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The Structure of Turbulent Flow through a Wall Subchannel of a Rod Bundle with Roughened Rods

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The structure of turbulent flow through a wall subchannel of a rod bundle with roughened rods

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Abstract

An experimental investigation was undertaken in order to obtain information on the transport properties of turbulent flow through a wall subchannel of a rod bundle with roughened rods and a smooth channel wall. Detailed measurement values were obtained on the distributions of mean flow velocity, intensity of turbulence in all directions and thus the kinetic energy of turbulence as well as the shear stresses perpendicular and parallel to the walls and of the wall shear stresses on the smooth wall. The rod bundle consisted of four parallel rods contained in a rectangular channel; the Reynolds number of this investigation was $Re=1.82\cdot 10^5$. From the measurement values the eddy viscosities in the directions perpendicular and parallel to the walls were calculated. The results are compared with predictions calculated by the VELASCO code.

Die Struktur der turbulenten Strömung in einem Wandkanal eines Stabbündels mit rauhen Rohren

Zusammenfassung

Eine experimentelle Untersuchung wurde durchgeführt mit dem Ziel, Informationen über die Transporteigenschaften der turbulenten Strömung in einem Stabbündel mit rauhen Stäben und glatten Kanalwänden zu erhalten. Detaillierte Verteilungen von Strömungsgeschwindigkeit, Turbulenzintensitäten in allen Richtungen und damit der kinetischen Energie der Turbulenz sowie der Schubspannungen in Richtung senkrecht und parallel zur Wand und der Wandschubspannung an der glatten Wand wurden gemessen. Das Stabbündel bestand aus vier parallelen rauhen Rohren umgeben von einem Rechteckkanal; die Reynoldszahl der Untersuchung war $Re=1.82\cdot 10^5$. Aus den Meßwerten wurden die Wirbelviskositäten senkrecht und parallel zu den Wänden berechnet. Die Ergebnisse wurden mit berechneten Werten mit dem VELASCO-code verglichen.

1. INTRODUCTION

Computer codes used to predict the thermodynamic and fluid dynamic performance of rod bundles with longitudinal turbulent flow require experimental knowledge of the turbulent transport properties. Anisotropic eddy viscosities are used in the most advanced codes applied to rod bundles /1,2/. The anisotropy of the momentum transport is described by different eddy viscosities in the radial direction, i.e., normal to the walls, and in the circumferential direction, i.e., parallel to the walls, respectively.

The eddy viscosity in the radial direction is defined by

$$\varepsilon_r = \frac{-\overline{u'v'}}{\partial u/\partial r} \qquad (1)$$

with $\overline{u'v'}$ as the time-mean correlation of the velocity fluctuations in the main direction of the flow (u') and in the direction normal to the wall (v'), respectively, $\bar{u}$ is the time-mean fluid velocity, and r is the coordinate normal to the wall. As a dimensionless quantity the radial eddy viscosity can be written as

$$\varepsilon_r^+ = \frac{\varepsilon_r}{L \cdot u^*} \qquad (2)$$

with L as the length of the velocity profile measured normal to the wall between the wall and the position of maximum velocity and u^* as the local shear velocity defined by

$$u^* = \sqrt{\frac{\tau_w}{\rho}} \qquad (3)$$

with τ_w as the shear stress at the wall.

Likewise, the eddy viscosity in the circumferential direction is defined by

$$\varepsilon_\phi = \frac{-\overline{u'w'}}{\frac{1}{r}\frac{\partial u}{\partial \phi}} \qquad (4)$$

with w' as the velocity fluctuation in the circumferential direction. As a dimensionless quantity the circumferential eddy viscosity yields

$$\varepsilon_{\phi}^{+} = \frac{\varepsilon_{\phi}}{L \cdot u^{*}} . \tag{5}$$

In channel flows the eddy viscosities in the radial and circumferential directions are non-isotropic; this fact is taken into account by an anisotropy factor n

$$n = \frac{\varepsilon_{\phi}^{+}}{\varepsilon_{r}^{+}} . \tag{6}$$

Up to now, experimental information on the value of the anisotropy factor and its local dependence has been very poor for non-circular channels. Information is available only for simple ducts, circular tubes and parallel plates, for which values between 2 and 3 have been measured.

For smooth rod bundles some results are known of the radial eddy viscosity from the experiments by Kjellström /3/, Trupp /4/ and Rehme /5 - 10/. Kjellström also reported a few values of the anisotropy factor n, but his results scatter widely and no conclusions can be drawn on the basis of those values. Detailed experimental data of the anisotropy factor for the turbulent flow through smooth rod bundles with different pitch-to-diameter ratios were published earlier /5 - 10/. Experimental results of the anisotropy factor in roughened rod bundles are not available. On the other hand, the anisotropy factor strongly influences the results calculated by the codes. Especially the circumferential variation of the mean flow velocity averaged normal to the walls, the variation of the wall shear stresses, and, hence, the resulting variation of the wall temperatures depend on the anisotropy factor /11/. For instance, the calculations with the VELASCO code /12/ for a smooth rod bundle with a pitch-to-diameter ratio of the rods P/D = 1.1 show that the ratio of $\tau_{w_{max}}/\tau_{w_{min}}$ changes from 1.86 to 1.06, if the anisotropy factor is changed from

1 to 30 /11/. The VELASCO code is also suited for the prediction of the turbulent flow through roughened rod bundles.

Precise experimental results on the anisotropy factor and its local distribution are therefore necessary to verify the assumptions made or to adjust the codes. Moreover, it is desirable to apply the more advanced codes (k'-models) to rod bundles. To test those models detailed experimental results of the flow structure are necessary.

2. EXPERIMENTAL SETUP

In this investigation experiments were performed in a wall subchannel of a rod bundle with roughened rods. Since the temperature gradients are the highest in wall and corner channels of nuclear fuel elements, knowledge of the tranport properties is most important for those channels. On the other hand, experiments in central subchannels are difficult to perform, since the flow will always be affected by the channel walls, as the results of different investigations show /3,4/.

A rectangular channel (180.2x642.2 mm) with 4 rods (D_{vol} = 106.21 mm) in parallel is used for the experiments (Fig.1). The rods were arranged at a pitch-to-diameter ratio of $P/D_{vol} = 1.45$ and a wall-to-diameter ratio of $W/D_{vol} = 1.35$. The surface of the rods was roughened by a trapezoidal roughness similar to the roughness used in the BR2-calibration experiments /13/. The ribs with a height of h = 1.4 mm were cut with a pitch of p = 16.2 mm into the outer surface of the aluminium tubes of D = 108.0 mm O.D. The width of the ribs was b_1 = 4.8 mm at the tip and b_2 = 6.76 mm at the root of the ribs, respectively (Fig.2). The choice of these dimensions means an enlargement of 13.5 : 1 compared to the dimensions of the rods used for the BR2 calibration experiments.

The rectangular channel was fabricated from plexiglass so that one of the short walls is adjustable to allow the channel dimensions to be changed for different geometries. The overall length of the test section is H = 7000 mm; it was made up of 4 portions of L_K = 1750 mm each for both the channel and the rods. This makes the length-to-diameter ratios

$$\frac{H}{D_{vol}} \approx 66$$

$$\frac{H}{D_{h_{wall}}} \approx 60.$$

Small pins of 2 mm O.D. were used as spacers at four levels to fix the rods inside the channel. The measurements were performed with air as the fluid at the open outlet, 30 mm downstream from the outlet. The air is taken in through a silencer and a filter (1 µm particle size) by a radial blower ($\dot{m}$ = 4.2 kgs^{-1}; Δp = 0.1 bar) and enters the test section through a honeycomb grid (Fig.1).

Measurements were taken of

(a) the time-mean value of the fluid velocity by Pitot tubes,

(b) the turbulent shear stresses in the radial and circumferential directions,

(c) the distribution of turbulence intensities and, hence, the kinetic energy of turbulence by hot-wire measurements (b) and (c) (DISA), and

(d) the distribution of the wall shear stresses by Preston tubes at the smooth channel wall.

In order to achieve the necessary accuracy of the measured values and their gradients, the flow cross section to be investigated was covered by a network of mesh points. Measurements were taken along the rod wall between 0 and 90 deg : 5 deg each and along the channel wall between 0 and 77 mm : 5 mm each for a different number of points normal to the walls, depending on the width of the flow cross section between 13 and 18 points. Thus, measurements were taken at a total of more than 500 positions in the symmetrical part of the wall channel by the technique used in ealier measurements on annuli /14,15/ and in smooth rod bundles /5 - 10/. The hot-wire measurements were performed by the single-wire method in six different positions against the flow, as suggested by Kjellström /3/. For evaluation of the results Kjellström's method was used. The difficulty in solving the set of six simultaneous equations with respect to the shear stress $\overline{v'w'}$ was overcome by disregarding this correlation, as reported already by Kjellström /3/. Since the measurement of all values at all positions takes a long time, nearly 3 months, the density of the air at the outlet changes with the conditions of the weather (temperature and barometer readings). Therefore, the speed of the blower was adjusted by controlling the revolutions per minute of the motor such that at a fixed point in the channel the fluid velocity measured by a Pitot tube remained constant (u_{REF} = 27.78 ms^{-1}). Details of the test section and the measuring technique can be taken from /16/.

3. RESULTS

The Reynolds number of this study based on the hydraulic diameter D_h and the velocity averaged across the subchannel

$$Re = \frac{\rho \cdot u_m \cdot D_h}{\mu} \tag{7}$$

was Re = $1.82 \cdot 10^5$. The tabulated results are included in this report in the appendix.

3.1 Time-mean velocity and wall shear stress

The velocity ditribution measured by Pitot tubes is shown in Fig.3 as lines of constant velocity (isotachs). The velocities measured are related to the velocity kept constant (u_{REF} = 27.78 ms^{-1}) by a fixed Pitot tube. The average fluid velocity over the cross section (u_m = 24.38 ms^{-1}) was calculated by an integration of the velocity distribution measured. The plot of the isotachs shows that the lines of constant velocity close to the walls are parallel to the walls. It is interesting to note that the line of maximum velocity is not conicident with the symmetry line between the rods. This effect is due to the influence of the edge channel on the flow distribution in the wall channel. Unfortunately, the measurements were taken in the wall channel which was connected with the edge channel. Since in the edge channel the mean flow velocity is lower than in the wall channel the line of maximum velocity is moved towards the center of the whole channel. The data were plotted by a computer. For the measurements near the rod wall cylindrical coordinates and near the channel wall karthesian coordinates were used. Therefore, two plots were drawn which were connected at the line of maximum velocity between the rods and the channel wall. This is the reason for the small steps of the isotachs near the line of maximum velocity.

The same data are shown in Fig.4 for the portion of the subchannel close to the rod wall and in Fig.5 for the portion close to the channel wall. In these figures the velocity distributions measured are plotted versus the relative distance from the respective wall: the distance from the wall is related to the length of the velocity profile between the wall and the position of maximum velocity. Fig.4 shows that the velocity distribution of the wall channel has a minimum in the gap between the rods (ϕ=5 deg), whereas the velocity in the gap between the rod and the smooth channel wall is slightly higher (ϕ=85 deg).

The wall shear stresses at the smooth channel wall were measured by means of Preston tubes /17/. The data were evaluated by using Patel's calibration equations /18/. The use of Preston tubes is not possible at the roughened wall. Therefore, the wall shear stresses were calculated from the velocity profiles measured assuming that they follow the law of the wall:

$$u^+ = 2.5 \ln \frac{y}{h} + R(h^+) \qquad (8)$$

$$u = 2.5\, u^* \ln y - 2.5\, u^* \ln h + u^* \cdot R(h^+) \qquad (9)$$

The data of the velocity u and the natural logarithm of the distance from the wall y were fitted by a straight line (LSF). Assuming the slope of the dimensionless velocity profile to 2.5, as usual, the shear velocity u^* and, thus, the wall shear stress τ_w were calculated

$$\tau_w = \rho\, u^{*2}. \qquad (10)$$

Considering the recent results on velocity profiles over rough surfaces by Baumann /19,20/ the assumption of a slope = 2.5 of the velocity profiles might not be true. The distance from the wall y was measured from the volumetric radius.
The results are shown in Fig.6. It turns out that the shear stress at the rod wall due to the roughness is about three times higher than that of the smooth wall. At the smooth channel wall the wall shear stress is nearly uniform, however, at the rough wall the shear stress is lowest in the gaps between the rods and channel wall, respectively. There is a relatively great variation of the wall shear stress of about 25%, the maximum value being at the ϕ = 40 deg position. This position is coincident with the position at which the length of the velocity profile between the wall and the maximum velocity has its maximum value.

Fig.7 shows the dimensionless velocity profiles for the rough part of the cross section. All profiles follow a straight line but there is considerable scatter with respect to the constant R of the velocity profile. The mean value of R calculated from Eq. (9) was R=6.6. With the different positions at the wall this constant changes between 6.2 and 7.2. The highest values of R are found in the gaps between the rod and channel wall and between the rods, respectively. This value of R is rather high compared with the value of R =5.4 used in the SAGAPO /21/ calculations for the BR2-bundle according to Dalle Donne and Meyer /22/. Using a combination of the methods of Lyall /23/ and Maubach /24/ the value of R = 5.55 was calculated from the BR2 calibration experiments /25/. This value is lower than that found in this investigation, too. Since it is felt that the assumption the slope of the non-dimensional velocity profile being 2.5 is most questionable it was tried to calculate the wall shear stress by extrapolation of the shear stresses measured in the direction normal to the rough wall. The extrapolated values scatter considerably, moreover, they are higher than those evaluated from the velocity profiles assuming the slope to be 2.5. The mean value of the wall shear stress was $\tau_{w_{av}} = 5.562\ Nm^{-2}$ calculated by extrapolation of the shear stress profiles compared with $\tau_{w_{av}} = 4.261\ Nm^{-2}$ from the profiles. However, the shear stresses measured near the rough wall are not very precise, since the maximum ratio of r.m.s axial fluctuation to mean velocity was 28%. The hot-wire equipment used without linearisators is not able to measure the shear stresses precisely at such high intensities /26,27,28/. Nevertheless, the non-dimensional velocity distributions are plotted in Fig.8 using the smoothed wall shear stress distribution calculated from the shear stress distributions measured. The plot shows that the profiles have a slope less than 2.5 but nearly the same constant (5.9). The lowest slope is found in the gaps (2.03) and the highest at 25 - 35 deg (2.30).

The average wall shear stress on the rough wall can be calculated by a force balance if the pressure drop gradient is known. Fig.9 shows the distribution of the static pressure measured along the smooth channel wall. The distribution shows small steps due to the presence of spacers. The pressure drop gradient was calculated from the measurements of the last five pressure taps:

$$\frac{\Delta p}{\Delta L} = \frac{142.98}{1.203} = 118.85\ Nm^{-2}.$$

The force balance can be written as

$$\tau_{sav} \cdot U_s + \tau_{Rav} \cdot U_R = \frac{\Delta p}{\Delta L} \cdot F.$$

From the measured wall shear stress distribution on the smooth wall τ_{sav} is calculated:

$$\tau_{sav} = 1.638 \ Nm^{-2}$$

and with $U_{R_{Vol}} = 83.415$ mm and $F_{Vol} = 4722.9$ mm^2 and $U_S = 77.0$ mm we get

$$\tau_{Rav} = 5.218 \ Nm^{-2}.$$

This value is only 6.2% lower than the average wall shear stress calculated via the extrapolation of the shear stress distributions in the direction normal to the wall.

Using this value of the wall shear stress constant around the rod surface the non-dimensional velocity plot (Fig.10) shows a strong dependence of the profiles on the circumferential position: the highest profiles at the 45 deg position with a slope of 2.28 and a constant of 5.8 and the lowest profiles in the gaps (5 deg and 85 deg position) with a slope of 1.78 and a constant of 5.0.

It can be concluded from a comparison of the figures 7,8 and 10 that the wall shear stress around the perimeter is not constant but there must be a distribution with lower values in the gaps.

Since it is not possible to evaluate the precise distribution from the measurements in the following the intensities, kinetic energy of turbulence and the eddy viscosities in the rough part of the channel are related to the average value of the wall shear stress (5.218 Nm^{-2}) which is felt to be the most precise value.

It is possible to calculate another value of the roughness parameter $R(h^+)$ by a combination of the Lyall /23/ and Maubach /24/ methods using the pressure drop measured:

$$\lambda = \frac{\Delta p/\Delta L}{\frac{\rho}{2} u_m^2 \frac{1}{D_h}} = 0.04033$$

$$Re = 1.824 \cdot 10^5$$

$$\frac{\lambda}{\lambda_s} = 2.527 \text{ and } \frac{U_R}{U_S} = 1.073.$$

From /23/ we get

$$\frac{\lambda_R}{\lambda} = 1.472$$

and

$$\lambda_R = 0.0594.$$

The annular zone is taken equivalent to the flow cross section between the surface and the position of maximum velocity ($F = 3194.2 \text{ mm}^2$). We get

$$\gamma = \frac{r_{u_{max}}}{r_{vol}} = 1.574$$

and from

$$\sqrt{\frac{8}{\lambda}} = 2.5 \ln \frac{L}{h} + R(h^+) - G$$

with

$$G = \frac{3.75 + 1.25\gamma}{1 + \gamma} = 2.221 \quad /24/$$

$$R(h^+) = 6.13.$$

This value is higher than those found in the BR2-calibration tests, too. The reason for this discrepancy is not clear. Perhaps the small differences in the roughness profiles are the reason for this difference. The profile used in this investigation was calculated as an enlarged profile of the original design of the BR2 roughness. But during the fabrication of the calibration test section the dimensions changed slightly:

	BR2 original design	BR2 actual mean dimension	this investigation
p/h	11.76	10.84	11.57
h/b	0.239	0.255	0.242
$\frac{p-b}{h}$	7.57	6.91	7.44

Moreover, the angle between the root of the ribs and the ribs was 45 deg for the BR2 rods whereas it was 35 deg (Fig.2) for the rods of this investigation.

The non-dimensional velocity profiles in the smooth part of the channel close to the channel wall are plotted in Fig.11 versus the non-dimensional distance from the wall. The slope of the profiles is nearly coincident with the slope of the Nikuradse profile in smooth tubes:

$$u^+ = 2.5 \ln y^+ + 5.5 \qquad (11)$$

which plotted as a straight line for comparison. The values measured are slightly lower than the tube profile. The same effect was already observed during the investigations in smooth rod bundles /6 - 10/.

3.2 Intensities and kinetic energy of turbulence

3.2.1 Axial turbulence intensities

Fig.12 and 13 show the measured turbulence intensities in the rough and the smooth zones of the wall channel. As mentioned before the axial intensity in the rough zone of the channel is related to the friction velocity based on the average wall shear stress. In the smooth zone the intensities are related to the local friction velocity based on the local wall shear stresses measured by Preston tubes.

It is interesting to note that the axial intensity decreases close to the rough wall (Fig.12). This cannot be noticed close to the smooth wall (Fig.13). The axial intensity depends on the circumferential position in the rough part of the channel the intensities being higher in the gaps and lower at the ϕ=35 to 45 deg position. This effect cannot be attributed to the reference friction velocity chosen since the intensities in the gaps are on the high side and they will be even higher if a slightly lower friction velocity is chosen as the reference velocity due to a variation in the wall shear stress. In the smooth part of the channel the data agree close to the wall. Far from the wall the intensities spread out depending on the position at the wall. The lowest values are found near the symmetry line of the channel (x=77 mm). It is interesting to note that the intensities show a minimum value especially near the gap. This is more pronounced in Fig.7 which shows the measured axial turbulence intensities in the wall channel made dimensionless by the reference wall shear velocity $u^*_{REF}=1.794\ Nm^{-2}$. The contour map of lines of equal intensity shows that the intensity is the highest near the rough wall, as is to be expected, but that the intensity drop towards the center of the flow on lines normal to the wall depends on the circumferential position at the wall. Again, as already observed for the time-mean velocity the line of minimum intensity between the rods is non-coincident with the symmetry line.

As already mentioned the line of minimum intensity between the rod and the channel wall is non-coincident with the line of maximum velocity. There is a considerable shift of the line of minimum intensity, which is almost parallel to the line of maximum velocity, towards the smooth channel wall. The same result was observed in smooth annuli with small radius ratios /9,10/, for which the line of minimum intensity was coincident with the line of zero shear stress. The same is true for the wall channel of a rod bundle.

The axial intensity close to the rough wall ($\sqrt{u'^2}/u^*_{REF} > 2.2$) is considerably higher than close to the smooth wall (1.5). The lowest values of the axial intensity close to the walls are found at ϕ = 40 deg and x = 77 mm. Towards the gaps the intensity close to the wall increases.

3.2.2 Turbulence intensities normal to the walls

The turbulence intensities in the direction normal to the walls are presented in Figures 15 and 16. In the rough part of the channel there is a drop of the intensities close to the rough wall similar to that found for the axial intensity. Towards the line of maximum velocity a decrease of the intensities normal to the wall is found. In the smooth part of the channel the data show some scatter and the data are more or less constant across the zone. Approaching the maximum velocity position a slight increase of the intensity can be noticed. The contour plot (Fig.17) shows the decline of the values with increasing distance from the rod wall and a somewhat non-uniform picture near the smooth surface.

3.2.3 Turbulence intensities parallel to the walls

Plots of the turbulence intensities parallel to the walls are presented in Figures 18 and 19. The trends of the azimuthal intensities are similar to those of the axial and normal intensities. The contour plot shows that the line of minimum intensity is shifted from the line of maximum velocity towards the smooth channel wall.

3.2.4 Kinetic energy of turbulence

The measured kinetic energy of turbulence (Figures 21 and 22)

$$k' = \frac{1}{2}\left[\sqrt{u'^2} + \sqrt{v'^2} + \sqrt{w'^2}\right]$$

decreases in general more or less with increasing distance from the wall except near the rough wall. Far from the wall the kinetic energy of turbulence depends on the circumferential position in the rough part whereas this dependence is less pronounced in the smooth part of the channel. Here again an increase in turbulence energy is found approaching the line of maximum velocity. This fact is clearly demonstrated in the contour plot of the data (Fig.23). An influence of secondary flows cannot be noticed, however, the shift of the position of minimum turbulence energy from the symmetry line towards the center of the channel which is caused by the neighboured corner subchannel is clearly indicated. The highest values of the kinetic energy are found close to the rough wall (k'/u^*_{REF} > 3.8) whereas at the smooth wall the maximum values are less than 1/2 of the maximum at the rough wall (< 1.6).

3.3 Shear stresses and correlation coefficients

3.3.1 Shear stress normal to the walls

The measured shear stresses normal to the walls are illustrated in Figures 24 and 25. Close to the rough wall the shear stress decreases. The data are spread with increasing distance from the wall. Similar results were found in /27/, the possible reason was already discussed before. In the smooth part of the channel the data follow reasonably well a linear shear stress distribution.

3.3.2 Shear stress parallel to the walls

The measured shear stresses parallel to the walls exhibit values which tend to zero close to the walls both in the rough and the smooth part of the channel (Figures 26 and 27). In the rough part the shear stress is negative for the region between ϕ = 5 and 35 deg, the sign changes to positive approaching the gap between rod and channel wall. This trend is reasonable because the gradient of the velocity in circumferential direction changes the sign at about 40 deg. The maximum of the shear stress parallel to the rough wall is found to be in the region of ϕ = 55 - 60 deg. In the smooth part of the channel the shear stress changes its sign at the x = 60 mm position. This is reasonable again because the gradient of the velocity parallel to the wall changes the sign due to the influence of the corner subchannel.

3.3.3 Correlation coefficient R_{uv}

The measured correlation coefficients of the shear stress in the direction normal to the walls (Figures 28 and 29)

$$R_{uv} = \frac{-\overline{u'v'}}{\sqrt{\overline{u'^2}} \cdot \sqrt{\overline{v'^2}}}$$

exhibit similar curves to that with circular tubes. The correlation coefficients are slightly higher than in circular tubes close to the rough wall (0.5 to 0.6). Over a wide region of the flow cross-section the correlation coefficients are between 0.4 and 0.5 in the smooth part of the channel.

3.3.4 Correlation coefficient R_{uw}

The calculated correlation coefficients of shear stress parallel to the walls (Figures 30 and 31)

$$R_{uw} = \frac{-\overline{u'w'}}{\sqrt{\overline{u'^2}} \cdot \sqrt{\overline{w'^2}}}$$

tend to zero close to the walls and rise gradually in the region distant from the wall. The behaviour is quite similar with the shear stress distribution in the direction parallel to the walls.

3.4 Eddy viscosities

From the data for the turbulent shear stresses and the distribution of the mean time-value of the flow velocity in the axial direction were determined the eddy viscosities in the directions both perpendicular and parallel to the walls. The eddy viscosities were calculated on the basis of their definitions (Eqn. 1 and 4) using the original results (not smoothed). The calculated values are plotted as non-dimensional quantities. For the rough part of the channel the viscosities are related to the average value of the wall shear stress; in the smooth part the local wall shear stresses are used.

3.4.1 Eddy viscosity normal to the walls

Fig.32 shows the calculated data for the roughened part of the channel as non-dimensional eddy viscosity versus the non-dimensional distance from the wall. For comparison with the smooth tube data the line according to Reichardt /29/ was added in the figure. Compared to the smooth tube values it is interesting to note that the slope of the eddy viscosity normal to the wall near the rough surface is steeper. Most interesting, however, is the fact that the eddy viscosity in radial direction is strongly dependent on the circumferential position at the wall. The highest values are found for the gaps between the rods and the rod and channel wall, respectively, whereas the values are slightly lower than for smooth tubes for ϕ = 30 - 45 deg. Towards the gaps the eddy viscosities increase gradually. The eddy viscosities normal to the wall in the smooth part of the cross section are plotted as non-dimensional quantities versus the non-dimensional distance from the wall in Fig. 33. Close to the wall the data measured are coincident with the smooth tube results. However, far from the wall (Y/L > 0.25) the eddy viscosities are higher than for tubes. This result was also observed in smooth rod bundles /3 - 10/. The large scatter in the region near the center line happens because of the small velocity gradients approaching zero at the center line. From the data shown we can conclude that the eddy viscosity normal to the wall is almost independent of the circumferential position for the smooth part of the channel, whereas in the rough part the eddy viscosities strongly depend on the local position.

3.4.2 Eddy viscosity parallel to the walls

The results for the eddy viscosities in the direction parallel to the walls differ quite considerably from those in the direction normal to the walls. The calculated values are shown in Figures 34 and 35. The eddy viscosities not only depend on the circumferential position but also on the position perpendicular to the wall. In the rough part of the cross section two main structures can be distinguished. In the region between the rough rods the eddy viscosities increase with increasing distance from the wall, as an example the values for the ϕ = 15 deg position are fitted by a curve. In the region between the rough rod and the smooth channel wall the eddy viscosities parallel to the rough wall decrease from high values close to the wall and with higher distance from the wall they are more or less constant: two examples are shown by curves for the ϕ = 50 and 65 deg position. In the smooth part of the channel the eddy viscosities show the same behaviour as observed with smooth rod bundles /6,7,8/. With increasing distance from the smooth wall the eddy viscosities first increase and after passing through a maximum they decrease. Curve fits are shown for the positions x = 30, 40 and 55 mm at the smooth wall. The calculated values for x > 60 behave different but in this region there is an influence on the flow distribution from the neighboured corner channel which was discussed before.

3.4.2 Anisotropy factor

The latter is true also for the anisotropy factor n which is the ratio of the eddy viscosities parallel and normal to the walls. The anisotropy factors calculated from the measurements are plotted in Fig. 36 for the rough portion of the wall channel. The anisotropy factor shows a strong dependence on the position in the cross section both in circumferential and radial directions. It assumes high values close to the wall of up to 20 and higher. The lowest values are found in the gap between the rods (ϕ <30 deg). Approaching the gap between the rod and the channel wall the anisotropy factor increases. The highest values were found at $\phi = 55 \div 75$ deg. Here, the anisotropy factors are found to be of the order of $3 \div 5$ even in the region far from the wall.

The anisotropy factors calculated for the smooth part of the wall channel (Fig. 37) are higher than in the rough part by a factor of more than $2 \div 3$. Close to the smooth wall anisotropy factors of 40 are found. The highest values also in this case are found near the gap between the rod and the channel wall (x < 40 mm). For this region values of $n = 8 \div 10$ were measured in the region far from the wall. Approaching the symmetry line between the rods (x = 77 mm) the anisotropy factors decrease and they assume values comparable to those in the rough part of the channel.

This strong dependence of the anisotropy factor on the circumferential and radial positions is in contrast to the assumptions in the codes /2,12,30/. In VELASCØ /12/ which is suited to calculate the flow distribution in roughened rod bundles the anisotropy factor far from the wall is always less than 2, moreover, the eddy viscosity parallel to the walls is assumed to be constant in the radial and circumferential directions.

4. COMPARISON OF THE EXPERIMENTAL RESULTS WITH PREDICTIONS BY VELASCØ

Since in VELASCØ only sand roughness can be taken into account the subroutine PROPA determining the characteristic velocity profile parameters of roughened surfaces was modified to allow calculations considering the recent results /22/ for the roughness parameter R of the velocity profile of rectangular roughness. The calculations were performed applying the function for the roughness parameter which was used for the SAGAPO-calculations of the BR2-calibration tests /21/.
The velocity field calculated by VELASCØ is plotted in Fig. 38. The lines of constant velocity are related to the same velocity as in Fig. 3, so the values in both figures are comparable.
It is obvious that the calculated velocity field is more uniform than the measured field. The ratio of the maximum velocity divided by the maximum velocity in the gap between the rods is 1.073 for the predictions compared with a value of 1.219 for the measurements. Another difference is found in the ratio of the maximum velocities in the gap. This ratio calculated as maximum velocity in the gap between the rod and the channel wall divided by the maximum velocity in the gap between the rods yields 0.989 for the predictions but 1.071 for the measurements. Most important is the fact, that it is impossible to diplay the measured shift of the maximum velocity in the cross section from the symmetry line due to the influence of the edge channel by the calculations.
The reason for the more uniform velocity field calculated obviously is the influence of secondary flows taken into account in the calculations. The assumption in VELASCØ overestimates the effect of secondary flows as the measurements with a smooth rod bundle already showed / 6 /.
The comparison between measured and calculated wall shear stresses (Fig. 39) also demonstrates that the calculated results are more uniform. The calculated shear stress at the smooth

channel wall is slightly higher that that measured. This is probably due to the noncoincidence between the positions of zero shear and maximum velocity. This effect of course is not taken into account in VELASCØ since both positions are assumed to be coincident.

5. CONCLUSIONS

Detailed experimental results of the velocity and turbulence structure and, thus, the eddy viscosities in directions normal and parallel to the walls were obtained in a wall subchannel of a roughened rod bundle for the first time by this investigation. Thus, applying the experimental results to the codes used for the prediction of flow and temperature distributions makes it possible to check the models and/or adjust them.
The eddy viscosities normal to the roughened rod wall measured showed that they strongly depend on the circumferential position. The same is true for the anisotropy factors in the rough as well as in the smooth portion of the cross section. Since rod bundle experiments /13, 31/showed that the temperature distribution is very sensitive against the gap width between the rods and shroud especially in the wall and edge channels, these experimental results may be used to improve the codes to achieve more reliable predictions of flow and temperature distributions in rod bundles.

Acknowledgement

The author would like to thank Mrs. Chr. Hausmann and Mrs. M.Mangelmann for the development of computer programs to calculate the eddy viscosities and the velocity averaged across the channel. The author would also like to express his gratitude to Mr. E. Mensinger and Mr. G. Wörner for their cooperation in performing the experiments.

