding to a few plate thicknesses downstream), where the rate of decay is high, was not investigated here.

### 4.2.2 Static Pressure Coefficients

A sharp pressure variation was observed in the immediate wake (X/D=0.042) of the lower axisymmetric body. The vertical variation is given in Figure 17. The maximum difference in static pressure is nearly 10% of the tunnel free-stream dynamic pressure. The gradient is reduced in the wake of the strut. The pressure gradients, like the axial velocity gradients, taper off with increasing Z/D as illustrated in Figure 18. It can be noted that the static pressure does not reach free-stream values until well beyond the extent of the wake.

A traverse of the flow field from the negative z-axis (270 deg.) to the positive z-axis (90 deg.) in Figure 19 indicates the effect of the image plane on the static pressure in the wake. The static pressure for the 135 deg. profile is found to be higher than the 225 deg. profile which is less affected by the presence of the rigid lid. This is consistent with the behavior noted with the axial velocity profiles. Also, the higher static pressure co-efficients for the 135 deg. profile extend well beyond the region affected the wake of the plate strut.

At X/D=1, the static pressure gradients are found to have decayed significantly from the closer station. This can be seen in Figures 20-22. The difference between the maximum static pressure in the wake and the free-stream static pressure is found to be only 2.5% of the free-stream dynamic pressure. Among the different wake characteristics, the static pressure was found to decay the fastest. The general features observed at X/D=0.042 are still present at X/D=1, though on a reduced scale.

At the far field, the pressure difference was found to have decayed to less than 1% of the tunnel dynamic pressure. This data has not been plotted.

It should be mentioned here that the station X/D=33 was located near the rear end of the tunnel test-section. The expanding tunnel cross-section and small gaps in the tunnel wall may have influenced the pressure readings at the far station. The difference between the free-stream static pressure at this station and that at X/D=1.0 was found to be about 10% of the free-stream dynamic pressure.

### 4.2.3 Turbulence Intensities

The effect of the flat plate strut on the turbulence intensity profiles is fairly pronounced. In the vertical turbulence intensity profiles at X/D=0.042 in Figure 23, there is an increase in the turbulence intensities near where the plate strut wake meets the wake of the axisymmetric body (Z/D $\approx$ 0.5). Also, the level of turbulence is higher in the wake of the strut compared to that in the wake of the

axisymmetric body. The turbulence intensity in the streamwise direction (u') is found to be higher than v' or w'. The horizontal profiles of turbulence intensity are presented in Figures 24-27. Reasonable symmetry about the vertical center plane (z-axis) is indicated. The spread of turbulence in the wake of the plate strut is found to be less than a quarter diameter from the strut center-line. This is consistent with the belief that the effects of the wake of the plate strut is contained within that region.

The redistribution of the turbulent kinetic energy among the various components of velocity fluctuations near the rigid lid plane can be observed in Figure 28. The relative magnitude of the component of turbulence intensity normal to the rigid lid plane (w') is reduced while that of the transverse component (v') is enhanced as the rigid lid plane is approached. This effect is not noticeable in the direct wake of the plate strut (Y/D=0) in Figure 23.

The effect of the image plane on the radial spread of turbulence can be seen by comparing Figures 29 and 30. The turbulence intensity between R/D of -0.25 and -0.5 for Figure 29 (135 Deg.) is somewhat higher than the corresponding values in Figure 30 (225 Deg.).

The turbulence intensity profiles for X/D=1 in Figures 31-37 have the same general features as the closer station. The decay of turbulence from X/D=0.042 to 1.0 is not very pronounced. The redistribution of velocity fluctuations near the rigid lid plane can be noted in Figure 35.

The turbulence at the far field station shown in Figures 38-43 is more nearly isotropic, with much smoother variations. Symmetry of turbulent kinetic energy about the rigid lid plane is indicated by a small drop in all three components of turbulence intensity at Z/D=1 in Figure 38. This also indicates that at this station the migration of the center of the wake towards the plane of symmetry is not very large. The turbulence intensities near and below the bottom of the lower body wake are somewhat higher than those in the "freestream" at X/D=0.042 and 1.0. It is possible that there is some interaction with the tunnel wall boundary layer near the rear end of the tunnel where this station is located. The influence, if any, does not appear large. The "free-stream" turbulence has been increased to about 1.5% from about 0.5% in regions free of any such effects.

The maximum turbulence level is found to have decayed to 3% of the free-stream velocity from about 6% observed in the near wake. It also was noted that the rate of decay of turbulence is more rapid in the wake of the plate strut than in the wake of the axisymmetric body. This feature, which can be noted from the profiles in Figure 44, can be attributed to the different rates of decay of turbulence for two-dimensional and three-dimensional wakes.

### 4.2.4 Reynolds Stresses

The three components of the Reynolds stress, $\overline{u'w'}$, $\overline{u'v'}$ and $\overline{v'w'}$, at X/D=0.042 are presented in Figures 45-51. The symmetry condition at the image plane is indicated by the absence of vertical

turbulent shear ($\overline{u'w'}$) at the image plane (Z/D=1) in Figure 45. Symmetry of vertical turbulent shear about the image plane can also be noted. One interesting feature of the $\overline{u'w'}$ profile is the slight dip where the wake of the strut interacts with the wake of the axisymmetric body.

The horizontal $\overline{u'v'}$ profile in Figure 46 indicates somewhat higher magnitudes of turbulent shear for positive Y/D than for negative Y/D. This is a consistent feature in the results and is believed to be the result of some slight model misalignment. The idea of upward components of velocity in the near wake as discussed earlier seems to be corroborated by the high values of vertical turbulent shear ($\overline{u'w'}$) on the y-axis in Figure 46. With increasing Z/D, the decreasing mean velocity gradients are seen to reduce the Reynolds stress values in Figures 47-49.

The effect of the image plane on the Reynolds stresses can be studied by comparing Figure 50 and Figure 51. Both the radial spread and magnitudes of Reynolds stresses are found to be higher for the 135 deg. profile in Figure 50.

The Reynolds stresses for X/D=1.0 are given in Figures 52-55. The broad features of the Reynolds stress profiles seen before for X/D=0.042 are repeated at this station. The influence of the image plane in increasing the magnitude and radial spread of turbulent shear can be seen by comparing Figure 54 and Figure 55.

The Reynolds stresses for X/D=33 are presented in Figures 56-58.The turbulent shear, though largely decayed, still maintains the broad features noted earlier.

A comparison of the vertical turbulent shear ($\overline{u'w'}$) in the vertical center plane of the wake along the three streamwise stations has been presented in Figure 59. For X/D=0.042, $\overline{u'w'}$ reaches its maximum value for positive Z/D. Interestingly, the trend is reversed for X/D=1 and 33. The decay of turbulent shear is also noted to be faster in the upper portion of the wake of the axisymmetric body. This is an effect of the interaction of the wake of the strut with that of the axisymmetric body. Also, the symmetry of vertical shear about the image plane is seen to be maintained for the three axial stations. The streamwise decay of $\overline{u'v'}$ on the y-axis is shown in Figure 60. The half-width of the wake of the axisymmetric body is noted to be less than half a diameter in the near wake and close to one diameter at the far (x/d=33) station.

## 5. CONCLUSIONS

1. The image plane concept has been utilized successfully to implement the rigid lid approximations to the free-surface boundary conditions. Mean flow quantities and turbulence quantities are found to be symmetrical about the plane of the rigid lid. Also, there was no net turbulent transport of momentum across the plane of the rigid lid. However, the presence of turbulence intensity normal to the rigid lid plane indicates that the rigid lid is "rigid" only in the mean.

2. The image plane is found to have considerable influences on the wake of the configuration. Noteworthy among them are:

   a) The velocity defect and the static pressure were found to increase as the image plane was approached. This is due to the blockage effect noted in section 4.2.1. This effect was found to extend beyond the region affected by the wake of the plate strut.

   b) An upward component of the mean velocity was noted in the near wake. However, it decayed rapidly with downstream distance and the migration of the center of the wake towards the image plane was not very evident up to X/D=33.

   c) A redistribution among the various components of velocity fluctuations was noted near the rigid lid plane. The component of turbulence intensity normal to the rigid lid

plane was subdued while the transverse component was enhanced. This effect was masked in the direct wake of the plate (Y/D=0). This kind of redistribution in the components of turbulent kinetic energy is usually noted near boundaries, for example, near a free surface or near the wall in turbulent boundary layers. However, the results from this study indicate that the same kind of behavior can be expected in infinite region flows in the presence of a plane of symmetry.

d) The radial spread and the magnitudes of turbulence intensities and Reynolds stresses were found to increase towards the image plane. However, these comparisons may have been tinted by the influence of the plate strut in that region.

3. Some interesting features of the interaction between the wake of the body and that of the strut were:

a) An increase in turbulence intensities and a drop in vertical turbulent shear ($\overline{u'w'}$) were noted at the region where the three-dimensional wake of the axisymmetric body meets the two-dimensional wake of the plate strut.

b) The decay of vertical turbulent shear ($\overline{u'w'}$) in the upper portion of the wake of the axisymmetric body was hastened by the interaction of the two wakes.

Finally, it should be noted that it is difficult to isolate the effect of the rigid lid in the direct wake of the plate strut. The individual influences of the rigid lid and the plate strut might be better understood by studying the influence of the strut on the wake of the axisymmetric body in the absence of the plane of symmetry and the influence of the rigid lid on the wake of the axisymmetric body in the absence of the of the plate strut.

## REFERENCES


1. Chevray, R., "Turbulence in the Wake of a Body of Revolution," The University of Iowa, Ph.D. Thesis, 1967.

2. Lee, H., "Computational and Experimental Study of Trailing Vortices," Ph.D. Thesis, VPI&SU, 1983.

3. Lim, J. T., Pao, Y. H. and Veenhuizen, S. D., "Turbulent Wake of a Propeller-Driven Slender Body in Stratified and Non-Stratified Fluids," Bull. Am. Phys. Soc., 18, 1484, 1974.

4. Naot, D. and Rodi, W., "Calculation of Secondary Currents in Channel Flow," Journal of the Hydraulics Division, ASCE, Vol. 108, No. HY8, pp. 948-968, 1982.

5. Schetz, J. A., "Foundations of Boundary Layer Theory for Momentum, Heat, and Mass Transfer," Prentice-Hall Inc., 1984.

6. Schetz, J. A., Daffan, E. B., Jakubowski, A. K., Cannon, S., Cox, R. and Dubberley, D., "Mean Flow and Turbulence Measurements in the Wake of Slender Propeller Driven Bodies Including Effects of Pitch Angle," VPI-Aero-050, 1976.

7. Schetz, J. A. and Stottmeister, H. P., "Experimental Measurements in the Near Wake Region of a Self-Propelled Slender Body with Attached Appendages," VPI-Aero-077, 1978.

8. Schetz, J. A., Lee, H. and Kong, F., "Measurements in the Near-Wake Region of a Slender, Self-Propelled Model at Pitch or Yaw," Journal of Ship Research, Vol. 27, No. 4, December 1983.

9. Swean, T. F., Jr. and Peltzer, R. D., "Free Surface Effects on the Wake of a Flat Plate," NRL Memorandum Report 5426, Naval Research Laboratory, 1984.

10. Swean, T.F., Jr. and Schetz, J. A., "The Flow About a Slender Propeller-Driven Body in a Temperature Stratified Fluid," VPI-Aero-062, 1977, also AIAA Paper No. 78-209.

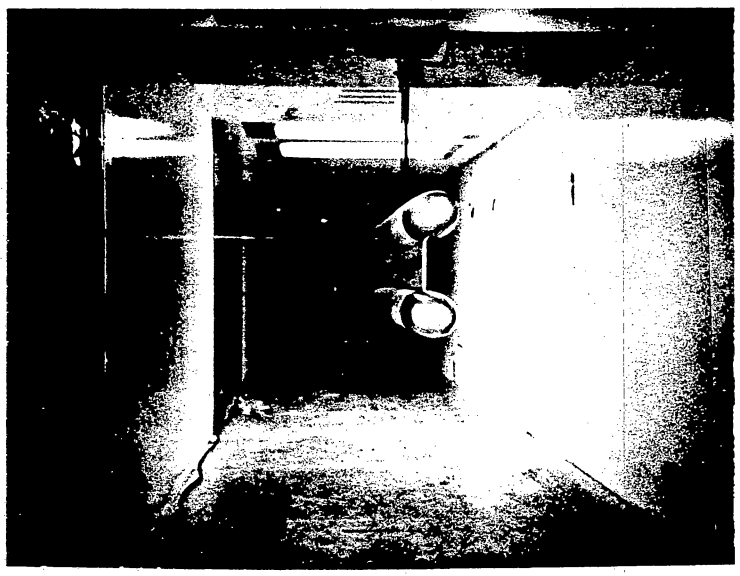

Fig. 1 Photograph of the Model in the Wind Tunnel - looking Downstream.

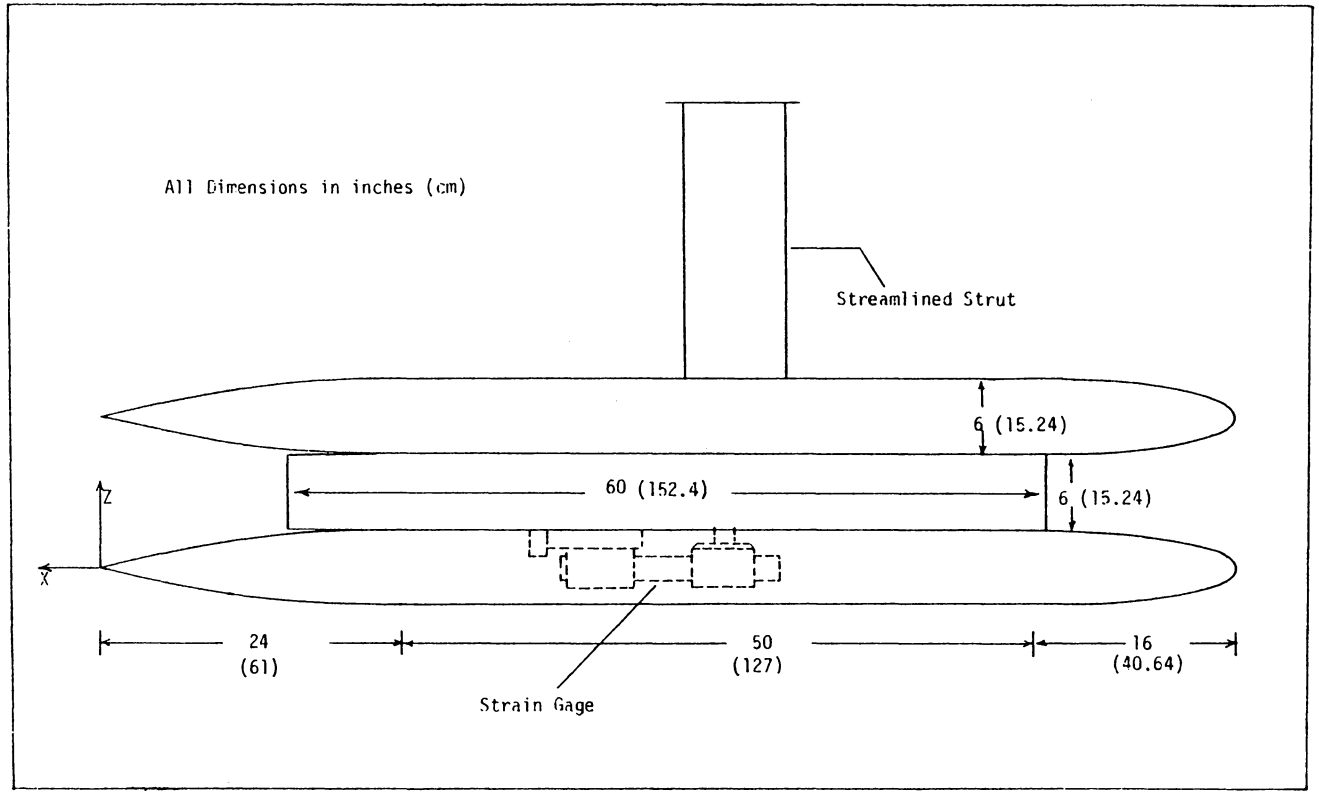


Fig. 2 Model Arrangement and Dimensions.

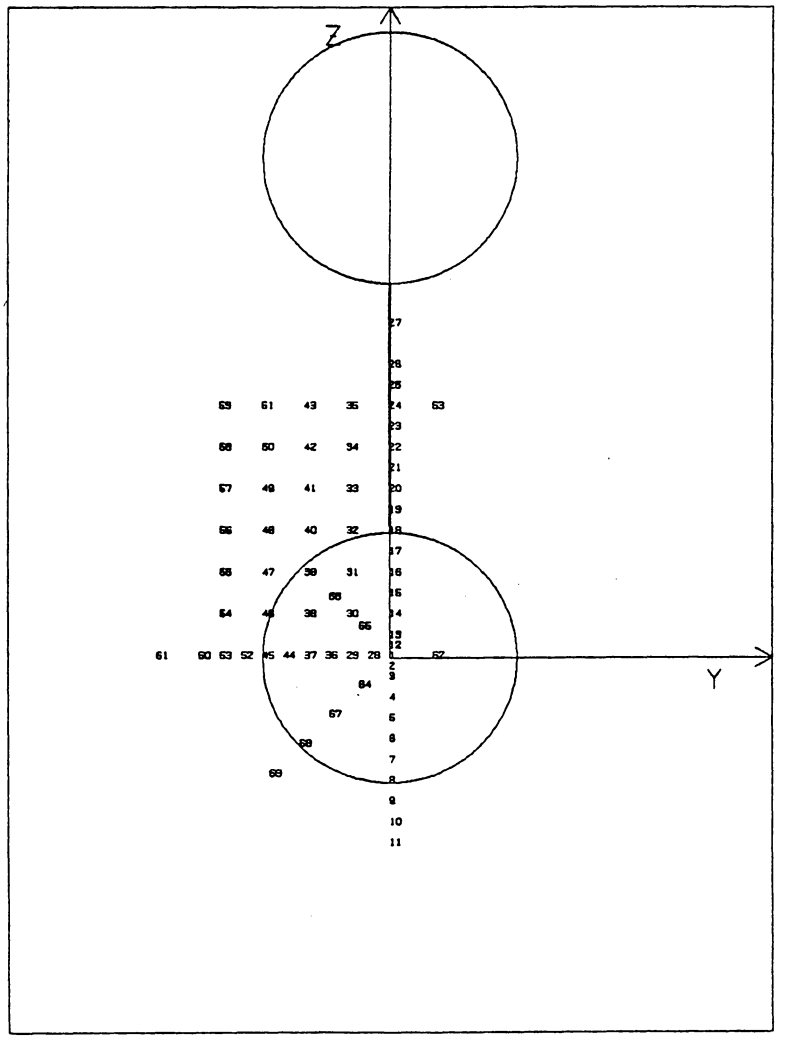


Fig. 3 Measurement Grid Layout used at X/D=0.042 (the point numbers are printed over the measurement locations)

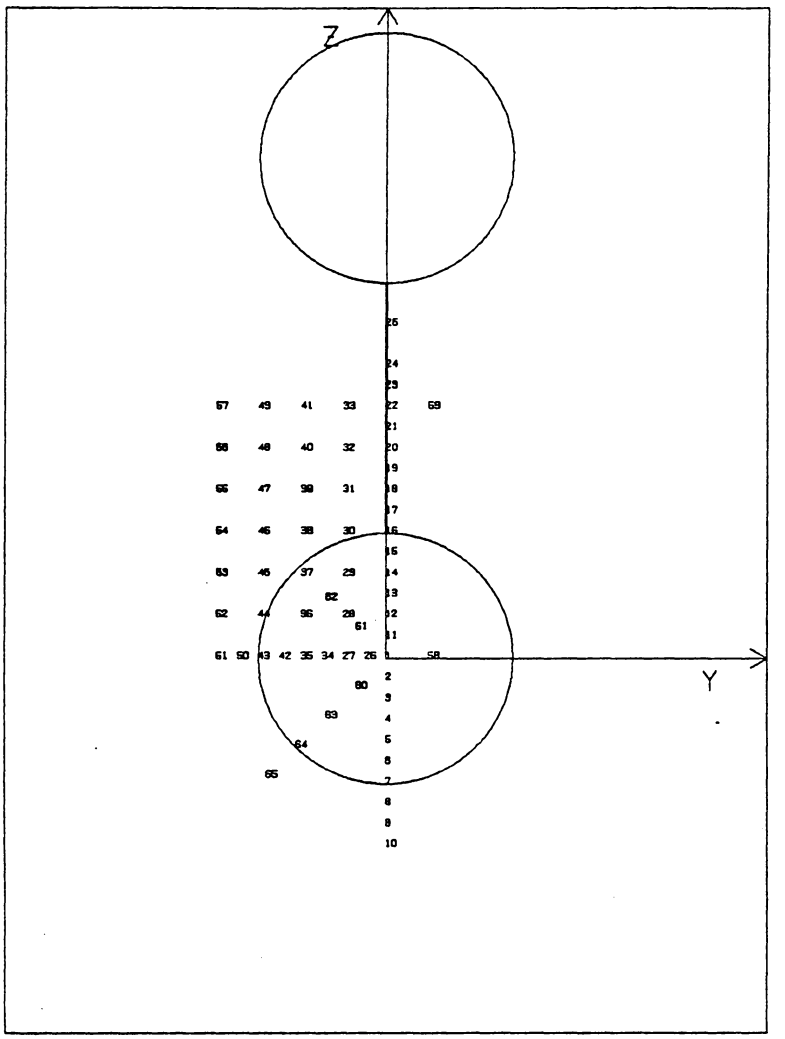


Fig. 4 Measurement Grid Layout used at X/D=1.0

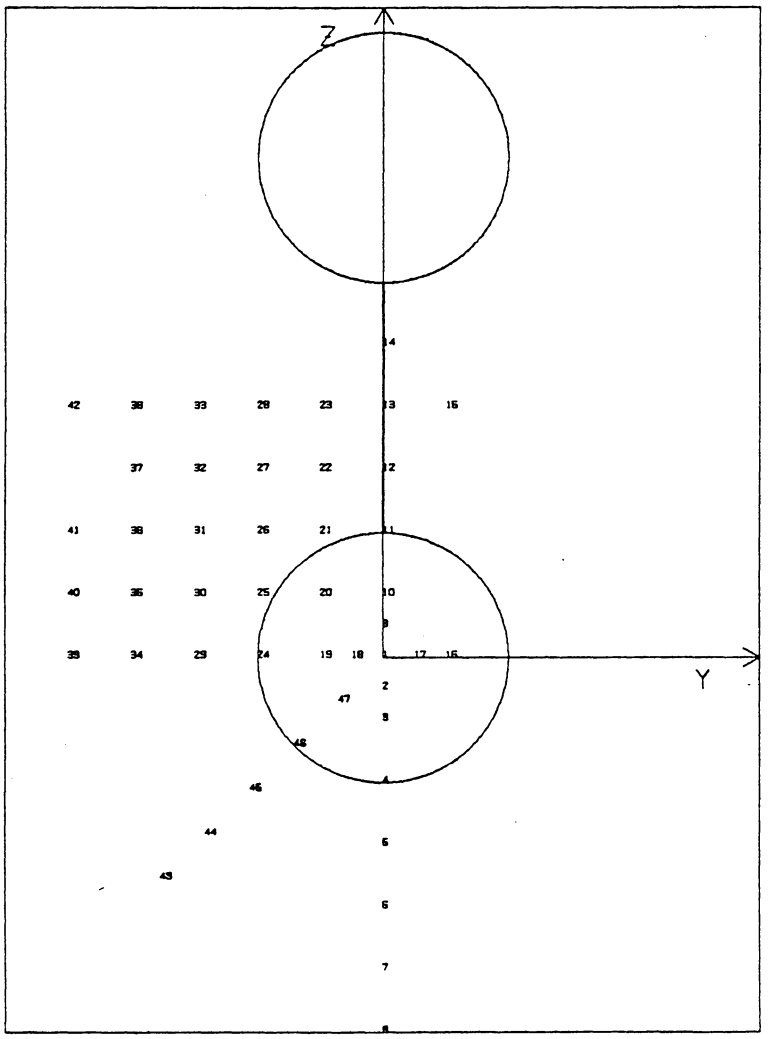


Fig. 5 Measurement Grid Layout used at X/D=33.0

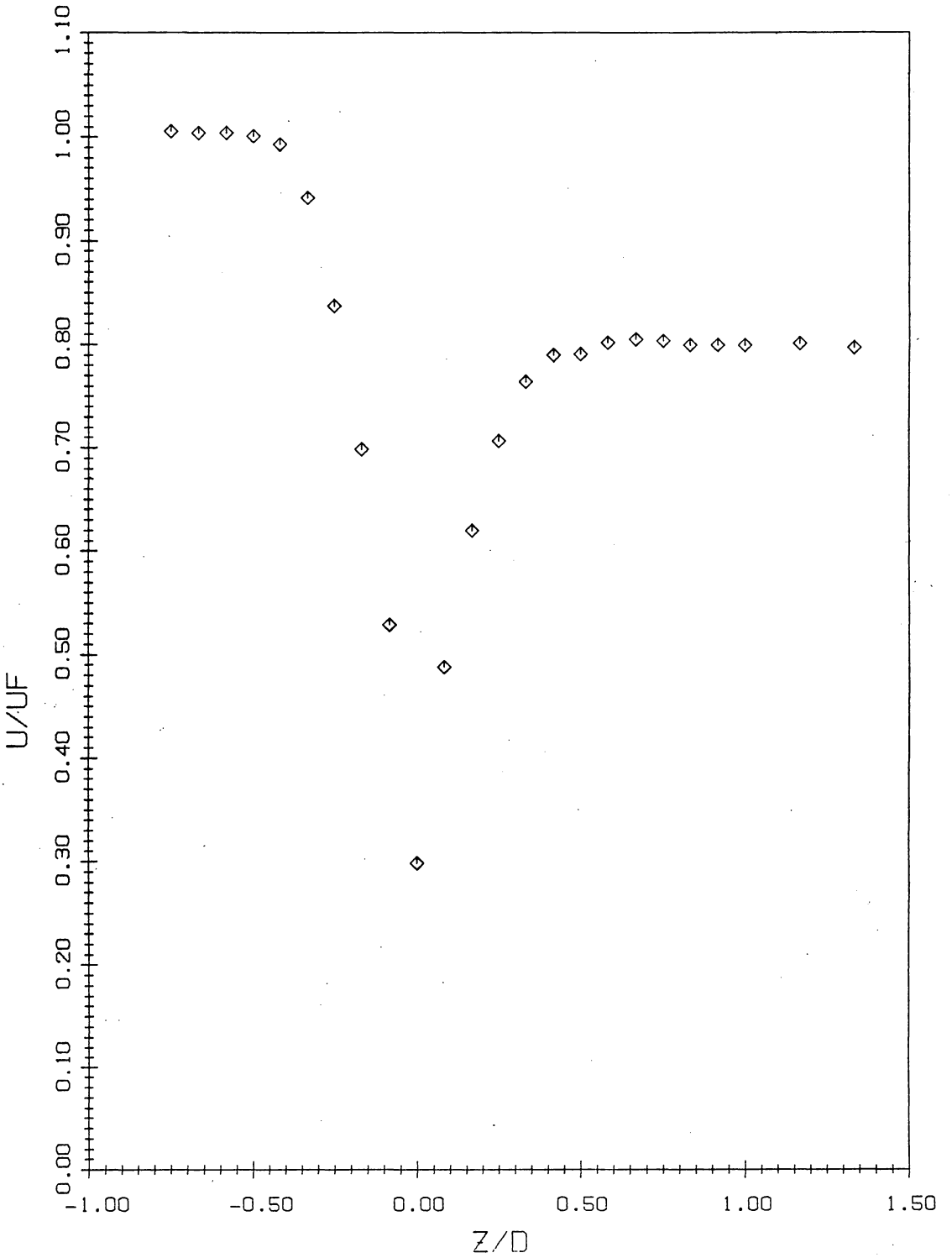


Fig. 6 Non-Dimensional Axial Velocity Profile in the Vertical Direction (Y/D=0) at X/D=0.042.

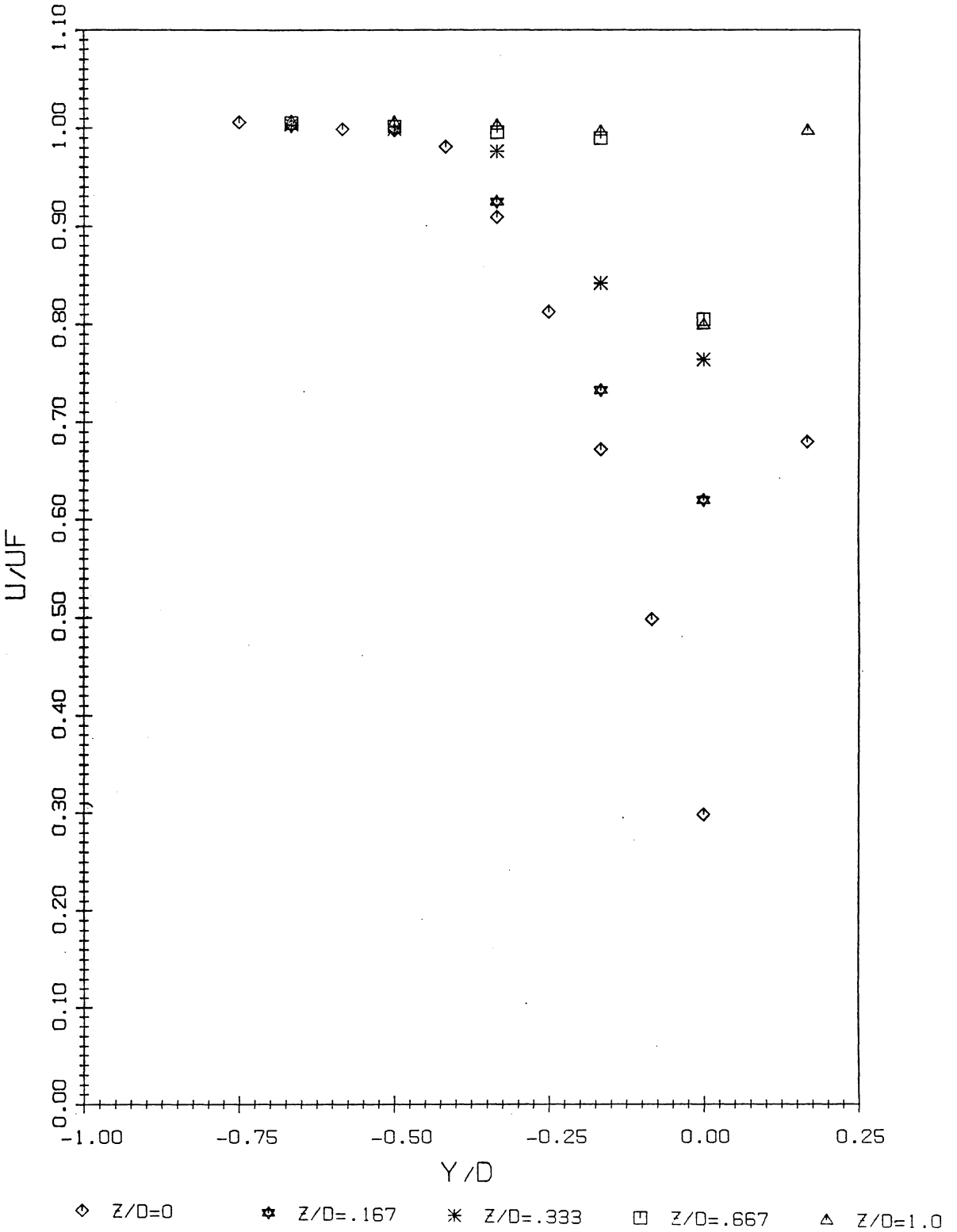


Fig. 7 Comparison of Horizontal Profiles of Axial Velocity for Various Heights above the Wake Centerline at X/D=0.042.

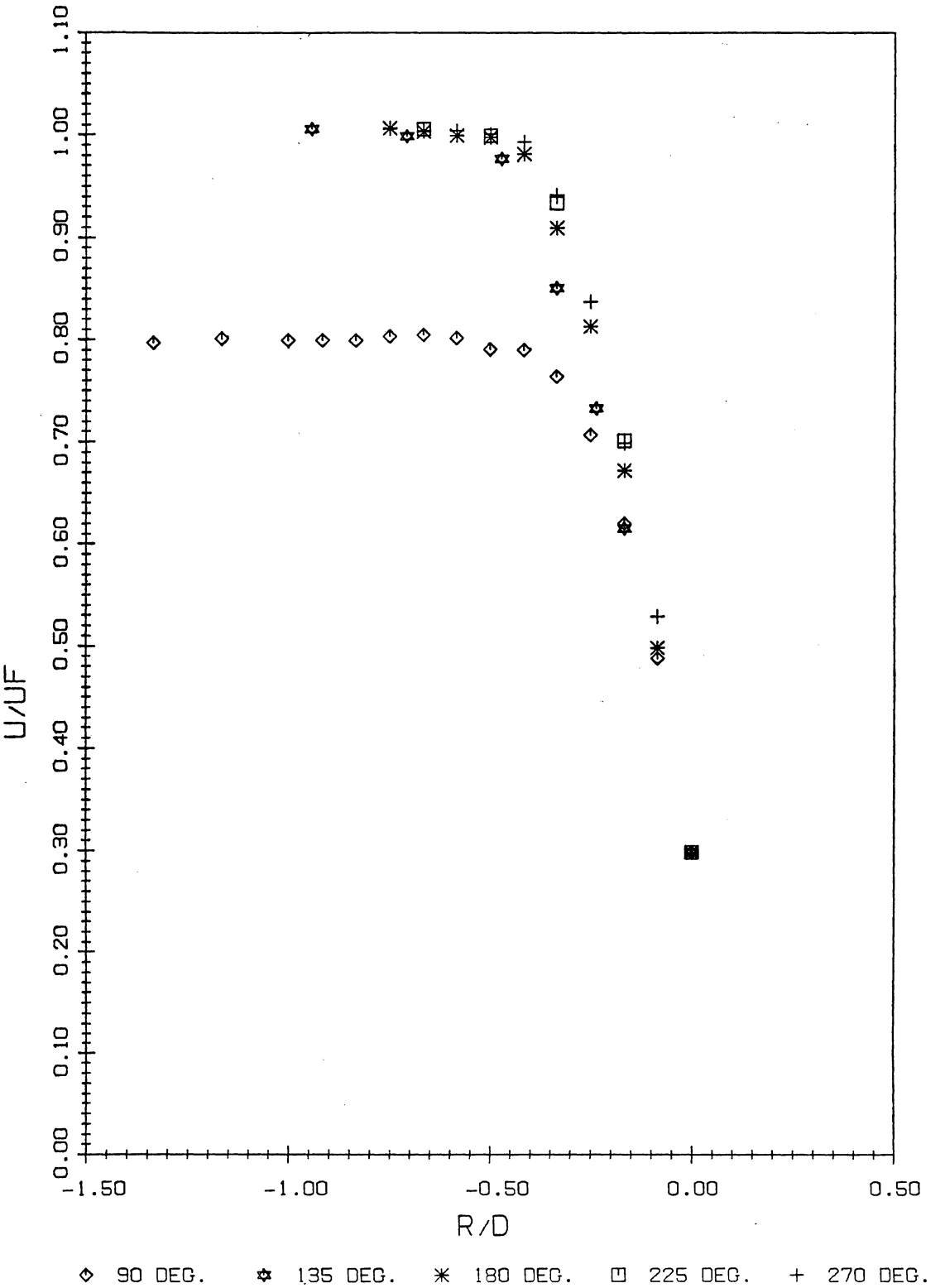


Fig. 8 Comparison of Radial Profiles of Axial Velocity along Various Angles through the Wake Center (90 Deg. is Vertical) at X/D=0.042.

