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THREE-DIMENSIONAL TURBULENT BOUNDARY LAYERS- DATA SETS FOR TWO-SPACE COORDINATE FLOWS

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Prepared from work sponsored by
NASA-NgL-05-020-420

Report MD-32

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Abstract

Seventeen sets of data (flows) from eight original sources on three-dimensional turbulent boundary layers have been reevaluated and tabulated in a common format. The flows studied were all of the type describable in only two space coordinates, e.g., flow over a swept wing of infinite span. The principal data in each set are profiles of the main and crossflow components of mean velocity. Turbulent shear stress vector profiles were available for two flows, Bradshaw and Terrell (1969) and Johnston (1970). Free stream pressure gradient, wall shear stress coefficient and angle, integral thickness and left and right hand sides of the momentum integral equations were evaluated in a consistent manner for each flow.

CONTENTS

NOMENCLATURE

A	Constant in law of the wall, general constant where defined
C_f	Normalized wall shear stress, $\tau_w/(\rho Q_\infty^2/2)$
C_{fs}	Normalized wall shear stress component in direction of external streamline, $\tau_{ws}/(\rho Q_\infty^2/2)$
H	Shape factor
P	Static pressure
Q	Wall parallel velocity magnitude
$\vec{Q}$	Wall parallel velocity vector
Q_τ	Shear velocity
r	Radial coordinate in r-θ-z cylindrical coordinate system
R	Local radius in radial vaneless diffuser
R_θ	Momentum thickness Reynolds number
R_{δ_1}	Displacement thickness Reynolds number
U	Component of velocity in x direction
U_s	Wall-parallel component of velocity in direction of external streamline
U_τ	Shear velocity in two-dimensional flow
$U_{\tau s}$	Streamwise shear velocity = $Q_\tau \sqrt{\cos\beta_w}$
V	Component of velocity normal to wall
$-\overline{v'w'}$	Reynolds stress in z direction
W	Component of velocity in z direction
W_s	Wall-parallel component of velocity normal to external streamline
x	Surface coordinate in direction of pressure gradient
$\tilde{x}$	Generalized independent variable
y	Coordinate normal to wall

$\tilde{y}$	Generalized dependent variable
$y+$	$= y\, Q_\tau/\nu$
z	Surface coordinate normal to x

Greek Letters

β	Angle of $\vec{Q}$ relative to external streamline
β_w	Angle of limiting wall streamline and wall shear stress relative to external flow direction
λ	Angle of Q relative to x axis
δ_{995}	Value of y where $Q/Q_\infty = 0.995$
δ_1	Two-dimensional displacement thickness, Eq. 1
δ_2	Integral parameter, Eq. 1
ζ	Surface coordinate normal to η
η	Surface coordinate in direction of external streamline
θ	Coordinate in r-θ-z cylindrical coordinate system
θ_{11}	Momentum thickness in two-dimensions, Eq. 1
θ_{12}	Integral parameter, Eq. 1
θ_{22}	Integral parameter, Eq. 1
κ	Karman constant, 0.41 in present work
ν	Kinematic viscosity
ρ	Density
τ_c	Shear stress in ζ direction
τ_s	Shear stress in η direction
τ_x	Shear stress in x direction
τ_z	Shear stress in y direction
ψ	Direction of external streamline relative to x axis
$\frac{\partial \hat{\theta}_{12}}{\partial x}$	Cross flow integral parameter on plane of symmetry

Subscripts

i	Inlet
∞	In free stream
w	At wall

INTRODUCTION

During the course of a program of evaluating prediction methods for three dimensional turbulent boundary layers, Wheeler and Johnston (1971), a significant quantity of experimental data was examined and recomputed. This volume is a summary of this data reevaluation work. It is similar in concept to the work of Coles and Hirst (1969) on two-dimensional turbulent boundary layers.

The documentation of 68 experimental flows* was first examined for completeness of the data sets. This work is summerized in Table 1. In some flows, vital information such as the free-stream pressure field is not adequately presented and hence the data is of little value for comparison to prediction methods. Of the experimental flows shown in Table 1, it is estimated that no more than 34 will be potentially useful and in all probability, less than 18 will actually be found of value.

There exists a subset of the flows shown in Table 1 which are particularly simple in that the three-component velocity profile development can be described using only two independent space coordinates rather than the more general three coordinates. These flows are:

1. Infinite swept wing flows (flow unchanging along span)
2. Radial vaneless diffusers (axially symmetric)
3. Rotating discs or cylinders (axially symmetric)
4. Plane of symmetry of symmetrical wing-body junctions

For the better quality flows of this two-space coordinate subset, detailed recomputation of relevant flow parameters has been performed. This recomputation consisted of estimating the free-stream pressure gradient from the experimental values of free-stream velocity, estimation of the wall shear stress magnitude from two different fits of the data to the "law of the wall", estimation of the wall shear stress direction, and computation of a set of integral parameters from the velocity profiles. In addition, an attempt was made to see how well the data satisfied the three-dimensional momentum integral equations. Finally, the computed results were tabulated in a consistent format.

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* A flow is an individual and distinctive run from a given source.

The flows reevaluated here did not include the special subgroup of our subset where the free stream simply converges or diverges and the velocity profiles remain everywhere collateral, see: Kehl (1943), Pierce (1964) and Crabbe (1971). A very recent data set of the rotating cylinder type,Bissonnette and Mellor (1971), was not studied. The latter source may be of some value because it contains turbulence as well as mean flow data. The Horning and Joubert (1963) plane of symmetry flow was omitted because of lack of tabular pressure field data which was available for the other two wing-body junction cases, see Table 1.

Data reduction methods are described in the following section. For some quantities more than one method was used where an absolute decision on a "best" method could not be made. Next, a short section gives the basic nomenclature of the tabulated data sets, or flows, which follow. Each flow is separately numbered and each page of tabulated data can be located by its IDENT number.

The editors have commented on each flow to help the user decide whether or not the flow may be of value for prediction method testing. Our primary purpose here was to put most of the well documented flows of apparently good quality into a uniform,easy-to-use, tabular format. The screening was not as thorough as that of Coles and Hurst (1969) primarily because "laws of the wake" and "laws of the wall" are yet to be clearly established for flows with skewed mean velocity profiles, the basic working data. Without such "laws" the final qualification and sorting of diverse data from different sources is nearly impossible. Decisions about the quality and accuracy of these data are thus much less certain than desirable and we have chosen not to eliminate some flows which may possibly, in future studies, be found defective. Additional comment on the flows may be found in Wheeler and Johnston (1971) where predictive methods were applied to flows 10, 14, 16, 18, 30, 32, 48, 50, 52 and 56.

DATA REDUCTION METHODS

Evaluation of Integral Parameters

A number of so called "integral parameters" appear in the integrated form of the boundary layer momentum equations. In terms of the streamline coordinate system in Figure 1 the integral parameters used by Cooke and Hall (1962) are:

$$\theta_{11} = \text{THET11} = \frac{1}{Q_\infty^2}\int_0^\delta (Q_\infty - U_s)U_s\,dy \qquad \delta_1 = \text{DELTA1} = \frac{1}{Q_\infty}\int_0^\delta (Q_\infty - U_s)\,dy$$

$$\theta_{12} = \text{THET12} = \frac{1}{Q_\infty^2}\int_0^\delta (Q_\infty - U_s)W_s\,dy \qquad \delta_2 = \text{DELTA2} = \frac{1}{Q_\infty}\int_0^\delta W_s\,dy \qquad (1)$$

$$\theta_{22} = \text{THET22} = \frac{1}{Q_\infty^2}\int_0^\delta W_s^2\,dy \qquad H = \delta_1/\theta_{11}$$

$$\theta_{21} = \frac{1}{Q_\infty^2}\int_0^\delta W_s U_s\,dy$$

Where δ is the boundary layer thickness.

A few integral parameters can in part represent the character of a complete velocity profile and so they are valuable even when differential prediction methods are to be compared to data. In the present work, each of these integral parameters has been evaluated from the experimental velocity profiles. All reported profile points have been used and no attempt has been made to smooth the profiles or remove obviously erroneous points.

The region between the wall and the first velocity data point away from the wall presents special problems. A linear variation of velocity (both streamwise and crossflow) from zero at the wall to the value at the first data point was assumed for evaluation of the integral parameters. In most flows, this wall region is small and different assumptions regarding the velocity distribution in this region cause variations in the final integral parameters of less than 1%. More sophicated velocity variations are not necessarily better since the first few velocities data points away from the wall are frequently inaccurate for various reasons, e.g.

probe interference effects. To really improve on our procedure, it is felt that one would have to use an inner layer function for the first three or four data points.

The actual integrations were performed using a parabolic integrating routine. A parabola of the form:

$$\tilde{y} = A + B\tilde{x} + C\tilde{x}^2 \qquad (2)$$

was fitted through three adjacent data points in the wall normal direction. $\tilde{x}$ represents the independent variable (e.g. y) and $\tilde{y}$ the dependent variable (e.g. U_s). The integration was then performed analytically along this parabola between the two points closest to the wall. Next the central point was moved one point outward and the intergration repeated step by step until $y = \delta$. This procedure has been checked by comparing its results to those obtained by intergrating analytic functions and also by comparing its results on actual data to integrations performed manually on the same data by use of a planimeter.

Estimation of the Pressure Gradient

In virtually all boundary layer experiments, it is the free stream pressure distribution(or velocity distribution) which is experimentally measured. On the other hand, it is the distribution of the gradient of pressure which is required in the momentum equations used for prediction methods. Differentiation of experimental data is a rather inaccurate process, partly because data is only supplied at discrete points and secondly because experimental scatter can produce apparent, but unreal variations in the gradient. It has been found that computer programs which differentiate data in which the gradients are large tend to be unreliable.

In the present program, a method similar to that used by Coles and Hirst (1969) has been used to differentiate the experimental velocity distributions. Here the free-stream velocity data is first plotted and then a smooth curve is faired through the data using french curves. The slope of the curve at discrete values of x is then obtained by using a front surfaced mirror which is attached to a drafting machine. The

mirror is placed on, and perpendicular to, the plot. It is then rotated about an axis normal to the paper until the image curve in the mirror is tangent to the real curve on the paper. The angle of the mirror relative to the ordinate of the plot can then be read from the drafting machine. To check the accuracy of this process for each curve, the derivatives are fed into a simple computer program which integrates the derivatives to recover the velocities again.

In general, it was found that the integrated velocities agreed with the faired experimental curves to within $\pm$ 0.5%. In some cases, adjustment of the derivatives were required to achieve this level of accuracy, however, the actual accuracy of the pressure gradients which result is not $\pm$ 0.5%. The actual fairing of the curve itself requires some judgment, particuarly if the data points are not close together or if there is significant experimental scatter. In addition, the pressure, or velocity, distribution itself is subject to experimental uncertainties. For the flows presented here the total effect of all effects may produce an uncertainty in the pressure gradient of $\pm$5% for low velocity flows (mainly the vaneless diffuser flows) and 1/2% at the higher (100-150 ft/sec) velocities of the other flows.

For each flow, we present a plot of the experimental free stream data. The curve shown on each plot was obtained by reintegrating the derivatives; although as has been mentioned, it deviates by an extremely small amount from the curve faired originally to obtain the velocity derivatives. In the case of flow 56, the pressure data rather than the velocities are plotted and the curves shown are those originally faired. In addition, for each flow, a table is presented which shows the derivatives of free stream velocity (or pressure) and values of velocity which correspond to the smooth curves. The velocity values which are presented in the tables with the integral parameters for each flow are the original experimental velocity data points.

Estimation of the Wall Shear Stress Magnitude

The wall shear stress magnitude has been evaluated by two different fits of the data to the "law of the wall" and by application of the Ludwieg and Tillmann shear stress equation. These three different wall

shear stress estimates can be better understood by examination of Fig. 1 which shows a three-dimensional velocity profile in a streamline coordinate system. The profile formed by the velocity components in the streamwise, or η, direction in many cases closely resemble a two-dimensional velocity profile. This resemblence leads one to assume that functional forms for the velocity profile which are good for two-dimensional flows will apply to the streamwise velocity profile in three-dimensional flows.

One possible form is the Ludwieg and Tillmann skin Friction equation is

$$C_{f_s} = 0.246 \quad e^{-1.561H} \quad R_\theta^{-0.268} \tag{3}$$

where H and $R_\theta = \theta_{11} Q_\infty / \nu$ are integral parameters. In three dimensions, it is assumed that the C_{f_s} obtained from equation 3 is the streamwise component of the wall shear stress.

$$C_{fs} = \text{CFSLT} = \tau_{ws} / \tfrac{1}{2} \rho Q_\infty^2$$

In two-dimensional flow, the law of the wall in the fully turbulent region is stated:

$$\frac{U}{U_\tau} = \frac{1}{\kappa} \ln \frac{y U_\tau}{\nu} + A \tag{4}$$

The constants κ and A have been assigned the values 0.41 and 5.0 to be consistent with the work of Coles and Hirst (1969). In three dimensions, it is assumed that equation (4) fits the inner portion of the fully turbulent streamwise velocity profile $(U=U_s)$ and that U_τ is

$$U_\tau = \sqrt{\tau_{ws}/\rho} = U_{\tau s} \tag{5}$$

Where τ_{ws} is the streamwise component of the wall shear stress. Cumpsty

(1968) concluded that the law of the wall does, to some extent, fit three-dimensional data when used in this way. The streamwise component of wall shear stress can be estimated by fitting equation (4) to the experimental velocity profile data in the region close to the wall (see below).

An alternate application of the law of the wall is to assume that the inner portion of the velocity magnitude, $Q = \sqrt{U_s^2 + W_s^2}$, profile follows the logarithmic law

$$\frac{Q}{Q_\tau} = \frac{1}{\kappa} \ln \frac{yQ_\tau}{\nu} + A \qquad (6)$$

In this case, Q_τ is $\sqrt{\tau_w/\rho}$ where τ_w is the wall shear stress magnitude. Some data, for example East and Hoxey (1969), indicate that the region in which the velocity magnitude can be logarithmically correlated is not as extensive as the log correlation region for the streamwise component of velocity. Nevertheless, a short logarithmic region does exist in the East and Hoxey data* so an estimate of the wall shear stress can be extracted. The data of East and Hoxey indicate that the wall shear stress so obtained is consistent with Preston tube measurements. Cumpsty (1968) concluded that all three methods described here give acceptable estimates of the wall shear stress.

In the tabulated data in this volume, CFSLT is the coefficient of the streamwise component of the wall shear stress based on equation 3. CFSLW is the coefficient of the streamwise component of the wall shear stress based on the streamwise velocity profile fit to the law of the wall, equation 4. CFMLW is the coefficient of the wall shear magnitude based on the fit of the velocity magnitude to the law of the wall, equation 6. $\rho Q_\infty^2/2$ is the common normalizing factor for each of these coefficients.

The procedure used to find the wall shear stress from the law of the wall is quite simple. Using a computer program, a U_τ or a

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* A more extensive region exists in the other data examined.

Q_τ value is calculated for each velocity profile data point by satisfing the law of the wall. These values of U_τ or Q_τ are then plotted versus the distance from the wall. If the law of the wall does in fact correlate the velocity profile over a range of y, then the correlating value of U_τ or Q_τ will be constant in this region. The values of U_τ and Q_τ from in the region where they are constant are the values used to compute CFSLW and CFMLW respectively. If no constant region is found, due either to experimental scatter or some other cause, the correlation is made at the point where yU_τ/ν or yQ_τ/ν has a value of 100.

Estimation of the Wall Shear Stress Direction

In turbulent flows, the flow right next to the wall is essentially laminar, and the direction of the limiting wall streamline(direction of the velocity an infinitesmal distance from the wall) is the same as the shear stress direction. Hence the direction of the wall shear stress can be estimated by extrapolating the direction of the mean velocity to the wall. Near the wall, in most flows, the velocity measurements are somewhat inaccurate and derivatives of velocity with respect to y are unreliable. It is thus risky to extrapolate the experimental velocity direction to the wall. In the present work, the direction of the shear stress has been approximated as the direction of the velocity at the first experimental data point away from the wall. In most cases, this first point is quite close to the wall and the approximation involved is not expected to be large.

An alternate method of estimating the direction of the wall shear stress was also tried. In this method, it was assumed that both methods of estimating the wall shear stress using the law (streamwise and magnitude) of the wall are valid. One method supplies the streamwise component of the wall shear stress, the other the magnitude. The shear stress direction is thus obtained from

$$\mathrm{Cos}\beta_w = \frac{U^2_{\tau s}}{Q^2_\tau} \qquad (7)$$

There are a number of basic objections to this method. In particular it has never been conclusively demonstrated that either Q_τ or $U_{\tau s}$ represent real wall shear velocity or its streamwise component. Furthermore, it can be shown that the two log law formulations are not compatible in the skewed regions of the velocity profiles where the profiles are fit to obtain Q_τ and $U_{\tau s}$. However, it was found that the shear stress directions achieved by this method appeared reasonable when compared to the directions of the velocity at the first mesh point. The accuracy of both methods is less than satisfactory. Direct measurements of wall shear stress angle would have been most welcome for many of the flows considered.

Momentum Integral Checks

It is possible to gain some insight into the accuracy of experimental boundary layer data by ascertaining if the data satisfies the momentum integral equations. Coles and Hirst did this with the experimental data which they prepared for the 1968 Stanford boundary layer conference. In the present work there are two applicable momentum integral equations which have been expressed in the fixed coordinates system shown in Figure 2. In this coordinate system, the x direction is oriented in the radial direction for axisymmetric flows and in the chordwise direction for infinite swept wing flows. The z axis is in the circumferential direction or spanwise direction respectively. For the plane of symmetry flows, the x axis is the surface coordinate in the plane of symmetry and the z axis is the surface coordinate normal to the plane of symmetry. For the infinite swept wing flows and the axially symmetric flows, the momentum integral equation in the x direction in terms of the integral parameters defined above is:

$$\frac{\partial}{\partial x}\left[(-C^2\theta_{11}-2CS\theta_{21} + S^2\theta_{22} + CS\delta_2)\ Q_\infty^2\right]$$

$$+\ Q_\infty^2\left[-C^2\theta_{11}-4CS\theta_{21} + (S^2 - C^2)\theta_{22} + CS\ \delta_2\right.$$

$$+S^2(\theta_{11} + \delta_1) - \left\{2(S^2\delta_1 - CS\delta_2)\right\} \Big/ (R_i+x)$$

$$-(CQ_\infty\delta_1 + SQ_\infty\delta_2)\frac{\partial Q_\infty C}{\partial x} = -0.5Q_\infty^2 C_{fs}(C-S(\tan\beta_w)) \qquad (8)$$

C and S are defined as

$$C = \cos\psi$$
$$S = \cos\psi$$

where $\psi = \gamma_\infty$ = the angle between the x axis and the external streamline. The term in brackets, $\{\}$, should only be used for rotating disc flows. C_{fs} is the streamwise skin friction coefficient based on a fit of the streamwise velocity profile to the law of the wall. The momentum equation in the z direction is:

$$\frac{\partial}{\partial x}\left[Q_\infty^2(-CS(\theta_{11} - \theta_{22}) + (C^2 - S^2)\theta_{21} + S^2\delta_2\right]$$

$$+2Q_\infty^2\left[CS(-\theta_{11} - \theta_{22}) + (C^2 - S^2)\theta_{21} + S^2\delta_2\right] \Big/ (R_i+x)$$

$$= -0.5Q_\infty^2 C_{fs}(S + C(\tan\beta_w)) \qquad (9)$$

For the plane of symmetry flows, only the momentum equation in the x direction has been evaluated. This equation is:

$$\frac{\partial\theta_{11}}{\partial x} + (2\theta_{11} + \delta_1)\frac{1}{Q_\infty}\frac{\partial Q_\infty}{\partial x} + \frac{\partial\hat{\theta}_{12}}{\partial z} = \frac{C_f}{2} \qquad (10)$$

where

$$\frac{\partial\hat{Q}_{12}}{\partial z} = \frac{1}{Q_\infty^2}\int_0^\delta \left[(Q_\infty - Q)\frac{\partial W}{\partial z}\right] dy \qquad (11)$$

For each flow, the left and right hand sides of the applicable momentum integral equations have been evaluated for each value of x where a velocity profile was measured. These left and right hand sides have been integrated from the start of each flow ($x=0$) to each value of x using the trapezoidal rule. After normalizing the left and right hand sides with the parameter

$$Pnorm = \int_0^x (-0.5Q_\infty^2 C_{fs}/\cos\beta_w)dx$$

The integrated left and right hand sides have been presented along with the integral parameters for each value of x. These left and right hand sides should be identical if the assumptions of the flow have been met and the data was taken accurately. The difference between the left and right hand sides indicates the accumulated error from the start of the flow to the value of x of interest.

An examination of the momentum integral balances in this volume will indicate that the left and right hand sides show poor agreement for most flows. The left hand side appears to be the erratic side in all cases. This is because the left hand side in adverse pressure gradient flows consists of the difference between two large terms. Thus, a small percentage error in one of the terms can produce a large percentage error in the total left hand side. For example, in one of the vaneless diffuser flows it was found that a 10% error in δ_1 would produce a 50% error in the left hand side. A part of the cause of the erratic behavior of the left hand sides is that, despite assumptions to the contrary, there are some spanwise or circumferential variations in the experimental flow. If the data were taken on the same external streamline, the boundary layer would appear to grow steadily and the parameterswould all show a smooth behavior with x. Unfortunately, in most flows, the profiles were not taken along the same external streamline and many of the integral parameters show a somewhat uneven behavior.

In summary, it should be emphasized that the momentum integral check applied in the manner described here is a very sensitive check and poor agreement between the left and right hand sides of the momentum equation does not necessarily condemn the data set.

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Number	AUTHOR(S) (REPORT DATE)	Reference or Free Stream Velocity (ft/sec)	Typical Unit Reynolds Number (ft^{-1})	Initial (Smallest) Boundary Layer Thickness (in.)	$U\theta_{11}/\nu$, Range or Characteristic Value	Free Stream Pressure Field	MEAN FLOW DATA: Velocity Profiles: Main Flow	Velocity Profiles: Cross Flow	Limiting Flow Angle at Wall	Integral Thickness Parameters: θ_{11}	Integral Thickness Parameters: δ_1^* or H_1	Integral Thickness Parameters: θ_{12} δ_2^* etc.	Wall Stress: Preston Tube	Wall Stress: Clauser Plot	TURBULENCE DATA: $\rho_{\overline{uv}}$	TURBULENCE DATA: $\frac{u}{U}_{rms}$	TURBULENCE DATA: $\frac{\overline{uv}}{\tau_w}$	TURBULENCE DATA: $\frac{\tau}{\tau_w}$	Number of Flows or Runs	Remarks See Table 2
	I.A. Swept Wing, Plate or Body (finite)																			
20	Kuethe, A.M., et.al. [1949]	74	4.65×10^5	0.5	2560	GA	GA	GA	IA	TA	TA	TA	NM	IA	NM	NM	NM	NM	1	
5	Brebner, G.C. and Wyatt, L.A. [1960]	200	1.3×10^6	0.1	NC	GS	TA	TA	IA	NC	NC	NC	NM	IA	NM	NM	NM	NM	7	
	I.B. Swept Wing, Plate or Body (infinite or approx. infinite span)																			
1	Altman, J.M. and Hayter, Nora-Lee [1951]	160	1×10^6	0.125	NC	GA	GS	GS	?	GA	GS	NR	NM	IS?	NM	NM	NM	NM	5	
3	Ashkenas, H. and Riddell, F.R. [1955]	?	2.5×10^5	0.4	800 3500	GA	GA	GS	IS	TA	TA	NC	NM	IA	NM	NM	NM	NM	2	
2	Ashkenas, H. [1958]	?	2.5×10^5	0.5	NC	GA	GA	NM	NM	TA	TA	NM	NM	GA	GA	GA	GA	NM	1	
26	Smith, P.D. [1966]	NR	NR	NR	NC	GA	NR	NR	GA	GA	GA	NR	NM	?	NM	NM	NM	NM	9	1
7	Cumpsty, N.A. and Head, M.R. [1969]	133	9.18×10^5	.162	1000 10000	TA	TA	TA	GA	TA	TA	TA	NM	GA	NM	NM	NM	NM	1	2
4	Bradshaw, P. and Terrell, M.G. [1969]	129	8.3×10^5	1.1	8000 9000	AZ	TA	TA	GA	NR	NR	NR	GA	GA	GS	GS	TA	TA	1	3
28	Swamy, N.V. [1969]	52.5	3.5×10^5	NR	NC	AZ	GS	GS	TA	NC	NC	NC	NM	TA	NM	NM	NM	NM	2	4
17	Johnston, J.P. [1970]	104	6.1×10^5	2.1	NC	TA	TA	TA	GA	NC	NC	NC	NM	GA	TS	TS	TS	TS	1	
	II. Wing-Body Junctions (layer on the body)																			
16	Johnston, J.P. [1957]	102	6×10^5	1.5	5500	TA	TA	TA	TA	TA	TA	TA	NM	TA	NM	NM	NM	NM	1	
14	Hornung, H.G. and Joubert, P.N. [1963]	50 80	3.5×10^5	4.8	NC	GA?	TA	TA	TA	IA	IA	IA	NM	GA	NM	NM	NM	NM	1	
8,9	East, L.F. and Hoxey, R.P., Parts 1 and 2 [1969]	200	10^6	5.0	50000	TA	TA	TA	IA	TA	TA	TA	TS	TS IA	NM	NM	NM	NM	1	

TABLE 1 SUMMARY OF DATA SOURCES, 1971

Number	AUTHOR(S) (REPORT DATE)	Reference or Free Stream Velocity (ft/sec)	Typical Unit Reynolds Number (ft^{-1})	Initial (Smallest) Boundary Layer Thickness (in.)	$U\theta_{11}/\nu$, Range or Characteristic Value	Free Stream Pressure Field	MEAN FLOW DATA									TURBULENCE DATA				Number of Flows or Runs	Remarks See Table IV
							Velocity Profiles		Limiting Flow Angle at Wall	Integral Thickness Parameters			Wall Stress								
							Main Flow	Cross Flow		θ_{11}	δ_1^* or H_1	θ_{12} δ_2^* etc.	Preston Tube	Clauser Plot	$\overline{q^2}$	$\overline{u_1^2}$	$\overline{-uv}$	λ_T		
	III. Vaneless Vortex Diffuser																				
11	Gardow,E.B.[1958]	41-67	?	0.2	360-4000?	TA	TA	TA	TS IA	TA	TA	TA	NM	IA	NM	NM	NM	NM	7	5,7
15	Jansen,W.[1959]	40-70	?	0.2	?	GA	GA	GA	IA	IA	IA	IA	NM	IA	NM	NM	NM	NM	3	
	IV. Curved Duct or Cascade (layer on end wall)																				
13	Gruschwitz,E.[1935]	43	2.24×10^5	0.4	1000	GA	GA	GA	IA	TA	TA	TA	NM	IA	NM	NM	NM	NM	1	
22	Mager,A.,et.al.[1952]	690	?	0.18	?	?	GS	GS	TA	TA	NR	NR	NM	IS	NM	NM	NM	NM	8	6
23	Moore,R.W.,Jr. and Richardson,D.L.[1955]	135	?	0.9	?	GA	GA	GA	IA	TA	TA	TA	NM	IA	NM	NM	NM	NM	1	7
10	Francis,G.P.[1965]	160	1.07×10^6	0.75	5800	GA	TA	TA	TA	TA	TA	TA	NM	TS IA	NM	TS	NM	NM	2	8
19	Klinksiek,W.F.[1967]	99	5.5×10^5	3.0	9000	?	TA	TA	IA	TA	TA	TA	NM	TA	NM	NM	NM	NM	1	9
21	Lewkowicz,A.K.[1965]	< 60	4×10^5	1.5	4000	GA	GA	GA	GA	GA	GA	GA	GA	GA	NM	NM	NM	NM		10
29	Wakhaloo,C.L.[1968]	< 65	3.5×10^5	0.4	1700	GA	GA	GA	GA	GA	GA	GA	GA	GA	NM	NM	NM	NM		10
	V. Rotating Bodies																				
12	Gregory,N.,et.al.[1955]	110	7×10^5	0.04	NC	AZ	GA	GA	IA	NC	NC	NC	NM	IA	NM	NM	NM	NM	2	
27	Stain,W.C.[1961]	100	10^6	NR	NR	AZ	GS	GS	GS	NC	NC	NC	NM	NR	NM	NM	NM			3
24	Parr,O.[1964]	?	4×10^5	0.6	NC	GA	GS	GS	IS	GA	GA	GA	NM	IS	NM	NM	NM	NM	2	
6	Cham,T.[1968]	76 230	4.6×10^5	0.24	1100 6000	AZ	GA	GA	IA	TA	TA	IA	NM	GA	NM	NM	NM	NM	3	
	VI. Collateral Layers in Converging or Diverging Flow (flat walls)																				
18	Kehl,A.[1943]	50 140	NC	0.6 2.3	2000 34000	IA	TA	NM	NM	GA	GA	NM	NM	IA	NM	NM	NM	NM	15	
25	Pierce,F.J.[1963]	NR	7.5×10^5	NR	4000 9000	NR	NR	NM	NM	GA	GA	NM	NM	IA	NM	NM	NM	NM	5	9

TABLE 1 (continued)

TABLE 2 - Key to Symbols and Remarks in Table 1

[A] Definition of Symbols

AZ - Assumed zero
GA - Graphical values given - all runs and/or profiles
GS - " " " - some " " " "
IA - May be inferred from given data - all runs and/or profiles
IS - " " " " " " - some " " " "
NC - Not calculated
NM - Not measured
NR - Not reported, may have been measured
TA - Tabulated values - all runs and/or profiles
TS - " " - some " " " "
? - No information, or considerable uncertainty indicated

[B] Numbered Remarks

1. Report suggests that complete data will be published at a later date.
2. Unpublished report obtained from authors.
3. Full data including all turbulence profile quantities in report which is not now in hand.
4. Only one profile given. Other integral data might be extracted with much effort. Source of moderate cross flows not clear.
5. Given integral parameters inaccurate, see Cham [1968].
6. Although flow at moderate subsonic Mach number, variations were small and density changes thought not to be important.
7. Value of ν for air at normal (room) pressure and temperature will probably suffice.
8. One-dimensional turbulence intensity measured along local mean flow direction.
9. Some question of completeness here as original data source not in hand.
10. Initial and normalizing conditions not given directly.