NOMENCLATURE

b	m	rib width
D	m	rod outer diameter
D_h	m	hydraulic diameter
D_{vol}	m	volumetric diameter
G		geometry parameter
H	m	length of the test section
h	m	rib height
k'	m^2s^{-2}	kinetic energy of turbulence
L	m	length of the velocity profile
L_K	m	length of the test channel
$\dot{m}$	ks^{-1}	mass flow rate
n	-	anisotropy factor
P	m	rod pitch
p	m	rib pitch
Δp	bar	pressure drop
r	m	radius
Re	-	Reynolds number
R	-	roughness parameter
U	m	perimeter
$\bar{u}$	ms^{-1}	time-mean velocity
u'	ms^{-1}	velocity fluatuating in the axial direction
u_m	ms^{-1}	velocity averaged over a channel
u_{REF}	ms^{-1}	reference velocity
u^*	ms^{-1}	shear velocity
u^+	-	non-dimensional velocity
v'	ms^{-1}	velocity fluctuating in the radial direction
w'	ms^{-1}	velocity fluctuating in the circumferential direction
W	m	distance between rod and channel wall + rod diameter
y	m	distance from the wall
y^+	-	non-dimensional distance from the wall
ε	m^2s^{-1}	eddy viscosity
ε^+	-	dimensionless eddy viscosity
ϕ	deg	angle
μ	$kgm^{-1}s^{-1}$	viscosity
λ	-	friction factor
γ	-	radius ratio

ρ	kgm^{-3}	density
τ_w	Nm^{-2}	wall shear stress

Subscripts

av	average
r	radial
ϕ	circumferential
S	smooth
R	rough

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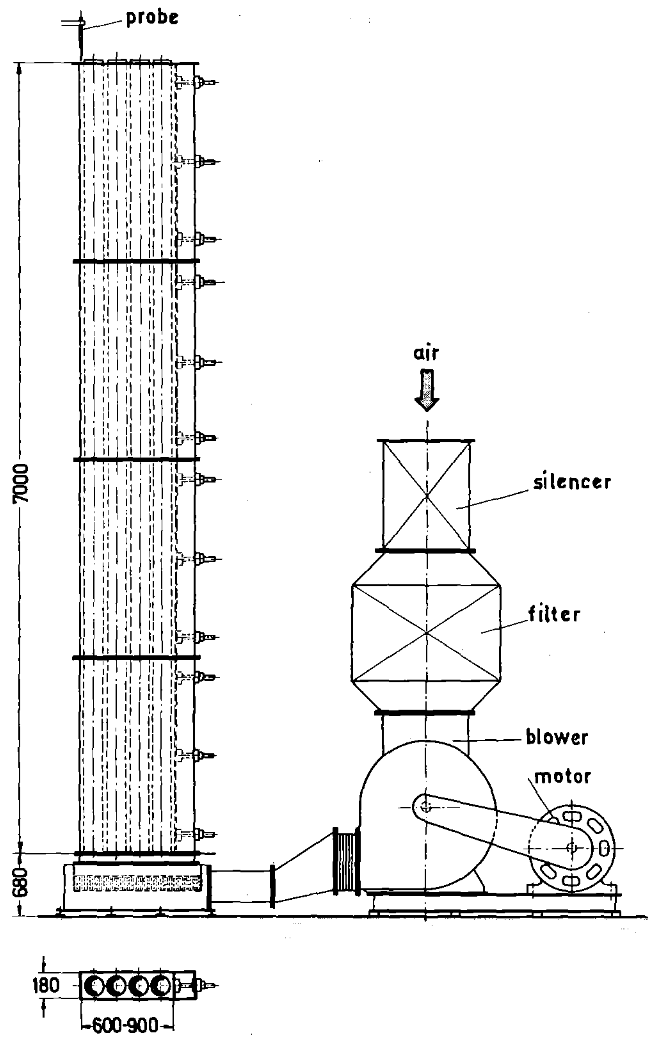


Fig. 1: Sketch of the test rig

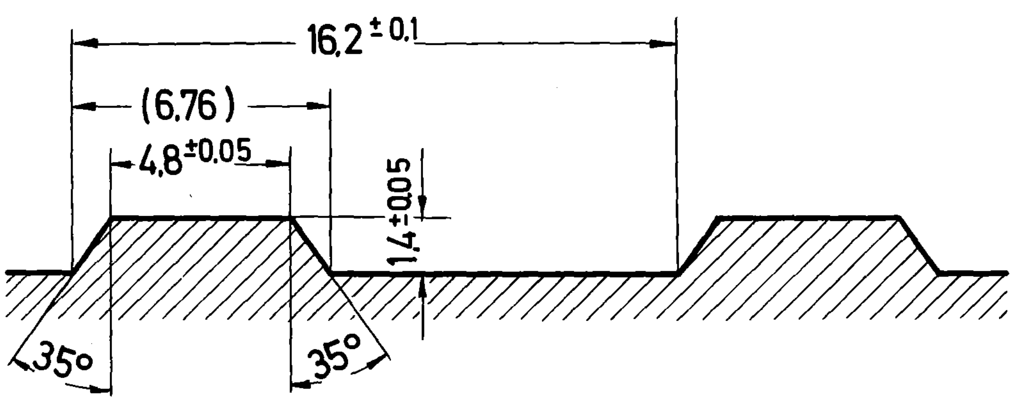
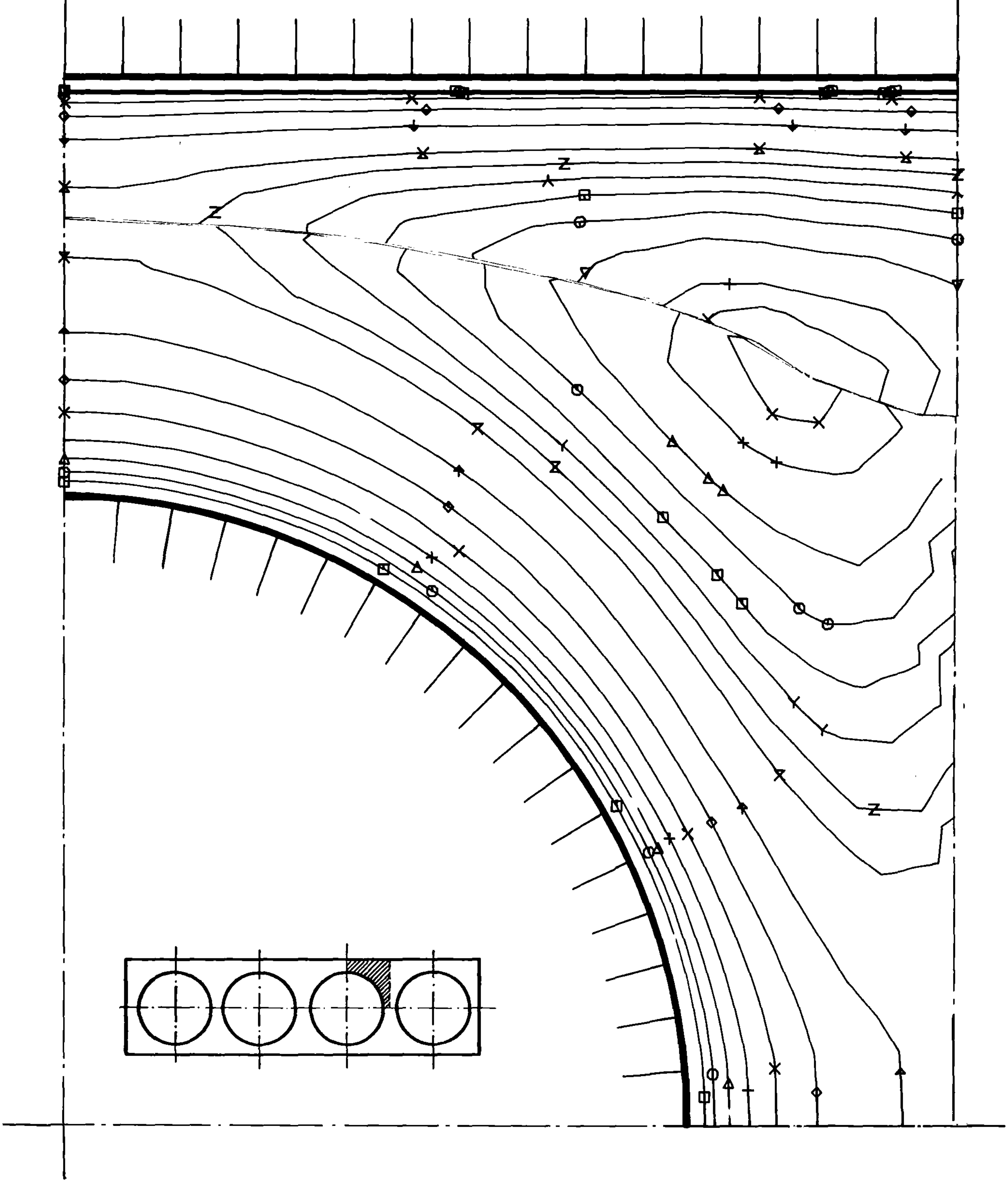


Fig. 2: Shape of the roughness



□	0.550E 00	◇	0.800E 00	□	0.960E 00
○	0.600E 00	↑	0.850E 00	○	0.980E 00
△	0.650E 00	⊼	0.900E 00	△	0.100E 01
+	0.700E 00	z	0.920E 00	+	0.102E 01
×	0.750E 00	Y	0.940E 00	×	0.103E 01

Fig. 3: Velocity field $\bar{u}/u_{REF}$ measured in the wall channel

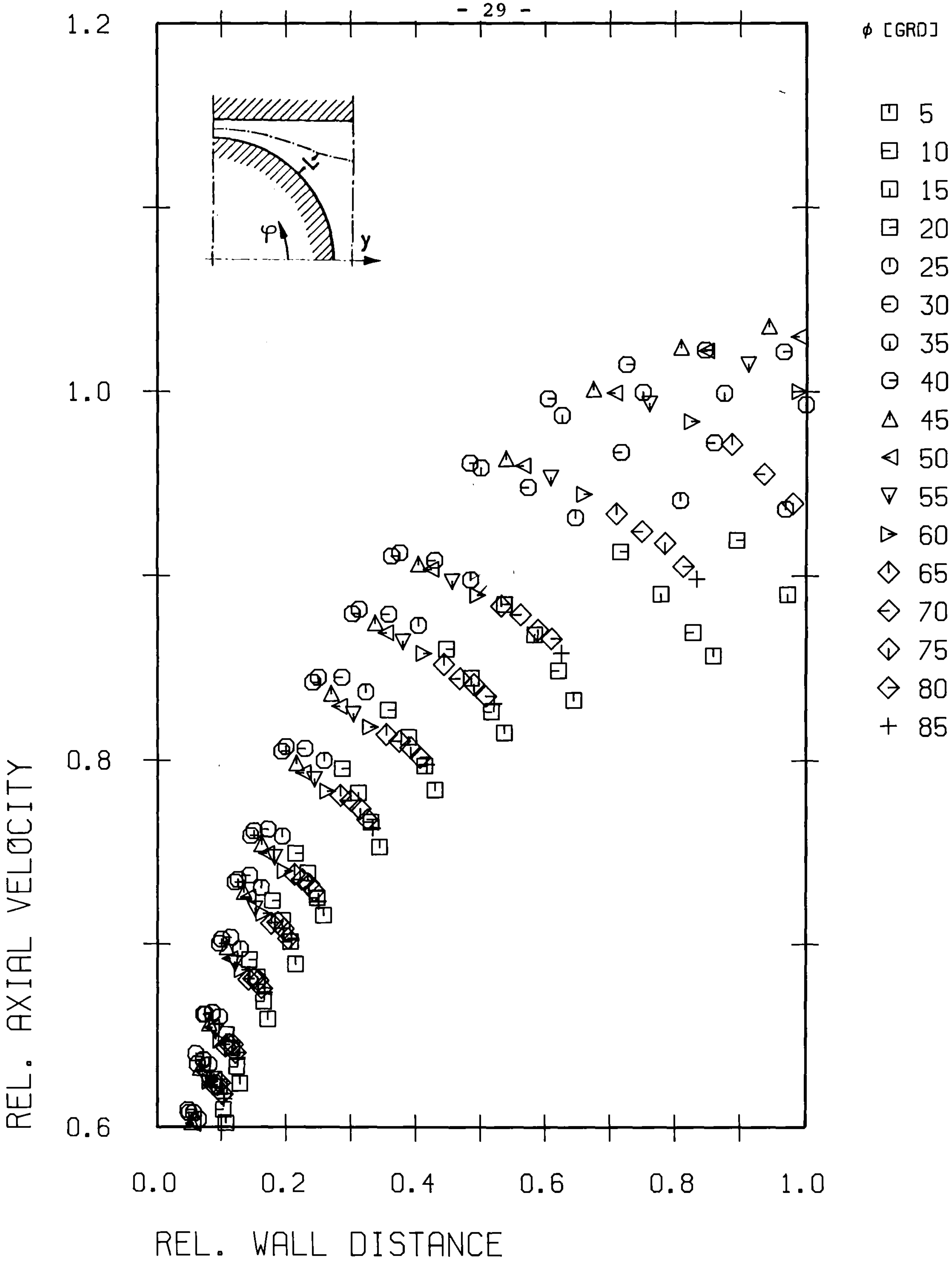


Fig. 4: Time mean value of flow velocity (r/φ)

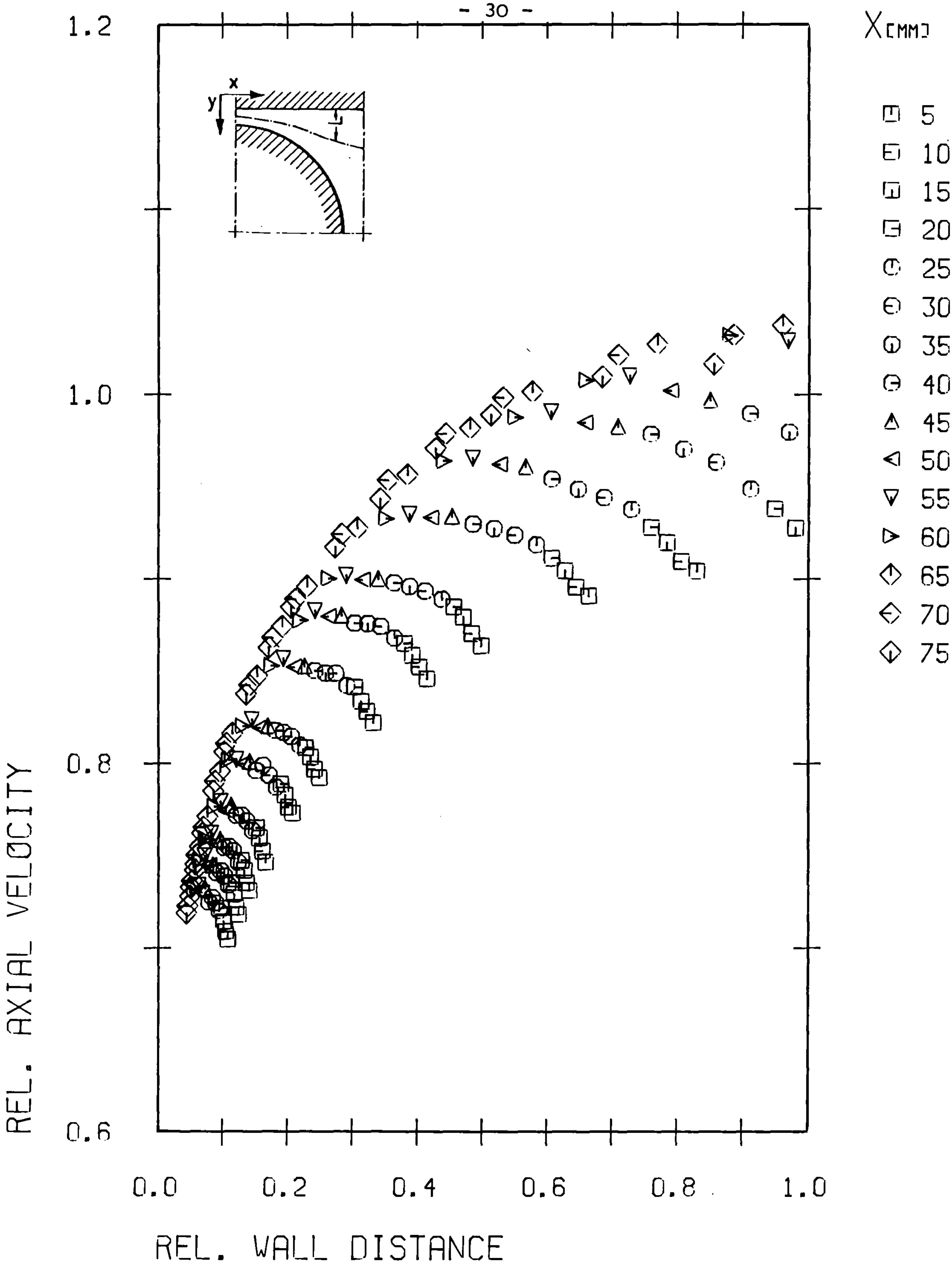


Fig. 5: Time mean value of flow velocity (x/y)

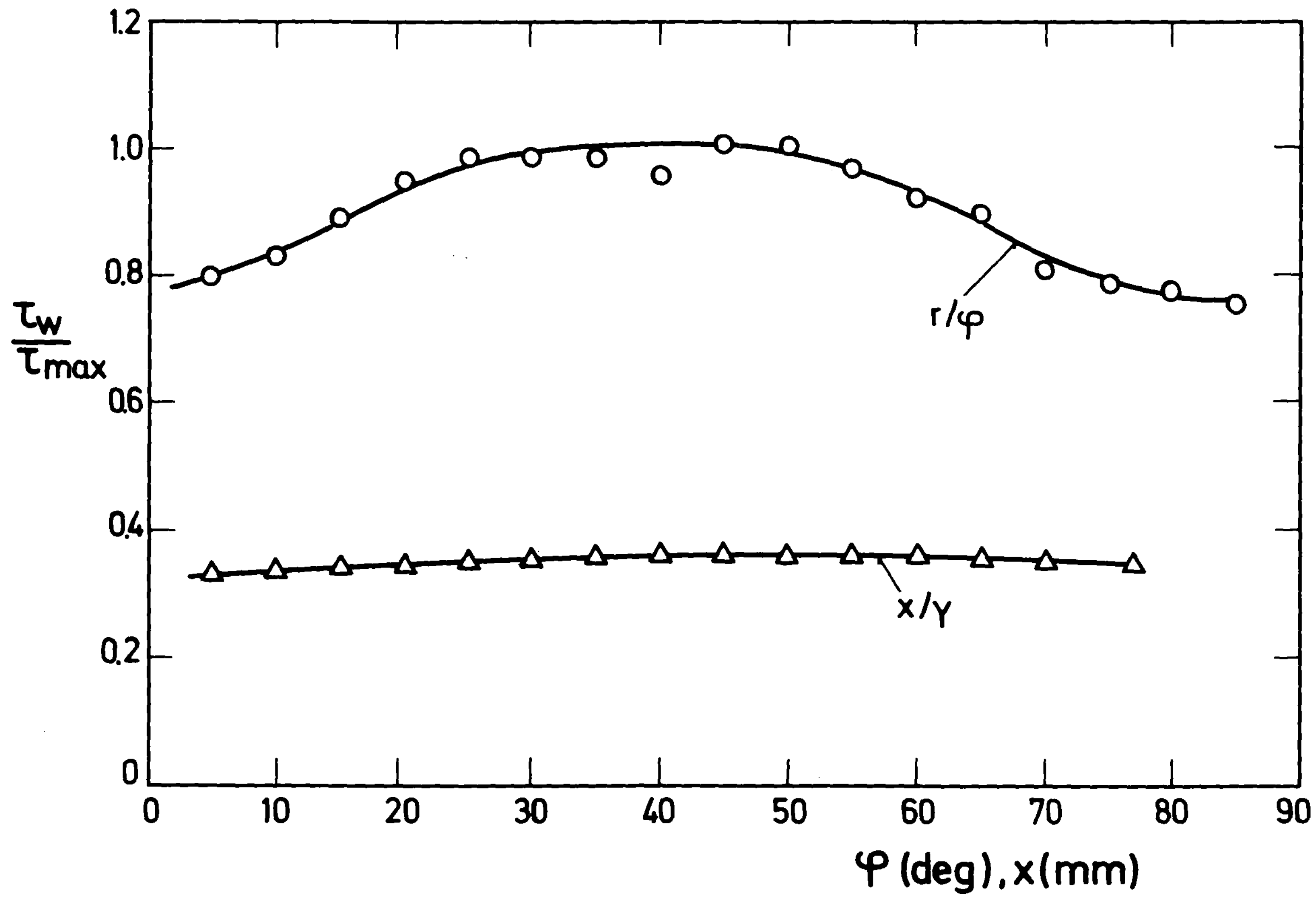


Fig. 6: Ditribution of wall shear stresses

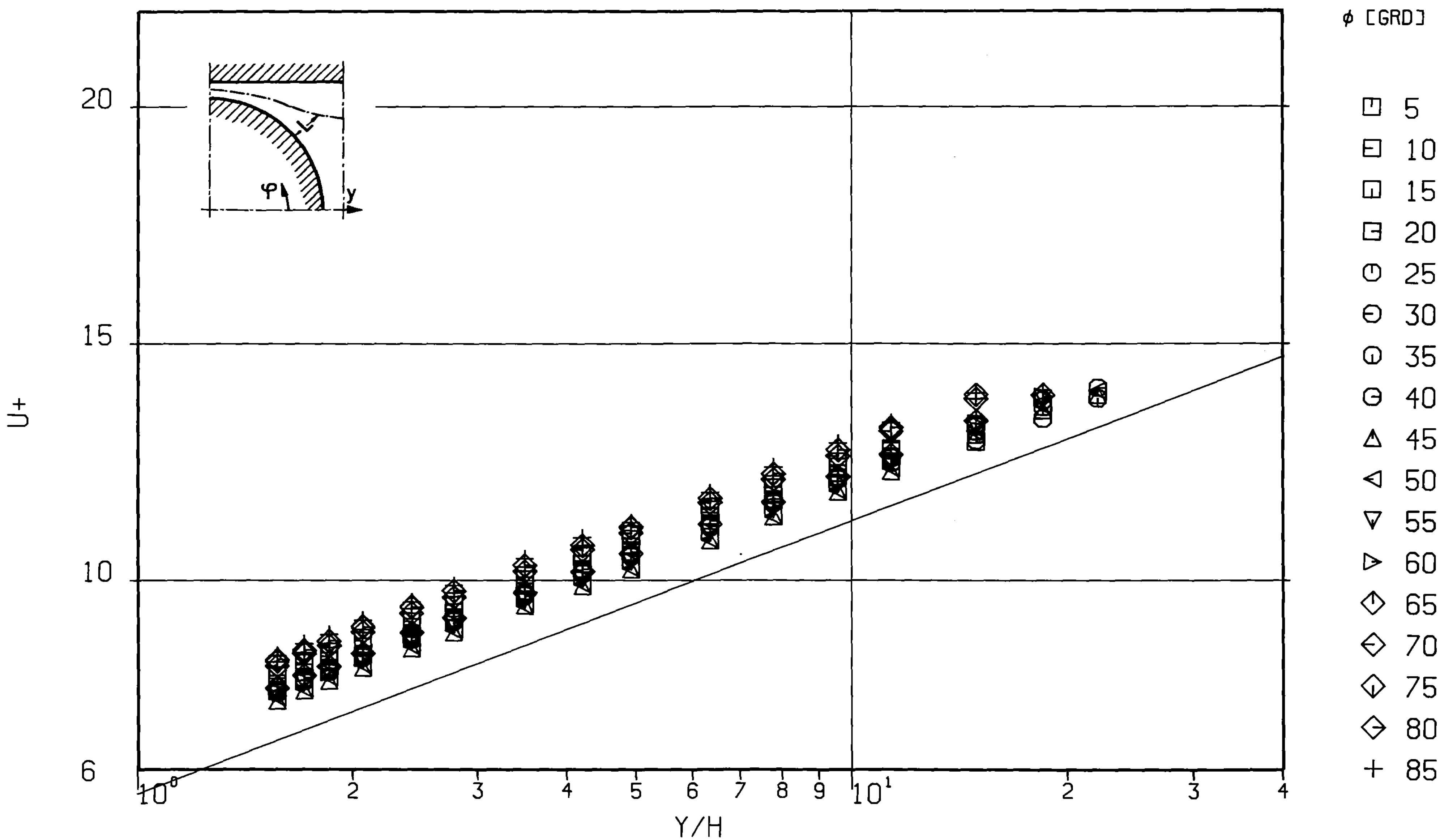


Fig. 7: (wall shear stress calculated with the assumption of a universal slope)

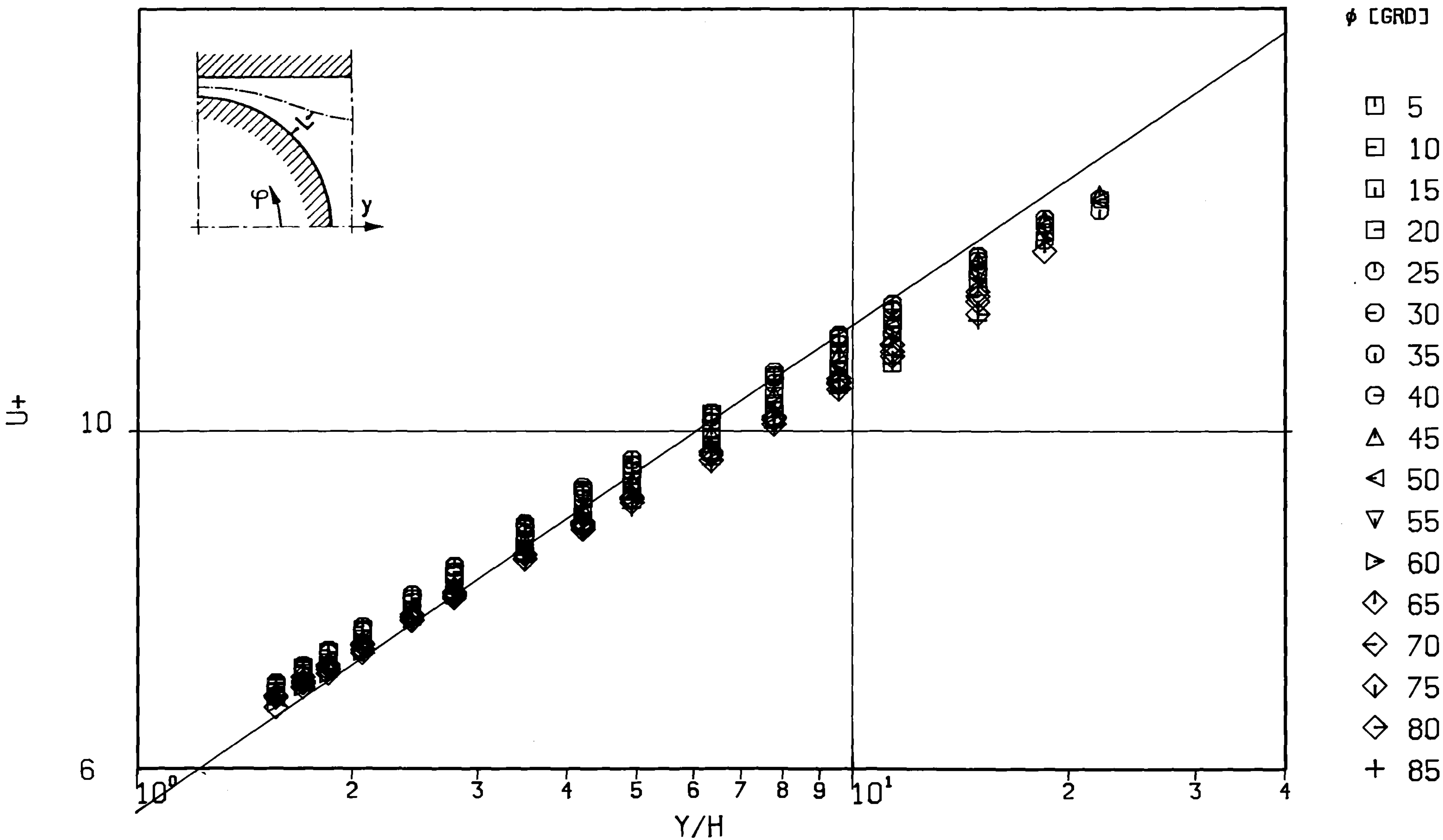


Fig. 8: Non-dimensional velocity profile (r/φ)
(wall shear stress evaluated from shear stress profile)

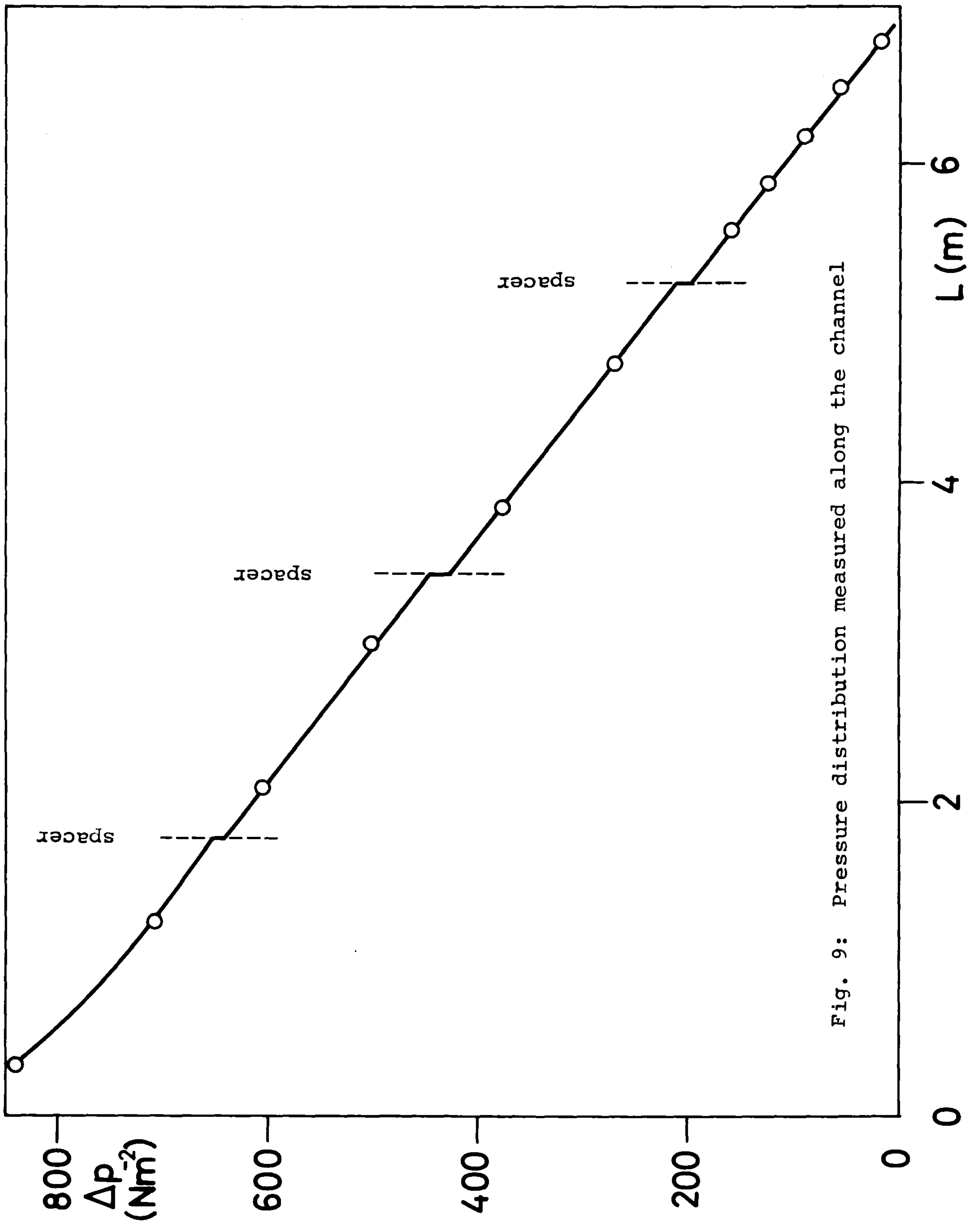


Fig. 9: Pressure distribution measured along the channel

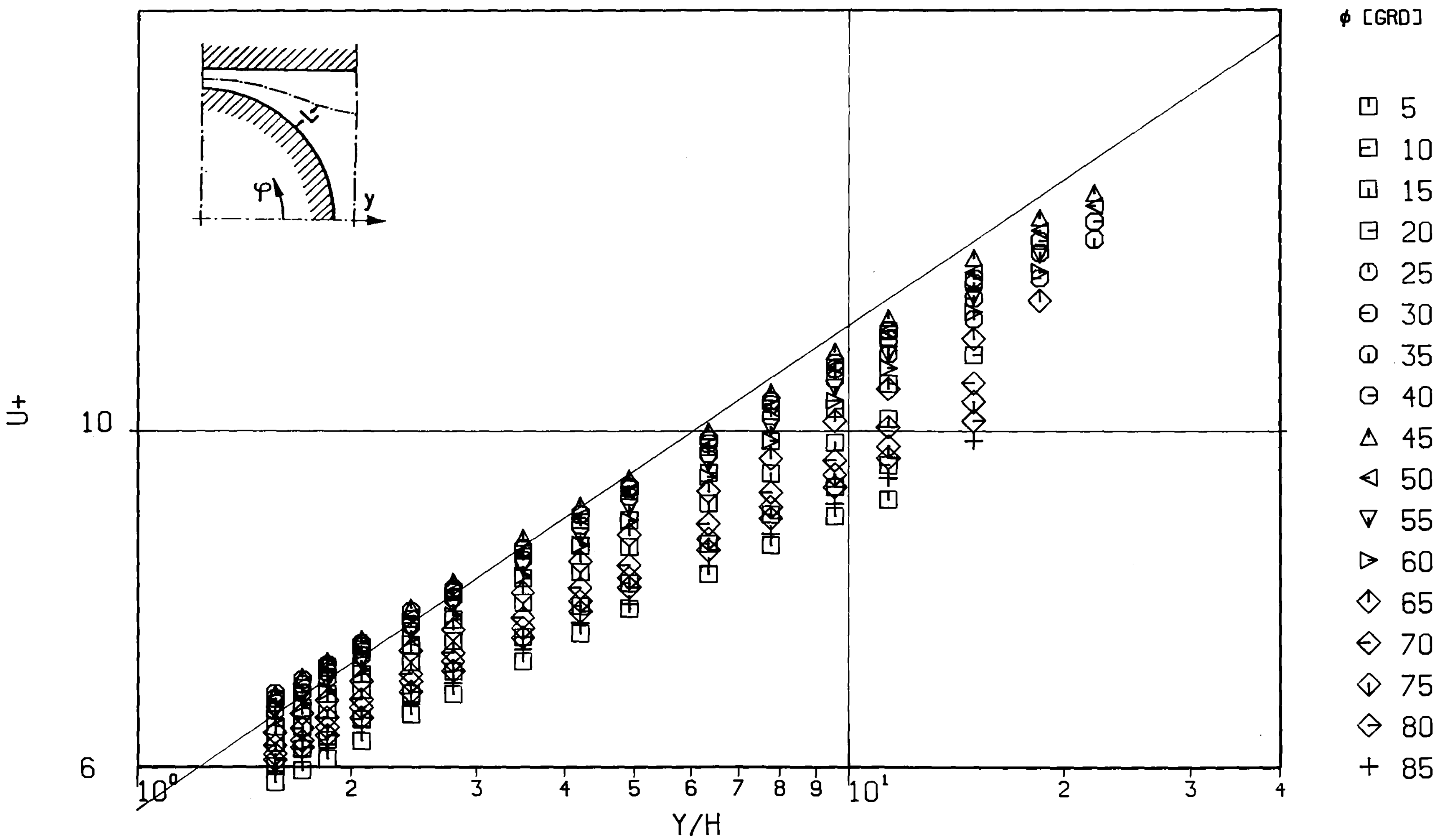


Fig.10: Non-dimensional velocity profile (r/ϕ)
(wall shear stress constant)