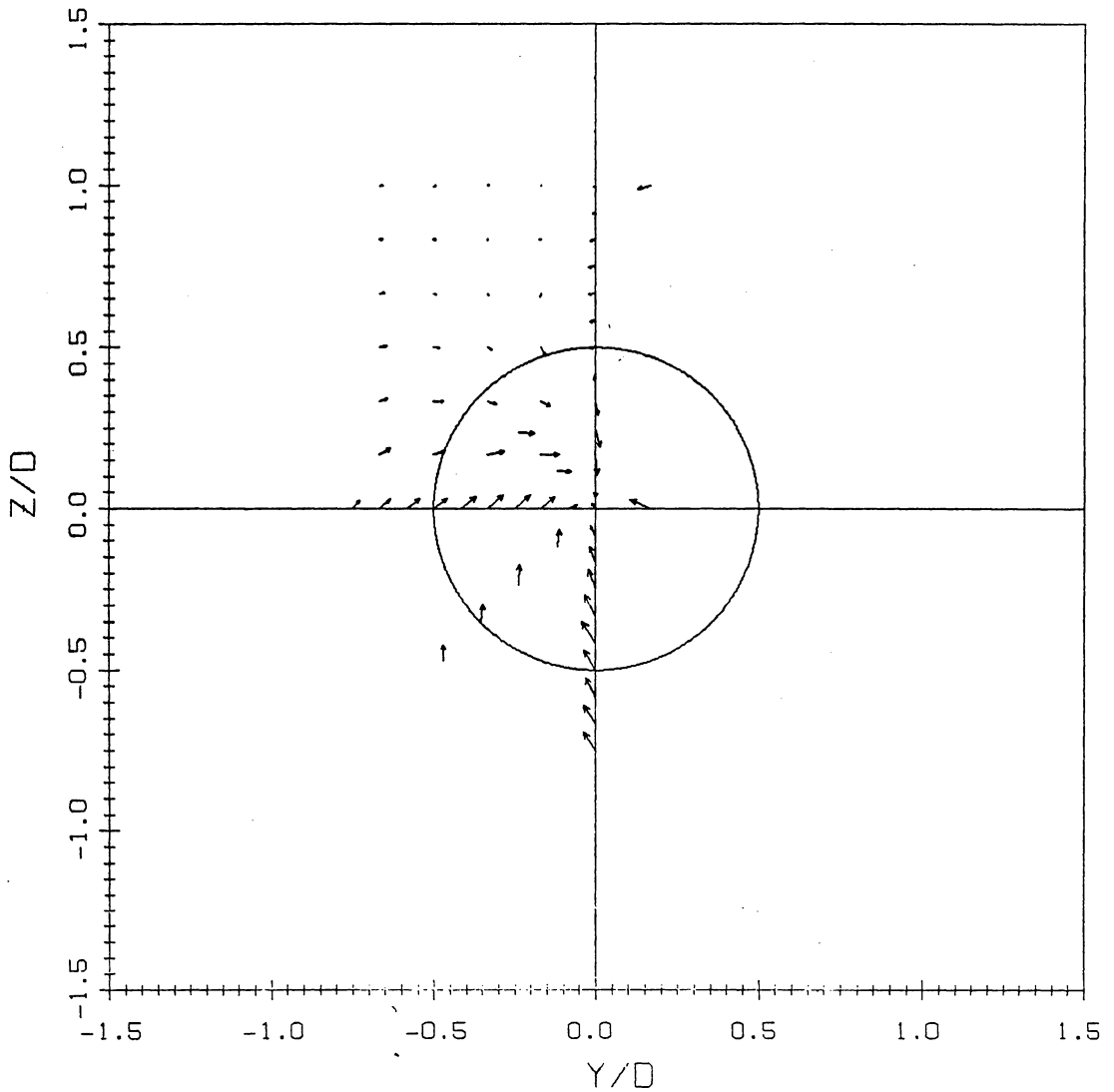


Fig. 9 Plot of Velocity Vectors in the Cross-plane at X/D=0.042 .

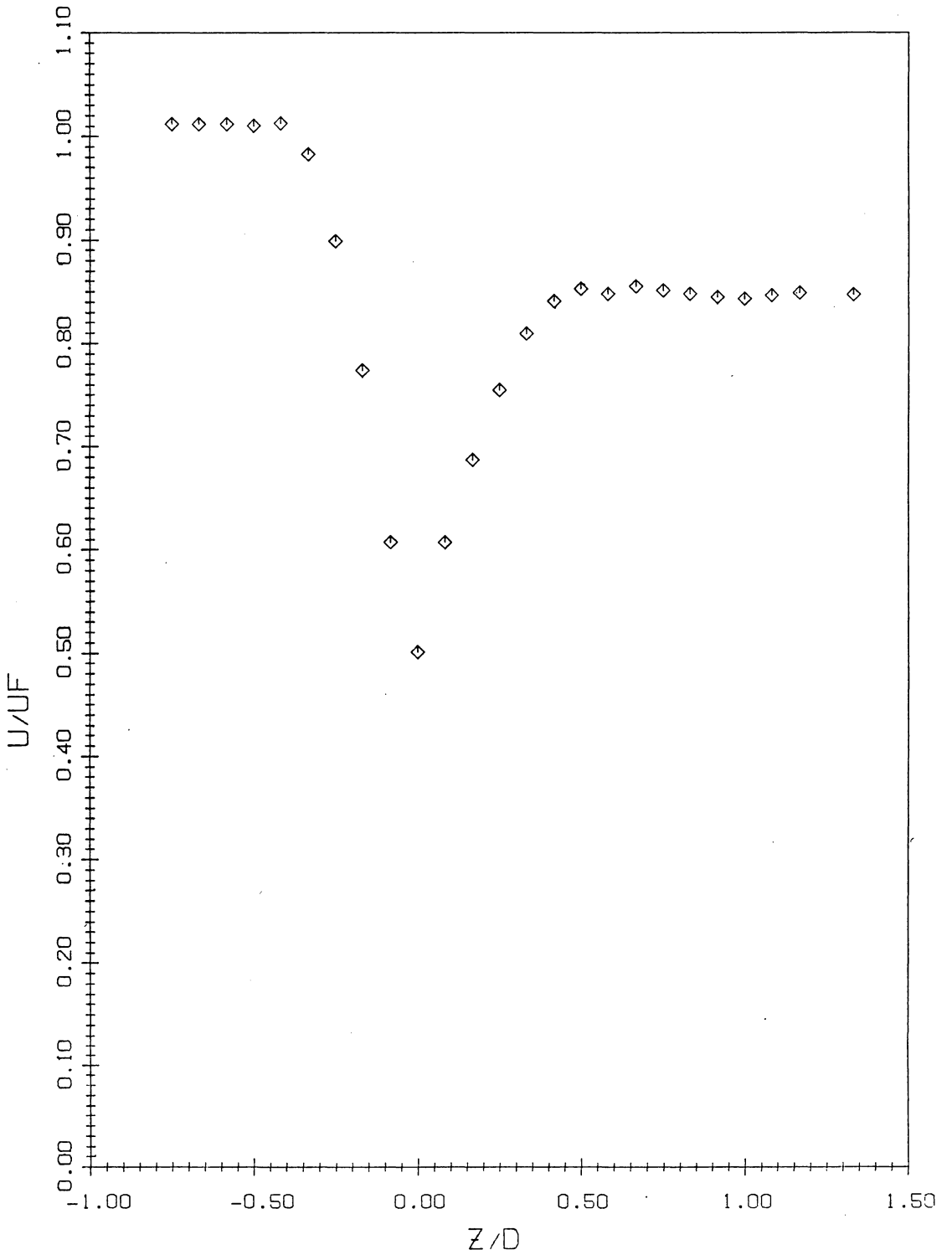


Fig. 10 Non-Dimensional Axial Velocity Profile in the Vertical Direction (Y/D=0) at X/D=1.0.

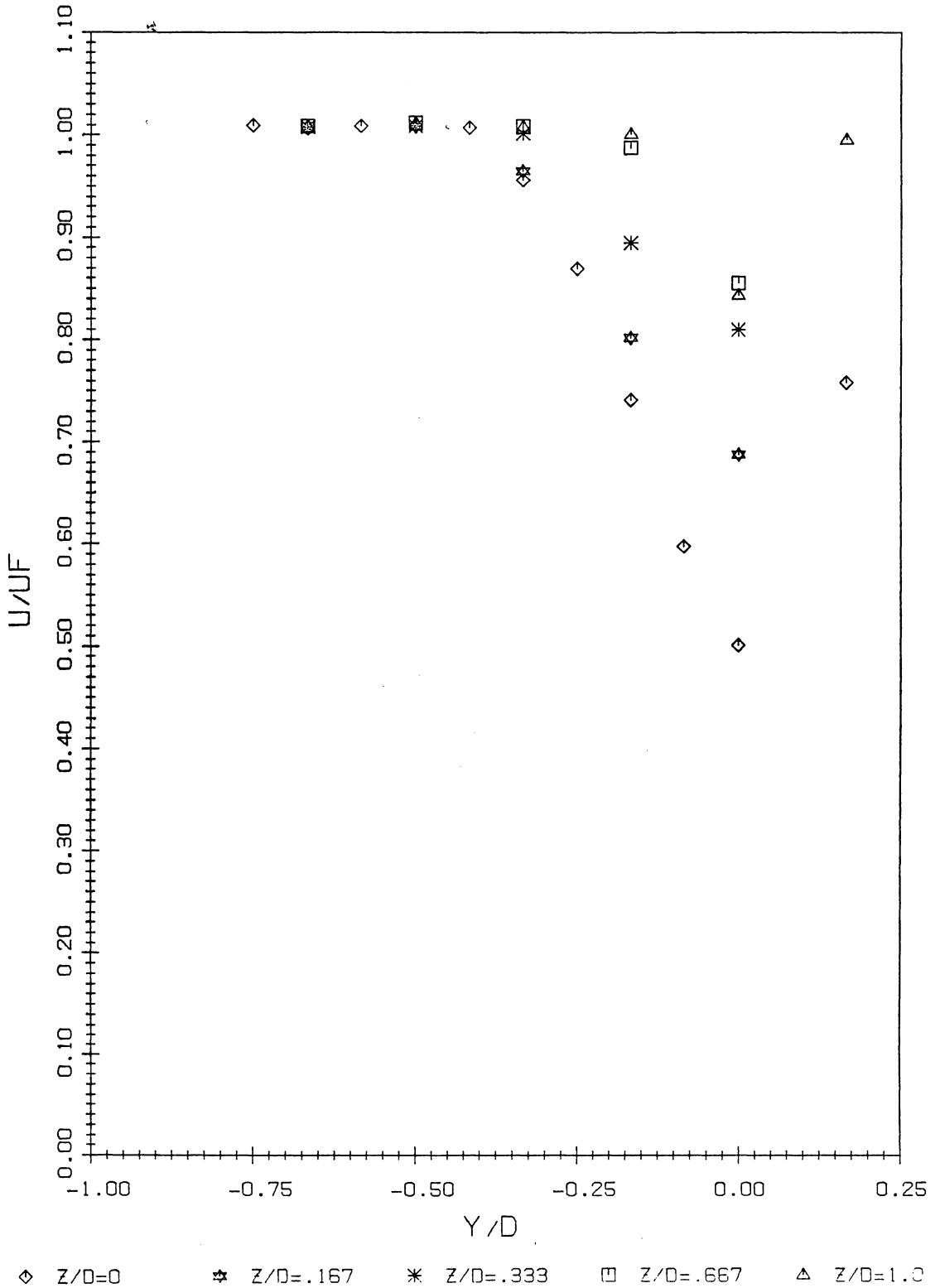


Fig. 11 Comparison of Horizontal Profiles of Axial Velocity for Various Heights above the Wake Centerline at X/D=1.0 .

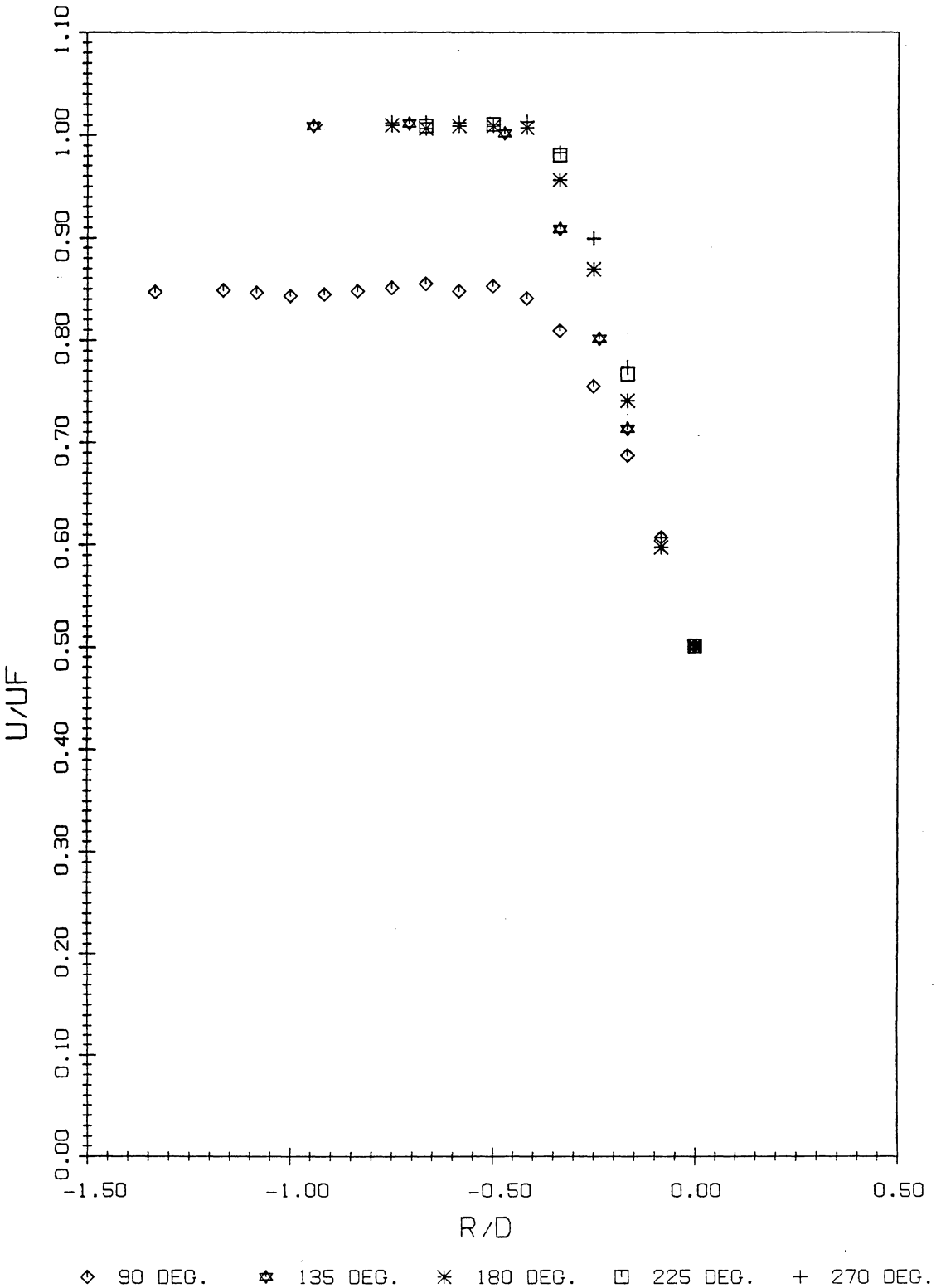


Fig. 12 Comparison of Radial Profiles of Axial Velocity along Various Angles through the Wake Center at X/D=1.0 .

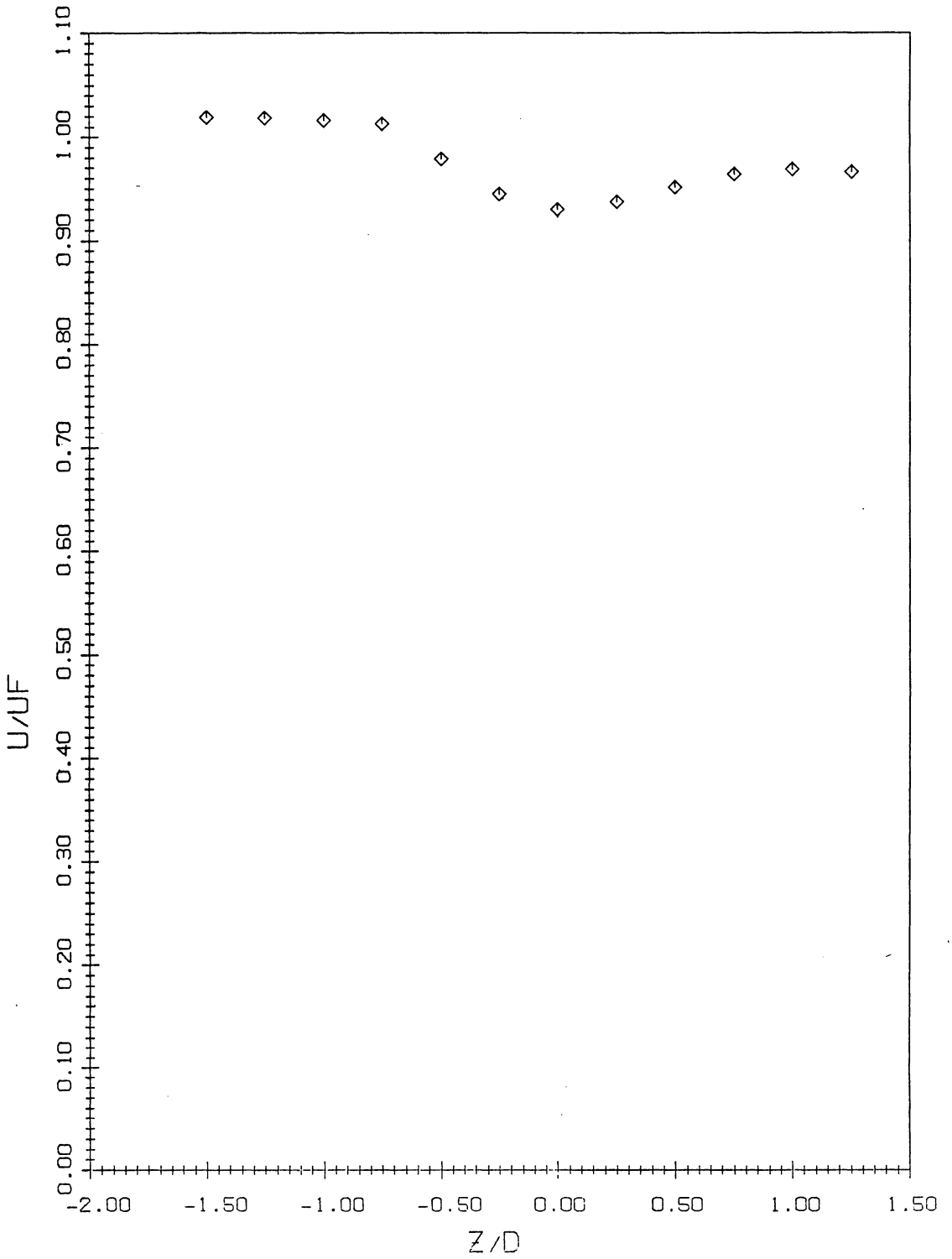


Fig. 13 Non-Dimensional Axial Velocity Profile in the Vertical Direction (Y/D=0) at X/D=33.0 .

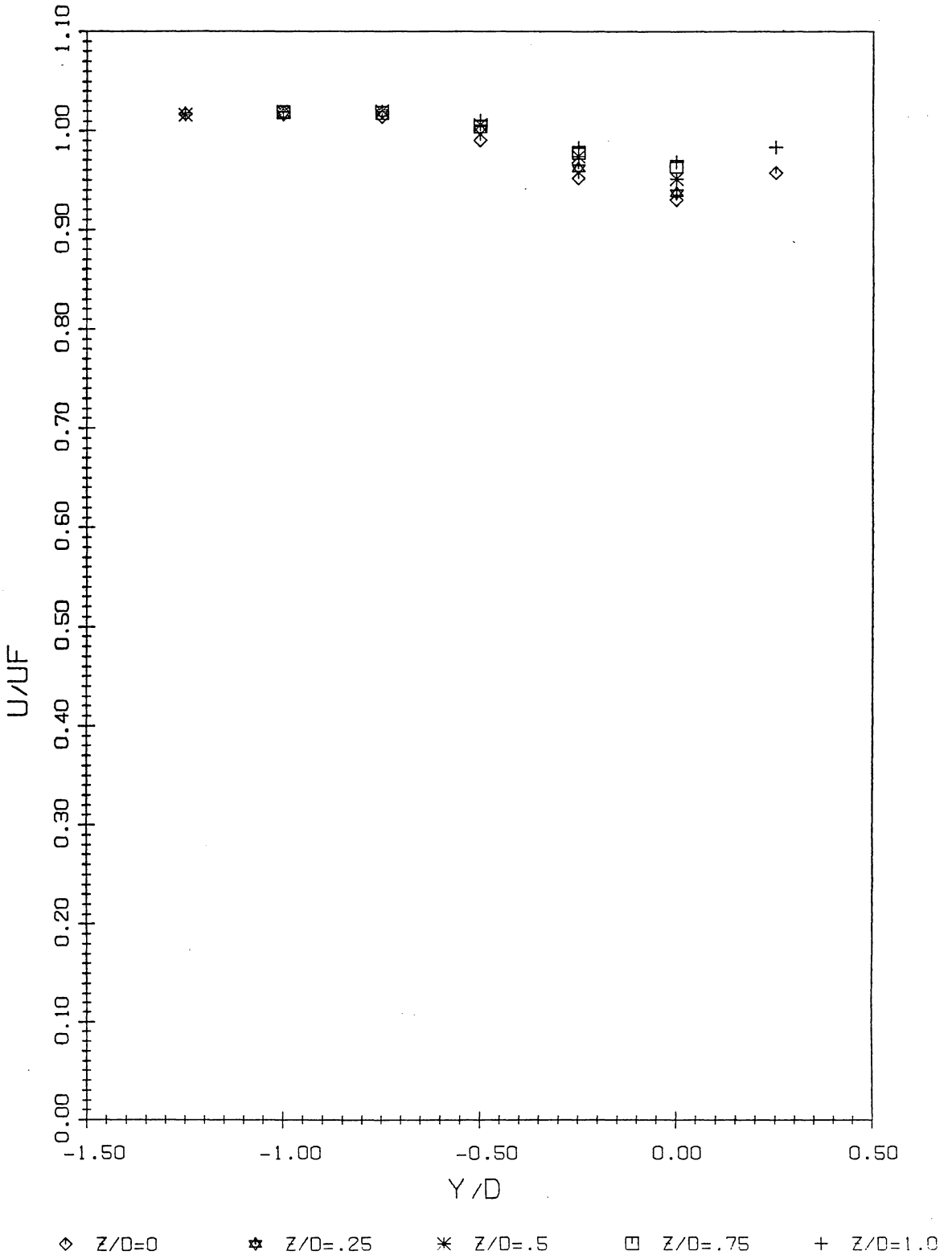


Fig. 14 Comparison of Horizontal Profiles of Axial Velocity for Various Heights above the Wake Centerline at X/D=33.0 .

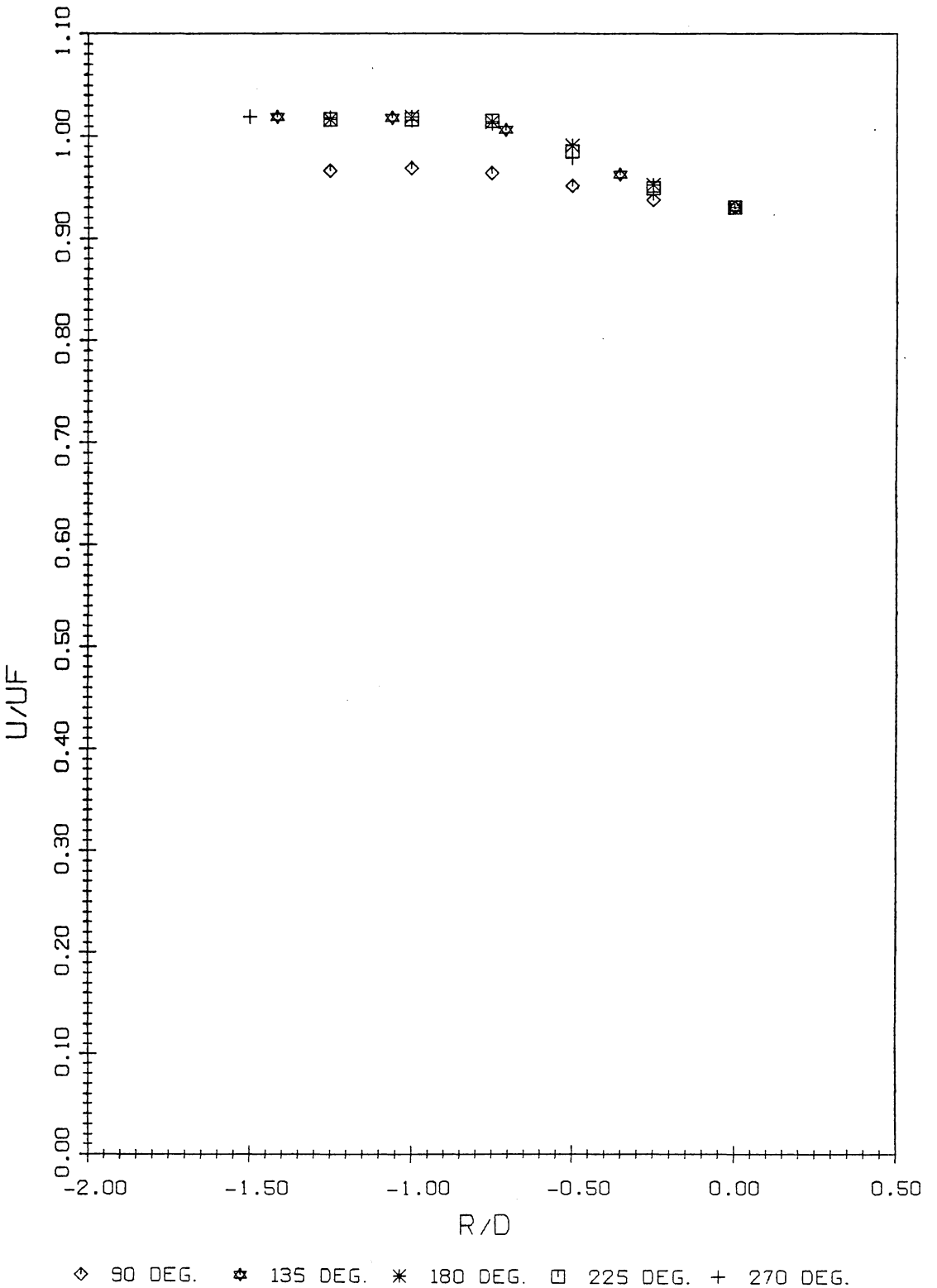


**Fig. 15** Comparison of Radial Profiles of Axial Velocity along Various Angles through the Wake Center at X/D=33.0 .

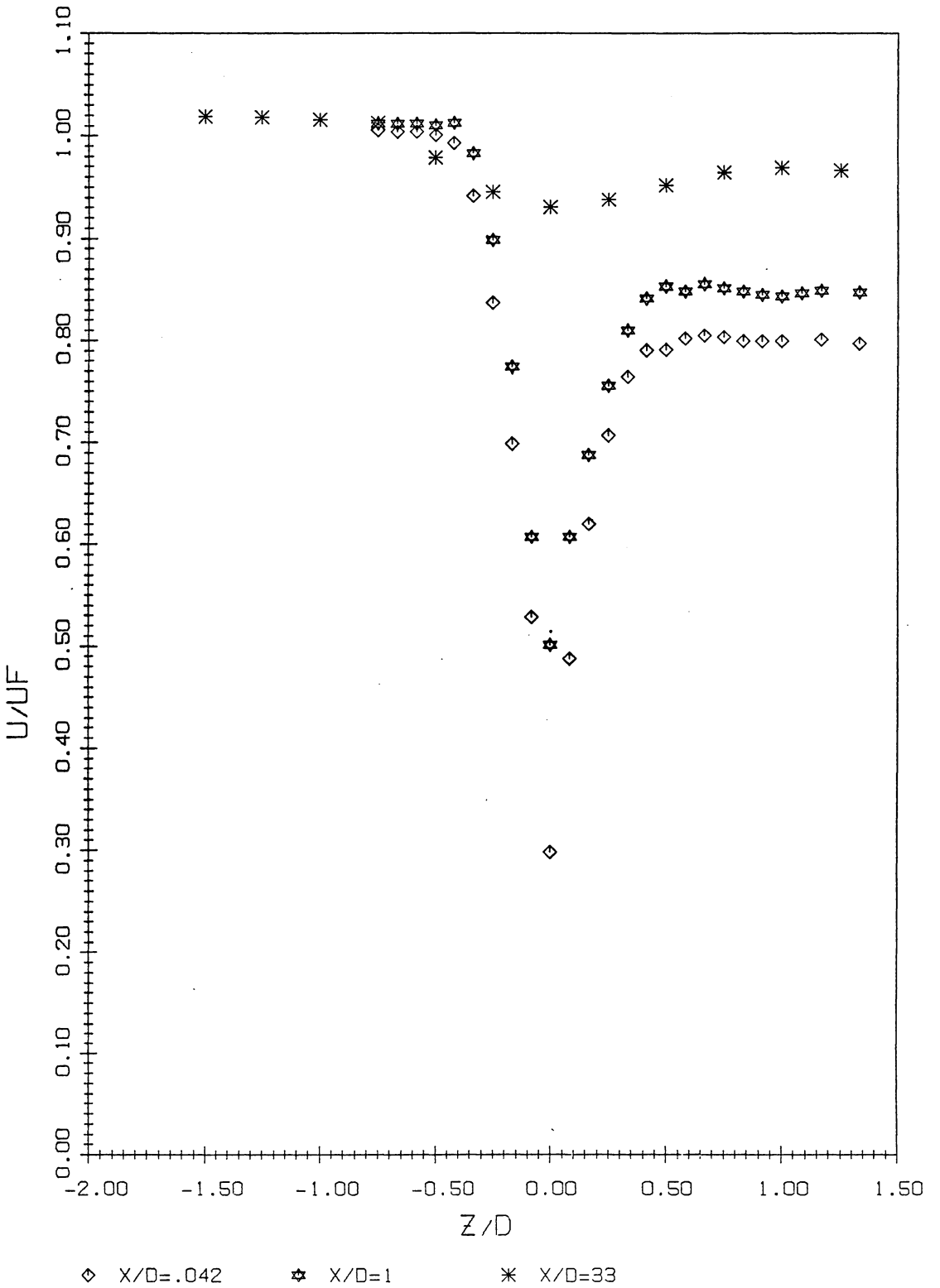


Fig. 16 Streamwise Decay of Axial Velocity Defect in Vertical Profiles through the Wake Center .

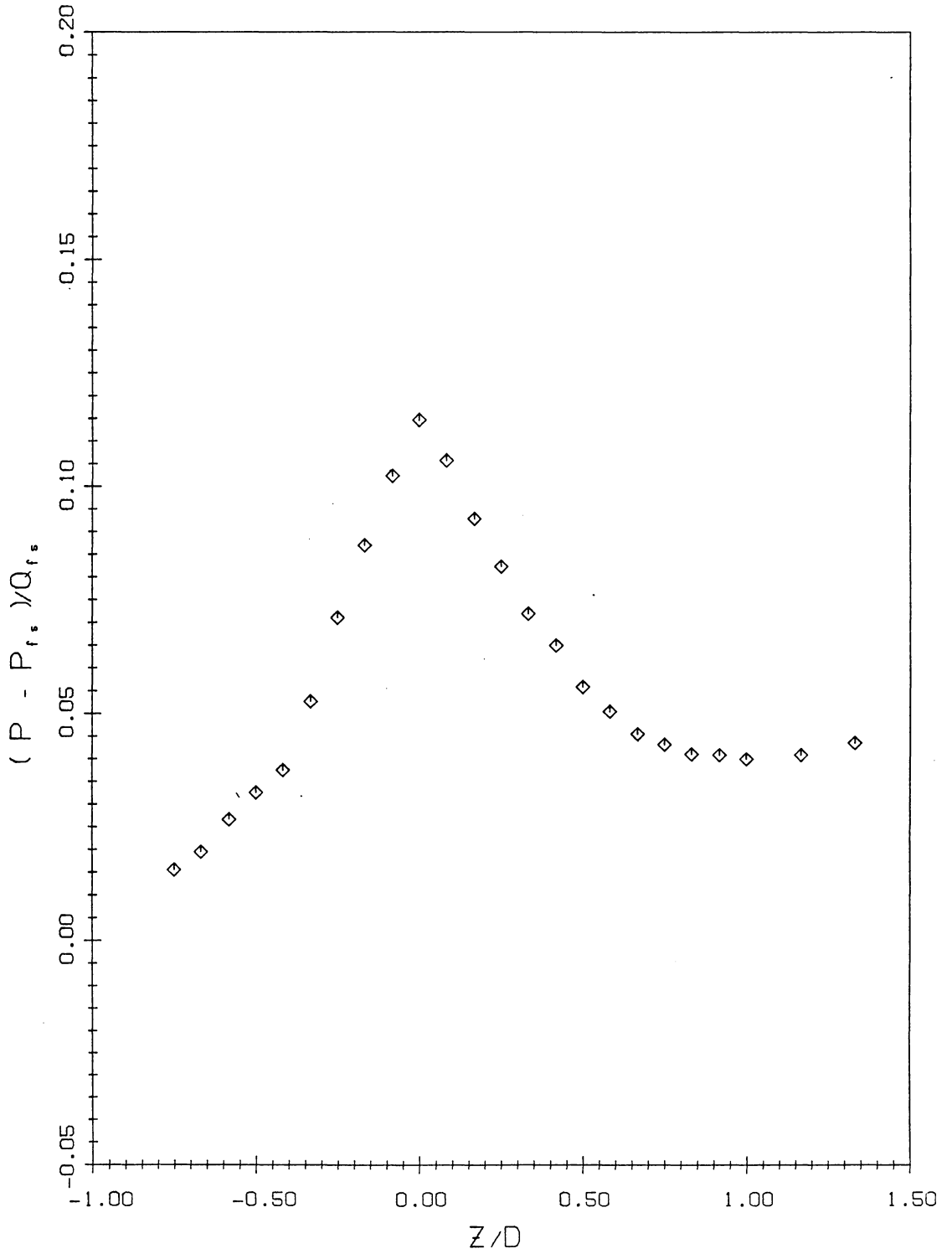


Fig. 17 Non-Dimensional Static Pressure Co-efficient Profile in the Vertical Direction through the Wake Center at X/D=0.042 .