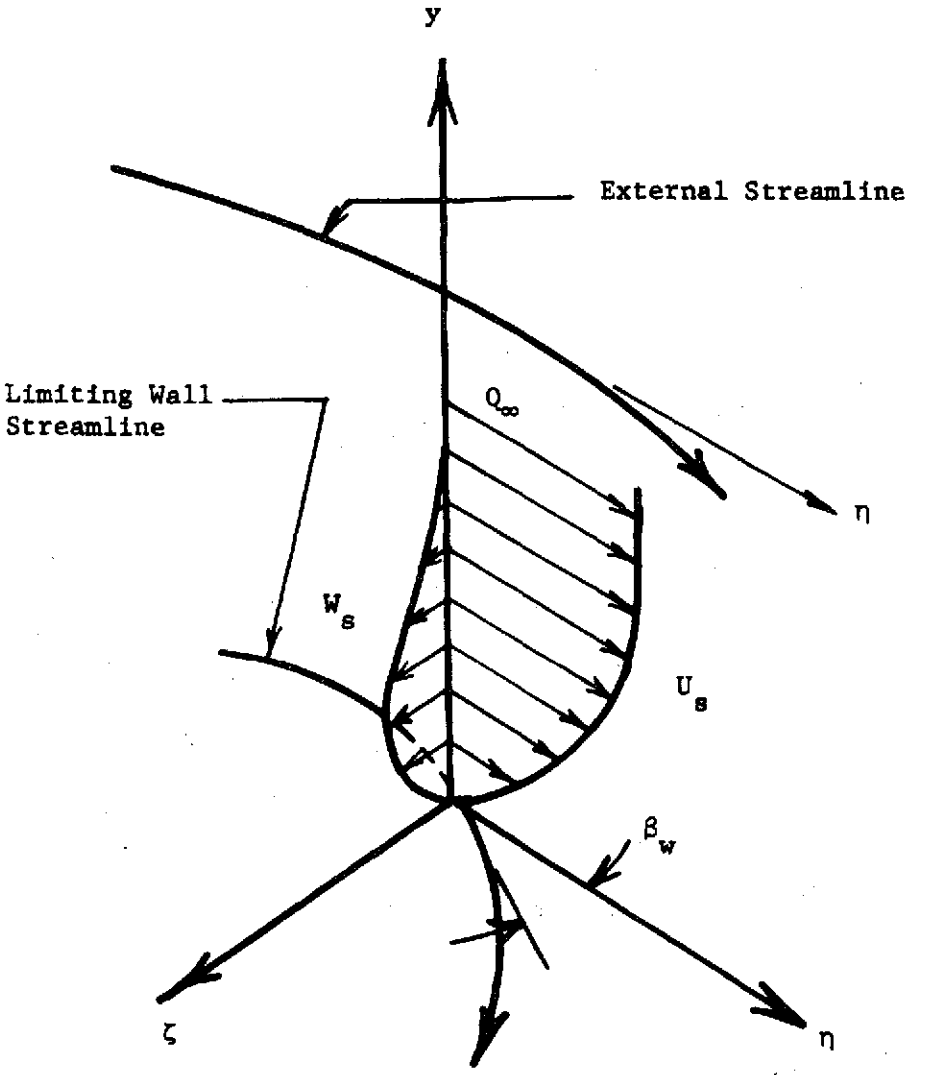


Figure 1 Three-Dimensional Wall-Parallel Velocity Components

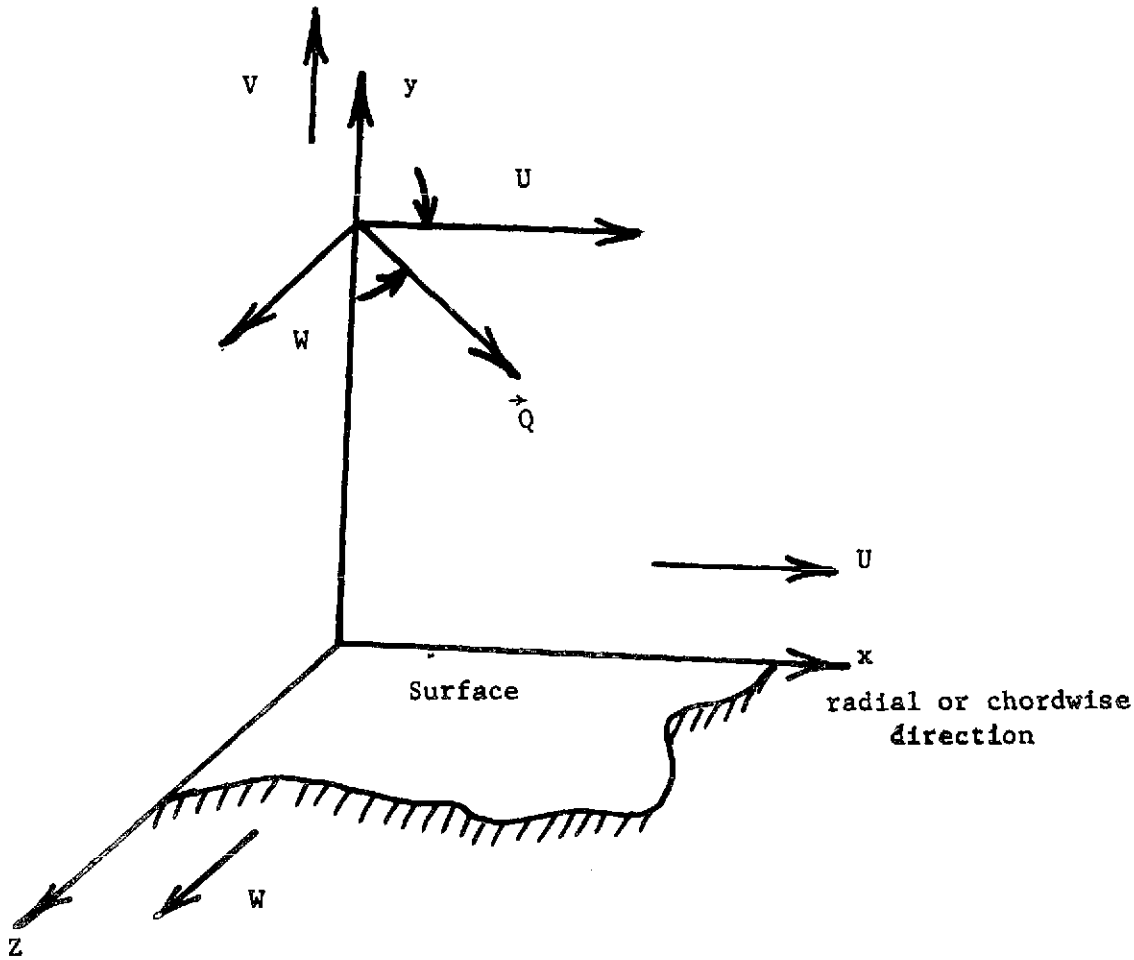


Figure 2 - x-y-z Coordinate System

PRESENTATION OF THE DATA

The following pages contain the results of the work on the data sets available to August 1971. Only one flow which was examined is not included. This is a vaneless diffuser flow due to Jansen (1959) in which the boundary layer completely filled the passage at all but the first profile station.

A brief description of each flow is presented including a sketch if it was considered useful. Any comments that the editors had about either the experiments or the data reduction are also listed. For each flow with non-zero pressure gradient, a tabulation of the velocity gradient and velocity based on the smoothed curves is presented. The free stream velocity data plot which was used for extraction of the pressure gradient is presented. Finally the tabulated integral and profile data for each flow is presented.

The nomenclature used in the data pages is as follows:

X — distance from the first profile in the chordwise or radial direction (or distance from first profile along surface in plane of symmetry).

RTHETA — Reynolds number based on momentum thickness, $Q_\infty \theta_{11}/\nu$

H — Streamwise shape factor, δ_1/θ_{11}

CFSLW — Coefficient of streamwise surface shear stress, based on fit of streamwise velocity profile to the law of the wall, $\tau_{ws}/\frac{1}{2}\rho Q_\infty^2$

CFMLW — Coefficient of the wall shear stress magnitude based on the fit of the velocity magnitude profile to the law of the wall, $\tau_w/\frac{1}{2}\rho Q_\infty^2$

CFSLT — Coefficient of streamwise wall shear stress based on Ludwieg and Tillmann formula, eq. (3)

BETAFP — Wall shear stress direction based on direction of velocity at first data point away from the wall, β_1, (degrees)

BETASF — Wall shear stress direction based on two fits to law of the wall, see eq. (7), (degrees)

DALTA1 — Displacement thickness, δ_1

THET11 — Momentum thickness, θ_{11}

DELTA2 Crossflow integral parameter, δ_2

THET22 Crossflow integral parameter, θ_{22}

THET21 Crossflow integral parameter, θ_{21}

THET12 Crossflow integral parameter, θ_{12}

PLX Integrated left hand side of momentum integral equation in x direction

PRX Integrated right hand side of momentum integral equation in x direction

PLT Integrated left hand side of momentum integral equation in z direction (spanwise or tangential direction)

PRT Integrated right hand side of momentum integral equation in z direction

QINF Free stream velocity magnitude supplied by originator, Q_∞

PSI Angle between external streamline and x axis, ψ or γ_∞ (degrees)

Y/TH11 y/θ_{11}

Y Distance from wall, y

US/QINF U_s, normalized on Q_∞

WS/QINF W_s, normalized on Q_∞

Y + (S) $yU_{\tau s}/\nu$, $U_{\tau s}$ basis same as CFSLW

US+ $U_s/U_{\tau s}$

Y + (M) yQ_τ/ν, Q_τ basis same as CFMLW

CFXLW Coefficient of wall shear stress based on fit of velocity profile to law of the wall for the plane of symmetry

$\tau_w/\frac{1}{2}\rho Q_\infty^2$

CFXLT Coefficient of wall shear stress based on the Ludwieg and Tillman formula for plane of symmetry, $\tau_w/\frac{1}{2}\rho Q_\infty^2$

THTWZZ $\partial\theta_{12}/\partial z$

WZ/WZINF $(\partial W/\partial z)/(\partial W_{\infty}/\partial z)$

Note: Kinematic viscosity given in (ft^2/sec) unless noted otherwise

TITLE: Gardow A-45.2 Vaneless Diffuser, Flow 10

REFERENCE: Gardow, E., "The three-dimensional turbulent boundary layer in a free vortex diffuser," MIT Gas Turbine Lab. Rept. 42, Jan. 1958

DESCRIPTION: The development of the turbulent boundary layer on one wall of a parallel walled, axially symmetric vaneless diffuser was measured, (Figure 10.1). The direction and magnitude of the velocity was measured with a three holed cobra probe (dimensions not given). No turbulence data was taken.

EDITORS' COMMENTS: The momentum Reynolds number of the first velocity profile is only 365 and the profile may not represent a fully turbulent flow. The boundary layer thicknesses at the last two values of x are 0.991 and 1.008 inches respectively. Assuming that the boundary layer on the other wall is of similar thickness, it is possible that the potential core no longer existed in this region. No value of the kinematic viscosity was supplied by the originator. Since it is known that the experiments were performed in room air, it has been assumed that the kinematic viscosity had a value of 0.000170 ft^2/sec.

PRESSURE GRADIENTS: (see Figure 10.2)

x feet	Q_∞ ft/sec	$\partial Q_\infty/\partial x$ sec^{-1}
-0.005	40.970	-27.84
0.095	38.367	-24.34
0.195	36.062	-21.60
0.295	34.092	-17.82
0.395	32.507	-14.16
0.495	31.193	-12.20
0.595	30.051	-10.72
0.695	29.028	-9.76
0.795	28.091	-8.94
0.895	27.258	-7.80
0.995	26.505	-7.20
1.095	25.837	-6.20
1.195	25.256	-5.44
1.295	24.743	-4.84
1.395	24.283	-4.36

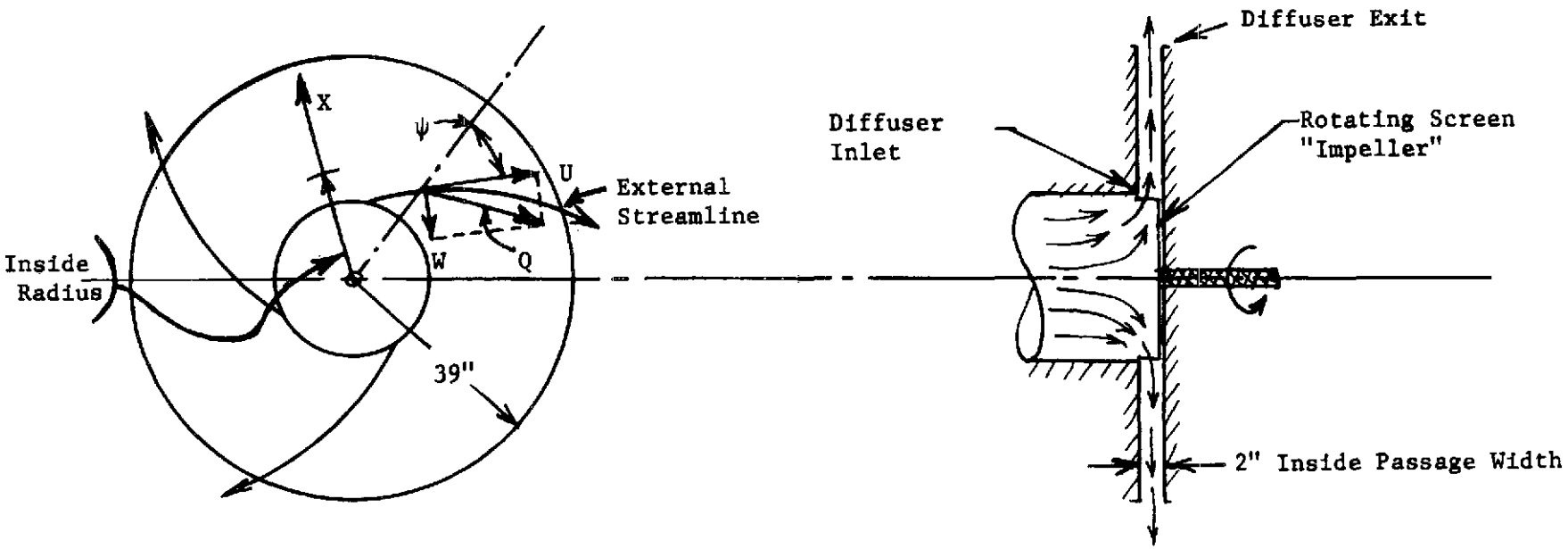


Figure 10.1 Gardow Vaneless Diffuser Test Rig

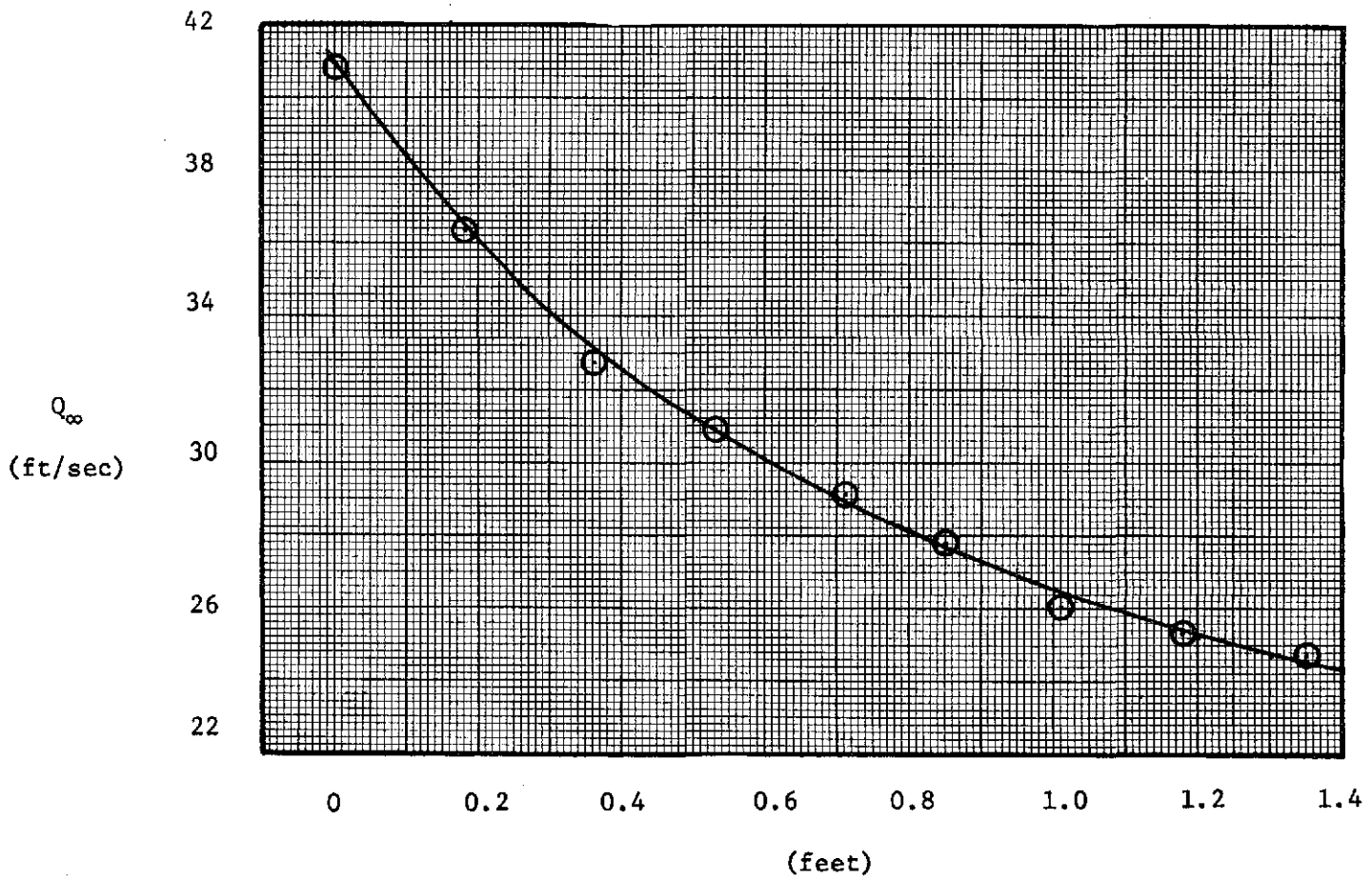


Figure 10.2 - Gardow A - 45.2 Q_∞ Distribution

GARDOW A-45.2, INLET R = 1.405 FT IDENT =10. KIN. VISC= 0.0001700

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	365.4	1.605	0.005400	0.004132	0.005451	6.98	7.85	0.002443	0.001522
0.18000	610.5	1.521	0.004755	0.004105	0.004809	12.04	8.58	0.004348	0.002859
0.36000	933.2	1.663	0.003562	0.002933	0.003719	14.25	16.68	0.008070	0.004852
0.53000	1081.1	1.622	0.003378	0.003007	0.003650	18.26	22.23	0.009647	0.005948
0.71000	1404.2	1.620	0.003123	0.002810	0.003289	20.63	18.23	0.013293	0.008203
0.85000	1501.2	1.648	0.002745	0.002643	0.002963	21.35	22.08	0.015131	0.009180
1.01000	1603.9	1.642	0.002504	0.002621	0.002841	21.51	28.20	0.017224	0.010487
1.19000	2015.7	1.645	0.002420	0.002455	0.002820	26.89	30.90	0.022278	0.013544
1.35000	2009.8	1.626	0.002655	0.002532	0.002959	25.97	26.17	0.022488	0.013833

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.000564	0.000029	0.000440	0.000124	0.000	0.000	0.000	0.000	40.80	45.2
0.18000	0.001231	0.000097	0.000896	0.000334	0.087	0.170	0.228	0.235	36.30	44.9
0.36000	0.002309	0.000220	0.001593	0.000716	0.163	0.274	0.482	0.399	32.70	44.4
0.53000	0.003545	0.000394	0.002472	0.001073	0.197	0.339	0.518	0.512	30.90	43.5
0.71000	0.004780	0.000599	0.003151	0.001629	0.329	0.393	0.765	0.615	29.10	42.4
0.85000	0.005804	0.000775	0.003824	0.001980	0.368	0.427	0.777	0.681	27.80	40.8
1.01000	0.006739	0.000893	0.004424	0.002316	0.245	0.460	0.819	0.741	26.00	39.6
1.19000	0.009732	0.001566	0.006185	0.003547	0.710	0.490	0.910	0.801	25.30	38.2
1.35000	0.009835	0.001546	0.006362	0.003473	0.488	0.515	0.988	0.855	24.70	39.0

GARCOW A-45.2, INLET R = 1.405 FT IDENT 10.

PROFILE NUMBER 2 X = 0.180 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.23	0.000667	0.43600	0.09300	6.94	8.94	6.98	9.09
0.29	0.000833	0.44700	0.09600	8.68	9.17	8.73	9.32
0.44	0.001250	0.51200	0.11000	13.01	10.50	13.09	10.68
0.58	0.001667	0.53900	0.10500	17.35	11.05	17.45	11.20
0.82	0.002333	0.59600	0.10600	24.29	12.22	24.43	12.35
1.11	0.003167	0.66400	0.10600	32.97	13.62	33.16	13.71
1.40	0.004000	0.69000	0.10800	41.65	14.15	41.88	14.24
1.69	0.004833	0.71100	0.09800	50.32	14.58	50.61	14.64
1.98	0.005666	0.71500	0.09000	59.00	14.66	59.33	14.70
2.27	0.006500	0.74200	0.08700	67.67	15.22	68.06	15.24
2.56	0.007333	0.75100	0.08000	76.35	15.40	76.78	15.40
2.86	0.008166	0.78900	0.07300	85.03	16.18	85.51	16.16
3.15	0.009000	0.80800	0.07200	93.70	16.57	94.23	16.54
3.73	0.010666	0.81800	0.06700	111.05	16.78	111.68	16.74
4.31	0.012333	0.85400	0.05100	128.41	17.51	129.13	17.45
4.60	0.013166	0.89100	0.04200	137.08	18.27	137.86	18.19
5.19	0.014833	0.91700	0.03400	154.43	18.81	155.31	18.71
5.77	0.016499	0.94000	0.02200	171.79	19.28	172.76	19.17
6.35	0.018166	0.95300	0.01300	189.14	19.54	190.21	19.44
7.81	0.022332	0.99500	0.00000	232.52	20.41	233.83	20.29
9.27	0.026499	1.00000	0.00000	275.90	20.51	277.46	20.39

GARDON A-45.2, INLET R = 1.405 FT IDENT 10.

PROFILE NUMBER 3 X = 0.360 FT

Y/THI1	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.14	0.000667	0.12600	0.03200	5.41	2.99	5.53	3.01
0.22	0.001083	0.25300	0.06400	8.79	5.99	8.99	6.05
0.31	0.001500	0.33800	0.08300	12.18	8.01	12.44	8.07
0.40	0.001917	0.45000	0.11000	15.56	10.66	15.90	10.74
0.48	0.002333	0.48700	0.12300	18.94	11.54	19.35	11.65
0.62	0.003000	0.52700	0.13000	24.35	12.49	24.88	12.59
0.79	0.003833	0.56100	0.13300	31.12	13.29	31.79	13.37
0.96	0.004667	0.57700	0.13400	37.88	13.67	38.71	13.74
1.13	0.005500	0.56900	0.12400	44.65	13.48	45.62	13.51
1.31	0.006333	0.60400	0.12400	51.41	14.31	52.53	14.30
1.48	0.007167	0.63800	0.12300	58.18	15.12	59.44	15.07
1.65	0.008000	0.64900	0.11900	64.94	15.38	66.35	15.30
1.99	0.009667	0.66700	0.11000	78.47	15.80	80.18	15.68
2.34	0.011333	0.70200	0.10200	92.00	16.63	94.00	16.45
2.68	0.013000	0.75600	0.09900	105.53	17.91	107.82	17.68
3.02	0.014667	0.76900	0.08900	119.06	18.22	121.65	17.95
3.37	0.016333	0.79200	0.07800	132.59	18.77	135.47	18.46
3.71	0.018000	0.81100	0.07100	146.12	19.22	149.29	18.88
4.14	0.020083	0.84700	0.05800	163.03	20.07	166.57	19.69
4.57	0.022167	0.88000	0.04600	179.94	20.85	183.85	20.44
5.43	0.026333	0.94000	0.02600	213.76	22.27	218.41	21.81
6.29	0.030500	0.95800	0.01000	247.59	22.70	252.97	22.22
7.15	0.034667	0.99600	0.00000	281.41	23.60	287.53	23.10
8.86	0.043000	1.00000	0.00000	349.06	23.70	356.65	23.19

GARDON A-45.2, INLET R = 1.405 FT IDENT 10.

PROFILE NUMBER 4 X = 0.530 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.11	0.000667	0.19700	0.06500	4.98	4.79	5.18	4.86
0.18	0.001083	0.29300	0.09600	8.09	7.13	8.41	7.22
0.25	0.001500	0.36500	0.12000	11.21	8.88	11.65	8.99
0.32	0.001917	0.38800	0.12600	14.32	9.44	14.88	9.55
0.39	0.002333	0.44000	0.14000	17.43	10.71	18.12	10.81
0.50	0.003000	0.49700	0.15300	22.41	12.09	23.29	12.17
0.64	0.003833	0.53500	0.16000	28.64	13.02	29.76	13.07
0.78	0.004666	0.52100	0.14900	34.86	12.68	36.23	12.69
0.92	0.005500	0.56700	0.15300	41.09	13.80	42.70	13.75
1.06	0.006333	0.58900	0.15300	47.31	14.33	49.17	14.25
1.20	0.007166	0.61600	0.15400	53.54	14.99	55.64	14.86
1.34	0.008000	0.62200	0.14800	59.76	15.13	62.12	14.97
1.49	0.008833	0.64800	0.14500	65.99	15.77	68.59	15.54
1.63	0.009666	0.63900	0.14100	72.21	15.55	75.06	15.32
1.77	0.010500	0.64400	0.13100	78.44	15.67	81.53	15.38
2.05	0.012166	0.65300	0.12200	90.89	15.89	94.47	15.55
2.33	0.013833	0.71100	0.12400	103.34	17.30	107.41	16.90
2.61	0.015499	0.74200	0.11700	115.79	18.05	120.35	17.58
2.89	0.017166	0.75600	0.10600	128.24	18.39	133.29	17.87
3.17	0.018833	0.78500	0.10400	140.69	19.10	146.23	18.54
3.87	0.022999	0.84400	0.08400	171.82	20.54	178.58	19.85
4.57	0.027166	0.90100	0.06000	202.94	21.92	210.93	21.14
5.27	0.031332	0.92700	0.03500	234.07	22.55	243.28	21.72
5.97	0.035499	0.94700	0.02500	265.20	23.04	275.64	22.18
6.67	0.039665	0.98600	0.00900	296.32	23.99	307.99	23.08
7.37	0.043832	0.98800	0.00700	327.45	24.04	340.34	23.13
8.77	0.052165	1.00000	0.00000	389.70	24.33	405.04	23.41

GARCOW A-45.2, INLET R = 1.405 FT IDENT 10.

PROFILE NUMBER 5 X = 0.710 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.08	0.000667	0.25500	0.09600	4.51	6.45	4.63	6.72
0.12	0.001000	0.31400	0.11800	6.76	7.95	6.94	8.27
0.17	0.001417	0.32000	0.12000	9.58	8.10	9.83	8.43
0.22	0.001833	0.36100	0.13400	12.40	9.13	12.72	9.50
0.27	0.002250	0.36100	0.13400	15.22	9.13	15.62	9.50
0.33	0.002667	0.44900	0.16700	18.04	11.36	18.51	11.81
0.38	0.003083	0.46400	0.17000	20.86	11.74	21.40	12.19
0.46	0.003750	0.49000	0.17400	25.37	12.40	26.03	12.82
0.56	0.004583	0.47700	0.16500	31.00	12.07	31.81	12.45
0.66	0.005416	0.51400	0.17200	36.64	13.01	37.60	13.37
0.76	0.006250	0.56000	0.18000	42.28	14.17	43.38	14.51
0.86	0.007083	0.54800	0.17300	47.91	13.87	49.16	14.17
0.97	0.007916	0.56600	0.17400	53.55	14.32	54.95	14.60
1.07	0.008750	0.58600	0.16900	59.19	14.83	60.73	15.04
1.17	0.009583	0.58000	0.16000	64.83	14.68	66.52	14.84
1.27	0.010416	0.62200	0.16700	70.46	15.74	72.30	15.88
1.37	0.011250	0.63300	0.16000	76.10	16.02	78.09	16.10
1.57	0.012916	0.64700	0.15100	87.37	16.37	89.65	16.38
1.78	0.014583	0.64800	0.14500	98.65	16.40	101.22	16.38
1.98	0.016249	0.67000	0.13700	109.92	16.95	112.79	16.86
2.18	0.017916	0.67900	0.13400	121.20	17.18	124.36	17.07
2.39	0.019583	0.68800	0.12400	132.47	17.41	135.93	17.24
2.90	0.023749	0.72300	0.10400	160.66	18.30	164.85	18.01
3.40	0.027916	0.74400	0.08600	188.84	18.83	193.77	18.47
3.91	0.032082	0.87200	0.07400	217.03	22.07	222.69	21.58
4.42	0.036249	0.88000	0.04900	245.21	22.27	251.61	21.74
4.93	0.040415	0.91300	0.03400	273.40	23.10	280.53	22.53
5.43	0.044582	0.95600	0.02200	301.58	24.19	309.45	23.58
6.45	0.052915	0.98200	0.00300	357.95	24.85	367.29	24.22
7.47	0.061248	1.00000	0.00000	414.32	25.30	425.13	24.66

GARDOW A-45.2, INLET R = 1.405 FT IDENT 10.

PROFILE NUMBER 6 X = 0.850 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.07	0.000667	0.17400	0.06800	4.04	4.70	4.20	4.85
0.13	0.001167	0.22600	0.08800	7.07	6.10	7.34	6.30
0.17	0.001583	0.28600	0.11100	9.59	7.72	9.97	7.97
0.22	0.002000	0.40400	0.15700	12.12	10.90	12.59	11.26
0.26	0.002417	0.41700	0.16200	14.64	11.25	15.21	11.62
0.31	0.002833	0.43500	0.16900	17.17	11.74	17.83	12.12
0.38	0.003500	0.46300	0.18000	21.21	12.50	22.03	12.91
0.47	0.004333	0.48000	0.18600	26.25	12.96	27.27	13.37
0.56	0.005166	0.49300	0.18300	31.30	13.31	32.52	13.66
0.65	0.006000	0.49800	0.18400	36.35	13.44	37.76	13.79
0.74	0.006833	0.53200	0.18700	41.40	14.36	43.01	14.65
0.84	0.007666	0.53800	0.18700	46.45	14.52	48.25	14.80
0.93	0.008500	0.54500	0.17900	51.50	14.71	53.50	14.90
1.02	0.009333	0.56500	0.18200	56.55	15.25	58.74	15.42
1.11	0.010166	0.54900	0.16900	61.60	14.82	63.99	14.92
1.20	0.011000	0.54600	0.15900	66.64	14.74	69.23	14.78
1.38	0.012666	0.58200	0.16100	76.74	15.71	79.72	15.69
1.56	0.014333	0.59800	0.15800	86.84	16.14	90.21	16.07
1.74	0.015999	0.63500	0.16000	96.94	17.14	100.70	17.01
1.92	0.017666	0.66400	0.15500	107.03	17.92	111.19	17.72
2.11	0.019333	0.68200	0.14700	117.13	18.41	121.68	18.13
2.33	0.021416	0.68300	0.14200	129.75	18.43	134.79	18.12
2.56	0.023499	0.68700	0.12500	142.38	18.54	147.91	18.14
2.79	0.025582	0.74100	0.12600	155.00	20.00	161.02	19.53
3.01	0.027666	0.75800	0.11500	167.62	20.46	174.13	19.92
3.24	0.029749	0.78200	0.10600	180.24	21.11	187.24	20.50
3.47	0.031832	0.80600	0.09700	192.86	21.75	200.35	21.09
3.69	0.033915	0.81200	0.08200	205.49	21.92	213.47	21.20
3.92	0.035999	0.84600	0.07700	218.11	22.83	226.58	22.07
4.38	0.040165	0.88200	0.06200	243.35	23.81	252.80	22.97
4.83	0.044332	0.90100	0.04700	268.60	24.32	279.03	23.44
5.28	0.048498	0.92300	0.03500	293.84	24.91	305.25	24.00
5.74	0.052665	0.95200	0.01300	319.08	25.69	331.48	24.74
6.64	0.060998	1.00000	0.00000	369.57	26.99	383.93	25.98

GARDON A-45.2, INLET R = 1.405 FT IDENT 10.