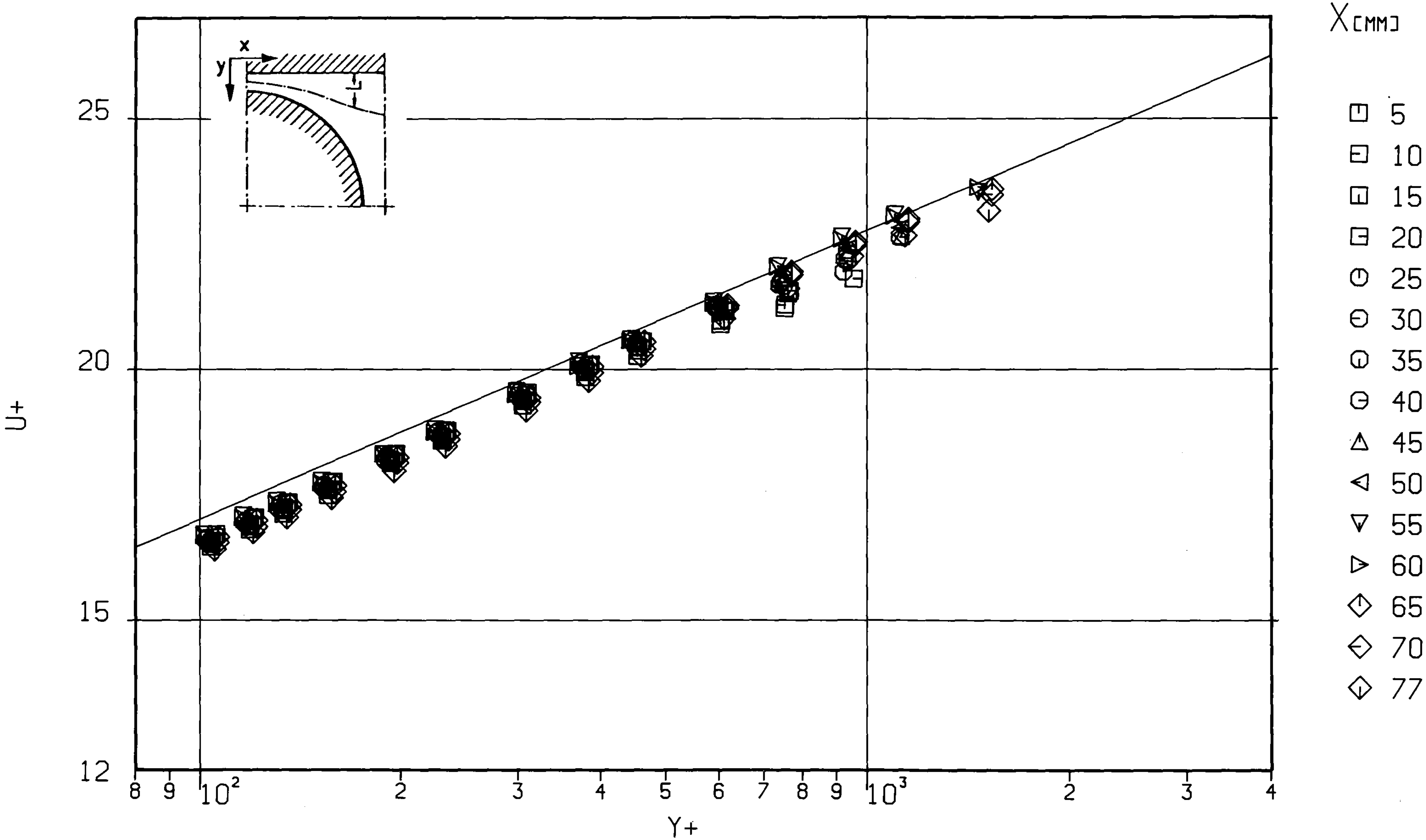


Fig.11: Dimensionless velocity vs. dimensionless distance from the wall (smooth)

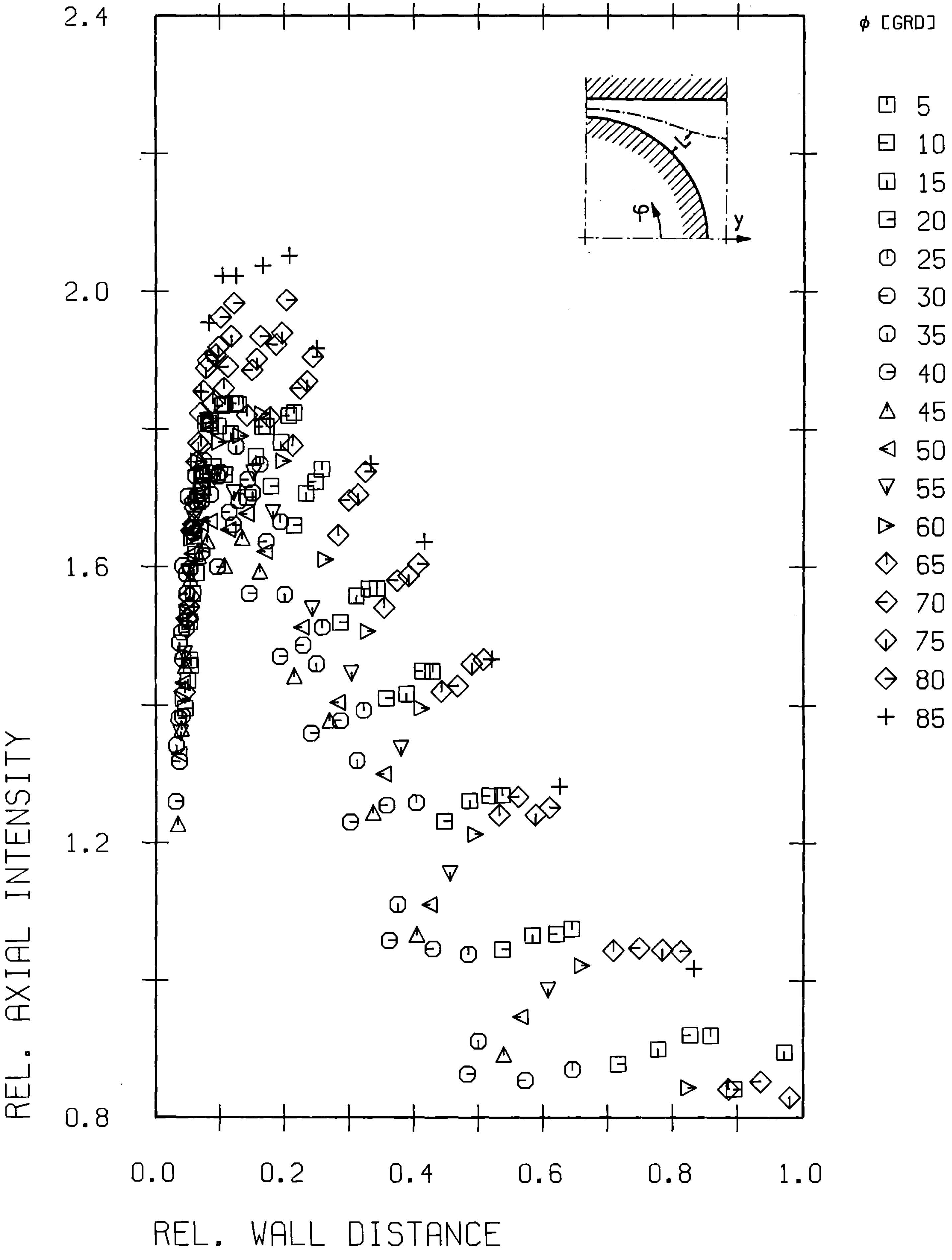


Fig.12: Axial turbulence intensity (r/ϕ)

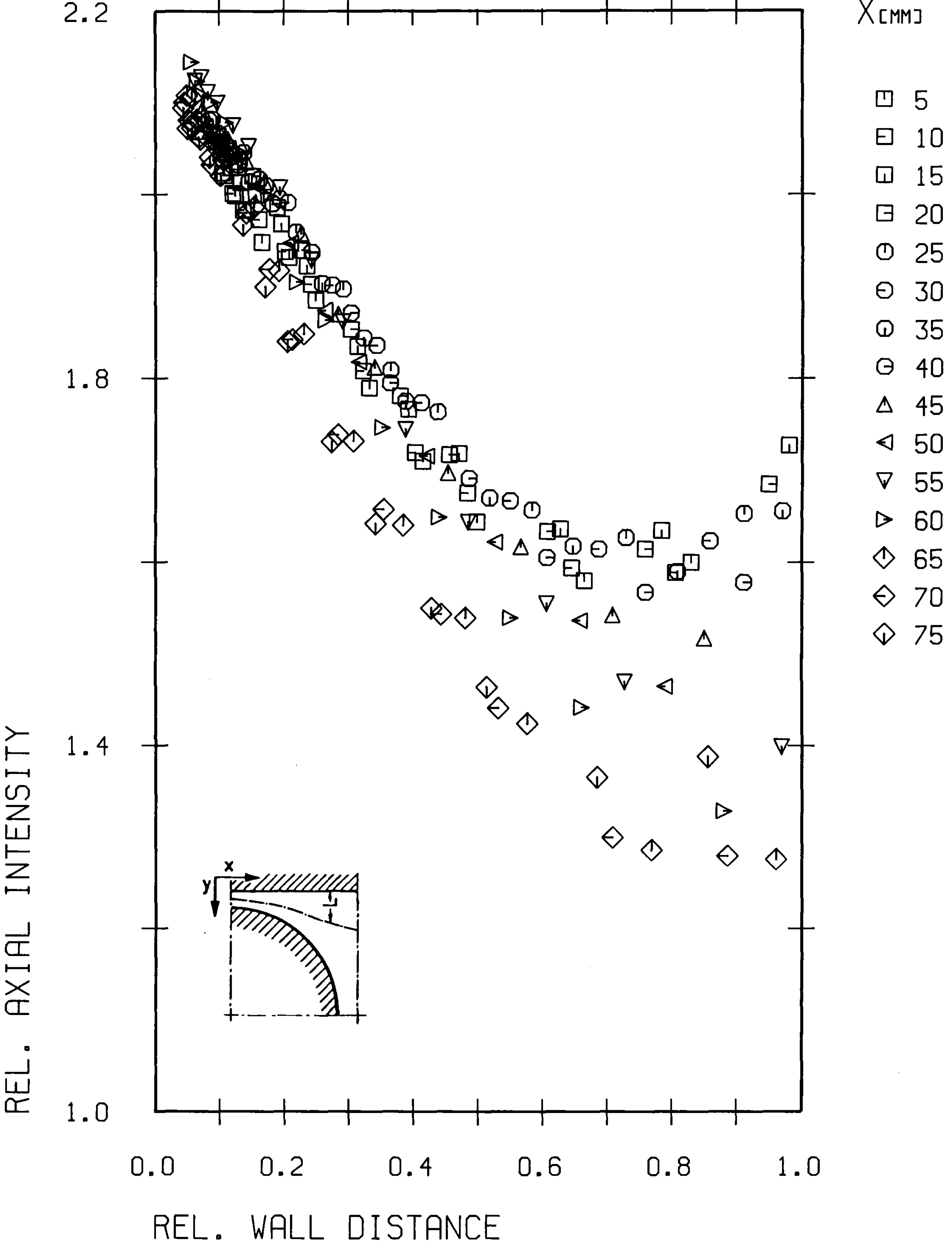


Fig.13: Axial turbulence intensity (x/y)

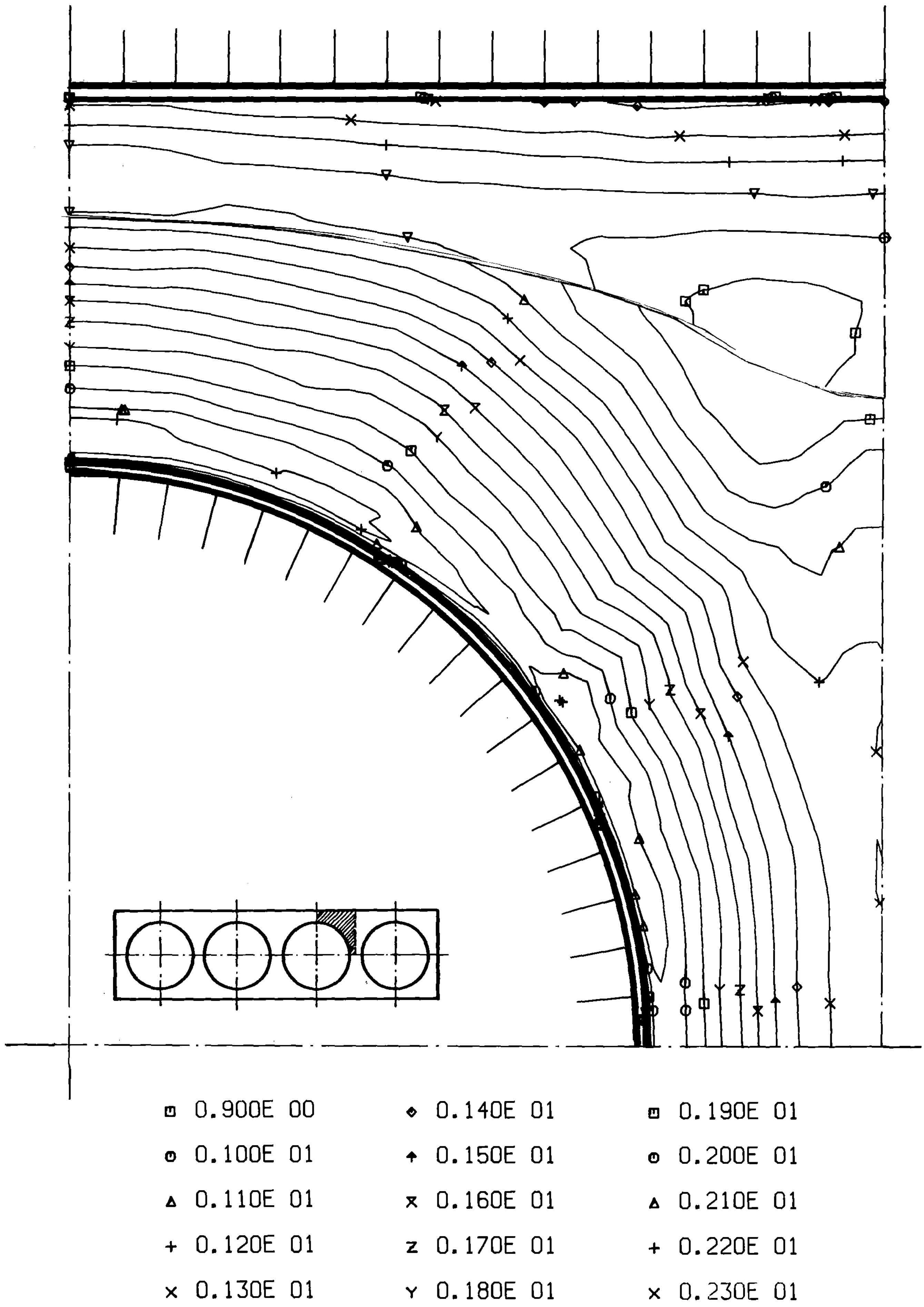


Fig.14: Axial turbulence intensity $\sqrt{\overline{u'^2}}/u^*_{REF}$

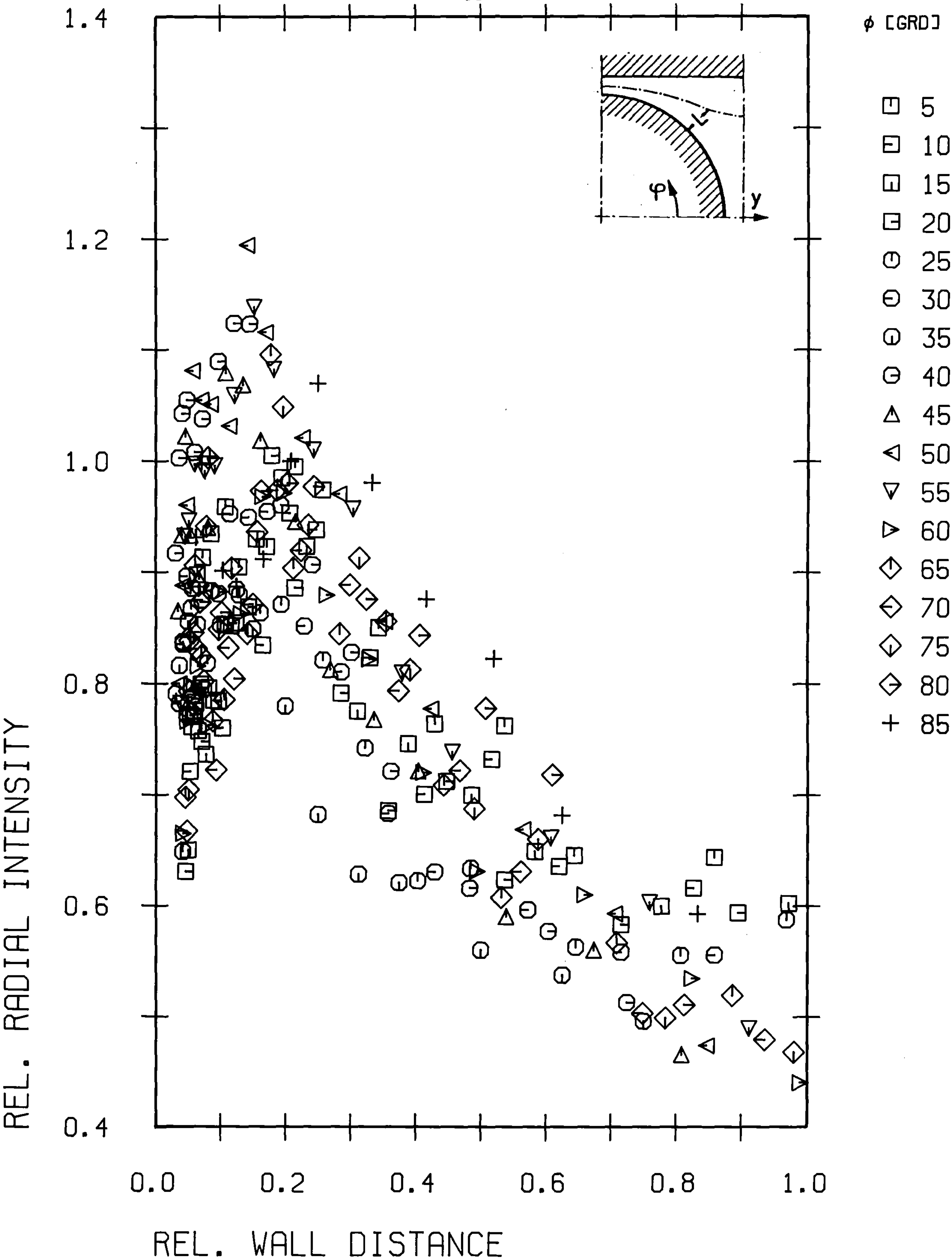


Fig.15: Radial turbulence intensity (r/ϕ)

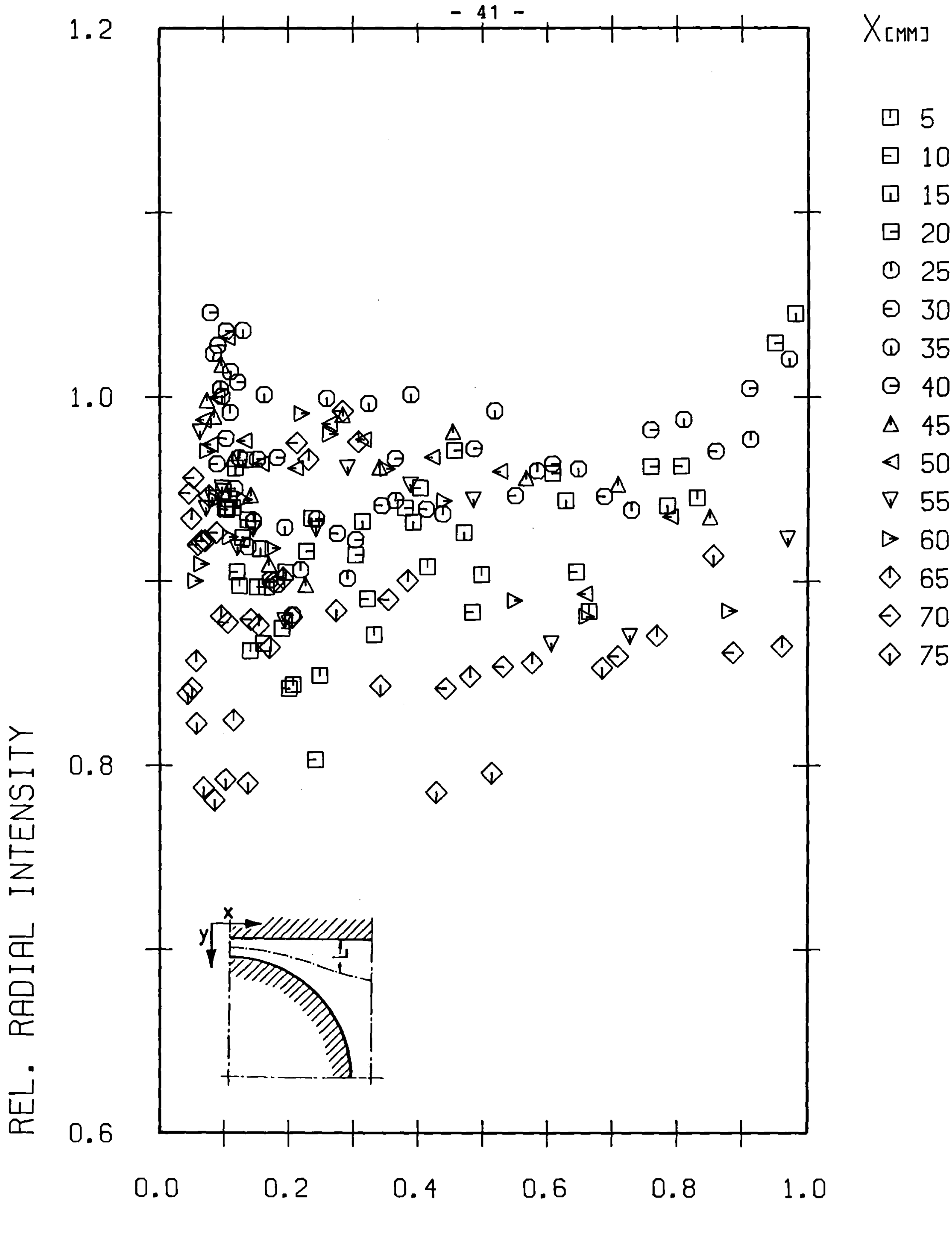
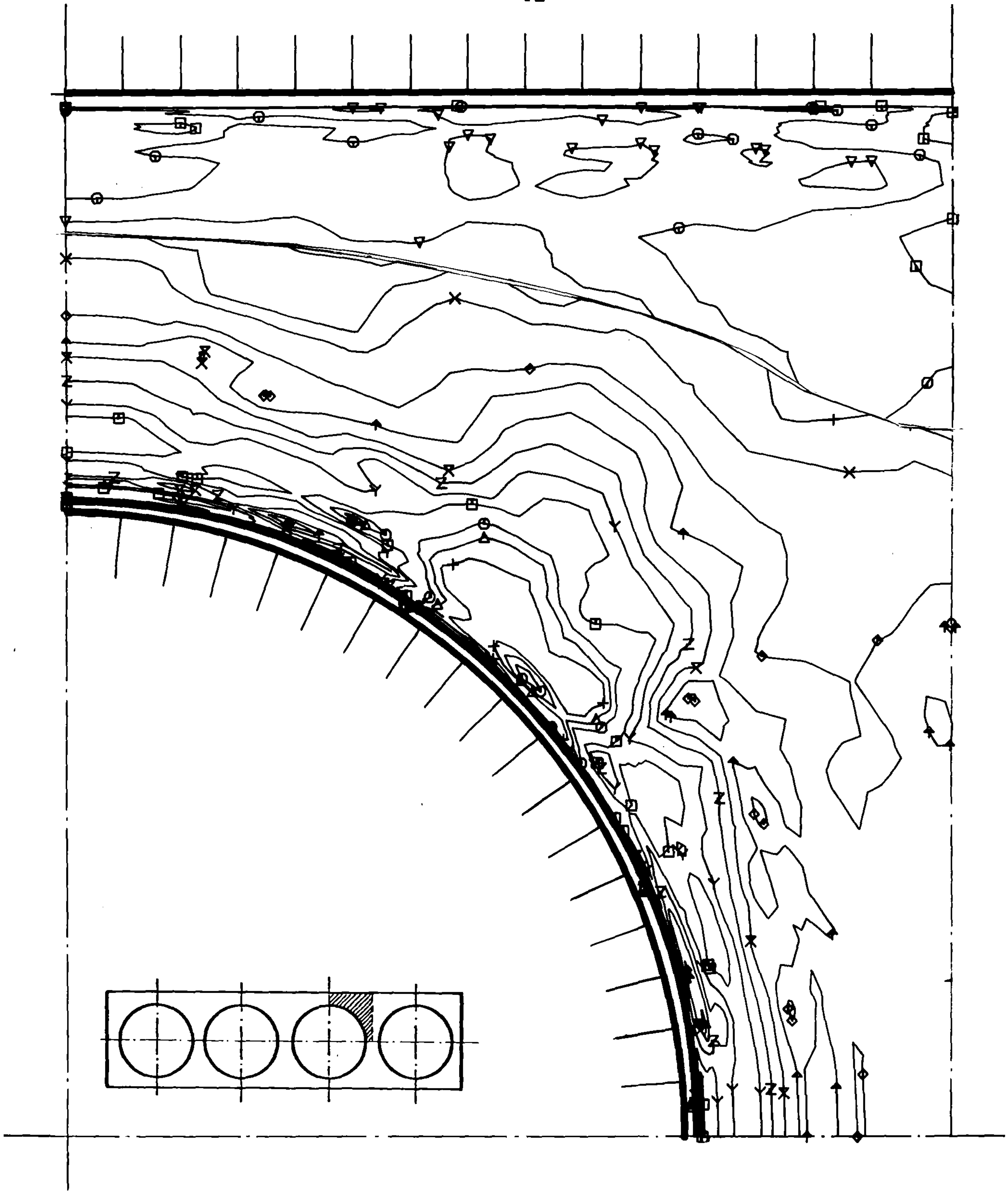


Fig.16: Radial turbulence intensity (x/y)



⊡ 0.550E 00	◇ 0.850E 00	⊡ 0.110E 01
⊙ 0.600E 00	↑ 0.900E 00	⊙ 0.120E 01
△ 0.650E 00	⨯ 0.950E 00	△ 0.125E 01
+ 0.700E 00	Z 0.100E 01	+ 0.130E 01
× 0.750E 00	Y 0.105E 01	

Fig.17: Radial turbulence intensity (contours)

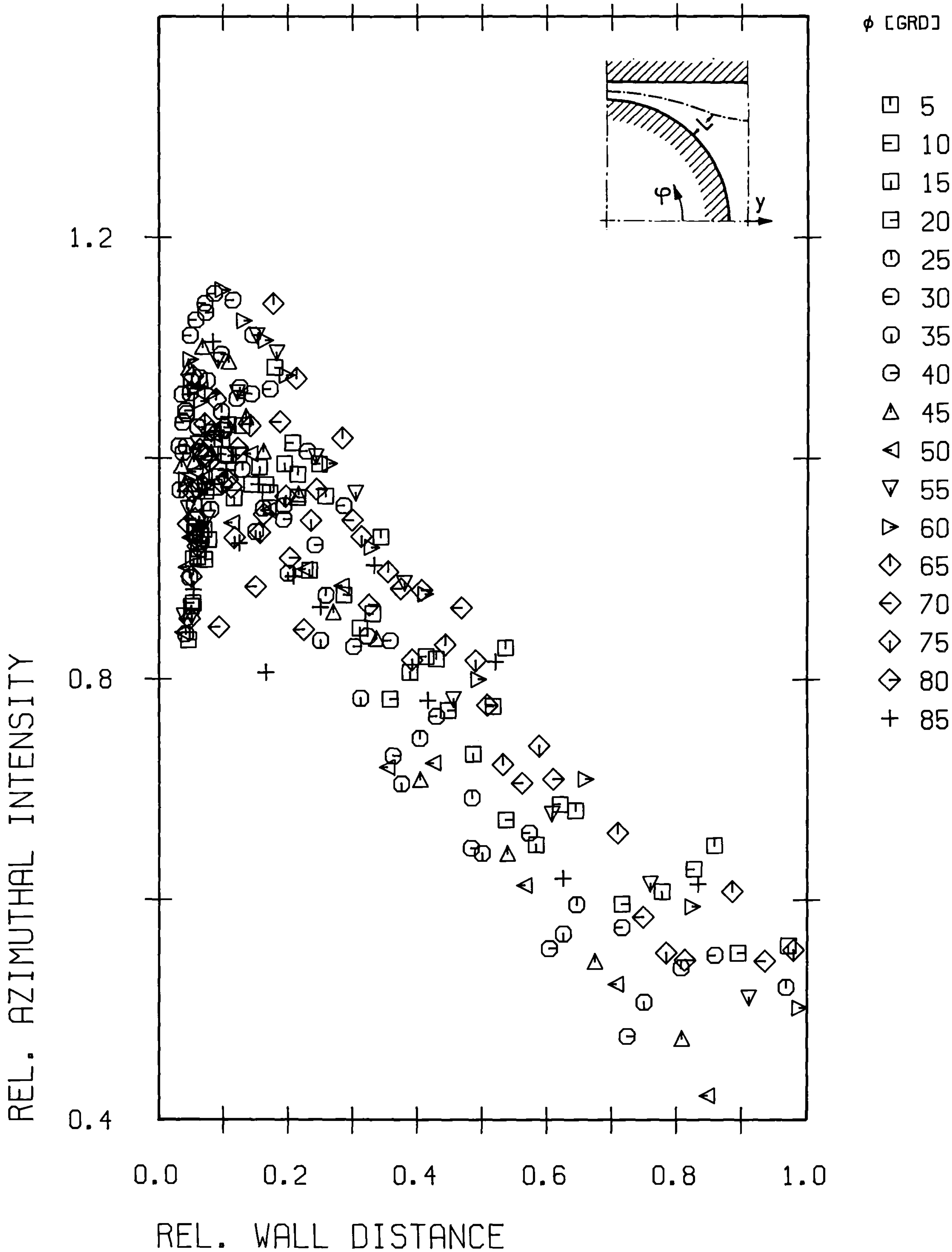


Fig.18: Azimuthal turbulence intensity (r/φ)