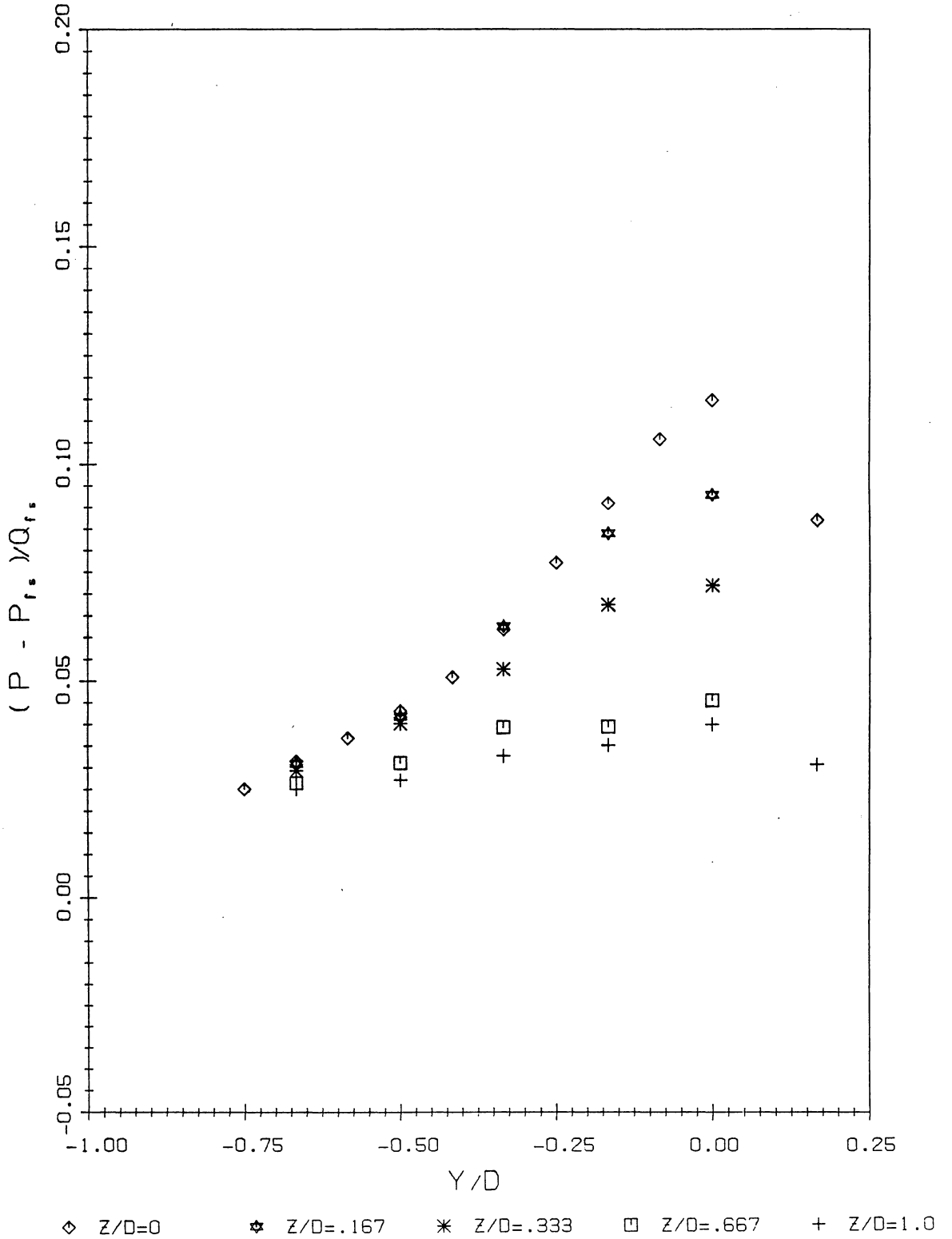


Fig. 18 Comparison of Static Pressure Co-efficient Profiles in the Horizontal Direction for Various Heights above the Wake Center at X/D=0.042 .

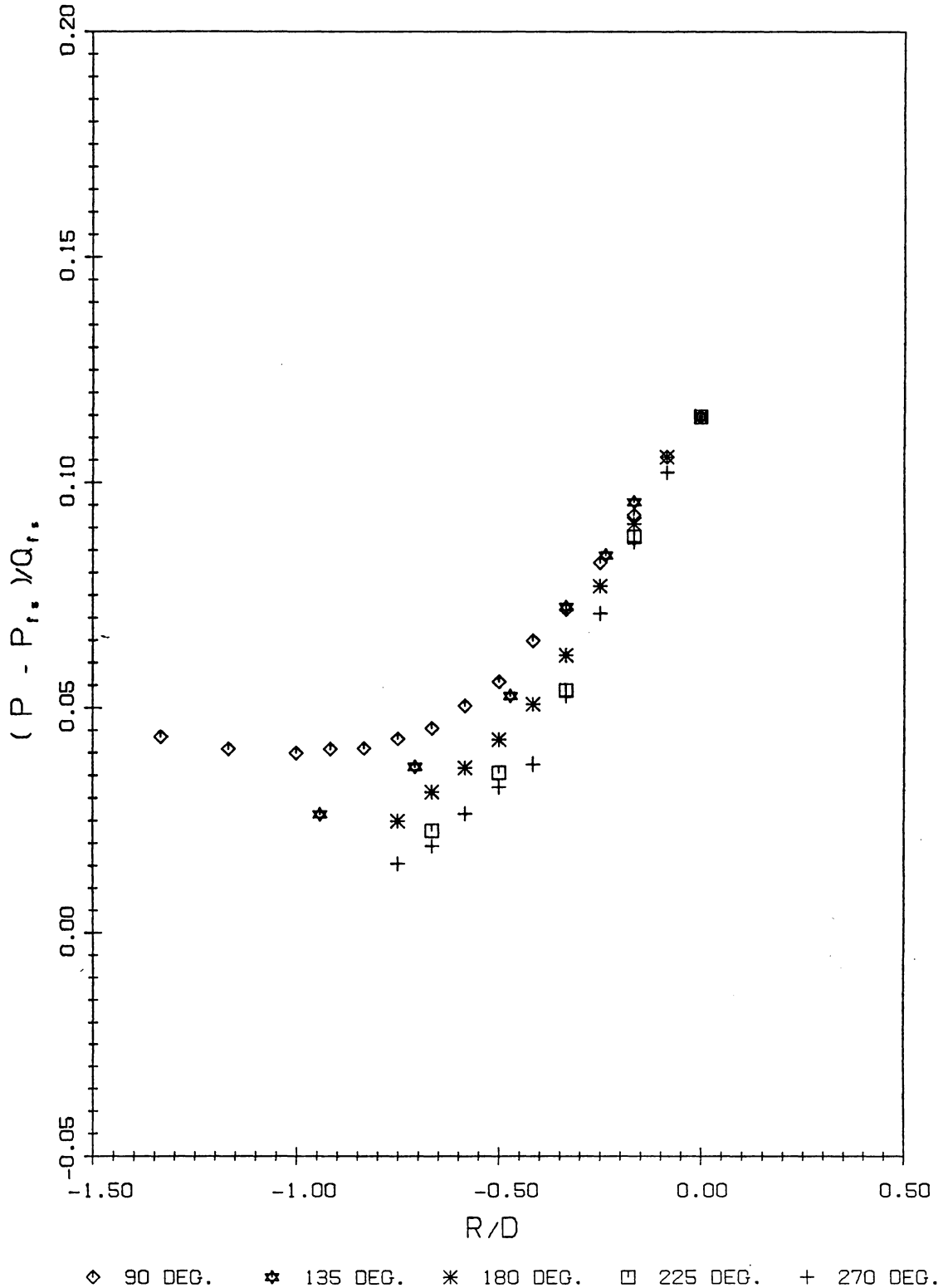


Fig. 19 Comparison of Radial Profiles of Static Pressure Co-efficient for Various Angles Through the Wake Center at X/D=0.042 .

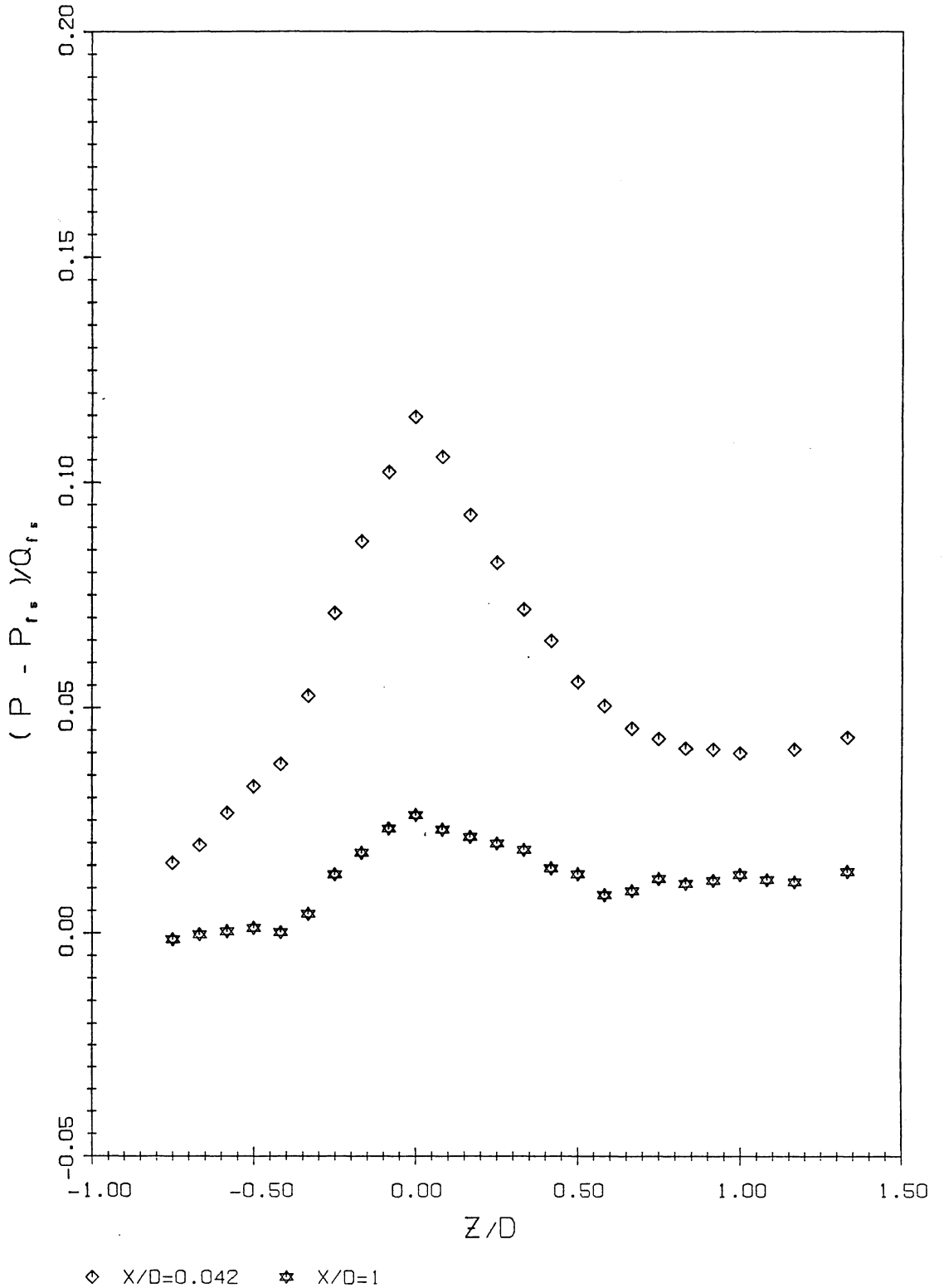


Fig. 20 Streamwise Decay of Static Pressure Co-efficient Profiles in the Vertical Direction (Y/D=0) for X/D=0.042 and 1.0 .

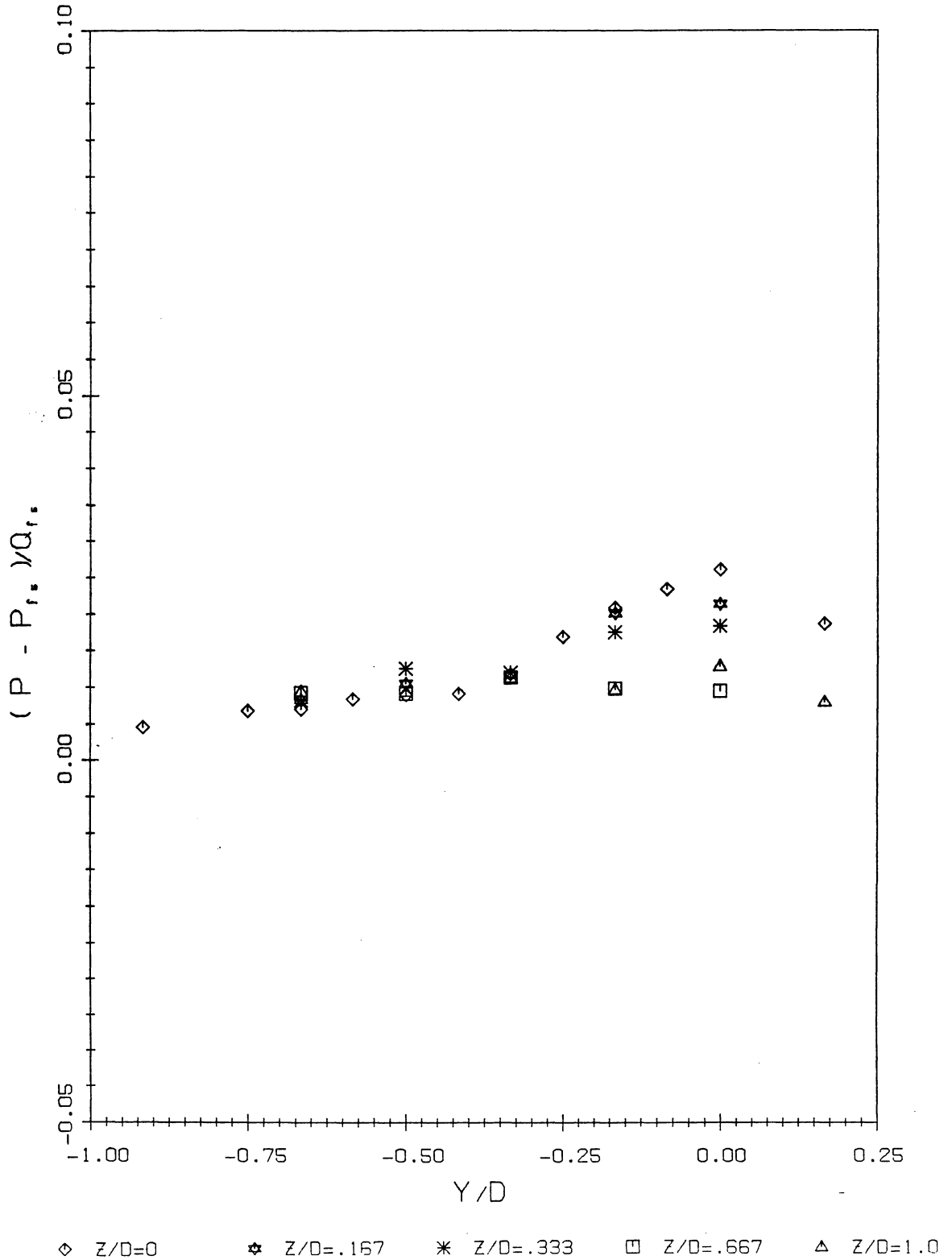


Fig. 21 Static Pressure Co-efficient Profiles in the Horizontal Direction for Various Heights above the Wake Center at X/D=1.0 .

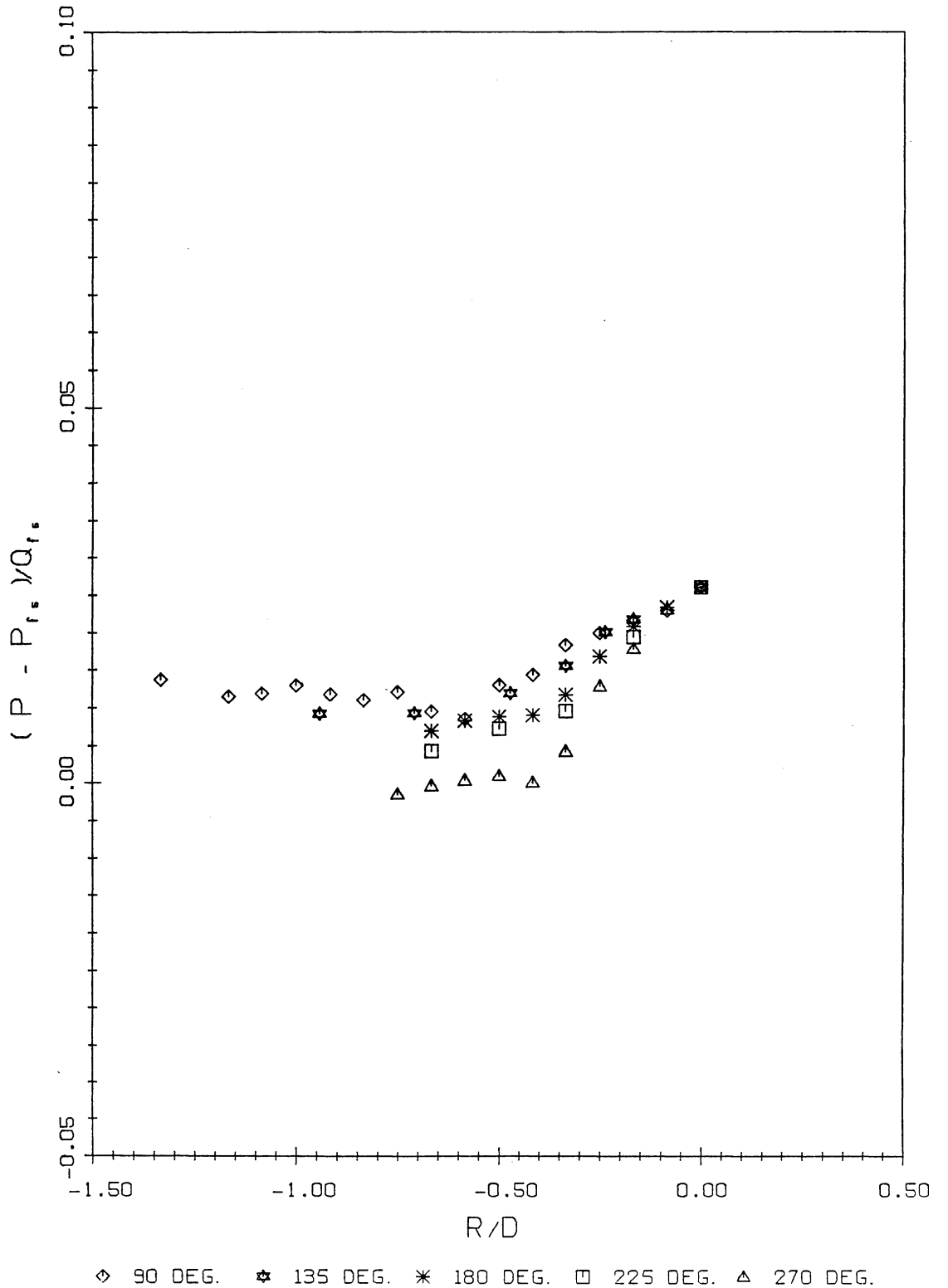


Fig. 22 Comparison of Radial Profiles of Static Pressure Co-efficients for Various Angles at X/D=1.0 .

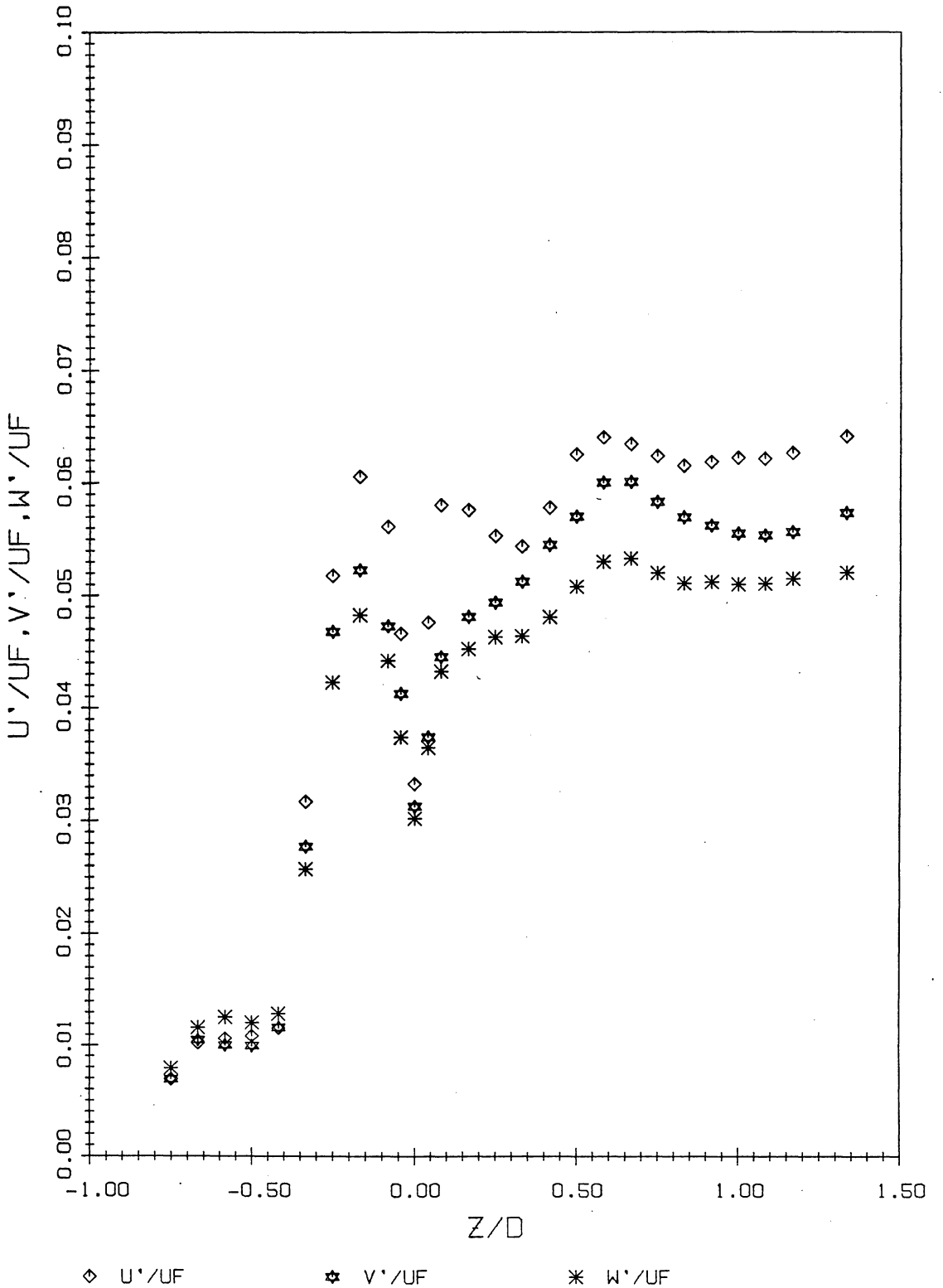


Fig. 23 Non-Dimensional Turbulence Intensity Profiles in the Vertical Direction (Y/D=0) at X/D=0.042 .

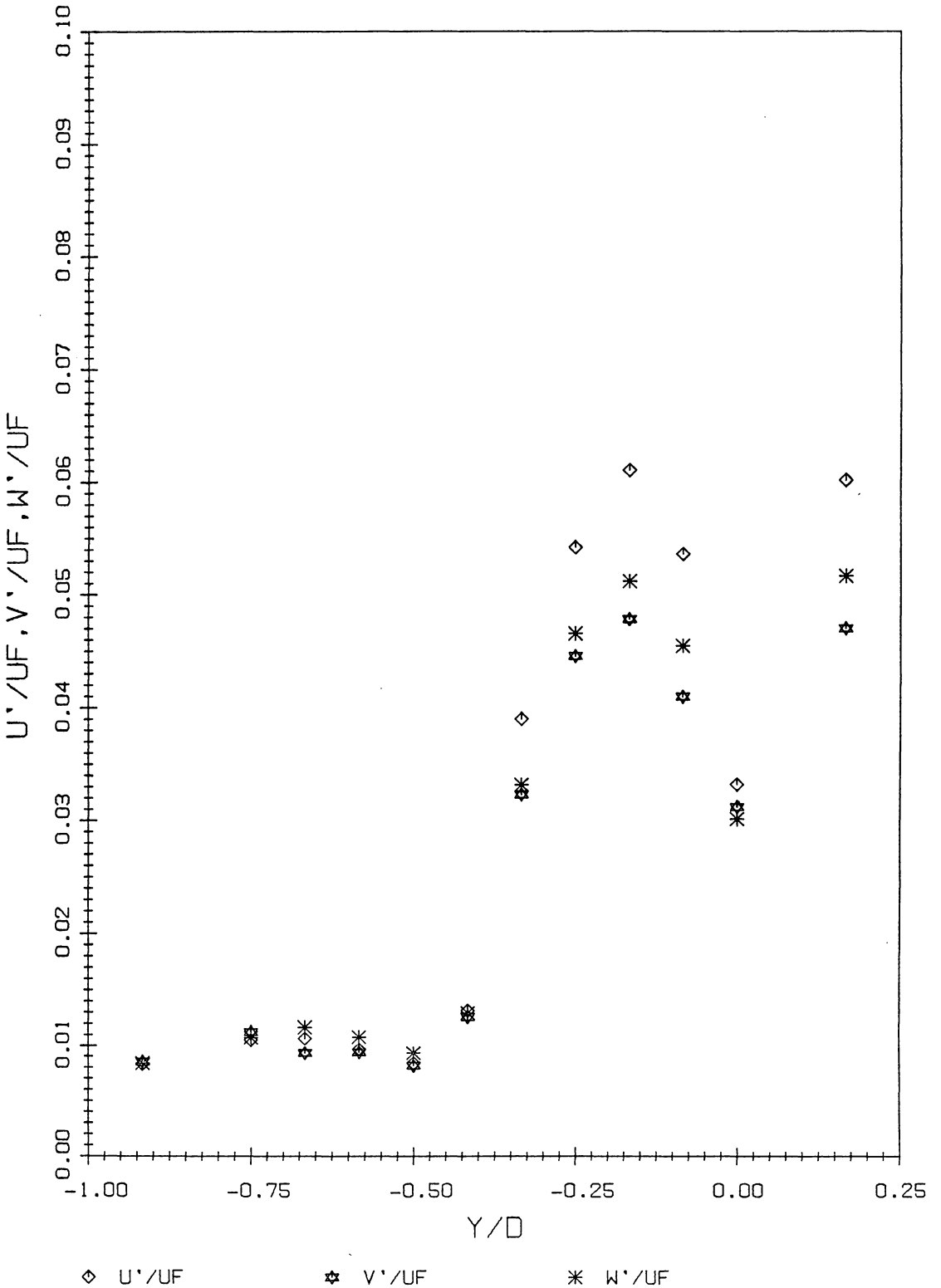


Fig. 24 Non-Dimensional Turbulence Intensity Profiles in the Horizontal Direction for Z/D=0 at X/D=0.042 .

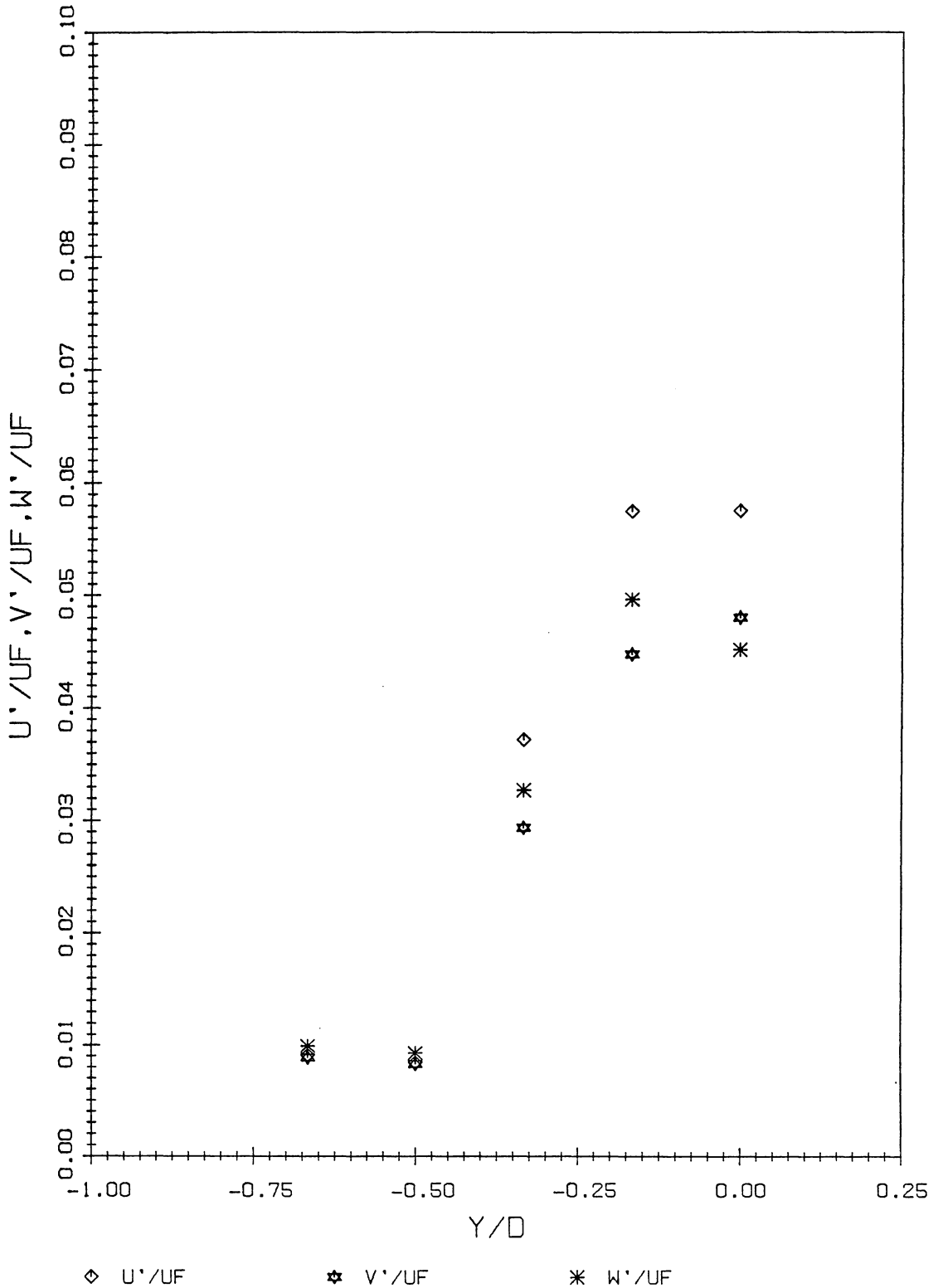


Fig. 25 Non-Dimensional Turbulence Intensity Profiles in the Horizontal Direction for Z/D=0.167 at X/D=0.042 .

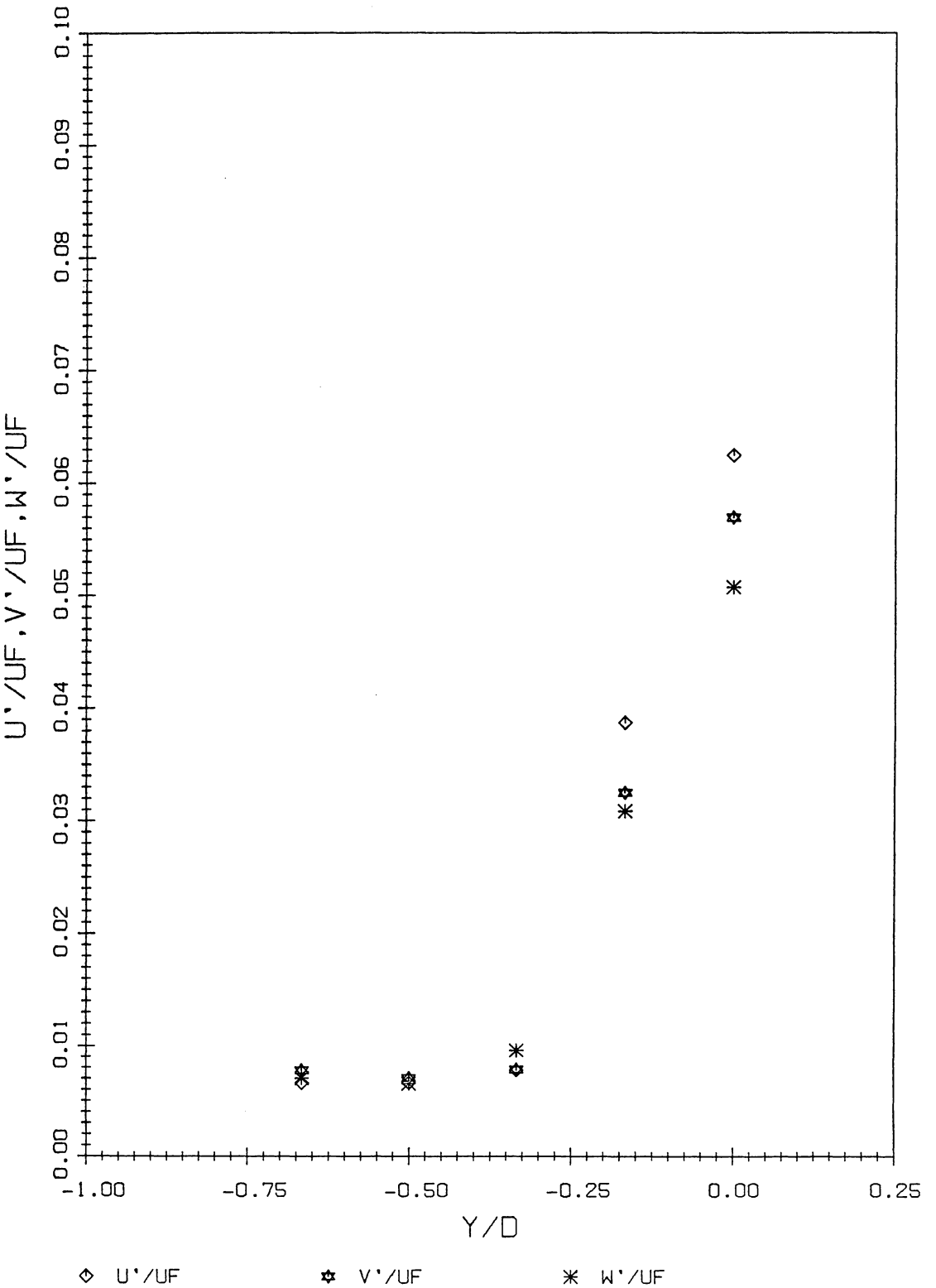


Fig. 26 Non-Dimensional Turbulence Intensity Profiles in the Horizontal Direction for Z/D=0.5 at X/D=0.042 .

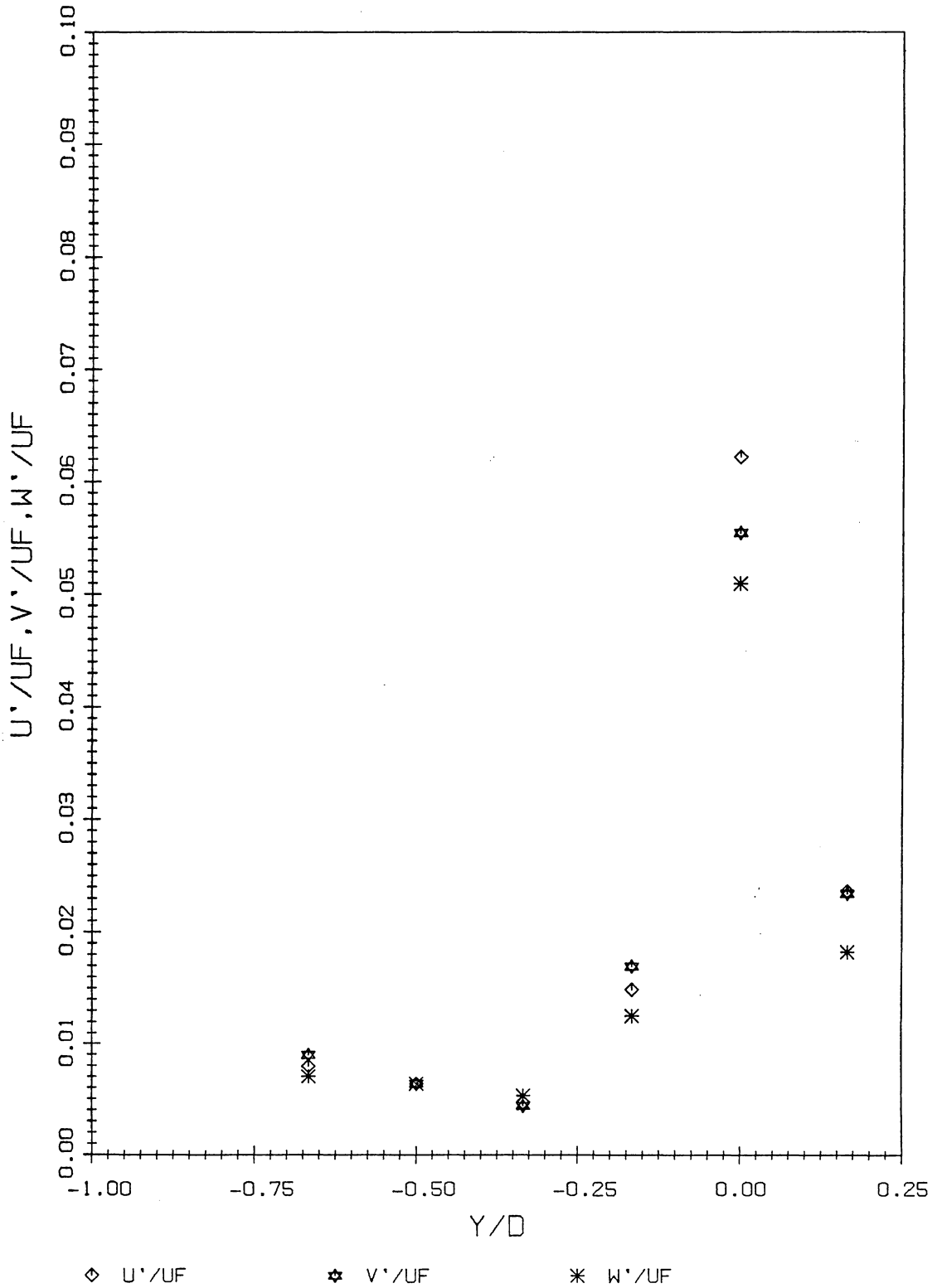


Fig. 27 Non-Dimensional Turbulence Intensity Profiles in the Horizontal Direction for Z/D=1.0 at X/D=0.042 .