PROFILE NUMBER 7 X = 1.010 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.06	0.000667	0.24100	0.09500	3.61	6.81	3.84	6.87
0.08	0.000833	0.25100	0.09900	4.51	7.09	4.80	7.16
0.12	0.001250	0.31300	0.12300	6.76	8.85	7.21	8.92
0.16	0.001667	0.34800	0.13700	9.02	9.83	9.61	9.92
0.22	0.002333	0.39500	0.15500	12.63	11.16	13.45	11.26
0.30	0.003167	0.43000	0.16900	17.14	12.15	18.25	12.26
0.38	0.004000	0.44400	0.17400	21.65	12.55	23.06	12.65
0.46	0.004833	0.46500	0.17500	26.16	13.14	27.86	13.18
0.54	0.005666	0.47100	0.17600	30.67	13.31	32.67	13.34
0.62	0.006500	0.48500	0.17800	35.18	13.71	37.47	13.71
0.70	0.007333	0.50600	0.17700	39.68	14.30	42.27	14.22
0.78	0.008166	0.51800	0.17900	44.19	14.64	47.08	14.54
0.86	0.009000	0.53200	0.17500	48.70	15.03	51.88	14.86
1.18	0.012333	0.57400	0.17300	66.74	16.22	71.10	15.91
1.33	0.013999	0.56500	0.16600	75.76	15.97	80.70	15.62
1.49	0.015666	0.60900	0.16800	84.78	17.21	90.31	16.76
1.65	0.017333	0.63400	0.16300	93.80	17.92	99.92	17.37
1.81	0.018999	0.62900	0.15500	102.82	17.78	109.52	17.19
1.97	0.020666	0.65100	0.15400	111.84	18.40	119.13	17.75
2.17	0.022749	0.64400	0.13600	123.11	18.20	131.14	17.46
2.37	0.024832	0.70200	0.14000	134.39	19.84	143.15	18.99
2.57	0.026916	0.69100	0.12700	145.66	19.53	155.16	18.64
2.77	0.028999	0.72500	0.12100	156.93	20.49	167.17	19.50
3.16	0.033165	0.76500	0.11300	179.48	21.62	191.19	20.52
3.56	0.037332	0.79400	0.09200	202.03	22.44	215.21	21.21
3.96	0.041498	0.82800	0.08200	224.58	23.40	239.23	22.07
4.35	0.045665	0.87300	0.06400	247.13	24.67	263.24	23.22
4.75	0.049831	0.89700	0.04700	269.68	25.35	287.26	23.83
5.15	0.053998	0.93300	0.03900	292.22	26.37	311.28	24.77
5.55	0.058164	0.96300	0.02700	314.77	27.22	335.30	25.56
5.94	0.062331	0.97600	0.01400	337.32	27.58	359.32	25.90
6.34	0.066497	0.99600	0.00500	359.87	28.15	383.34	26.42
6.74	0.070664	1.00000	0.00000	382.42	28.26	407.36	26.53

GARCOW A-45.2, INLET R = 1.405 FT IDENT 10.

PROFILE NUMBER 8 X = 1.190 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.05	0.000667	0.21100	0.10700	3.45	6.07	3.73	6.30
0.08	0.001083	0.28100	0.14200	5.61	8.08	6.05	8.38
0.14	0.001917	0.33500	0.17000	9.92	9.63	10.71	10.00
0.19	0.002583	0.39600	0.20100	13.37	11.39	14.44	11.83
0.25	0.003417	0.41800	0.20900	17.69	12.02	19.09	12.45
0.31	0.004250	0.42500	0.21000	22.00	12.22	23.75	12.62
0.38	0.005083	0.46200	0.21800	26.31	13.28	28.41	13.60
0.44	0.005916	0.46400	0.21400	30.63	13.34	33.06	13.61
0.56	0.007583	0.49100	0.22000	39.25	14.12	42.38	14.33
0.68	0.009250	0.50300	0.22200	47.88	14.46	51.69	14.64
0.81	0.010916	0.52000	0.21600	56.51	14.95	61.00	15.00
0.93	0.012583	0.54000	0.21600	65.13	15.53	70.32	15.49
1.05	0.014249	0.55500	0.21000	73.76	15.96	79.63	15.80
1.18	0.015916	0.57500	0.20700	82.39	16.53	88.94	16.28
1.33	0.017999	0.58300	0.20000	93.17	16.76	100.58	16.41
1.48	0.020083	0.60400	0.19500	103.96	17.36	112.23	16.90
1.64	0.022166	0.61600	0.18700	114.74	17.71	123.87	17.14
1.79	0.024249	0.62800	0.18800	125.52	18.05	135.51	17.46
1.94	0.026332	0.63800	0.17500	136.31	18.34	147.15	17.62
2.10	0.028416	0.66000	0.17200	147.09	18.97	158.79	18.16
2.25	0.030499	0.66900	0.15800	157.88	19.23	170.43	18.31
2.41	0.032582	0.67600	0.14900	168.66	19.43	182.08	18.44
2.56	0.034665	0.68700	0.14300	179.44	19.75	193.72	18.69
2.71	0.036749	0.69900	0.13500	190.23	20.10	205.36	18.96
2.87	0.038832	0.72000	0.13200	201.01	20.70	217.00	19.49
3.02	0.040915	0.74000	0.12500	211.80	21.27	228.64	19.99
3.33	0.045082	0.76700	0.10600	233.36	22.05	251.93	20.62
3.64	0.049248	0.79500	0.09400	254.93	22.86	275.21	21.32
3.94	0.053415	0.82700	0.08400	276.50	23.78	298.49	22.14
4.25	0.057581	0.85300	0.06600	298.07	24.52	321.78	22.78
4.56	0.061748	0.87800	0.05400	319.63	25.24	345.06	23.43
4.87	0.065914	0.91800	0.04300	341.20	26.39	368.34	24.47
5.17	0.070080	0.93400	0.02800	362.77	26.85	391.63	24.89
5.48	0.074247	0.96000	0.02300	384.34	27.60	414.91	25.57
5.79	0.078413	0.99000	0.00700	405.90	28.46	438.19	26.37
6.10	0.082580	1.00000	0.00000	427.47	28.75	461.48	26.63

GARDON A-45.2, INLET R = 1.405 FT IDENT 10.

PROFILE NUMBER 9 X = 1.350 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.05	0.000667	0.15600	0.07600	3.53	4.28	3.73	4.51
0.09	0.001250	0.25700	0.12600	6.62	7.05	6.99	7.44
0.12	0.001667	0.30000	0.14600	8.82	8.23	9.31	8.67
0.15	0.002083	0.33800	0.16400	11.03	9.28	11.64	9.77
0.18	0.002500	0.38100	0.18500	13.23	10.46	13.97	11.01
0.23	0.003167	0.43200	0.21000	16.76	11.86	17.70	12.49
0.29	0.004000	0.46200	0.21300	21.18	12.68	22.35	13.23
0.35	0.004833	0.47600	0.22000	25.59	13.06	27.01	13.63
0.41	0.005666	0.48900	0.22500	30.00	13.42	31.67	14.00
0.47	0.006500	0.49400	0.22800	34.41	13.56	36.32	14.15
0.53	0.007333	0.51000	0.22600	38.82	14.00	40.98	14.50
0.65	0.009000	0.51400	0.21800	47.65	14.11	50.29	14.52
0.77	0.010666	0.53100	0.21000	56.47	14.57	59.61	14.85
0.89	0.012333	0.55300	0.20400	65.29	15.18	68.92	15.33
1.01	0.013999	0.57100	0.20900	74.11	15.67	78.23	15.81
1.13	0.015666	0.57300	0.20400	82.94	15.73	87.55	15.81
1.25	0.017333	0.58200	0.20000	91.76	15.97	96.86	16.00
1.40	0.019416	0.58500	0.18800	102.79	16.05	108.50	15.98
1.55	0.021499	0.60700	0.17600	113.82	16.66	120.14	16.43
1.70	0.023582	0.62500	0.17900	124.85	17.15	131.78	16.90
1.86	0.025666	0.63300	0.17100	135.88	17.37	143.43	17.05
2.01	0.027749	0.65800	0.16500	146.91	18.06	155.07	17.64
2.16	0.029832	0.66900	0.15800	157.93	18.36	166.71	17.87
2.31	0.031915	0.68200	0.15400	168.96	18.72	178.35	18.18
2.46	0.033999	0.69500	0.14600	179.99	19.07	189.99	18.46
2.61	0.036082	0.70600	0.14300	191.02	19.38	201.63	18.73
2.76	0.038165	0.72300	0.13400	202.05	19.84	213.28	19.12
2.91	0.040248	0.74400	0.13100	213.08	20.42	224.92	19.64
3.06	0.042332	0.74500	0.12300	224.11	20.45	236.56	19.63
3.36	0.046498	0.77200	0.11000	246.17	21.19	259.84	20.27
3.66	0.050665	0.79600	0.09400	268.22	21.85	283.13	20.84
3.96	0.054831	0.82600	0.08000	290.28	22.67	306.41	21.58
4.27	0.058998	0.84900	0.07200	312.34	23.30	329.69	22.15
4.57	0.063164	0.88000	0.06000	334.40	24.15	352.98	22.93
4.87	0.067331	0.91000	0.04600	356.46	24.97	376.26	23.69
5.17	0.071497	0.92600	0.03500	378.51	25.41	399.54	24.09
5.47	0.075664	0.95400	0.01800	400.57	26.18	422.83	24.81
5.77	0.079830	0.98500	0.01000	422.63	27.03	446.11	25.61
5.92	0.081913	0.98900	0.00000	433.66	27.14	457.75	25.71
6.07	0.083997	1.00000	0.00000	444.69	27.44	469.39	26.00

TITLE: Gardow A-51.6 Vaneless Diffuser, Flow 12

REFERENCE: Gardow, E., "The three-dimensional turbulent boundary layer in a free vortex diffuser," MIT Gas Turbine Lab. Rept. 42, Jan. 1958

DESCRIPTION: The development of the turbulent boundary layer on one wall of a parallel walled, axially symmetric vaneless diffuser was measured (Figure 10.1). The direction and magnitude of the velocity was measured with a three holed cobra probe (dimensions not given). No turbulence data were taken.

EDITORS' COMMENTS: The momantum thickness Reynolds number of the first profile is only 444 and the profile may not be fully turbulent. AT the last two profiles, the boundary layer thickness is 0.943 and 1.321 inches respectively. Assuming that the boundary layer on the opposite wall is of similar thickness, it is possible that the potential core (inviscid external flow) no longer exists in this region. No value of the kinematic viscosity was supplied by the originator. Since it is known that the experiments were performed in room air, it is assumed that the kinematic viscosity has a value of .000170 ft^2/sec.

PRESSURE GRADIENT: (See Figure 12.1)

x feet	Q_∞ ft/sec	$\partial Q_\infty/\partial x$ sec^{-1}
-0.005	45.500	23.13
0.095	43.252	21.88
0.195	41.107	21.0
0.295	39.044	20.12
0.395	37.111	18.49
0.495	35.361	16.47
0.595	33.832	14.22
0.695	32.490	12.62
0.795	31.314	11.00
0.895	30.269	9.90

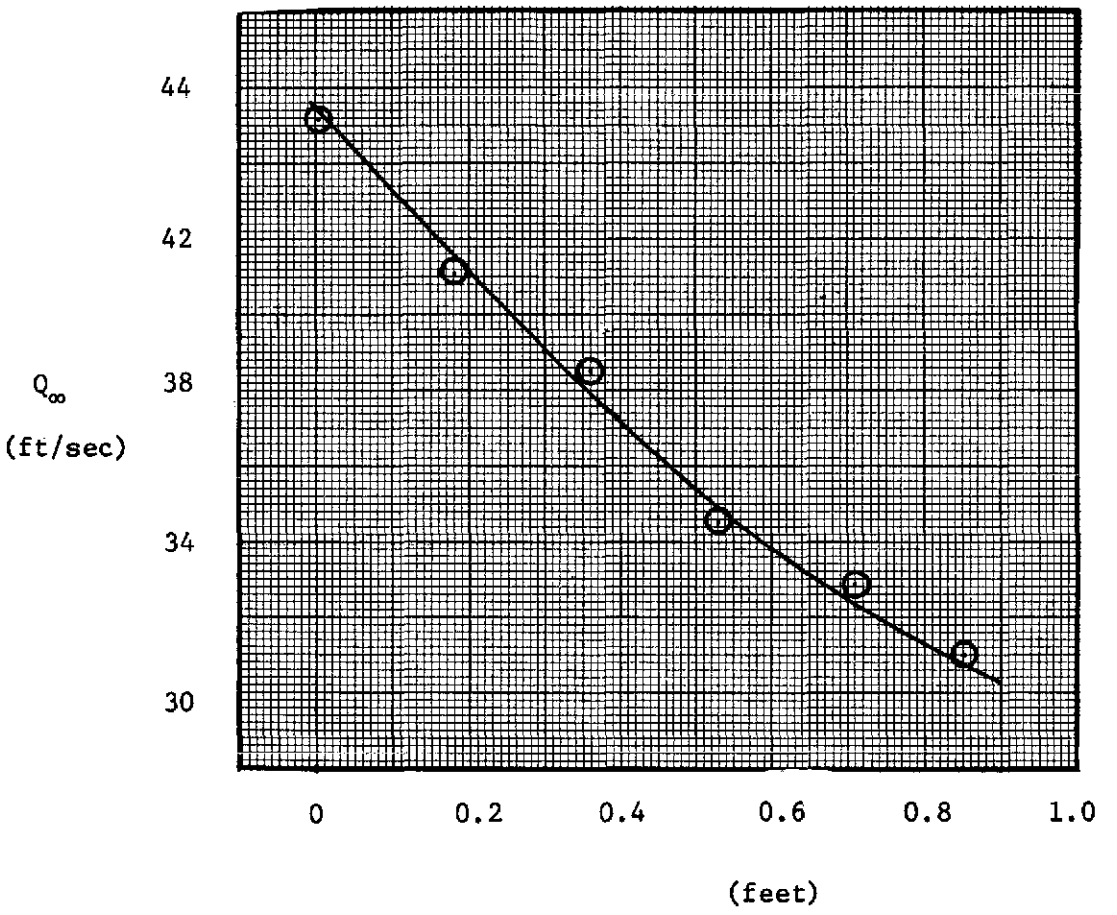


Figure 12.1 Gardow A-51.6 Q_∞ Distribution

GARDOW A-51.6 VANELESS DIFFUSER FLOW ,INLET R = 1.405 FT IDENT =12. KIN. VISC= 0.0001700

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	444.0	1.614	0.004483	0.003867	0.004567	9.97	11.02	0.002695	0.001670
0.18000	932.9	1.494	0.003922	0.003818	0.004096	15.24	16.77	0.005766	0.003859
0.36000	1380.0	1.509	0.003498	0.003363	0.003854	20.59	24.83	0.009192	0.006093
0.53000	1470.4	1.593	0.002972	0.002897	0.003341	22.77	27.16	0.011543	0.007246
0.71000	1880.3	1.687	0.002444	0.002342	0.002887	26.79	32.18	0.016393	0.009716
0.85000	2282.9	1.747	0.002081	0.002026	0.002473	27.70	32.68	0.021867	0.012519
1.19000	2746.6	1.564	0.002448	0.002564	0.002881	27.87	31.83	0.024104	0.015410

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.000703	0.000047	0.000519	0.000184	0.000	0.000	0.000	0.000	45.20	51.6
0.18000	0.002147	0.000223	0.001555	0.000592	0.265	0.124	0.385	0.253	41.10	51.5
0.36000	0.004397	0.000644	0.003096	0.001301	0.516	0.203	0.599	0.454	38.50	50.2
0.53000	0.005345	0.000803	0.003630	0.001715	-0.019	0.253	0.664	0.600	34.50	49.3
0.71000	0.007286	0.001194	0.004648	0.002638	0.047	0.287	0.917	0.714	32.90	48.1
0.85000	0.009005	0.001452	0.005457	0.003549	0.317	0.306	1.163	0.782	31.00	45.3
1.19000	0.013573	0.002498	0.009155	0.004418	1.987	0.360	1.027	0.930	30.30	40.0

GARDOW A-51.6 VANELESS DIFFUSER FLOW ,INLET R = 1.405 FT IDENT 12.

PROFILE NUMBER 1 X = 0.000 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.40	0.000667	0.47200	0.08300	8.39	9.97	8.47	10.03
0.50	0.000833	0.49000	0.08600	10.49	10.35	10.59	10.41
0.60	0.001000	0.51900	0.09200	12.59	10.96	12.71	11.03
0.85	0.001417	0.57500	0.10200	17.83	12.14	18.00	12.22
1.00	0.001667	0.58700	0.10400	20.98	12.40	21.18	12.47
1.25	0.002083	0.61500	0.10200	26.22	12.99	26.47	13.05
1.50	0.002500	0.64000	0.09700	31.47	13.52	31.76	13.55
1.75	0.002917	0.67400	0.09300	36.71	14.24	37.06	14.24
2.00	0.003333	0.69600	0.08800	41.96	14.70	42.35	14.68
2.25	0.003750	0.71700	0.08000	47.20	15.14	47.65	15.10
2.49	0.004166	0.74800	0.07100	52.45	15.80	52.94	15.72
2.99	0.005000	0.79300	0.06200	62.94	16.75	63.53	16.64
3.49	0.005833	0.83200	0.05700	73.43	17.57	74.11	17.45
3.99	0.006666	0.85800	0.05100	83.92	18.12	84.70	17.99
4.49	0.007500	0.88400	0.04500	94.41	18.67	95.29	18.52
4.99	0.008333	0.90800	0.04000	104.90	19.18	105.88	19.02
5.49	0.009166	0.92600	0.03400	115.39	19.56	116.47	19.39
5.99	0.010000	0.94400	0.02800	125.88	19.94	127.05	19.76
6.49	0.010833	0.95800	0.02300	136.37	20.23	137.64	20.05
6.99	0.011666	0.97300	0.01800	146.86	20.55	148.23	20.36
7.48	0.012499	0.98400	0.01400	157.35	20.78	158.82	20.59
7.98	0.013333	0.99000	0.00900	167.84	20.91	169.40	20.72
8.48	0.014166	0.99800	0.00300	178.33	21.08	179.99	20.88
8.98	0.014999	1.00000	0.00300	188.82	21.12	190.58	20.93
9.48	0.015833	1.00000	0.00000	199.31	21.12	201.17	20.93

GARCOW A-51.6 VANELESS DIFFUSER FLOW ,INLET R = 1.405 FT IDENT 12.

PROFILE NUMBER 2 X = 0.180 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.17	0.000667	0.45500	0.12400	7.14	10.28	7.29	10.42
0.28	0.001083	0.46500	0.12600	11.60	10.50	11.85	10.65
0.39	0.001500	0.52200	0.14000	16.06	11.79	16.41	11.94
0.50	0.001917	0.55000	0.14300	20.52	12.42	20.97	12.56
0.71	0.002750	0.58600	0.14600	29.44	13.23	30.09	13.34
0.89	0.003417	0.61400	0.14400	36.58	13.87	37.38	13.94
1.10	0.004250	0.64000	0.14000	45.50	14.45	46.50	14.48
1.32	0.005083	0.66700	0.13600	54.42	15.06	55.62	15.04
1.53	0.005916	0.68400	0.12900	63.34	15.45	64.73	15.38
1.75	0.006750	0.70100	0.12500	72.26	15.83	73.85	15.73
1.97	0.007583	0.71900	0.12000	81.18	16.24	82.97	16.11
2.18	0.008416	0.73600	0.11600	90.10	16.62	92.08	16.46
2.40	0.009250	0.74600	0.11200	99.03	16.85	101.20	16.67
2.61	0.010083	0.76500	0.10700	107.95	17.28	110.32	17.07
2.83	0.010916	0.76900	0.10200	116.87	17.37	119.44	17.14
3.05	0.011750	0.78400	0.09600	125.79	17.70	128.55	17.45
3.26	0.012583	0.79700	0.08800	134.71	18.00	137.67	17.72
3.69	0.014249	0.83400	0.07700	152.55	18.83	155.91	18.51
4.12	0.015916	0.85500	0.06700	170.40	19.31	174.14	18.95
4.56	0.017583	0.88000	0.05400	188.24	19.87	192.37	19.48
4.99	0.019249	0.90500	0.04600	206.08	20.44	210.61	20.02
5.42	0.020916	0.92300	0.03500	223.92	20.84	228.84	20.41
5.85	0.022582	0.94500	0.02600	241.76	21.34	247.08	20.89
6.28	0.024249	0.94600	0.01800	259.61	21.36	265.31	20.91
6.72	0.025916	0.97400	0.01000	277.45	22.00	283.55	21.52
7.26	0.027999	0.98900	0.00300	299.75	22.33	306.34	21.85
7.80	0.030082	0.99800	0.00200	322.06	22.54	329.13	22.05
8.34	0.032165	1.00000	0.00000	344.36	22.58	351.93	22.10

GARDOW A-51.6 VANELESS DIFFUSER FLOW ,INLET R = 1.405 FT IDENT 12.

PROFILE NUMBER 3 X = 0.360 FT

Y/THI1	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.11	0.000667	0.35400	0.13300	6.31	8.47	6.63	8.61
0.18	0.001083	0.36500	0.13700	10.26	8.73	10.77	8.88
0.25	0.001500	0.44500	0.16700	14.21	10.64	14.91	10.83
0.31	0.001917	0.50400	0.18900	18.15	12.05	19.05	12.26
0.38	0.002333	0.52400	0.19700	22.10	12.53	23.20	12.75
0.45	0.002750	0.54800	0.20300	26.04	13.10	27.34	13.31
0.59	0.003583	0.57300	0.20700	33.93	13.70	35.62	13.88
0.70	0.004250	0.60100	0.21000	40.25	14.37	42.25	14.50
0.83	0.005083	0.60400	0.20200	48.14	14.44	50.53	14.51
0.97	0.005916	0.61100	0.19800	56.03	14.61	58.82	14.63
1.11	0.006750	0.62900	0.19300	63.92	15.04	67.10	14.99
1.24	0.007583	0.64200	0.18900	71.82	15.35	75.38	15.25
1.38	0.008416	0.65500	0.18300	79.71	15.66	83.67	15.49
1.52	0.009250	0.67200	0.18200	87.60	16.07	91.95	15.86
1.65	0.010083	0.68100	0.17700	95.49	16.28	100.24	16.03
1.79	0.010916	0.69500	0.17200	103.38	16.62	108.52	16.31
1.93	0.011750	0.69600	0.16800	111.27	16.64	116.80	16.31
2.06	0.012583	0.71200	0.16200	119.17	17.03	125.09	16.63
2.20	0.013416	0.73400	0.16000	127.06	17.55	133.37	17.11
2.48	0.015083	0.74300	0.14700	142.84	17.77	149.94	17.25
2.75	0.016749	0.75800	0.13600	158.63	18.13	166.51	17.54
3.02	0.018416	0.77300	0.12700	174.41	18.48	183.08	17.85
3.30	0.020083	0.79400	0.11500	190.19	18.99	199.64	18.28
3.57	0.021749	0.80600	0.10500	205.98	19.27	216.21	18.52
3.84	0.023416	0.82900	0.09300	221.76	19.82	232.78	19.00
4.12	0.025082	0.85000	0.08000	237.54	20.33	249.35	19.45
4.39	0.026749	0.86700	0.07300	253.33	20.73	265.92	19.82
4.66	0.028416	0.88200	0.06200	269.11	21.09	282.48	20.14
4.94	0.030082	0.90000	0.04700	284.90	21.52	299.05	20.53
5.21	0.031749	0.92000	0.03900	300.68	22.00	315.62	20.98
5.48	0.033415	0.92800	0.03300	316.46	22.19	332.19	21.15
5.76	0.035082	0.94200	0.02600	332.25	22.53	348.76	21.47
6.03	0.036749	0.96100	0.02000	348.03	22.98	365.32	21.90
6.30	0.038415	0.97100	0.01400	363.81	23.22	381.89	22.12
6.58	0.040082	0.98100	0.00500	379.60	23.46	398.46	22.35
6.85	0.041748	0.98400	0.00300	395.38	23.53	415.03	22.42
7.12	0.043415	0.99100	0.00200	411.16	23.70	431.59	22.58
7.40	0.045082	0.99700	0.00000	426.95	23.84	448.16	22.71
7.67	0.046748	1.00000	0.00000	442.73	23.91	464.73	22.78

GARDON A-51.6 VANELESS DIFFUSER FLOW ,INLET R = 1.405 FT IDENT 12.

PROFILE NUMBER 4 X = 0.530 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.09	0.000667	0.27400	0.11500	5.22	7.11	5.53	7.27
0.13	0.000917	0.28000	0.11700	7.17	7.26	7.60	7.43
0.18	0.001333	0.34200	0.14300	10.43	8.87	11.06	9.07
0.24	0.001750	0.40200	0.16800	13.69	10.43	14.51	10.66
0.30	0.002167	0.44200	0.18500	16.95	11.47	17.97	11.72
0.41	0.003000	0.47100	0.19600	23.47	12.22	24.88	12.48
0.53	0.003833	0.50300	0.20100	29.99	13.05	31.79	13.25
0.62	0.004500	0.53000	0.20300	35.20	13.75	37.32	13.89
0.74	0.005333	0.54600	0.20400	41.72	14.16	44.23	14.26
0.85	0.006166	0.56300	0.20700	48.24	14.60	51.14	14.68
0.97	0.007000	0.58700	0.20600	54.76	15.23	58.06	15.22
1.08	0.007833	0.58000	0.19400	61.28	15.05	64.97	14.96
1.20	0.008666	0.59200	0.19000	67.80	15.36	71.88	15.21
1.31	0.009500	0.59800	0.18700	74.32	15.51	78.79	15.33
1.43	0.010333	0.62100	0.18600	80.84	16.11	85.70	15.86
1.54	0.011166	0.63600	0.18500	87.36	16.50	92.61	16.21
1.77	0.012833	0.66000	0.17900	100.40	17.12	106.44	16.73
2.00	0.014499	0.67800	0.17300	113.44	17.59	120.26	17.12
2.23	0.016166	0.69200	0.16200	126.48	17.95	134.08	17.39
2.46	0.017833	0.71300	0.15400	139.51	18.50	147.91	17.85
2.69	0.019499	0.74000	0.14600	152.55	19.20	161.73	18.46
2.92	0.021166	0.75500	0.13700	165.59	19.58	175.55	18.78
3.15	0.022832	0.78700	0.13200	178.63	20.41	189.37	19.53
3.38	0.024499	0.79200	0.11900	191.67	20.54	203.20	19.60
3.61	0.026166	0.81500	0.11000	204.71	21.14	217.02	20.12
3.84	0.027832	0.83000	0.10100	217.75	21.53	230.84	20.46
4.42	0.031999	0.87100	0.07400	250.34	22.59	265.40	21.39
4.99	0.036165	0.91100	0.04700	282.94	23.63	299.96	22.32
5.57	0.040332	0.95000	0.03100	315.54	24.64	334.52	23.26
6.14	0.044498	0.97100	0.01400	348.13	25.19	369.07	23.76
6.72	0.048665	0.98800	0.00000	380.73	25.63	403.63	24.17
7.29	0.052831	1.00000	0.00000	413.33	25.94	438.19	24.47

GARDOW A-51.6 VANELESS DIFFUSER FLOW ,INLET R = 1.405 FT IDENT 12.

PROFILE NUMBER S X = 0.710 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.07	0.000667	0.20000	0.10100	4.51	5.72	4.90	5.90
0.09	0.000917	0.20900	0.10600	6.20	5.98	6.74	6.17
0.14	0.001333	0.22400	0.11300	9.02	6.41	9.80	6.60
0.18	0.001750	0.29400	0.14900	11.84	8.41	12.87	8.68
0.22	0.002167	0.34700	0.17600	14.66	9.93	15.93	10.24
0.27	0.002583	0.39200	0.19800	17.47	11.21	18.99	11.56
0.31	0.003000	0.41300	0.20900	20.29	11.82	22.06	12.18
0.35	0.003417	0.41400	0.20700	23.11	11.84	25.12	12.18
0.44	0.004250	0.45300	0.22500	28.75	12.96	31.25	13.31
0.51	0.004916	0.46500	0.22100	33.26	13.30	36.15	13.55
0.59	0.005750	0.47300	0.22000	38.90	13.53	42.28	13.73
0.68	0.006583	0.50100	0.22700	44.53	14.33	48.40	14.48
0.76	0.007416	0.51700	0.22800	50.17	14.79	54.53	14.87
0.85	0.008250	0.52700	0.22400	55.81	15.08	60.66	15.07
0.93	0.009083	0.53600	0.22200	61.44	15.33	66.79	15.27
1.02	0.009916	0.54600	0.21900	67.08	15.62	72.91	15.48
1.11	0.010750	0.56100	0.21500	72.72	16.05	79.04	15.81
1.19	0.011583	0.56300	0.21200	78.35	16.11	85.17	15.83
1.28	0.012416	0.56900	0.21300	83.99	16.28	91.30	15.99
1.45	0.014083	0.59400	0.20300	95.27	16.99	103.55	16.52
1.62	0.015749	0.61400	0.19700	106.54	17.57	115.80	16.97
1.79	0.017416	0.62000	0.18900	117.81	17.74	128.06	17.06
1.96	0.019083	0.63000	0.17900	129.09	18.02	140.31	17.24
2.14	0.020749	0.63300	0.17000	140.36	18.11	152.57	17.25
2.31	0.022416	0.65300	0.16600	151.64	18.68	164.82	17.73
2.48	0.024082	0.67200	0.15400	162.91	19.23	177.08	18.15
2.65	0.025749	0.70300	0.15000	174.18	20.11	189.33	18.92
2.82	0.027416	0.71700	0.14300	185.46	20.51	201.58	19.24
2.99	0.029082	0.72600	0.13400	196.73	20.77	213.84	19.43
3.21	0.031165	0.76200	0.12800	210.82	21.80	229.16	20.34
3.42	0.033249	0.78300	0.11600	224.92	22.40	244.48	20.83
3.64	0.035332	0.80300	0.10600	239.01	22.97	259.79	21.32
3.85	0.037415	0.82400	0.10000	253.10	23.57	275.11	21.85
4.28	0.041582	0.86900	0.07400	281.29	24.86	305.75	22.95
4.71	0.045748	0.90300	0.05200	309.47	25.83	336.38	23.81
5.14	0.049915	0.94300	0.03600	337.66	26.98	367.02	24.84
5.57	0.054081	0.95500	0.01600	365.84	27.32	397.66	25.14
6.00	0.058248	0.98100	0.00900	394.03	28.07	428.29	25.82
6.42	0.062414	0.98900	0.00000	422.21	28.29	458.93	26.03
6.85	0.066581	1.00000	0.00000	450.40	28.61	489.56	26.32

GARDOW A-51.6 VANELESS DIFFUSER FLOW ,INLET R = 1.405 FT IDENT 12.

PRCFILE NUMBER 6 X = 0.850 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.05	0.000667	0.21900	0.11500	3.92	6.79	4.27	7.03
0.10	0.001250	0.25000	0.13100	7.35	7.75	8.01	8.03
0.17	0.002083	0.35400	0.18600	12.25	10.97	13.36	11.37
0.23	0.002917	0.39900	0.21000	17.16	12.37	18.70	12.82
0.29	0.003583	0.40400	0.21200	21.08	12.52	22.97	12.98
0.35	0.004416	0.40700	0.21400	25.98	12.62	28.32	13.08
0.42	0.005250	0.40700	0.21400	30.88	12.62	33.66	13.08
0.49	0.006083	0.45100	0.22700	35.78	13.98	39.00	14.36
0.55	0.006916	0.45400	0.22900	40.68	14.07	44.35	14.46
0.62	0.007750	0.45800	0.22200	45.59	14.20	49.69	14.48
0.75	0.009416	0.47500	0.22200	55.39	14.73	60.37	14.91
0.89	0.011083	0.49000	0.22600	65.19	15.19	71.06	15.35
1.02	0.012749	0.50700	0.21300	75.00	15.72	81.75	15.64
1.15	0.014416	0.52000	0.21200	84.80	16.12	92.43	15.97
1.28	0.016083	0.52900	0.20100	94.60	16.40	103.12	16.09
1.45	0.018166	0.54200	0.18900	106.86	16.80	116.48	16.32
1.62	0.020249	0.54900	0.18300	119.11	17.02	129.83	16.46
1.78	0.022332	0.56500	0.17300	131.37	17.51	143.19	16.81
1.95	0.024416	0.60100	0.17100	143.62	18.63	156.55	17.77
2.12	0.026499	0.61600	0.16200	155.88	19.10	169.90	18.11
2.28	0.028582	0.63200	0.15800	168.13	19.59	183.26	18.53
2.45	0.030665	0.65100	0.15400	180.38	20.18	196.62	19.03
2.62	0.032749	0.66800	0.14600	192.64	20.71	209.98	19.45
2.95	0.036915	0.70600	0.13000	217.15	21.89	236.69	20.42
3.28	0.041082	0.75000	0.11100	241.66	23.25	263.41	21.56
3.61	0.045248	0.79600	0.09900	266.17	24.68	290.12	22.81
3.95	0.049415	0.83400	0.08500	290.67	25.85	316.84	23.84
4.28	0.053581	0.87100	0.06400	315.18	27.00	343.55	24.84
4.61	0.057748	0.89900	0.05200	339.69	27.87	370.26	25.61
4.95	0.061914	0.93500	0.03600	364.20	28.98	396.98	26.61
5.28	0.066081	0.96200	0.02300	388.71	29.82	423.69	27.37
5.61	0.070247	0.97400	0.01400	413.22	30.19	450.41	27.70
5.94	0.074414	0.99500	0.00700	437.73	30.84	477.12	28.30
6.28	0.078580	1.00000	0.00000	462.24	31.00	503.84	28.44

GARDOW A-51.6 VANELESS DIFFUSER FLOW ,INLET R = 1.405 FT IDENT 12.