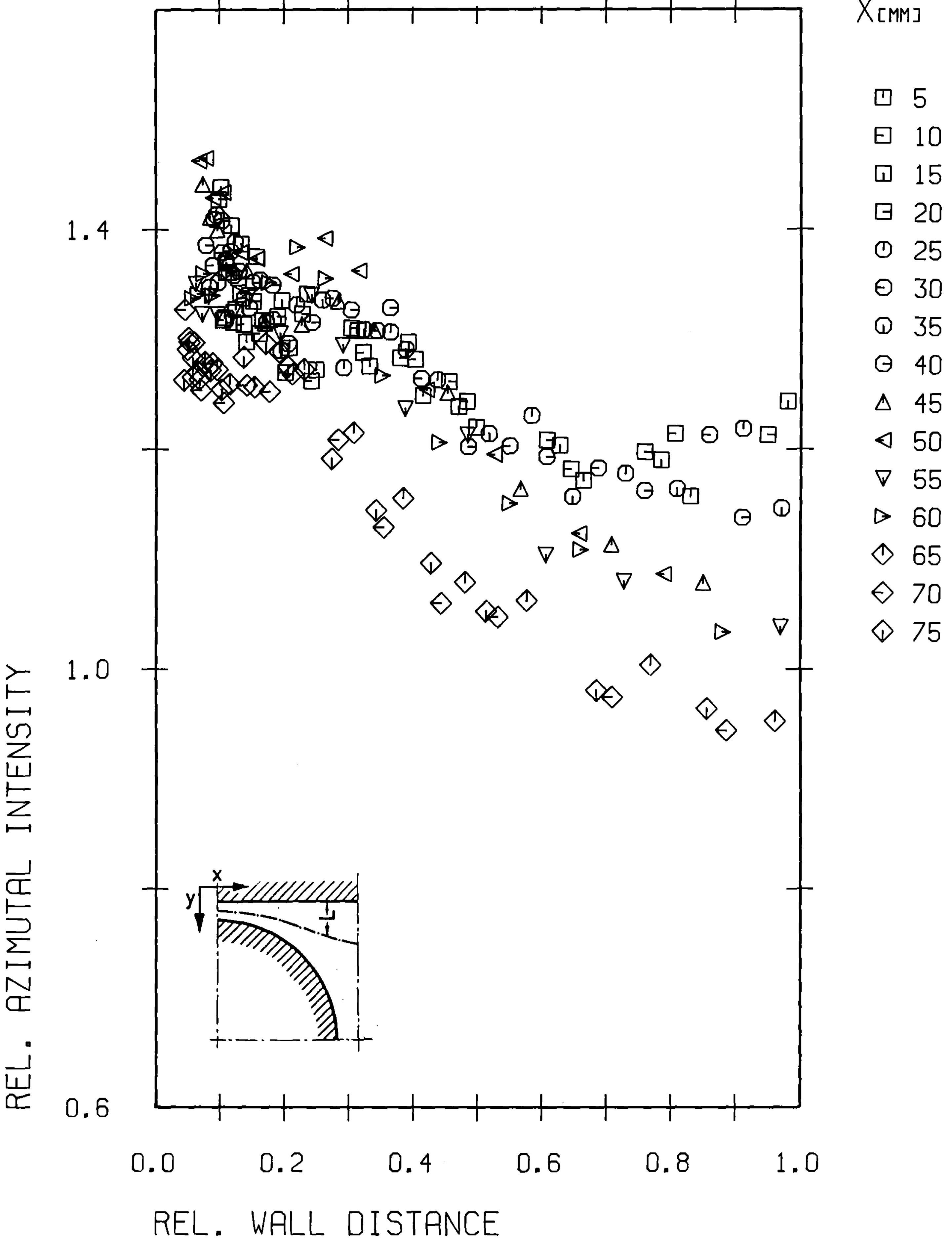


Fig.19: Azimuthal turbulence intensity (x/y)

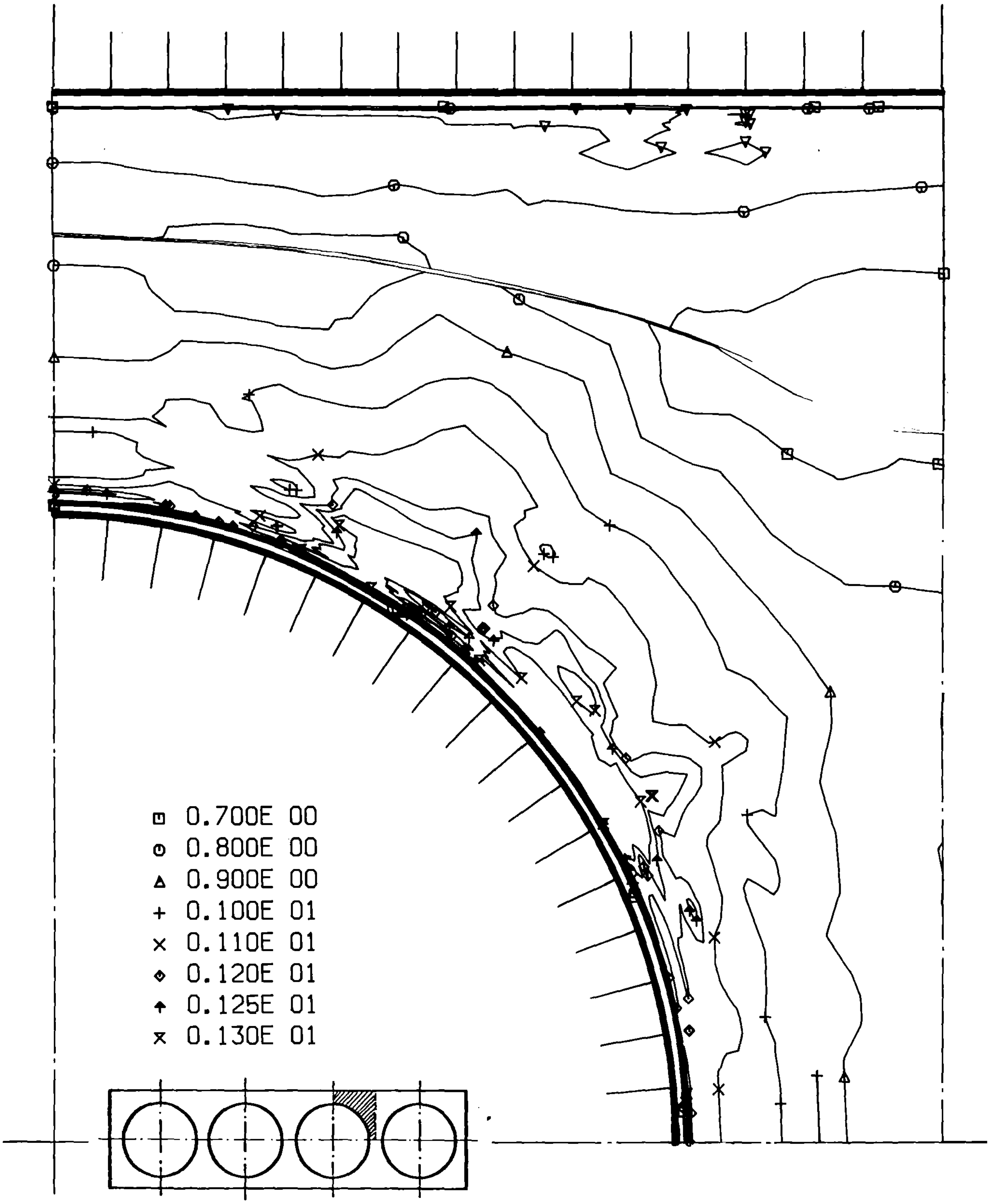


Fig.20: Azimuthal turbulence intensity (contours)

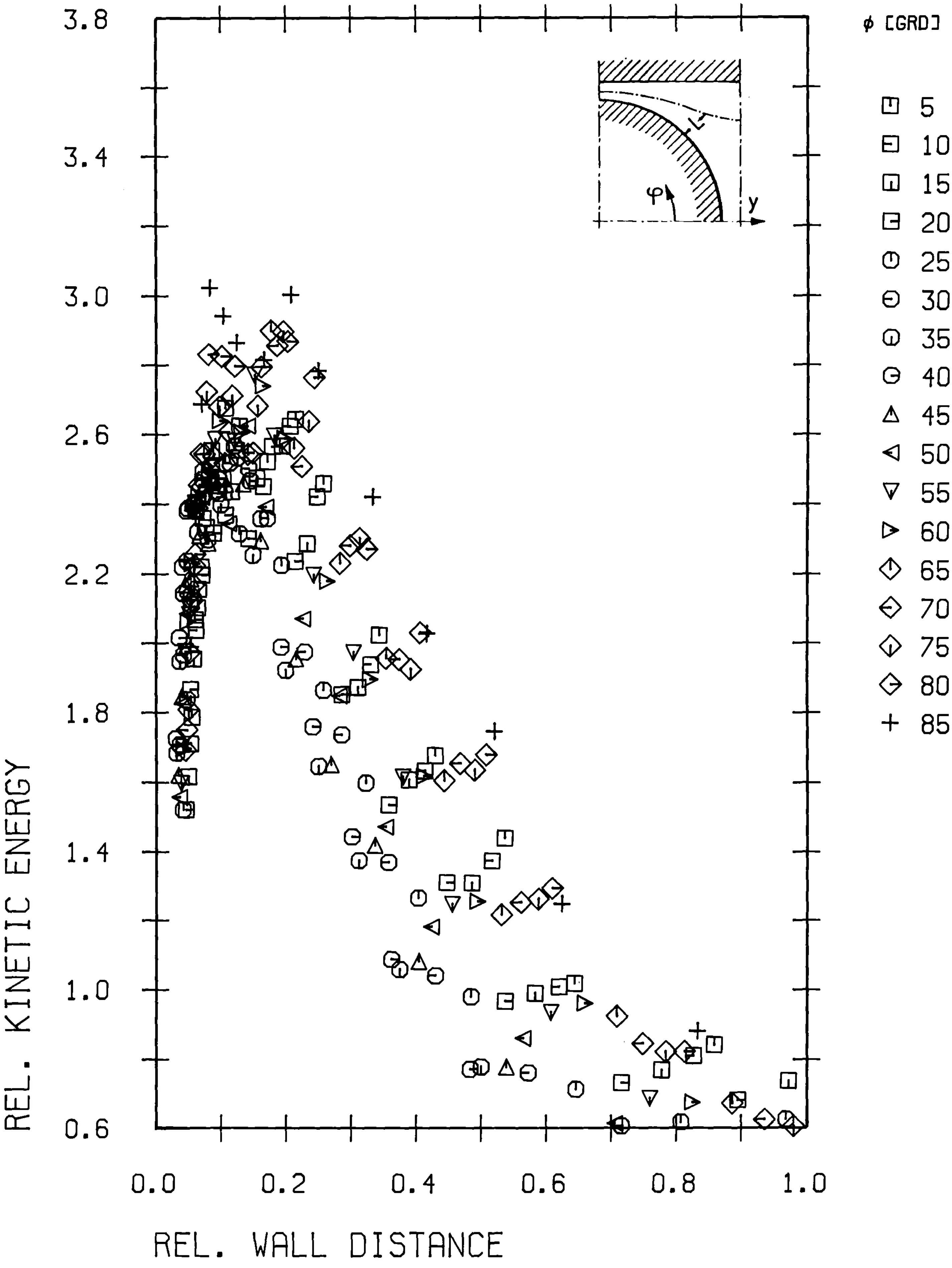


Fig.21: Kinetic energy of turbulence (r/φ)

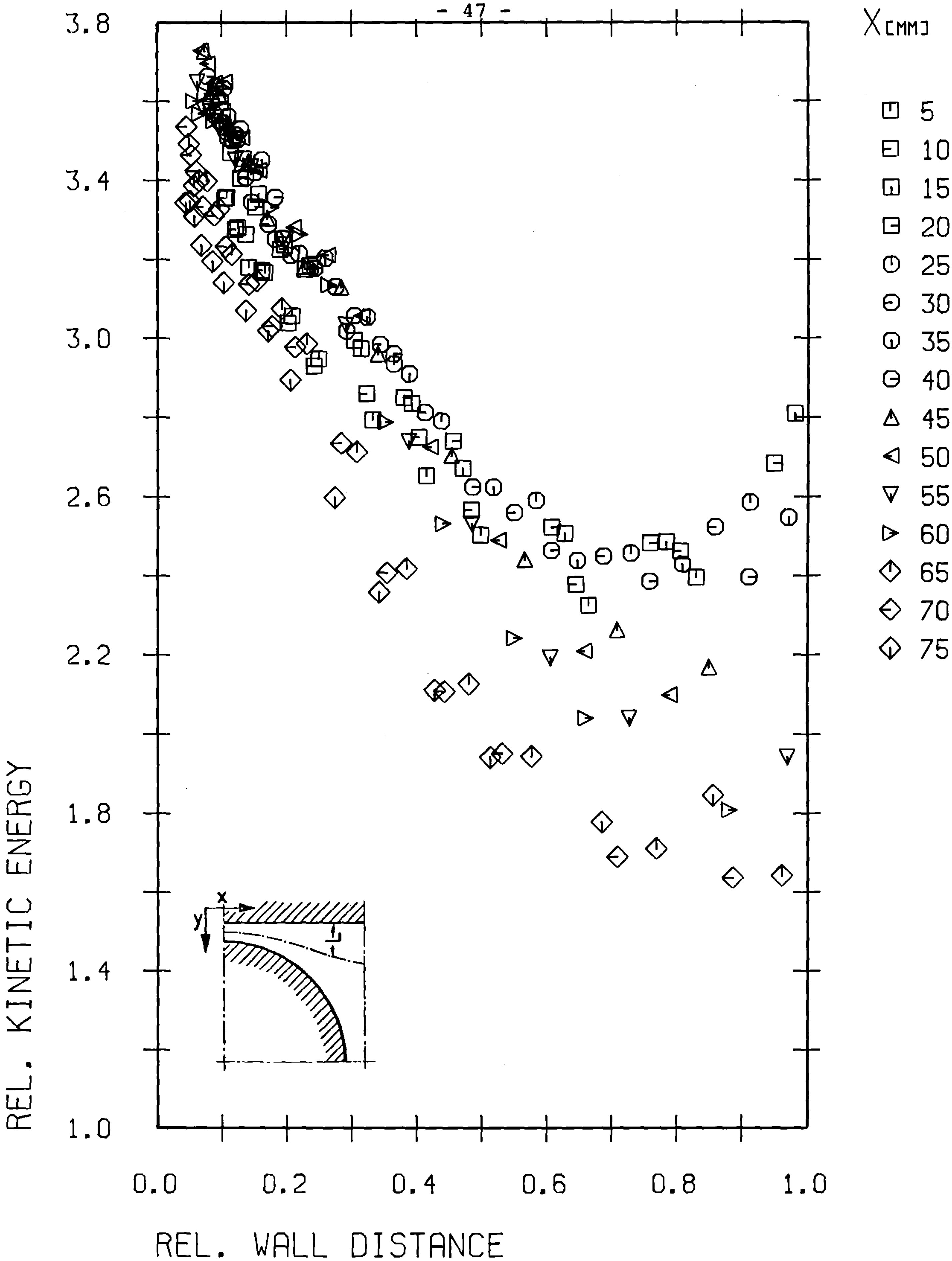


Fig.22: Kinetic energy of turbulence (x/y)

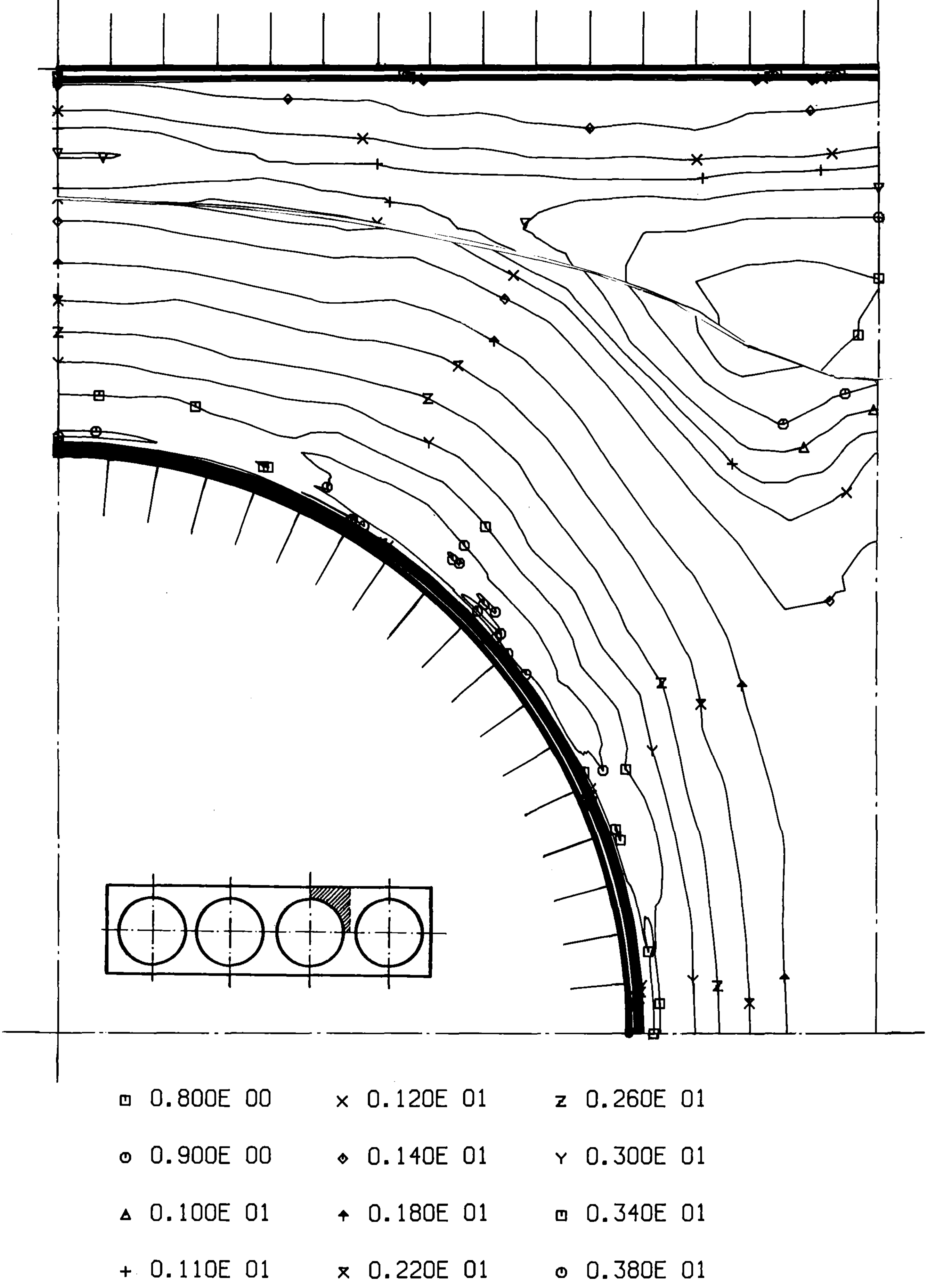


Fig.23: Kinetic energy of turbulence $\overline{k'}/u^{*2}_{REF}$

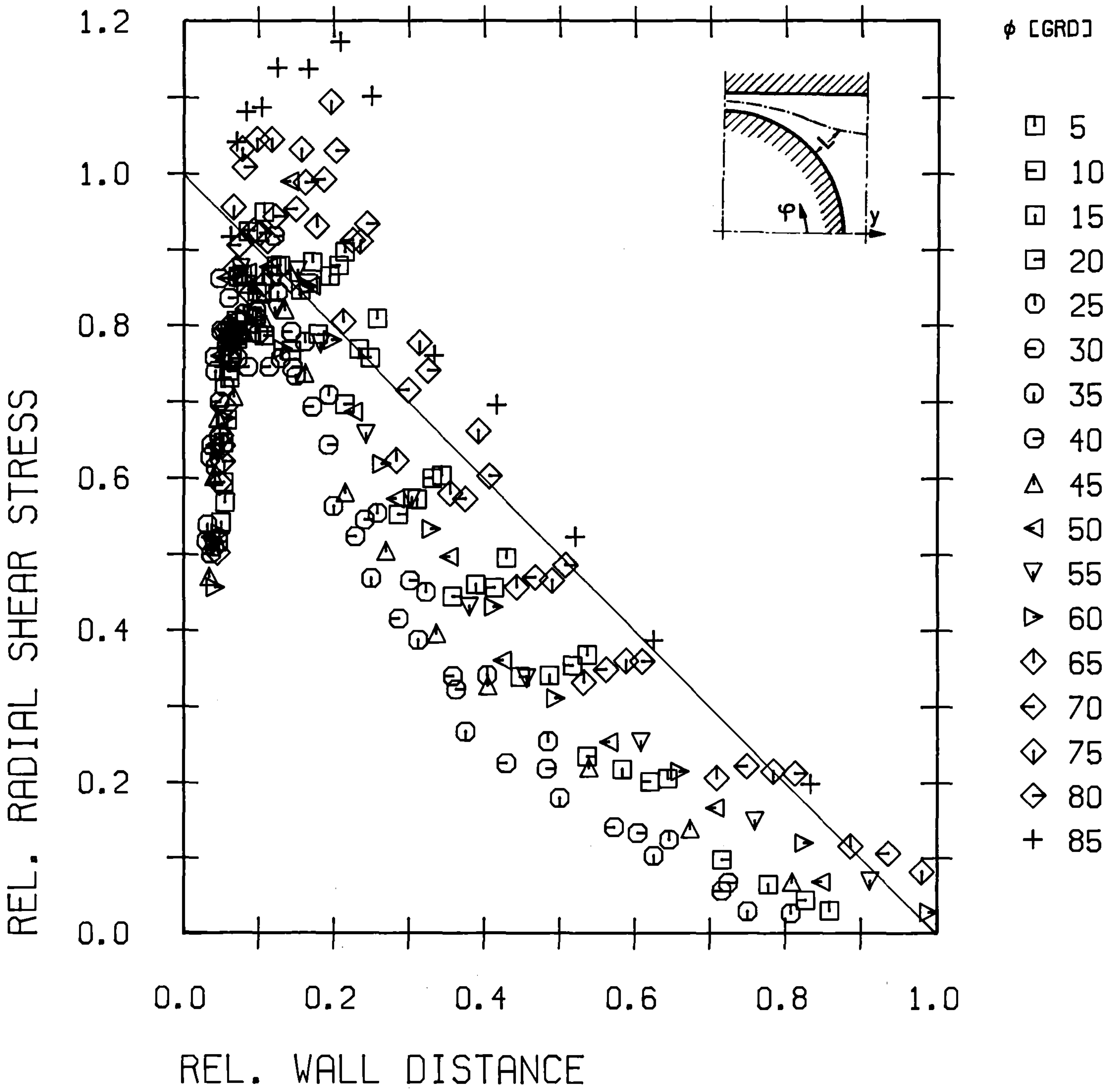


Fig.24: Shear stress normal to the wall (r/ϕ)

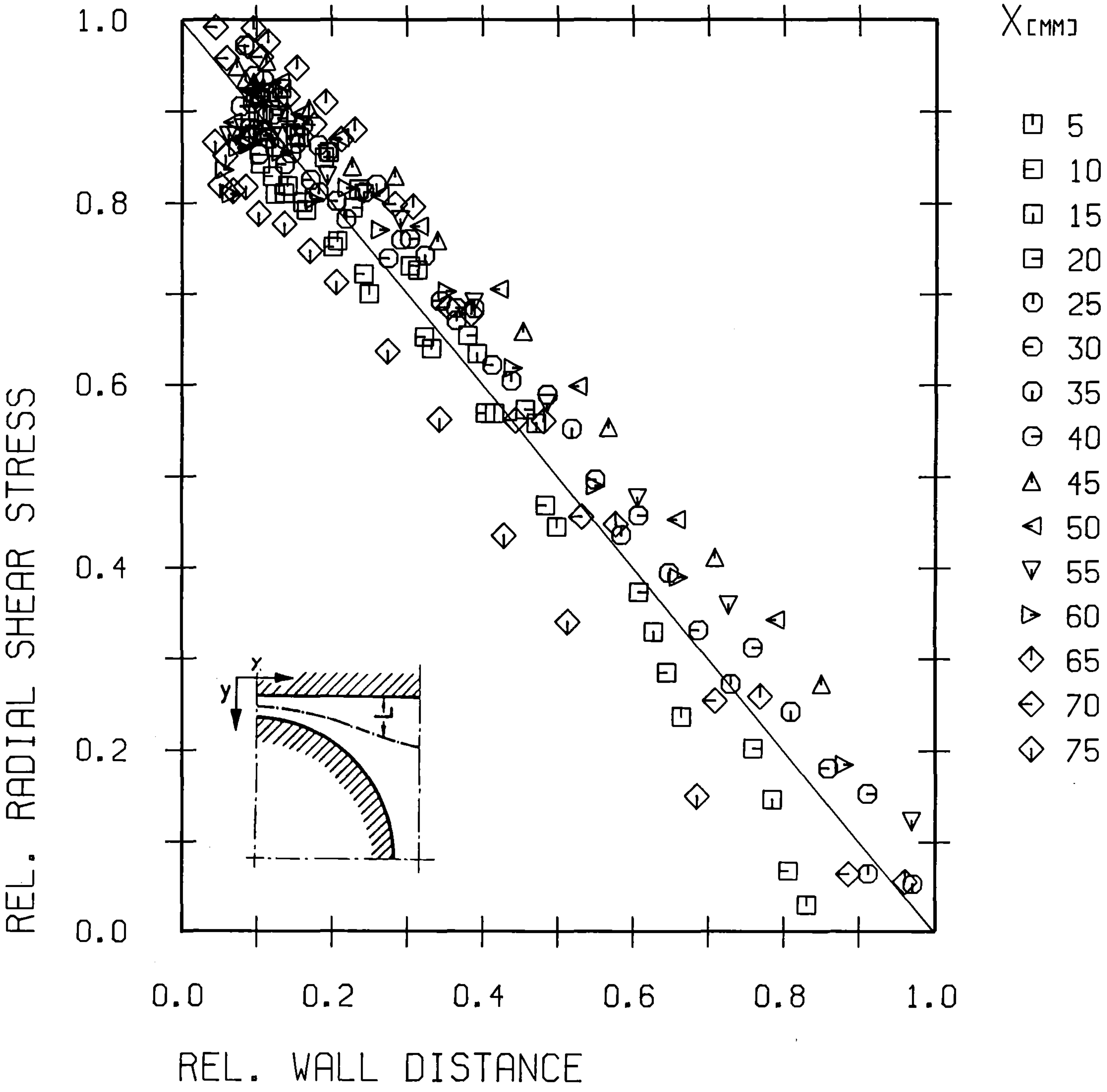


Fig.25: Shear stress normal to the wall (x/y)

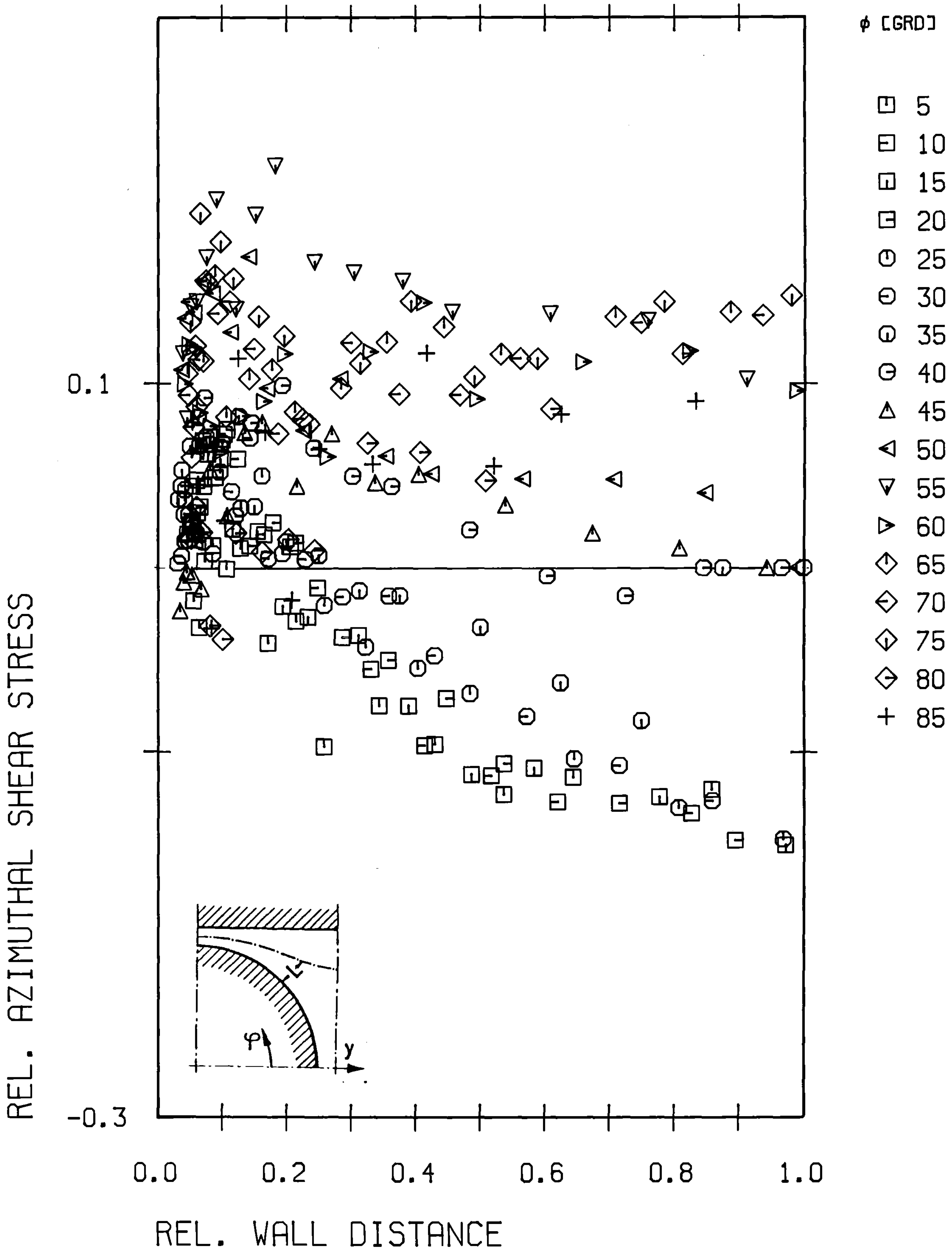


Fig.26: Shear stress parallel to the wall (r/φ)

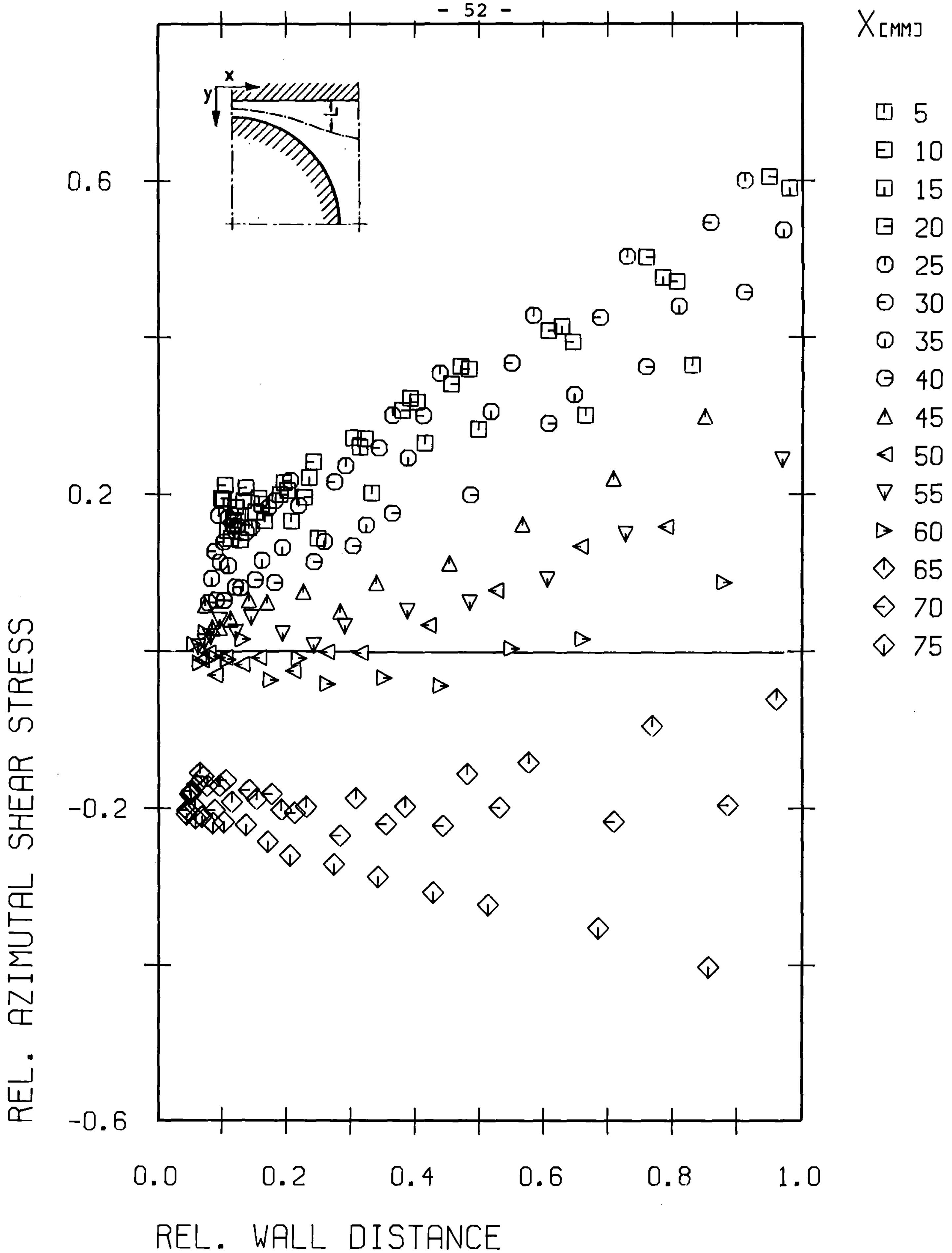


Fig.27: Shear stress parallel to the wall (x/y)