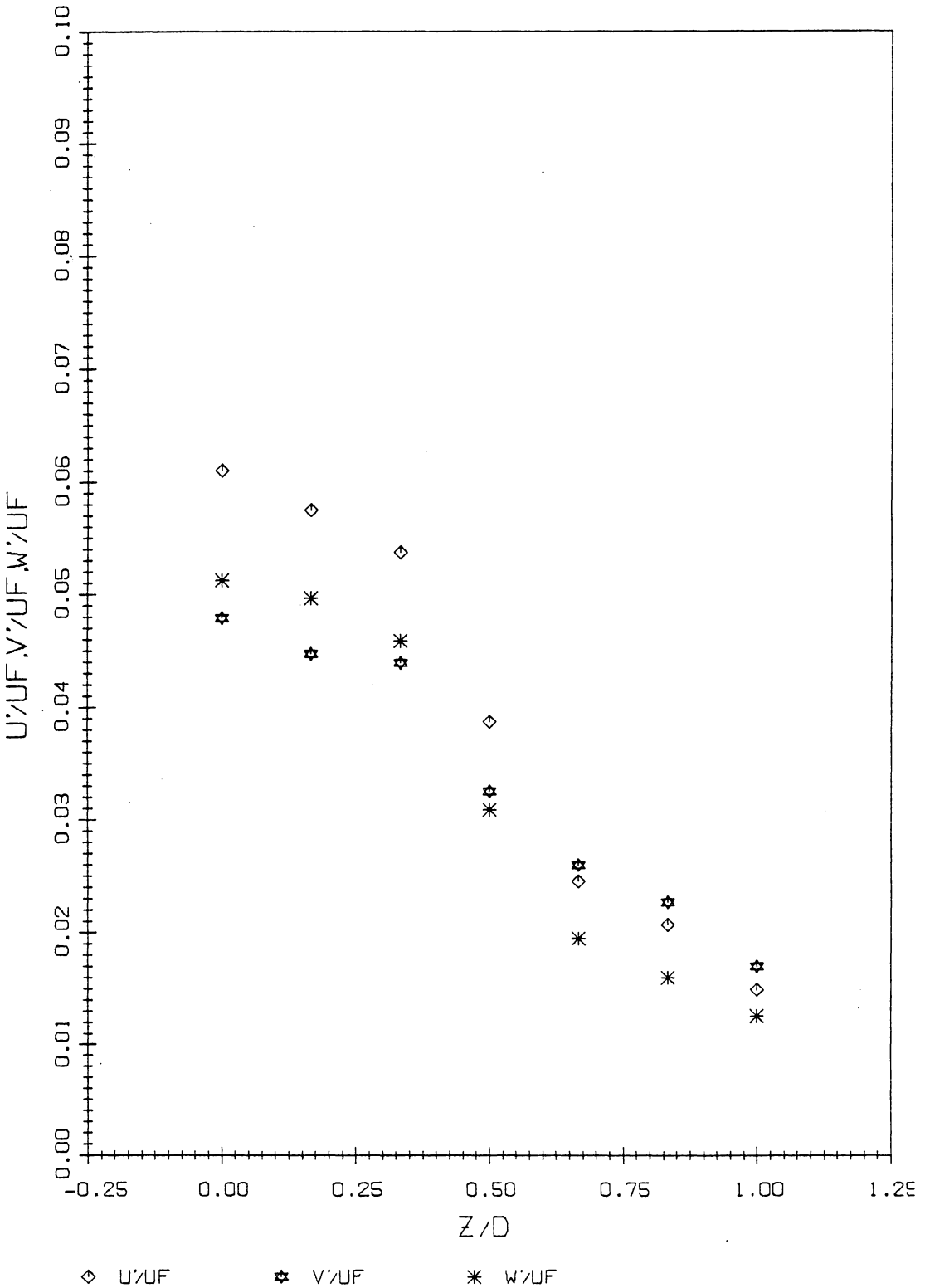


Fig. 28 Non-Dimensional Turbulence Intensity Profiles in the Vertical Direction (Y/D=-0.167) at X/D=0.042 .

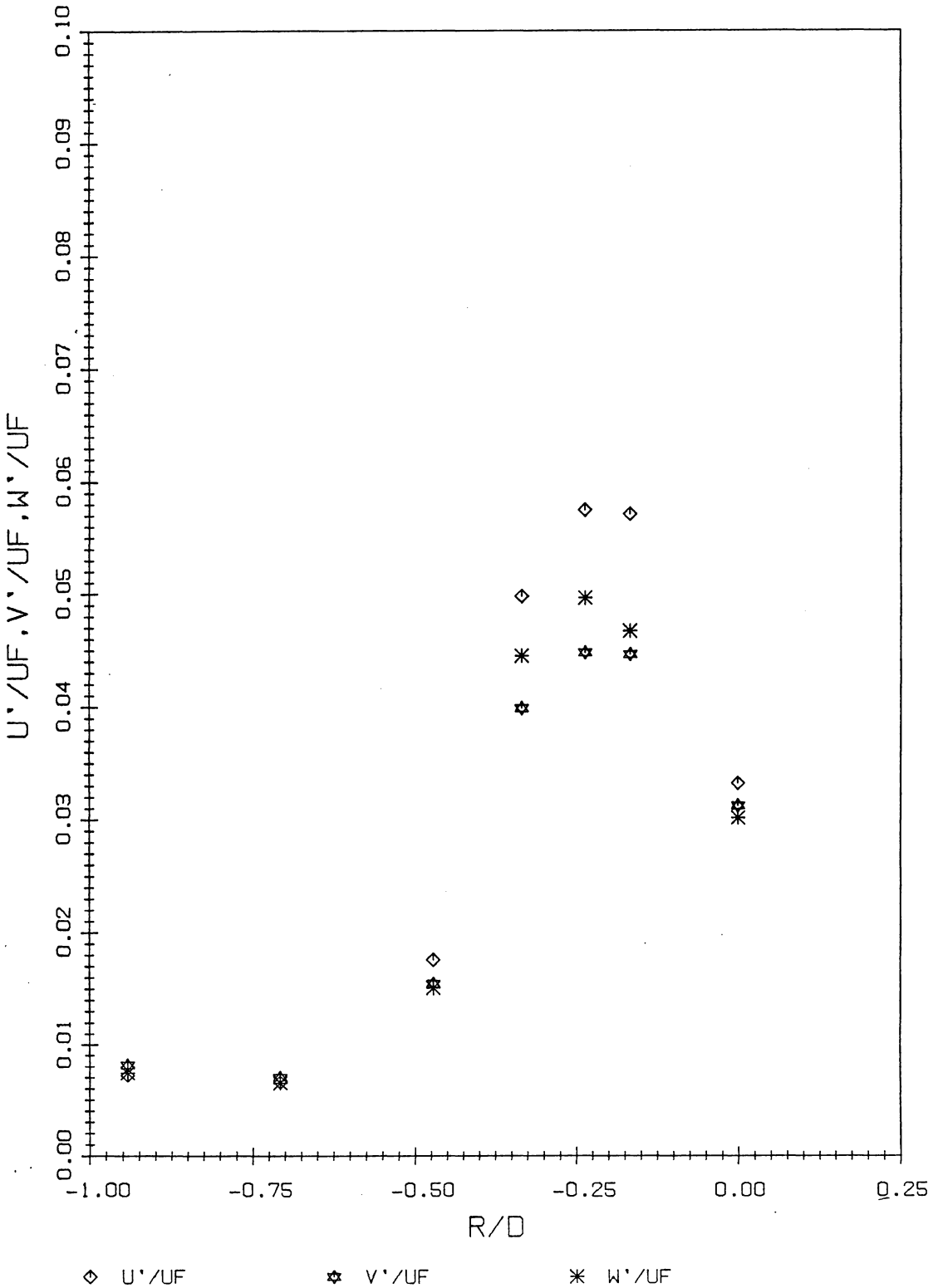


Fig. 29 Non-Dimensional Turbulence Intensity Profiles along the 135 Deg. Ray at X/D=0.042 .

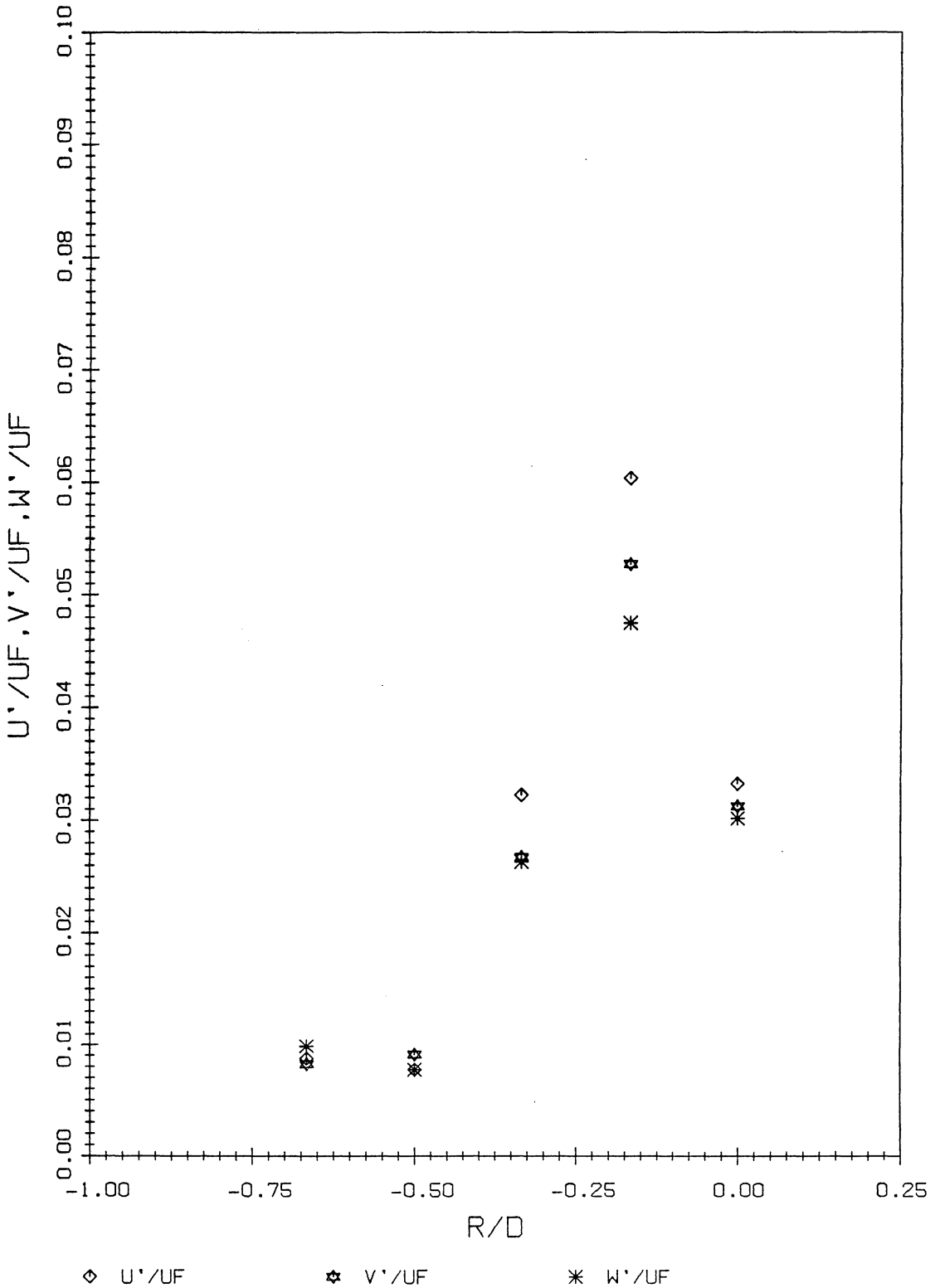


Fig. 30 Non-Dimensional Turbulence Intensity Profiles along the 225 Deg. Ray at X/D=0.042 .

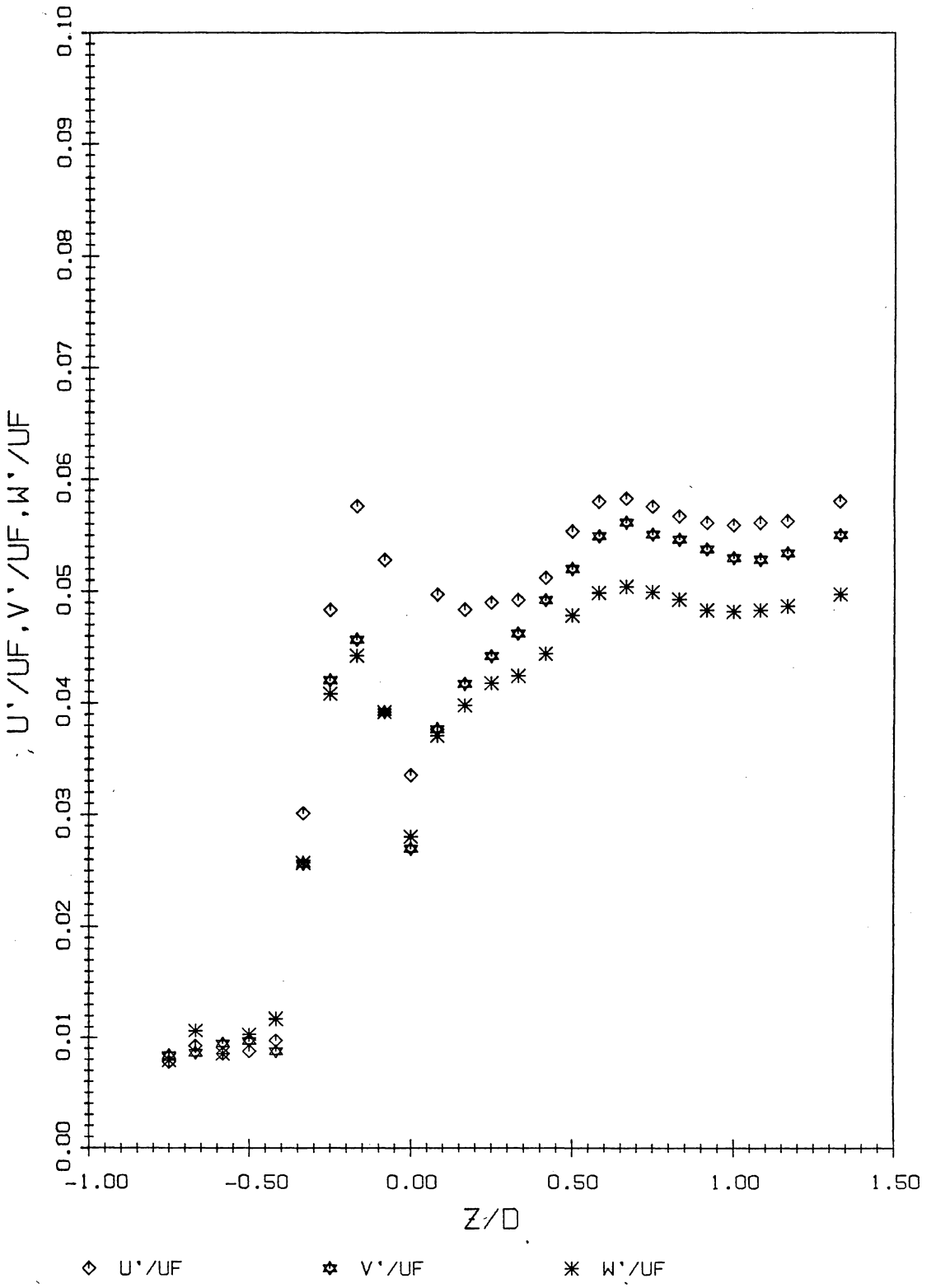


Fig. 31 Non-Dimensional Turbulence Intensity Profiles in the Vertical Direction (Y/D=0) at X/D=1.0 .

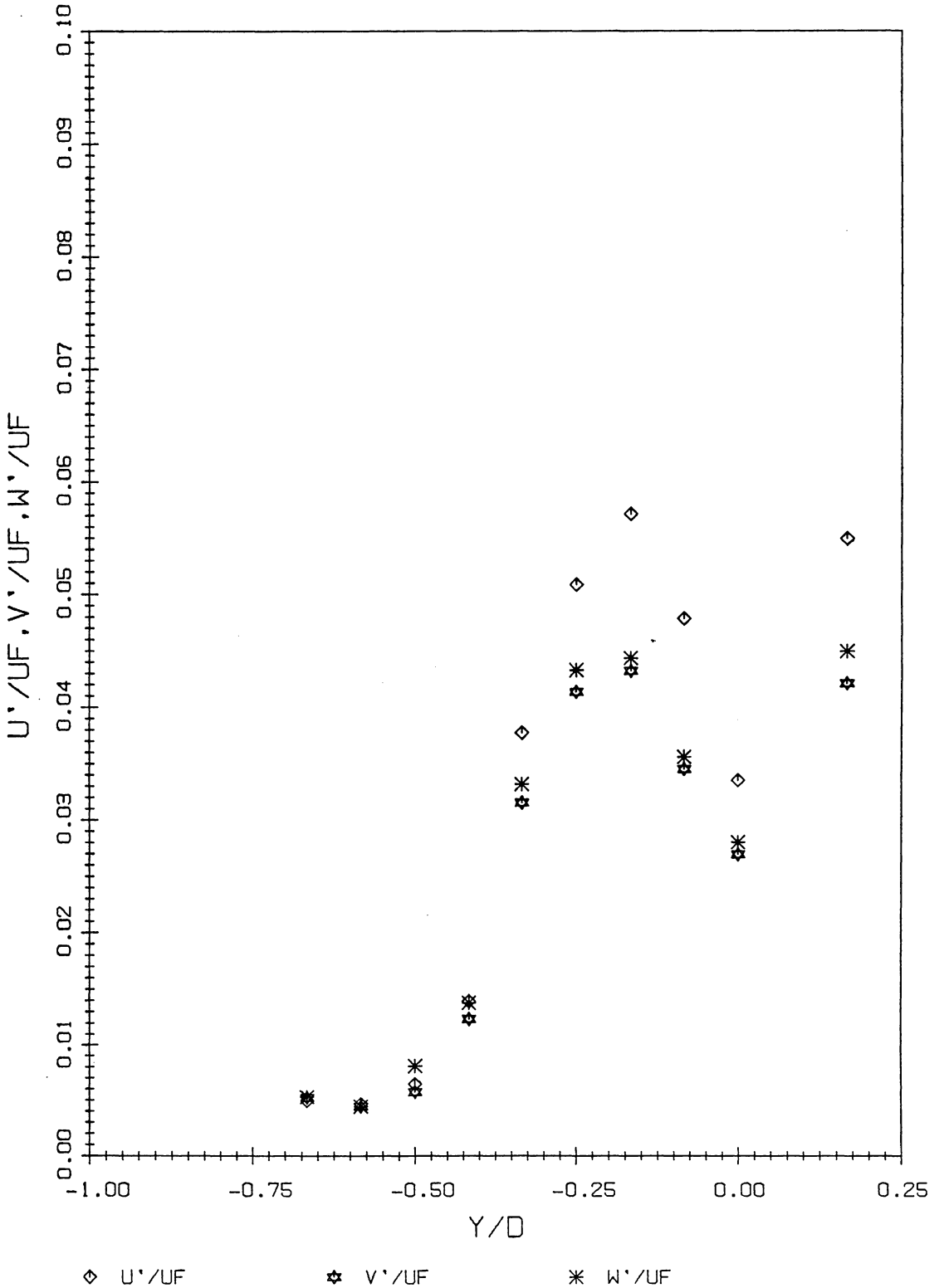


Fig. 32 Non-Dimensional Turbulence Intensity Profiles in the Horizontal Direction for Z/D=0 at X/D=1.0 .

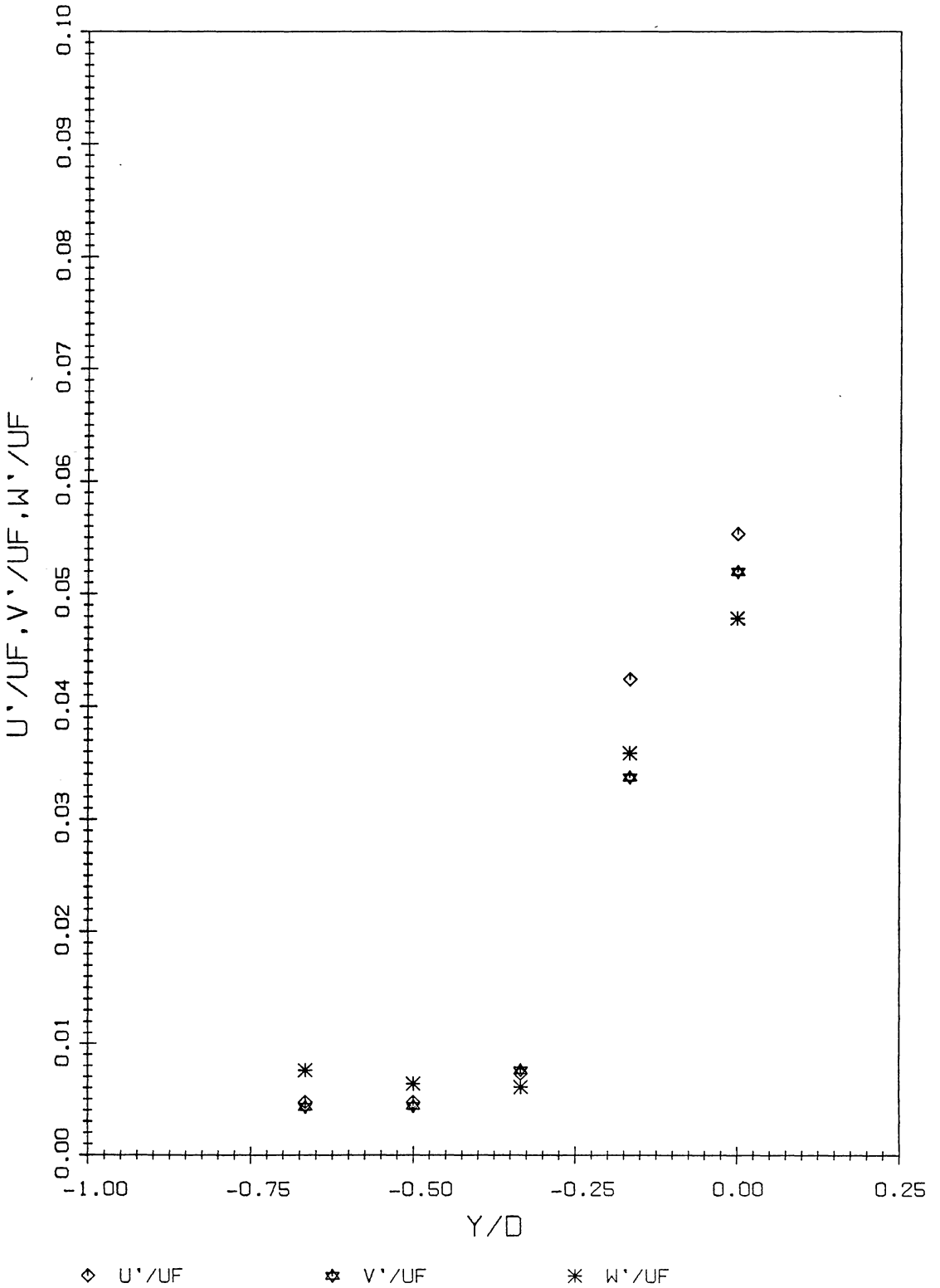


Fig. 33 Non-Dimensional Turbulence Intensity Profiles in the Horizontal Direction for Z/D=0.5 at X/D=1.0 .

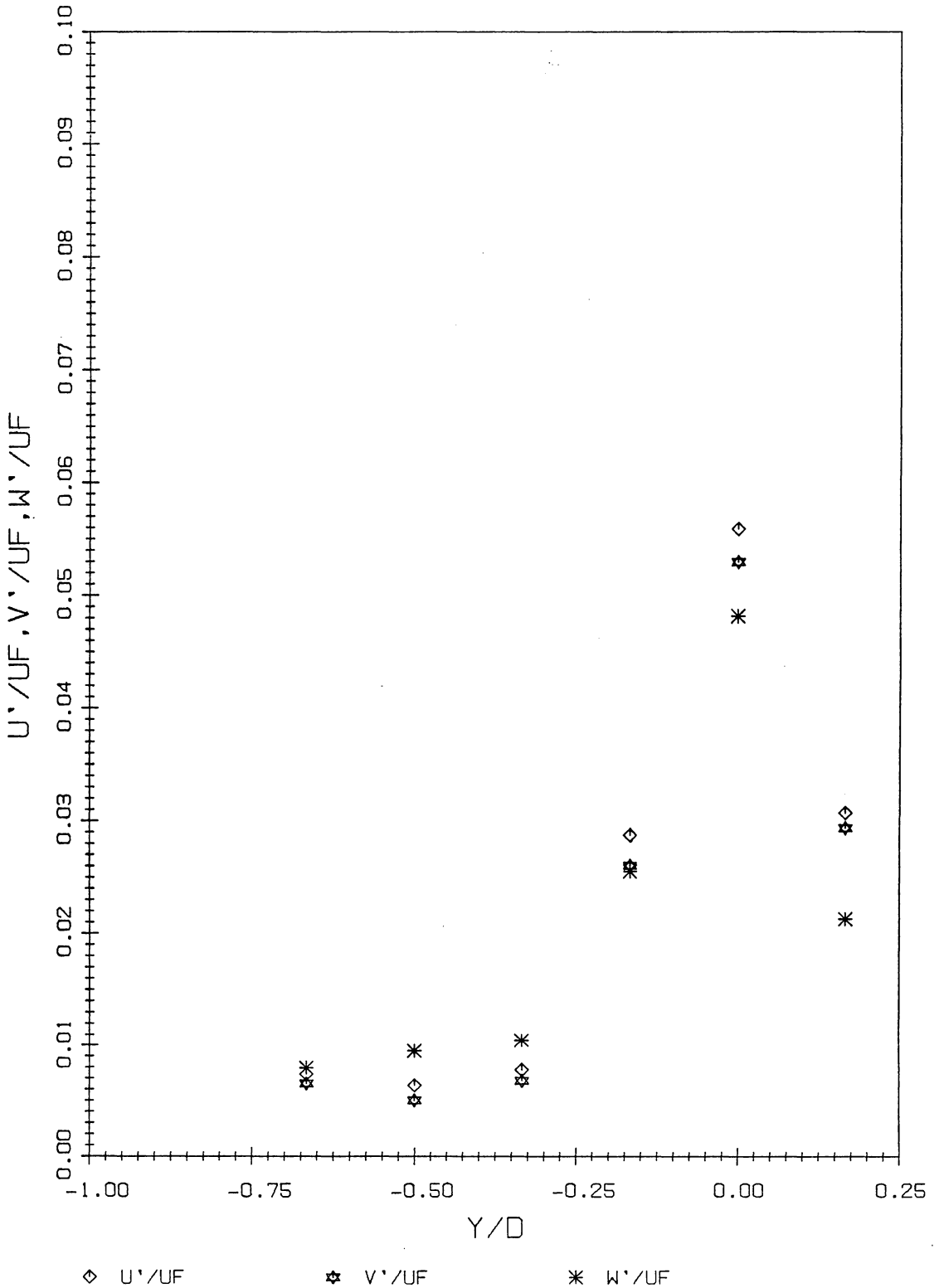


Fig. 34 Non-Dimensional Turbulence Intensity Profiles in the Horizontal Direction for Z/D=1.0 at X/D=1.0 .

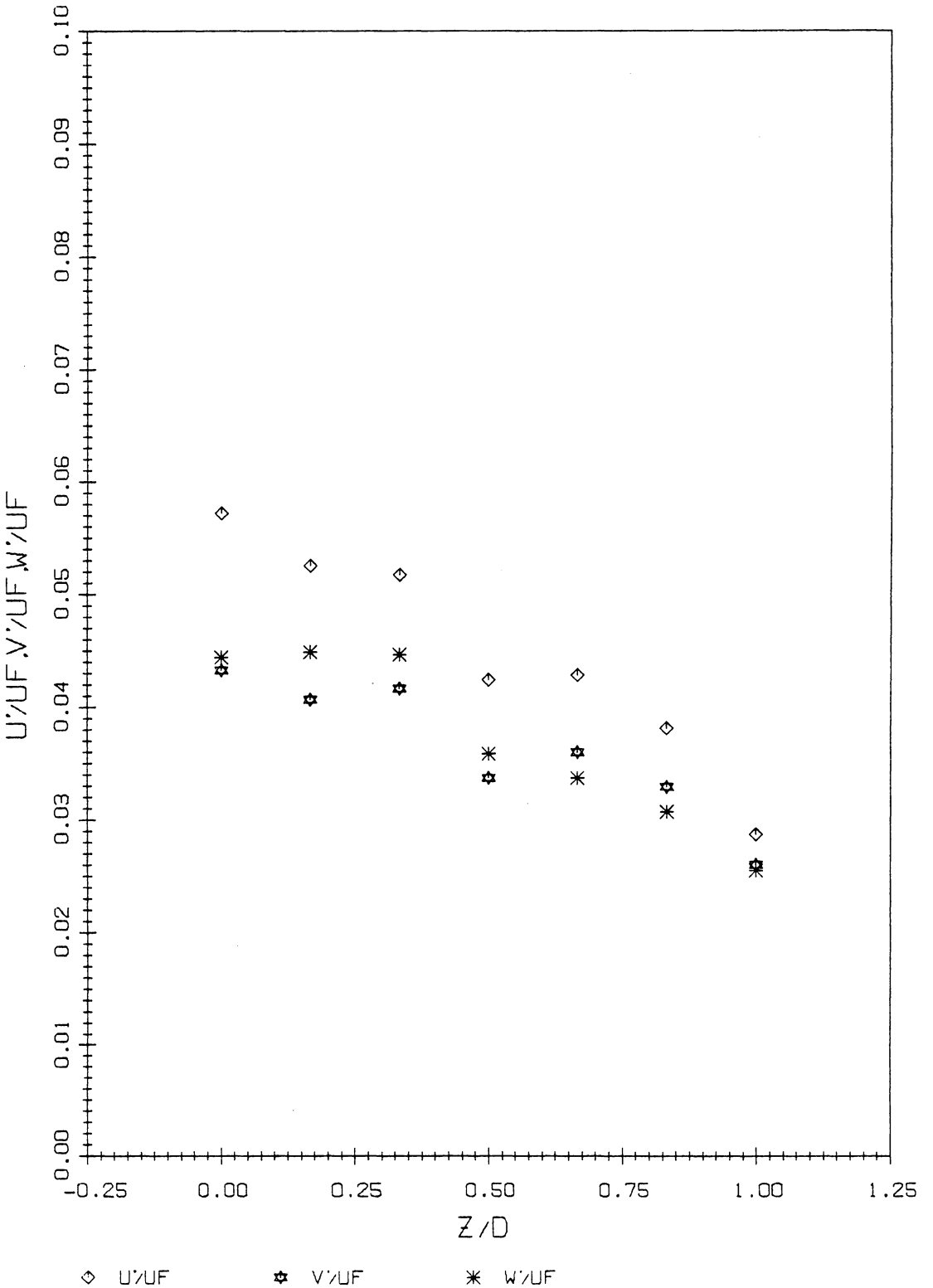


Fig. 35 Non-Dimensional Turbulence Intensity Profiles in the Vertical Direction (Y/D=-0.167) at X/D=1.0 .

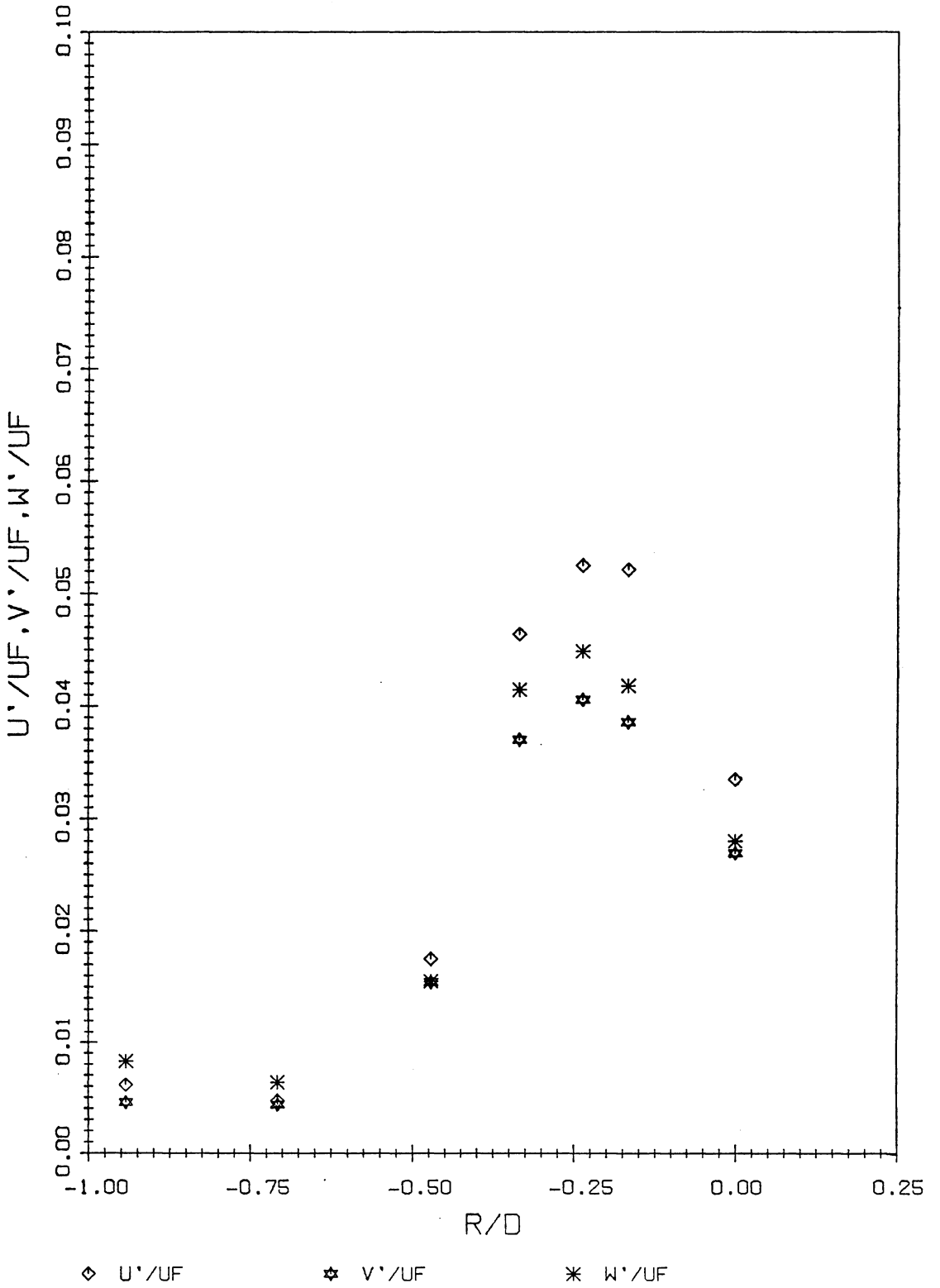


Fig. 36 Non-Dimensional Turbulence Intensity Profiles along the 135 Deg. Ray at X/D=1.0 .