PROFILE NUMBER 7 X = 1.190 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.04	0.000667	0.20800	0.11000	4.16	5.95	4.51	6.20
0.07	0.001083	0.27400	0.14500	6.75	7.83	7.33	8.17
0.12	0.001917	0.38300	0.20400	11.95	10.95	12.97	11.43
0.25	0.003833	0.43200	0.22900	23.90	12.35	25.93	12.88
0.38	0.005916	0.48300	0.24600	36.89	13.81	40.02	14.28
0.52	0.008000	0.50900	0.24800	49.88	14.55	54.12	14.92
0.65	0.010083	0.51700	0.24200	62.87	14.78	68.21	15.04
0.79	0.012166	0.55800	0.25400	75.86	15.95	82.30	16.15
0.92	0.014249	0.56900	0.24600	88.85	16.26	96.39	16.33
1.20	0.018416	0.59300	0.23400	114.83	16.95	124.58	16.80
1.47	0.022582	0.62700	0.22700	140.81	17.92	152.76	17.57
1.74	0.026749	0.65800	0.22100	166.79	18.81	180.95	18.29
2.01	0.030915	0.68000	0.20700	192.77	19.44	209.13	18.73
2.28	0.035082	0.71600	0.19400	218.75	20.47	237.32	19.55
2.55	0.039248	0.72700	0.17600	244.73	20.78	265.50	19.71
2.82	0.043415	0.75300	0.16700	270.70	21.52	293.69	20.32
3.09	0.047581	0.77600	0.14800	296.68	22.18	321.87	20.81
3.36	0.051748	0.79700	0.13200	322.66	22.78	350.06	21.29
3.63	0.055914	0.81500	0.12300	348.64	23.30	378.24	21.72
3.90	0.060081	0.83600	0.11100	374.62	23.90	406.43	22.22
4.17	0.064247	0.83900	0.09100	400.60	23.98	434.61	22.24
4.44	0.068414	0.87600	0.08300	426.58	25.04	462.80	23.18
4.71	0.072580	0.89500	0.07000	452.56	25.58	490.98	23.65
4.85	0.074664	0.89600	0.06300	465.55	25.61	505.08	23.67
4.98	0.076747	0.91600	0.05800	478.54	26.18	519.17	24.18
5.12	0.078830	0.92400	0.05400	491.53	26.41	533.26	24.39
5.25	0.080913	0.93100	0.04100	504.52	26.61	547.35	24.55
5.52	0.085080	0.94800	0.02800	530.50	27.10	575.54	24.99
5.79	0.089246	0.95800	0.02200	556.48	27.38	603.73	25.25
6.06	0.093413	0.96600	0.01200	582.46	27.61	631.91	25.45
6.33	0.097579	0.98400	0.01000	608.44	28.13	660.09	25.93
6.60	0.101746	0.98800	0.00700	634.42	28.24	688.28	26.03
6.87	0.105912	0.99300	0.00000	660.39	28.38	716.47	26.16
7.14	0.110079	1.00000	0.00000	686.37	28.58	744.65	26.35

TITLE: Gardow B-50.6 Vaneless Diffuser, Flow 14

REFERENCE: Gardow, E., "The three-dimensional turbulent boundary layer in a free vortex diffuser," MIT Gas Turbine Lab. Rept. 42, Jan 1958.

DESCRIPTION: The development of the turbulent boundary layer on one wall of a parallel walled, axially symmetric vaneless diffuser was measured (Figure 10.1). The direction and magnitude of the velocity was measured with a three holed cobra probe (dimensions not given). No turbulence data were taken.

EDITORS' COMMENTS: The first profile showed a logarithmic region. The momentum Reynolds number of the first profile is only 561 and may not be fully turbulent. At the last two profiles, the boundary layer thicknesses are 1.17 and 1.33 inches respectively. Assuming that the boundary layer on the other wall is of similar thickness, it is possible that the potential core (inviscid external flow) no longer exists in this region. No value of the kinematic viscosity was supplied by the originator. Since it is known that the experiments were performed in room air, it is assumed that the kinematic viscosity has a value of .000170 ft^2/sec.

PRESSURE GRADIENT: (see Figure 14.1)

x feet	Q_∞ ft/sec	$\partial Q_\infty/\partial x$ sec^{-1}
-0.005	44.000	-17.60
0.095	42.221	-18.04
0.195	40.370	-18.81
0.295	38.481	-18.60
0.395	36.746	-16.20
0.495	35.214	-14.35
0.595	33.900	-12.00
0.695	32.790	-10.10
0.795	31.913	-7.54
0.895	31.241	-5.61
0.995	30.882	-1.93
1.095	30.764	-0.43

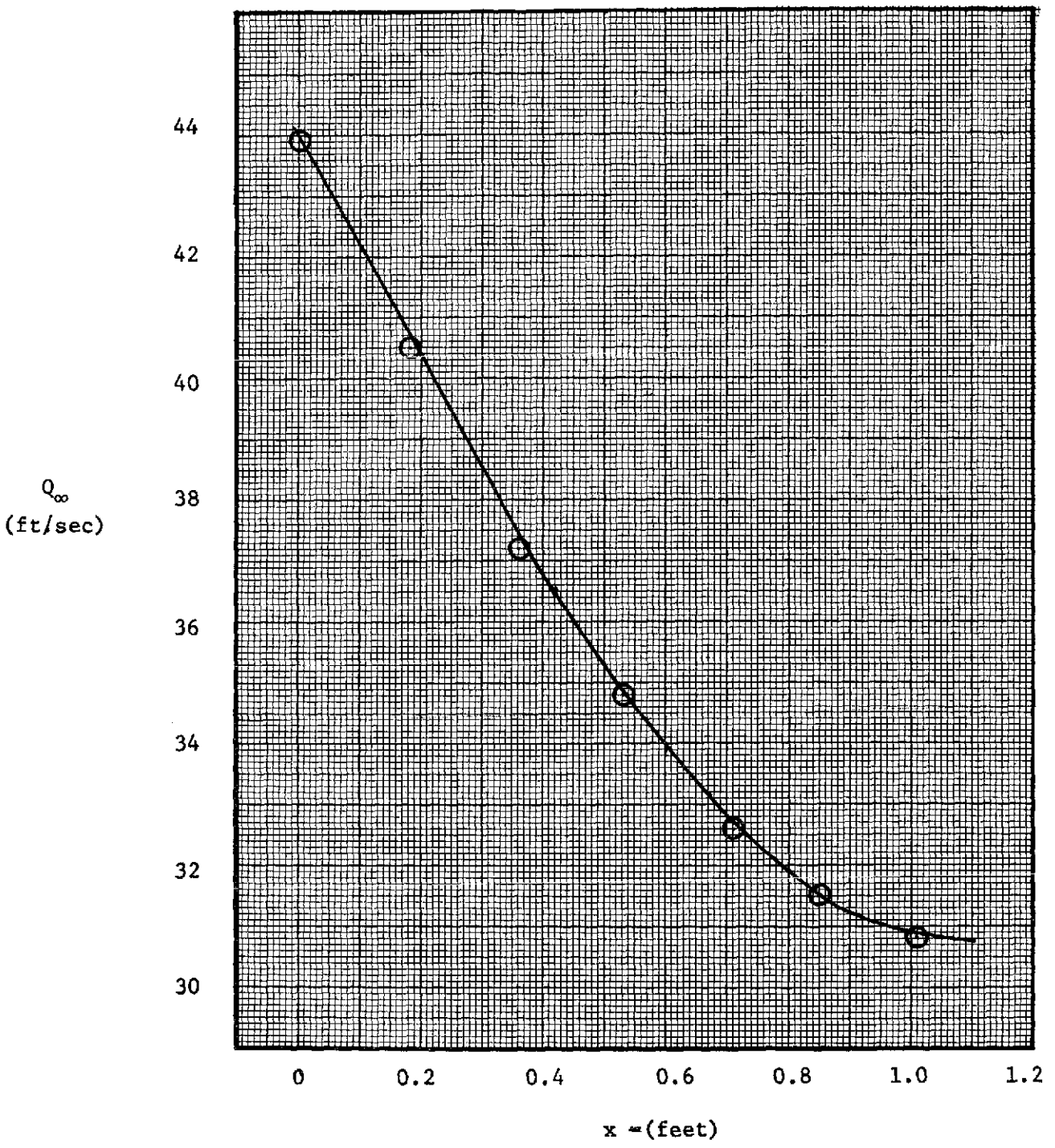


Figure 14.1 Gardow B-50.6 Q_∞ Distribution

GARDOW B50.6 VANELESS DIFFUSER , INLET R = 1.405 FT IDENT =14. KIN. VISC= 0.0001700

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	561.4	1.836	—	0.002567	—	7.13	—	0.003991	0.002174
0.18000	1004.9	1.563	0.003607	0.003364	0.003820	16.09	19.21	0.006592	0.004218
0.36000	1353.2	1.661	0.002914	0.002642	0.003295	20.39	27.83	0.010577	0.006367
0.53000	1738.7	1.655	0.002622	0.002514	0.003010	25.81	29.41	0.014059	0.008494
0.71000	1986.1	1.709	0.002277	0.002231	0.002665	28.10	31.30	0.017699	0.010357
0.85000	2586.7	1.715	0.001936	0.002059	0.002439	31.29	37.47	0.023937	0.013960
1.01000	3029.0	1.667	0.002066	0.002128	0.002551	32.64	35.90	0.027863	0.016718

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.000574	0.000028	0.000411	0.000163	—	—	—	—	43.90	50.6
0.18000	0.002288	0.000237	0.001609	0.000679	0.000	0.000	0.000	0.000	40.50	49.6
0.36000	0.004274	0.000573	0.002901	0.001372	0.159	0.128	0.336	0.300	37.20	48.1
0.53000	0.006239	0.000954	0.004092	0.002147	0.124	0.205	0.643	0.517	34.80	47.0
0.71000	0.008204	0.001370	0.005224	0.002980	-0.095	0.262	0.804	0.704	32.60	45.6
0.85000	0.011106	0.001997	0.006816	0.004290	1.374	0.296	1.251	0.820	31.50	42.6
1.01000	0.014143	0.002673	0.008897	0.005246	2.833	0.332	1.351	0.942	30.80	40.6

GARDOW B50.6 VANELESS DIFFUSER , INLET R = 1.405 FT IDENT 14.

PROFILE NUMBER 1 X = 0.000 FT

Y/THI1	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.31	0.000667	0.14400	0.01800	8.67	2.86	8.67	2.88
0.46	0.001000	0.19800	0.02500	13.00	3.93	13.00	3.96
0.65	0.001417	0.35300	0.04400	18.42	7.01	18.42	7.07
0.84	0.001833	0.50400	0.06300	23.83	10.01	23.83	10.09
0.96	0.002083	0.56300	0.07000	27.08	11.18	27.08	11.27
1.15	0.002500	0.59500	0.06900	32.50	11.82	32.50	11.90
1.53	0.003333	0.64700	0.06800	43.33	12.85	43.33	12.92
1.92	0.004166	0.68200	0.06400	54.16	13.55	54.16	13.61
2.30	0.005000	0.72800	0.06000	65.00	14.46	65.00	14.51
3.07	0.006666	0.77900	0.05200	86.66	15.47	86.66	15.51
3.83	0.008333	0.82700	0.03700	108.33	16.43	108.33	16.44
4.60	0.010000	0.86600	0.02900	129.99	17.20	129.99	17.21
5.37	0.011666	0.90400	0.01900	151.66	17.96	151.66	17.96
6.13	0.013333	0.94100	0.00900	173.33	18.69	173.33	18.69
7.09	0.015416	0.97400	0.00900	200.41	19.35	200.41	19.35
8.05	0.017499	1.00000	0.00000	227.49	19.86	227.49	19.86

GARDON B50.6 VANELESS DIFFUSER , INLET R = 1.405 FT IDENT 14.

PROFILE NUMBER 2 X = 0.180 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.16	0.000667	0.31900	0.09200	6.74	7.51	6.94	7.60
0.24	0.001000	0.44300	0.12700	10.12	10.43	10.41	10.54
0.34	0.001417	0.48400	0.13700	14.33	11.40	14.75	11.51
0.53	0.002250	0.52100	0.14300	22.76	12.27	23.43	12.36
0.69	0.002917	0.56800	0.15100	29.51	13.37	30.37	13.45
0.89	0.003750	0.60400	0.14900	37.94	14.22	39.04	14.23
1.28	0.005416	0.64100	0.13600	54.80	15.09	56.39	14.99
1.68	0.007083	0.65300	0.12400	71.66	15.38	73.75	15.21
2.07	0.008750	0.67000	0.11300	88.53	15.78	91.10	15.55
2.47	0.010416	0.76200	0.10600	105.39	17.94	108.45	17.60
2.86	0.012083	0.75600	0.09400	122.25	17.80	125.80	17.43
3.26	0.013749	0.78700	0.08700	139.11	18.53	143.16	18.12
3.75	0.015833	0.81400	0.07500	160.19	19.17	164.85	18.70
4.25	0.017916	0.85900	0.06300	181.27	20.23	186.54	19.71
5.24	0.022082	0.92000	0.03900	223.42	21.66	229.92	21.07
6.22	0.026249	0.96900	0.01600	265.58	22.82	273.30	22.18
7.21	0.030415	0.99700	0.00200	307.73	23.48	316.68	22.81
8.20	0.034582	1.00000	0.00000	349.89	23.55	360.06	22.88

GARDOW 850.6 VANELESS DIFFUSER . INLET R = 1.405 FT IDENT 14.

PROFILE NUMBER 3 X = 0.360 FT

Y/THIL	Y (FT)	LS/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.10	0.000667	0.15600	0.05800	5.57	4.09	5.92	4.10
0.16	0.001000	0.20700	0.07700	8.35	5.42	8.88	5.44
0.22	0.001417	0.27400	0.10200	11.83	7.18	12.58	7.20
0.35	0.002250	0.42400	0.15900	18.79	11.11	19.98	11.16
0.46	0.002917	0.48400	0.18100	24.36	12.68	25.91	12.73
0.59	0.003750	0.50800	0.18600	31.32	13.31	33.31	13.33
0.72	0.004583	0.54300	0.19100	38.28	14.23	40.71	14.18
0.98	0.006250	0.56100	0.17700	52.20	14.70	55.51	14.49
1.24	0.007916	0.60200	0.17700	66.12	15.77	70.32	15.46
1.51	0.009583	0.63000	0.17400	80.05	16.50	85.12	16.10
1.77	0.011250	0.64100	0.15800	93.97	16.79	99.92	16.26
2.03	0.012916	0.67300	0.15400	107.89	17.63	114.73	17.01
2.29	0.014583	0.69400	0.14600	121.81	18.18	129.53	17.47
2.62	0.016666	0.71000	0.13300	139.21	18.60	148.03	17.80
2.94	0.018749	0.74400	0.12600	156.61	19.49	166.54	18.59
3.27	0.020832	0.75100	0.11400	174.01	19.67	185.04	18.71
3.60	0.022916	0.81400	0.10700	191.41	21.32	203.55	20.23
4.25	0.027082	0.85700	0.07300	226.22	22.45	240.55	21.19
4.91	0.031249	0.90800	0.05100	261.02	23.79	277.56	22.40
5.56	0.035415	0.95000	0.02900	295.82	24.89	314.57	23.41
6.22	0.039582	0.98200	0.01400	330.62	25.73	351.58	24.19
6.87	0.043748	0.98600	0.00700	365.43	25.83	388.59	24.29
7.53	0.047915	1.00000	0.00000	400.23	26.20	425.60	24.64

GARDOW B50.6 VANELESS DIFFUSER , INLET R = 1.405 FT IDENT 14.

PROFILE NUMBER 4 X = 0.530 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.08	0.000667	0.21300	0.10300	4.94	5.88	5.29	6.10
0.10	0.000833	0.25100	0.12100	6.18	6.93	6.62	7.18
0.15	0.001250	0.29100	0.14100	9.26	8.04	9.93	8.34
0.20	0.001667	0.33500	0.16200	12.35	9.25	13.23	9.59
0.29	0.002500	0.38000	0.18400	18.53	10.50	19.85	10.88
0.37	0.003167	0.45800	0.21400	23.47	12.65	25.15	13.03
0.47	0.004000	0.45000	0.20000	29.65	12.43	31.76	12.69
0.57	0.004833	0.46300	0.20300	35.82	12.79	38.38	13.03
0.77	0.006500	0.52500	0.21200	48.17	14.50	51.62	14.60
0.96	0.008166	0.55300	0.20900	60.53	15.27	64.85	15.24
1.16	0.009833	0.56500	0.20400	72.88	15.60	78.09	15.48
1.35	0.011500	0.58900	0.19900	85.23	16.27	91.32	16.03
1.55	0.013166	0.61900	0.19100	97.58	17.10	104.55	16.70
1.75	0.014833	0.62800	0.18100	109.94	17.34	117.79	16.85
1.99	0.016916	0.65400	0.16900	125.38	18.06	134.33	17.41
2.24	0.018999	0.65600	0.15300	140.82	18.12	150.88	17.36
2.48	0.021082	0.71400	0.15200	156.26	19.72	167.42	18.82
2.73	0.023166	0.72800	0.14400	171.70	20.11	183.96	19.13
2.97	0.025249	0.74000	0.13200	187.14	20.44	200.51	19.38
3.22	0.027332	0.75200	0.12000	202.58	20.77	217.05	19.63
3.46	0.029415	0.80700	0.11200	218.02	22.29	233.59	21.00
3.71	0.031499	0.82500	0.10300	233.46	22.79	250.14	21.43
4.20	0.035665	0.86100	0.07900	264.34	23.78	283.22	22.29
4.69	0.039832	0.90600	0.05700	295.22	25.02	316.31	23.40
5.18	0.043998	0.92500	0.03500	326.10	25.55	349.40	23.86
5.67	0.048165	0.96600	0.02300	356.99	26.68	382.48	24.91
6.16	0.052331	0.97000	0.01200	387.87	26.79	415.57	25.01
6.65	0.056498	0.98900	0.00700	418.75	27.32	448.66	25.49
7.14	0.060664	1.00000	0.00000	449.63	27.62	481.74	25.78

GARDON 850.6 VANELESS DIFFUSER , INLET R = 1.405 FT IDENT 14.

PROFILE NUMBER 5 X = 0.710 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.06	0.000667	0.19100	0.10200	4.31	5.66	4.67	5.93
0.08	0.000833	0.21600	0.11500	5.39	6.40	5.83	6.70
0.12	0.001250	0.22300	0.11900	8.09	6.61	8.75	6.92
0.20	0.002083	0.34500	0.18300	13.48	10.22	14.58	10.70
0.28	0.002917	0.40400	0.21100	18.87	11.97	20.42	12.49
0.35	0.003583	0.41000	0.21300	23.19	12.15	25.08	12.66
0.51	0.005250	0.45600	0.22800	33.97	13.51	36.75	13.97
0.67	0.006916	0.48900	0.23300	44.75	14.49	48.41	14.84
0.87	0.009000	0.50400	0.22700	58.23	14.94	63.00	15.14
1.07	0.011083	0.52500	0.21600	71.71	15.56	77.58	15.55
1.27	0.013166	0.53900	0.21000	85.19	15.97	92.16	15.85
1.47	0.015249	0.57300	0.20400	98.67	16.98	106.75	16.66
1.67	0.017333	0.58900	0.20000	112.15	17.46	121.33	17.04
1.87	0.019416	0.60900	0.18500	125.63	18.05	135.91	17.44
2.08	0.021499	0.63900	0.18600	139.11	18.94	150.49	18.23
2.28	0.023582	0.67200	0.18200	152.59	19.92	165.08	19.07
2.48	0.025666	0.69300	0.16500	166.07	20.54	179.66	19.52
2.68	0.027749	0.70000	0.16000	179.55	20.75	194.24	19.67
2.88	0.029832	0.72000	0.15100	193.03	21.34	208.82	20.15
3.08	0.031915	0.74800	0.14000	206.51	22.17	223.41	20.85
3.28	0.033999	0.76500	0.12600	219.99	22.67	237.99	21.24
3.48	0.036082	0.77900	0.11700	233.47	23.09	252.57	21.58
3.68	0.038165	0.80000	0.11000	246.95	23.71	267.16	22.12
3.89	0.040248	0.82200	0.09900	260.43	24.36	281.74	22.68
4.29	0.044415	0.86700	0.08200	287.39	25.69	310.90	23.86
4.69	0.048581	0.90400	0.06200	314.35	26.79	340.07	24.82
5.09	0.052748	0.92600	0.04100	341.31	27.44	369.23	25.39
5.50	0.056914	0.96300	0.02700	368.27	28.54	398.40	26.39
5.90	0.061081	0.98500	0.01700	395.23	29.19	427.57	26.99
6.30	0.065247	0.99100	0.00900	422.19	29.37	456.73	27.15
6.70	0.069414	1.00000	0.00000	449.15	29.64	485.90	27.39

GARDOW 850.6 VANELESS DIFFUSER , INLET R = 1.405 FT IDENT 14.

PROFILE NUMBER 6 X = 0.850 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.05	0.000667	0.18100	0.11000	3.84	5.82	4.31	6.07
0.07	0.001000	0.23100	0.14100	5.76	7.42	6.47	7.75
0.13	0.001833	0.32100	0.19600	10.57	10.32	11.86	10.77
0.19	0.002667	0.36000	0.21900	15.37	11.57	17.25	12.07
0.24	0.003333	0.36800	0.22500	19.21	11.83	21.57	12.35
0.36	0.005000	0.41500	0.24500	28.82	13.34	32.35	13.80
0.48	0.006666	0.44800	0.25200	38.43	14.40	43.14	14.72
0.63	0.008750	0.45900	0.24900	50.44	14.75	56.62	14.95
0.78	0.010833	0.49700	0.24900	62.45	15.97	70.10	15.92
0.93	0.012916	0.47500	0.22700	74.46	15.27	83.58	15.08
1.07	0.014999	0.50800	0.22700	86.47	16.33	97.05	15.93
1.22	0.017083	0.53900	0.23500	98.48	17.32	110.53	16.84
1.37	0.019166	0.54500	0.22100	110.49	17.52	124.01	16.84
1.52	0.021249	0.56500	0.21300	122.50	18.16	137.49	17.29
1.67	0.023332	0.58900	0.20900	134.50	18.93	150.97	17.90
1.82	0.025416	0.60700	0.20300	146.51	19.51	164.45	18.33
1.97	0.027499	0.62800	0.19500	158.52	20.19	177.93	18.83
2.12	0.029582	0.64800	0.18800	170.53	20.83	191.41	19.32
2.27	0.031665	0.64400	0.18200	182.54	20.70	204.89	19.16
2.57	0.035832	0.67300	0.15700	206.56	21.63	231.85	19.79
2.87	0.039998	0.71700	0.14600	230.58	23.05	258.81	20.95
3.16	0.044165	0.74700	0.12300	254.60	24.01	285.77	21.68
3.46	0.048331	0.78300	0.11700	278.62	25.17	312.73	22.67
3.76	0.052498	0.82200	0.09800	302.63	26.42	339.69	23.71
4.06	0.056664	0.85500	0.08100	326.65	27.48	366.65	24.59
4.66	0.064997	0.91100	0.04900	374.69	29.28	420.57	26.13
5.25	0.073330	0.95000	0.02500	422.73	30.54	474.49	27.21
5.85	0.081663	0.98200	0.00900	470.77	31.56	528.41	28.12
6.45	0.089996	0.98400	0.00500	518.80	31.63	582.33	28.18
7.04	0.098329	1.00000	0.00000	566.84	32.14	636.25	28.64

GARDOW 850.6 VANELESS DIFFUSER , INLET R = 1.405 FT IDENT 14.

PROFILE NUMBER 7 X = 1.010 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (N)	Q+
0.04	0.000667	0.19200	0.12300	3.88	5.97	4.31	6.38
0.07	0.001167	0.22500	0.14400	6.79	7.00	7.55	7.48
0.12	0.002000	0.30700	0.19700	11.65	9.55	12.94	10.21
0.17	0.002833	0.38200	0.21000	16.50	11.88	18.33	12.21
0.21	0.003500	0.38100	0.24400	20.38	11.85	22.65	12.67
0.26	0.004333	0.40800	0.25900	25.23	12.69	28.04	13.53
0.36	0.006000	0.42500	0.26000	34.94	13.22	38.82	13.95
0.46	0.007666	0.45100	0.27000	44.65	14.03	49.61	14.72
0.56	0.009333	0.45000	0.25400	54.35	14.00	60.39	14.47
0.66	0.011000	0.48300	0.26800	64.06	15.03	71.17	15.47
0.78	0.013083	0.50600	0.26100	76.19	15.74	84.65	15.94
0.91	0.015166	0.53600	0.26600	88.32	16.68	98.13	16.75
1.03	0.017249	0.53000	0.25000	100.45	16.49	111.61	16.41
1.16	0.019333	0.54000	0.24400	112.58	16.80	125.09	16.59
1.28	0.021416	0.55000	0.23400	124.72	17.11	138.57	16.74
1.41	0.023499	0.56200	0.22600	136.85	17.48	152.05	16.96
1.53	0.025582	0.59400	0.22800	148.98	18.48	165.53	17.82
1.65	0.027666	0.60200	0.21900	161.11	18.73	179.01	17.94
1.78	0.029749	0.61800	0.21500	173.24	19.23	192.49	18.32
1.90	0.031832	0.63300	0.20800	185.37	19.69	205.97	18.66
2.03	0.033915	0.64300	0.20000	197.51	20.00	219.45	18.85
2.15	0.035999	0.66200	0.19500	209.64	20.60	232.93	19.32
2.40	0.040165	0.68100	0.17700	233.90	21.19	259.89	19.70
2.65	0.044332	0.70500	0.16400	258.17	21.93	286.85	20.27
2.90	0.048498	0.73700	0.14200	282.43	22.93	313.81	21.02
3.15	0.052665	0.75600	0.13400	306.69	23.52	340.77	21.50
3.40	0.056831	0.78900	0.11800	330.96	24.55	367.73	22.34
3.65	0.060998	0.82100	0.10700	355.22	25.54	394.69	23.18
3.90	0.065164	0.83800	0.09300	379.48	26.07	421.65	23.61
4.15	0.069331	0.85600	0.08100	403.75	26.63	448.61	24.08
4.65	0.077663	0.89800	0.05300	452.28	27.94	502.53	25.19
5.14	0.085996	0.93000	0.03700	500.80	28.93	556.45	26.06
5.64	0.094329	0.96100	0.02300	549.33	29.90	610.37	26.92
6.14	0.102663	0.98600	0.01000	597.86	30.68	664.29	27.61
6.64	0.110995	1.00000	0.00000	646.39	31.11	718.21	28.00

TITLE: Gardow B-52.1 Vaneless Diffuser, Flow 16

REFERENCE: Gardow, E., "The three-dimensional turbulent boundary layer in a free vortex diffuser," MIT Gas Turbine Lab. Rept. 42, Jan.1958

DESCRIPTION: The development of the turbulent boundary layer on one wall of a parallel walled, axially symmetric vaneless diffuser was measured (Figure 10.1). The direction and magnitude of the velocity was measured with a three holed cobra probe (dimensions not given). No turbulence data were taken.

EDITORS' COMMENTS: The first profile showed no logarithmic region and it may not be a fully turbulent profile. At the last two profiles, the boundary layers are 1.089 and 1.388 inches thick respectively. Assuming that the boundary layer on the other wall is of similar thickness, it is possible that the potential core (inviscid external flow) no longer exists in this region. No value of the kinematic viscosity was supplied by the orginator. Since it is known that the experiments were performed in room air, it is assumed that the kinematic viscosity has a value of .000170 ft^2/sec.

PRESSURE GRADIENT: (see Figure 16.1)

x feet	Q_∞ ft/sec	$\partial Q_\infty/\partial x$ sec-1
-0.005	48.100	-23.00
0.095	45.863	-21.74
0.195	43.744	-20.50
0.295	41.801	-18.40
0.395	40.046	-16.60
0.495	38.509	-14.10
0.595	37.227	-11.40
0.695	36.263	-7.90
0.795	35.642	-4.50
0.895	35.371	-0.91

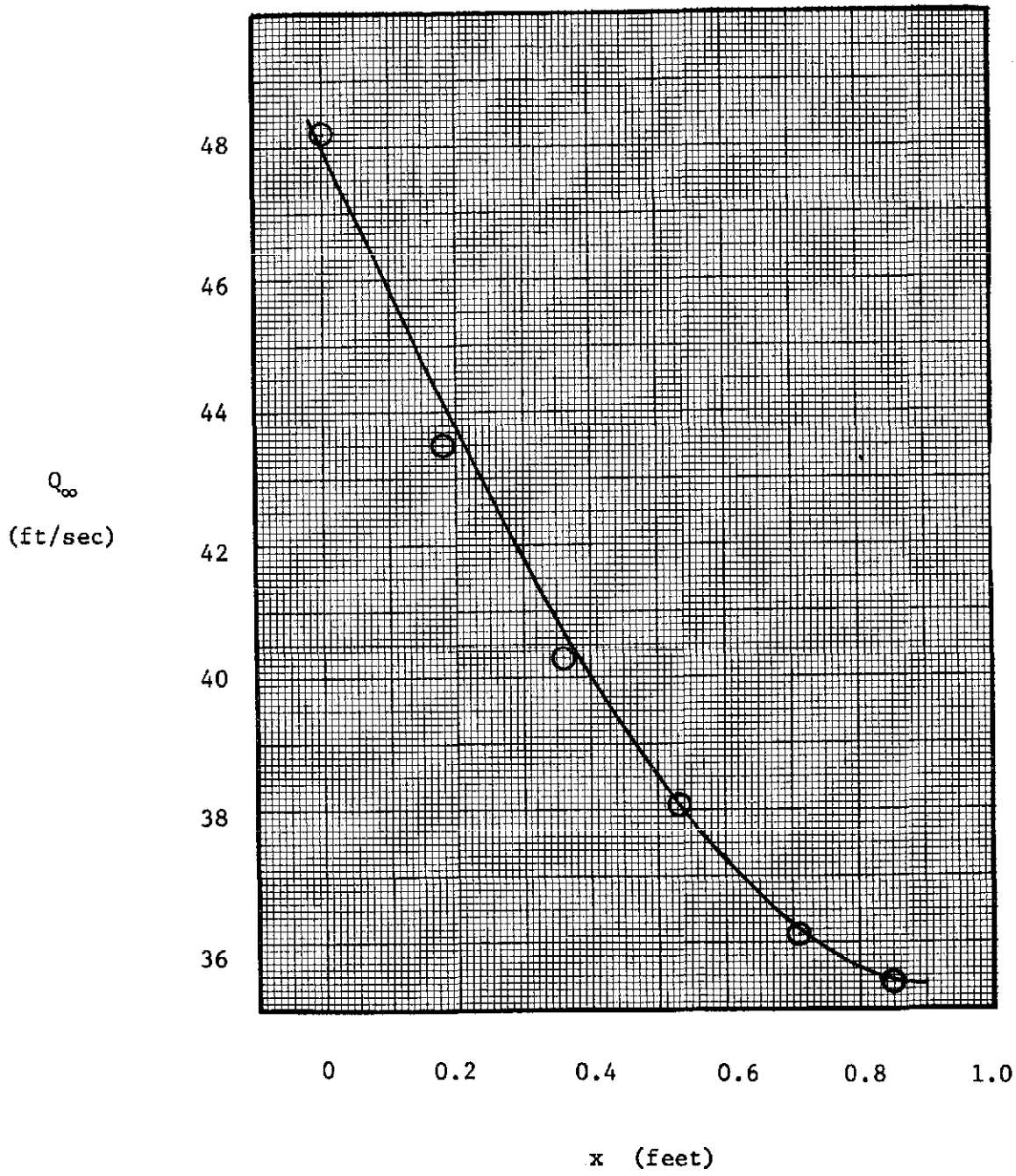


Figure 16.1 - Gardow B-52.1 Q_∞ Distribution

GARDOW VANELESS DIFFUSER B=52.1, INLET R = 1.405 FT IDENT =16. KIN. VISC= 0.0001700

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	670.3	1.646	--	0.003293	—	8.06	--	0.003891	0.002364
0.18000	1255.7	1.538	0.003463	0.003296	0.003696	18.89	20.47	0.007545	0.004907
0.36000	1762.4	1.671	0.002625	0.002443	0.002959	23.96	27.47	0.012425	0.007434
0.53000	2223.4	1.699	0.002153	0.002198	0.002548	28.78	32.35	0.016855	0.009921
0.71000	2842.5	1.774	0.001823	0.001832	0.002322	32.59	38.25	0.023742	0.013386
0.85000	3418.4	1.717	0.001760	0.001904	0.002454	37.25	44.19	0.028187	0.016416

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.000770	0.000046	0.000564	0.000206	—	—	—	—	48.20	52.1
0.18000	0.002883	0.000356	0.001981	0.000902	0.000	0.000	0.000	0.000	43.50	52.1
0.36000	0.005277	0.000805	0.003445	0.001832	0.192	0.117	0.522	0.367	40.30	50.2
0.53000	0.007763	0.001347	0.004861	0.002902	0.188	0.181	0.969	0.617	38.10	48.8
0.71000	0.010194	0.001829	0.006026	0.004169	0.928	0.225	1.842	0.824	36.10	46.2
0.85000	0.015345	0.003222	0.009371	0.005973	3.788	0.252	1.494	0.966	35.40	42.6

GARDOW VANELESS DIFFUSER B-52.1,INLET R = 1.405 IDENT 16.