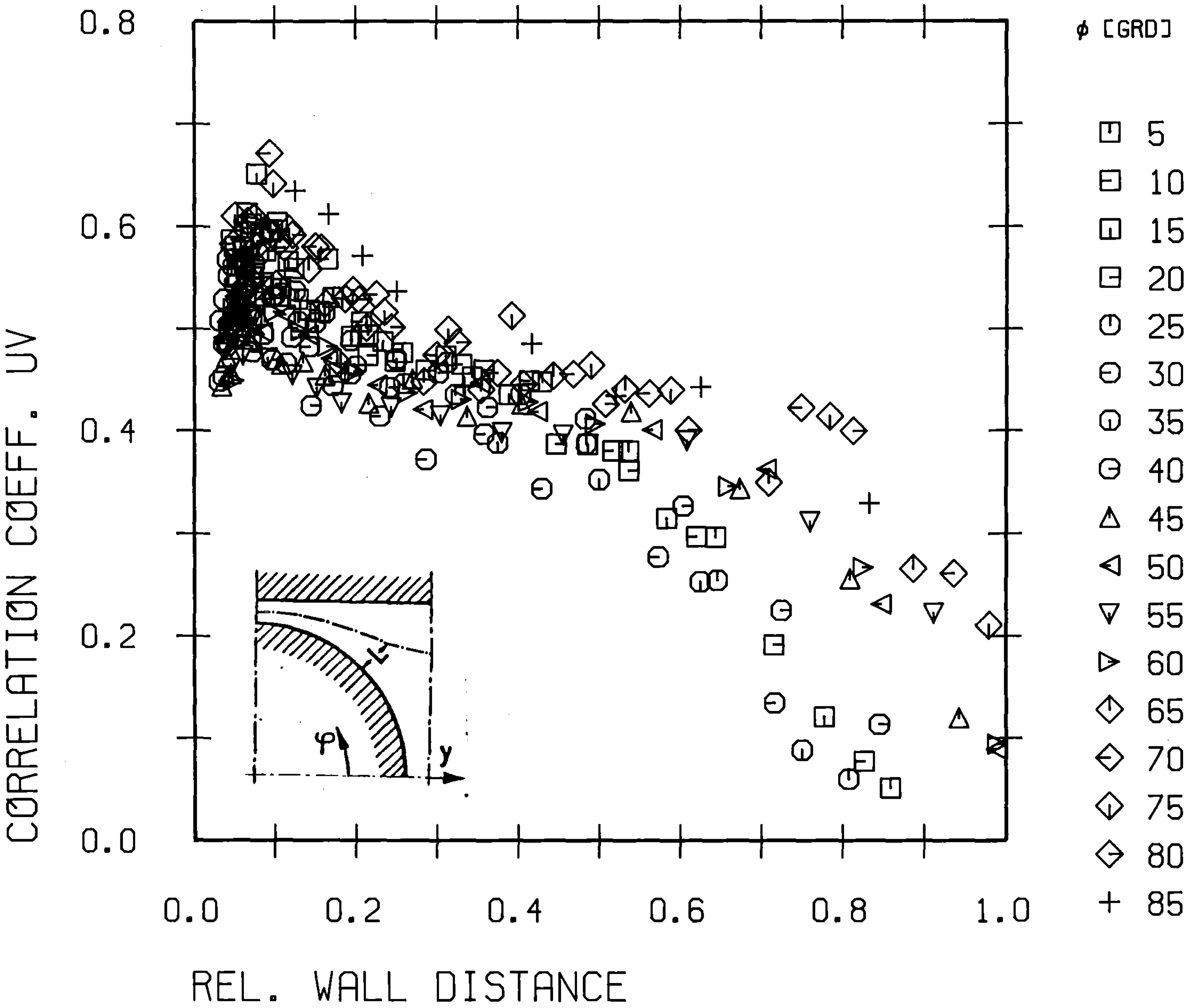


Fig.28: Correlation coefficient R_{uv} (r/ϕ)

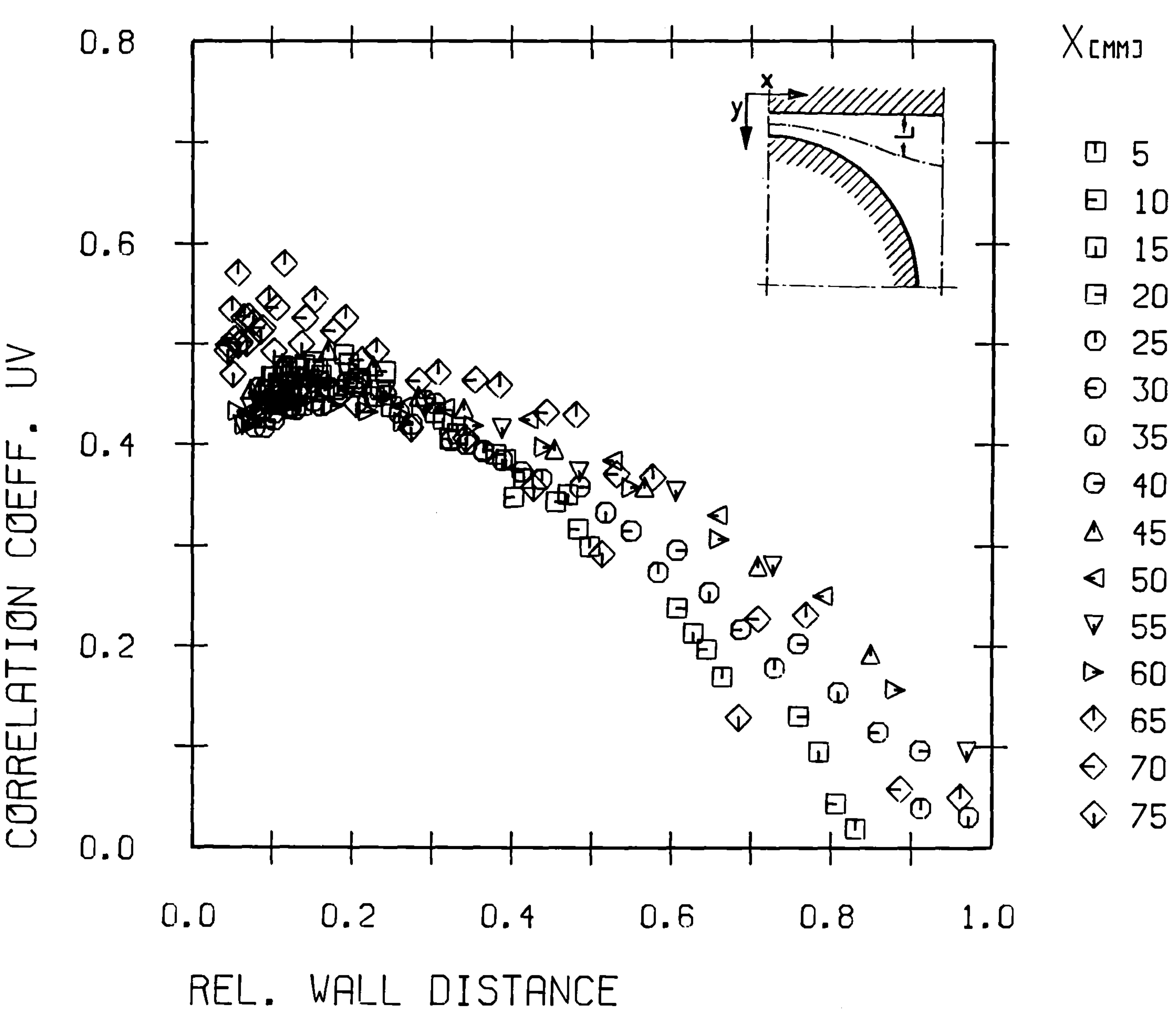


Fig.29: Correlation coefficient R_{uv} (x/y)

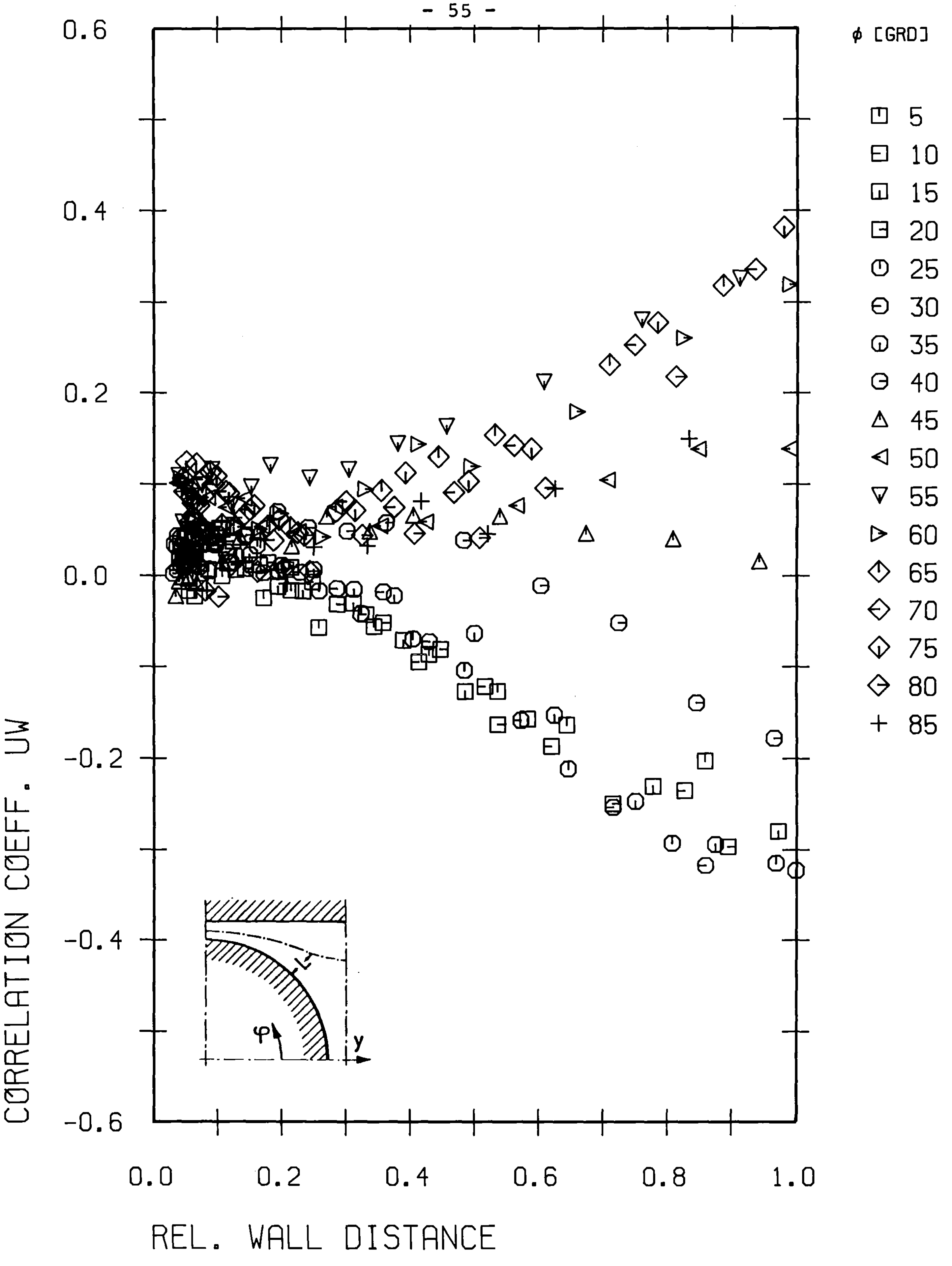


Fig.30: Correlation coefficient R_{uw} (r/ϕ)

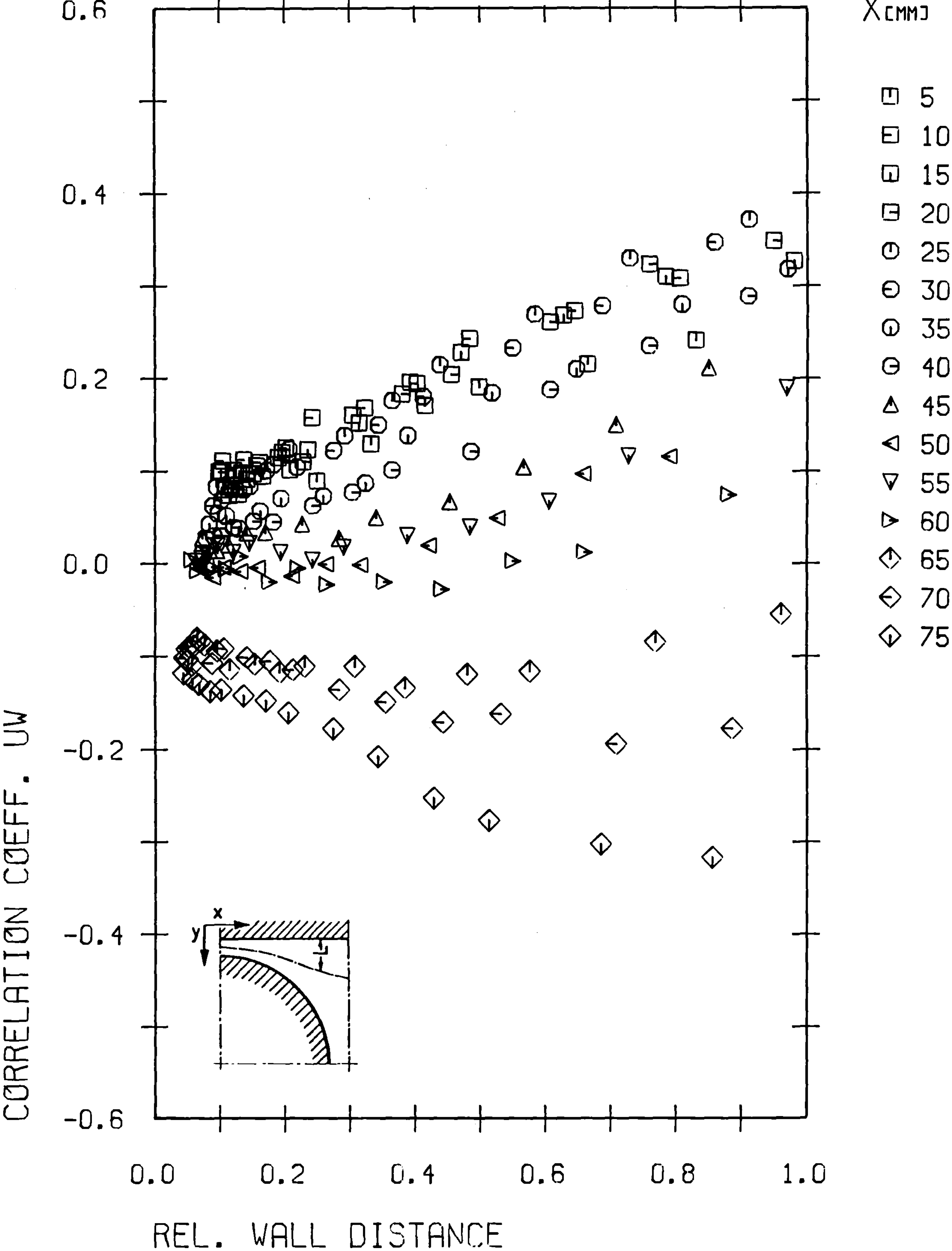


Fig.31: Correlation coefficient R_{uw} (x/y)

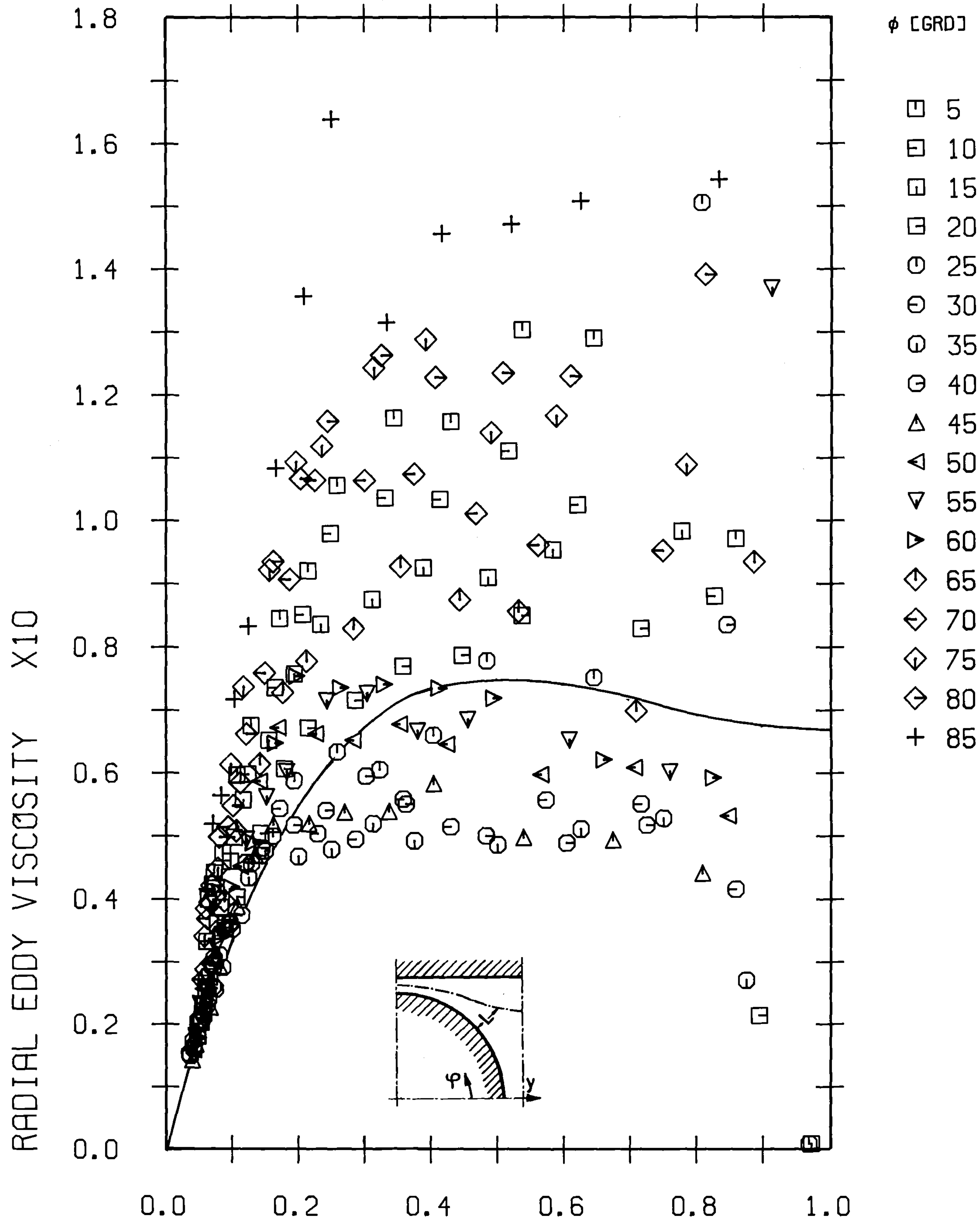


Fig.32: Non-dimensional eddy viscosity normal to the wall vs. non-dimensional distance from the wall (r/ϕ)

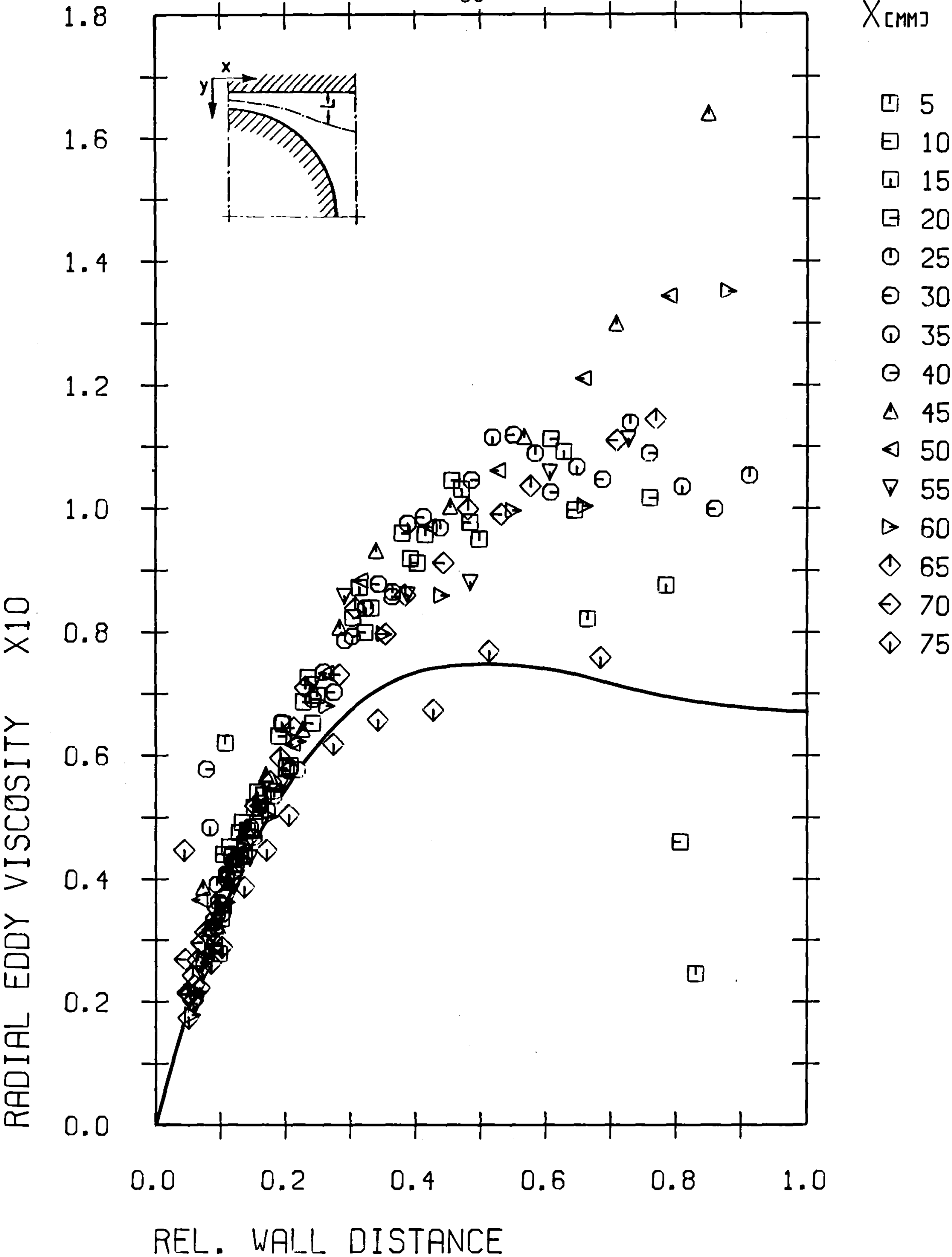


Fig.33: Non-dimensional eddy viscosity normal to the wall vs. non-dimensional distance from the wall (x/y)

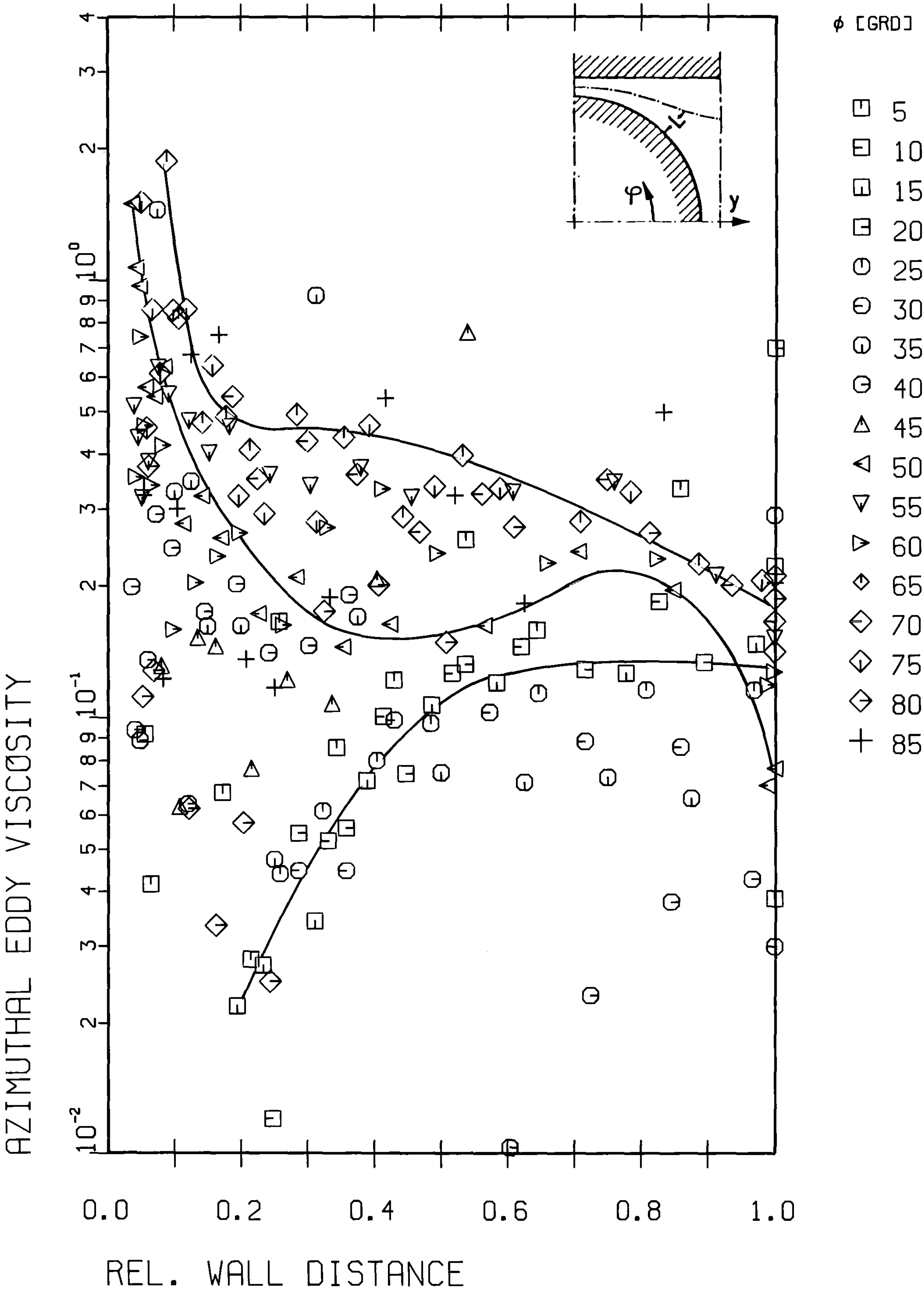


Fig.34: Non-dimensional eddy viscosity parallel to the wall vs. non-dimensional distance from the wall (r/ϕ)

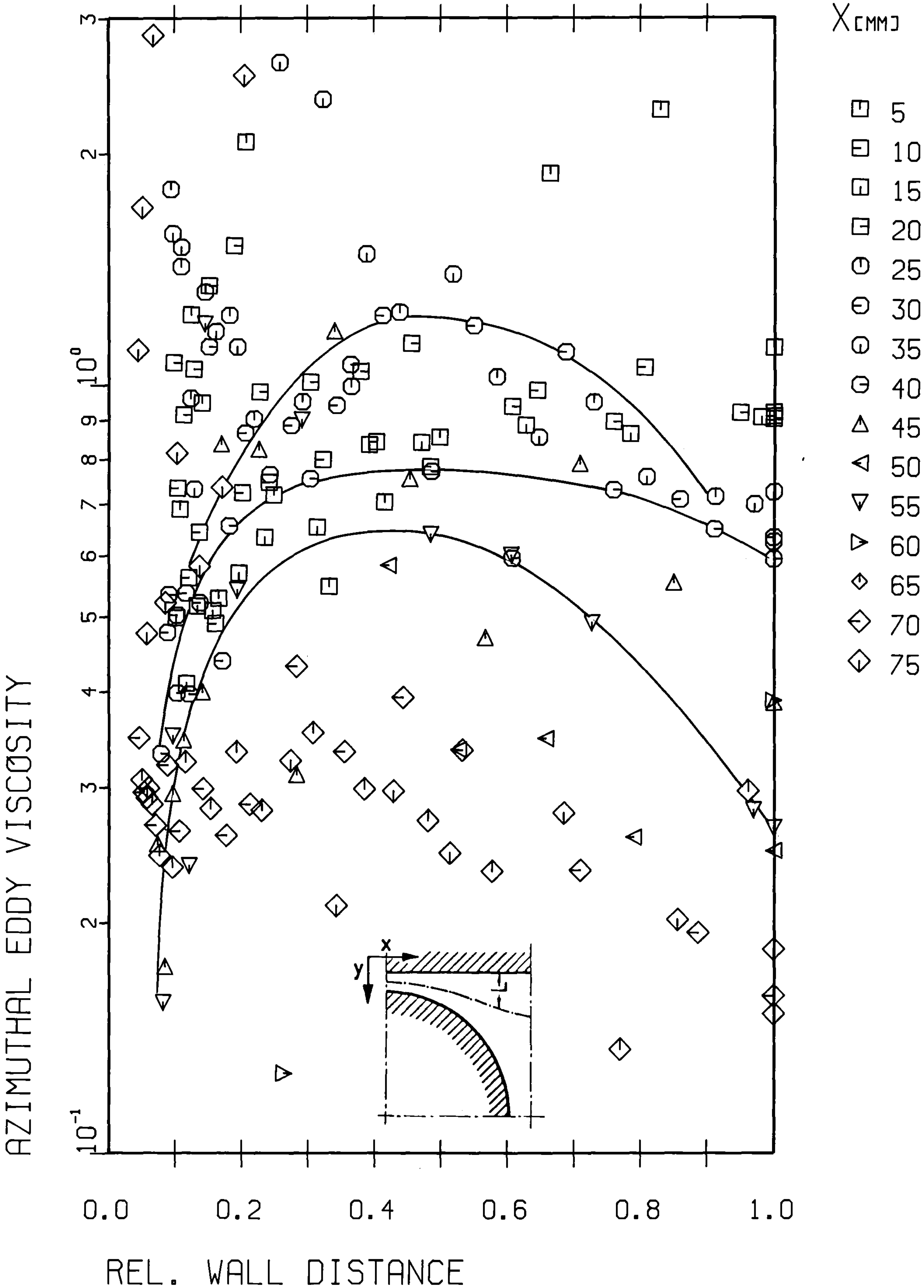


Fig.35: Non-dimensional eddy viscosity parallel to the wall vs. non-dimensional distance from the wall (x/y)