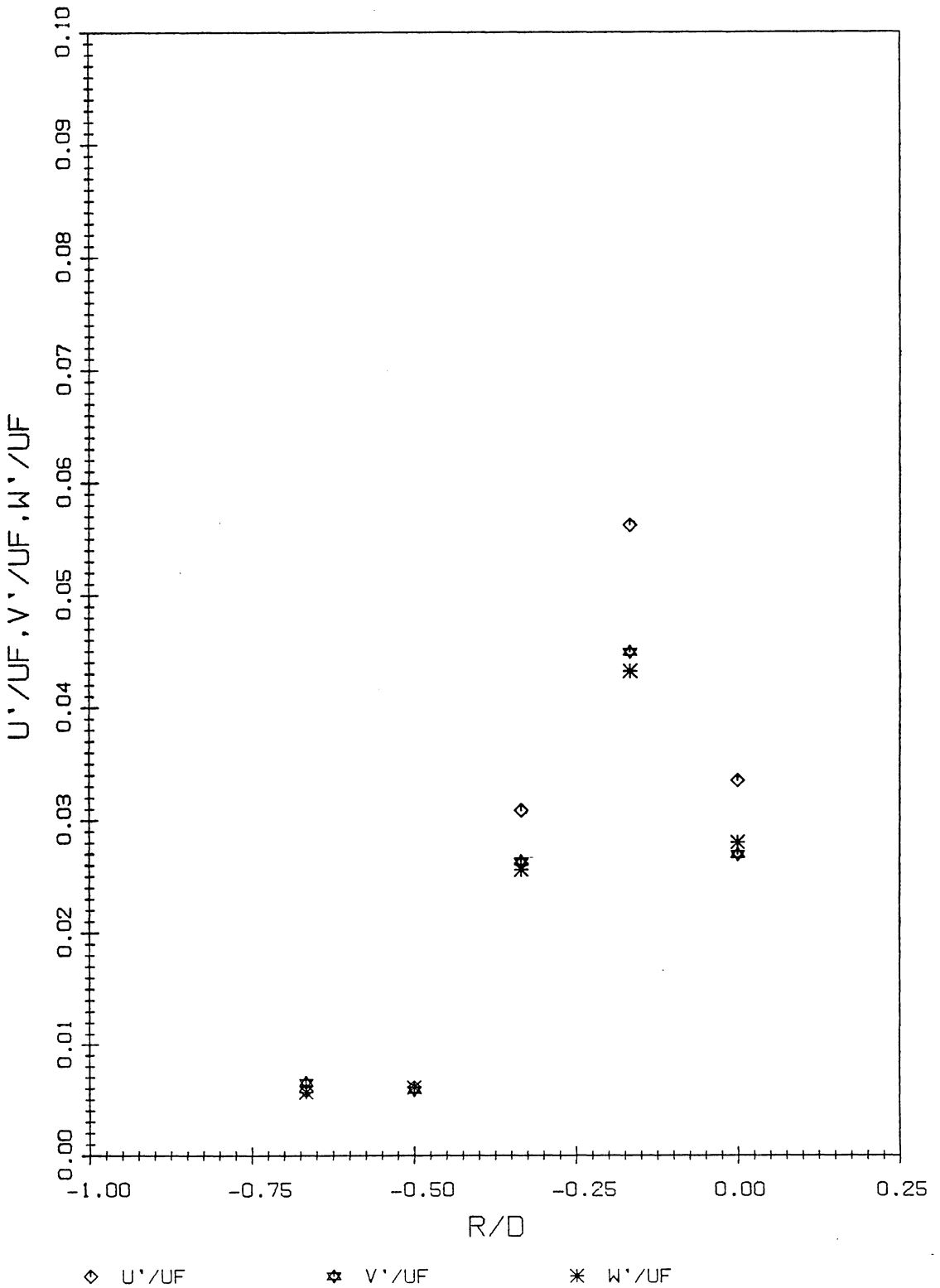


Fig. 37 Non-Dimensional Turbulence Intensity Profiles along the 225 Deg. Ray at X/D=1.0 .

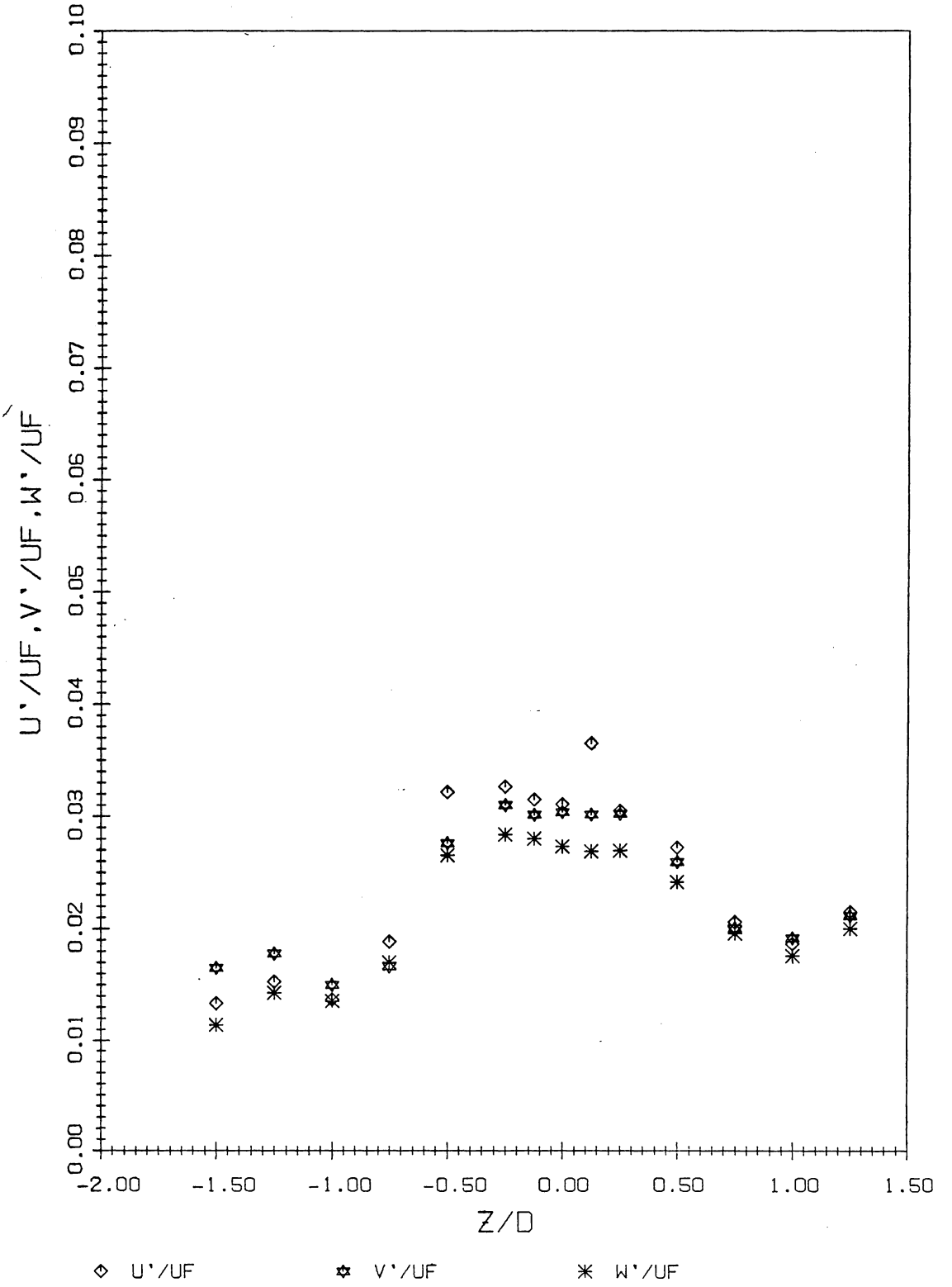


Fig. 38 Non-Dimensional Turbulence Intensity Profiles in the Vertical Direction (Y/D=0) at X/D=33.0 .

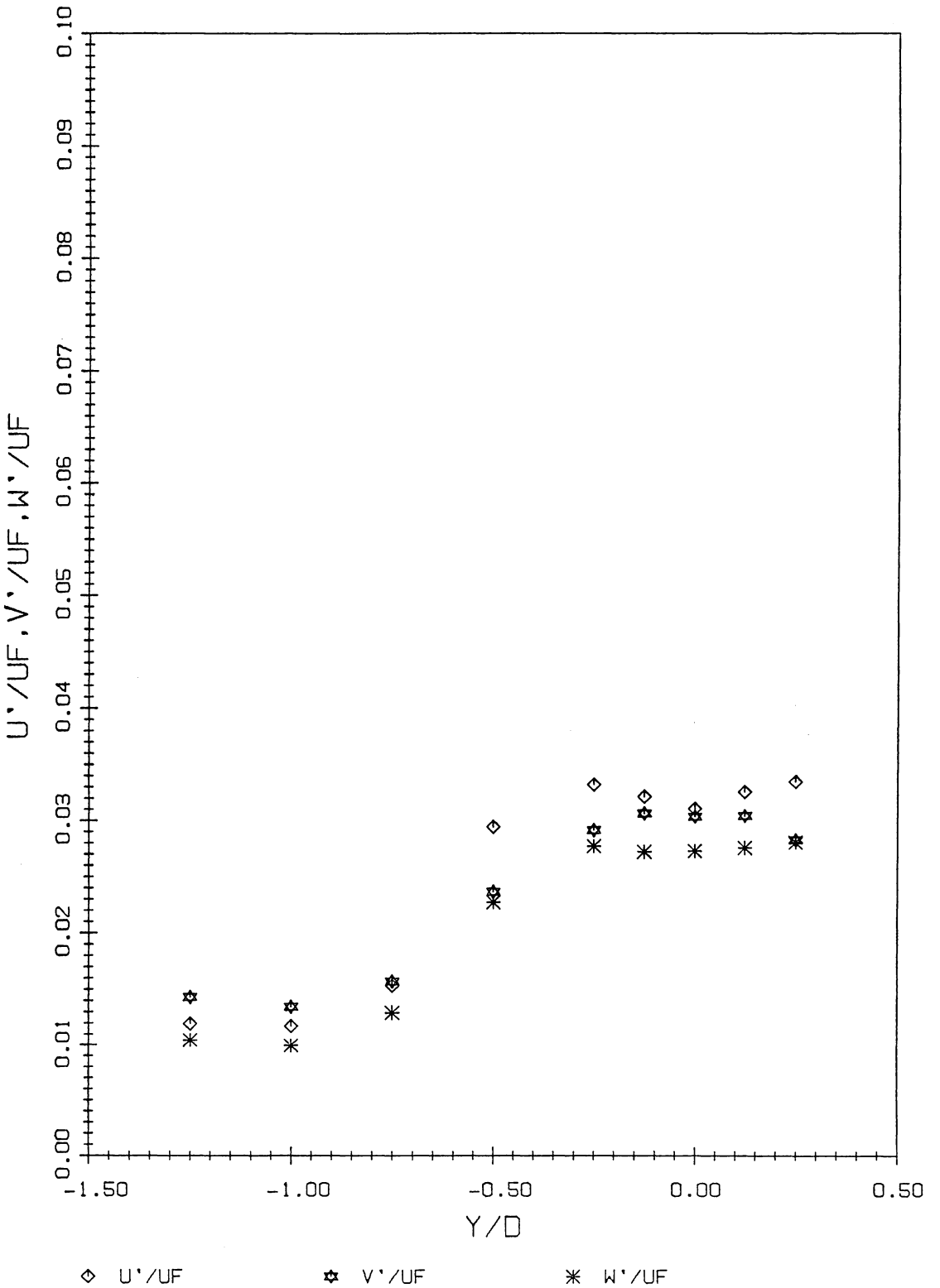


Fig. 39 Non-Dimensional Turbulence Intensity Profiles in the Horizontal Direction for Z/D=0 at X/D=33.0 .

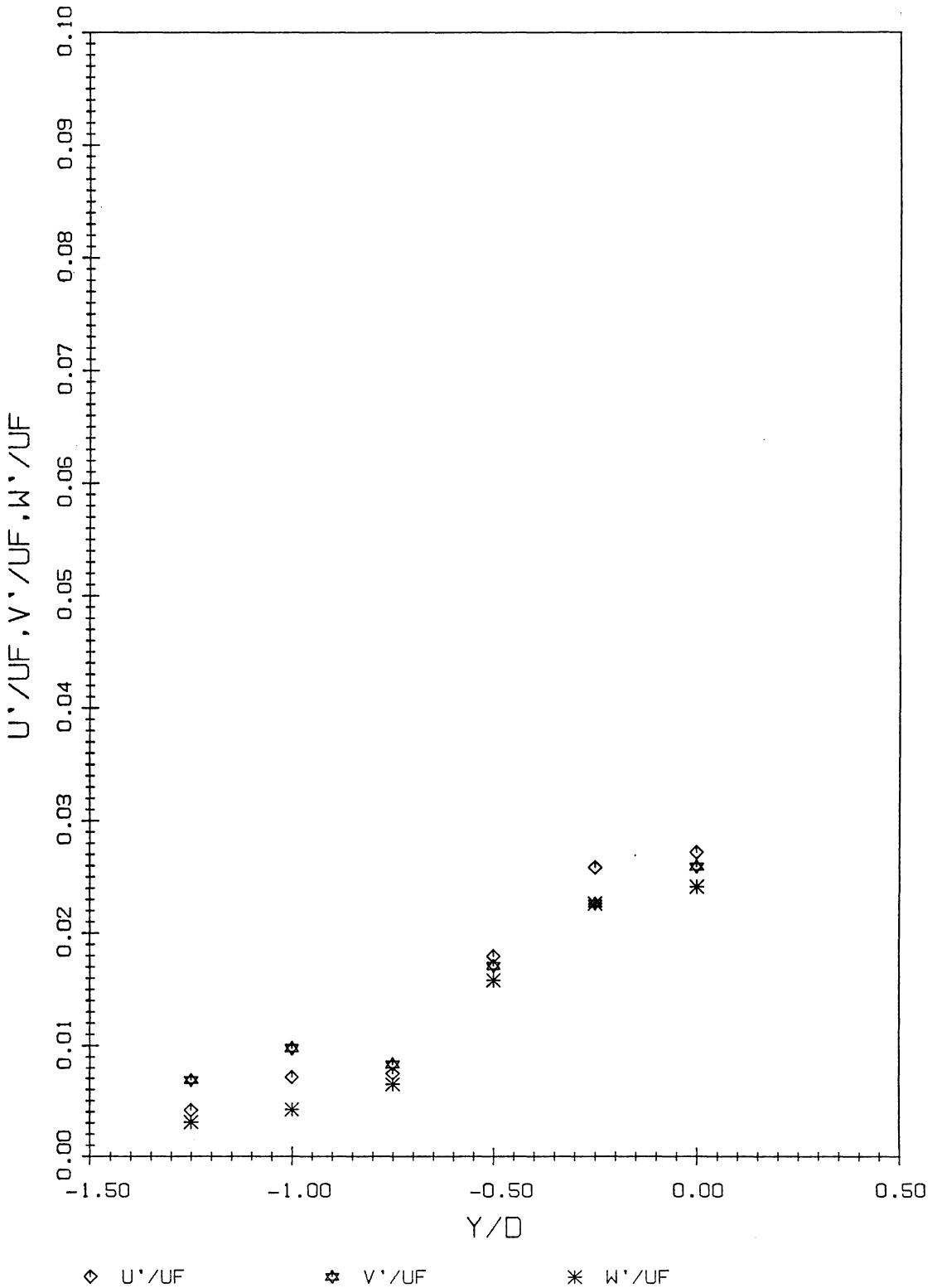


Fig. 40 Non-Dimensional Turbulence Intensity Profiles in the Horizontal Direction for Z/D=0.5 at X/D=33.0 .

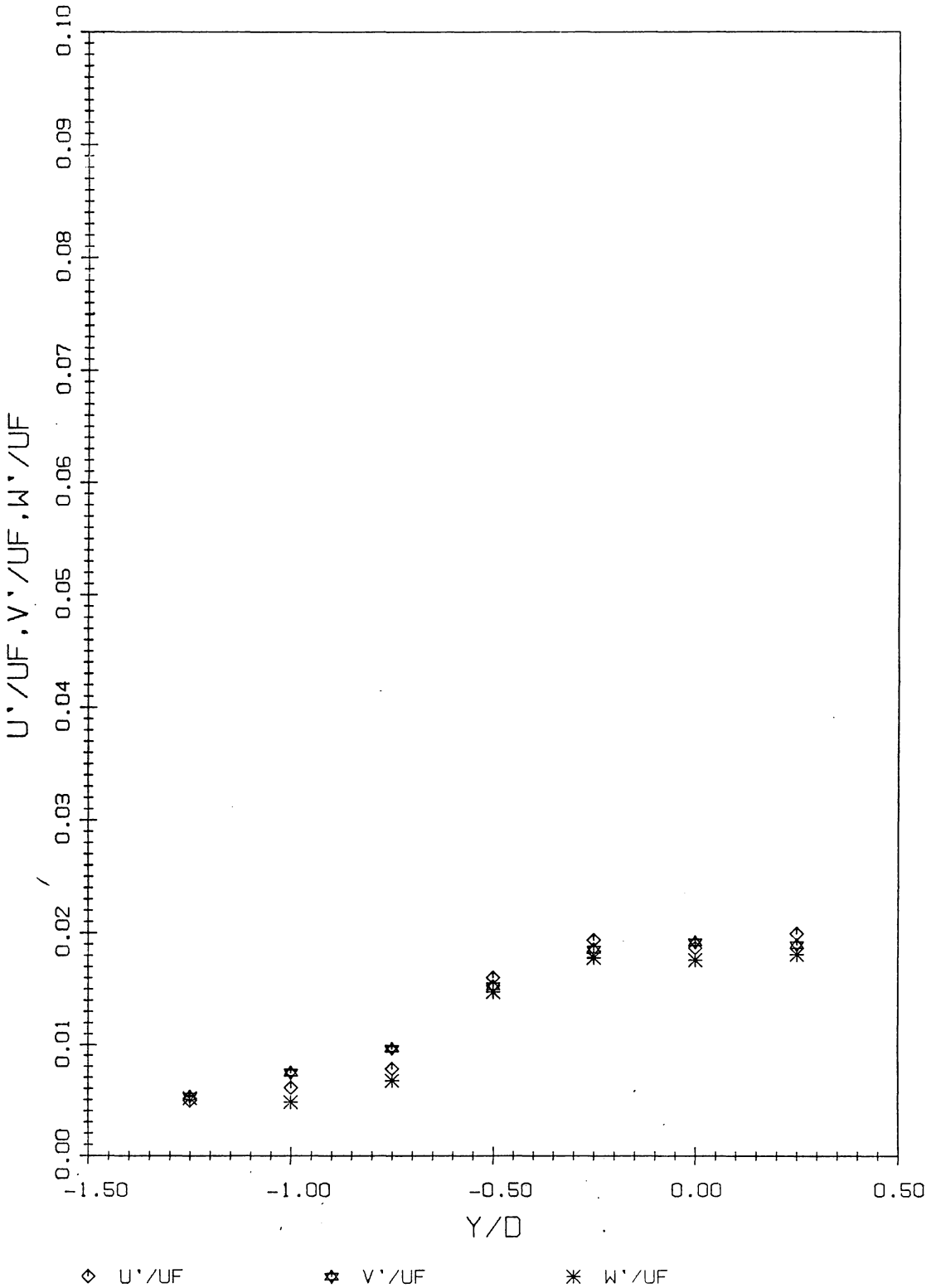


Fig. 41 Non-Dimensional Turbulence Intensity Profiles in the Horizontal Direction for Z/D=1.0 at X/D=33.0 .

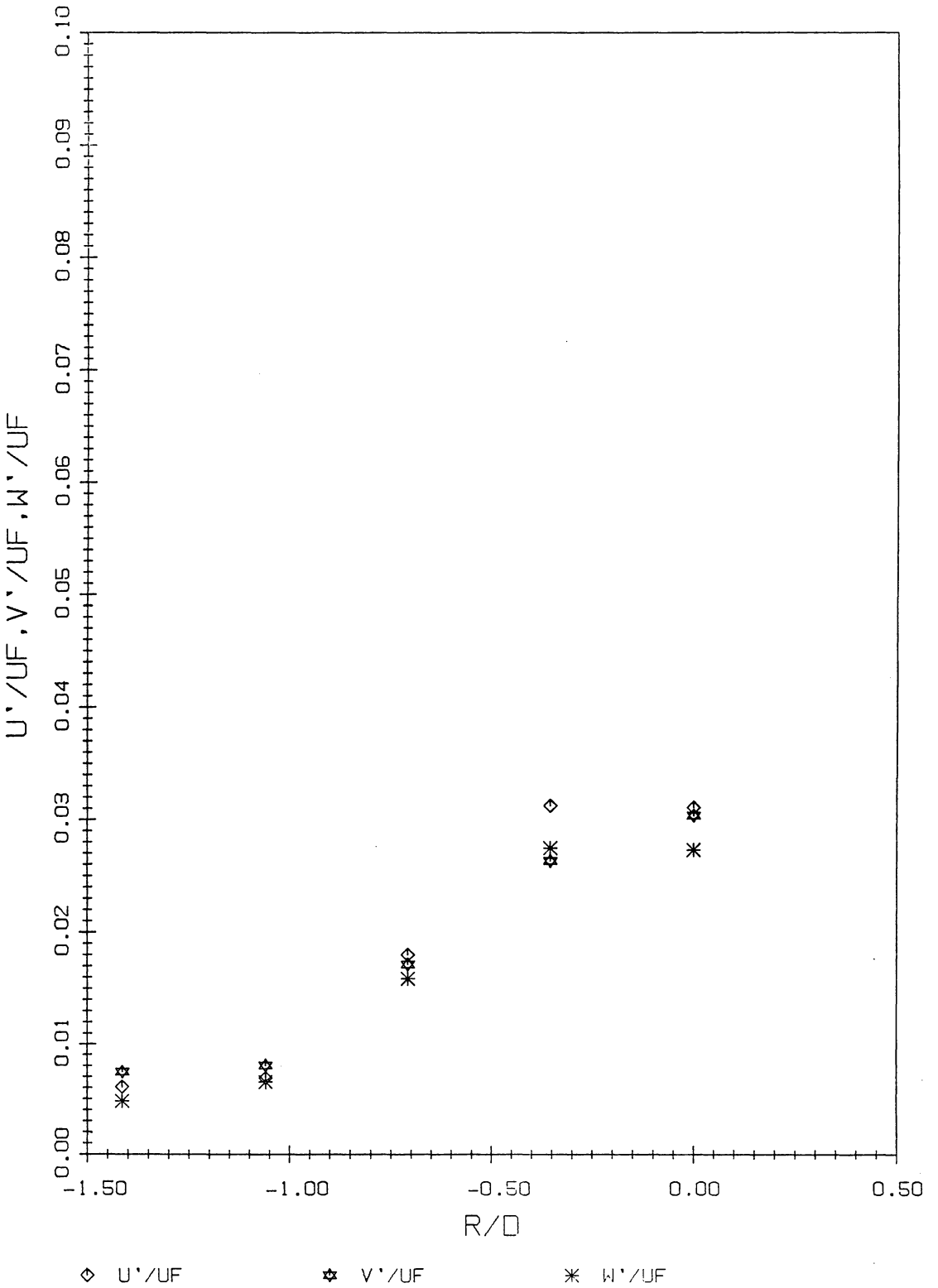


Fig. 42 Non-Dimensional Turbulence Intensity Profiles along the 135 Deg. Ray at X/D=33.0 .

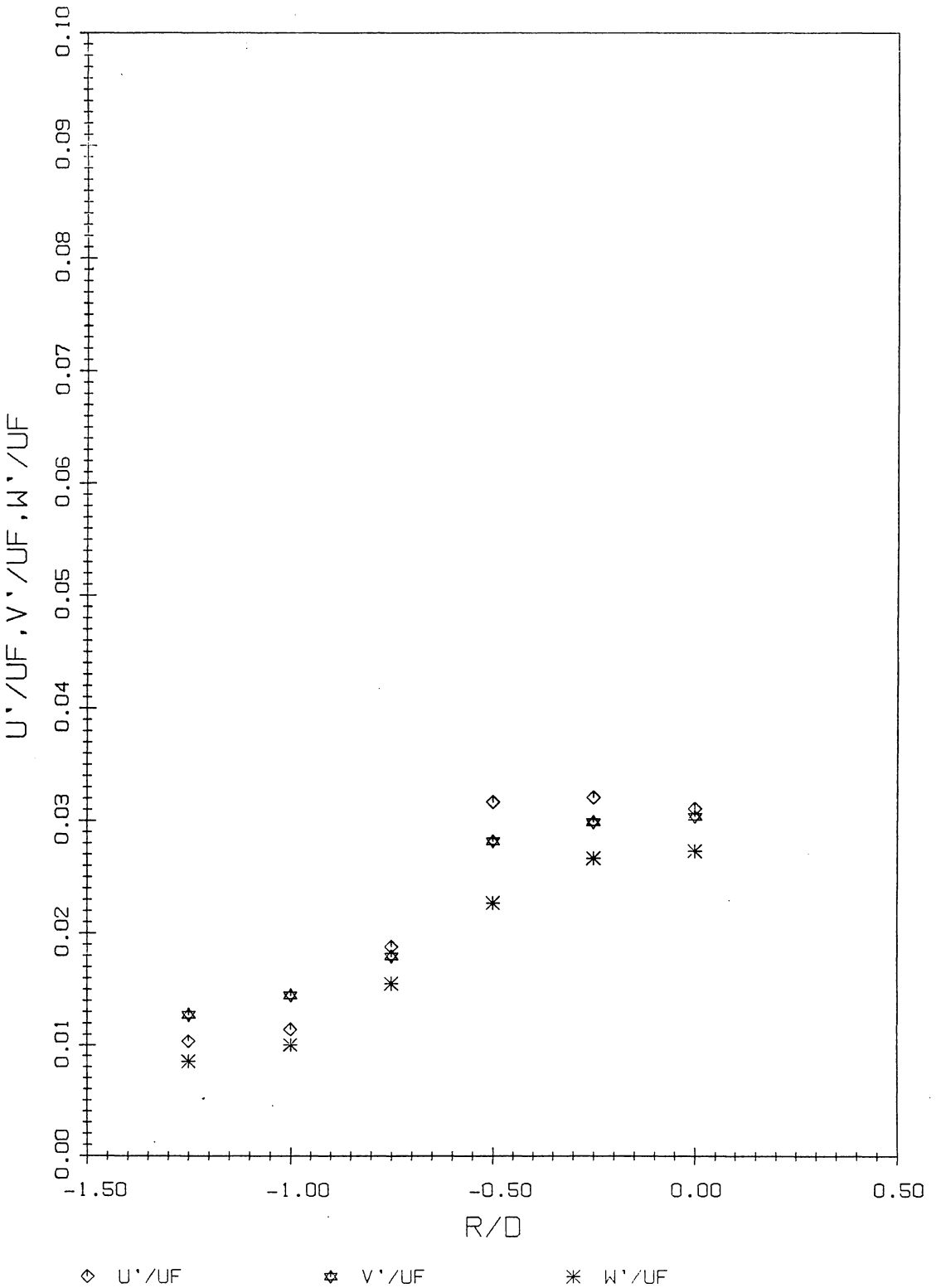


Fig. 43 Non-Dimensional Turbulence Intensity Profiles along the 225 Deg. Ray at X/D=33.0 .

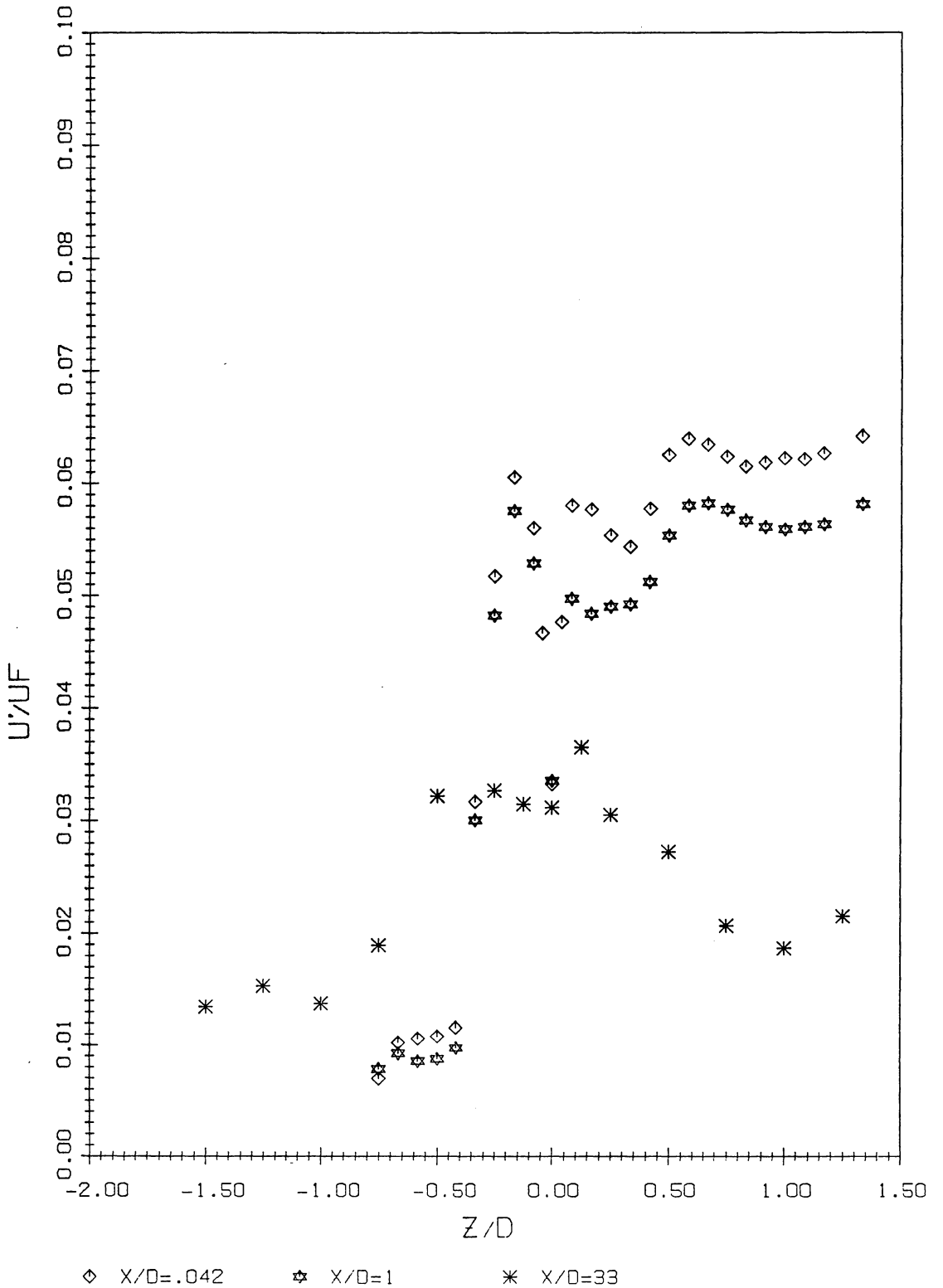


Fig. 44 Streamwise Decay of Axial Turbulence Intensity in Vertical Profiles Through the Wake Center .

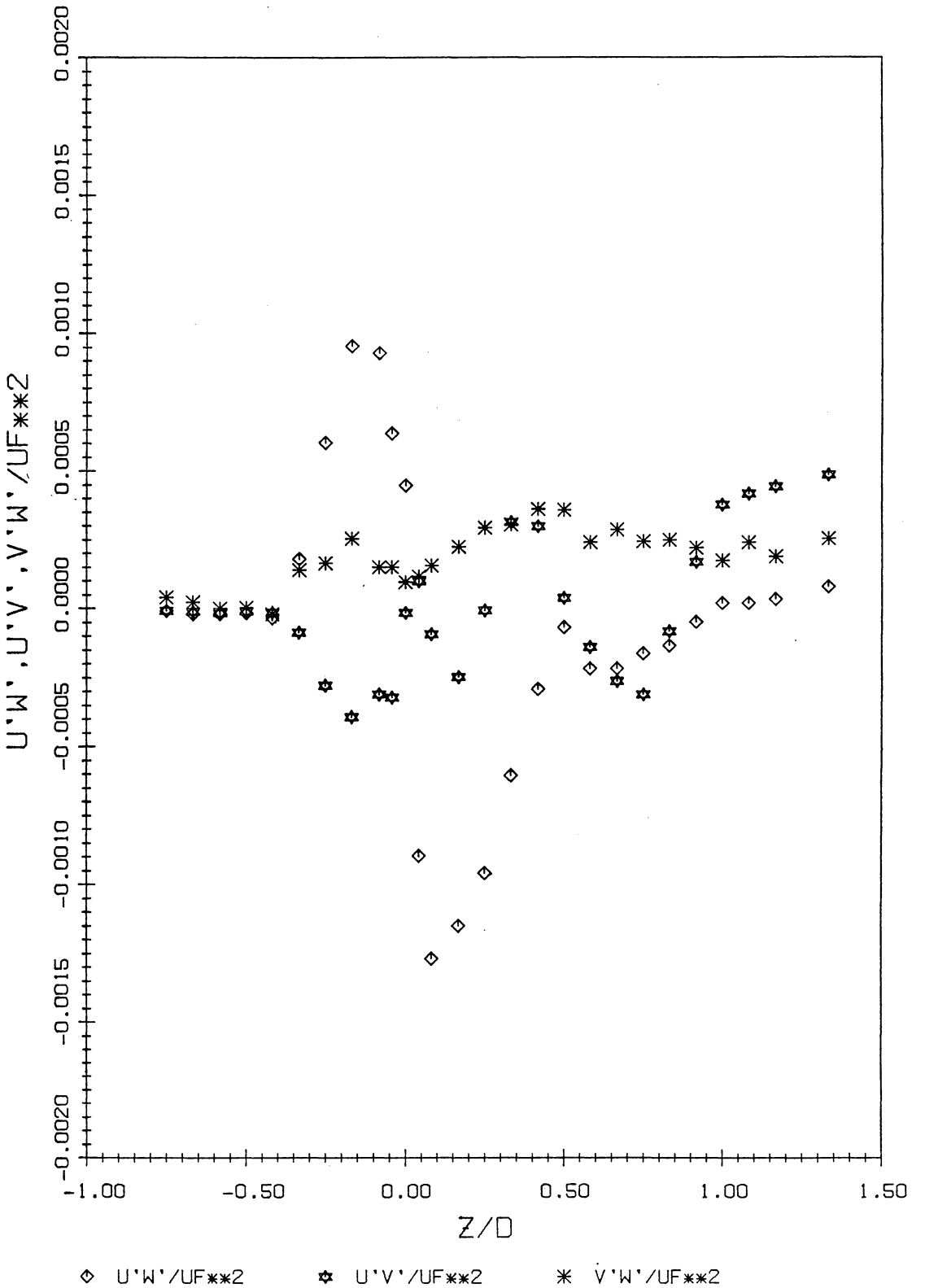


Fig. 45 Non-Dimensional Turbulent Shear Profiles in the Vertical Direction (Y/D=0) at X/D=0.042 .