PROFILE NUMBER 1 X = 0.000 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.28	0.000667	0.22600	0.03200	3.92	10.89	3.92	11.00
0.46	0.001083	0.45300	0.06400	6.37	21.83	6.37	22.05
0.63	0.001500	0.51900	0.07300	8.82	25.02	8.82	25.26
0.99	0.002333	0.59700	0.07900	13.72	28.78	13.72	29.03
1.27	0.003000	0.62400	0.07700	17.65	30.08	17.65	30.30
1.62	0.003833	0.69200	0.07700	22.55	33.35	22.55	33.56
2.33	0.005500	0.75400	0.07800	32.35	36.34	32.35	36.54
3.03	0.007166	0.79900	0.06000	42.16	38.51	42.16	38.62
3.74	0.008833	0.83200	0.04700	51.96	40.10	51.96	40.17
4.44	0.010500	0.86100	0.03400	61.76	41.50	61.76	41.53
5.15	0.012166	0.90100	0.02300	71.57	43.43	71.57	43.44
6.91	0.016333	0.97400	0.00700	96.07	46.95	96.07	46.95
8.67	0.020499	0.99400	0.00200	120.58	47.91	120.58	47.91
10.43	0.024666	1.00000	0.00000	145.09	48.20	145.09	48.20

GARDOW VANELESS DIFFUSER B-52.1,INLET R = 1.405 IDENT 16.

PROFILE NUMBER 2 X = 0.180 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (N)	Q+
0.14	0.000667	0.41800	0.14300	7.10	10.05	7.33	10.28
0.24	0.001167	0.42100	0.14400	12.42	10.12	12.83	10.35
0.32	0.001583	0.47200	0.15900	16.86	11.34	17.42	11.59
0.49	0.002417	0.50500	0.16300	25.73	12.14	26.58	12.34
0.63	0.003083	0.56500	0.17200	32.83	13.58	33.92	13.74
0.97	0.004750	0.60500	0.16800	50.57	14.54	52.25	14.61
1.31	0.006416	0.63700	0.15900	68.32	15.31	70.58	15.27
1.65	0.008083	0.66800	0.14700	86.06	16.05	88.91	15.91
1.99	0.009750	0.70000	0.13800	103.80	16.82	107.25	16.60
2.33	0.011416	0.71500	0.12300	121.55	17.18	125.58	16.88
2.67	0.013083	0.75700	0.11700	139.29	18.19	143.91	17.82
3.09	0.015166	0.76600	0.10000	161.47	18.41	166.83	17.97
3.52	0.017249	0.79800	0.08400	183.65	19.18	189.74	18.67
3.94	0.019333	0.84000	0.07200	205.83	20.19	212.66	19.61
4.36	0.021416	0.86400	0.05300	228.02	20.76	235.57	20.14
5.21	0.025582	0.92600	0.03100	272.38	22.25	281.41	21.55
6.06	0.029749	0.96400	0.00900	316.74	23.17	327.24	22.43
6.91	0.033915	0.99000	0.00200	361.10	23.79	373.07	23.03
7.76	0.038082	1.00000	0.00000	405.46	24.03	418.90	23.26

GARDOW VANELESS DIFFUSER B-52.1,INLET R = 1.405 IDENT 16.

PROFILE NUMBER 3 X = 0.360 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.09	0.000667	0.15300	0.06800	5.73	4.22	6.08	4.35
0.11	0.000833	0.18700	0.08300	7.16	5.16	7.60	5.32
0.17	0.001250	0.24500	0.10900	10.73	6.76	11.40	6.97
0.22	0.001667	0.38200	0.17000	14.31	10.54	15.20	10.87
0.34	0.002500	0.43700	0.19500	21.47	12.06	22.79	12.44
0.43	0.003167	0.47800	0.21100	27.19	13.19	28.87	13.58
0.54	0.004000	0.48700	0.20500	34.35	13.44	36.47	13.74
0.65	0.004833	0.50400	0.20800	41.51	13.91	44.07	14.18
0.76	0.005666	0.53900	0.21500	48.66	14.88	51.66	15.09
0.99	0.007333	0.53000	0.19600	62.98	14.63	66.86	14.69
1.21	0.009000	0.56200	0.20200	77.29	15.51	82.06	15.53
1.43	0.010666	0.59700	0.18800	91.60	16.48	97.25	16.27
1.66	0.012333	0.61200	0.18000	105.92	16.89	112.45	16.59
1.88	0.013999	0.64700	0.17800	120.23	17.86	127.64	17.45
2.16	0.016083	0.67800	0.16700	138.12	18.71	146.64	18.15
2.44	0.018166	0.69900	0.15500	156.01	19.29	165.63	18.62
2.72	0.020249	0.71300	0.13900	173.90	19.68	184.62	18.89
3.00	0.022332	0.74300	0.12800	191.80	20.51	203.62	19.60
3.56	0.026499	0.80200	0.10400	227.58	22.14	241.61	21.03
4.12	0.030665	0.83700	0.07700	263.36	23.10	279.60	21.85
4.69	0.034832	0.89400	0.05300	299.14	24.68	317.59	23.28
5.25	0.038998	0.93300	0.03100	334.93	25.75	355.57	24.27
5.81	0.043165	0.97200	0.01600	370.71	26.83	393.56	25.28
6.37	0.047331	0.98800	0.00500	406.49	27.27	431.55	25.69
6.93	0.051498	1.00000	0.00000	442.28	27.60	469.54	26.00

GARDOW VANELESS DIFFUSER B-52.1,INLET R = 1.405 IDENT 16.

PROFILE NUMBER 4 X = 0.530 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.07	0.000667	0.21300	0.11700	4.90	6.49	5.33	6.81
0.10	0.001000	0.25400	0.13900	7.35	7.74	8.00	8.11
0.14	0.001417	0.31200	0.17100	10.42	9.51	11.33	9.97
0.23	0.002250	0.38500	0.21100	16.54	11.73	18.00	12.30
0.31	0.003083	0.41200	0.22600	22.67	12.56	24.67	13.16
0.46	0.004583	0.43900	0.22900	33.70	13.38	36.67	13.87
0.63	0.006250	0.48700	0.24200	45.95	14.84	50.00	15.23
0.80	0.007916	0.49600	0.23200	58.21	15.12	63.33	15.34
0.97	0.009583	0.49500	0.21600	70.46	15.09	76.66	15.13
1.13	0.011250	0.53600	0.22600	82.72	16.34	90.00	16.30
1.30	0.012916	0.53500	0.20800	94.97	16.31	103.33	16.08
1.47	0.014583	0.57300	0.21200	107.23	17.47	116.66	17.12
1.68	0.016666	0.60500	0.20900	122.54	18.44	133.33	17.93
1.89	0.018749	0.63800	0.20300	137.86	19.45	149.99	18.76
2.10	0.020832	0.63400	0.18200	153.18	19.32	166.66	18.48
2.31	0.022916	0.66600	0.17500	168.50	20.30	183.33	19.29
2.52	0.024999	0.67200	0.16200	183.82	20.48	199.99	19.37
2.73	0.027082	0.70900	0.15200	199.13	21.61	216.66	20.31
2.94	0.029165	0.73000	0.14400	214.45	22.25	233.32	20.84
3.15	0.031249	0.76300	0.13700	229.77	23.26	249.99	21.72
3.57	0.035415	0.78800	0.11100	260.41	24.02	283.32	22.29
3.99	0.039582	0.84100	0.08900	291.04	25.63	316.65	23.69
4.41	0.043748	0.87300	0.06700	321.68	26.61	349.99	24.53
4.83	0.047915	0.92000	0.04500	352.31	28.04	383.32	25.80
5.25	0.052081	0.94500	0.03100	382.95	28.80	416.65	26.49
5.67	0.056248	0.97000	0.01200	413.59	29.57	449.98	27.18
6.09	0.060414	0.98400	0.00300	444.22	29.99	483.31	27.57
6.51	0.064581	1.00000	0.00000	474.86	30.48	516.64	28.01

GARCOW VANELESS DIFFUSER B-52.1, INLET R = 1.405 IDENT 16.

PROFILE NUMBER 5 X = 0.710 FT

Y/THIL	Y (FT)	LS/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.05	0.000667	0.12200	0.07800	4.27	4.04	4.82	4.25
0.07	0.000917	0.16400	0.10500	5.88	5.43	6.63	5.72
0.10	0.001333	0.24200	0.15600	8.55	8.01	9.65	8.45
0.13	0.001750	0.29600	0.19000	11.22	9.80	12.66	10.32
0.19	0.002583	0.35400	0.22700	16.56	11.72	18.69	12.34
0.24	0.003250	0.38300	0.24600	20.84	12.68	23.51	13.36
0.31	0.004083	0.35200	0.21900	26.18	11.66	29.54	12.17
0.37	0.004916	0.40000	0.24600	31.52	13.25	35.57	13.78
0.43	0.005750	0.39100	0.23300	36.87	12.95	41.60	13.36
0.55	0.007416	0.43900	0.25000	47.55	14.54	53.66	14.83
0.68	0.009083	0.45300	0.24400	58.24	15.00	65.72	15.10
0.80	0.010750	0.46400	0.24000	68.92	15.37	77.78	15.33
0.93	0.012416	0.46900	0.22900	79.61	15.53	89.83	15.32
1.05	0.014083	0.49800	0.23300	90.30	16.49	101.89	16.14
1.18	0.015749	0.51700	0.22900	100.98	17.12	113.95	16.60
1.33	0.017833	0.53700	0.22600	114.34	17.79	129.02	17.10
1.49	0.019916	0.53700	0.21400	127.70	17.79	144.10	16.97
1.64	0.021999	0.56200	0.20800	141.05	18.61	159.17	17.59
1.80	0.024082	0.59100	0.20100	154.41	19.57	174.24	18.32
1.95	0.026166	0.60200	0.19100	167.77	19.94	189.32	18.54
2.11	0.028249	0.60800	0.18200	181.13	20.14	204.39	18.63
2.27	0.030332	0.62600	0.17300	194.48	20.73	219.46	19.06
2.42	0.032415	0.63000	0.15700	207.84	20.87	234.53	19.06
2.73	0.036582	0.67900	0.14900	234.55	22.49	264.68	20.40
3.04	0.040748	0.73200	0.13000	261.27	24.24	294.83	21.82
3.36	0.044915	0.76400	0.11400	287.98	25.30	324.97	22.67
3.67	0.049081	0.81000	0.09600	314.70	26.83	355.12	23.94
3.98	0.053248	0.84400	0.07800	341.41	27.95	385.26	24.88
4.29	0.057414	0.87100	0.05900	368.13	28.85	415.41	25.62
4.60	0.061581	0.90500	0.04600	394.84	29.97	445.56	26.60
4.91	0.065747	0.93300	0.03100	421.56	30.90	475.70	27.40
5.53	0.074080	0.96100	0.01200	474.99	31.83	535.99	28.21
6.16	0.082413	0.99300	0.00000	528.41	32.89	596.28	29.14
6.78	0.090746	1.00000	0.00000	581.84	33.12	656.58	29.35

GARCOW VANELESS DIFFUSER B-52.1,INLET R = 1.405 IDENT 16.

PROFILE NUMBER 6 X = 0.850 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.04	0.000667	0.19200	0.14600	4.12	6.47	4.86	6.89
0.05	0.000833	0.23000	0.17400	5.15	7.75	6.08	8.23
0.08	0.001250	0.26200	0.19900	7.72	8.83	9.12	9.39
0.10	0.001667	0.29800	0.22600	10.29	10.05	12.16	10.68
0.15	0.002500	0.33500	0.25400	15.44	11.29	18.23	12.00
0.19	0.003167	0.36600	0.27800	19.56	12.34	23.10	13.12
0.24	0.004000	0.37900	0.28800	24.70	12.78	29.18	13.59
0.29	0.004833	0.38000	0.28000	29.85	12.81	35.25	13.48
0.35	0.005666	0.40800	0.29300	35.00	13.76	41.33	14.34
0.45	0.007333	0.43500	0.30700	45.29	14.67	53.49	15.20
0.57	0.009416	0.45100	0.29600	58.16	15.21	68.68	15.40
0.70	0.011500	0.45900	0.28900	71.03	15.47	83.88	15.48
0.83	0.013583	0.47600	0.28100	83.89	16.05	99.07	15.78
0.95	0.015666	0.49900	0.28000	96.76	16.82	114.27	16.34
1.08	0.017749	0.52300	0.28200	109.63	17.63	129.47	16.96
1.21	0.019833	0.54100	0.27300	122.50	18.24	144.66	17.30
1.34	0.021916	0.53300	0.25500	135.36	17.97	159.86	16.87
1.46	0.023999	0.55400	0.25000	148.23	18.68	175.05	17.35
1.59	0.026082	0.57100	0.24100	161.10	19.25	190.25	17.69
1.72	0.028166	0.58900	0.23700	173.96	19.86	205.44	18.13
1.84	0.030249	0.59600	0.22800	186.83	20.09	220.64	18.22
1.97	0.032332	0.60500	0.21700	199.70	20.40	235.83	18.35
2.10	0.034415	0.63500	0.21600	212.56	21.41	251.03	19.15
2.22	0.036499	0.64700	0.20400	225.43	21.81	266.22	19.37
2.35	0.038582	0.65900	0.20000	238.30	22.22	281.42	19.66
2.48	0.040665	0.67500	0.19400	251.17	22.76	296.62	20.05
2.73	0.044832	0.70600	0.17400	276.90	23.80	327.01	20.76
2.98	0.048998	0.73000	0.15900	302.63	24.61	357.40	21.33
3.24	0.053165	0.76900	0.14200	328.37	25.93	387.79	22.32
3.49	0.057331	0.77300	0.12000	354.10	26.06	418.18	22.33
3.75	0.061498	0.80900	0.10800	379.84	27.27	448.57	23.30
4.00	0.065664	0.84900	0.09500	405.57	28.62	478.96	24.39
4.25	0.069830	0.86500	0.07900	431.31	29.16	509.35	24.80
4.51	0.073997	0.88300	0.06600	457.04	29.77	539.74	25.28
5.02	0.082330	0.94600	0.04000	508.51	31.89	600.52	27.03
5.52	0.090663	0.98200	0.02600	559.98	33.11	661.31	28.04
6.03	0.098996	0.97400	0.01400	611.45	32.84	722.09	27.81
6.54	0.107329	0.98900	0.00700	662.91	33.34	782.87	28.24
7.05	0.115662	1.00000	0.00000	714.38	33.71	843.65	28.55

TITLE : Gardow B-54.5 Vaneless Diffuser, Flow 18

REFERENCE: Gardow, E., "The three-dimensional turbulent boundary layer in a free vortex diffuser," MIT Gas Turbine Lab. Rept. 42, Jan. 1958

DESCRIPTION: The development of the turbulent boundary layer on one wall of a parallel walled, axially symmetric vaneless diffuser was measured (Figure 10.1). The direction and magnitude of the velocity was measured with a three holed cobra probe (dimensions not given). No turbulence data were taken.

EDITORS' COMMENTS: The first profile showed no logarithmic region and it may not be a fully turbulent profile. At the last three profiles, the boundary layers are 1.387 and 1.383 inches thick respectively. Assuming that the boundary layer on the other wall is of similar thickness, it is possible that the potential core (inviscid external flow) no longer exists in this region. No value of the kinematic viscosity was supplied by the originator. Since it is known that the experiments were performed in room air, it is assumed that the kinematic viscosity has a value of .000170 ft^2/sec.

PRESSURE GRADIENT: (see Figure 18.1)

x feet	Q_∞ ft/sec	$\partial Q_\infty/\partial x$ (sec^{-1})
-0.005	53.400	-32.14
0.095	50.369	-28.46
0.195	47.706	-24.62
0.295	45.501	-19.72
0.395	43.707	-16.24
0.495	42.239	-13.24
0.595	41.033	-11.04
0.695	39.998	-9.72
0.795	39.070	-8.82
0.895	38.243	-7.84
0.995	37.476	-7.52
1.095	36.734	-7.32

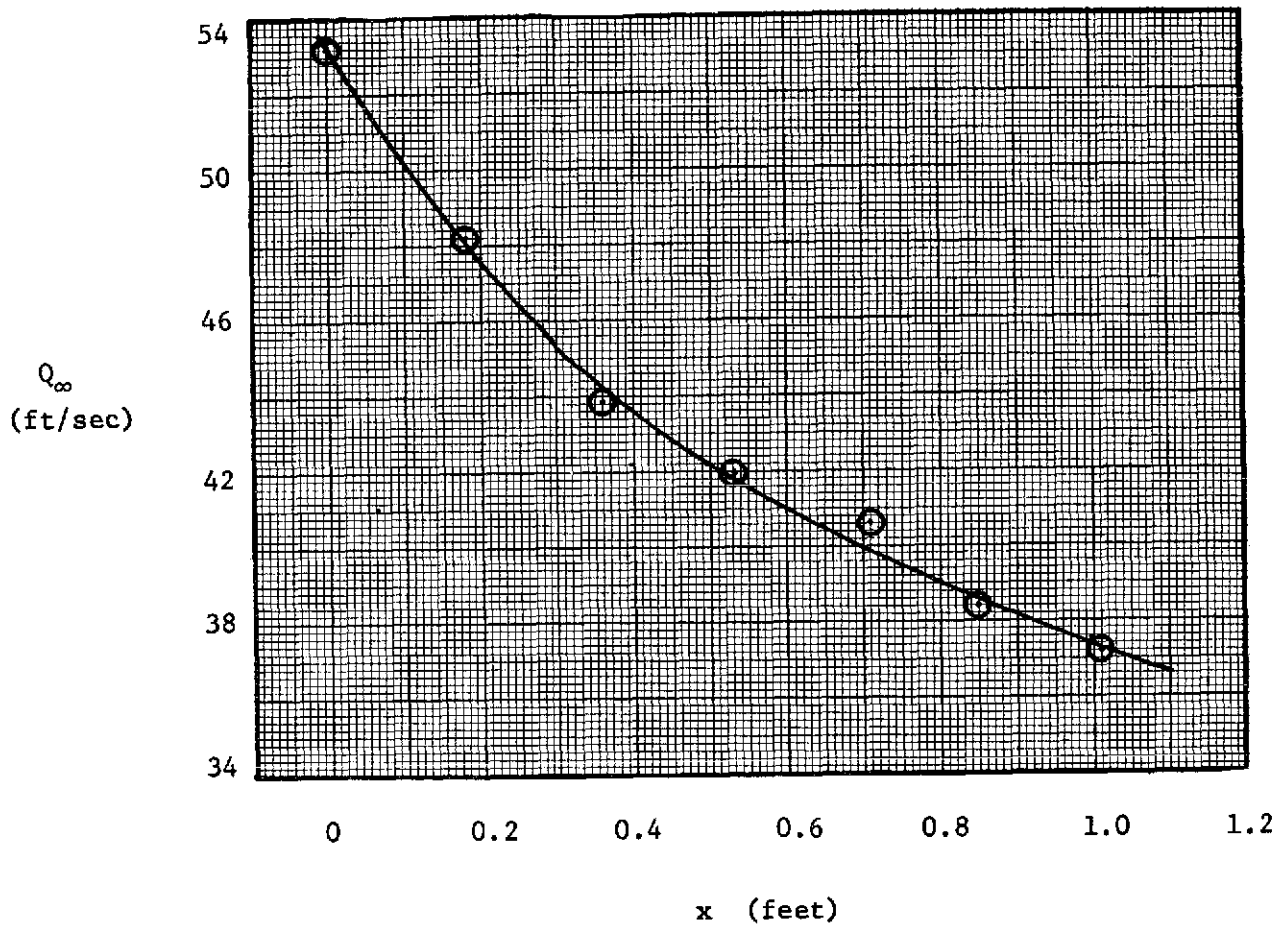


Figure 18.1 - Gardow B-54.5 Q_∞ Distribution

GARDOW 854.5 VANELESS DIFFUSER, INLET R = 1.405 FT IDENT =18. KIN. VISC= 0.0001700

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	739.0	1.626	—	0.003308	—	8.67	—	0.003841	0.002362
0.18000	1552.8	1.629	0.002789	0.002701	0.003043	23.59	23.55	0.008919	0.005477
0.36000	2165.3	1.669	0.002335	0.002319	0.002791	28.35	33.22	0.013995	0.008385
0.53000	2755.2	1.744	0.001946	0.001934	0.002417	32.83	36.38	0.019449	0.011152
0.71000	3863.8	1.766	0.001577	0.001706	0.002211	39.21	44.51	0.028579	0.016179
0.85000	4017.6	1.686	0.001794	0.001913	0.002583	39.02	46.02	0.029994	0.017786
1.01000	3692.3	1.649	0.001911	0.002075	0.002595	36.79	42.56	0.027822	0.016873

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.000842	0.000054	0.000618	0.000224	—	—	—	—	53.20	54.5
0.18000	0.003679	0.000523	0.002430	0.001249	0.000	0.000	0.000	0.000	48.20	54.5
0.36000	0.006661	0.001174	0.004266	0.002395	0.208	0.060	0.459	0.302	43.90	51.4
0.53000	0.009313	0.001757	0.005652	0.003662	0.415	0.095	0.975	0.519	42.00	49.6
0.71000	0.014526	0.003056	0.008539	0.005987	3.116	0.116	1.678	0.706	40.60	45.5
0.85000	0.017881	0.004228	0.010943	0.006937	2.836	0.130	1.375	0.838	38.40	44.0
1.01000	0.018217	0.004058	0.011795	0.006422	2.008	0.151	0.885	0.988	37.20	44.0

GARDOW B54.5 VANELESS DIFFUSER, INLET R = 1.405 FT IDENT 18.

PROFILE NUMBER 1 X = 0.000 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.28	0.000667	0.28200	0.04300	3.92	15.00	3.92	15.18
0.64	0.001500	0.53200	0.08100	8.82	28.30	8.82	28.63
0.99	0.002333	0.60700	0.09200	13.72	32.29	13.72	32.66
1.27	0.003000	0.65300	0.09200	17.65	34.74	17.65	35.08
1.62	0.003833	0.68600	0.08600	22.55	36.50	22.55	36.78
1.98	0.004666	0.72800	0.08300	27.45	38.73	27.45	38.98
2.33	0.005500	0.74400	0.07300	32.35	39.58	32.35	39.77
3.03	0.007166	0.79000	0.06200	42.16	42.03	42.16	42.16
3.74	0.008833	0.83000	0.05200	51.96	44.16	51.96	44.24
4.45	0.010500	0.86900	0.03900	61.76	46.23	61.76	46.28
5.15	0.012166	0.90400	0.02700	71.57	48.09	71.57	48.11
5.86	0.013833	0.93600	0.01800	81.37	49.80	81.37	49.80
6.74	0.015916	0.96600	0.01000	93.62	51.39	93.62	51.39
7.62	0.017999	0.99000	0.00300	105.88	52.67	105.88	52.67
8.50	0.020083	0.99400	0.00200	118.13	52.88	118.13	52.88
9.39	0.022166	0.99900	0.00200	130.39	53.15	130.39	53.15
11.15	0.026332	1.00000	0.00000	154.90	53.20	154.90	53.20
12.91	0.030499	1.00000	0.00000	179.40	53.20	179.40	53.20

GARDOW B54.5 VANELESS DIFFUSER, INLET R = 1.405 FT IDENT 18.

PROFILE NUMBER 2 X = 0.180 FT

Y/TH11	Y (FT)	LS/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.12	0.000667	0.30000	0.13100	7.06	8.03	7.37	8.39
0.20	0.001083	0.36500	0.16000	11.47	9.77	11.98	10.22
0.35	0.001917	0.44300	0.18900	20.29	11.86	21.20	12.35
0.50	0.002750	0.48300	0.19700	29.12	12.93	30.41	13.37
0.62	0.003417	0.51300	0.19800	36.17	13.74	37.78	14.10
0.78	0.004250	0.53100	0.19500	45.00	14.22	47.00	14.50
1.08	0.005916	0.56400	0.18700	62.64	15.10	65.43	15.23
1.38	0.007583	0.59500	0.17300	80.29	15.93	83.86	15.89
1.69	0.009250	0.62600	0.16400	97.94	16.76	102.29	16.59
1.99	0.010916	0.65300	0.15300	115.58	17.49	120.72	17.20
2.30	0.012583	0.67900	0.14600	133.23	18.18	139.15	17.81
2.60	0.014249	0.70900	0.13100	150.88	18.99	157.58	18.49
2.98	0.016333	0.76800	0.13100	172.93	20.57	180.62	19.97
3.36	0.018416	0.79800	0.11200	194.99	21.37	203.66	20.66
3.74	0.020499	0.84500	0.08000	217.05	22.63	226.70	21.76
4.12	0.022582	0.86100	0.07900	239.11	23.06	249.74	22.17
4.50	0.024666	0.89000	0.06200	261.17	23.83	272.77	22.87
4.88	0.026749	0.90900	0.04500	283.22	24.34	295.81	23.33
5.26	0.028832	0.93400	0.03100	305.28	25.01	318.85	23.96
5.64	0.030915	0.95300	0.01800	327.34	25.52	341.89	24.44
6.03	0.032999	0.97200	0.00900	349.40	26.03	364.93	24.92
6.41	0.035082	0.98400	0.00300	371.46	26.35	387.96	25.23
6.79	0.037165	0.98900	0.00200	393.51	26.48	411.00	25.36
7.17	0.039248	0.98400	0.00000	415.57	26.35	434.04	25.23
7.93	0.043415	1.00000	0.00000	459.69	26.78	480.12	25.64

GARDOW B54.5 VANELESS DIFFUSER, INLET R = 1.405 FT IDENT 18.

PROFILE NUMBER 3 X = 0.360 FT

Y/TH11	Y (FT)	LS/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.08	0.000667	0.15200	0.08200	5.88	4.45	6.43	4.62
0.13	0.001083	0.27300	0.14700	9.56	7.99	10.45	8.30
0.18	0.001500	0.35100	0.18900	13.23	10.27	14.47	10.67
0.28	0.002333	0.42200	0.22800	20.59	12.35	22.51	12.84
0.38	0.003167	0.44500	0.23900	27.94	13.02	30.55	13.52
0.46	0.003833	0.46900	0.24200	33.82	13.73	36.98	14.13
0.56	0.004666	0.48600	0.24200	41.17	14.22	45.02	14.53
0.76	0.006333	0.50800	0.23600	55.88	14.87	61.10	14.99
0.95	0.008000	0.53900	0.23800	70.59	15.77	77.17	15.77
1.15	0.009666	0.55700	0.22700	85.29	16.30	93.25	16.10
1.35	0.011333	0.57700	0.21700	100.00	16.89	109.33	16.50
1.55	0.012999	0.60500	0.21400	114.70	17.71	125.41	17.18
1.75	0.014666	0.62400	0.20800	129.41	18.26	141.48	17.61
2.00	0.016749	0.64400	0.19200	147.79	18.85	161.58	17.99
2.25	0.018833	0.66800	0.18300	166.17	19.55	181.68	18.54
2.49	0.020916	0.69800	0.16900	184.55	20.43	201.78	19.22
2.74	0.022999	0.72200	0.15500	202.93	21.13	221.87	19.77
2.99	0.025082	0.74100	0.14000	221.31	21.69	241.97	20.19
3.24	0.027166	0.76300	0.12500	239.70	22.33	262.07	20.70
3.49	0.029249	0.78900	0.11400	258.08	23.09	282.17	21.34
3.74	0.031332	0.80500	0.10100	276.46	23.56	302.26	21.72
4.21	0.035332	0.85000	0.07600	311.75	24.88	340.85	22.84
4.73	0.039665	0.90100	0.05100	349.99	26.37	382.65	24.16
5.23	0.043832	0.94100	0.03300	386.75	27.54	422.85	25.20
5.72	0.047998	0.96800	0.01200	423.51	28.33	463.04	25.91
6.22	0.052165	0.99200	0.00700	460.28	29.03	503.23	26.55
6.72	0.056331	0.99600	0.00200	497.04	29.15	543.43	26.66
7.22	0.060498	1.00000	0.00000	533.80	29.27	583.62	26.77

GARDOW 854.5 VANELESS DIFFUSER, INLET R = 1.405 FT IDENT 18.

PROFILE NUMBER 4 X = 0.530 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.06	0.000667	0.18600	0.12000	5.14	5.96	5.73	6.37
0.07	0.000833	0.21800	0.14000	6.42	6.99	7.16	7.45
0.11	0.001250	0.27500	0.17700	9.63	8.82	10.73	9.41
0.15	0.001667	0.32100	0.20700	12.84	10.29	14.31	10.99
0.19	0.002083	0.35100	0.22500	16.05	11.25	17.89	11.99
0.26	0.002917	0.36900	0.23600	22.47	11.83	25.05	12.60
0.32	0.003583	0.40500	0.25300	27.61	12.98	30.77	13.74
0.40	0.004416	0.42400	0.26100	34.03	13.59	37.93	14.32
0.47	0.005250	0.43400	0.26000	40.45	13.91	45.09	14.55
0.55	0.006083	0.44300	0.26000	46.88	14.20	52.24	14.78
0.62	0.006916	0.45200	0.25300	53.30	14.49	59.40	14.90
0.77	0.008583	0.48200	0.26100	66.14	15.45	73.71	15.77
0.92	0.010250	0.49200	0.25000	78.98	15.77	88.03	15.88
1.07	0.011916	0.50300	0.24100	91.82	16.13	102.34	16.04
1.22	0.013583	0.52300	0.23700	104.67	16.77	116.65	16.52
1.37	0.015249	0.54100	0.23000	117.51	17.35	130.97	16.91
1.55	0.017333	0.56100	0.22400	133.56	17.99	148.86	17.38
1.74	0.019416	0.58100	0.21600	149.62	18.63	166.75	17.83
1.93	0.021499	0.59200	0.20500	165.67	18.98	184.64	18.02
2.11	0.023582	0.62600	0.18300	181.72	20.07	202.53	18.76
2.30	0.025666	0.63900	0.18800	197.78	20.49	220.42	19.16
2.49	0.027749	0.65700	0.17600	213.83	21.06	238.31	19.57
2.68	0.029832	0.69100	0.17000	229.88	22.15	256.21	20.47
2.86	0.031915	0.70700	0.15600	245.94	22.67	274.10	20.83
3.05	0.033999	0.73500	0.14900	261.99	23.56	291.99	21.57
3.24	0.036082	0.75800	0.13800	278.04	24.30	309.88	22.16
3.61	0.040248	0.79200	0.11300	310.15	25.39	345.66	23.01
3.98	0.044415	0.83300	0.09300	342.26	26.71	381.45	24.11
4.36	0.048581	0.87600	0.06800	374.36	28.09	417.23	25.28
4.73	0.052748	0.90700	0.04900	406.47	29.08	453.01	26.13
5.10	0.056914	0.94400	0.03300	438.58	30.27	488.79	27.17
5.48	0.061081	0.96400	0.01800	470.68	30.91	524.58	27.74
5.85	0.065247	0.98600	0.00900	502.79	31.61	560.36	28.37
6.22	0.069414	0.99900	0.00300	534.89	32.03	596.14	28.74
6.60	0.073580	1.00000	0.00000	567.00	32.06	631.92	28.77

GARDON 854.5 VANELESS DIFFUSER, INLET R = 1.405 FT IDENT 18.