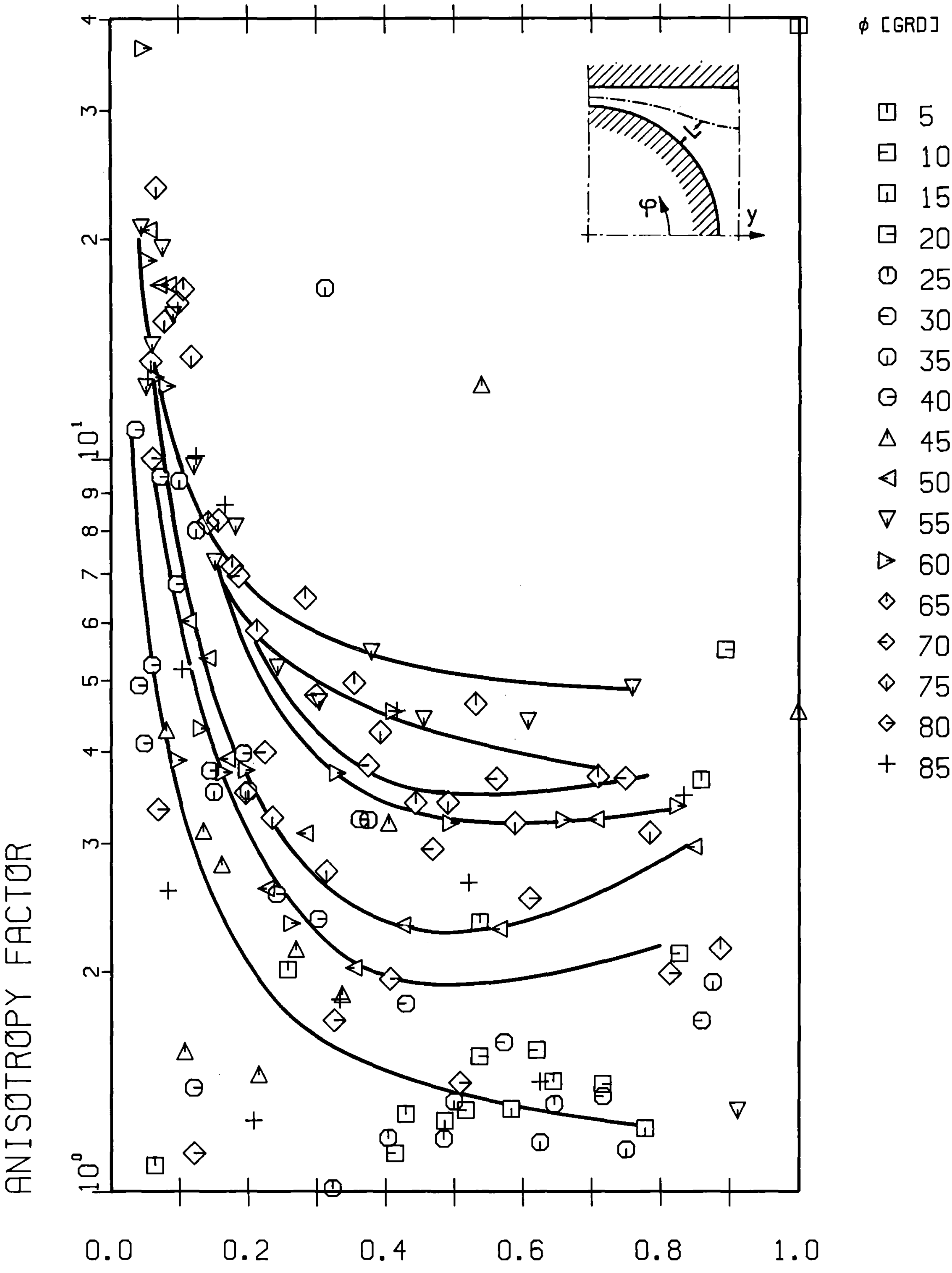


Fig.36: Anisotropy factor (rough)

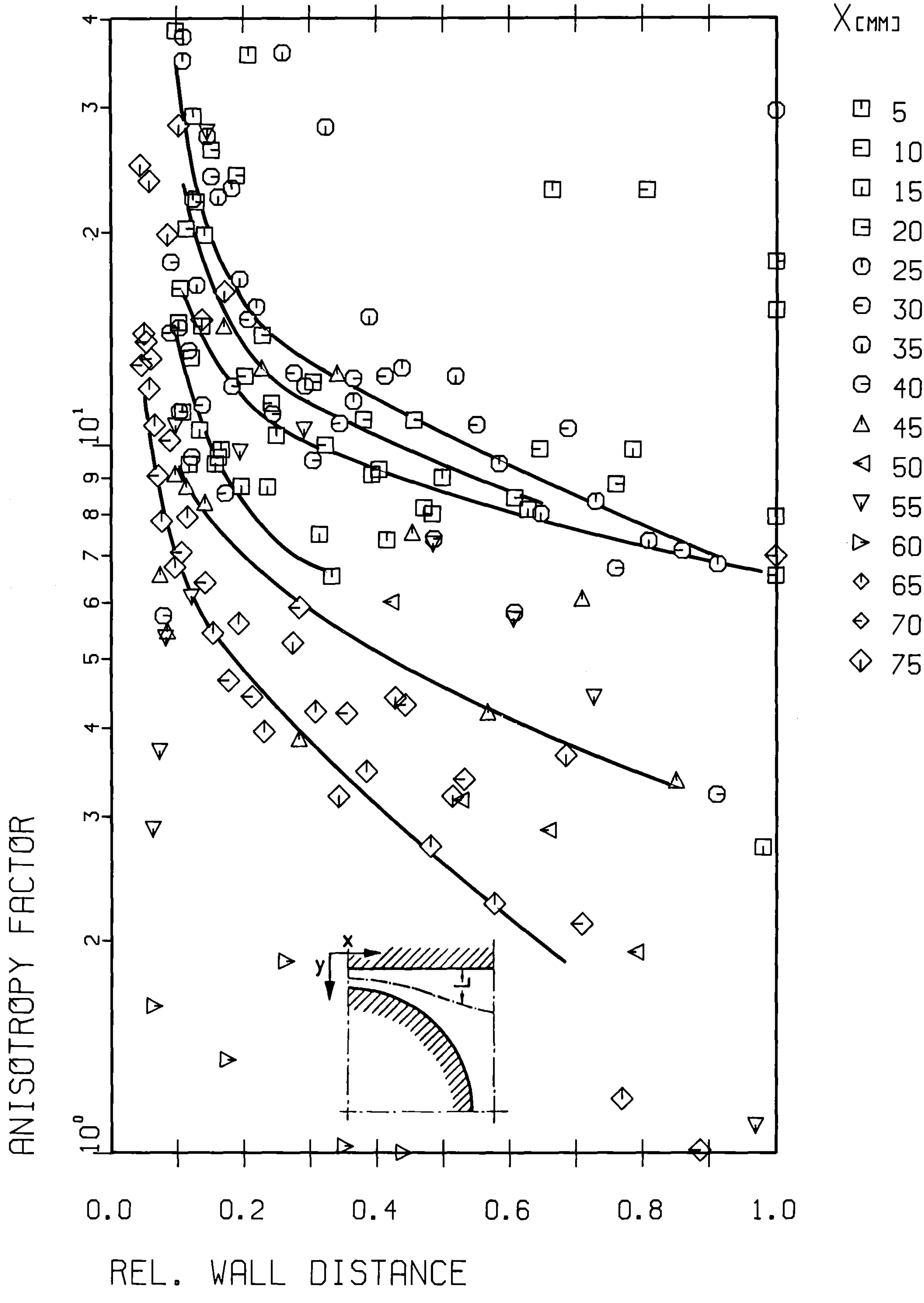


Fig.37: Anisotropy factor (smooth)

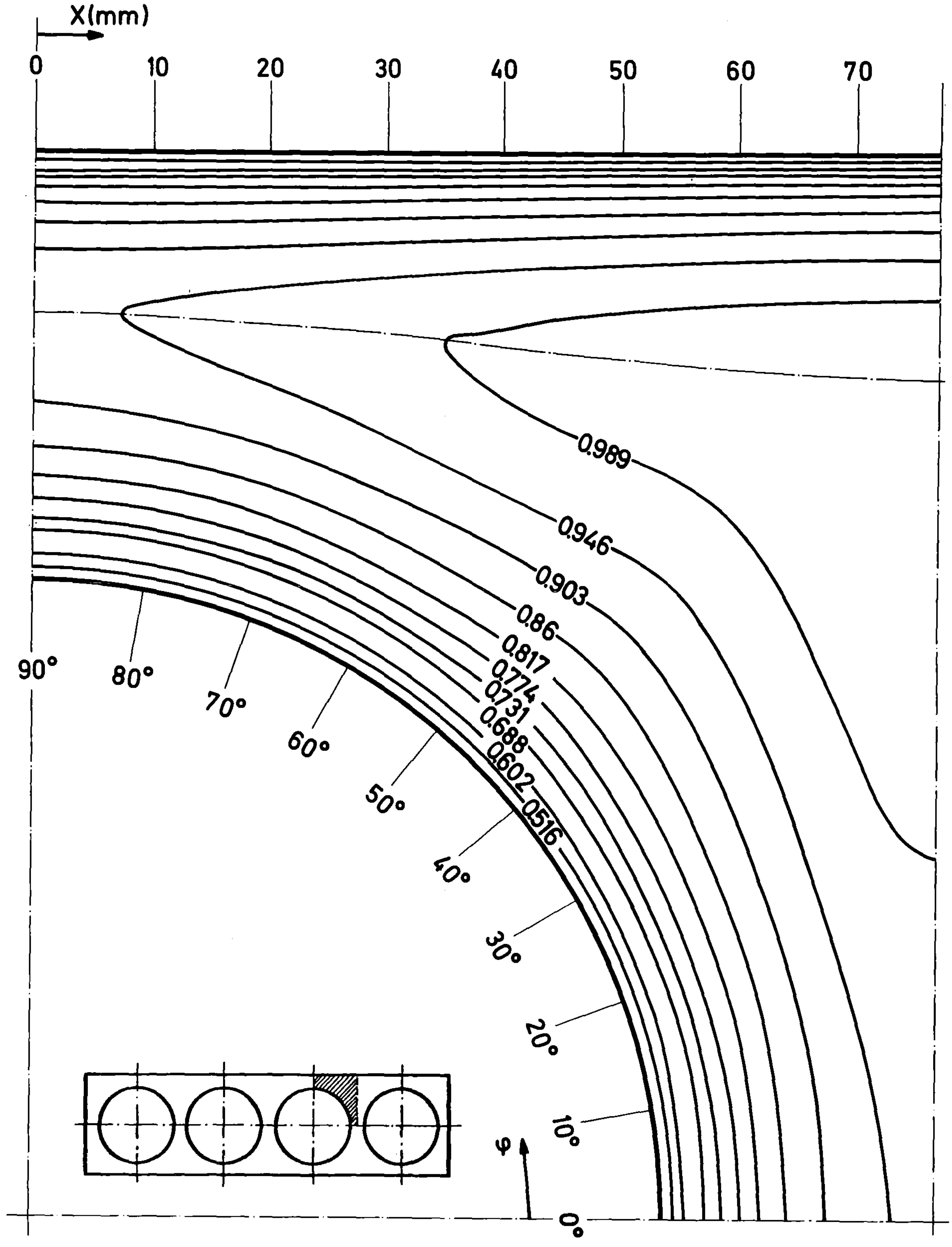


Fig.38: Velocity field $\bar{u}/\bar{u}_{REF}$ calculated by VELASCO

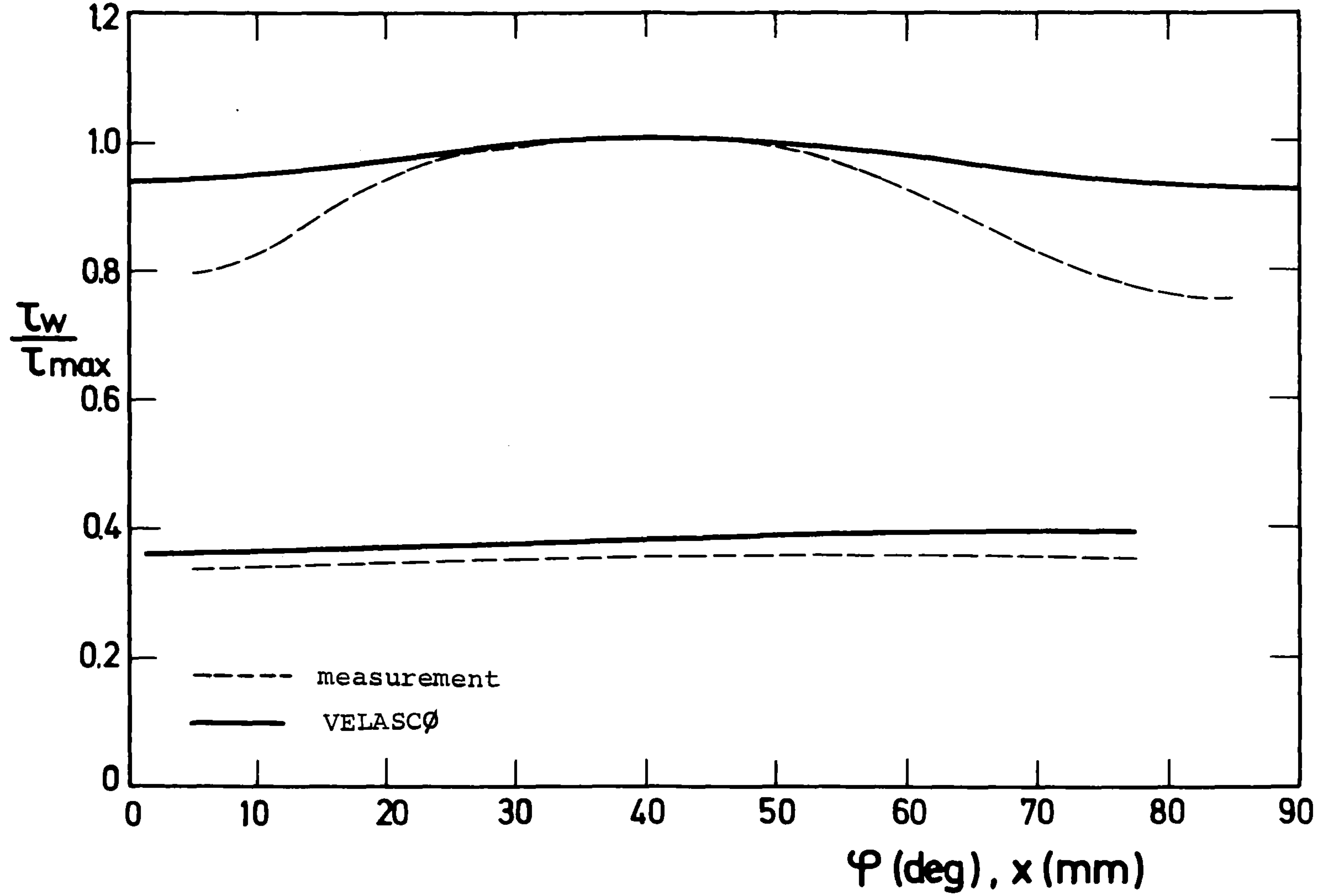


Fig.39: Comparison between experimental and computed distributions of wall shear stresses

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 5. GRAD

WANDSCHUBSPANNUNG TAUW = 3.749 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.767 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.794 (M/S)

PROFILLAENGE (UMAX) YMAX = 23.290 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5313	1.9356	1.0117	1.2398	3.1534	-1.0028	-0.0321	-0.5121	-0.0164	0.0558	158.63	8.109
1.5	0.5437	1.9779	1.1162	1.1582	3.2498	-1.1777	-0.0504	-0.5335	-0.0228	0.0644	181.38	8.307
1.7	0.5559	2.0342	1.0828	1.1501	3.3166	-1.2143	0.0052	-0.5513	0.0024	0.0730	204.13	8.500
2.0	0.5744	2.0728	1.0687	1.1133	3.3389	-1.2079	0.0159	-0.5453	0.0072	0.0859	238.26	8.791
2.5	0.6026	2.0838	1.0882	1.1691	3.4466	-1.2232	-0.0009	-0.5394	-0.0004	0.1073	295.13	9.231
3.0	0.6241	2.0692	1.0201	1.1603	3.3343	-1.1172	0.0136	-0.5293	0.0064	0.1288	352.01	9.566
4.0	0.6593	2.0308	1.0394	1.0908	3.1972	-1.1204	-0.0521	-0.5308	-0.0247	0.1717	465.77	10.110
5.0	0.6893	1.9771	1.0792	1.0685	3.1077	-1.0547	-0.0344	-0.4943	-0.0161	0.2147	579.52	10.574
6.0	0.7158	1.9239	1.0762	1.0669	2.9988	-0.9866	-0.1185	-0.4765	-0.0572	0.2576	693.27	10.981
8.0	0.7531	1.7952	0.9727	1.0628	2.6493	-0.7912	-0.0980	-0.4530	-0.0561	0.3435	920.78	11.555
10.0	0.7841	1.6913	0.8919	0.9550	2.2840	-0.6756	-0.1305	-0.4479	-0.0865	0.4294	1148.29	12.031
12.5	0.8152	1.5299	0.9186	0.9978	2.0900	-0.5344	-0.1784	-0.3802	-0.1269	0.5367	1432.67	12.511
15.0	0.8328	1.4068	0.8453	0.8918	1.7445	-0.3530	-0.1944	-0.2968	-0.1635	0.6441	1717.06	12.783
20.0	0.8569	1.2382	0.8669	0.8745	1.5247	-0.0557	-0.2176	-0.0518	-0.2027	0.8587	2285.83	13.159
25.0	0.8511	1.2892	0.8600	0.8866	1.5939	0.1879	-0.2053	0.1694	-0.1852	1.0734	2854.60	13.076

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 10. GRAD

WANDSCHUBSPANNUNG TAUW = 3.929 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.742 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.790 (M/S)

PROFILLAENGE (UMAX) YMAX = 24.180 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.5356	1.9918	0.9809	1.1813	3.1625	-1.0992	0.0819	-0.5626	0.0419	0.0538	163.94	7.993
1.5	0.5530	2.0596	0.9972	1.1678	3.3001	-1.1838	0.0486	-0.5764	0.0237	0.0620	187.46	8.262
1.7	0.5624	2.0766	0.9703	1.1356	3.2717	-1.1869	0.1016	-0.5890	0.0504	0.0703	210.97	8.409
2.0	0.5834	2.1172	0.9325	1.1981	3.3938	-1.1702	0.0970	-0.5927	0.0491	0.0827	246.24	8.730
2.5	0.6099	2.1304	0.8836	1.1661	3.3396	-1.1366	0.0979	-0.6038	0.0520	0.1034	305.02	9.135
3.0	0.6332	2.1199	0.9862	1.1574	3.4032	-1.1696	0.0788	-0.5594	0.0377	0.1241	363.80	9.490
4.0	0.6689	2.0786	0.9621	1.1250	3.2561	-1.1366	0.0240	-0.5683	0.0120	0.1654	481.37	10.031
5.0	0.7015	2.0195	1.0583	1.1254	3.2324	-1.0834	0.0141	-0.5069	0.0066	0.2068	598.93	10.522
6.0	0.7253	1.9493	1.0609	1.1248	3.0952	-0.9684	-0.0141	-0.4683	-0.0068	0.2481	716.50	10.880
8.0	0.7666	1.8372	0.9645	1.0063	2.6592	-0.8243	-0.0758	-0.4652	-0.0428	0.3309	951.62	11.501
10.0	0.7972	1.7326	0.8371	0.9803	2.3318	-0.6511	-0.1376	-0.4489	-0.0948	0.4136	1186.75	11.962
12.5	0.8266	1.5651	0.9034	0.9568	2.0905	-0.5387	-0.1713	-0.3810	-0.1211	0.5170	1480.66	12.404
15.0	0.8490	1.4308	0.8522	0.9208	1.8107	-0.3629	-0.2278	-0.2977	-0.1868	0.6203	1774.57	12.742
20.0	0.8694	1.2687	0.8490	0.3651	1.5394	-0.0839	-0.2528	-0.0779	-0.2347	0.8271	2362.40	13.055
25.0	0.8690	1.3038	0.8472	0.8485	1.5688	0.1537	-0.2966	0.1391	-0.2685	1.0339	2950.22	13.056

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 15. GRAD

WANDSCHUBSPANNUNG TAUW = 4.198 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.747 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.791 (M/S)

PROFILLAENGE (UMAX) YMAX = 25.710 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5418	2.0179	0.9141	1.2168	3.1941	-1.0709	0.0460	-0.5806	0.0249	0.0506	169.48	7.822
1.5	0.5575	2.0537	1.0138	1.2327	3.3826	-1.1705	0.0261	-0.5621	0.0125	0.0583	193.79	8.058
1.7	0.5741	2.1263	0.9510	1.1665	3.3932	-1.2401	0.0523	-0.6133	0.0258	0.0661	218.09	8.304
2.0	0.5943	2.1865	0.8915	1.1208	3.4160	-1.2691	0.0904	-0.6510	0.0464	0.0778	254.55	8.604
2.5	0.6222	2.1668	0.9421	1.2214	3.5373	-1.2180	0.0848	-0.5967	0.0415	0.0972	315.32	9.017
3.0	0.6435	2.1393	1.0164	1.1502	3.4663	-1.2309	0.0302	-0.5661	0.0139	0.1167	376.09	9.331
4.0	0.6822	2.0982	1.1078	1.1819	3.5134	-1.2015	0.0281	-0.5169	0.0121	0.1556	497.62	9.898
5.0	0.7129	2.0437	1.1304	1.1415	3.3788	-1.1391	-0.0278	-0.4931	-0.0120	0.1945	619.15	10.346
6.0	0.7389	1.9950	1.0791	1.0501	3.1236	-1.0499	-0.0367	-0.4877	-0.0171	0.2334	740.69	10.724
8.0	0.7825	1.8862	0.9395	1.0245	2.7449	-0.8394	-0.0540	-0.4736	-0.0305	0.3112	983.75	11.359
10.0	0.8127	1.7498	0.9219	0.9956	2.4515	-0.7021	-0.1145	-0.4352	-0.0710	0.3890	1226.82	11.798
12.5	0.8447	1.6083	0.8924	0.9341	2.1277	-0.5550	-0.1821	-0.3867	-0.1269	0.4862	1530.65	12.263
15.0	0.8682	1.4761	0.8994	0.9007	1.8996	-0.4184	-0.2081	-0.3152	-0.1568	0.5834	1834.49	12.608
20.0	0.8902	1.2819	0.8543	0.8653	1.5609	-0.1326	-0.2519	-0.1211	-0.2300	0.7779	2442.16	12.933
25.0	0.8901	1.2956	0.8716	0.8032	1.5457	0.0950	-0.3154	0.0841	-0.2793	0.9724	3049.82	12.938

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 20. GRAD

WANDSCHUBSPANNUNG TAUW = 4.402 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.777 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.796 (M/S)

PROFILLAENGE (UMAX) YMAX = 27.940 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5468	2.0083	0.9084	1.2021	3.1517	-1.0711	0.0377	-0.5871	0.0207	0.0465	170.24	7.693
1.5	0.5644	2.0476	1.0404	1.2240	3.3867	-1.1729	0.0441	-0.5506	0.0207	0.0537	194.66	7.948
1.7	0.5781	2.1129	0.9967	1.1698	3.4131	-1.2215	0.0784	-0.5800	0.0372	0.0608	219.07	8.149
2.0	0.5975	2.1491	0.9271	1.1255	3.3725	-1.2004	0.0680	-0.6025	0.0341	0.0716	255.70	8.429
2.5	0.6263	2.1477	0.9659	1.2092	3.5040	-1.1960	0.0740	-0.5765	0.0357	0.0895	316.74	8.844
3.0	0.6510	2.1176	1.0418	1.2244	3.5344	-1.1738	0.1118	-0.5321	0.0507	0.1074	377.78	9.198
4.0	0.6917	2.0759	1.0597	1.1912	3.4256	-1.1407	0.0177	-0.5185	0.0081	0.1432	499.86	9.779
5.0	0.7238	2.0178	1.1810	1.2711	3.5410	-1.0883	0.0341	-0.4567	0.0143	0.1790	621.94	10.236
6.0	0.7495	1.9873	1.0602	1.1545	3.2032	-0.9981	0.0193	-0.4737	0.0091	0.2147	744.01	10.601
8.0	0.7958	1.8842	0.9817	1.0861	2.8467	-0.8497	-0.0583	-0.4594	-0.0315	0.2863	988.17	11.257
10.0	0.8275	1.7831	0.8673	0.9887	2.4547	-0.7108	-0.0804	-0.4596	-0.0520	0.3579	1232.33	11.707
12.5	0.8603	1.6076	0.9299	1.0080	2.2326	-0.5786	-0.1210	-0.3871	-0.0809	0.4474	1537.53	12.172
15.0	0.8846	1.4829	0.8846	0.9544	1.9462	-0.4738	-0.2136	-0.3612	-0.1628	0.5369	1842.73	12.518
20.0	0.9133	1.2807	0.8507	0.8693	1.5598	-0.2091	-0.2716	-0.1919	-0.2493	0.7158	2453.13	12.929
25.0	0.9195	1.2468	0.8801	0.8179	1.4990	0.0217	-0.3252	0.0198	-0.2964	0.8948	3063.53	13.025
30.0	0.9050	1.3523	0.8435	0.7986	1.5891	0.1918	-0.3755	0.1682	-0.3292	1.0737	3673.93	12.827

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 25. GRAD

WANDSCHUBSPANNUNG TAUW = 4.564 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.782 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.797 (M/S)

PROFILLAENGE (UMAX) YMAX = 30.960 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.5521	2.0285	0.9514	1.2320	3.2689	-1.0965	0.0790	-0.5681	0.0409	0.0420	173.38	7.628
1.5	0.5694	2.0724	1.0598	1.2234	3.4572	-1.2327	0.0278	-0.5613	0.0127	0.0484	198.25	7.876
1.7	0.5827	2.0901	1.1349	1.2532	3.6135	-1.2317	0.0411	-0.5192	0.0173	0.0549	223.11	8.067
2.0	0.6047	2.1492	1.0759	1.2693	3.6940	-1.2486	0.1054	-0.5400	0.0456	0.0646	260.41	8.379
2.5	0.6342	2.1754	1.0249	1.1942	3.6045	-1.2777	0.1051	-0.5731	0.0471	0.0807	322.58	8.796
3.0	0.6604	2.1542	1.0955	1.2961	3.7603	-1.2546	0.0802	-0.5316	0.0340	0.0969	384.74	9.164
4.0	0.6975	2.1069	1.0928	1.2295	3.5725	-1.1679	0.0503	-0.5072	0.0218	0.1292	509.07	9.685
5.0	0.7308	2.0922	1.0330	1.1423	3.3746	-1.1142	0.0713	-0.5155	0.0330	0.1615	633.40	10.149
6.0	0.7589	2.0302	1.0613	1.1664	3.3043	-1.0532	0.0115	-0.4888	0.0053	0.1938	757.73	10.541
8.0	0.8002	1.9092	1.0369	1.1058	2.9717	-0.8832	-0.0329	-0.4461	-0.0166	0.2584	1006.39	11.116
10.0	0.8372	1.7940	0.9559	1.0802	2.6494	-0.7469	-0.0718	-0.4355	-0.0419	0.3230	1255.05	11.632
12.5	0.8734	1.6732	0.8278	0.9929	2.2353	-0.6033	-0.0963	-0.4356	-0.0695	0.4037	1565.88	12.135
15.0	0.8979	1.4999	0.9158	1.0010	2.0452	-0.5322	-0.1424	-0.3875	-0.1037	0.4845	1876.71	12.478
20.0	0.9318	1.2318	0.8367	0.8842	1.5754	-0.2755	-0.2282	-0.2549	-0.2111	0.6460	2498.36	12.955
25.0	0.9413	1.2062	0.8387	0.8124	1.4091	-0.0614	-0.2960	-0.0607	-0.2926	0.8075	3120.01	13.094
30.0	0.9365	1.2434	0.9157	0.8123	1.5223	0.1316	-0.3580	0.1156	-0.3144	0.9690	3741.67	13.036

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 30. GRAD

WANDSCHUBSPANNUNG TAUW = 4.598 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.741 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.792 (M/S)

PROFILLAENGE (UMAX) YMAX = 34.910 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5570	1.9399	1.1511	1.5184	3.6969	-1.0847	0.0137	-0.4857	0.0061	0.0372	175.87	7.678
1.5	0.5715	2.0199	1.1503	1.4320	3.7270	-1.1664	0.0278	-0.5020	0.0120	0.0430	201.09	7.886
1.7	0.5868	2.0497	1.1771	1.4585	3.8571	-1.2065	0.0257	-0.5000	0.0107	0.0487	226.32	8.103
2.0	0.6081	2.0989	1.1214	1.4246	3.8460	-1.2385	0.0305	-0.5262	0.0130	0.0573	264.15	8.404
2.5	0.6371	2.1313	1.0996	1.4333	3.9031	-1.1946	0.0224	-0.5097	0.0096	0.0716	327.21	8.813
3.0	0.6628	2.1293	1.1029	1.4345	3.9040	-1.1616	0.0120	-0.4946	0.0051	0.0859	390.27	9.175
4.0	0.7038	2.0946	1.1879	1.4254	3.9151	-1.1595	0.0645	-0.4660	0.0259	0.1146	516.39	9.747
5.0	0.7377	2.0740	1.1401	1.2704	3.6075	-1.1413	0.1015	-0.4827	0.0429	0.1432	642.51	10.219
6.0	0.7627	2.0021	1.1678	1.2994	3.5303	-1.0382	0.0074	-0.4440	0.0032	0.1719	768.62	10.567
8.0	0.8068	1.8840	1.0790	1.2753	3.1702	-0.8417	0.0075	-0.4140	0.0037	0.2292	1020.86	11.180
10.0	0.8452	1.7810	1.0479	1.2371	2.9002	-0.6942	-0.0263	-0.3720	-0.0141	0.2865	1273.09	11.713
12.5	0.8792	1.6741	0.9116	1.1136	2.4369	-0.6057	-0.0272	-0.3969	-0.0178	0.3581	1588.39	12.186
15.0	0.9085	1.5167	0.9145	1.1115	2.1860	-0.4767	-0.1005	-0.3437	-0.0725	0.4297	1903.68	12.594
20.0	0.9484	1.2742	0.8893	0.9853	1.6926	-0.3142	-0.1789	-0.2773	-0.1578	0.5729	2534.27	13.152
25.0	0.9672	1.1468	0.8460	0.8708	1.3946	-0.1307	-0.2456	-0.1347	-0.2531	0.7161	3164.86	13.421
30.0	0.9724	1.1188	0.8701	0.8606	1.3747	0.0202	-0.3088	0.0207	-0.3172	0.8594	3795.45	13.501
35.0	0.9625	1.1814	0.9026	0.8258	1.4461	0.1401	-0.3545	0.1314	-0.3324	1.0026	4426.04	13.374

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 35. GRAD

WANDSCHUBSPANNUNG TAUW = 4.629 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.730 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.790 (M/S)

PROFILLAENGE (UMAX) YMAX = 40.000 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5591	1.9803	1.1673	1.4335	3.6697	-1.1748	0.0812	-0.5082	0.0351	0.0325	177.78	7.688
1.5	0.5725	2.0578	1.1276	1.3887	3.7173	-1.2276	0.1011	-0.5291	0.0436	0.0375	203.27	7.880
1.7	0.5882	2.1094	1.1033	1.3318	3.7203	-1.2848	0.0737	-0.5520	0.0317	0.0425	228.77	8.103
2.0	0.6082	2.1635	1.0876	1.3591	3.8552	-1.2801	0.1065	-0.5440	0.0453	0.0500	267.02	8.385
2.5	0.6347	2.1846	0.9833	1.3528	3.7848	-1.2018	0.1300	-0.5595	0.0605	0.0625	330.76	8.758
3.0	0.6620	2.1978	0.9961	1.3404	3.8098	-1.2347	0.1113	-0.5640	0.0508	0.0750	394.50	9.140
4.0	0.7027	2.1733	1.0675	1.2825	3.7539	-1.2368	0.1059	-0.5331	0.0457	0.1000	521.98	9.708
5.0	0.7354	2.1386	1.0657	1.2814	3.6757	-1.2249	0.1193	-0.5374	0.0523	0.1250	649.47	10.162
6.0	0.7618	2.0957	1.0419	1.1458	3.3952	-1.1056	0.0502	-0.5064	0.0230	0.1500	776.95	10.528
8.0	0.8076	1.9831	0.9920	1.1389	3.1068	-0.9117	0.0230	-0.4635	0.0117	0.2000	1031.92	11.162
10.0	0.8451	1.8926	0.8851	1.0825	2.7686	-0.7882	0.0114	-0.4705	0.0068	0.2500	1286.89	11.682
12.5	0.8819	1.7671	0.8413	1.0479	2.4842	-0.6944	-0.0224	-0.4671	-0.0151	0.3125	1605.60	12.192
15.0	0.9126	1.6152	0.9034	1.0266	2.2394	-0.5662	-0.0323	-0.3881	-0.0221	0.3750	1924.31	12.619
20.0	0.9587	1.3635	0.8380	0.9606	1.7421	-0.4027	-0.0724	-0.3525	-0.0634	0.5000	2561.73	13.262
25.0	0.9872	1.1543	0.8174	0.8645	1.3739	-0.2394	-0.1439	-0.2537	-0.1525	0.6250	3199.15	13.665
30.0	0.9997	1.0628	0.7786	0.7966	1.1852	-0.0735	-0.2039	-0.0888	-0.2464	0.7500	3836.57	13.846
35.0	0.9992	1.0529	0.7888	0.7660	1.1587	0.0220	-0.2439	0.0265	-0.2937	0.8750	4473.99	13.850
40.0	0.9929	1.0766	0.7983	0.7850	1.2063	0.0920	-0.2773	0.1070	-0.3226	1.0000	5111.41	13.772

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 40. GRAD

WANDSCHUBSPANNUNG TAUW = 4.635 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.738 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.787 (M/S)