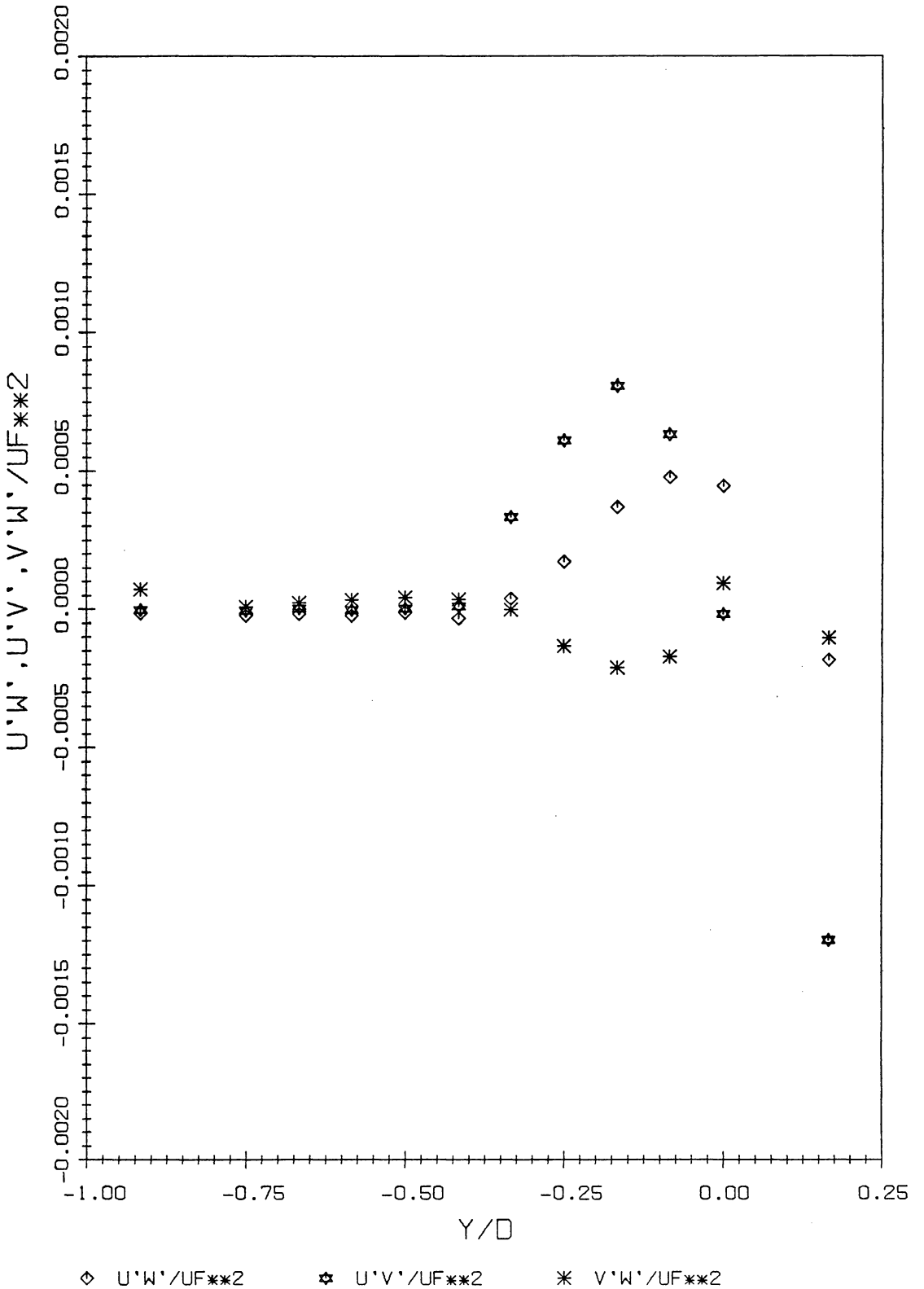


Fig. 46 Non-Dimensional Turbulent Shear Profiles in the Horizontal Direction for Z/D=0 at X/D=0.042 .

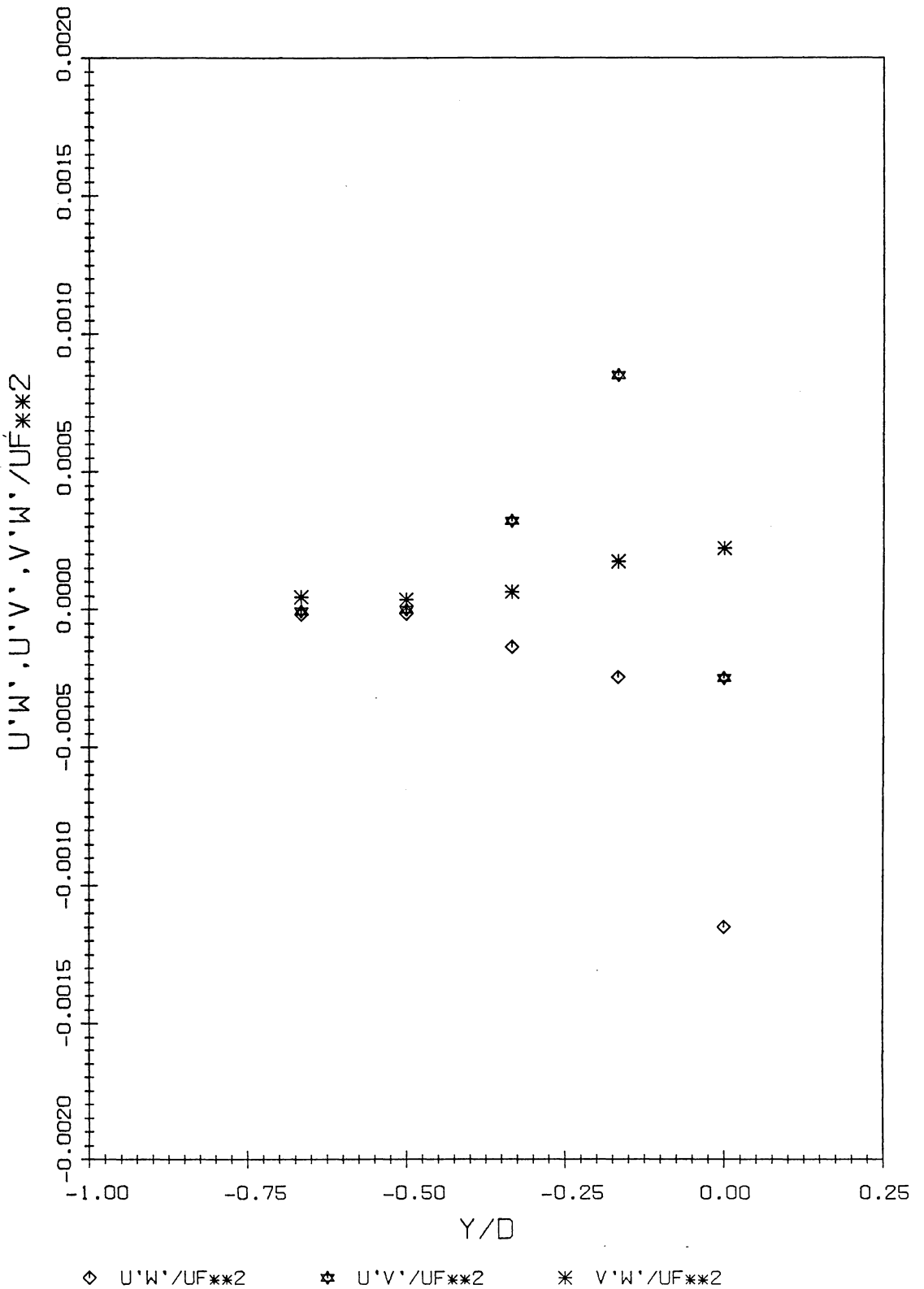


Fig. 47 Non-Dimensional Turbulent Shear Profiles in the Horizontal Direction for Z/D=0.167 at X/D=0.042 .

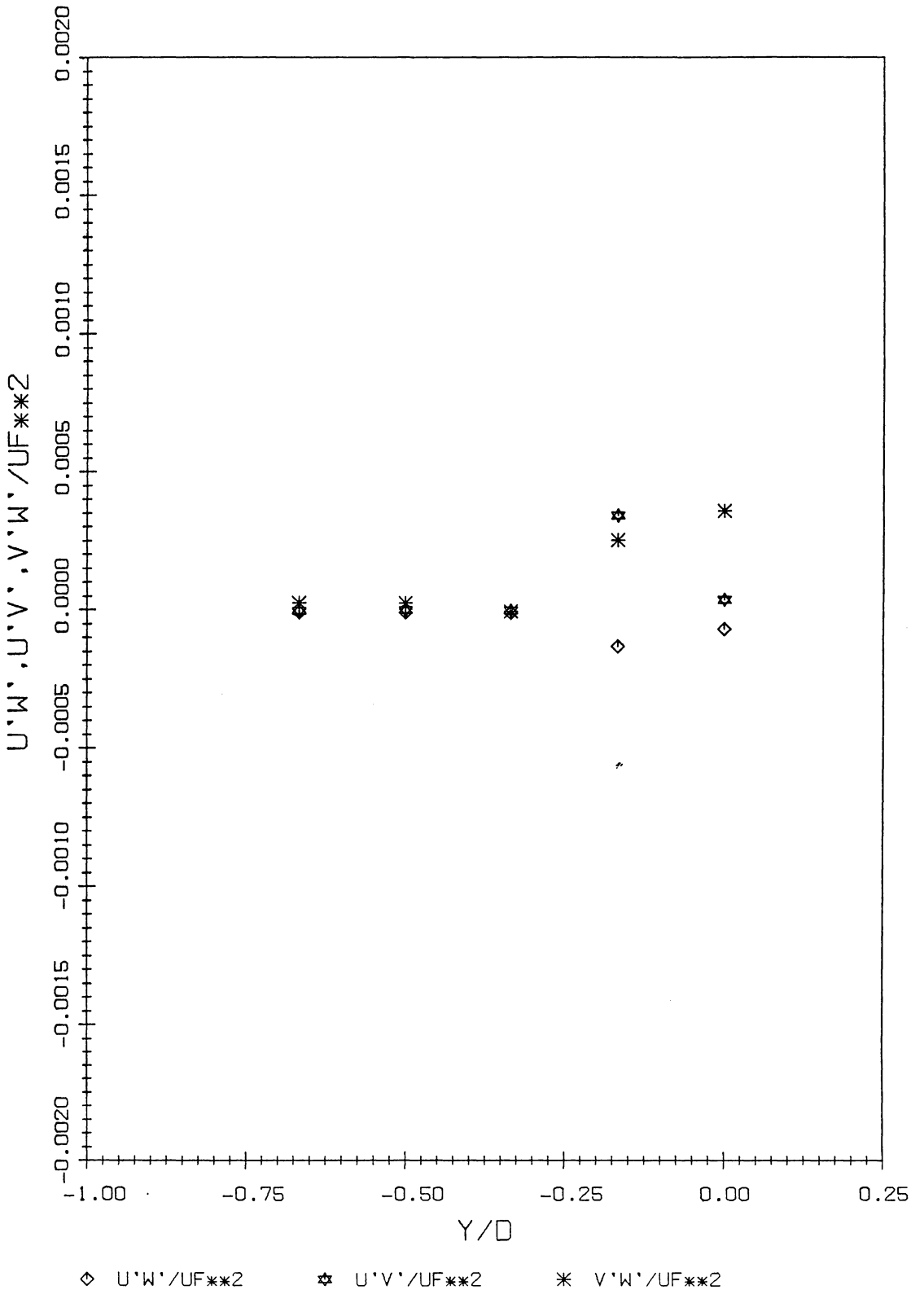


Fig. 48 Non-Dimensional Turbulent Shear Profiles in the Horizontal Direction for Z/D=0.5 at X/D=0.042 .

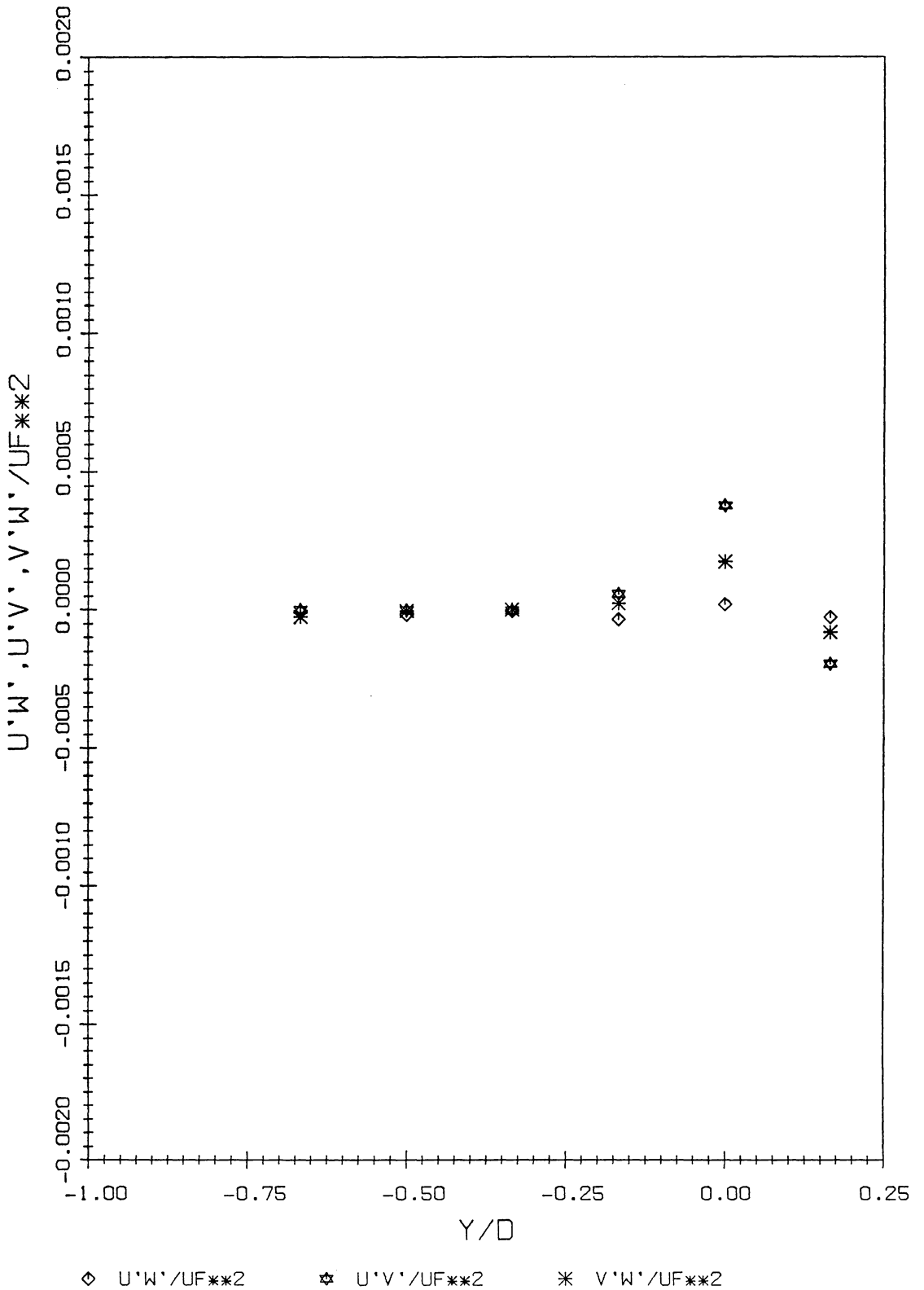


Fig. 49 Non-Dimensional Turbulent Shear Profiles in the Horizontal Direction for Z/D=1.0 at X/D=0.042 .

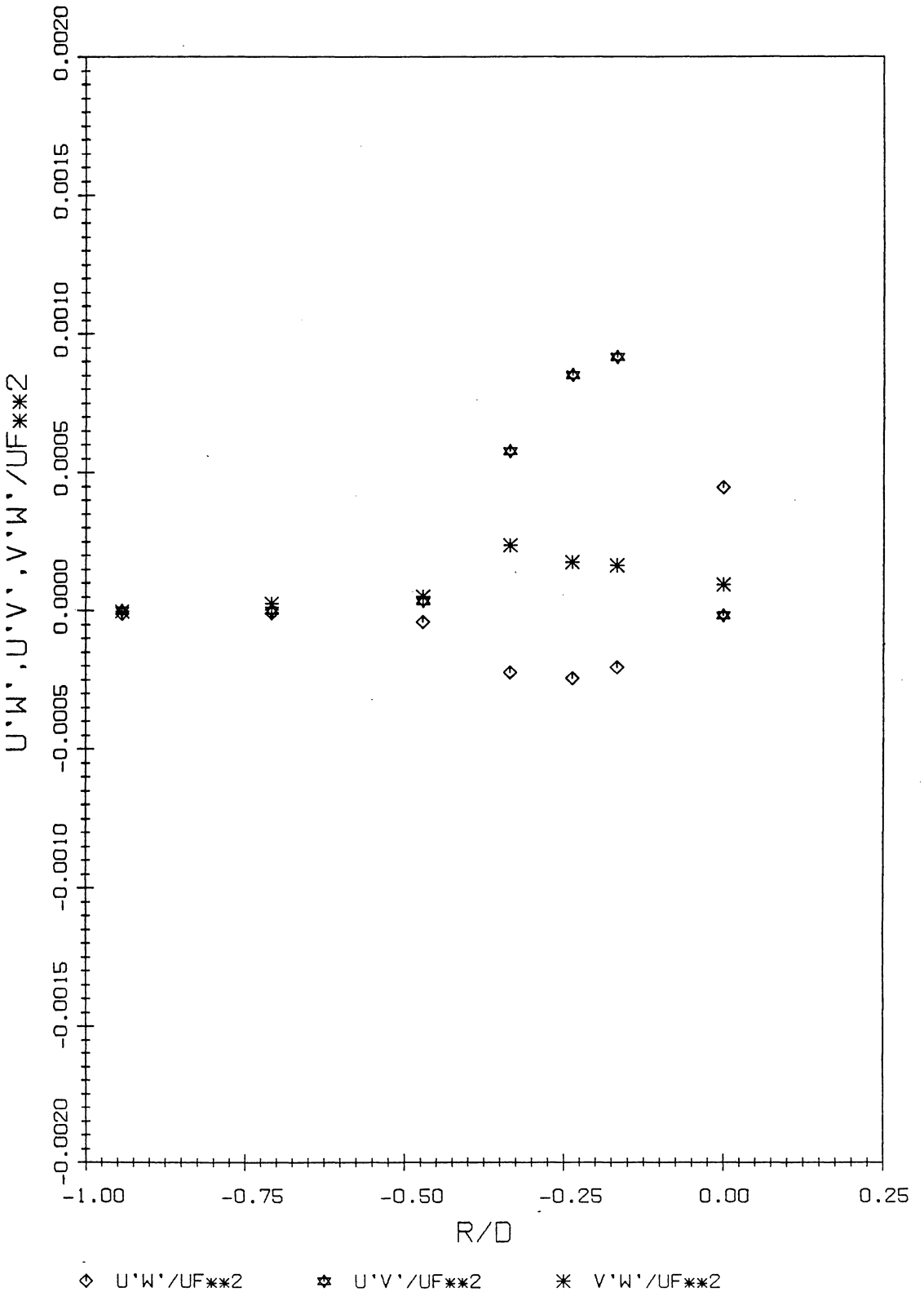


Fig. 50 Non-Dimensional Turbulent Shear Profiles along the 135 Deg. Ray at X/D=0.042 .

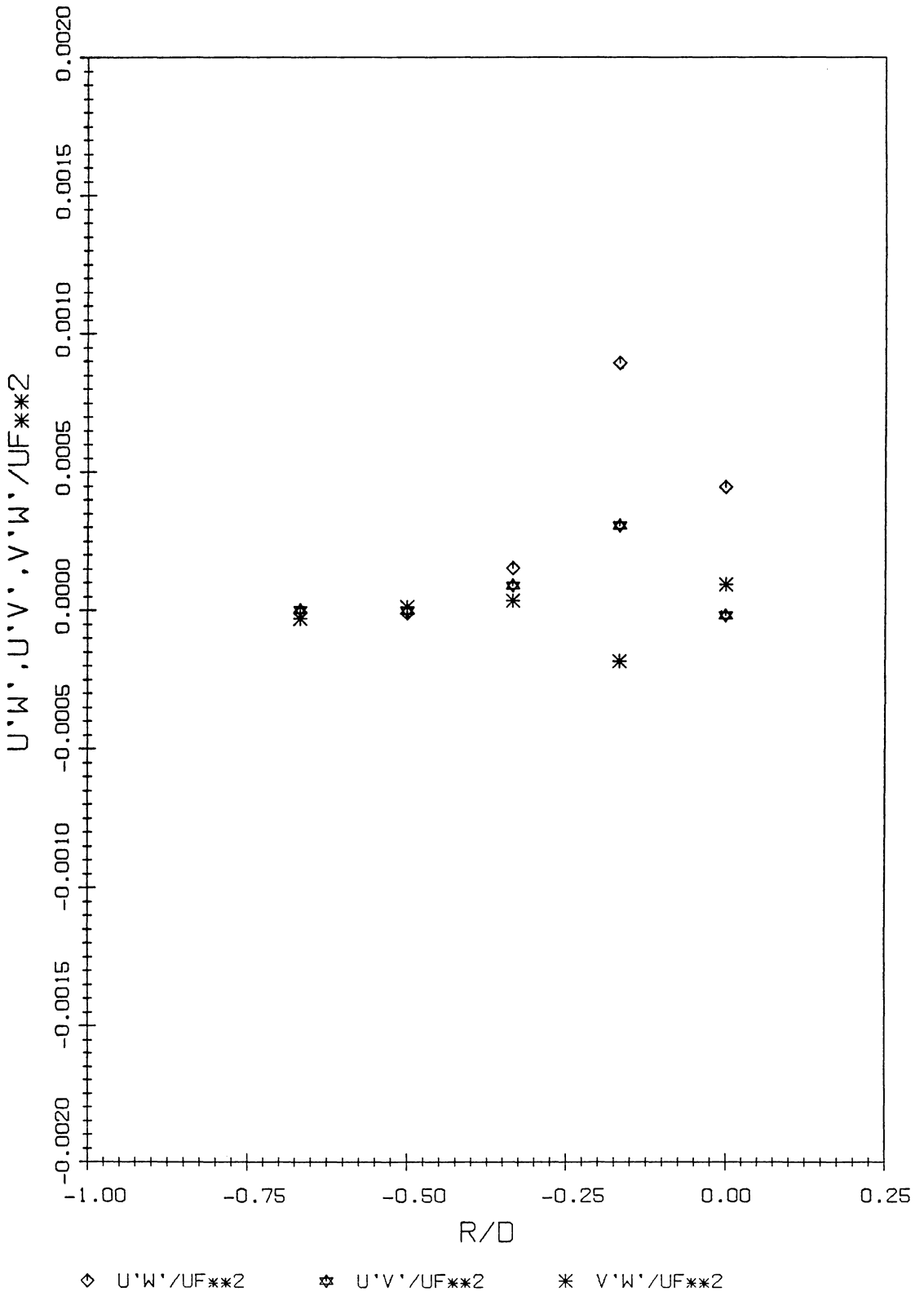


Fig. 51 Non-Dimensional Turbulent Shear Profiles along the 225 Deg. Ray at X/D=0.042 .

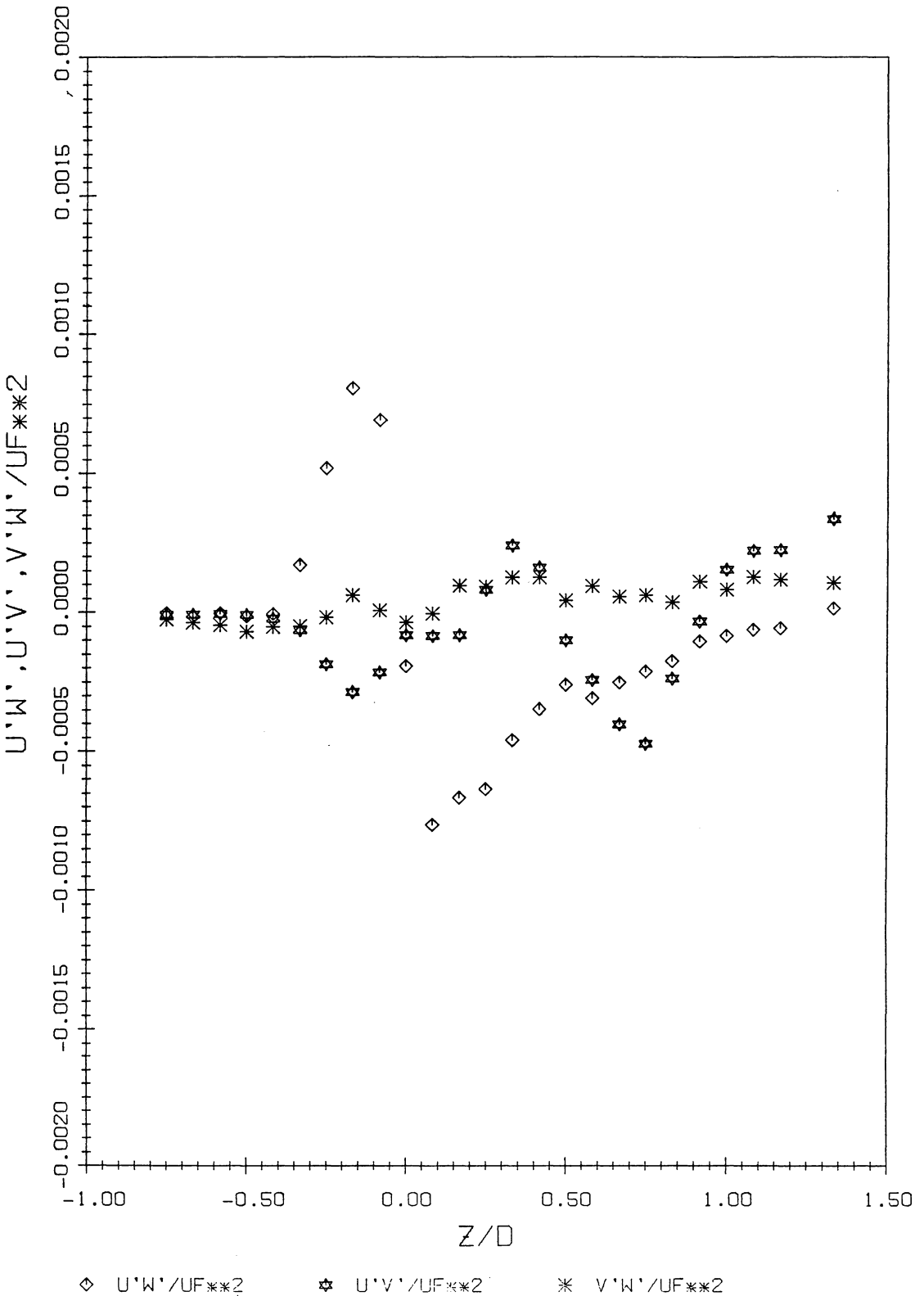


Fig. 52 Non-Dimensional Turbulent Shear Profiles in the Vertical Direction (Y/D=0) at X/D=1.0 .

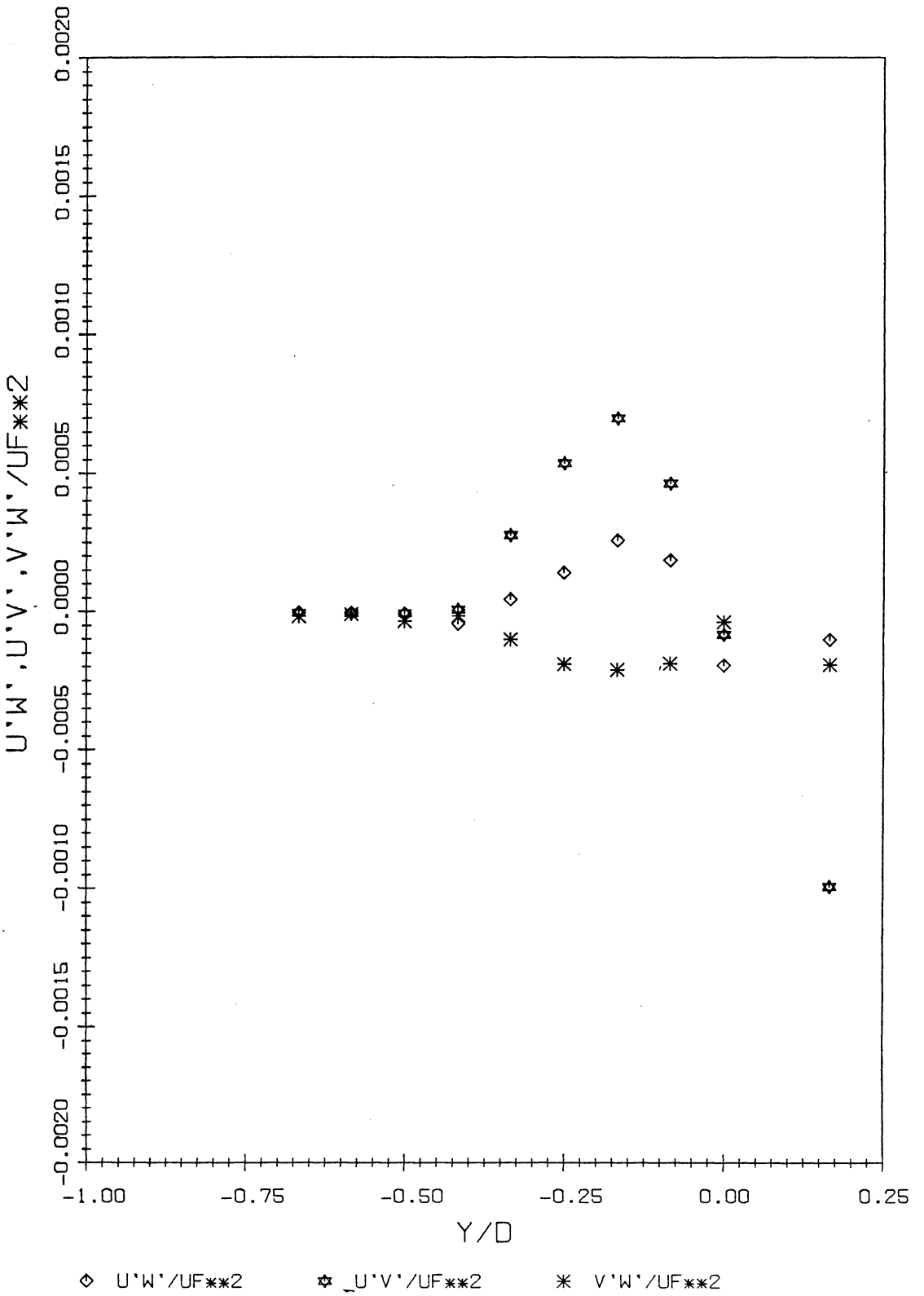


Fig. 53 Non-Dimensional Turbulent Shear Profiles in the Horizontal Direction for Z/D=0 at X/D=1.0 .

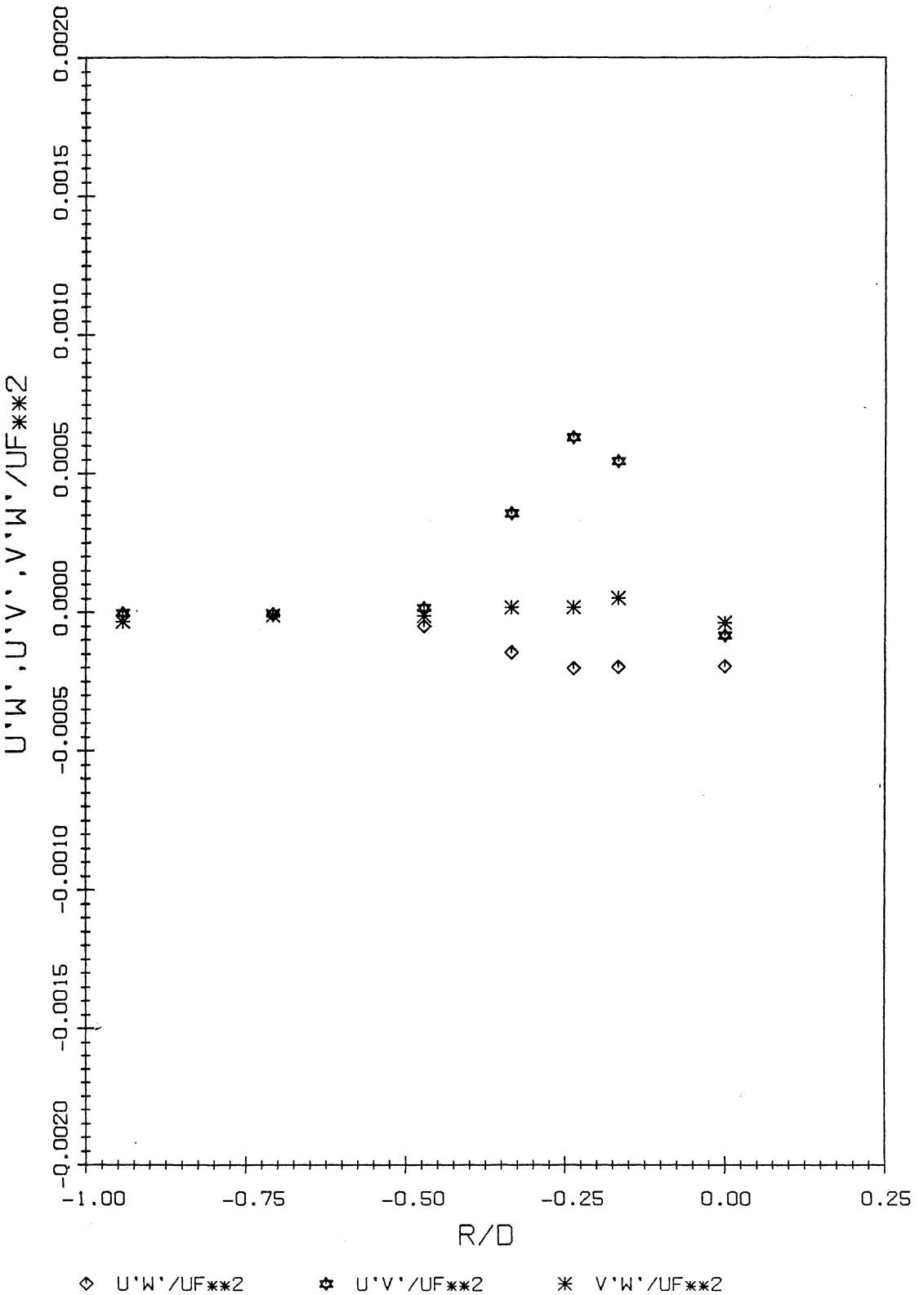


Fig. 54 Non-Dimensional Turbulent Shear Profiles along the 135 Deg. Ray at X/D=1.0 .