PROFILE NUMBER 5 X = 0.710 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.04	0.000667	0.16300	0.13300	4.47	5.81	5.29	6.33
0.05	0.000750	0.21100	0.17200	5.03	7.51	5.96	8.19
0.10	0.001583	0.26500	0.21600	10.62	9.44	12.57	10.28
0.15	0.002417	0.31000	0.25400	16.21	11.04	19.19	12.05
0.20	0.003250	0.35300	0.28900	21.79	12.57	25.81	13.72
0.24	0.003917	0.36800	0.29200	26.26	13.11	31.10	14.13
0.29	0.004750	0.38500	0.29500	31.85	13.71	37.72	14.59
0.35	0.005583	0.39200	0.29900	37.44	13.96	44.34	14.83
0.45	0.007250	0.40700	0.29700	48.62	14.49	57.57	15.15
0.55	0.008916	0.42400	0.29300	59.79	15.10	70.81	15.50
0.65	0.010583	0.44100	0.29300	70.97	15.71	84.04	15.92
0.76	0.012250	0.45500	0.29000	82.14	16.20	97.28	16.23
0.86	0.013916	0.46700	0.28200	93.32	16.63	110.51	16.41
0.96	0.015583	0.48800	0.27100	104.50	17.38	123.75	16.79
1.09	0.017666	0.48800	0.27000	118.47	17.38	140.29	16.77
1.22	0.019749	0.50600	0.26300	132.44	18.02	156.83	17.15
1.35	0.021832	0.52100	0.25400	146.41	18.55	173.38	17.43
1.48	0.023916	0.53100	0.24800	160.38	18.91	189.92	17.63
1.61	0.025999	0.55100	0.24000	174.35	19.62	206.46	18.07
1.74	0.028082	0.57400	0.23500	188.32	20.44	223.01	18.65
1.86	0.030165	0.58100	0.22600	202.29	20.69	239.55	18.75
1.99	0.032249	0.59300	0.21000	216.26	21.12	256.09	18.92
2.12	0.034332	0.61400	0.21200	230.23	21.87	272.64	19.54
2.25	0.036415	0.63900	0.20200	244.20	22.76	289.18	20.15
2.51	0.040582	0.66900	0.18500	272.14	23.83	322.27	20.87
2.77	0.044748	0.69500	0.16700	300.08	24.75	355.35	21.50
3.02	0.048915	0.72600	0.14700	328.02	25.86	388.44	22.28
3.28	0.053081	0.75500	0.12900	355.96	26.89	421.53	23.03
3.54	0.057248	0.79200	0.11300	383.90	28.21	454.61	24.06
3.80	0.061414	0.81900	0.09300	411.84	29.17	487.70	24.79
4.05	0.065581	0.85600	0.07900	439.78	30.49	520.79	25.85
4.57	0.073914	0.90400	0.05300	495.66	32.20	586.96	27.23
5.08	0.082247	0.94500	0.02800	551.54	33.66	653.14	28.43
5.60	0.090580	0.97200	0.01700	607.42	34.62	719.31	29.24
6.11	0.098913	0.98500	0.00900	663.30	35.08	785.48	29.62
6.63	0.107246	0.99400	0.00500	719.18	35.40	851.66	29.89
7.14	0.115579	1.00000	0.00000	775.06	35.61	917.83	30.07

GARCOW B54.5 VANELESS DIFFUSER, INLET R = 1.405 FT IDENT 18.

PROFILE NUMBER 6 X = 0.850 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.04	0.000667	0.19500	0.15800	4.51	6.51	5.41	6.98
0.07	0.001167	0.23700	0.19200	7.89	7.91	9.47	8.49
0.09	0.001583	0.27900	0.22500	10.71	9.32	12.85	9.97
0.11	0.002000	0.30000	0.24200	13.53	10.02	16.23	10.73
0.16	0.002833	0.35300	0.28500	19.17	11.79	23.00	12.62
0.24	0.004333	0.40100	0.32400	29.31	13.39	35.18	14.35
0.34	0.006000	0.41800	0.32600	40.59	13.96	48.70	14.75
0.45	0.008083	0.44600	0.33400	54.68	14.89	65.61	15.50
0.57	0.010166	0.46400	0.32700	68.77	15.49	82.53	15.80
0.69	0.012250	0.48000	0.32600	82.86	16.03	99.44	16.15
0.81	0.014333	0.49800	0.32300	96.96	16.63	116.35	16.52
0.92	0.016416	0.51200	0.21800	111.05	17.10	133.26	15.48
1.04	0.018499	0.53800	0.32100	125.14	17.96	150.17	17.43
1.16	0.020583	0.54900	0.31200	139.23	18.33	167.08	17.57
1.27	0.022666	0.55700	0.29900	153.33	18.60	183.99	17.59
1.39	0.024749	0.56800	0.29100	167.42	18.97	200.90	17.76
1.51	0.026832	0.58500	0.28600	181.51	19.53	217.81	18.12
1.63	0.028915	0.60000	0.26700	195.60	20.03	234.73	18.27
1.74	0.030999	0.60300	0.26700	209.70	20.13	251.64	18.35
1.86	0.033082	0.61900	0.26300	223.79	20.67	268.55	18.71
1.98	0.035165	0.63000	0.25100	237.88	21.04	285.46	18.87
2.09	0.037248	0.64200	0.24400	251.98	21.44	302.37	19.11
2.21	0.039332	0.64900	0.23100	266.07	21.67	319.28	19.17
2.45	0.043498	0.67400	0.21300	294.25	22.51	353.10	19.67
2.68	0.047665	0.69200	0.19200	322.44	23.11	386.93	19.98
2.91	0.051831	0.71400	0.17600	350.62	23.84	420.75	20.46
3.15	0.055998	0.73800	0.15700	378.81	24.64	454.57	21.00
3.38	0.060164	0.76100	0.14200	406.99	25.41	488.39	21.54
3.62	0.064331	0.78900	0.12500	435.18	26.35	522.21	22.23
3.85	0.068497	0.82000	0.10800	463.36	27.38	556.04	23.01
4.09	0.072664	0.87600	0.09300	491.55	29.25	589.86	24.51
4.55	0.080997	0.88100	0.06400	547.92	29.42	657.50	24.58
5.02	0.089330	0.93000	0.03900	604.29	31.05	725.15	25.90
5.49	0.097663	0.97100	0.01800	660.66	32.42	792.79	27.02
5.96	0.105996	0.98800	0.00500	717.03	32.99	860.44	27.49
6.43	0.114329	1.00000	0.00000	773.40	33.39	928.08	27.83

GARDOW B54.5 VANELESS DIFFUSER, INLET R = 1.405 FT IDENT 18.

PROFILE NUMBER 7 X = 1.010 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.04	0.000667	0.23800	0.17800	4.51	7.70	5.25	8.25
0.05	0.000833	0.25100	0.18700	5.64	8.12	6.57	8.69
0.07	0.001250	0.30400	0.22800	8.46	9.83	9.85	10.55
0.12	0.002083	0.34500	0.25800	14.09	11.16	16.42	11.96
0.16	0.002750	0.36900	0.27600	18.60	11.94	21.68	12.79
0.21	0.003583	0.38300	0.27900	24.24	12.39	28.24	13.15
0.31	0.005250	0.42000	0.29200	35.51	13.59	41.38	14.20
0.41	0.006916	0.45400	0.30700	46.79	14.69	54.52	15.21
0.53	0.009000	0.47000	0.30500	60.88	15.20	70.94	15.55
0.66	0.011083	0.49300	0.30000	74.97	15.95	87.36	16.02
0.78	0.013166	0.51100	0.30000	89.06	16.53	103.78	16.45
0.90	0.015249	0.51900	0.29300	103.16	16.79	120.20	16.55
1.03	0.017333	0.54400	0.29200	117.25	17.60	136.62	17.14
1.15	0.019416	0.55700	0.28600	131.34	18.02	153.04	17.38
1.27	0.021499	0.56200	0.27500	145.44	18.18	169.46	17.37
1.40	0.023582	0.58100	0.28100	159.53	18.79	185.88	17.92
1.64	0.027749	0.60100	0.26500	187.71	19.44	218.73	18.23
1.89	0.031915	0.63200	0.25300	215.90	20.44	251.57	18.90
2.14	0.036082	0.66500	0.24200	244.08	21.51	284.41	19.65
2.39	0.040248	0.66500	0.21800	272.27	21.51	317.25	19.43
2.63	0.044415	0.71300	0.21100	300.45	23.06	350.09	20.64
2.88	0.048581	0.73500	0.18300	328.64	23.78	382.94	21.03
3.13	0.052748	0.75600	0.18100	356.82	24.45	415.78	21.58
3.37	0.056914	0.77700	0.17200	385.01	25.13	448.62	22.09
3.62	0.061081	0.81100	0.15600	413.19	26.23	481.46	22.93
3.87	0.065247	0.82400	0.14000	441.38	26.65	514.30	23.20
4.36	0.073580	0.87300	0.10900	497.75	28.24	579.99	24.42
4.85	0.081913	0.90800	0.07800	554.12	29.37	645.67	25.30
5.35	0.090246	0.94700	0.05100	610.49	30.63	711.35	26.33
5.84	0.098579	0.98200	0.02600	666.86	31.77	777.04	27.27
6.34	0.106912	0.99800	0.01000	723.23	32.28	842.72	27.71
6.83	0.115245	1.00000	0.00000	779.60	32.35	908.40	27.76

TITLE: Gardow B-59.0 Vaneless Diffuser, Flow 20

REFERENCE: Gardow, E., "The three-dimensional turbulent boundary layer in a free vortex diffuser," MIT Gas Turbine Lab. Rept. 42, Jan.1958

DESCRIPTION: The development of the turbulent boundary layer on one wall of a parallel walled, axially symmetric vaneless diffuser was measured (Figure 10.1). The direction and magnitude of the velocity was measured with a three holed cobra probe (dimensions not given). No turbulence data were taken.

EDITORS' COMMENTS: At the last three profiles, the boundary layer thicknesses are 0.956, 0.957 and 1.363 inches respectively. Assuming that the boundary layer on the opposite wall is of similar thickness , it is possible that the potential core (inviscid external flow) no longer exists in this region. In addition, $\beta_w + \psi$ is close to 90° at the last three profiles, and it is possible that the flow has passed through a point of ordinary separation. No value of the kinematic viscosity was supplied by the orginator. Since it is known that the experiments were performed in room air, it is assumed that the kinematic viscosity has a value of .000170 ft^2/sec.

PRESSURE GRADIENT: (see Figure 20.1)

x feet	Q_∞ ft/sec	$\partial Q_\infty/\partial x$ (sec^{-1})
-0.005	63.020	-23.93
0.095	60.627	-23.93
0.195	58.234	-23.93
0.295	55.841	-23.93
0.395	53.448	-23.93
0.495	51.055	-23.93
0.595	48.662	-23.93

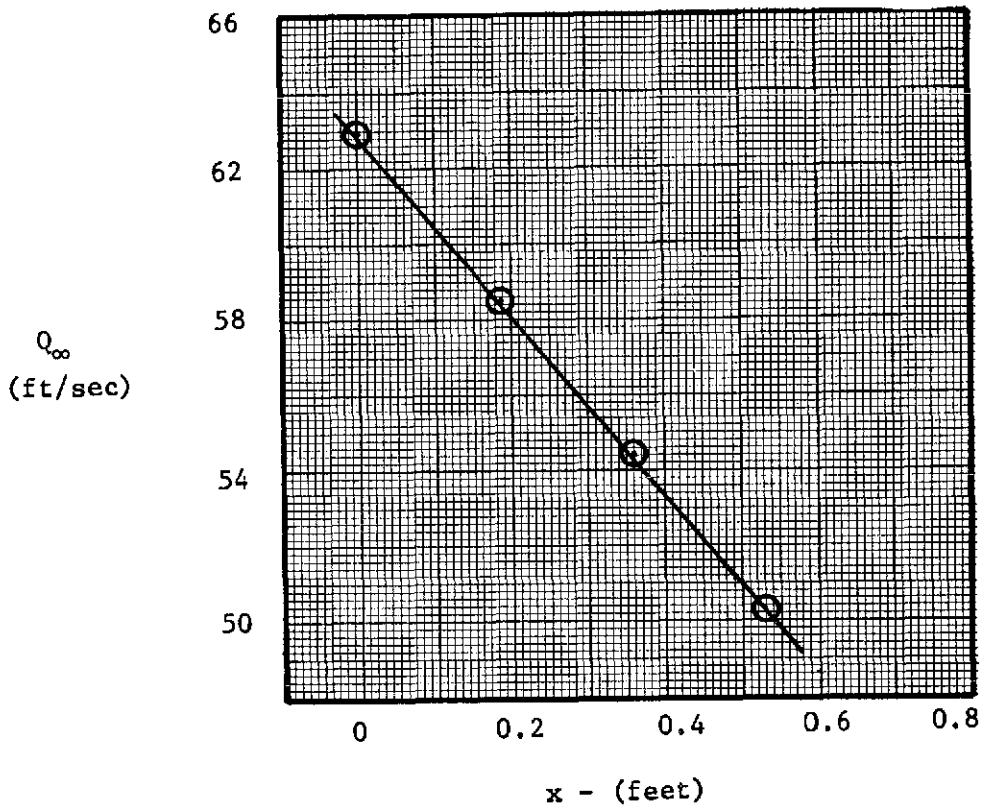


Figure 20.1 - Gardow B-59.0 Q_∞ Distribution

GARDOW VANELESS DIFFUSER B59.0, INLET R = 1.405 FT IDENT =20. KIN. VISC= 0.0001700

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	1531.5	1.532	0.003185	0.003154	0.003417	17.95	21.26	0.006340	0.004139
0.18000	3206.9	1.638	0.002110	0.002190	0.002701	33.41	38.65	0.015268	0.009319
0.36000	3813.9	1.659	0.002023	0.002026	0.002596	36.46	38.82	0.019768	0.011918
0.53000	4362.9	1.632	0.001850	0.002036	0.002366	34.14	38.54	0.024070	0.014745

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.002821	0.000385	0.001970	0.000851	0.000	0.000	0.000	0.000	62.90	59.0
0.18000	0.006710	0.001852	0.005522	0.003187	0.682	0.061	0.828	0.428	58.50	56.0
0.36000	0.012105	0.002821	0.007614	0.004491	0.201	0.063	1.229	0.748	54.40	53.5
0.53000	0.013778	0.002618	0.009060	0.004719	-0.480	0.069	2.012	0.993	50.30	52.9

GARDOW VANELESS DIFFUSER B59.0, INLET R = 1.405 IDENT 20.

PROFILE NUMBER 1 X = 0.000 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.16	0.000667	0.46300	0.15000	9.84	11.60	10.20	11.77
0.26	0.001083	0.49300	0.16000	15.99	12.35	16.57	12.54
0.36	0.001500	0.51600	0.16800	22.15	12.93	22.94	13.13
0.46	0.001917	0.53700	0.17500	28.30	13.46	29.31	13.66
0.62	0.002583	0.57000	0.18500	38.14	14.28	39.51	14.50
0.83	0.003417	0.57900	0.18800	50.44	14.51	52.25	14.73
1.33	0.005500	0.62900	0.17800	81.20	15.76	84.11	15.81
1.83	0.007583	0.66900	0.16000	111.96	16.76	115.98	16.64
2.34	0.009666	0.71100	0.14400	142.72	17.82	147.84	17.55
2.84	0.011750	0.75300	0.12800	173.48	18.87	179.70	18.48
3.34	0.013833	0.79400	0.11100	204.24	19.90	211.56	19.40
3.85	0.015916	0.84400	0.09000	235.00	21.15	243.42	20.53
4.35	0.017999	0.87100	0.07200	265.75	21.83	275.28	21.14
4.85	0.020083	0.90400	0.05100	296.51	22.65	307.14	21.90
5.86	0.024249	0.95800	0.02000	358.03	24.01	370.87	23.18
6.87	0.028416	0.98600	0.00500	419.55	24.71	434.59	23.85
7.87	0.032582	1.00000	0.00000	481.06	25.06	498.31	24.19

GARDOW VANELESS DIFFUSER B59.0, INLET R = 1.405 IDENT 20.

PROFILE NUMBER 2 X = 0.180 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.07	0.000667	0.28800	0.19000	7.45	8.87	8.43	9.39
0.12	0.001083	0.33800	0.22400	12.11	10.41	13.70	11.03
0.16	0.001500	0.36900	0.24500	16.76	11.36	18.97	12.05
0.23	0.002167	0.41400	0.27400	24.21	12.75	27.40	13.51
0.32	0.003000	0.44200	0.28500	33.53	13.61	37.94	14.31
0.50	0.004666	0.47700	0.29200	52.15	14.69	59.02	15.22
0.72	0.006750	0.50700	0.28800	75.44	15.61	85.36	15.87
0.95	0.008833	0.53700	0.28500	98.72	16.53	111.71	16.54
1.17	0.010916	0.55900	0.27400	122.00	17.21	138.06	16.94
1.39	0.012999	0.58300	0.26000	145.29	17.95	164.41	17.37
1.62	0.015083	0.59900	0.24900	168.57	18.44	190.75	17.65
1.84	0.017166	0.62700	0.23800	191.85	19.30	217.10	18.25
2.07	0.019249	0.65000	0.22400	215.14	20.01	243.45	18.71
2.29	0.021332	0.67200	0.20800	238.42	20.69	269.79	19.14
2.51	0.023416	0.69700	0.19300	261.70	21.46	296.14	19.68
2.74	0.025499	0.72000	0.18000	284.99	22.17	322.49	20.19
3.18	0.029665	0.76600	0.14900	331.56	23.58	375.18	21.23
3.63	0.033832	0.81200	0.12000	378.12	25.00	427.87	22.33
4.08	0.037998	0.84800	0.08600	424.69	26.11	480.57	23.19
4.52	0.042165	0.89600	0.05900	471.26	27.59	533.26	24.43
4.97	0.046331	0.93200	0.03900	517.82	28.70	585.96	25.38
5.42	0.050498	0.95800	0.01800	564.39	29.50	638.65	26.07
5.87	0.054664	0.97400	0.01200	610.96	29.99	691.34	26.50
6.31	0.058831	0.98500	0.00900	657.52	30.33	744.04	26.80
6.76	0.062997	0.99100	0.00400	704.09	30.51	796.73	26.96
7.65	0.071330	0.99800	0.00200	797.22	30.73	902.12	27.15
8.55	0.079663	1.00000	0.00000	890.36	30.79	1007.51	27.21

GARCOW VANELESS DIFFUSER B59.0, INLET R = 1.405 IDENT 20.

PROFILE NUMBER 3 X = 0.360 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.06	0.000667	0.15700	0.11600	6.78	4.94	7.69	5.42
0.06	0.000750	0.18300	0.13600	7.63	5.75	8.65	6.33
0.13	0.001583	0.35500	0.26300	16.11	11.16	18.25	12.26
0.19	0.002250	0.39600	0.29300	22.90	12.45	25.94	13.67
0.26	0.003083	0.43500	0.32000	31.38	13.68	35.55	14.99
0.40	0.004750	0.46500	0.32900	48.34	14.62	54.76	15.81
0.57	0.006833	0.48600	0.32200	69.54	15.28	78.78	16.18
0.75	0.008916	0.50500	0.31600	90.74	15.88	102.80	16.53
0.92	0.011000	0.53400	0.31500	111.94	16.79	126.82	17.21
1.10	0.013083	0.55100	0.30100	133.14	17.33	150.84	17.43
1.27	0.015166	0.56500	0.29100	154.34	17.77	174.86	17.64
1.45	0.017249	0.58800	0.28200	175.54	18.49	198.87	18.10
1.62	0.019333	0.59800	0.26900	196.74	18.80	222.89	18.20
1.80	0.021416	0.61400	0.25500	217.94	19.31	246.91	18.45
1.97	0.023499	0.62900	0.24500	239.14	19.78	270.93	18.74
2.15	0.025582	0.64100	0.23200	260.34	20.16	294.95	18.92
2.32	0.027666	0.66600	0.22000	281.54	20.94	318.97	19.47
2.50	0.029749	0.67800	0.20800	302.74	21.32	342.99	19.68
2.85	0.033915	0.72500	0.18600	345.14	22.80	391.02	20.77
3.20	0.038082	0.75800	0.15900	387.54	23.84	439.06	21.50
3.54	0.042248	0.79600	0.13300	429.94	25.03	487.10	22.40
3.89	0.046415	0.82900	0.11000	472.34	26.07	535.14	23.21
4.24	0.050581	0.86800	0.08600	514.74	27.29	583.17	24.21
4.59	0.054748	0.89800	0.06500	557.14	28.24	631.21	24.99
5.29	0.063081	0.94700	0.03300	641.94	29.78	727.28	26.30
5.99	0.071414	0.98100	0.01000	726.74	30.85	823.36	27.23
6.69	0.079747	1.00000	0.00000	811.54	31.45	919.43	27.76

GARDOW VANELESS DIFFUSER B59.0, INLET R = 1.405 IDENT 20.

PROFILE NUMBER 4 X = 0.530 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.05	0.000667	0.17400	0.11800	6.00	5.72	6.78	6.11
0.06	0.000833	0.20900	0.14200	7.50	6.87	8.48	7.35
0.08	0.001250	0.28200	0.19100	11.25	9.27	12.72	9.90
0.11	0.001667	0.31500	0.21400	15.00	10.36	16.96	11.07
0.14	0.002083	0.34400	0.23300	18.75	11.31	21.20	12.08
0.19	0.002750	0.38800	0.26100	24.75	12.76	27.98	13.60
0.24	0.003583	0.40100	0.26100	32.25	13.18	36.46	13.91
0.36	0.005250	0.43700	0.27500	47.25	14.37	53.42	15.01
0.50	0.007333	0.46600	0.27500	66.00	15.32	74.62	15.73
0.64	0.009416	0.47700	0.26600	84.75	15.68	95.82	15.88
0.78	0.011500	0.50600	0.26600	103.50	16.64	117.02	16.62
0.92	0.013583	0.52900	0.25800	122.25	17.39	138.22	17.11
1.06	0.015666	0.54400	0.24900	140.99	17.88	159.42	17.40
1.20	0.017749	0.56500	0.24500	159.74	18.57	180.62	17.91
1.34	0.019833	0.58100	0.23800	178.49	19.10	201.83	18.26
1.49	0.021916	0.59500	0.23200	197.24	19.56	223.03	18.57
1.63	0.023999	0.60900	0.22300	215.99	20.02	244.23	18.86
1.77	0.026082	0.63300	0.22100	234.74	20.81	265.43	19.49
2.05	0.030249	0.66100	0.20300	272.24	21.73	307.83	20.10
2.33	0.034415	0.69600	0.19300	309.74	22.88	350.23	21.00
2.62	0.038582	0.71800	0.17900	347.24	23.60	392.63	21.51
2.90	0.042748	0.75000	0.16100	384.73	24.66	435.03	22.30
3.18	0.046915	0.78100	0.15000	422.23	25.68	477.43	23.12
3.46	0.051081	0.81200	0.13000	459.73	26.70	519.83	23.91
3.75	0.055248	0.83800	0.11900	497.23	27.55	562.23	24.61
4.31	0.063581	0.88400	0.08800	572.23	29.06	647.03	25.83
4.88	0.071914	0.91800	0.06300	647.22	30.18	731.83	26.75
5.44	0.080247	0.94400	0.03600	722.22	31.03	816.63	27.47
6.01	0.088580	0.96700	0.02700	797.22	31.79	901.43	28.13
6.57	0.096913	0.98000	0.01700	872.21	32.22	986.23	28.50
7.14	0.105246	0.99000	0.01000	947.21	32.55	1071.03	28.79
7.70	0.113579	1.00000	0.00000	1022.21	32.88	1155.83	29.08

TITLE: Gardow B-59.6 vaneless Diffuser, Flow 22

REFERENCE: Gardow, E., "The three-dimensional turbulent boundary layer in a free vortex diffuser," MIT Gas Turbine Lab. Rept. 42, Jan. 1958

DESCRIPTION: The development of the turbulent boundary layer on one wall of a parallel walled, axially symmetric vaneless diffuser was measured (Figure 10.1). The direction and magnitude of the velocity was measured with a three-holed cobra probe (dimensions not given). No turbulence data were taken.

EDITORS' COMMENTS: At the last four profiles, the boundary layers are 1.050, 1.358, 1.371 and 1.377 inches thick respectively. Assuming that the boundary layer on the other wall is of similar thickness, it is likely that the potential core (inviscid external flow) no longer exists in this region. Furthermore, $\beta_w + \psi$ is greater than 90° at the second, third and fourth profiles and close to 90° at the last two. Thus it is probable that the flow has passed through a region of ordinary separation. No value of the kinematic viscosity was supplied by the orginator. Since it is known that the experiments were performed in room air, it is assumed that the kinematic viscosity has a value of .000170 ft^2/sec.

PRESSURE GRADIENT: (see Figure 22)

x feet	Q_∞ ft/sec	$\partial Q_\infty/\partial x$ $(sec)^{-1}$
-0.005	67.400	-28.04
0.095	64.615	-27.62
0.195	61.883	-27.02
0.295	59.206	-26.36
0.395	56.654	-24.78
0.495	54.218	-23.80
0.595	51.932	-21.90
0.695	49.840	-19.94
0.795	47.931	-18.00
0.895	46.299	-14.64

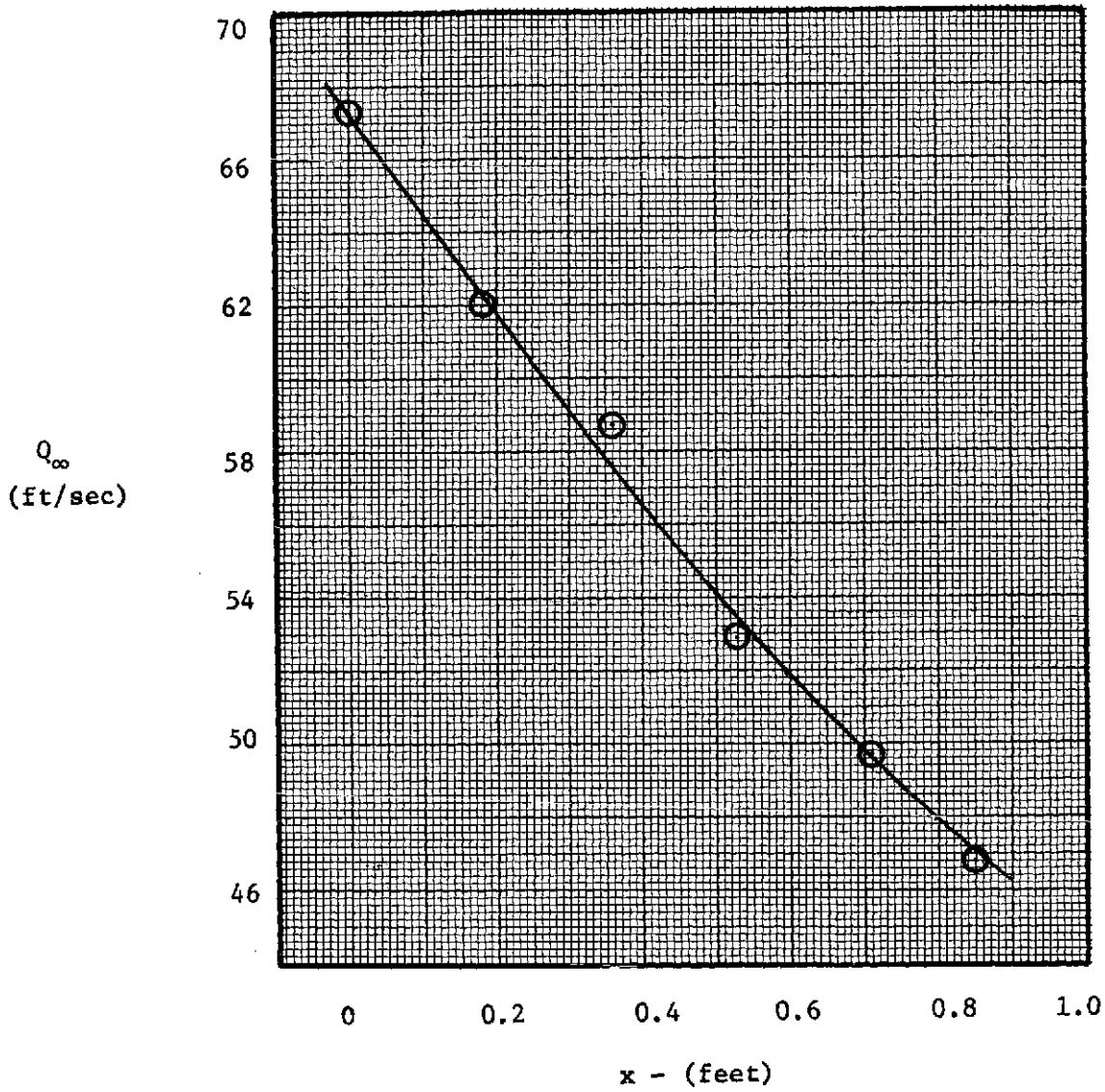


Figure 22.1 - Gardow B-59.6 Q_∞ Distribution

GARDOW VANELESS DIFFUSER B59.6 ,INLET R = 1.405 FT IDENT =22. KIN. VISC= 0.0001700

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	1862.6	1.615	0.002760	0.002627	0.002917	17.18	18.87	0.007599	0.004705
0.18000	3475.3	1.687	0.001958	0.001988	0.002518	34.95	38.96	0.016073	0.009529
0.36000	4225.4	1.637	0.002051	0.002038	0.002633	37.59	38.83	0.020035	0.012237
0.53000	5142.0	1.590	0.002065	0.002080	0.002718	41.45	40.53	0.026279	0.016524
0.71000	4699.1	1.538	0.002231	0.002314	0.002862	36.83	38.77	0.024716	0.016073
0.85000	4584.7	1.570	0.002194	0.002215	0.002796	36.57	38.33	0.026144	0.016654

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.002705	0.000315	0.001818	0.000887	0.000	0.000	0.000	0.000	67.30	59.6
0.18000	0.009219	0.002049	0.005680	0.003538	0.040	0.035	0.203	0.272	62.00	56.1
0.36000	0.013348	0.003346	0.008404	0.004944	-0.138	0.030	0.447	0.496	58.70	54.0
0.53000	0.019356	0.005314	0.012425	0.006931	0.069	0.023	0.674	0.691	52.90	50.8
0.71000	0.019113	0.004643	0.013073	0.006040	-0.741	0.024	0.519	0.871	49.70	50.4
0.85000	0.020661	0.004853	0.014252	0.006409	-0.705	0.032	0.216	0.995	46.80	48.2

GARCOW VANELESS DIFFUSER B59.6 ,INLET R = 1.405 FT IDENT 22.

PROFILE NUMBER 1 X = 0.000 FT

Y/TH11	Y (FT)	LS/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.14	0.000667	0.37200	0.11500	9.80	10.01	10.08	10.20
0.32	0.001500	0.46000	0.14300	22.06	12.38	22.68	12.61
0.50	0.002333	0.51200	0.15900	34.31	13.78	35.27	14.04
0.90	0.004250	0.56200	0.16500	62.50	15.13	64.25	15.34
1.35	0.006333	0.59600	0.15900	93.13	16.04	95.74	16.15
1.79	0.008416	0.61900	0.11900	123.77	16.66	127.24	16.51
2.23	0.010500	0.66900	0.12000	154.41	18.01	158.73	17.80
2.67	0.012583	0.71100	0.11200	185.04	19.14	190.22	18.85
3.12	0.014666	0.76700	0.10200	215.68	20.65	221.72	20.26
3.56	0.016749	0.81100	0.08600	246.31	21.83	253.21	21.36
4.00	0.018833	0.84100	0.07200	276.95	22.64	284.70	22.10
4.45	0.020916	0.88000	0.06000	307.59	23.69	316.20	23.10
4.89	0.022999	0.91900	0.04100	338.22	24.74	347.69	24.09
5.77	0.027166	0.96600	0.01800	399.49	26.00	410.68	25.30
6.66	0.031332	0.99100	0.00500	460.77	26.68	473.67	25.95
7.54	0.035499	1.00000	0.00000	522.04	26.92	536.65	26.19

GARDOW VANELESS DIFFUSER B59.6 ,INLET R = 1.405 FT IDENT 22.