PROFILLAENGE (UMAX) YMAX = 41.400 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5627	1.8603	1.3544	1.4931	3.7620	-1.1304	0.0055	-0.4487	0.0022	0.0314	180.81	7.748
1.5	0.5752	1.9092	1.3864	1.4618	3.8521	-1.2000	0.0850	-0.4533	0.0321	0.0362	206.74	7.929
1.7	0.5895	1.9839	1.3746	1.3745	3.8573	-1.3179	0.0506	-0.4833	0.0185	0.0411	232.67	8.131
2.0	0.6097	2.0213	1.3415	1.3461	3.8487	-1.3932	0.0467	-0.5138	0.0172	0.0483	271.56	8.416
2.5	0.6405	2.0814	1.2721	1.2972	3.8167	-1.3314	0.0297	-0.5028	0.0112	0.0604	336.39	8.849
3.0	0.6620	2.0330	1.3012	1.4188	3.9196	-1.2638	0.1451	-0.4778	0.0548	0.0725	401.22	9.151
4.0	0.7004	2.0030	1.3641	1.3693	3.8740	-1.2834	0.1026	-0.4697	0.0376	0.0966	530.88	9.687
5.0	0.7340	2.0026	1.3549	1.2706	3.7303	-1.3346	0.0410	-0.4919	0.0151	0.1208	660.53	10.155
6.0	0.7593	1.9172	1.3794	1.3649	3.7207	-1.1225	0.1187	-0.4245	0.0449	0.1449	790.19	10.505
8.0	0.8052	1.8709	1.2217	1.2021	3.2190	-1.0423	0.1603	-0.4560	0.0701	0.1932	1049.50	11.142
10.0	0.8424	1.7643	1.1763	1.1959	2.9634	-0.9188	0.1095	-0.4427	0.0527	0.2415	1308.81	11.658
12.5	0.8795	1.6481	1.1094	1.1113	2.5909	-0.8352	0.0895	-0.4568	0.0490	0.3019	1632.95	12.172
15.0	0.9109	1.5398	1.0500	1.0642	2.3030	-0.6839	0.0939	-0.4230	0.0581	0.3623	1957.09	12.610
20.0	0.9614	1.2925	0.9218	0.9685	1.7291	-0.4907	0.0465	-0.4118	0.0391	0.4831	2605.37	13.315
25.0	0.9962	1.0796	0.8781	0.8453	1.3255	-0.3098	-0.0102	-0.3268	-0.0108	0.6039	3253.65	13.806
30.0	1.0147	0.9162	0.8060	0.7483	1.0245	-0.1665	-0.0381	-0.2255	-0.0515	0.7246	3901.93	14.072
35.0	1.0228	0.8487	0.7504	0.6965	0.8842	-0.0725	-0.0888	-0.1138	-0.1394	0.8454	4550.21	14.194
40.0	1.0218	0.8397	0.7233	0.6702	0.8387	0.0187	-0.1078	0.0309	-0.1774	0.9662	5198.49	14.191

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 45. GRAD

WANDSCHUBSPANNUNG TAUW = 4.813 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.736 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.789 (M/S)

PROFILLAENGE (UMAX) YMAX = 37.100 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5527	1.8471	1.3019	1.4950	3.6709	-1.0664	-0.0534	-0.4434	-0.0222	0.0350	182.31	7.459
1.5	0.5683	1.9246	1.3148	1.3760	3.6631	-1.1952	-0.0160	-0.4723	-0.0063	0.0404	208.46	7.677
1.7	0.5829	1.9569	1.3737	1.4538	3.9149	-1.2248	-0.0044	-0.4556	-0.0016	0.0458	234.60	7.880
2.0	0.6030	2.0511	1.2089	1.2918	3.6686	-1.2825	-0.0070	-0.5172	-0.0028	0.0539	273.82	8.158
2.5	0.6325	2.0773	1.1493	1.4157	3.8202	-1.1689	-0.0191	-0.4896	-0.0080	0.0674	339.19	8.565
3.0	0.6570	2.0918	1.2012	1.2840	3.7335	-1.2893	0.0870	-0.5131	0.0346	0.0809	404.56	8.902
4.0	0.6984	2.0430	1.3771	1.3875	3.9977	-1.3081	0.0460	-0.4649	0.0164	0.1078	535.30	9.469
5.0	0.7287	2.0180	1.3129	1.2745	3.7101	-1.2385	0.1109	-0.4675	0.0419	0.1348	666.03	9.881
6.0	0.7546	1.9942	1.2747	1.2593	3.5937	-1.1545	0.1232	-0.4542	0.0485	0.1617	796.77	10.234
8.0	0.7989	1.8695	1.2259	1.2546	3.2860	-0.9774	0.0744	-0.4265	0.0325	0.2156	1058.24	10.835
10.0	0.8363	1.8231	1.0749	1.1381	2.8871	-0.8829	0.1272	-0.4505	0.0649	0.2695	1319.71	11.344
12.5	0.8747	1.6983	1.0485	1.1422	2.6441	-0.7374	0.0867	-0.4141	0.0487	0.3369	1646.54	11.867
15.0	0.9066	1.5820	1.0703	1.0530	2.3786	-0.7209	0.1122	-0.4258	0.0663	0.4043	1973.38	12.302
20.0	0.9637	1.3605	0.9004	0.9796	1.8106	-0.5128	0.0798	-0.4186	0.0651	0.5391	2627.06	13.083
25.0	1.0012	1.1184	0.8684	0.8436	1.3583	-0.3339	0.0454	-0.3438	0.0468	0.6739	3280.73	13.600
30.0	1.0241	0.9207	0.7456	0.7596	0.9903	-0.1760	0.0277	-0.2563	0.0403	0.8086	3934.41	13.921
35.0	1.0355	0.8031	0.6849	0.6416	0.7629	-0.0660	0.0088	-0.1201	0.0160	0.9434	4588.09	14.086
40.0	1.0334	0.7746	0.6441	0.6264	0.7037	0.0287	0.0058	0.0576	0.0116	1.0782	5241.76	14.067

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 50. GRAD

WANDSCHUBSPANNUNG TAUW = 4.725 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.742 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.792 (M/S)

PROFILLAENGE (UMAX) YMAX = 35.400 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5531	1.9819	1.1932	1.2557	3.4644	-1.1630	0.2391	-0.4918	0.1011	0.0367	178.71	7.522
1.5	0.5661	1.9989	1.2392	1.2580	3.5569	-1.2523	0.2645	-0.5056	0.1068	0.0424	204.34	7.707
1.7	0.5836	2.0561	1.2786	1.2355	3.6944	-1.3465	0.2567	-0.5122	0.0976	0.0480	229.97	7.951
2.0	0.6023	2.0779	1.3883	1.2681	3.9267	-1.4216	0.2292	-0.4928	0.0795	0.0565	268.42	8.213
2.5	0.6306	2.1183	1.3440	1.2516	3.9300	-1.4008	0.2537	-0.4920	0.0891	0.0706	332.49	8.607
3.0	0.6547	2.1095	1.3306	1.2925	3.9455	-1.3942	0.2396	-0.4967	0.0854	0.0847	396.57	8.942
4.0	0.6922	2.0911	1.3039	1.1905	3.7450	-1.4020	0.2046	-0.5142	0.0750	0.1130	524.72	9.459
5.0	0.7257	2.0419	1.4544	1.2223	3.8894	-1.4671	0.2513	-0.4940	0.0846	0.1412	652.88	9.920
6.0	0.7495	2.0110	1.3837	1.1317	3.6776	-1.3106	0.1497	-0.4710	0.0538	0.1695	781.03	10.246
8.0	0.7936	1.9432	1.3117	1.1557	3.4161	-1.1335	0.1230	-0.4447	0.0482	0.2260	1037.34	10.850
10.0	0.8295	1.8403	1.2715	1.1589	3.1732	-0.9846	0.1765	-0.4208	0.0754	0.2825	1293.64	11.342
12.5	0.8692	1.7591	1.1575	0.9748	2.6922	-0.9097	0.1112	-0.4468	0.0546	0.3531	1614.03	11.887
15.0	0.9037	1.6312	1.1431	1.0649	2.5507	-0.7806	0.1104	-0.4187	0.0592	0.4237	1934.41	12.360
20.0	0.9599	1.4317	1.0109	0.9264	1.9650	-0.5801	0.1109	-0.4008	0.0766	0.5650	2575.18	13.134
25.0	0.9994	1.1928	0.9105	0.8041	1.4492	-0.3941	0.1134	-0.3629	0.1044	0.7062	3215.94	13.682
30.0	1.0223	0.9909	0.7516	0.6696	0.9976	-0.1724	0.1029	-0.2314	0.1382	0.8475	3856.71	14.006
35.0	1.0298	0.8489	0.7310	0.6377	0.8308	-0.0556	0.0859	-0.0895	0.1385	0.9887	4497.48	14.118
40.0	1.0207	0.8431	0.6947	0.6158	0.7863	0.0578	0.0762	0.0986	0.1302	1.1299	5138.24	14.003

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 55. GRAD

WANDSCHUBSPANNUNG TAUW = 4.561 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.729 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.790 (M/S)

PROFILLAENGE (UMAX) YMAX = 32.900 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5509	1.9922	1.1464	1.2556	3.4299	-1.0968	0.2500	-0.4802	0.1095	0.0395	175.98	7.628
1.5	0.5655	2.0207	1.2786	1.3090	3.7158	-1.1918	0.1518	-0.4613	0.0588	0.0456	201.22	7.839
1.7	0.5799	2.0832	1.2373	1.1198	3.5623	-1.3408	0.2434	-0.5202	0.0944	0.0517	226.46	8.045
2.0	0.5984	2.1058	1.2580	1.2773	3.8241	-1.2561	0.2308	-0.4742	0.0871	0.0608	264.32	8.308
2.5	0.6271	2.1510	1.2409	1.1840	3.7843	-1.3722	0.2651	-0.5141	0.0993	0.0760	327.41	8.715
3.0	0.6526	2.1520	1.2385	1.3535	3.9983	-1.2563	0.3101	-0.4714	0.1163	0.0912	390.51	9.074
4.0	0.6897	2.1209	1.3152	1.3151	3.9788	-1.2688	0.2174	-0.4548	0.0779	0.1216	516.71	9.595
5.0	0.7193	2.0768	1.3615	1.3283	3.9655	-1.2484	0.2749	-0.4415	0.0972	0.1520	642.90	10.010
6.0	0.7475	2.0459	1.3186	1.3342	3.8522	-1.1520	0.3248	-0.4270	0.1204	0.1824	769.10	10.403
8.0	0.7899	1.9430	1.2749	1.2639	3.4991	-1.0479	0.2653	-0.4230	0.1071	0.2432	1021.49	10.996
10.0	0.8253	1.8615	1.2320	1.2469	3.2689	-0.9512	0.2666	-0.4148	0.1162	0.3040	1273.88	11.488
12.5	0.8643	1.7781	1.0759	1.1732	2.8538	-0.7621	0.2759	-0.3983	0.1442	0.3799	1589.37	12.033
15.0	0.8971	1.6685	1.0668	1.1288	2.5980	-0.7041	0.2907	-0.3956	0.1633	0.4559	1904.86	12.492
20.0	0.9534	1.4639	0.9821	1.0068	2.0606	-0.5614	0.3048	-0.3905	0.2120	0.6079	2535.84	13.282
25.0	0.9934	1.2002	0.9098	0.9265	1.5633	-0.3406	0.3064	-0.3119	0.2806	0.7599	3166.82	13.847
30.0	1.0148	1.0001	0.7625	0.7967	1.1081	-0.1701	0.2488	-0.2230	0.3263	0.9119	3797.80	14.155
35.0	1.0129	0.9152	0.6936	0.6805	0.8909	-0.0197	0.2052	-0.0310	0.3233	1.0638	4428.77	14.137

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 60. GRAD

WANDSCHUBSPANNUNG TAUW = 4.472 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.724 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.786 (M/S)

PROFILLAENGE (UMAX) YMAX = 30.300 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5471	2.0451	0.9654	1.4226	3.5691	-0.9610	0.2098	-0.4868	0.1062	0.0429	177.43	7.666
1.5	0.5618	2.0817	1.0409	1.4786	3.8017	-0.9733	0.2237	-0.4492	0.1032	0.0495	202.88	7.881
1.7	0.5741	2.1252	1.0347	1.3756	3.7398	-1.1370	0.2007	-0.5170	0.0912	0.0561	228.32	8.059
2.0	0.5948	2.1904	1.0190	1.3132	3.7803	-1.2290	0.1312	-0.5506	0.0588	0.0660	266.49	8.357
2.5	0.6253	2.2438	0.9457	1.3119	3.8250	-1.2451	0.1181	-0.5867	0.0557	0.0825	330.11	8.793
3.0	0.6475	2.1931	1.0863	1.4190	4.0016	-1.2307	0.0954	-0.5166	0.0401	0.0990	393.73	9.111
4.0	0.6863	2.2016	1.0606	1.3823	3.9415	-1.1629	0.1246	-0.4980	0.0534	0.1320	520.96	9.662
5.0	0.7167	2.1572	1.1466	1.3103	3.8426	-1.1940	0.1265	-0.4827	0.0511	0.1650	648.20	10.092
6.0	0.7401	2.1159	1.1716	1.2965	3.7653	-1.1362	0.1691	-0.4583	0.0682	0.1980	775.43	10.423
8.0	0.7834	2.0127	1.0993	1.2439	3.4033	-0.9671	0.0940	-0.4371	0.0425	0.2640	1029.90	11.035
10.0	0.8183	1.9207	1.0478	1.1718	3.0801	-0.8667	0.1908	-0.4307	0.0948	0.3300	1284.37	11.527
12.5	0.8582	1.8372	0.9478	1.1540	2.8025	-0.7460	0.2501	-0.4284	0.1437	0.4125	1602.46	12.091
15.0	0.8897	1.7338	0.9026	1.1438	2.5645	-0.6364	0.1872	-0.4066	0.1196	0.4950	1920.54	12.536
20.0	0.9446	1.5025	0.8969	1.0435	2.0754	-0.4660	0.2414	-0.3458	0.1792	0.6601	2556.72	13.316
25.0	0.9838	1.2603	0.7985	0.8870	1.5063	-0.2691	0.2625	-0.2674	0.2609	0.8251	3192.89	13.877
30.0	1.0001	1.0521	0.6794	0.7748	1.0844	-0.0676	0.2282	-0.0946	0.3193	0.9901	3829.07	14.116
35.0	0.9873	0.9997	0.6648	0.7676	1.0153	0.0860	0.2221	0.1295	0.3341	1.1551	4465.24	13.945

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 65. GRAD

WANDSCHUBSPANNUNG TAUW = 4.332 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.734 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.788 (M/S)

PROFILLAENGE (UMAX) YMAX = 28.200 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.5429	2.0260	0.9967	1.3430	3.4507	-1.0245	0.2151	-0.5074	0.1065	0.0461	174.11	7.726
1.5	0.5614	2.0800	1.1208	1.4353	3.8213	-1.1480	0.1070	-0.4924	0.0459	0.0532	199.08	7.998
1.7	0.5740	2.1625	1.0067	1.2394	3.6129	-1.2274	0.1421	-0.5638	0.0653	0.0603	224.05	8.184
2.0	0.5931	2.1835	1.0139	1.2673	3.7008	-1.1884	0.1697	-0.5368	0.0766	0.0709	261.50	8.463
2.5	0.6232	2.2417	0.9357	1.2846	3.7756	-1.2536	0.2372	-0.5976	0.1131	0.0887	323.93	8.902
3.0	0.6442	2.2527	0.9523	1.1884	3.6969	-1.2554	0.1203	-0.5852	0.0561	0.1064	386.36	9.207
4.0	0.6810	2.2028	1.0229	1.2457	3.7252	-1.2590	0.1504	-0.5588	0.0667	0.1418	511.21	9.737
5.0	0.7115	2.1172	1.2771	1.3289	3.9397	-1.2657	0.1465	-0.4681	0.0542	0.1773	636.06	10.177
6.0	0.7381	2.1092	1.0729	1.2726	3.6097	-1.1349	0.1192	-0.5015	0.0527	0.2128	760.91	10.558
8.0	0.7811	2.0253	1.0390	1.2521	3.3747	-0.9432	0.1479	-0.4482	0.0703	0.2837	1010.62	11.176
10.0	0.8143	1.9335	1.0736	1.1253	3.0787	-0.9138	0.1932	-0.4402	0.0931	0.3546	1260.32	11.651
12.5	0.8521	1.8394	0.9184	1.0763	2.6927	-0.7669	0.2196	-0.4540	0.1300	0.4433	1572.45	12.193
15.0	0.8838	1.7461	0.8553	1.0178	2.4082	-0.6583	0.2299	-0.4408	0.1540	0.5319	1884.58	12.650
20.0	0.9340	1.5104	0.8204	0.9565	1.9347	-0.4334	0.2861	-0.3498	0.2309	0.7092	2508.85	13.374
25.0	0.9714	1.2370	0.7636	0.8927	1.4550	-0.2514	0.3006	-0.2661	0.3183	0.8865	3133.11	13.918
30.0	0.9778	1.0570	0.6892	0.7950	1.1122	-0.0313	0.2642	-0.0429	0.3626	1.0638	3757.37	14.018
35.0	0.9519	1.0638	0.6491	0.8025	1.0985	0.1485	0.2682	0.2151	0.3885	1.2411	4381.63	13.656

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 70. GRAD

WANDSCHUBSPANNUNG TAUW = 3.987 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.728 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.782 (M/S)

PROFILLAENGE (UMAX) YMAX = 26.700 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5507	2.0893	0.9147	1.1706	3.2859	-1.1149	0.1757	-0.5834	0.0919	0.0487	171.39	8.196
1.5	0.5681	2.1195	1.0106	1.2120	3.4912	-1.1401	0.1256	-0.5323	0.0586	0.0562	195.97	8.463
1.7	0.5788	2.1428	1.0165	1.2326	3.5719	-1.1763	0.1691	-0.5401	0.0777	0.0637	220.55	8.630
2.0	0.5974	2.1867	0.9465	1.1813	3.5366	-1.2601	0.2178	-0.6088	0.1052	0.0749	257.42	8.914
2.5	0.6234	2.2329	0.8461	0.9914	3.3424	-1.2687	0.1896	-0.6715	0.1004	0.0936	318.87	9.309
3.0	0.6453	2.1977	0.9676	1.1324	3.5242	-1.2325	0.1961	-0.5796	0.0922	0.1124	380.32	9.642
4.0	0.6814	2.1894	1.0115	1.0262	3.4348	-1.2861	0.1603	-0.5807	0.0724	0.1498	503.22	10.186
5.0	0.7120	2.1499	1.0893	1.1552	3.5716	-1.2408	0.0911	-0.5298	0.0389	0.1873	626.12	10.646
6.0	0.7354	2.1173	1.0475	0.9624	3.2532	-1.1840	0.1049	-0.5338	0.0473	0.2247	749.02	10.997
8.0	0.7784	2.0026	1.0487	1.1143	3.1760	-0.9961	0.1705	-0.4743	0.0812	0.2996	994.83	11.642
10.0	0.8107	1.9023	0.9555	1.0614	2.8291	-0.8305	0.1365	-0.4569	0.0751	0.3745	1240.63	12.125
12.5	0.8446	1.7745	0.8974	1.0740	2.5538	-0.7258	0.1450	-0.4558	0.0911	0.4682	1547.88	12.634
15.0	0.8790	1.7110	0.8522	0.9539	2.2819	-0.6363	0.2073	-0.4364	0.1421	0.5618	1855.13	13.152
20.0	0.9244	1.4535	0.6985	0.8112	1.6294	-0.4291	0.2569	-0.4226	0.2530	0.7491	2469.64	13.839
25.0	0.9554	1.2023	0.6760	0.7683	1.2463	-0.2125	0.2731	-0.2615	0.3360	0.9363	3084.15	14.312
30.0	0.9528	1.0721	0.5597	0.6637	0.9549	-0.0072	0.2362	-0.0121	0.3936	1.1236	3698.65	14.281

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 75. GRAD

WANDSCHUBSPANNUNG TAUW = 3.878 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.734 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.783 (M/S)

PROFILLAENGE (UMAX) YMAX = 25.500 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.5494	2.0597	0.9521	1.2061	3.3018	-1.1968	0.2442	-0.6103	0.1245	0.0510	168.76	8.290
1.5	0.5630	2.1016	1.0694	1.1723	3.4672	-1.2735	0.1930	-0.5666	0.0859	0.0588	192.96	8.503
1.7	0.5766	2.1465	1.0707	1.1770	3.5697	-1.3903	0.2808	-0.6049	0.1222	0.0667	217.16	8.716
2.0	0.5974	2.1956	1.0949	1.1597	3.6822	-1.3976	0.2095	-0.5814	0.0872	0.0784	253.47	9.037
2.5	0.6244	2.2150	0.9799	1.1282	3.5696	-1.3929	0.2367	-0.6418	0.1091	0.0980	313.97	9.453
3.0	0.6455	2.2182	1.0363	1.0645	3.5639	-1.3740	0.2072	-0.5977	0.0901	0.1176	374.48	9.778
4.0	0.6804	2.1776	1.0724	1.0634	3.5167	-1.3531	0.1793	-0.5794	0.0768	0.1569	495.50	10.313
5.0	0.7086	2.1386	1.1567	1.0651	3.5229	-1.3311	0.1533	-0.5381	0.0620	0.1961	616.51	10.741
6.0	0.7328	2.1000	1.0588	1.0504	3.3278	-1.1498	0.0984	-0.5171	0.0443	0.2353	737.52	11.110
8.0	0.7738	1.9845	1.0621	1.0816	3.1181	-1.0530	0.1505	-0.4996	0.0714	0.3137	979.55	11.733
10.0	0.8071	1.8843	0.9647	0.9703	2.7113	-0.9329	0.2048	-0.5132	0.1127	0.3922	1221.58	12.239
12.5	0.8413	1.7887	0.8427	1.0010	2.4558	-0.6999	0.1558	-0.4643	0.1033	0.4902	1524.12	12.759
15.0	0.8708	1.6524	0.8793	0.9851	2.2370	-0.6388	0.2015	-0.4396	0.1387	0.5882	1826.66	13.209
20.0	0.9179	1.4299	0.6831	0.7559	1.5413	-0.4045	0.2714	-0.4141	0.2778	0.7843	2431.73	13.931
25.0	0.9395	1.1537	0.6510	0.7714	1.1750	-0.1586	0.2867	-0.2111	0.3817	0.9804	3036.81	14.268
30.0	0.9230	1.0660	0.5613	0.7077	0.9762	0.0478	0.2300	0.0799	0.3844	1.1765	3641.88	14.027

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 80. GRAD

WANDSCHUBSPANNUNG TAUW = 3.817 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.740 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.784 (M/S)

PROFILLAENGE (UMAX) YMAX = 24.600 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.5479	2.0663	1.0632	1.2996	3.5444	-1.1174	0.0288	-0.5087	0.0131	0.0528	166.51	8.327
1.5	0.5608	2.1156	1.1368	1.1343	3.5502	-1.2556	0.0519	-0.5221	0.0216	0.0610	190.39	8.531
1.7	0.5731	2.1800	1.0446	1.1985	3.6400	-1.2516	0.0275	-0.5496	0.0121	0.0691	214.27	8.725
2.0	0.5914	2.1910	1.1574	1.1320	3.7686	-1.3434	-0.0422	-0.5298	-0.0166	0.0813	250.10	9.012
2.5	0.6185	2.2466	0.9890	1.1771	3.7055	-1.2092	-0.0513	-0.5442	-0.0231	0.1016	309.80	9.433
3.0	0.6410	2.2545	0.9151	1.1476	3.6188	-1.2216	0.0246	-0.5921	0.0119	0.1220	369.50	9.781
4.0	0.6763	2.1971	1.1058	1.0786	3.6068	-1.2758	0.0111	-0.5251	0.0046	0.1626	488.91	10.325
5.0	0.7032	2.1739	1.0726	0.9952	3.4335	-1.2336	0.0186	-0.5290	0.0080	0.2033	608.31	10.739
6.0	0.7291	2.1225	1.0892	1.0334	3.4325	-1.1603	0.0120	-0.5019	0.0052	0.2439	727.72	11.134
8.0	0.7680	2.0072	1.0108	1.0010	3.0262	-0.9876	0.0903	-0.4868	0.0445	0.3252	966.53	11.730
10.0	0.8019	1.8891	0.9930	1.0369	2.8150	-0.8365	0.0871	-0.4459	0.0464	0.4065	1205.34	12.250
12.5	0.8350	1.7822	0.9461	0.9442	2.4814	-0.7186	0.0703	-0.4262	0.0417	0.5081	1503.85	12.758
15.0	0.8660	1.6533	0.9485	0.9379	2.2563	-0.6280	0.1504	-0.4005	0.0959	0.6098	1802.37	13.233
20.0	0.9053	1.4160	0.6940	0.7408	1.5178	-0.3930	0.2143	-0.3999	0.2181	0.8130	2399.40	13.841
25.0	0.9224	1.1214	0.6790	0.7555	1.1446	-0.1229	0.2175	-0.1614	0.2857	1.0163	2996.43	14.110
30.0	0.8959	1.0741	0.5924	0.7653	1.0452	0.1048	0.2091	0.1647	0.3285	1.2195	3593.45	13.714

VERSUCH NR. 15 (WANDKANAL)

DATUM 3.03.1976

POSITION 85. GRAD

WANDSCHUBSPANNUNG TAUW = 3.695 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.742 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.785 (M/S)

PROFILLAENGE (UMAX) YMAX = 24.000 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.5447	2.0821	1.1104	1.1618	3.4590	-1.2964	0.1372	-0.5607	0.0593	0.0542	163.52	8.411
1.5	0.5605	2.1476	1.1492	1.1602	3.6394	-1.3973	0.0689	-0.5662	0.0279	0.0625	186.98	8.664
1.7	0.5727	2.1812	1.1737	1.1437	3.7215	-1.4436	0.0874	-0.5639	0.0341	0.0708	210.43	8.860
2.0	0.5916	2.2179	1.1402	1.2545	3.8965	-1.3928	-0.0426	-0.5507	-0.0169	0.0833	245.61	9.159
2.5	0.6158	2.2793	1.0157	1.1147	3.7347	-1.3802	0.0327	-0.5962	0.0141	0.1042	304.24	9.543
3.0	0.6381	2.2632	0.9929	1.0332	3.5879	-1.4266	0.1425	-0.6349	0.0634	0.1250	362.87	9.894
4.0	0.6741	2.2770	1.0191	0.9009	3.5174	-1.4202	0.0917	-0.6120	0.0395	0.1667	480.14	10.457
5.0	0.7024	2.2084	1.0765	0.9612	3.4800	-1.3591	-0.0206	-0.5717	-0.0087	0.2083	597.40	10.898
6.0	0.7233	2.1014	1.1732	0.9486	3.3461	-1.3241	0.0775	-0.5371	0.0314	0.2500	714.66	11.225
8.0	0.7633	1.9880	1.1140	1.0259	3.1227	-0.9809	0.0727	-0.4429	0.0328	0.3333	949.19	11.847
10.0	0.7980	1.8962	1.0145	0.9047	2.7217	-0.9342	0.1566	-0.4856	0.0814	0.4167	1183.72	12.386
12.5	0.8310	1.7541	0.9839	0.9759	2.4986	-0.7492	0.0791	-0.4341	0.0459	0.5208	1476.87	12.901
15.0	0.8583	1.6672	0.8862	0.8046	2.1062	-0.6538	0.1404	-0.4425	0.0950	0.6250	1770.03	13.327
20.0	0.8983	1.3590	0.7923	0.8204	1.5738	-0.3547	0.1611	-0.3295	0.1496	0.8333	2356.35	13.955
25.0	0.9100	1.0958	0.6780	0.7459	1.1084	-0.0882	0.1790	-0.1187	0.2410	1.0417	2942.67	14.144
30.0	0.8746	1.0813	0.6105	0.7541	1.0554	0.1603	0.1493	0.2428	0.2261	1.2500	3528.99	13.603

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 5. (MM)

WANDSCHUBSPANNUNG TAUW = 1.608 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.779 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.794 (M/S)

PROFILLAENGE (UMAX) YMAX = 12.040 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.7048	1.3219	0.6180	0.8632	1.4372	-0.3763	-0.0657	-0.4607	-0.0804	0.1080	103.96	16.474
1.5	0.7184	1.3077	0.5872	0.8682	1.4043	-0.3468	-0.0738	-0.4516	-0.0961	0.1246	118.87	16.805
1.7	0.7316	1.2976	0.5642	0.8488	1.3614	-0.3507	-0.0672	-0.4789	-0.0917	0.1412	133.78	17.124
2.0	0.7469	1.2747	0.5868	0.8617	1.3558	-0.3393	-0.0710	-0.4536	-0.0949	0.1661	156.15	17.493
2.5	0.7735	1.2640	0.5522	0.8453	1.3085	-0.3247	-0.0709	-0.4652	-0.1016	0.2076	193.42	18.128
3.0	0.7925	1.2338	0.5555	0.8323	1.2617	-0.2998	-0.0614	-0.4374	-0.0897	0.2492	230.70	18.580
4.0	0.8222	1.1708	0.5700	0.8344	1.1959	-0.2739	-0.0863	-0.4104	-0.1293	0.3322	305.25	19.284
5.0	0.8460	1.1186	0.5941	0.8168	1.1357	-0.2436	-0.1135	-0.3665	-0.1707	0.4153	379.80	19.845
6.0	0.8639	1.0757	0.5912	0.7982	1.0719	-0.1907	-0.1212	-0.2999	-0.1906	0.4983	454.35	20.267
8.0	0.8910	1.0338	0.5782	0.7664	0.9953	-0.1015	-0.1287	-0.1698	-0.2154	0.6645	603.45	20.905
10.0	0.9044	1.0469	0.6183	0.7570	1.0257	-0.0129	-0.1559	-0.0200	-0.2409	0.8306	752.55	21.224
12.5	0.9091	1.1260	0.6919	0.7941	1.1886	0.1106	-0.1823	0.1419	-0.2340	1.0382	938.92	21.337
15.0	0.9008	1.2625	0.7147	0.8109	1.3812	0.2424	-0.2083	0.2686	-0.2309	1.2458	1125.30	21.147

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 10. (MM)

WANDSCHUBSPANNUNG TAUW = 1.616 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.775 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.794 (M/S)

PROFILLAENGE (UMAX) YMAX = 12.400 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.7092	1.3270	0.6157	0.8640	1.4433	-0.3626	-0.0910	-0.4438	-0.1114	0.1048	104.19	16.536
1.5	0.7224	1.3123	0.5936	0.8625	1.4092	-0.3569	-0.0790	-0.4581	-0.1014	0.1210	119.14	16.858
1.7	0.7358	1.3007	0.6121	0.8614	1.4042	-0.3489	-0.0896	-0.4382	-0.1126	0.1371	134.08	17.181
2.0	0.7529	1.2940	0.5683	0.8559	1.3650	-0.3448	-0.0807	-0.4689	-0.1098	0.1613	156.50	17.593
2.5	0.7766	1.2713	0.5522	0.8327	1.3073	-0.3236	-0.0880	-0.4609	-0.1254	0.2016	193.86	18.158
3.0	0.7970	1.2482	0.5268	0.8278	1.2603	-0.3107	-0.1040	-0.4725	-0.1582	0.2419	231.21	18.643
4.0	0.8283	1.1860	0.5842	0.8446	1.2306	-0.2808	-0.1164	-0.4053	-0.1681	0.3226	305.93	19.382
5.0	0.8525	1.1274	0.6235	0.8406	1.1832	-0.2448	-0.1366	-0.3483	-0.1944	0.4032	380.65	19.951
6.0	0.8707	1.0988	0.5795	0.8155	1.1041	-0.2018	-0.1546	-0.3170	-0.2428	0.4839	455.37	20.378
8.0	0.8958	1.0455	0.5936	0.7753	1.0232	-0.1227	-0.1694	-0.1977	-0.2730	0.6452	604.80	20.968
10.0	0.9096	1.0423	0.6313	0.7964	1.0596	-0.0292	-0.2029	-0.0444	-0.3084	0.8065	754.24	21.293
12.5	0.9165	1.1160	0.6935	0.8025	1.1852	0.0834	-0.2181	0.1078	-0.2818	1.0081	941.04	21.460
15.0	0.9110	1.2417	0.7649	0.8538	1.4279	0.2128	-0.2650	0.2240	-0.2790	1.2097	1127.83	21.338

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 15. (MM)

WANDSCHUBSPANNUNG TAUW = 1.621 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.757 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.791 (M/S)