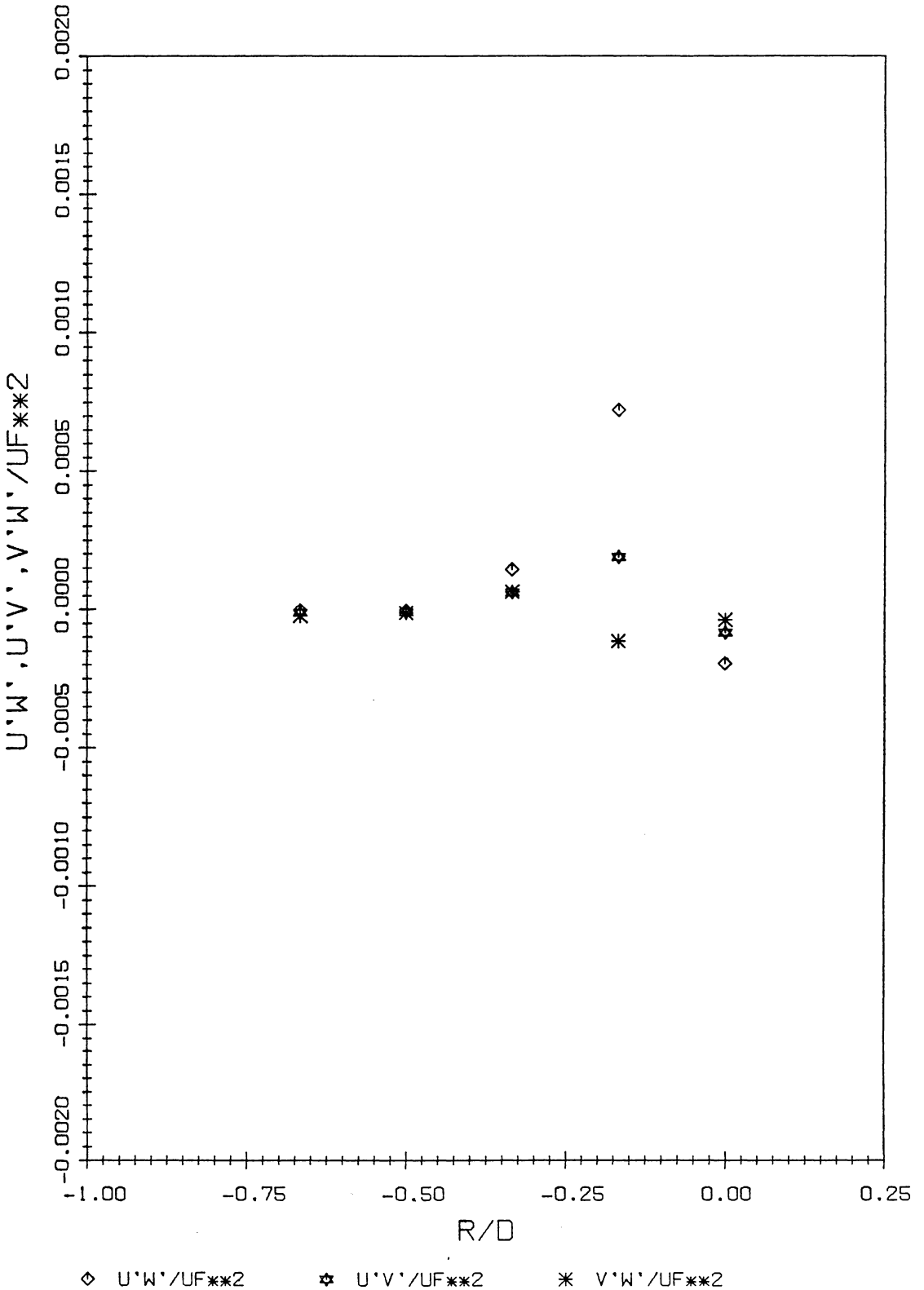


Fig. 55 Non-Dimensional Turbulent Shear Profiles along the 225 Deg. Ray at X/D=1.0 .

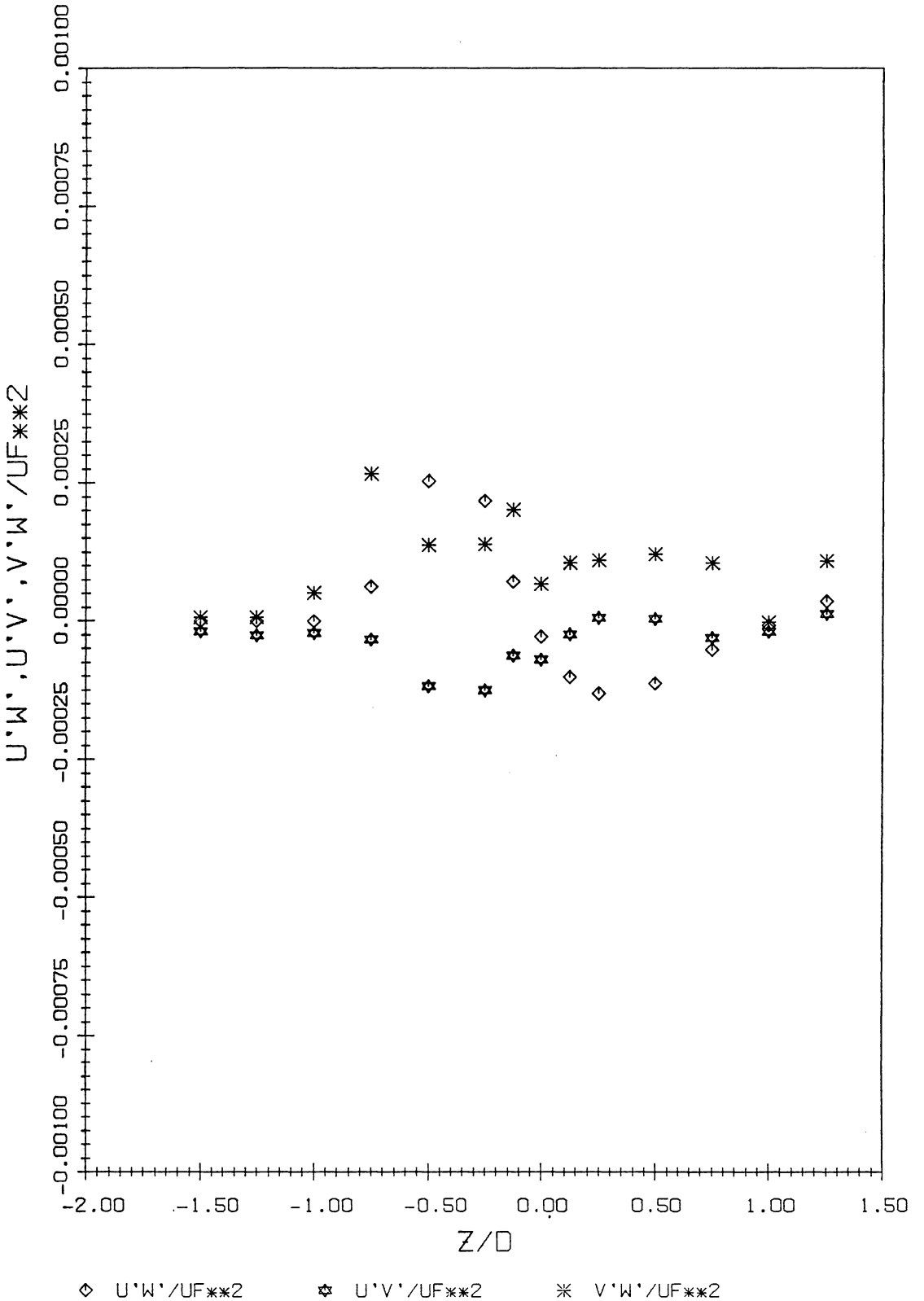


Fig. 56 Non-Dimensional Turbulent Shear Profiles in the Vertical Direction (Y/D=0) at X/D=33.0 .

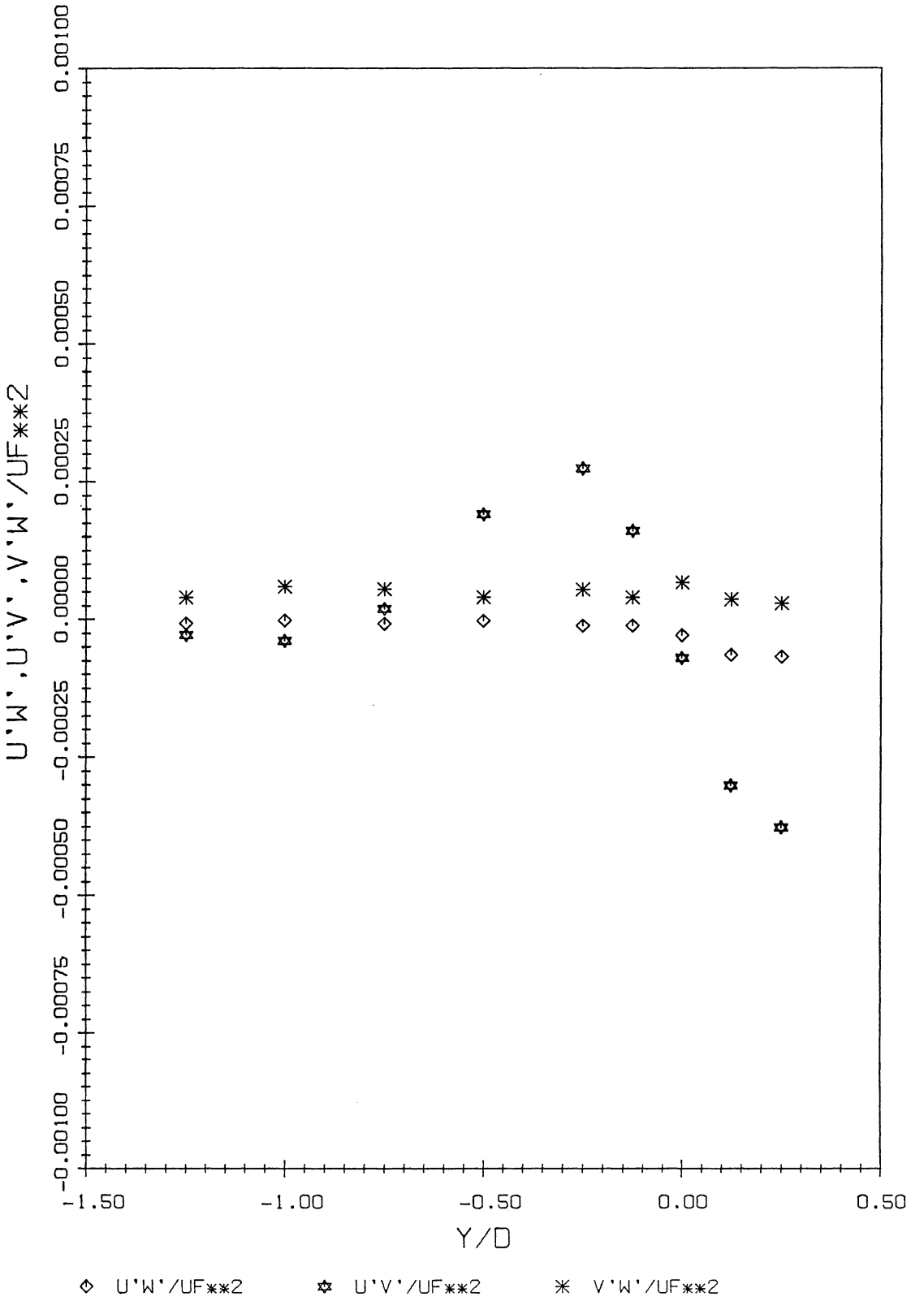


Fig. 57 Non-Dimensional Turbulent Shear Profiles in the Horizontal Direction for Z/D=0 at X/D=33.0 .

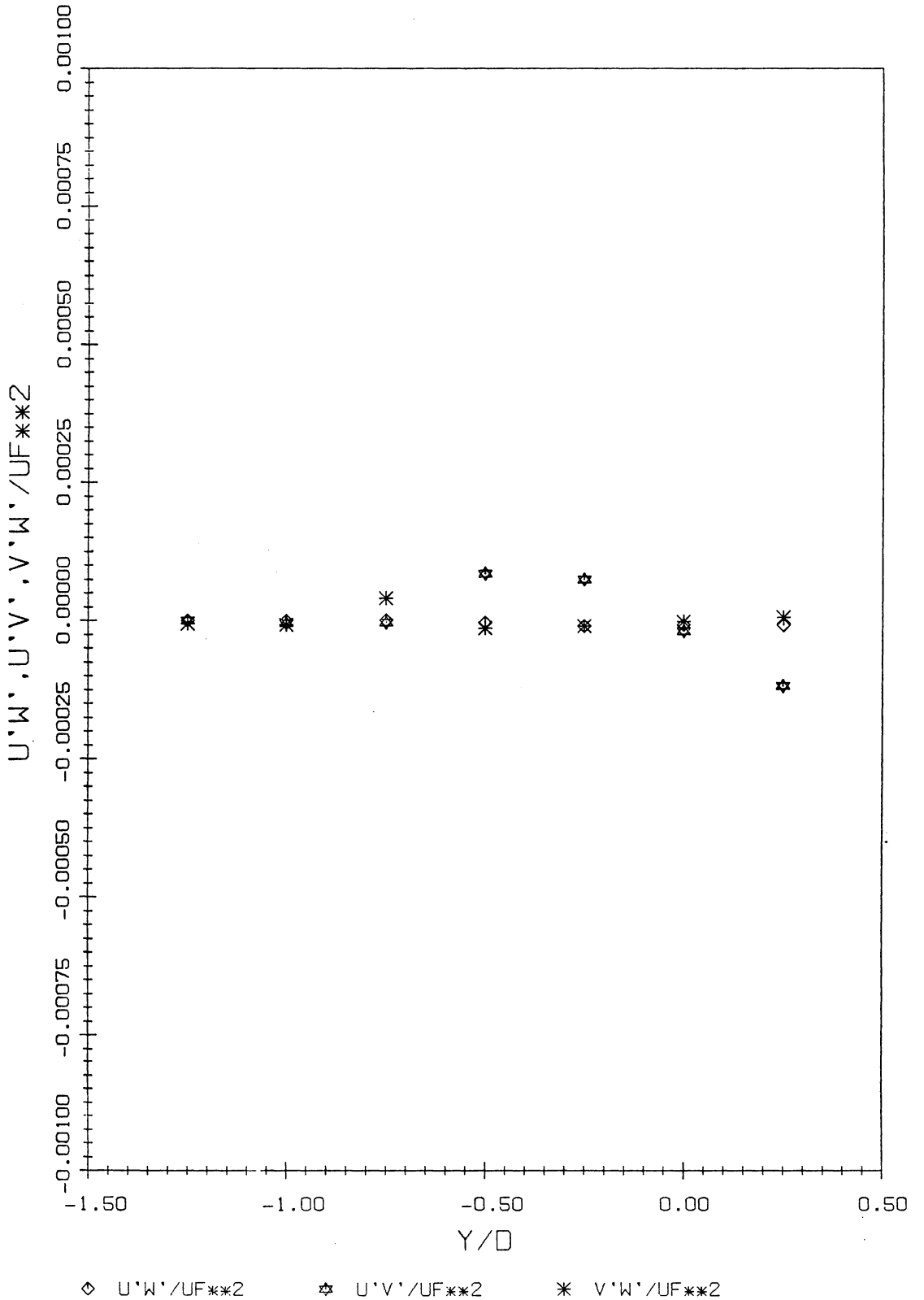


**Fig. 58 Non-Dimensional Turbulent Shear Profiles in the Horizontal Direction for Z/D=1.0 at X/D=33.0 .**

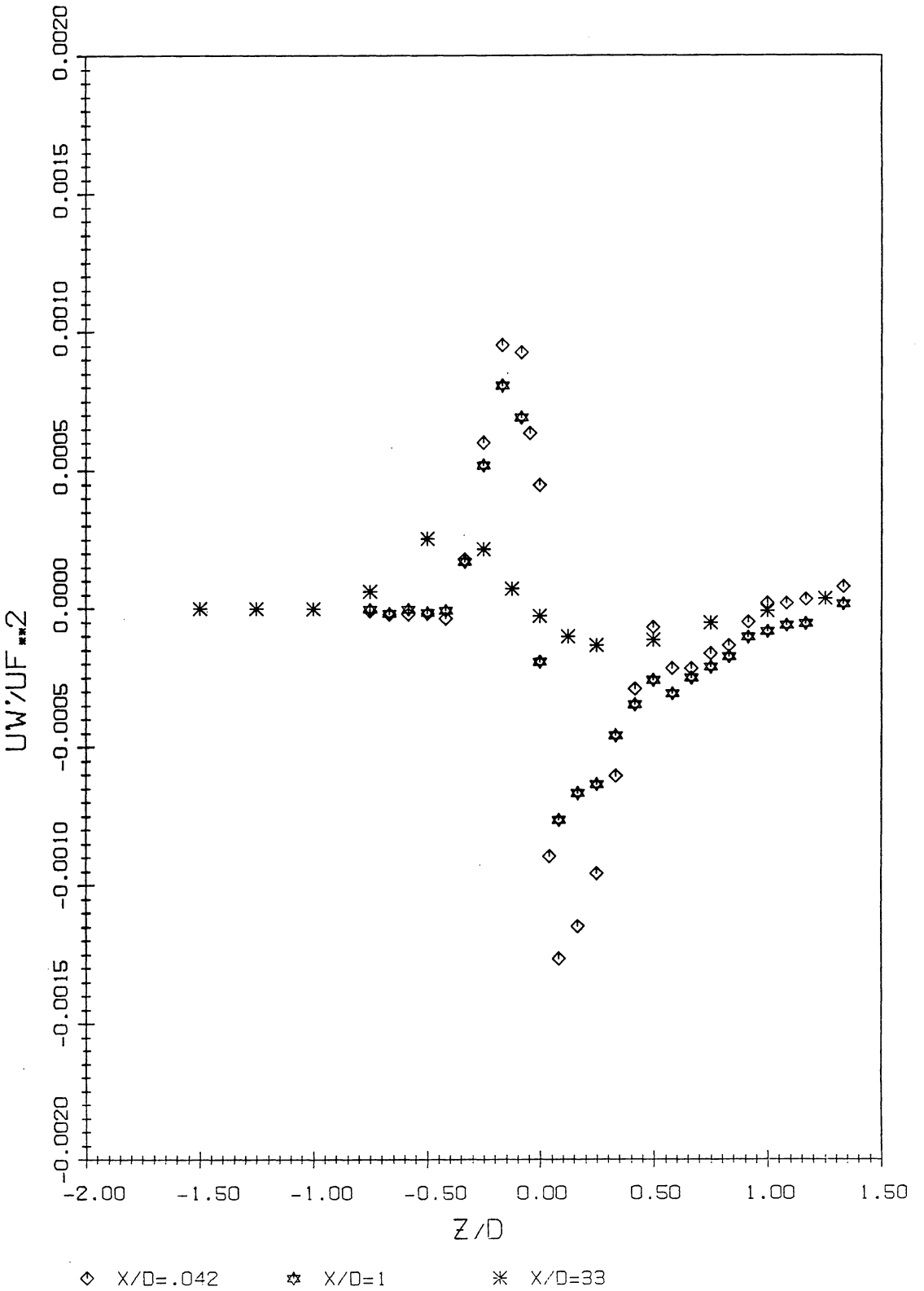


Fig. 59 Streamwise Decay of Vertical Turbulent Shear in Vertical Profiles through the Wake Center .

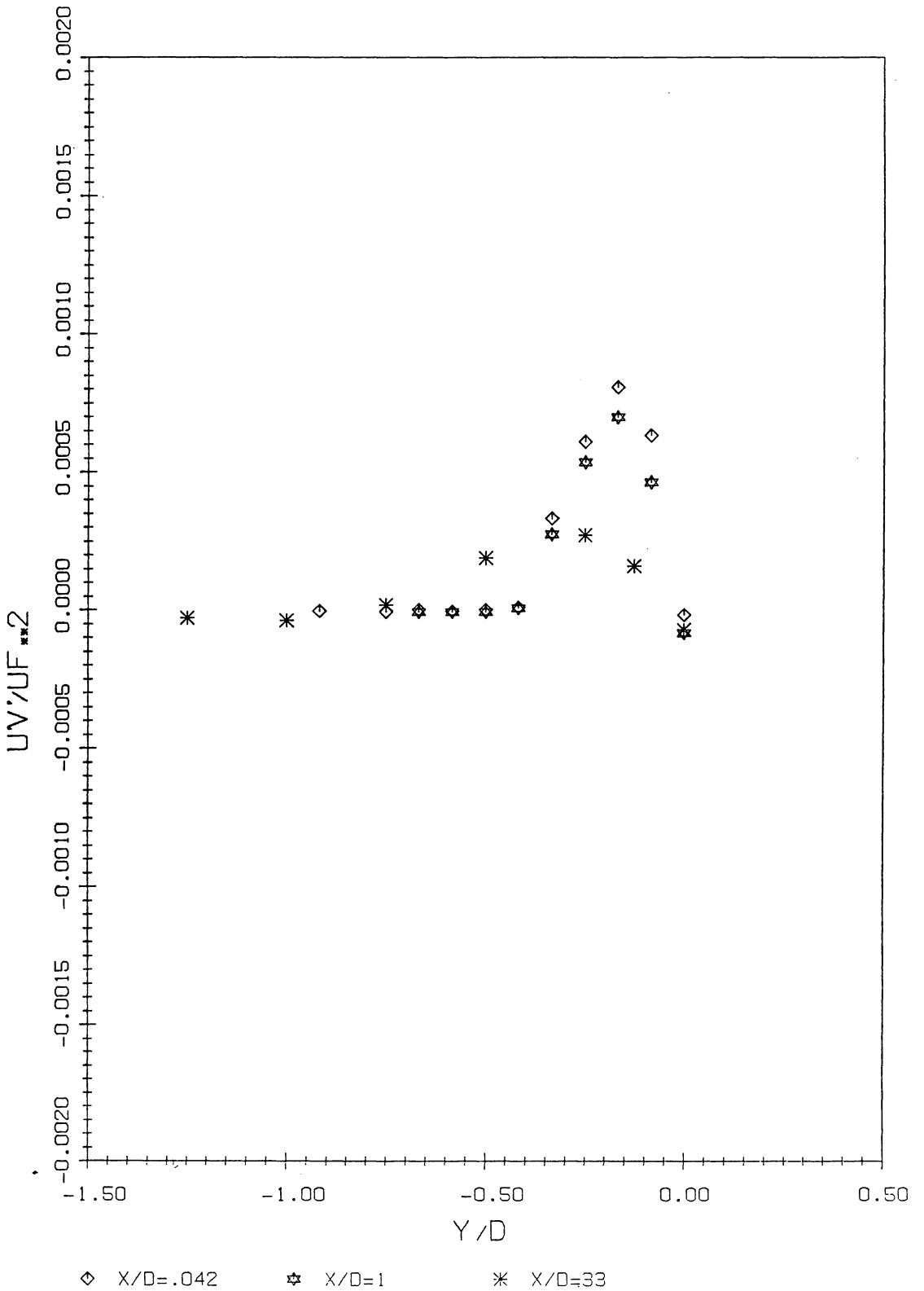


Fig. 60 Streamwise Decay of Horizontal Turbulent Shear in Horizontal Profiles through the Wake Center .

## APPENDIX A. DATA AT X/D=0.042

THE LAYOUT OF THE GRID IS PLOTTED IN FIG.3 .

POINT NUMBER = 1
X/D= 0.042 Y/D= 0.000 Z/D= 0.000

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.2988 | -0.0080 | 0.0100 | 0.1147 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0333 | 0.0313 | 0.0302 | -0.1299E-04 | 0.4495E-03 | 0.9676E-04 |

POINT NUMBER = 2
X/D= 0.042 Y/D= 0.000 Z/D=-0.042

| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
|---|---|---|---|---|---|
| 0.0467 | 0.0413 | 0.0374 | -0.3210E-03 | 0.6363E-03 | 0.1515E-03 |

POINT NUMBER = 3
X/D= 0.042 Y/D= 0.000 Z/D=-0.083

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.5290 | -0.0106 | 0.0205 | 0.1023 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0561 | 0.0473 | 0.0442 | -0.3082E-03 | 0.9285E-03 | 0.1519E-03 |

POINT NUMBER = 4
X/D= 0.042 Y/D= 0.000 Z/D=-0.167

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.6982 | -0.0118 | 0.0319 | 0.0869 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0606 | 0.0523 | 0.0483 | -0.3923E-03 | 0.9532E-03 | 0.2531E-03 |

POINT NUMBER = 5
X/D= 0.042 Y/D= 0.000 Z/D=-0.250

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.8371 | -0.0150 | 0.0399 | 0.0711 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0518 | 0.0468 | 0.0423 | -0.2777E-03 | 0.6033E-03 | 0.1666E-03 |

POINT NUMBER = 6
X/D= 0.042 Y/D= 0.000 Z/D=-0.333

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9409 | -0.0223 | 0.0439 | 0.0527 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0317 | 0.0277 | 0.0257 | -0.8647E-04 | 0.1803E-03 | 0.1410E-03 |

POINT NUMBER = 7
X/D= 0.042 Y/D= 0.000 Z/D=-0.417

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9934 | -0.0279 | 0.0447 | 0.0375 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0116 | 0.0117 | 0.0129 | -0.1372E-04 | -0.3405E-04 | -0.1924E-04 |

POINT NUMBER = 8
X/D= 0.042 Y/D= 0.000 Z/D=-0.500

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0008 | -0.0233 | 0.0420 | 0.0324 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0108 | 0.0099 | 0.0120 | -0.1220E-04 | -0.1666E-04 | 0.1854E-05 |

POINT NUMBER = 9
X/D= 0.042 Y/D= 0.000 Z/D=-0.583

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0038 | -0.0208 | 0.0394 | 0.0266 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0106 | 0.0100 | 0.0126 | -0.1629E-04 | -0.2104E-04 | 0.3102E-08 |

POINT NUMBER = 10
X/D= 0.042 Y/D= 0.000 Z/D=-0.667

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0040 | -0.0239 | 0.0385 | 0.0195 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0102 | 0.0105 | 0.0116 | -0.1022E-04 | -0.1950E-04 | 0.2286E-04 |

POINT NUMBER = 11
X/D= 0.042 Y/D= 0.000 Z/D=-0.750

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0055 | -0.0241 | 0.0376 | 0.0156 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0069 | 0.0069 | 0.0079 | -0.7123E-05 | -0.8382E-05 | 0.3989E-04 |

POINT NUMBER = 12
X/D= 0.042 Y/D= 0.000 Z/D= 0.042

| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
|---|---|---|---|---|---|
| 0.0477 | 0.0374 | 0.0365 | 0.1008E-03 | -0.8935E-03 | 0.1161E-03 |

POINT NUMBER = 13
X/D= 0.042 Y/D= 0.000 Z/D= 0.083

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.4881 | -0.0005 | -0.0325 | 0.1057 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0581 | 0.0446 | 0.0433 | -0.9188E-04 | -0.1267E-02 | 0.1569E-03 |

POINT NUMBER = 14
X/D= 0.042 Y/D= 0.000 Z/D= 0.167

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.6201 | 0.0049 | -0.0415 | 0.0928 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0577 | 0.0482 | 0.0453 | -0.2470E-03 | -0.1148E-02 | 0.2259E-03 |

```
POINT NUMBER =  15
X/D= 0.042  Y/D= 0.000  Z/D= 0.250
 U/UF          V/UF          W/UF          CP(STATIC)
0.7066         0.0098       -0.0393        0.0822
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0554   0.0494   0.0464   -0.4935E-05   -0.9559E-03    0.2942E-03

POINT NUMBER =  16
X/D= 0.042  Y/D= 0.000  Z/D= 0.333
 U/UF          V/UF          W/UF          CP(STATIC)
0.7637         0.0059       -0.0284        0.0720
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0544   0.0513   0.0464    0.3156E-03   -0.6022E-03    0.3063E-03

POINT NUMBER =  17
X/D= 0.042  Y/D= 0.000  Z/D= 0.417
 U/UF          V/UF          W/UF          CP(STATIC)
0.7898        -0.0032       -0.0120        0.0650
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0578   0.0545   0.0481    0.3013E-03   -0.2881E-03    0.3643E-03

POINT NUMBER =  18
X/D= 0.042  Y/D= 0.000  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
0.7904        -0.0096       -0.0034        0.0558
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0626   0.0571   0.0509    0.4063E-04   -0.6460E-04    0.3614E-03

POINT NUMBER =  19
X/D= 0.042  Y/D= 0.000  Z/D= 0.583
 U/UF          V/UF          W/UF          CP(STATIC)
0.8017        -0.0115       -0.0035        0.0506
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0640   0.0601   0.0531   -0.1360E-03   -0.2152E-03    0.2439E-03

POINT NUMBER =  20
X/D= 0.042  Y/D= 0.000  Z/D= 0.667
 U/UF          V/UF          W/UF          CP(STATIC)
0.8043        -0.0147       -0.0030        0.0455
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0635   0.0602   0.0533   -0.2610E-03   -0.2151E-03    0.2873E-03

POINT NUMBER =  21
X/D= 0.042  Y/D= 0.000  Z/D= 0.750
 U/UF          V/UF          W/UF          CP(STATIC)
0.8033        -0.0138       -0.0028        0.0432
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0624   0.0584   0.0520   -0.3081E-03   -0.1591E-03    0.2466E-03

POINT NUMBER =  22
X/D= 0.042  Y/D= 0.000  Z/D= 0.833
 U/UF          V/UF          W/UF          CP(STATIC)
0.7989        -0.0093       -0.0027        0.0410
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0616   0.0570   0.0512   -0.8137E-04   -0.1325E-03    0.2502E-03

POINT NUMBER =  23
X/D= 0.042  Y/D= 0.000  Z/D= 0.917
 U/UF          V/UF          W/UF          CP(STATIC)
0.7987        -0.0064       -0.0024        0.0410
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0619   0.0563   0.0513    0.1709E-03   -0.4543E-04    0.2238E-03

POINT NUMBER =  24
X/D= 0.042  Y/D= 0.000  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.7991        -0.0042       -0.0019        0.0399
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0623   0.0556   0.0511    0.3810E-03    0.2158E-04    0.1773E-03

POINT NUMBER =  25
X/D= 0.042  Y/D= 0.000  Z/D= 1.083
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0622   0.0554   0.0512    0.4196E-03    0.2426E-04    0.2438E-03

POINT NUMBER =  26
X/D= 0.042  Y/D= 0.000  Z/D= 1.167
 U/UF          V/UF          W/UF          CP(STATIC)
0.8009        -0.0028       -0.0003        0.0409
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0627   0.0557   0.0516    0.4452E-03    0.3697E-04    0.1928E-03

POINT NUMBER =  27
X/D= 0.042  Y/D= 0.000  Z/D= 1.333
 U/UF          V/UF          W/UF          CP(STATIC)
0.7969        -0.0028       -0.0004        0.0436
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0642   0.0575   0.0521    0.4887E-03    0.8175E-04    0.2583E-03

POINT NUMBER =  28
X/D= 0.042  Y/D=-0.083  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.4984         0.0183        0.0071        0.1057
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0537   0.0410   0.0455    0.6338E-03    0.4798E-03   -0.1673E-03

POINT NUMBER =  29
X/D= 0.042  Y/D=-0.167  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.6715         0.0274        0.0246        0.0908
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0611   0.0479   0.0513    0.8087E-03    0.3719E-03   -0.2094E-03
```

```
POINT NUMBER =  30
X/D= 0.042  Y/D=-0.167  Z/D= 0.167
 U/UF          V/UF          W/UF          CP(STATIC)
0.7327         0.0372         0.0015         0.0840
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0576   0.0448   0.0497   0.8504E-03  -0.2416E-03   0.1759E-03

POINT NUMBER =  31
X/D= 0.042  Y/D=-0.167  Z/D= 0.333
 U/UF          V/UF          W/UF          CP(STATIC)
0.8416         0.0180        -0.0098         0.0675
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0538   0.0440   0.0459   0.7144E-03  -0.2655E-03   0.3097E-03

POINT NUMBER =  32
X/D= 0.042  Y/D=-0.167  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
0.9523         0.0063        -0.0166         0.0524
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0388   0.0326   0.0309   0.3430E-03  -0.1274E-03   0.2535E-03

POINT NUMBER =  33
X/D= 0.042  Y/D=-0.167  Z/D= 0.667
 U/UF          V/UF          W/UF          CP(STATIC)
0.9901        -0.0033        -0.0063         0.0395
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0246   0.0260   0.0195   0.1994E-03  -0.1778E-04   0.1753E-03

POINT NUMBER =  34
X/D= 0.042  Y/D=-0.167  Z/D= 0.833
 U/UF          V/UF          W/UF          CP(STATIC)
0.9950        -0.0042         0.0009         0.0357
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0207   0.0227   0.0160   0.1233E-03  -0.2788E-04   0.5842E-04

POINT NUMBER =  35
X/D= 0.042  Y/D=-0.167  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9974        -0.0008         0.0020         0.0351
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0149   0.0170   0.0126   0.5992E-04  -0.3147E-04   0.2557E-04

POINT NUMBER =  36
X/D= 0.042  Y/D=-0.250  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.8122         0.0321         0.0287         0.0771
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0543   0.0447   0.0466   0.6110E-03   0.1730E-03  -0.1323E-03

POINT NUMBER =  37
X/D= 0.042  Y/D=-0.333  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9090         0.0331         0.0275         0.0618
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0391   0.0324   0.0332   0.3336E-03   0.3974E-04  -0.1360E-05

POINT NUMBER =  38
X/D= 0.042  Y/D=-0.333  Z/D= 0.167
 U/UF          V/UF          W/UF          CP(STATIC)
0.9250         0.0337         0.0071         0.0625
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0373   0.0294   0.0328   0.3225E-03  -0.1330E-03   0.6586E-04

POINT NUMBER =  39
X/D= 0.042  Y/D=-0.333  Z/D= 0.333
 U/UF          V/UF          W/UF          CP(STATIC)
0.9763         0.0181        -0.0052         0.0527
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0176   0.0154   0.0151   0.3296E-04  -0.4090E-04   0.5065E-04

POINT NUMBER =  40
X/D= 0.042  Y/D=-0.333  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
0.9956         0.0089        -0.0059         0.0458
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0077   0.0078   0.0096  -0.9850E-07  -0.8640E-05  -0.1425E-05

POINT NUMBER =  41
X/D= 0.042  Y/D=-0.333  Z/D= 0.667
 U/UF          V/UF          W/UF          CP(STATIC)
0.9963         0.0023        -0.0036         0.0394
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0050   0.0061   0.0056  -0.4391E-06  -0.2979E-05   0.4924E-05

POINT NUMBER =  42
X/D= 0.042  Y/D=-0.333  Z/D= 0.833
 U/UF          V/UF          W/UF          CP(STATIC)
1.0004         0.0003        -0.0014         0.0347
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0054   0.0050   0.0057  -0.2296E-05  -0.5095E-05  -0.4523E-05

POINT NUMBER =  43
X/D= 0.042  Y/D=-0.333  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0033         0.0013         0.0006         0.0327
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0047   0.0044   0.0053  -0.1083E-05  -0.2239E-05   0.3009E-05
```

```
POINT NUMBER =  44
X/D= 0.042  Y/D=-0.417  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9811         0.0326        0.0245        0.0508
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0132  0.0126  0.0129   0.1281E-04  -0.3125E-04   0.3713E-04

POINT NUMBER =  45
X/D= 0.042  Y/D=-0.500  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9976         0.0280        0.0209        0.0431
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0083  0.0081  0.0093   0.1683E-05  -0.1130E-04   0.4279E-04

POINT NUMBER =  46
X/D= 0.042  Y/D=-0.500  Z/D= 0.167
 U/UF          V/UF          W/UF          CP(STATIC)
0.9988         0.0243        0.0084        0.0418
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0084  0.0083  0.0093  -0.1271E-05  -0.1374E-04   0.3734E-04

POINT NUMBER =  47
X/D= 0.042  Y/D=-0.500  Z/D= 0.333
 U/UF          V/UF          W/UF          CP(STATIC)
0.9996         0.0200        0.0000        0.0402
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0070  0.0076  0.0067  -0.2167E-05  -0.8740E-05   0.5007E-04

POINT NUMBER =  48
X/D= 0.042  Y/D=-0.500  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
0.9985         0.0114       -0.0006        0.0369
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0065  0.0070  0.0065  -0.1280E-05  -0.7443E-05   0.2670E-04

POINT NUMBER =  49
X/D= 0.042  Y/D=-0.500  Z/D= 0.667
 U/UF          V/UF          W/UF          CP(STATIC)
1.0017         0.0054       -0.0018        0.0310
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0067  0.0080  0.0068  -0.4386E-05  -0.9779E-05   0.8779E-05

POINT NUMBER =  50
X/D= 0.042  Y/D=-0.500  Z/D= 0.833
 U/UF          V/UF          W/UF          CP(STATIC)
1.0040         0.0034       -0.0010        0.0279
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0057  0.0058  0.0070   0.2297E-06  -0.4797E-05  -0.1396E-04

POINT NUMBER =  51
X/D= 0.042  Y/D=-0.500  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0062         0.0043        0.0007        0.0272
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0063  0.0063  0.0064   0.8194E-07  -0.1798E-04  -0.2864E-05

POINT NUMBER =  52
X/D= 0.042  Y/D=-0.583  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9997         0.0266        0.0206        0.0367
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0096  0.0094  0.0108  -0.1970E-05  -0.2234E-04   0.3365E-04

POINT NUMBER =  53
X/D= 0.042  Y/D=-0.667  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0036         0.0232        0.0193        0.0314
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0106  0.0093  0.0116   0.3354E-05  -0.1787E-04   0.2253E-04

POINT NUMBER =  54
X/D= 0.042  Y/D=-0.667  Z/D= 0.167
 U/UF          V/UF          W/UF          CP(STATIC)
1.0024         0.0231        0.0132        0.0310
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0091  0.0089  0.0099  -0.5473E-05  -0.1694E-04   0.4620E-04

POINT NUMBER =  55
X/D= 0.042  Y/D=-0.667  Z/D= 0.333
 U/UF          V/UF          W/UF          CP(STATIC)
1.0042         0.0171        0.0055        0.0293
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0081  0.0088  0.0079   0.4025E-06  -0.9516E-05   0.1698E-04

POINT NUMBER =  56
X/D= 0.042  Y/D=-0.667  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
1.0053         0.0142        0.0023        0.0274
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0065  0.0077  0.0070  -0.1456E-05  -0.7618E-05   0.2441E-04

POINT NUMBER =  57
X/D= 0.042  Y/D=-0.667  Z/D= 0.667
 U/UF          V/UF          W/UF          CP(STATIC)
1.0058         0.0101        0.0005        0.0265
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0072  0.0081  0.0074  -0.5853E-06  -0.1169E-04  -0.3985E-05

POINT NUMBER =  58
X/D= 0.042  Y/D=-0.667  Z/D= 0.833
 U/UF          V/UF          W/UF          CP(STATIC)
1.0073         0.0065       -0.0002        0.0261
 U'/UF   V'/UF   W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0081  0.0075  0.0091  -0.1012E-05  -0.1972E-04  -0.2434E-04
```

```
POINT NUMBER =  59
X/D= 0.042  Y/D=-0.667  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0073        0.0065       -0.0003        0.0250
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0079   0.0089   0.0070   0.3977E-06  -0.7890E-05  -0.2426E-04

POINT NUMBER =  60
X/D= 0.042  Y/D=-0.750  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0067        0.0168        0.0169        0.0250
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0105   0.0112   0.0107  -0.5359E-05  -0.2206E-04   0.7894E-05

POINT NUMBER =  61
X/D= 0.042  Y/D=-0.917  Z/D= 0.000
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0083   0.0085   0.0083  -0.2010E-05  -0.1512E-04   0.7043E-04

POINT NUMBER =  62
X/D= 0.042  Y/D= 0.167  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.6796       -0.0407        0.0187        0.0870
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0603   0.0471   0.0518  -0.1197E-02  -0.1805E-03  -0.9881E-04

POINT NUMBER =  63
X/D= 0.042  Y/D= 0.167  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9982       -0.0244       -0.0057        0.0308
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0237   0.0235   0.0183  -0.1926E-03  -0.2373E-04  -0.7812E-04

POINT NUMBER =  64
X/D= 0.042  Y/D=-0.118  Z/D=-0.118
 U/UF          V/UF          W/UF          CP(STATIC)
0.7005        0.0048        0.0343        0.0881
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0604   0.0528   0.0475   0.3079E-03   0.8965E-03  -0.1813E-03

POINT NUMBER =  65
X/D= 0.042  Y/D=-0.118  Z/D= 0.118
 U/UF          V/UF          W/UF          CP(STATIC)
0.6154        0.0290       -0.0023        0.0957
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0572   0.0447   0.0468   0.9179E-03  -0.2033E-03   0.1649E-03

POINT NUMBER =  66
X/D= 0.042  Y/D=-0.236  Z/D= 0.236
 U/UF          V/UF          W/UF          CP(STATIC)
0.8501        0.0304       -0.0013        0.0724
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0499   0.0400   0.0446   0.5776E-03  -0.2217E-03   0.2379E-03

POINT NUMBER =  67
X/D= 0.042  Y/D=-0.236  Z/D=-0.236
 U/UF          V/UF          W/UF          CP(STATIC)
0.9336        0.0008        0.0415        0.0540
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0323   0.0268   0.0264   0.9068E-04   0.1549E-03   0.3848E-04

POINT NUMBER =  68
X/D= 0.042  Y/D=-0.354  Z/D=-0.354
 U/UF          V/UF          W/UF          CP(STATIC)
0.9993        0.0031        0.0378        0.0358
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0077   0.0090   0.0077   0.1534E-06  -0.8778E-05   0.1472E-04

POINT NUMBER =  69
X/D= 0.042  Y/D=-0.471  Z/D=-0.471
 U/UF          V/UF          W/UF          CP(STATIC)
1.0055       -0.0002        0.0331        0.0229
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0087   0.0082   0.0098   0.1495E-05  -0.9757E-05  -0.2903E-04
```

## APPENDIX B. DATA AT X/D=1.0

THE LAYOUT OF THE GRID IS PLOTTED IN FIG.4 .