PROFILE NUMBER 2 X = 0.180 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.07	0.000667	0.29900	0.20900	7.61	9.56	8.63	10.28
0.09	0.000833	0.31600	0.22000	9.51	10.10	10.78	10.85
0.17	0.001667	0.38200	0.26700	19.02	12.21	21.57	13.13
0.26	0.002500	0.41900	0.28800	28.53	13.39	32.35	14.33
0.33	0.003167	0.42800	0.29100	36.14	13.68	40.98	14.59
0.55	0.005250	0.46300	0.29800	59.91	14.80	67.94	15.52
0.77	0.007333	0.49500	0.29800	83.68	15.82	94.90	16.28
0.99	0.009416	0.51500	0.28600	107.46	16.46	121.86	16.60
1.21	0.011500	0.53600	0.27800	131.23	17.13	148.82	17.02
1.43	0.013583	0.56700	0.26900	155.00	18.12	175.78	17.69
1.64	0.015666	0.59200	0.26000	178.78	18.92	202.74	18.22
1.86	0.017749	0.61200	0.24600	202.55	19.56	229.70	18.59
2.08	0.019833	0.62900	0.23000	226.32	20.10	256.66	18.87
2.30	0.021916	0.65300	0.21800	250.10	20.87	283.62	19.40
2.52	0.023999	0.67900	0.20700	273.87	21.70	310.58	20.00
2.74	0.026082	0.70500	0.18900	297.64	22.53	337.54	20.57
2.96	0.028166	0.72600	0.17900	321.42	23.20	364.49	21.07
3.39	0.032332	0.77000	0.14400	368.97	24.61	418.41	22.08
3.83	0.036499	0.82100	0.11300	416.51	26.24	472.33	23.36
4.27	0.040665	0.86100	0.07900	464.06	27.52	526.25	24.37
4.70	0.044832	0.91200	0.05100	511.61	29.15	580.17	25.74
5.14	0.048998	0.93300	0.03100	559.15	29.82	634.09	26.31
5.58	0.053165	0.97400	0.01600	606.70	31.13	688.01	27.45
6.02	0.057331	0.99800	0.00700	654.25	31.89	741.93	28.13
6.45	0.061498	1.00000	0.00000	701.79	31.96	795.85	28.18

GARDOW VANELESS DIFFUSER 859.6 ,INLET R = 1.405 FT IDENT 22.

PROFILE NUMBER 3 X = 0.360 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.05	0.000667	0.27800	0.21400	7.37	8.68	8.35	9.67
0.08	0.001000	0.29600	0.22700	11.06	9.24	12.53	10.28
0.12	0.001417	0.35800	0.27500	15.67	11.18	17.75	12.44
0.15	0.001833	0.38500	0.29600	20.27	12.02	22.97	13.38
0.22	0.002667	0.42900	0.32900	29.49	13.39	33.41	14.90
0.27	0.003333	0.45000	0.34200	36.86	14.05	41.76	15.58
0.34	0.004166	0.46200	0.34700	46.08	14.43	52.20	15.92
0.51	0.006250	0.49300	0.34600	69.11	15.39	78.31	16.60
0.68	0.008333	0.51300	0.34200	92.15	16.02	104.41	16.99
0.85	0.010416	0.52600	0.32900	115.19	16.42	130.51	17.10
1.02	0.012499	0.55100	0.32800	138.23	17.20	156.61	17.67
1.19	0.014583	0.55900	0.31600	161.27	17.45	182.71	17.70
1.36	0.016666	0.57800	0.30600	184.31	18.05	208.82	18.02
1.53	0.018749	0.59100	0.29400	207.34	18.45	234.92	18.19
1.70	0.020832	0.60700	0.28300	230.38	18.95	261.02	18.46
1.87	0.022916	0.62400	0.27000	253.42	19.48	287.12	18.74
2.04	0.024999	0.64000	0.25600	276.46	19.98	313.22	19.00
2.21	0.027082	0.65000	0.24900	299.50	20.30	339.32	19.18
2.38	0.029165	0.67000	0.23700	322.54	20.92	365.43	19.59
2.55	0.031249	0.68700	0.22700	345.57	21.45	391.53	19.94
2.72	0.033332	0.70400	0.21300	368.61	21.98	417.63	20.27
2.89	0.035415	0.72400	0.19800	391.65	22.61	443.73	20.69
3.06	0.037498	0.74200	0.18300	414.69	23.17	469.83	21.06
3.40	0.041665	0.77100	0.15200	460.77	24.07	522.04	21.66
3.75	0.045831	0.81100	0.12800	506.84	25.32	574.24	22.63
4.09	0.049998	0.85000	0.10400	552.92	26.54	626.45	23.60
4.43	0.054164	0.88000	0.08300	599.00	27.48	678.65	24.36
4.77	0.058331	0.91600	0.06100	645.07	28.60	730.85	25.30
5.11	0.062497	0.94200	0.04100	691.15	29.41	783.06	25.98
5.45	0.066664	0.96300	0.02500	737.22	30.07	835.26	26.55
5.79	0.070830	0.97900	0.01200	783.30	30.57	887.46	26.98
6.47	0.079163	0.99800	0.00000	875.45	31.16	991.87	27.50
7.15	0.087496	1.00000	0.00000	967.61	31.22	1096.28	27.56

GARDOW VANELESS DIFFUSER 859.6 ,INLET R = 1.405 FT IDENT 22.

PROFILE NUMBER 4 X = 0.530 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.04	0.000667	0.19700	0.17400	6.67	6.13	7.65	7.13
0.05	0.000833	0.20000	0.17600	8.33	6.22	9.56	7.23
0.10	0.001667	0.34700	0.30500	16.67	10.80	19.12	12.53
0.15	0.002500	0.40100	0.35400	25.00	12.48	28.68	14.51
0.19	0.003167	0.42900	0.37600	31.67	13.35	36.32	15.48
0.24	0.004000	0.44300	0.37700	40.00	13.79	45.88	15.78
0.29	0.004833	0.47000	0.38800	48.33	14.63	55.44	16.53
0.42	0.006916	0.49000	0.38700	69.16	15.25	79.33	16.94
0.54	0.009000	0.51600	0.38500	90.00	16.06	103.23	17.47
0.67	0.011083	0.53900	0.38100	110.83	16.77	127.13	17.91
0.80	0.013166	0.54300	0.36900	131.66	16.90	151.02	17.81
0.92	0.015249	0.56500	0.36400	152.49	17.58	174.92	18.23
1.05	0.017333	0.57400	0.35400	173.33	17.86	198.82	18.29
1.17	0.019416	0.59100	0.34700	194.16	18.39	222.71	18.59
1.30	0.021499	0.60300	0.33700	214.99	18.76	246.61	18.74
1.55	0.025666	0.62400	0.31800	256.66	19.42	294.40	19.00
1.81	0.029832	0.64100	0.29600	298.32	19.95	342.19	19.15
2.06	0.033999	0.66000	0.27500	339.99	20.54	389.98	19.40
2.31	0.038165	0.67700	0.24900	381.65	21.07	437.78	19.57
2.56	0.042332	0.70800	0.23200	423.32	22.03	485.57	20.21
2.81	0.046498	0.73000	0.21200	464.98	22.72	533.36	20.62
3.07	0.050665	0.74400	0.18700	506.65	23.15	581.15	20.81
3.32	0.054831	0.77200	0.16700	548.31	24.02	628.94	21.43
3.82	0.063164	0.81800	0.12500	631.64	25.45	724.53	22.45
4.33	0.071497	0.86800	0.09200	714.97	27.01	820.11	23.68
4.83	0.079830	0.91400	0.06000	798.30	28.44	915.70	24.85
5.34	0.088163	0.95300	0.02900	881.63	29.66	1011.28	25.87
5.84	0.096496	0.97200	0.01200	964.96	30.25	1106.87	26.37
6.34	0.104829	0.98800	0.00300	1048.29	30.74	1202.45	26.80
6.85	0.113162	1.00000	0.00000	1131.62	31.12	1298.03	27.13

GARDOW VANELESS DIFFUSER B59.6 ,INLET R = 1.405 FT IDENT 22.

PROFILE NUMBER 5 X = 0.710 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.04	0.000667	0.21100	0.15800	6.51	6.32	7.37	6.97
0.07	0.001083	0.27200	0.20300	10.58	8.14	11.98	8.97
0.12	0.001917	0.35800	0.26800	18.71	10.72	21.20	11.82
0.17	0.002750	0.43200	0.32100	26.85	12.93	30.41	14.23
0.21	0.003417	0.44800	0.33300	33.36	13.41	37.78	14.76
0.26	0.004250	0.47000	0.34300	41.50	14.07	47.00	15.38
0.32	0.005083	0.48500	0.34600	49.64	14.52	56.21	15.75
0.37	0.005916	0.50000	0.34500	57.77	14.97	65.43	16.06
0.50	0.008000	0.52500	0.34200	78.11	15.72	88.47	16.56
0.63	0.010083	0.54300	0.34200	98.46	16.26	111.51	16.96
0.76	0.012166	0.54700	0.34500	118.80	16.38	134.54	17.10
0.89	0.014249	0.57400	0.32600	139.14	17.19	157.58	17.45
1.02	0.016333	0.59200	0.32100	159.48	17.72	180.62	17.80
1.15	0.018416	0.60400	0.31300	179.83	18.08	203.66	17.98
1.28	0.020499	0.62400	0.31000	200.17	18.68	226.70	18.42
1.40	0.022582	0.63100	0.29800	220.51	18.89	249.74	18.45
1.53	0.024666	0.64700	0.29600	240.85	19.37	272.77	18.81
1.66	0.026749	0.65800	0.28700	261.20	19.70	295.81	18.98
1.79	0.028832	0.67200	0.28000	281.54	20.12	318.85	19.25
1.92	0.030915	0.68100	0.27100	301.88	20.39	341.89	19.38
2.18	0.035082	0.69900	0.25000	342.56	20.93	387.96	19.63
2.44	0.039248	0.72400	0.23500	383.25	21.68	434.04	20.12
2.70	0.043415	0.74100	0.22100	423.93	22.19	480.12	20.44
2.96	0.047581	0.76300	0.20600	464.62	22.84	526.19	20.89
3.22	0.051748	0.79400	0.18900	505.30	23.77	572.27	21.58
3.48	0.055914	0.80400	0.16900	545.99	24.07	618.35	21.72
3.74	0.060081	0.83000	0.15300	586.67	24.85	664.42	22.31
4.00	0.064247	0.84400	0.13300	627.36	25.27	710.50	22.59
4.52	0.072580	0.88400	0.10200	708.73	26.47	802.65	23.52
5.03	0.080913	0.92100	0.07400	790.09	27.57	894.81	24.43
5.55	0.089246	0.94200	0.05100	871.46	28.20	986.96	24.94
6.07	0.097579	0.96400	0.03000	952.83	28.86	1079.11	25.50
6.59	0.105912	0.97800	0.01900	1034.20	29.28	1171.27	25.86
7.11	0.114245	1.00000	0.00000	1115.57	29.94	1263.42	26.46

GARDON VANELESS DIFFUSER 859.6 ,INLET R = 1.405 FT IDENT 22.

PROFILE NUMBER 6 X = 0.850 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.04	0.000667	0.18600	0.13800	6.08	5.62	6.86	6.19
0.05	0.000750	0.21500	0.16000	6.84	6.49	7.72	7.17
0.10	0.001583	0.30900	0.22900	14.44	9.33	16.30	10.29
0.15	0.002417	0.37900	0.28100	22.03	11.44	24.88	12.62
0.19	0.003083	0.41400	0.30800	28.11	12.50	31.74	13.80
0.29	0.004750	0.45200	0.32100	43.31	13.65	48.90	14.83
0.39	0.006416	0.47700	0.32700	58.50	14.40	66.05	15.47
0.51	0.008500	0.50700	0.32800	77.50	15.31	87.50	16.15
0.64	0.010583	0.53000	0.32800	96.49	16.00	108.94	16.67
0.76	0.012666	0.53600	0.32200	115.49	16.18	130.39	16.72
0.89	0.014749	0.56200	0.32200	134.48	16.97	151.83	17.32
1.01	0.016833	0.55200	0.30200	153.47	16.67	173.28	16.83
1.14	0.018916	0.57400	0.30200	172.47	17.33	194.72	17.35
1.26	0.020999	0.59900	0.30300	191.46	18.09	216.17	17.95
1.39	0.023082	0.61800	0.29900	210.46	18.66	237.61	18.36
1.64	0.027249	0.64400	0.28400	248.45	19.44	280.50	18.82
1.89	0.031415	0.67200	0.26900	286.43	20.29	323.39	19.36
2.14	0.035582	0.69300	0.25600	324.42	20.92	366.28	19.76
2.39	0.039748	0.71900	0.24200	362.41	21.71	409.17	20.29
2.64	0.043915	0.73900	0.23300	400.40	22.31	452.06	20.72
2.89	0.048081	0.76200	0.21500	438.39	23.01	494.96	21.17
3.39	0.056414	0.80000	0.18900	514.37	24.15	580.74	21.98
3.89	0.064747	0.83800	0.16100	590.34	25.30	666.52	22.82
4.39	0.073080	0.87300	0.13500	666.32	26.36	752.30	23.62
4.89	0.081413	0.90400	0.10700	742.30	27.29	838.08	24.34
5.39	0.089746	0.93300	0.08200	818.27	28.17	923.86	25.05
5.89	0.098079	0.95900	0.05700	894.25	28.96	1009.64	25.69
6.39	0.106412	0.98000	0.03600	970.23	29.59	1095.42	26.23
6.89	0.114745	1.00000	0.00000	1046.21	30.19	1181.20	26.74

TITLE: Cumpsty and Head 61° Infinite Swept Wing, Flow 30

REFERENCE: Cumpsty, N. and Head, M., "The calculation of three dimensional turbulent boundary layers, Part IV. Comparison with measurements on the rearof a swept wing," The Aeronautical Quarterly, Vol. XXI, May 1970, Part 2.

DESCRIPTION: Measurements were made of the developing boundary layer on the rear of a swept wing (Figure 30.1). Difficulties were encountered with the probe traverse gear interference altering the separation point location but these difficulties were finally minimized by using a slender traverse gear.

ORGINATORS' COMMENTS: "At the outset these measurements had been intended to provide a definitive set of results for comparison with calculations. In the event, however, too many uncertainties arose for this to be reasonably claimed..."

EDITORS' COMMENTS: It appears that there exist significant spanwise variations in the flow and the "infinite span" assumption is probably invalid. The pressure gradient results are based on the "downstream pressure tappings". All velocity profile tabulations are based on measurements with the "slender traverse gear".

PRESSURE GRADIENT: (See Figure 30.2)

x feet	$Q_\infty/U^*_{1\infty}$	$\partial Q_\infty/\partial x$ $(sec)^{-1}$
0.000	2.640	0
0.100	2.575	-70.47
0.200	2.469	-63.6
0.300	2.386	-45.0
0.400	2.323	-35.6
0.500	2.274	-28.0
0.600	2.235	-22.2
0.700	2.206	-15.73
0.800	2.184	-12.08
0.900	2.169	- 7.23
1.000	2.162	- 2.31
1.100	2.161	+ 1.73

* U_{1_∞} = 64.24 ft/sec

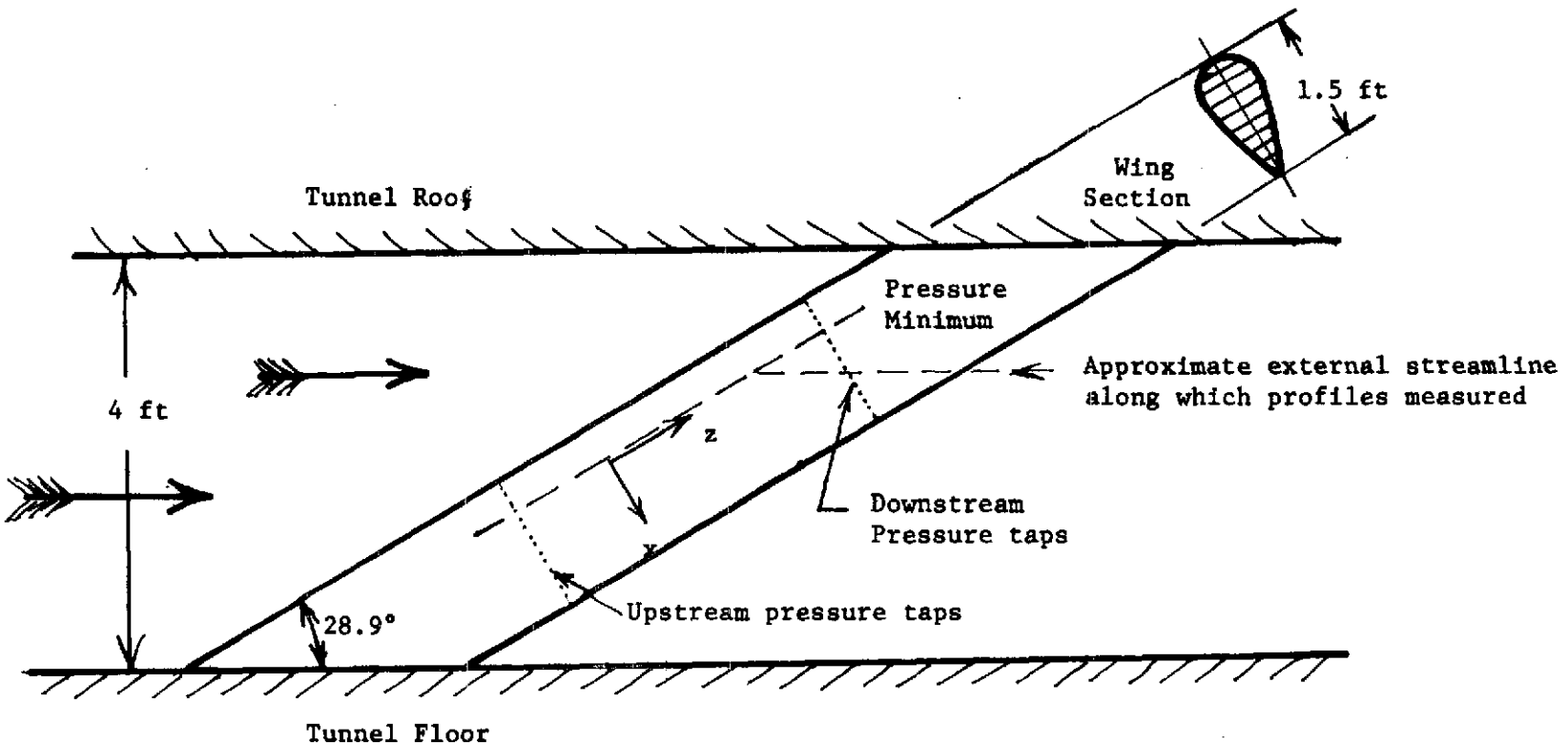


Figure 30.1 - Configuration of Cumpsty and Head Flow

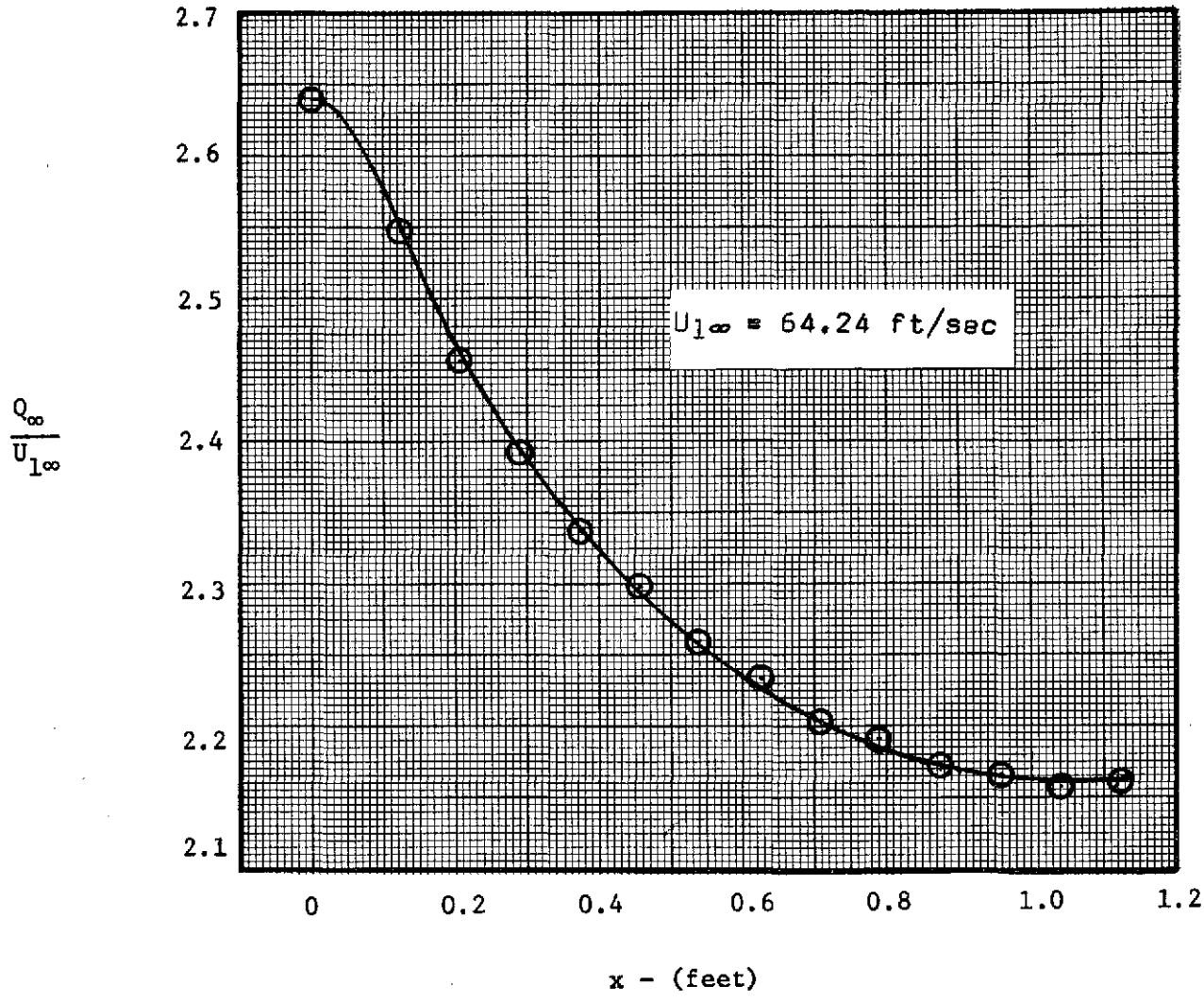


Figure 30.2 - Cumpsty and Head 61° Infinite Swept Wing Q_∞ Distribution

CUMPSTY & HEAD INFINITE SWEPT WING

IDENT =30. KIN. VISC= 0.0001450

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THETI1 (FT)
0.00000	1173.5	1.413	0.004230	0.004078	0.004230	-2.96	0.00	0.001417	0.001003
0.21700	2362.1	1.497	0.002891	0.002966	0.002891	6.82	0.00	0.003248	0.002170
0.46600	4187.0	1.539	0.002298	0.002383	0.002335	15.95	10.21	0.006346	0.004124
0.65000	6474.1	1.573	0.001893	0.002010	0.002078	20.93	24.39	0.010347	0.006578
0.81300	10754.4	1.712	0.001319	0.001411	0.001644	32.07	36.68	0.019045	0.011123

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	-0.000378	0.000016	-0.000318	-0.000060	0.000	0.000	0.000	0.000	169.60	43.1
0.21700	0.000172	0.000009	0.000088	0.000084	0.347	0.288	0.180	0.293	157.80	47.5
0.46600	0.001315	0.000098	0.000861	0.000454	0.494	0.439	0.429	0.554	147.20	51.9
0.65000	0.003483	0.000416	0.002267	0.001216	0.716	0.493	0.594	0.712	142.70	54.3
0.81300	0.008616	0.001580	0.005143	0.003473	0.956	0.512	0.680	0.825	140.20	55.6

CUMPSTY & HEAD INFINITE SWEPT WING IDENT 30.

PROFILE NUMBER 1 X = 0.000 FT

Y/THI1	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.17	0.000167	0.48400	-0.02500	8.96	10.52	8.96	10.54
0.33	0.000333	0.55300	-0.02800	17.92	12.02	17.92	12.04
0.50	0.000500	0.60300	-0.03200	26.89	13.11	26.89	13.13
0.66	0.000666	0.62800	-0.03400	35.85	13.65	35.85	13.67
0.83	0.000833	0.65300	-0.04500	44.81	14.20	44.81	14.23
1.00	0.001000	0.67100	-0.04900	53.77	14.59	53.77	14.63
1.41	0.001416	0.70200	-0.05200	76.18	15.26	76.18	15.31
1.83	0.001833	0.73800	-0.05200	98.58	16.05	98.58	16.09
3.07	0.003082	0.82000	-0.05500	165.80	17.83	165.80	17.87
4.32	0.004332	0.87700	-0.05000	233.01	19.07	233.01	19.10
5.15	0.005165	0.91300	-0.04400	277.82	19.85	277.82	19.87
7.22	0.007247	0.96800	-0.02700	389.84	21.05	389.84	21.06
9.30	0.009330	0.99300	-0.01200	501.87	21.59	501.87	21.59
11.37	0.011412	0.99900	-0.00300	613.89	21.72	613.89	21.72
13.45	0.013495	1.00000	0.00000	725.92	21.74	725.92	21.74

CUMPSTY & HEAD INFINITE SWEPT WING IDENT 30.

PROFILE NUMBER 2 X = 0.217 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.08	0.000167	0.37600	0.04500	6.89	9.89	6.89	9.96
0.15	0.000333	0.43900	0.05300	13.79	11.55	13.79	11.63
0.35	0.000750	0.51100	0.05700	31.02	13.44	31.02	13.52
0.54	0.001166	0.54800	0.05300	48.26	14.41	48.26	14.48
0.73	0.001583	0.57400	0.05400	65.49	15.10	65.49	15.16
1.11	0.002416	0.61900	0.04000	99.96	16.28	99.96	16.31
1.69	0.003665	0.67400	0.03000	151.66	17.73	151.66	17.74
2.65	0.005748	0.75400	0.01300	237.84	19.83	237.84	19.83
3.61	0.007830	0.82300	0.00200	324.01	21.64	324.01	21.64
4.57	0.009913	0.88800	-0.00700	410.18	23.35	410.18	23.36
5.53	0.011995	0.93700	-0.01100	496.35	24.64	496.35	24.64
6.49	0.014078	0.97400	-0.00600	582.53	25.62	582.53	25.62
7.45	0.016160	0.99300	0.00000	668.70	26.12	668.70	26.12
8.60	0.018659	1.00000	0.00000	772.10	26.30	772.10	26.30

CUMPSTY & HEAD INFINITE SWEPT WING IDENT 30.

PROFILE NUMBER 3 X = 0.466 FT

Y/THIC	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.04	0.000167	0.28000	0.08000	5.73	8.26	5.78	8.52
0.10	0.000416	0.36400	0.10200	14.33	10.74	14.45	11.06
0.20	0.000833	0.43600	0.10400	28.67	12.86	28.90	13.12
0.40	0.001666	0.50200	0.10600	57.33	14.81	57.79	15.01
0.91	0.003748	0.57700	0.10100	129.00	17.02	130.03	17.14
1.41	0.005831	0.63400	0.08300	200.67	18.70	202.28	18.71
1.92	0.007913	0.67600	0.07800	272.33	19.94	274.52	19.91
2.42	0.009996	0.71900	0.06600	344.00	21.21	346.76	21.13
2.93	0.012078	0.76100	0.05400	415.67	22.45	419.00	22.33
3.94	0.016243	0.83900	0.03000	559.00	24.75	563.48	24.57
4.95	0.020408	0.90800	0.01500	702.33	26.79	707.96	26.58
5.96	0.024573	0.96700	0.00300	845.67	28.53	852.45	28.30
6.97	0.028738	0.99600	0.00000	989.00	29.38	996.93	29.15
7.98	0.032903	1.00000	0.00000	1132.33	29.50	1141.41	29.26

CUMPSTY & HEAD INFINITE SWEPT WING IDENT 30.

PROFILE NUMBER 4 X = 0.650 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.05	0.000333	0.33200	0.12700	10.09	10.79	10.57	11.03
0.11	0.000750	0.38600	0.15100	22.70	12.55	23.78	12.86
0.24	0.001583	0.44300	0.15800	47.92	14.40	50.21	14.59
0.37	0.002416	0.47300	0.16200	73.14	15.38	76.64	15.51
0.56	0.003665	0.50700	0.16200	110.97	16.48	116.28	16.51
0.87	0.005748	0.54900	0.15800	174.02	17.85	182.34	17.72
1.19	0.007830	0.58600	0.15200	237.07	19.05	248.41	18.78
1.51	0.009913	0.61900	0.14300	300.12	20.12	314.47	19.71
2.14	0.014078	0.68100	0.12200	426.21	22.14	446.60	21.46
2.77	0.018243	0.73900	0.09700	552.31	24.02	578.73	23.12
3.41	0.022408	0.79300	0.07600	678.41	25.78	710.86	24.71
4.04	0.026573	0.85000	0.05200	804.51	27.63	843.00	26.42
4.67	0.030738	0.89600	0.03200	930.61	29.13	975.13	27.81
5.31	0.034903	0.94500	0.01800	1056.71	30.72	1107.26	29.32
5.94	0.039068	0.97500	0.00500	1182.81	31.69	1239.39	30.25
7.21	0.047398	0.99600	0.00000	1435.01	32.38	1503.65	30.90
8.47	0.055728	1.00000	0.00000	1687.20	32.51	1767.91	31.02

CUMPSTY & HEAD INFINITE SWEPT WING IDENT 30.

PROFILE NUMBER 5 X = 0.813 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.03	0.000333	0.30800	0.19300	8.27	11.99	9.24	12.68
0.05	0.000583	0.32700	0.19700	14.48	12.73	16.17	13.31
0.13	0.001416	0.36300	0.20800	35.16	14.14	39.26	14.59
0.29	0.003249	0.39500	0.22600	80.66	15.38	90.07	15.87
0.31	0.003499	0.41300	0.22100	86.86	16.08	97.00	16.34
0.48	0.005331	0.42700	0.24100	132.36	16.63	147.80	17.10
0.67	0.007414	0.46000	0.23600	184.06	17.91	205.54	18.03
0.69	0.007664	0.46900	0.22700	190.27	18.26	212.47	18.17
1.04	0.011579	0.50700	0.23200	287.47	19.74	321.01	19.45
1.42	0.015744	0.54900	0.21900	390.88	21.38	436.48	20.61
1.44	0.015994	0.56000	0.20600	397.08	21.81	443.41	20.81
1.81	0.020159	0.60300	0.18600	500.49	23.48	558.88	22.01
2.16	0.024074	0.63200	0.18700	597.69	24.61	667.42	22.99
2.91	0.032404	0.71900	0.14100	804.51	28.00	898.36	25.55
3.66	0.040734	0.80400	0.09500	1011.32	31.31	1129.31	28.24
4.41	0.049064	0.88200	0.05200	1218.13	34.35	1360.25	30.81
5.16	0.057394	0.94700	0.01900	1424.95	36.88	1591.19	33.03
5.91	0.065724	0.99100	0.00200	1631.76	38.59	1822.13	34.56
6.66	0.074054	1.00000	0.00000	1838.57	38.94	2053.07	34.88

TITLE: Jansen 47 Degree Vaneless Diffuser, Flow 32

REFERENCE: Jansen, W., "Incompressible fluid flow in a radial vaneless diffuser," MIT Gas Turbine Lab. Rept. 52, May, 1959

DESCRIPTION: Measurements were made in essentially the same apparatus used by Gardow (Figure 10.1). Jansen, unlike Gardow, measured the developing boundary layers on both walls and took pains to insure that the flow on the two opposite walls was the same.