PROFILLAENGE (UMAX) YMAX = 12.740 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.7146	1.3478	0.6183	0.9463	1.5472	-0.3892	-0.0840	-0.4671	-0.1008	0.1020	105.20	16.654
1.5	0.7295	1.3347	0.6324	0.9235	1.5171	-0.3985	-0.0723	-0.4721	-0.0856	0.1177	120.29	17.017
1.7	0.7426	1.3244	0.6354	0.9123	1.4950	-0.4003	-0.0829	-0.4757	-0.0985	0.1334	135.37	17.332
2.0	0.7599	1.3154	0.6035	0.9046	1.4565	-0.3773	-0.0844	-0.4752	-0.1064	0.1570	158.00	17.748
2.5	0.7831	1.2946	0.5953	0.8783	1.4009	-0.3703	-0.0930	-0.4804	-0.1206	0.1962	195.72	18.301
3.0	0.8035	1.2649	0.6144	0.8821	1.3779	-0.3528	-0.0959	-0.4540	-0.1234	0.2355	233.44	18.786
4.0	0.8337	1.2072	0.6133	0.8603	1.2867	-0.3145	-0.1125	-0.4248	-0.1520	0.3140	308.88	19.499
5.0	0.8588	1.1619	0.6131	0.8532	1.2270	-0.2744	-0.1396	-0.3852	-0.1959	0.3925	384.32	20.088
6.0	0.8795	1.1302	0.6094	0.8149	1.1563	-0.2417	-0.1569	-0.3509	-0.2279	0.4710	459.76	20.574
8.0	0.9046	1.0764	0.6208	0.7917	1.0854	-0.1427	-0.1792	-0.2135	-0.2681	0.6279	610.63	21.164
10.0	0.9196	1.0753	0.6189	0.7830	1.0761	-0.0636	-0.2063	-0.0956	-0.3101	0.7849	761.51	21.517
12.5	0.9275	1.1358	0.6875	0.8180	1.2159	0.0452	-0.2554	0.0579	-0.3271	0.9812	950.10	21.707
15.0	0.9239	1.2545	0.7596	0.8325	1.4219	0.1725	-0.2803	0.1810	-0.2942	1.1774	1138.69	21.629
20.0	0.8947	1.5224	0.8929	0.9367	1.9962	0.4264	-0.3051	0.3137	-0.2245	1.5699	1515.88	20.959

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 20. (MM)

WANDSCHUBSPANNUNG TAUW = 1.642 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.757 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.791 (M/S)

PROFILLAENGE (UMAX) YMAX = 13.160 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.7221	1.3664	0.6280	0.9452	1.5774	-0.4012	-0.0853	-0.4675	-0.0994	0.0988	105.88	16.722
1.5	0.7359	1.3577	0.6221	0.9011	1.5213	-0.4038	-0.0628	-0.4780	-0.0744	0.1140	121.07	17.055
1.7	0.7481	1.3438	0.6115	0.8977	1.4927	-0.3914	-0.0620	-0.4763	-0.0754	0.1292	136.25	17.348
2.0	0.7656	1.3375	0.5939	0.8835	1.4611	-0.3833	-0.0777	-0.4826	-0.0978	0.1520	159.03	17.765
2.5	0.7891	1.3149	0.5790	0.8744	1.4144	-0.3728	-0.0875	-0.4896	-0.1149	0.1900	196.99	18.323
3.0	0.8086	1.2843	0.6067	0.8758	1.3924	-0.3486	-0.0862	-0.4473	-0.1106	0.2280	234.96	18.783
4.0	0.8415	1.2276	0.6054	0.8674	1.3129	-0.3206	-0.1192	-0.4314	-0.1604	0.3040	310.89	19.554
5.0	0.8653	1.1791	0.6222	0.8493	1.2494	-0.2867	-0.1345	-0.3908	-0.1834	0.3799	386.81	20.110
6.0	0.8850	1.1366	0.6429	0.8352	1.2014	-0.2513	-0.1493	-0.3439	-0.2043	0.4559	462.74	20.569
8.0	0.9113	1.0817	0.6346	0.8001	1.1065	-0.1638	-0.1791	-0.2385	-0.2609	0.6079	614.60	21.183
10.0	0.9279	1.0691	0.6371	0.7930	1.0889	-0.0889	-0.2204	-0.1305	-0.3236	0.7599	766.45	21.570
12.5	0.9378	1.1153	0.6814	0.8033	1.1767	0.0189	-0.2653	0.0248	-0.3490	0.9498	956.27	21.806
15.0	0.9376	1.2247	0.7654	0.8213	1.3801	0.1339	-0.3000	0.1429	-0.3200	1.1398	1146.09	21.807
20.0	0.9117	1.4659	0.8543	0.9261	1.8977	0.3472	-0.3424	0.2735	-0.2697	1.5198	1525.73	21.219

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 25. (MM)

WANDSCHUBSPANNUNG TAUW = 1.644 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.791 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.800 (M/S)

PROFILLAENGE (UMAX) YMAX = 13.700 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.7204	1.3528	0.6618	0.9314	1.5678	-0.3947	-0.0750	-0.4408	-0.0838	0.0949	102.17	16.603
1.5	0.7345	1.3468	0.6535	0.9041	1.5292	-0.3895	-0.0739	-0.4426	-0.0839	0.1095	116.83	16.943
1.7	0.7469	1.3414	0.6372	0.9150	1.5213	-0.3740	-0.0693	-0.4376	-0.0810	0.1241	131.48	17.238
2.0	0.7641	1.3274	0.6144	0.8754	1.4529	-0.3711	-0.0685	-0.4550	-0.0840	0.1460	153.46	17.646
2.5	0.7873	1.3115	0.5919	0.8684	1.4122	-0.3525	-0.0834	-0.4541	-0.1074	0.1825	190.10	18.197
3.0	0.8099	1.2911	0.5971	0.8773	1.3965	-0.3400	-0.0807	-0.4410	-0.1046	0.2190	226.73	18.727
4.0	0.8423	1.2506	0.5943	0.8394	1.3109	-0.3301	-0.1027	-0.4441	-0.1382	0.2920	300.00	19.483
5.0	0.8682	1.1922	0.6219	0.8608	1.2746	-0.2914	-0.1306	-0.3929	-0.1761	0.3650	373.27	20.084
6.0	0.8891	1.1622	0.6172	0.8322	1.2121	-0.2626	-0.1539	-0.3661	-0.2145	0.4380	446.54	20.571
8.0	0.9185	1.0919	0.6325	0.8111	1.1251	-0.1895	-0.1859	-0.2744	-0.2692	0.5839	593.07	21.252
10.0	0.9375	1.0723	0.6185	0.7764	1.0676	-0.1185	-0.2188	-0.1786	-0.3299	0.7299	739.61	21.693
12.5	0.9485	1.0893	0.6439	0.8033	1.1232	-0.0282	-0.2608	-0.0402	-0.3718	0.9124	922.78	21.953
15.0	0.9501	1.1595	0.7201	0.8676	1.3078	0.0659	-0.3095	0.0790	-0.3707	1.0949	1105.95	21.997
20.0	0.9320	1.4273	0.7906	0.8947	1.7314	0.2743	-0.3458	0.2431	-0.3065	1.4599	1472.30	21.592

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 30. (MM)

WANDSCHUBSPANNUNG TAUW = 1.658 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.795 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.801 (M/S)

PROFILLAENGE (UMAX) YMAX = 14.540 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.7250	1.3782	0.6377	0.9046	1.5623	-0.3818	-0.0555	-0.4344	-0.0631	0.0894	102.62	16.638
1.5	0.7395	1.3618	0.6469	0.9124	1.5528	-0.3739	-0.0608	-0.4243	-0.0690	0.1032	117.34	16.985
1.7	0.7531	1.3552	0.6287	0.9132	1.5329	-0.3811	-0.0698	-0.4473	-0.0820	0.1169	132.06	17.308
2.0	0.7692	1.3536	0.6079	0.8848	1.4924	-0.3690	-0.0662	-0.4484	-0.0805	0.1376	154.14	17.691
2.5	0.7938	1.3299	0.5961	0.8701	1.4405	-0.3616	-0.0801	-0.4562	-0.1011	0.1719	190.93	18.268
3.0	0.8148	1.3177	0.5835	0.8577	1.4063	-0.3514	-0.0952	-0.4571	-0.1239	0.2063	227.73	18.760
4.0	0.8490	1.2586	0.6127	0.8850	1.3712	-0.3239	-0.0946	-0.4201	-0.1227	0.2751	301.32	19.554
5.0	0.8744	1.2154	0.6227	0.8654	1.3069	-0.3030	-0.1136	-0.4004	-0.1501	0.3439	374.91	20.142
6.0	0.8936	1.1736	0.6215	0.8365	1.2317	-0.2723	-0.1315	-0.3733	-0.1803	0.4127	448.51	20.585
8.0	0.9239	1.1030	0.6262	0.7961	1.1213	-0.2176	-0.1608	-0.3151	-0.2328	0.5502	595.69	21.286
10.0	0.9439	1.0686	0.6260	0.7828	1.0733	-0.1453	-0.1864	-0.2173	-0.2786	0.6878	742.87	21.750
12.5	0.9631	1.0742	0.6422	0.8027	1.1054	-0.0792	-0.2396	-0.1148	-0.3473	0.8597	926.85	22.197
15.0	0.9707	1.1300	0.6866	0.8435	1.2300	0.0117	-0.2983	0.0151	-0.3844	1.0316	1110.83	22.377
20.0	0.9595	1.3442	0.8001	0.9171	1.6440	0.2096	-0.3621	0.1949	-0.3367	1.3755	1478.79	22.133

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 35. (MM)

WANDSCHUBSPANNUNG TAUW = 1.687 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.795 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.800 (M/S)

PROFILLAENGE (UMAX) YMAX = 15.440 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.7279	1.3898	0.6833	0.8996	1.6038	-0.4333	-0.0411	-0.4562	-0.0432	0.0842	103.62	16.563
1.5	0.7423	1.3799	0.6678	0.9022	1.5821	-0.4184	-0.0504	-0.4540	-0.0547	0.0972	118.48	16.906
1.7	0.7553	1.3715	0.6768	0.9142	1.5875	-0.4163	-0.0484	-0.4485	-0.0522	0.1101	133.34	17.211
2.0	0.7723	1.3569	0.6917	0.9093	1.5732	-0.4078	-0.0358	-0.4345	-0.0382	0.1295	155.63	17.609
2.5	0.7991	1.3463	0.6686	0.9039	1.5383	-0.3945	-0.0515	-0.4382	-0.0572	0.1619	192.78	18.234
3.0	0.8170	1.3321	0.6204	0.8610	1.4503	-0.3814	-0.0586	-0.4616	-0.0709	0.1943	229.93	18.649
4.0	0.8492	1.2711	0.6673	0.8916	1.4279	-0.3657	-0.0621	-0.4311	-0.0733	0.2591	304.24	19.391
5.0	0.8760	1.2314	0.6654	0.8736	1.3612	-0.3310	-0.0716	-0.4039	-0.0874	0.3238	378.54	20.007
6.0	0.8960	1.1351	0.6685	0.8617	1.2970	-0.3049	-0.1099	-0.3849	-0.1387	0.3886	452.85	20.465
8.0	0.9272	1.1150	0.6627	0.8106	1.1697	-0.2463	-0.1362	-0.3333	-0.1843	0.5181	601.45	21.179
10.0	0.9484	1.0800	0.6414	0.7723	1.0871	-0.1760	-0.1456	-0.2540	-0.2102	0.6477	750.06	21.668
12.5	0.9703	1.0616	0.6596	0.7772	1.0830	-0.1082	-0.1959	-0.1545	-0.2798	0.8096	935.82	22.172
15.0	0.9794	1.1053	0.6814	0.7652	1.1358	-0.0238	-0.2396	-0.0316	-0.3181	0.9715	1121.58	22.387
20.0	0.9748	1.2790	0.8239	0.8655	1.5319	0.1586	-0.3630	0.1506	-0.3445	1.2953	1493.10	22.297

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 40. (MM)

WANDSCHUBSPANNUNG TAUW = 1.683 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.795 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.800 (M/S)

PROFILLAENGE (UMAX) YMAX = 16.460 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.7253	1.3851	0.6974	0.9240	1.6294	-0.4027	-0.0274	-0.4169	-0.0284	0.0790	103.51	16.521
1.5	0.7414	1.3722	0.6856	0.9400	1.6183	-0.3921	-0.0288	-0.4168	-0.0306	0.0911	118.35	16.903
1.7	0.7550	1.3665	0.6908	0.9391	1.6160	-0.4077	-0.0286	-0.4312	-0.0302	0.1033	133.20	17.223
2.0	0.7721	1.3617	0.6723	0.9058	1.5633	-0.3987	-0.0363	-0.4355	-0.0397	0.1215	155.46	17.625
2.5	0.7964	1.3473	0.6444	0.9012	1.5213	-0.3846	-0.0402	-0.4430	-0.0464	0.1519	192.57	18.192
3.0	0.8179	1.3270	0.6450	0.8998	1.4932	-0.3841	-0.0388	-0.4487	-0.0454	0.1823	229.69	18.691
4.0	0.8504	1.2922	0.6226	0.8771	1.4134	-0.3612	-0.0507	-0.4489	-0.0630	0.2430	303.91	19.439
5.0	0.8762	1.2484	0.6152	0.8847	1.3598	-0.3385	-0.0596	-0.4408	-0.0776	0.3038	378.14	20.034
6.0	0.8980	1.1971	0.6447	0.8359	1.3167	-0.3045	-0.0782	-0.3945	-0.1013	0.3645	452.36	20.533
8.0	0.9297	1.1276	0.6483	0.8018	1.1673	-0.2622	-0.0886	-0.3588	-0.1212	0.4860	600.81	21.260
10.0	0.9540	1.0706	0.6427	0.7959	1.0563	-0.2038	-0.1293	-0.2961	-0.1879	0.6075	749.26	21.819
12.5	0.9784	1.0454	0.6550	0.7752	1.0615	-0.1390	-0.1611	-0.2029	-0.2353	0.7594	934.82	22.381
15.0	0.9896	1.0525	0.6701	0.7588	1.0663	-0.0682	-0.2037	-0.0967	-0.2888	0.9113	1120.38	22.644
20.0	0.9915	1.1819	0.7568	0.8509	1.3468	0.0823	-0.3341	0.0920	-0.3735	1.2151	1491.50	22.702
25.0	0.9718	1.3166	0.9886	1.0286	1.8844	0.2356	-0.4055	0.1810	-0.3116	1.5188	1862.62	22.269

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 45. (MM)

WANDSCHUBSPANNUNG TAUW = 1.705 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.801 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.801 (M/S)

PROFILLAENGE (UMAX) YMAX = 17.640 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.7325	1.4045	0.6698	0.9671	1.6782	-0.4272	-0.0263	-0.4542	-0.0280	0.0737	103.94	16.574
1.5	0.7453	1.3882	0.6639	0.9467	1.6321	-0.4209	-0.0131	-0.4567	-0.0142	0.0850	118.85	16.877
1.7	0.7593	1.3815	0.6827	0.9391	1.6282	-0.4193	-0.0133	-0.4446	-0.0141	0.0964	133.75	17.203
2.0	0.7774	1.3825	0.6484	0.9214	1.5903	-0.4299	-0.0183	-0.4796	-0.0204	0.1134	156.12	17.627
2.5	0.8011	1.3659	0.6351	0.9137	1.5519	-0.4047	-0.0290	-0.4665	-0.0334	0.1417	193.38	18.176
3.0	0.8203	1.3511	0.6100	0.8818	1.4877	-0.4066	-0.0279	-0.4933	-0.0339	0.1701	230.65	18.618
4.0	0.8529	1.3136	0.6026	0.8810	1.4325	-0.3782	-0.0339	-0.4777	-0.0429	0.2268	305.19	19.365
5.0	0.8804	1.2550	0.6646	0.8953	1.4091	-0.3736	-0.0226	-0.4479	-0.0272	0.2834	379.72	19.991
6.0	0.9001	1.2160	0.6453	0.8772	1.3323	-0.3418	-0.0392	-0.4356	-0.0499	0.3401	454.26	20.442
8.0	0.9336	1.1387	0.6584	0.8395	1.2174	-0.2966	-0.0503	-0.3957	-0.0671	0.4535	603.33	21.206
10.0	0.9605	1.0850	0.6414	0.7809	1.0993	-0.2493	-0.0728	-0.3582	-0.1045	0.5669	752.40	21.819
12.5	0.9826	1.0349	0.6391	0.7468	1.0187	-0.1853	-0.0991	-0.2802	-0.1498	0.7086	938.74	22.324
15.0	0.9969	1.0179	0.6272	0.7235	0.9765	-0.1228	-0.1346	-0.1924	-0.2109	0.8503	1125.08	22.657
20.0	1.0061	1.0979	0.6929	0.7457	1.1209	0.0052	-0.2336	0.0069	-0.3070	1.1338	1497.76	22.882
25.0	0.9947	1.2732	0.8141	0.8257	1.4828	0.1532	-0.3453	0.1478	-0.3332	1.4172	1870.44	22.639

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 50. (MM)

WANDSCHUBSPANNUNG TAUW = 1.698 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.787 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.800 (M/S)

PROFILLAENGE (UMAX) YMAX = 19.000 (MM)

Y (MM)	U UREF	U' U*	V' U*	W' U*	K' (U*)**2	U'V' (U*)**2	U'W' (U*)**2	U'V' U'*V'	U'W' U'*W'	Y YMAX	Y+	U+
1.3	0.7306	1.3967	0.6615	0.9796	1.6739	-0.3985	0.0049	-0.4313	0.0053	0.0684	103.68	16.562
1.5	0.7452	1.3888	0.6526	0.9814	1.6590	-0.3905	0.0010	-0.4309	0.0012	0.0789	118.55	16.909
1.7	0.7573	1.3815	0.6697	0.9572	1.6366	-0.4142	0.0136	-0.4478	0.0147	0.0895	133.42	17.192
2.0	0.7748	1.3696	0.6914	0.9605	1.6382	-0.4130	0.0036	-0.4361	0.0038	0.1053	155.73	17.601
2.5	0.8001	1.3665	0.6540	0.9236	1.5740	-0.4182	0.0075	-0.4680	0.0084	0.1316	192.90	18.189
3.0	0.8196	1.3458	0.6456	0.9200	1.5371	-0.4026	0.0036	-0.4634	0.0042	0.1579	230.08	18.640
4.0	0.8525	1.3044	0.6439	0.9103	1.4724	-0.3910	0.0111	-0.4656	0.0133	0.2105	304.43	19.395
5.0	0.8799	1.2559	0.6602	0.9324	1.4412	-0.3628	0.0004	-0.4375	0.0005	0.2632	378.78	20.021
6.0	0.8997	1.2179	0.6544	0.9126	1.3722	-0.3477	0.0010	-0.4362	0.0012	0.3158	453.13	20.472
8.0	0.9331	1.1491	0.6480	0.8401	1.2230	-0.3165	-0.0147	-0.4251	-0.0197	0.4211	601.83	21.236
10.0	0.9619	1.0866	0.6427	0.8007	1.1175	-0.2686	-0.0345	-0.3846	-0.0495	0.5263	750.54	21.895
12.5	0.9848	1.0292	0.5984	0.7524	0.9917	-0.2036	-0.0598	-0.3305	-0.0971	0.6579	936.41	22.419
15.0	1.0020	0.9811	0.6263	0.7276	0.9421	-0.1539	-0.0711	-0.2505	-0.1157	0.7895	1122.29	22.818
20.0	1.0182	1.0005	0.6681	0.7201	0.9830	-0.0321	-0.1548	-0.0480	-0.2315	1.0526	1494.05	23.203
25.0	1.0157	1.1282	0.7346	0.7689	1.2019	0.0718	-0.2507	0.0867	-0.3025	1.3158	1865.80	23.163

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 55. (MM)

WANDSCHUBSPANNUNG TAUW = 1.680 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.772 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.802 (M/S)

PROFILLAENGE (UMAX) YMAX = 20.620 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.7344	1.4139	0.6529	0.8986	1.6165	-0.3869	-0.0025	-0.4191	-0.0028	0.0630	101.68	16.714
1.5	0.7504	1.4165	0.6251	0.8802	1.5861	-0.3867	-0.0053	-0.4367	-0.0060	0.0727	116.26	17.091
1.7	0.7626	1.4059	0.6290	0.8911	1.5831	-0.3906	-0.0081	-0.4417	-0.0092	0.0824	130.84	17.380
2.0	0.7796	1.3978	0.6326	0.8800	1.5642	-0.3875	-0.0173	-0.4382	-0.0195	0.0970	152.72	17.779
2.5	0.8023	1.3813	0.6110	0.8814	1.5291	-0.3863	-0.0107	-0.4578	-0.0126	0.1212	189.18	18.311
3.0	0.8239	1.3660	0.6178	0.8915	1.5213	-0.3883	-0.0188	-0.4600	-0.0223	0.1455	225.63	18.811
4.0	0.8571	1.3359	0.5848	0.8635	1.4405	-0.3675	-0.0097	-0.4704	-0.0124	0.1940	298.55	19.577
5.0	0.8831	1.2838	0.6178	0.8918	1.4125	-0.3589	-0.0034	-0.4525	-0.0042	0.2425	371.46	20.172
6.0	0.9019	1.2393	0.6400	0.8614	1.3437	-0.3463	-0.0141	-0.4367	-0.0178	0.2910	444.38	20.606
8.0	0.9348	1.1608	0.6337	0.8231	1.2133	-0.3060	-0.0225	-0.4160	-0.0306	0.3880	590.21	21.359
10.0	0.9654	1.0939	0.6283	0.8071	1.1214	-0.2568	-0.0272	-0.3736	-0.0396	0.4850	736.03	22.060
12.5	0.9908	1.0348	0.5766	0.7344	0.9712	-0.2113	-0.0404	-0.3542	-0.0677	0.6062	918.32	22.645
15.0	1.0100	0.9779	0.5792	0.7186	0.9041	-0.1591	-0.0661	-0.2810	-0.1167	0.7274	1100.61	23.091
20.0	1.0292	0.9310	0.6142	0.6909	0.8607	-0.0547	-0.1082	-0.0956	-0.1892	0.9699	1465.18	23.543
25.0	1.0316	0.9953	0.6649	0.7218	0.9768	0.0454	-0.1689	0.0686	-0.2552	1.2124	1829.75	23.617
30.0	1.0206	1.1366	0.7133	0.7596	1.1889	0.1479	-0.2359	0.1824	-0.2910	1.4549	2194.32	23.385

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 60. (MM)

WANDSCHUBSPANNUNG TAUW = 1.676 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.776 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.802 (M/S)

PROFILLAENGE (UMAX) YMAX = 22.700 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.7326	1.4262	0.5984	0.3889	1.5911	-0.3696	-0.0039	-0.4330	-0.0046	0.0573	101.59	16.689
1.5	0.7478	1.4122	0.6045	0.8915	1.5772	-0.3579	0.0066	-0.4193	0.0077	0.0661	116.16	17.050
1.7	0.7596	1.4020	0.6452	0.9039	1.5995	-0.3804	-0.0105	-0.4205	-0.0116	0.0749	130.73	17.330
2.0	0.7770	1.3970	0.6275	0.8905	1.5693	-0.3815	0.0030	-0.4352	0.0034	0.0881	152.59	17.737
2.5	0.8021	1.3818	0.6142	0.9041	1.5520	-0.3863	0.0045	-0.4551	0.0053	0.1101	189.02	18.323
3.0	0.8203	1.3603	0.6277	0.8919	1.5200	-0.3782	-0.0068	-0.4430	-0.0080	0.1322	225.44	18.747
4.0	0.8533	1.3286	0.6102	0.8984	1.4724	-0.3555	0.0159	-0.4385	0.0196	0.1762	298.29	19.508
5.0	0.8779	1.2668	0.6589	0.9198	1.4424	-0.3609	0.0039	-0.4324	0.0047	0.2203	371.15	20.074
6.0	0.9004	1.2392	0.6514	0.9009	1.3859	-0.3407	0.0182	-0.4221	0.0225	0.2643	444.00	20.591
8.0	0.9326	1.1608	0.6389	0.8422	1.2324	-0.3106	0.0146	-0.4189	0.0198	0.3524	589.70	21.330
10.0	0.9638	1.0963	0.6273	0.8018	1.1191	-0.2734	0.0191	-0.3976	0.0278	0.4405	735.41	22.047
12.5	0.9878	1.0234	0.5914	0.7648	0.9911	-0.2167	-0.0016	-0.3579	-0.0027	0.5507	917.54	22.598
15.0	1.0076	0.9585	0.5857	0.7368	0.9023	-0.1724	-0.0069	-0.3071	-0.0123	0.6608	1099.67	23.059
20.0	1.0322	0.8840	0.5878	0.6874	0.7997	-0.0818	-0.0386	-0.1575	-0.0743	0.8811	1463.93	23.637
25.0	1.0381	0.8856	0.6595	0.6918	0.8489	0.0204	-0.0788	0.0349	-0.1350	1.1013	1828.19	23.791
30.0	1.0333	0.9832	0.6747	0.7254	0.9741	0.0911	-0.1041	0.1373	-0.1570	1.3216	2192.45	23.700

VERSUCH NR. 1[illegible] (WANDKANAL)

DATUM 26.05.1976

POSITION 65. (MM)

WANDSCHUBSPANNUNG TAUW = 1.682 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.786 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.794 (M/S)

PROFILLAENGE (UMAX) YMAX = 26.000 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.7285	1.4108	0.6247	0.8634	1.5631	-0.4709	0.0815	-0.5343	0.0924	0.0500	106.50	16.655
1.5	0.7427	1.4093	0.5733	0.8467	1.5158	-0.4614	0.0886	-0.5711	0.1097	0.0577	121.77	16.993
1.7	0.7555	1.3930	0.6165	0.8500	1.5215	-0.4520	0.0692	-0.5263	0.0806	0.0654	137.05	17.297
2.0	0.7716	1.3819	0.6330	0.8556	1.5212	-0.4560	0.0766	-0.5213	0.0876	0.0769	159.96	17.677
2.5	0.7958	1.3811	0.5896	0.8513	1.4899	-0.4438	0.0767	-0.5450	0.0942	0.0962	198.15	18.242
3.0	0.8164	1.3647	0.5518	0.8425	1.4383	-0.4370	0.0859	-0.5804	0.1141	0.1154	236.33	18.721
4.0	0.8476	1.3290	0.5863	0.8406	1.4033	-0.4243	0.0843	-0.5445	0.1082	0.1538	312.70	19.442
5.0	0.8744	1.2832	0.6033	0.8619	1.3767	-0.4074	0.0904	-0.5263	0.1168	0.1923	389.07	20.062
6.0	0.8961	1.2371	0.6463	0.8515	1.3366	-0.3939	0.0885	-0.4927	0.1107	0.2308	465.45	20.560
8.0	0.9275	1.1585	0.6528	0.8129	1.2145	-0.3564	0.0838	-0.4713	0.1108	0.3077	618.19	21.285
10.0	0.9564	1.0976	0.6025	0.7730	1.0626	-0.3036	0.0885	-0.4591	0.1339	0.3846	770.93	21.948
12.5	0.9817	1.0300	0.5678	0.7218	0.9521	-0.2511	0.0698	-0.4294	0.1194	0.4808	961.86	22.536
15.0	1.0015	0.9529	0.5727	0.7108	0.8706	-0.2008	0.0632	-0.3679	0.1158	0.5769	1152.79	22.996
20.0	1.0273	0.8611	0.5825	0.6719	0.7661	-0.1160	0.0424	-0.2313	0.0846	0.7692	1534.65	23.605
25.0	1.0373	0.8540	0.5787	0.6376	0.7354	-0.0250	0.0271	-0.0506	0.0549	0.9615	1916.50	23.856
30.0	1.0321	0.8946	0.6282	0.6881	0.8342	0.0504	-0.0000	0.0896	-0.0001	1.1538	2298.36	23.757
35.0	1.0223	1.0013	0.6304	0.7031	0.9472	0.1128	-0.0390	0.1787	-0.0618	1.3462	2680.22	23.553

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 70. (MM)

WANDSCHUBSPANNUNG TAUW = 1.680 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.786 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.794 (M/S)

PROFILLAENGE (UMAX) YMAX = 28.200 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.7232	1.4045	0.6335	0.8870	1.5804	-0.4437	0.0905	-0.4986	0.1017	0.0461	106.42	16.545
1.5	0.7370	1.3914	0.6391	0.8672	1.5482	-0.4494	0.0795	-0.5054	0.0893	0.0532	121.69	16.875
1.7	0.7510	1.3895	0.6149	0.8670	1.5302	-0.4283	0.0758	-0.5013	0.0888	0.0603	136.95	17.205
2.0	0.7659	1.3776	0.6162	0.8381	1.4899	-0.4478	0.0710	-0.5275	0.0836	0.0709	159.84	17.557
2.5	0.7906	1.3590	0.6193	0.8545	1.4802	-0.4344	0.0904	-0.5161	0.1074	0.0887	198.00	18.137
3.0	0.8109	1.3625	0.5869	0.8303	1.4452	-0.4290	0.0732	-0.5366	0.0916	0.1064	236.16	18.610
4.0	0.8427	1.3238	0.5879	0.8410	1.4027	-0.4095	0.0788	-0.5262	0.1013	0.1418	312.48	19.345
5.0	0.8683	1.2832	0.6015	0.8372	1.3547	-0.3959	0.0811	-0.5130	0.1051	0.1773	388.79	19.937
6.0	0.8892	1.2321	0.6519	0.8479	1.3310	-0.3888	0.0919	-0.4840	0.1144	0.2128	465.11	20.419
8.0	0.9242	1.1624	0.6636	0.8082	1.2224	-0.3573	0.1048	-0.4632	0.1358	0.2837	617.74	21.223
10.0	0.9533	1.1085	0.5952	0.7546	1.0762	-0.3062	0.0982	-0.4641	0.1488	0.3546	770.38	21.895
12.5	0.9787	1.0322	0.5630	0.7035	0.9422	-0.2511	0.0992	-0.4320	0.1707	0.4433	961.17	22.482
15.0	0.9984	0.9634	0.5710	0.7003	0.8723	-0.2042	0.0889	-0.3712	0.1617	0.5319	1151.96	22.942
20.0	1.0214	0.8696	0.5746	0.6518	0.7556	-0.1138	0.0969	-0.2277	0.1939	0.7092	1533.54	23.487
25.0	1.0323	0.8561	0.5760	0.6314	0.7317	-0.0289	0.0876	-0.0586	0.1776	0.8865	1915.12	23.758
30.0	1.0293	0.8984	0.6062	0.6502	0.7987	0.0390	0.0823	0.0717	0.1511	1.0638	2296.70	23.709
35.0	1.0200	0.9758	0.6226	0.6876	0.9063	0.1035	0.0718	0.1704	0.1182	1.2411	2678.29	23.517

VERSUCH NR. 16 (WANDKANAL)

DATUM 26.05.1976

POSITION 77. (MM)

WANDSCHUBSPANNUNG TAUW = 1.682 (N/M**2)

BEZUGSWERTE

REFERENZGESCHWINDIGKEIT UREF = 27.762 (M/S)

SCHUBSPANNUNGSGESCHWINDIGKEIT U* = 1.795 (M/S)

PROFILLAENGE (UMAX) YMAX = 29.200 (MM)

Y (MM)	U / UREF	U' / U*	V' / U*	W' / U*	K' / (U*)**2	U'V' / (U*)**2	U'W' / (U*)**2	U'V' / U'*V'	U'W' / U'*W'	Y / YMAX	Y+	U+
1.3	0.7193	1.4009	0.5613	0.8446	1.4954	-0.3876	0.0928	-0.4929	0.1181	0.0445	105.30	16.423
1.5	0.7334	1.3859	0.5632	0.8702	1.4976	-0.3668	0.0805	-0.4699	0.1032	0.0514	120.41	16.759
1.7	0.7459	1.3864	0.5504	0.8579	1.4805	-0.3810	0.0948	-0.4993	0.1242	0.0582	135.51	17.055
2.0	0.7625	1.3797	0.5270	0.8450	1.4477	-0.3639	0.0941	-0.5005	0.1295	0.0685	158.16	17.444
2.5	0.7853	1.3649	0.5225	0.8504	1.4296	-0.3658	0.0979	-0.5129	0.1372	0.0856	195.92	17.977
3.0	0.8064	1.3515	0.5301	0.8388	1.4055	-0.3529	0.0972	-0.4926	0.1357	0.1027	233.68	18.468
4.0	0.8378	1.3156	0.5288	0.8584	1.3738	-0.3478	0.0989	-0.4999	0.1421	0.1370	309.19	19.193
5.0	0.8631	1.2710	0.5780	0.8669	1.3505	-0.3345	0.1084	-0.4553	0.1475	0.1712	384.70	19.775
6.0	0.8850	1.2311	0.5890	0.8528	1.2949	-0.3191	0.1163	-0.4401	0.1603	0.2055	460.22	20.280
8.0	0.9173	1.1576	0.5914	0.7970	1.1624	-0.2850	0.1212	-0.4162	0.1771	0.2740	611.24	21.022
10.0	0.9432	1.0984	0.5641	0.7653	1.0552	-0.2517	0.1284	-0.4062	0.2072	0.3425	762.27	21.618
12.5	0.9707	1.0369	0.5255	0.7333	0.9445	-0.1949	0.1374	-0.3578	0.2521	0.4281	951.05	22.253
15.0	0.9889	0.9792	0.5325	0.7041	0.8690	-0.1525	0.1442	-0.2925	0.2766	0.5137	1139.83	22.677
20.0	1.0097	0.9140	0.5707	0.6561	0.7958	-0.0676	0.1575	-0.1296	0.3020	0.6849	1517.40	23.169
25.0	1.0166	0.9289	0.6112	0.6451	0.8262	0.0222	0.1799	0.0392	0.3168	0.8562	1894.97	23.348
30.0	1.0121	0.9923	0.6316	0.6607	0.9100	0.0955	0.1898	0.1525	0.3029	1.0274	2272.54	23.264