POINT NUMBER = 1
X/D= 1.000 Y/D= 0.000 Z/D= 0.000

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.5013 | -0.0029 | -0.0089 | 0.0262 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0336 | 0.0270 | 0.0281 | -0.8107E-04 | -0.1903E-03 | -0.3427E-04 |

POINT NUMBER = 2
X/D= 1.000 Y/D= 0.000 Z/D=-0.083

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.6070 | -0.0125 | -0.0014 | 0.0233 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0529 | 0.0392 | 0.0392 | -0.2155E-03 | 0.6944E-03 | 0.7295E-05 |

POINT NUMBER = 3
X/D= 1.000 Y/D= 0.000 Z/D=-0.167

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.7738 | -0.0133 | 0.0054 | 0.0179 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0576 | 0.0457 | 0.0443 | -0.2859E-03 | 0.8082E-03 | 0.6394E-04 |

POINT NUMBER = 4
X/D= 1.000 Y/D= 0.000 Z/D=-0.250

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.8985 | -0.0184 | 0.0105 | 0.0130 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0483 | 0.0421 | 0.0408 | -0.1866E-03 | 0.5205E-03 | -0.1815E-04 |

POINT NUMBER = 5
X/D= 1.000 Y/D= 0.000 Z/D=-0.333

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9828 | -0.0251 | 0.0127 | 0.0043 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0301 | 0.0256 | 0.0257 | -0.6202E-04 | 0.1718E-03 | -0.4826E-04 |

POINT NUMBER = 6
X/D= 1.000 Y/D= 0.000 Z/D=-0.417

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0126 | -0.0224 | 0.0119 | 0.0002 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0097 | 0.0087 | 0.0117 | -0.2145E-04 | -0.7026E-05 | -0.5193E-04 |

POINT NUMBER = 7
X/D= 1.000 Y/D= 0.000 Z/D=-0.500

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0102 | -0.0251 | 0.0129 | 0.0010 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0087 | 0.0097 | 0.0103 | -0.8241E-05 | -0.1521E-04 | -0.6826E-04 |

POINT NUMBER = 8
X/D= 1.000 Y/D= 0.000 Z/D=-0.583

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0117 | -0.0258 | 0.0139 | 0.0004 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0085 | 0.0095 | 0.0085 | -0.4725E-05 | -0.3574E-05 | -0.4670E-04 |

POINT NUMBER = 9
X/D= 1.000 Y/D= 0.000 Z/D=-0.667

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0118 | -0.0252 | 0.0143 | -0.0003 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0092 | 0.0086 | 0.0107 | -0.7417E-05 | -0.1748E-04 | -0.3852E-04 |

POINT NUMBER = 10
X/D= 1.000 Y/D= 0.000 Z/D=-0.750

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0118 | -0.0252 | 0.0143 | -0.0015 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0078 | 0.0084 | 0.0079 | -0.8478E-05 | -0.3911E-05 | -0.2681E-04 |

POINT NUMBER = 11
X/D= 1.000 Y/D= 0.000 Z/D= 0.083

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.6073 | 0.0013 | -0.0200 | 0.0230 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0498 | 0.0377 | 0.0372 | -0.8343E-04 | -0.7619E-03 | -0.3418E-05 |

POINT NUMBER = 12
X/D= 1.000 Y/D= 0.000 Z/D= 0.167

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.6879 | 0.0070 | -0.0200 | 0.0215 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0484 | 0.0418 | 0.0399 | -0.7932E-04 | -0.6648E-03 | 0.9762E-04 |

POINT NUMBER = 13
X/D= 1.000 Y/D= 0.000 Z/D= 0.250

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.7554 | 0.0082 | -0.0165 | 0.0201 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0491 | 0.0443 | 0.0418 | 0.8402E-04 | -0.6336E-03 | 0.9295E-04 |

POINT NUMBER = 14
X/D= 1.000 Y/D= 0.000 Z/D= 0.333

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.8097 | 0.0054 | -0.0109 | 0.0185 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0493 | 0.0463 | 0.0425 | 0.2442E-03 | -0.4577E-03 | 0.1285E-03 |

```
POINT NUMBER =  15
X/D= 1.000  Y/D= 0.000  Z/D= 0.417
 U/UF          V/UF          W/UF          CP(STATIC)
0.8409        -0.0035       -0.0009        0.0145
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0513   0.0493   0.0445    0.1638E-03   -0.3464E-03    0.1300E-03

POINT NUMBER =  16
X/D= 1.000  Y/D= 0.000  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
0.8525        -0.0124        0.0078        0.0132
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0554   0.0521   0.0479   -0.9773E-04   -0.2577E-03    0.4637E-04

POINT NUMBER =  17
X/D= 1.000  Y/D= 0.000  Z/D= 0.583
 U/UF          V/UF          W/UF          CP(STATIC)
0.8477        -0.0164        0.0064        0.0087
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0581   0.0550   0.0499   -0.2389E-03   -0.3058E-03    0.9678E-04

POINT NUMBER =  18
X/D= 1.000  Y/D= 0.000  Z/D= 0.667
 U/UF          V/UF          W/UF          CP(STATIC)
0.8549        -0.0167        0.0040        0.0095
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0583   0.0562   0.0505   -0.3995E-03   -0.2496E-03    0.5963E-04

POINT NUMBER =  19
X/D= 1.000  Y/D= 0.000  Z/D= 0.750
 U/UF          V/UF          W/UF          CP(STATIC)
0.8513        -0.0165        0.0004        0.0122
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0577   0.0551   0.0500   -0.4694E-03   -0.2078E-03    0.6490E-04

POINT NUMBER =  20
X/D= 1.000  Y/D= 0.000  Z/D= 0.833
 U/UF          V/UF          W/UF          CP(STATIC)
0.8474        -0.0115       -0.0012        0.0111
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0568   0.0547   0.0494   -0.2331E-03   -0.1715E-03    0.4127E-04

POINT NUMBER =  21
X/D= 1.000  Y/D= 0.000  Z/D= 0.917
 U/UF          V/UF          W/UF          CP(STATIC)
0.8447        -0.0075       -0.0024        0.0118
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0562   0.0538   0.0484   -0.2834E-04   -0.1011E-03    0.1143E-03

POINT NUMBER =  22
X/D= 1.000  Y/D= 0.000  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.8432        -0.0058       -0.0044        0.0130
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0560   0.0531   0.0483    0.1568E-03   -0.7909E-04    0.8619E-04

POINT NUMBER =  23
X/D= 1.000  Y/D= 0.000  Z/D= 1.083
 U/UF          V/UF          W/UF          CP(STATIC)
0.8463        -0.0043       -0.0059        0.0120
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0562   0.0529   0.0484    0.2255E-03   -0.5798E-04    0.1316E-03

POINT NUMBER =  24
X/D= 1.000  Y/D= 0.000  Z/D= 1.167
 U/UF          V/UF          W/UF          CP(STATIC)
0.8487        -0.0037       -0.0063        0.0115
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0564   0.0535   0.0488    0.2286E-03   -0.5190E-04    0.1229E-03

POINT NUMBER =  25
X/D= 1.000  Y/D= 0.000  Z/D= 1.333
 U/UF          V/UF          W/UF          CP(STATIC)
0.8473        -0.0023       -0.0107        0.0137
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0582   0.0551   0.0499    0.3413E-03    0.2099E-04    0.1127E-03

POINT NUMBER =  26
X/D= 1.000  Y/D=-0.083  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.5983         0.0012        0.0032        0.0235
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0480   0.0346   0.0356    0.4652E-03    0.1895E-03   -0.1846E-03

POINT NUMBER =  27
X/D= 1.000  Y/D=-0.167  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.7408         0.0017        0.0169        0.0209
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0572   0.0433   0.0444    0.6990E-03    0.2606E-03   -0.2079E-03

POINT NUMBER =  28
X/D= 1.000  Y/D=-0.167  Z/D= 0.167
 U/UF          V/UF          W/UF          CP(STATIC)
0.8015         0.0203        0.0064        0.0202
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0526   0.0407   0.0449    0.6307E-03   -0.1997E-03    0.1999E-04

POINT NUMBER =  29
X/D= 1.000  Y/D=-0.167  Z/D= 0.333
 U/UF          V/UF          W/UF          CP(STATIC)
0.8944         0.0094       -0.0018        0.0176
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0518   0.0417   0.0447    0.6493E-03   -0.1985E-03    0.1622E-03
```

```
POINT NUMBER =  30
X/D= 1.000  Y/D=-0.167  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
0.9713         0.0014       -0.0103        0.0125
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0425   0.0338   0.0359   0.4402E-03  -0.1025E-04   0.2270E-03

POINT NUMBER =  31
X/D= 1.000  Y/D=-0.167  Z/D= 0.667
 U/UF          V/UF          W/UF          CP(STATIC)
0.9876        -0.0075       -0.0064        0.0099
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0429   0.0361   0.0338   0.5739E-03   0.5919E-04   0.2495E-03

POINT NUMBER =  32
X/D= 1.000  Y/D=-0.167  Z/D= 0.833
 U/UF          V/UF          W/UF          CP(STATIC)
0.9933        -0.0067       -0.0024        0.0081
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0382   0.0330   0.0308   0.4368E-03  -0.3925E-04   0.1162E-03

POINT NUMBER =  33
X/D= 1.000  Y/D=-0.167  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0013        -0.0048       -0.0043        0.0098
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0288   0.0261   0.0256   0.2178E-03  -0.3838E-04   0.5311E-04

POINT NUMBER =  34
X/D= 1.000  Y/D=-0.250  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.8692         0.0025        0.0216        0.0169
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0509   0.0414   0.0434   0.5383E-03   0.1429E-03  -0.1881E-03

POINT NUMBER =  35
X/D= 1.000  Y/D=-0.333  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9560         0.0012        0.0191        0.0119
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0378   0.0316   0.0332   0.2767E-03   0.4475E-04  -0.9893E-04

POINT NUMBER =  36
X/D= 1.000  Y/D=-0.333  Z/D= 0.167
 U/UF          V/UF          W/UF          CP(STATIC)
0.9651         0.0086        0.0108        0.0119
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0351   0.0283   0.0318   0.2632E-03  -0.9301E-04  -0.5422E-04

POINT NUMBER =  37
X/D= 1.000  Y/D=-0.333  Z/D= 0.333
 U/UF          V/UF          W/UF          CP(STATIC)
1.0017         0.0005       -0.0013        0.0120
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0175   0.0155   0.0155   0.1784E-04  -0.4770E-04  -0.1021E-04

POINT NUMBER =  38
X/D= 1.000  Y/D=-0.333  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
1.0092        -0.0036       -0.0036        0.0120
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0073   0.0076   0.0061  -0.4427E-05  -0.7747E-05  -0.1754E-04

POINT NUMBER =  39
X/D= 1.000  Y/D=-0.333  Z/D= 0.667
 U/UF          V/UF          W/UF          CP(STATIC)
1.0089        -0.0068       -0.0054        0.0114
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0071   0.0068   0.0066  -0.6672E-05  -0.2383E-05  -0.2319E-04

POINT NUMBER =  40
X/D= 1.000  Y/D=-0.333  Z/D= 0.833
 U/UF          V/UF          W/UF          CP(STATIC)
1.0090        -0.0081       -0.0048        0.0109
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0075   0.0062   0.0092  -0.8551E-05  -0.1547E-04  -0.3637E-04

POINT NUMBER =  41
X/D= 1.000  Y/D=-0.333  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0086        -0.0068       -0.0065        0.0113
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0078   0.0068   0.0105  -0.1202E-04  -0.9193E-05  -0.5288E-04

POINT NUMBER =  42
X/D= 1.000  Y/D=-0.417  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0072        -0.0028        0.0112        0.0091
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0139   0.0124   0.0138   0.8766E-05  -0.4373E-04  -0.1481E-04

POINT NUMBER =  43
X/D= 1.000  Y/D=-0.500  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0089        -0.0030        0.0081        0.0089
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0064   0.0057   0.0081  -0.5555E-05  -0.6633E-05  -0.3480E-04

POINT NUMBER =  44
X/D= 1.000  Y/D=-0.500  Z/D= 0.167
 U/UF          V/UF          W/UF          CP(STATIC)
1.0079        -0.0016        0.0040        0.0105
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0053   0.0053   0.0066  -0.5508E-05  -0.6256E-05  -0.2449E-04
```

```
POINT NUMBER =  45
X/D= 1.000  Y/D=-0.500  Z/D= 0.333
 U/UF          V/UF          W/UF          CP(STATIC)
1.0092        -0.0006        0.0004        0.0126
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0057   0.0042   0.0084  -0.4911E-05  -0.1534E-04  -0.2688E-04

POINT NUMBER =  46
X/D= 1.000  Y/D=-0.500  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
1.0116        -0.0016       -0.0024        0.0094
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0047   0.0044   0.0064  -0.4324E-05  -0.9411E-05  -0.1188E-04

POINT NUMBER =  47
X/D= 1.000  Y/D=-0.500  Z/D= 0.667
 U/UF          V/UF          W/UF          CP(STATIC)
1.0119        -0.0029       -0.0042        0.0092
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0052   0.0040   0.0065  -0.2800E-05  -0.6347E-05  -0.1642E-04

POINT NUMBER =  48
X/D= 1.000  Y/D=-0.500  Z/D= 0.833
 U/UF          V/UF          W/UF          CP(STATIC)
1.0124        -0.0033       -0.0047        0.0092
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0064   0.0045   0.0098  -0.5664E-05  -0.1501E-04  -0.3243E-04

POINT NUMBER =  49
X/D= 1.000  Y/D=-0.500  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0118        -0.0031       -0.0058        0.0093
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0064   0.0050   0.0095  -0.7678E-05   0.1412E-03  -0.3049E-04

POINT NUMBER =  50
X/D= 1.000  Y/D=-0.583  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0090        -0.0019        0.0077        0.0084
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0047   0.0044   0.0044  -0.5184E-05  -0.1989E-05  -0.8118E-05

POINT NUMBER =  51
X/D= 1.000  Y/D=-0.667  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0066        -0.0007        0.0072        0.0070
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0049   0.0052   0.0053  -0.6218E-05  -0.2776E-05  -0.1601E-04

POINT NUMBER =  52
X/D= 1.000  Y/D=-0.667  Z/D= 0.167
 U/UF          V/UF          W/UF          CP(STATIC)
1.0085        -0.0005        0.0043        0.0083
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0046   0.0039   0.0049  -0.4555E-05  -0.3331E-05  -0.9840E-05

POINT NUMBER =  53
X/D= 1.000  Y/D=-0.667  Z/D= 0.333
 U/UF          V/UF          W/UF          CP(STATIC)
1.0082         0.0006        0.0043        0.0082
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0051   0.0044   0.0056  -0.3918E-05  -0.3561E-05  -0.1265E-04

POINT NUMBER =  54
X/D= 1.000  Y/D=-0.667  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
1.0072         0.0008       -0.0012        0.0109
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0047   0.0043   0.0075  -0.3210E-05  -0.4694E-05  -0.2597E-04

POINT NUMBER =  55
X/D= 1.000  Y/D=-0.667  Z/D= 0.667
 U/UF          V/UF          W/UF          CP(STATIC)
1.0085         0.0002       -0.0036        0.0092
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0061   0.0045   0.0083  -0.3918E-05  -0.1461E-04  -0.3542E-04

POINT NUMBER =  56
X/D= 1.000  Y/D=-0.667  Z/D= 0.833
 U/UF          V/UF          W/UF          CP(STATIC)
1.0057        -0.0009       -0.0050        0.0106
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0073   0.0054   0.0107  -0.7452E-05  -0.1953E-04  -0.5165E-04

POINT NUMBER =  57
X/D= 1.000  Y/D=-0.667  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0072        -0.0002       -0.0065        0.0094
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0074   0.0065   0.0080  -0.1100E-04  -0.2272E-05  -0.1684E-04

POINT NUMBER =  58
X/D= 1.000  Y/D= 0.167  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.7582        -0.0174        0.0044        0.0188
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0551   0.0422   0.0451  -0.9924E-03  -0.9595E-04  -0.1893E-03

POINT NUMBER =  59
X/D= 1.000  Y/D= 0.167  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9957        -0.0197       -0.0100        0.0081
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0308   0.0295   0.0214  -0.4661E-03  -0.3569E-04   0.1210E-03
```

```
POINT NUMBER =  60
X/D= 1.000  Y/D=-0.118  Z/D=-0.118
 U/UF          V/UF          W/UF          CP(STATIC)
0.7668        -0.0118        0.0134        0.0195
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0563   0.0450   0.0433   0.1917E-03   0.7225E-03  -0.1112E-03

POINT NUMBER =  61
X/D= 1.000  Y/D=-0.118  Z/D= 0.118
 U/UF          V/UF          W/UF          CP(STATIC)
0.7137         0.0161        0.0029        0.0218
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0522   0.0386   0.0419   0.5461E-03  -0.1929E-03   0.5409E-04

POINT NUMBER =  62
X/D= 1.000  Y/D=-0.236  Z/D= 0.236
 U/UF          V/UF          W/UF          CP(STATIC)
0.9080         0.0141        0.0022        0.0157
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0464   0.0371   0.0415   0.3576E-03  -0.1425E-03   0.1908E-04

POINT NUMBER =  63
X/D= 1.000  Y/D=-0.236  Z/D=-0.236
 U/UF          V/UF          W/UF          CP(STATIC)
0.9802        -0.0149        0.0178        0.0097
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0309   0.0264   0.0257   0.6294E-04   0.1471E-03   0.6467E-04

POINT NUMBER =  64
X/D= 1.000  Y/D=-0.354  Z/D=-0.354
 U/UF          V/UF          W/UF          CP(STATIC)
1.0107        -0.0134        0.0132        0.0073
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0060   0.0059   0.0061  -0.9473E-05  -0.3522E-05  -0.1105E-04

POINT NUMBER =  65
X/D= 1.000  Y/D=-0.471  Z/D=-0.471
 U/UF          V/UF          W/UF          CP(STATIC)
1.0089        -0.0103        0.0130        0.0043
 U'/UF    V'/UF    W'/UF   U'V'/UF**2   U'W'/UF**2   V'W'/UF**2
0.0058   0.0065   0.0057  -0.1121E-04  -0.1766E-05  -0.2366E-04
```

## APPENDIX C. DATA AT X/D=33.0

THE LAYOUT OF THE GRID IS PLOTTED IN FIG. 5 .

POINT NUMBER = 1
X/D=33.000 Y/D= 0.000 Z/D= 0.000

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9301 | 0.0171 | -0.0104 | 0.0051 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0312 | 0.0304 | 0.0273 | -0.6851E-04 | -0.2656E-04 | 0.6850E-04 |

POINT NUMBER = 2
X/D=33.000 Y/D= 0.000 Z/D=-0.125

| U/UF | V/UF | W/UF | | |
|---|---|---|---|---|
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0315 | 0.0302 | 0.0281 | -0.6211E-04 | 0.7314E-04 | 0.2023E-03 |

POINT NUMBER = 3
X/D=33.000 Y/D= 0.000 Z/D=-0.250

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9449 | 0.0185 | -0.0099 | 0.0053 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0327 | 0.0311 | 0.0285 | -0.1238E-03 | 0.2180E-03 | 0.1396E-03 |

POINT NUMBER = 4
X/D=33.000 Y/D= 0.000 Z/D=-0.500

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9792 | 0.0142 | -0.0090 | 0.0066 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0322 | 0.0276 | 0.0265 | -0.1168E-03 | 0.2547E-03 | 0.1384E-03 |

POINT NUMBER = 5
X/D=33.000 Y/D= 0.000 Z/D=-0.750

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0124 | 0.0161 | -0.0098 | 0.0079 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0189 | 0.0167 | 0.0170 | -0.3306E-04 | 0.6295E-04 | 0.2669E-03 |

POINT NUMBER = 6
X/D=33.000 Y/D= 0.000 Z/D=-1.000

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0160 | 0.0189 | -0.0094 | 0.0057 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0137 | 0.0150 | 0.0136 | -0.2164E-04 | 0.7189E-06 | 0.5138E-04 |

POINT NUMBER = 7
X/D=33.000 Y/D= 0.000 Z/D=-1.250

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0181 | 0.0222 | -0.0079 | 0.0022 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0153 | 0.0178 | 0.0143 | -0.2620E-04 | 0.2921E-06 | 0.6556E-05 |

POINT NUMBER = 8
X/D=33.000 Y/D= 0.000 Z/D=-1.500

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 1.0193 | 0.0190 | -0.0076 | 0.0015 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0134 | 0.0165 | 0.0115 | -0.1848E-04 | -0.6304E-06 | 0.7315E-05 |

POINT NUMBER = 9
X/D=33.000 Y/D= 0.000 Z/D= 0.125

| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
|---|---|---|---|---|---|
| 0.0366 | 0.0302 | 0.0269 | -0.2227E-04 | -0.9956E-04 | 0.1066E-03 |

POINT NUMBER = 10
X/D=33.000 Y/D= 0.000 Z/D= 0.250

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9374 | 0.0163 | -0.0080 | 0.0025 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0306 | 0.0303 | 0.0270 | 0.7305E-05 | -0.1304E-03 | 0.1112E-03 |

POINT NUMBER = 11
X/D=33.000 Y/D= 0.000 Z/D= 0.500

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9515 | 0.0166 | -0.0080 | 0.0002 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0273 | 0.0260 | 0.0242 | 0.5670E-05 | -0.1114E-03 | 0.1224E-03 |

POINT NUMBER = 12
X/D=33.000 Y/D= 0.000 Z/D= 0.750

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9639 | 0.0157 | -0.0113 | -0.0002 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0207 | 0.0201 | 0.0197 | -0.2798E-04 | -0.4993E-04 | 0.1072E-03 |

POINT NUMBER = 13
X/D=33.000 Y/D= 0.000 Z/D= 1.000

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9685 | 0.0168 | -0.0155 | -0.0008 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0187 | 0.0192 | 0.0176 | -0.1765E-04 | -0.5608E-05 | -0.2571E-06 |

POINT NUMBER = 14
X/D=33.000 Y/D= 0.000 Z/D= 1.250

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9661 | 0.0185 | -0.0187 | -0.0027 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0216 | 0.0212 | 0.0201 | 0.1619E-04 | 0.3929E-04 | 0.1112E-03 |

POINT NUMBER = 15
X/D=33.000 Y/D= 0.250 Z/D= 1.000

| U/UF | V/UF | W/UF | CP(STATIC) | |
|---|---|---|---|---|
| 0.9835 | 0.0204 | -0.0174 | -0.0046 | |
| U'/UF | V'/UF | W'/UF | U'V'/UF**2 | U'W'/UF**2 | V'W'/UF**2 |
| 0.0200 | 0.0190 | 0.0182 | -0.1163E-03 | -0.5765E-05 | 0.8978E-05 |

```
POINT NUMBER =  16
X/D=33.000  Y/D= 0.250  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9575         0.0156       -0.0123        0.0043
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0336   0.0283   0.0282   -0.3761E-03   -0.6584E-04    0.3215E-04

POINT NUMBER =  17
X/D=33.000  Y/D= 0.125  Z/D= 0.000
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0326   0.0305   0.0276   -0.2997E-03   -0.6295E-04    0.3904E-04

POINT NUMBER =  18
X/D=33.000  Y/D=-0.125  Z/D= 0.000
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0322   0.0307   0.0273    0.1616E-03   -0.9883E-05    0.4101E-04

POINT NUMBER =  19
X/D=33.000  Y/D=-0.250  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9522         0.0223       -0.0102        0.0041
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0333   0.0292   0.0278    0.2748E-03   -0.9467E-05    0.5568E-04

POINT NUMBER =  20
X/D=33.000  Y/D=-0.250  Z/D= 0.250
 U/UF          V/UF          W/UF          CP(STATIC)
0.9629         0.0226       -0.0118        0.0019
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0313   0.0263   0.0275    0.2215E-03   -0.6679E-04    0.7453E-04

POINT NUMBER =  21
X/D=33.000  Y/D=-0.250  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
0.9747         0.0200       -0.0128        0.0007
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0259   0.0227   0.0227    0.1279E-03   -0.6483E-05    0.4759E-04

POINT NUMBER =  22
X/D=33.000  Y/D=-0.250  Z/D= 0.750
 U/UF          V/UF          W/UF          CP(STATIC)
0.9779         0.0163       -0.0132        0.0011
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0203   0.0188   0.0189    0.8561E-04   -0.2680E-05    0.1528E-04

POINT NUMBER =  23
X/D=33.000  Y/D=-0.250  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9830         0.0171       -0.0158       -0.0013
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0194   0.0186   0.0178    0.7638E-04   -0.7972E-05   -0.9053E-05

POINT NUMBER =  24
X/D=33.000  Y/D=-0.500  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
0.9905         0.0245       -0.0071        0.0053
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0295   0.0237   0.0228    0.1915E-03   -0.1620E-05    0.4080E-04

POINT NUMBER =  25
X/D=33.000  Y/D=-0.500  Z/D= 0.250
 U/UF          V/UF          W/UF          CP(STATIC)
1.0018         0.0241       -0.0111        0.0032
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0240   0.0198   0.0192    0.1031E-03   -0.5203E-04    0.2766E-04

POINT NUMBER =  26
X/D=33.000  Y/D=-0.500  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
1.0066         0.0225       -0.0156        0.0025
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0180   0.0171   0.0158    0.6097E-04    0.1229E-04    0.2579E-05

POINT NUMBER =  27
X/D=33.000  Y/D=-0.500  Z/D= 0.750
 U/UF          V/UF          W/UF          CP(STATIC)
1.0053         0.0202       -0.0162        0.0014
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0165   0.0152   0.0147    0.9551E-04    0.1233E-04    0.8668E-05

POINT NUMBER =  28
X/D=33.000  Y/D=-0.500  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0101         0.0199       -0.0168       -0.0008
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0160   0.0153   0.0148    0.8602E-04   -0.2363E-05   -0.1302E-04

POINT NUMBER =  29
X/D=33.000  Y/D=-0.750  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0141         0.0280       -0.0077        0.0050
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0153   0.0157   0.0129    0.1951E-04   -0.6901E-05    0.5570E-04

POINT NUMBER =  30
X/D=33.000  Y/D=-0.750  Z/D= 0.250
 U/UF          V/UF          W/UF          CP(STATIC)
1.0186         0.0257       -0.0105        0.0029
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0135   0.0143   0.0129    0.4631E-05   -0.4149E-05    0.3428E-04

POINT NUMBER =  31
X/D=33.000  Y/D=-0.750  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
1.0197         0.0241       -0.0138        0.0014
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0075   0.0083   0.0065   -0.1286E-05    0.5016E-05    0.5431E-04
```

```
POINT NUMBER =  32
X/D=33.000  Y/D=-0.750  Z/D= 0.750
 U/UF          V/UF          W/UF          CP(STATIC)
1.0187         0.0225       -0.0149       -0.0005
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0068   0.0080   0.0065    0.4889E-05    0.2421E-05    0.4180E-04

POINT NUMBER =  33
X/D=33.000  Y/D=-0.750  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0193         0.0224       -0.0164       -0.0019
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0078   0.0097   0.0067   -0.3296E-05    0.8127E-06    0.4077E-04

POINT NUMBER =  34
X/D=33.000  Y/D=-1.000  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0188         0.0277       -0.0092        0.0072
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0117   0.0134   0.0100   -0.3813E-04   -0.1272E-05    0.6015E-04

POINT NUMBER =  35
X/D=33.000  Y/D=-1.000  Z/D= 0.250
 U/UF          V/UF          W/UF          CP(STATIC)
1.0170         0.0254       -0.0105        0.0053
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0119   0.0135   0.0103   -0.2370E-04   -0.7439E-06    0.6514E-04

POINT NUMBER =  36
X/D=33.000  Y/D=-1.000  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
1.0187         0.0242       -0.0135        0.0033
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0071   0.0098   0.0042   -0.2198E-05   -0.1096E-06    0.7857E-05

POINT NUMBER =  37
X/D=33.000  Y/D=-1.000  Z/D= 0.750
 U/UF          V/UF          W/UF          CP(STATIC)
1.0191         0.0227       -0.0147        0.0013
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0074   0.0059   0.0047   -0.1250E-05    0.2243E-05    0.1606E-04

POINT NUMBER =  38
X/D=33.000  Y/D=-1.000  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0193         0.0224       -0.0164        0.0000
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0060   0.0074   0.0048   -0.4376E-05   -0.5527E-07   -0.6616E-05

POINT NUMBER =  39
X/D=33.000  Y/D=-1.250  Z/D= 0.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0168         0.0284       -0.0093        0.0094
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0119   0.0143   0.0104   -0.2796E-04   -0.7033E-05    0.4021E-04

POINT NUMBER =  40
X/D=33.000  Y/D=-1.250  Z/D= 0.250
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0117   0.0149   0.0096   -0.2330E-04    0.3512E-05    0.2180E-04

POINT NUMBER =  41
X/D=33.000  Y/D=-1.250  Z/D= 0.500
 U/UF          V/UF          W/UF          CP(STATIC)
1.0157         0.0244       -0.0129        0.0049
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0042   0.0069   0.0031    0.1800E-05    0.4331E-06    0.1472E-04

POINT NUMBER =  42
X/D=33.000  Y/D=-1.250  Z/D= 1.000
 U/UF          V/UF          W/UF          CP(STATIC)
1.0177         0.0227       -0.0158        0.0010
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0049   0.0053   0.0052   -0.2131E-06   -0.9219E-08   -0.5078E-05

POINT NUMBER =  43
X/D=33.000  Y/D=-0.884  Z/D=-0.884
 U/UF          V/UF          W/UF          CP(STATIC)
1.0170         0.0274       -0.0073        0.0095
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0103   0.0127   0.0085    0.1955E-04   -0.1240E-05    0.1252E-04

POINT NUMBER =  44
X/D=33.000  Y/D=-0.707  Z/D=-0.707
 U/UF          V/UF          W/UF          CP(STATIC)
1.0168         0.0244       -0.0072        0.0087
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0115   0.0145   0.0100    0.9032E-05   -0.3238E-05    0.3594E-04

POINT NUMBER =  45
X/D=33.000  Y/D=-0.530  Z/D=-0.530
 U/UF          V/UF          W/UF          CP(STATIC)
1.0154         0.0236       -0.0073        0.0080
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0188   0.0179   0.0155    0.3972E-04    0.4839E-04    0.1104E-04

POINT NUMBER =  46
X/D=33.000  Y/D=-0.354  Z/D=-0.354
 U/UF          V/UF          W/UF          CP(STATIC)
0.9854         0.0199       -0.0047        0.0065
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0317   0.0282   0.0227    0.1037E-03    0.1809E-03    0.3738E-04
```

```
POINT NUMBER =  47
X/D=33.000  Y/D=-0.177  Z/D=-0.177
 U/UF          V/UF          W/UF          CP(STATIC)
0.9491        0.0204        -0.0094        0.0050
 U'/UF    V'/UF    W'/UF    U'V'/UF**2    U'W'/UF**2    V'W'/UF**2
0.0321   0.0299   0.0267    0.1395E-03    0.1193E-03    0.4517E-04
```

The vita has been removed from the scanned document