EDITORS' COMMENTS: The momentum thickness Reynolds number of the flow at the first value of x is only 311 and the flow may not be fully turbulent. No value of kinematic viscosity was supplied by the originator. Since it is known that the experiments were performed in room air, a value of 0.000170 ft^2/sec. has been assured by the editors. No tabulated values of the velocity profile data are available and thus it was necessary to read values from the graphs of rather small scales which are contained in the report. A considerable loss of accuracy has resulted from this graph reading process.

PRESSURE GRADIENT: (See Figure 32.1)

x feet	Q_∞ ft/sec	$\partial Q_\infty/\partial x$ $(sec)^{-1}$
-0.050	33.5	-23.0
0.000	32.4	-22.2
0.050	31.3	-20.8
0.100	30.3	-19.9
0.150	29.3	-18.6
0.200	28.5	-16.3
0.250	27.7	-14.0
0.300	27.1	-12.4
0.350	26.5	-11.0
0.400	25.9	-10.5
0.450	25.4	-10.0
0.500	24.9	- 9.3
0.550	24.5	- 9.2

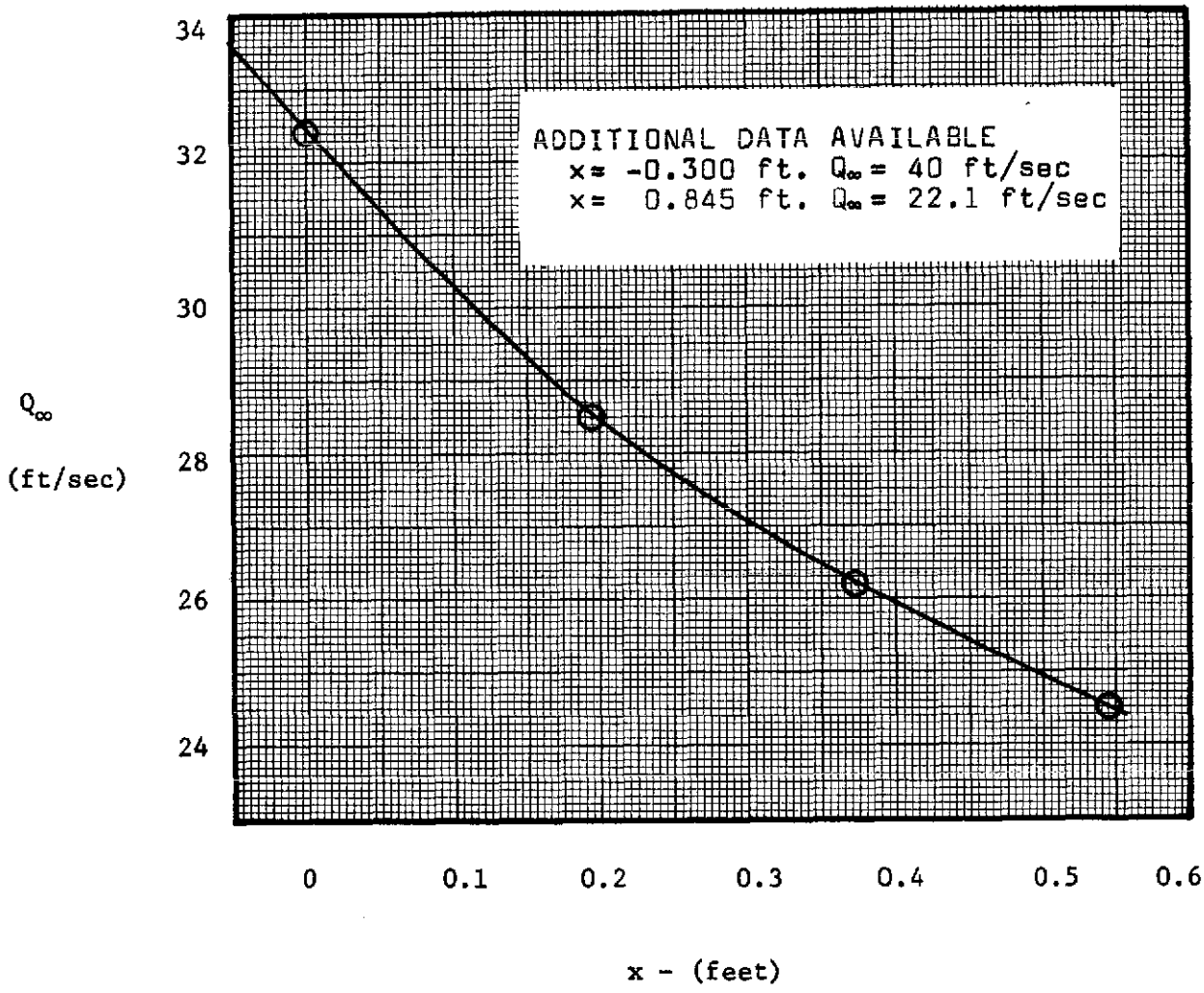


Figure 32.1 - Jansen 47 Degree Q_∞ Distribution

JANSEN 47 DEG. VANELESS DIFFUSER, INLET R = 1.45 FT IDENT =32. KIN. VISC= 0.0001700

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	311.9	1.368	0.006326	0.006241	0.006326	6.59	0.00	0.002229	0.001629
0.19500	448.5	1.392	0.005497	0.005455	0.005570	10.31	9.26	0.003659	0.002630
0.37300	608.4	1.401	0.004964	0.004956	0.005041	10.73	10.01	0.005552	0.003964
0.54500	695.3	1.485	0.004237	0.004195	0.004352	15.38	13.22	0.007276	0.004901

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.000853	0.000055	0.000717	0.000135	0.000	0.000	0.000	0.000	32.4	46.3
0.19500	0.001201	0.000084	0.000945	0.000256	0.040	0.279	0.271	0.382	28.5	45.0
0.37300	0.001997	0.000157	0.001552	0.000444	0.059	0.453	0.463	0.636	26.2	45.0
0.54500	0.002755	0.000275	0.002018	0.000737	-0.011	0.572	0.540	0.820	24.5	43.7

JANSEN 47 DEG. VANELESS DIFFUSER, INLET R = 1.45 FT IDENT 32.

PROFILE NUMBER 1 X = 0.000 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.41	0.000666	0.69121	0.07979	7.17	12.29	7.17	12.37
1.28	0.002082	0.78491	0.08822	22.42	13.96	22.42	14.04
2.56	0.004165	0.82602	0.08063	44.83	14.69	44.83	14.76
3.83	0.006247	0.85832	0.06891	67.25	15.26	67.25	15.31
5.11	0.008330	0.89274	0.05497	89.67	15.87	89.67	15.90
6.39	0.010412	0.92716	0.04103	112.09	16.49	112.09	16.50
7.67	0.012495	0.95723	0.02720	134.50	17.02	134.50	17.03
8.95	0.014577	0.97650	0.01583	156.92	17.36	156.92	17.36
10.22	0.016660	0.98608	0.00797	179.34	17.53	179.34	17.53
11.50	0.018742	0.99566	0.00011	201.76	17.70	201.76	17.70
12.78	0.020825	0.99889	-0.00106	224.17	17.76	224.17	17.76
14.06	0.022907	1.00000	0.00000	246.59	17.78	246.59	17.78

JANSEN 47 DEG. VANELESS DIFFUSER, INLET R = 1.45 FT IDENT 32.

PROFILE NUMBER 2 X = 0.195 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.25	0.000666	0.61084	0.11111	5.96	11.65	6.00	11.77
0.79	0.002082	0.67415	0.10074	18.62	12.86	18.74	12.92
1.58	0.004165	0.73983	0.08303	37.24	14.11	37.48	14.11
2.38	0.006247	0.78127	0.08018	55.86	14.90	56.23	14.88
3.17	0.008330	0.81778	0.07251	74.48	15.60	74.97	15.56
3.96	0.010412	0.85666	0.05750	93.10	16.34	93.71	16.27
4.75	0.012495	0.88829	0.04987	111.72	16.94	112.45	16.86
5.54	0.014577	0.91741	0.03495	130.34	17.50	131.20	17.40
6.34	0.016660	0.94900	0.02245	148.96	18.10	149.94	17.99
7.13	0.018742	0.96117	0.01989	167.58	18.33	168.68	18.22
7.92	0.020825	0.97571	0.00999	186.20	18.61	187.42	18.49
8.71	0.022907	0.98542	0.00502	204.82	18.80	206.17	18.67
9.50	0.024990	0.99271	0.00251	223.44	18.94	224.91	18.81
10.29	0.027072	1.00000	0.00000	242.06	19.07	243.65	18.95

JANSEN 47 DEG. VANELESS DIFFUSER, INLET R = 1.45 FT IDENT 32.

PROFILE NUMBER 3 X = 0.373 FT

Y/THIL	Y (FT)	LS/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.17	0.000666	0.53470	0.10134	5.10	10.73	5.14	10.84
0.53	0.002082	0.62957	0.10328	15.92	12.64	16.05	12.71
1.05	0.004165	0.68108	0.10557	31.85	13.67	32.09	13.73
1.58	0.006247	0.71893	0.09443	47.77	14.43	48.14	14.44
2.10	0.008330	0.75960	0.09681	63.70	15.25	64.19	15.25
2.63	0.010412	0.78665	0.09117	79.62	15.79	80.24	15.77
3.15	0.012495	0.81097	0.08284	95.55	16.28	96.28	16.24
3.68	0.014577	0.83529	0.07451	111.47	16.77	112.33	16.70
4.20	0.016660	0.85957	0.06076	127.40	17.25	128.38	17.16
4.73	0.018742	0.88390	0.05243	143.32	17.74	144.43	17.64
5.25	0.020825	0.90280	0.04415	159.25	18.12	160.48	18.00
5.78	0.022907	0.92712	0.03582	175.17	18.61	176.52	18.48
6.30	0.024990	0.94607	0.03296	191.10	18.99	192.57	18.86
6.83	0.027072	0.96493	0.01926	207.02	19.37	208.62	19.22
7.36	0.029155	0.97572	0.01375	222.95	19.58	224.67	19.44
7.88	0.031237	0.98652	0.00824	238.88	19.80	240.71	19.65
8.41	0.033320	0.99463	0.00546	254.80	19.96	256.76	19.81
8.93	0.035402	0.99731	0.00273	270.72	20.02	272.81	19.86
9.46	0.037485	1.00000	0.00000	286.65	20.07	288.85	19.92

JANSEN 47 DEG. VANELESS DIFFUSER, INLET R = 1.45 FT IDENT 32.

PROFILE NUMBER 4 X = 0.545 FT

Y/THI1	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.14	0.000666	0.46074	0.12676	4.35	10.01	4.41	10.24
0.42	0.002082	0.53408	0.12533	13.60	11.60	13.78	11.76
0.85	0.004165	0.60169	0.11792	27.19	13.07	27.56	13.14
1.27	0.006247	0.64847	0.12475	40.79	14.09	41.34	14.16
1.70	0.008330	0.68663	0.12260	54.39	14.92	55.12	14.95
2.12	0.010412	0.72767	0.12344	67.99	15.81	68.91	15.82
2.55	0.012495	0.75723	0.11232	81.58	16.45	82.69	16.41
2.97	0.014577	0.78678	0.10119	95.18	17.09	96.47	17.01
3.40	0.016660	0.81633	0.09007	108.78	17.74	110.25	17.61
3.82	0.018742	0.83703	0.08170	122.38	18.19	124.03	18.03
4.25	0.020825	0.86072	0.07045	135.97	18.70	137.81	18.51
4.67	0.022907	0.88142	0.06208	149.57	19.15	151.59	18.94
5.10	0.024990	0.91098	0.05096	163.17	19.79	165.37	19.56
5.52	0.027072	0.92881	0.03959	176.77	20.18	179.16	19.93
5.95	0.029155	0.94951	0.03122	190.36	20.63	192.94	20.37
6.37	0.031237	0.96159	0.01387	203.96	20.89	206.72	20.62
6.80	0.033320	0.98074	0.00987	217.56	21.31	220.50	21.03
7.22	0.035402	0.99115	0.00275	231.16	21.54	234.28	21.25
7.65	0.037485	0.99414	-0.00012	244.75	21.60	248.06	21.31
8.07	0.039567	1.00000	0.00000	258.35	21.73	261.84	21.44

TITLE: Jansen 67 Degree Vaneless Diffuser, Flow 35

REFERENCE: Jansen, W., "Incompressible fluid flow in a radial vaneless diffuser," MIT Gas Turbine Lab. Rept. 52, May, 1959

DESCRIPTION: Measurements were made in essentially the same apparatus used by Gardow (Figure 10.1). Jansen, unlike Gardow, measured the developing boundary layers on both walls of the diffuser and took pains to insure that the flow on the opposite walls was the same.

EDITORS' COMMENTS: At the last two values of x, the boundary layers appear to fill the passage and it is probable that the inviscid core no longer exists. No value of the kinematic viscosity was supplied by the originator. Since it is known that the experiments were performed in room air, a value of 0.00017 has been assumed by the editors. No tabulations of the velocity profile data are available and hence it was necessary to read values from small scale graphs in the report. This graph reading has resulted in a considerable loss of accuracy.

PRESSURE GRADIENT: (See Figure 35.1)

x feet	Q_∞ ft/sec	$\partial Q_\infty/\partial x$ $(\text{sec})^{-1}$
-0.050	57.5	-34.6
0.000	55.9	-29.6
0.050	54.5	-27.1
0.100	53.2	-26.5
0.150	51.8	-25.8
0.200	50.6	-24.6
0.250	49.4	-23.2
0.300	48.2	-22.4
0.350	47.2	-21.4
0.400	46.1	-20.4
0.450	45.1	-19.3
0.500	44.2	-18.2
0.550	43.3	-16.8

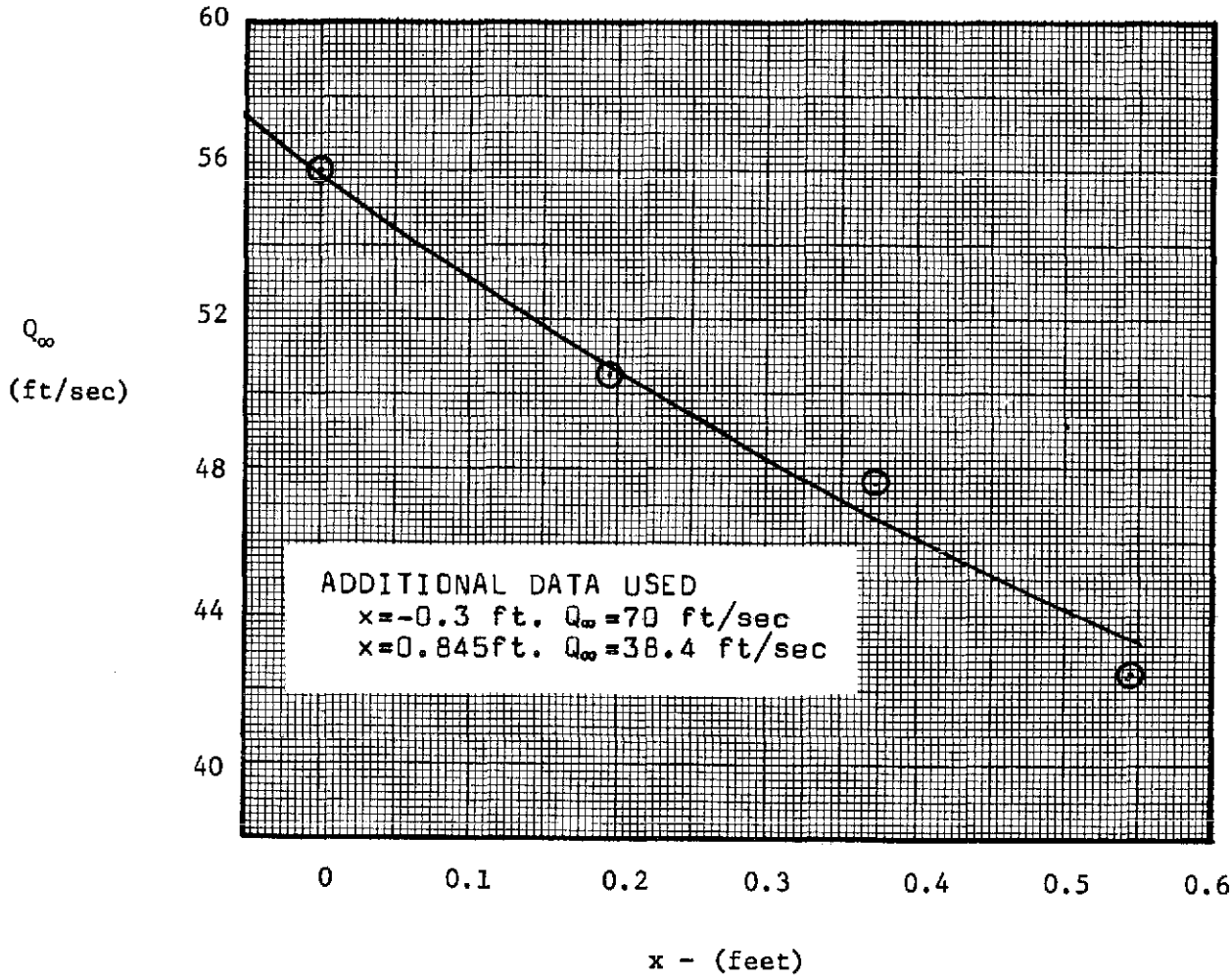


Figure 35.1 Jansen 67 Degree Q_∞ Distribution

JANSEN 67 DEG. VANELESS DIFFUSER, INLET R = 1.45 FT IDENT =35. KIN. VISC= 0.0001700

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	1089.2	1.359	0.004349	0.004524	0.004349	9.33	0.00	0.004462	0.003283
0.19500	1459.6	1.412	0.003723	0.003854	0.003827	13.04	13.37	0.006964	0.004934
0.37300	1788.1	1.482	0.003213	0.003271	0.003383	18.28	18.26	0.009452	0.006379
0.54500	1940.9	1.402	0.003568	0.003625	0.003770	22.85	18.85	0.010914	0.007785

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.001431	0.000116	0.001103	0.000328	0.000	0.000	0.000	0.000	56.0	62.3
0.19500	0.002239	0.000233	0.001598	0.000641	-0.679	0.135	0.494	0.431	50.5	61.0
0.37300	0.003599	0.000437	0.002499	0.001101	-0.494	0.215	0.882	0.722	47.6	57.0
0.54500	0.006085	0.000903	0.004501	0.001584	-1.078	0.271	0.766	0.962	42.4	56.1

JANSEN 67 DEG. VANELESS DIFFUSER, INLET R = 1.45 FT IDENT 35.

PROFILE NUMBER 1 X = 0.000 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.20	0.000666	0.64842	0.10648	10.31	13.91	10.31	14.09
0.63	0.002082	0.68724	0.10874	32.22	14.74	32.22	14.92
1.27	0.004165	0.71581	0.10765	64.43	15.35	64.43	15.52
1.90	0.006247	0.74766	0.10028	96.65	16.03	96.65	16.18
2.54	0.008330	0.78197	0.08819	128.87	16.77	128.87	16.88
3.17	0.010412	0.81163	0.06967	161.09	17.41	161.09	17.47
3.81	0.012495	0.84758	0.05444	193.30	18.18	193.30	18.21
4.44	0.014577	0.87861	0.04864	225.52	18.84	225.52	18.87
5.07	0.016660	0.90363	0.02370	257.74	19.38	257.74	19.39
5.71	0.018742	0.92441	0.01454	289.96	19.82	289.96	19.83
6.34	0.020825	0.94273	0.01010	322.17	20.22	322.17	20.22
6.98	0.022907	0.96022	0.00724	354.39	20.59	354.39	20.59
7.61	0.024990	0.97294	0.00587	386.61	20.87	386.61	20.87
8.25	0.027072	0.98250	0.00287	418.83	21.07	418.83	21.07
8.88	0.029155	0.98647	0.00294	451.04	21.16	451.04	21.16
9.52	0.031237	0.99754	0.00472	483.26	21.39	483.26	21.39
10.15	0.033320	0.99918	0.00157	515.48	21.43	515.48	21.43
10.78	0.035402	1.00000	0.00000	547.70	21.45	547.70	21.45

JANSEN 67 DEG. VANELESS DIFFUSER, INLET R = 1.45 FT IDENT 35.

PROFILE NUMBER 2 X = 0.195 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.14	0.000666	0.56674	0.13126	8.51	13.14	8.62	13.30
0.42	0.002082	0.60737	0.13975	26.58	14.08	26.95	14.25
0.84	0.004165	0.63593	0.13716	53.16	14.74	53.90	14.87
1.27	0.006247	0.67273	0.12773	79.75	15.59	80.85	15.65
1.69	0.008330	0.70793	0.11290	106.33	16.41	107.80	16.39
2.11	0.010412	0.73489	0.10492	132.91	17.03	134.75	16.97
2.53	0.012495	0.76469	0.09169	159.49	17.72	161.70	17.61
2.95	0.014577	0.78816	0.08181	186.08	18.27	188.65	18.12
3.38	0.016660	0.81083	0.06923	212.66	18.79	215.60	18.60
3.80	0.018742	0.83699	0.05855	239.24	19.40	242.55	19.18
4.22	0.020825	0.86045	0.04866	265.82	19.94	269.50	19.70
4.64	0.022907	0.88392	0.03878	292.41	20.49	296.45	20.23
5.07	0.024990	0.90564	0.02795	318.99	20.99	323.40	20.71
5.49	0.027072	0.92291	0.01697	345.57	21.39	350.35	21.10
5.91	0.029155	0.94448	0.01058	372.15	21.89	377.30	21.59
6.33	0.031237	0.96256	0.00229	398.74	22.31	404.25	22.01
6.75	0.033320	0.97349	-0.00534	425.32	22.56	431.20	22.26
7.18	0.035402	0.98253	-0.00949	451.90	22.77	458.15	22.46
7.60	0.037485	0.98567	-0.01013	478.48	22.94	485.10	22.63
8.02	0.039567	0.99396	-0.00554	505.07	23.04	512.05	22.72
8.44	0.041650	0.99476	-0.00285	531.65	23.06	539.00	22.74
10.13	0.049980	1.00000	0.00000	637.98	23.18	646.80	22.86

JANSEN 67 DEG. VANELESS DIFFUSER, INLET R = 1.45 FT IDENT 35.

PROFILE NUMBER 3 X = 0.373 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.10	0.000666	0.45720	0.15104	7.49	11.41	7.68	11.71
0.33	0.002082	0.52612	0.16816	23.40	13.13	24.01	13.43
0.65	0.004165	0.57565	0.17274	46.79	14.36	48.02	14.61
0.98	0.006247	0.61224	0.16643	70.19	15.27	72.03	15.43
1.31	0.008330	0.64820	0.15721	93.59	16.17	96.04	16.22
1.63	0.010412	0.67246	0.14292	116.99	16.78	120.05	16.71
1.96	0.012495	0.69558	0.13039	140.38	17.35	144.06	17.21
2.29	0.014577	0.71983	0.11609	163.78	17.96	168.07	17.73
2.61	0.016660	0.74295	0.10356	187.18	18.54	192.08	18.24
2.94	0.018742	0.76958	0.09331	210.58	19.20	216.09	18.85
3.26	0.020825	0.79622	0.08305	233.97	19.87	240.10	19.46
3.59	0.022907	0.82638	0.07508	257.37	20.62	264.11	20.17
3.92	0.024990	0.84660	0.06317	280.77	21.12	288.12	20.64
4.24	0.027072	0.87147	0.05178	304.17	21.74	312.13	21.23
4.57	0.029155	0.89169	0.03987	327.56	22.25	336.14	21.70
4.90	0.031237	0.91252	0.03086	350.96	22.77	360.15	22.20
5.22	0.033320	0.92931	0.02423	374.36	23.19	384.16	22.60
5.55	0.035402	0.94082	0.01418	397.76	23.47	408.17	22.88
5.88	0.037485	0.95357	0.00993	421.15	23.79	432.18	23.19
6.20	0.039567	0.96518	0.00745	444.55	24.08	456.19	23.47
6.53	0.041650	0.97564	0.00673	467.95	24.34	480.20	23.72
7.84	0.049980	0.99306	0.00300	561.54	24.78	576.24	24.14
9.14	0.058310	1.00000	0.00000	655.13	24.95	672.28	24.31

JANSEN 67 DEG. VANELESS DIFFUSER, INLET R = 1.45 FT IDENT 35.

PROFILE NUMBER 4 X = 0.545 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.09	0.000666	0.42601	0.17948	7.02	10.09	7.21	10.65
0.27	0.002082	0.56944	0.22885	21.93	13.48	22.54	14.14
0.53	0.004165	0.61545	0.21169	43.85	14.57	45.08	14.99
0.80	0.006247	0.64505	0.19762	65.78	15.27	67.62	15.54
1.07	0.008330	0.67456	0.19206	87.71	15.97	90.16	16.16
1.34	0.010412	0.69424	0.18835	109.64	16.44	112.70	16.57
1.60	0.012495	0.71463	0.17942	131.56	16.92	135.24	16.97
1.87	0.014577	0.73501	0.17048	153.49	17.40	157.78	17.38
2.14	0.016660	0.75089	0.15561	175.42	17.78	180.32	17.66
2.41	0.018742	0.76277	0.14658	197.35	18.06	202.86	17.89
2.67	0.020825	0.77660	0.13888	219.27	18.39	225.40	18.17
2.94	0.022907	0.79043	0.13118	241.20	18.71	247.94	18.46
3.21	0.024990	0.80364	0.12020	263.13	19.03	270.48	18.72
3.48	0.027072	0.81747	0.11250	285.06	19.36	293.02	19.01
3.74	0.029155	0.83457	0.10418	306.98	19.76	315.56	19.37
4.01	0.031237	0.84973	0.09453	328.91	20.12	338.10	19.69
4.28	0.033320	0.86294	0.08355	350.84	20.43	360.64	19.97
4.55	0.035402	0.87483	0.07452	372.77	20.71	383.18	20.22
4.81	0.037485	0.88865	0.06682	394.69	21.04	405.72	20.53
5.08	0.039567	0.90248	0.05912	416.62	21.37	428.26	20.83
5.35	0.041650	0.91631	0.05142	438.55	21.70	450.80	21.14
6.42	0.049980	0.95656	0.02177	526.26	22.65	540.96	22.04
7.49	0.058310	0.98494	0.00114	613.97	23.32	631.12	22.69
8.56	0.066640	1.00000	0.00000	701.68	23.68	721.28	23.03

TITLE: Cham Rotating Disc, 515 RPM, Flow 40

REFERENCE: Cham, T. "Turbulent boundary layers in rotating flow," Ph.D. dissertation, Department of Engineering, University of Cambridge, May 1968. Partially available in JFM, 37, p. 129

DESCRIPTION: Boundary layer measurements were made above the surface of a 36 inch diameter steel disc rotating in still room air. Velocity direction was measured with a single wire hot wire anemometer rotated into two different angles (90° apart) until the same reading was obtained. The direction was then the mean of these two angles. The velocity magnitudes were measured with the central hole on a three hole yaw probe. No turbulence quantities were measured. The radius to the first velocity profile is 1.08 feet.

EDITORS' COMMENTS: The originator was unable to supply tabulations of his velocity profiles. Hence, the tabulation provided here were read from graphs contained in the dissertation. Some loss in accuracy is to be expected.

PRESSURE GRADIENT: The external pressure is constant and the absolute velocity is zero outside the boundary layer.

CHAM,515 RPM ROTATING DISC

IDENT =40. KIN. VISC= 0.0001640

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	1304.3	1.438	0.004353	0.003994	0.004353	-15.31	0.00	0.005166	0.003669
0.16600	1870.2	1.376	0.004025	0.003815	0.004025	-16.20	0.00	0.006288	0.004571
0.33300	2315.4	1.360	0.003830	0.003693	0.003876	-15.51	8.85	0.006784	0.004990

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	-0.001751	0.000126	-0.001371	-0.000380	0.000	0.000	0.000	0.000	58.30	90.0
0.16600	-0.002409	0.000183	-0.001919	-0.000491	0.133	0.122	0.445	0.431	67.10	90.0
0.33300	-0.003007	0.000254	-0.002427	-0.000580	0.242	0.272	1.025	0.962	76.10	90.0

CHAM,515 RPM ROTATING DISC IDENT 40.

PROFILE NUMBER 1 X = 0.000 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.12	0.000426	0.28500	-0.07800	7.07	6.11	7.07	5.33
0.19	0.000710	0.41500	-0.09700	11.78	8.90	11.78	9.13
0.26	0.000958	0.46000	-0.10600	15.90	9.86	15.90	10.12
0.37	0.001349	0.53000	-0.10900	22.37	11.36	22.37	11.60
0.45	0.001633	0.57000	-0.11200	27.08	12.22	27.08	12.45
0.60	0.002201	0.62500	-0.10900	36.50	13.40	36.50	13.60
0.85	0.003124	0.67000	-0.10600	51.81	14.36	51.81	14.54
1.07	0.003940	0.70500	-0.10200	65.35	15.11	65.35	15.27
1.33	0.004863	0.72500	-0.09800	80.66	15.54	80.66	15.68
1.54	0.005645	0.74500	-0.09400	93.62	15.97	93.62	16.09
1.76	0.006461	0.76500	-0.09000	107.16	16.40	107.16	15.51
2.21	0.008094	0.79500	-0.08300	134.24	17.04	134.24	17.13
2.67	0.009798	0.82000	-0.07300	162.50	17.58	162.50	17.65
3.36	0.012318	0.84000	-0.06800	204.31	18.00	204.31	13.06
4.05	0.014874	0.86500	-0.05900	246.70	18.54	246.70	18.58
4.73	0.017359	0.89000	-0.04500	287.91	19.08	287.91	19.10
5.39	0.019773	0.92500	-0.03200	327.95	19.83	327.95	19.84
6.09	0.022329	0.93500	-0.02800	370.34	20.04	370.34	20.05
6.75	0.024779	0.95000	-0.02200	410.97	20.35	410.97	20.37
7.23	0.026518	0.95500	-0.02000	439.82	20.47	439.82	20.47
7.67	0.028152	0.96000	-0.01800	466.90	20.58	466.90	20.58
8.13	0.029820	0.96500	-0.01600	494.58	20.68	494.58	20.69
8.35	0.030637	0.97500	-0.01000	508.12	20.90	508.12	20.90
10.64	0.039050	1.00000	0.00000	647.66	21.43	647.66	21.43

CHAM,515 RPM ROTATING DISC IDENT 40.

PROFILE NUMBER 2 X = 0.166 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.10	0.000445	0.26500	-0.07700	8.17	5.91	8.17	5.15
0.20	0.000935	0.46000	-0.11400	17.15	10.25	17.15	10.56
0.28	0.001291	0.52500	-0.11600	23.69	11.70	23.69	11.99
0.42	0.001914	0.60500	-0.11500	35.12	13.49	35.12	13.73
0.59	0.002715	0.65500	-0.11000	49.82	14.60	49.82	14.81
0.80	0.003649	0.69000	-0.10600	66.97	15.38	66.97	15.56
1.09	0.004984	0.72500	-0.10400	91.47	16.16	91.47	16.33
1.55	0.007075	0.75500	-0.10000	129.86	16.83	129.86	16.98
2.29	0.010458	0.80500	-0.08600	191.93	17.95	191.93	18.05
2.85	0.013039	0.82500	-0.08000	239.30	18.39	239.30	18.48
3.41	0.015575	0.85000	-0.07000	285.86	18.95	285.86	19.01
4.03	0.018423	0.86500	-0.06400	338.13	19.23	338.13	19.34
4.55	0.020782	0.88500	-0.05800	381.42	19.73	381.42	19.77
5.68	0.025944	0.91000	-0.04400	476.16	20.29	476.16	20.31
6.03	0.027546	0.92500	-0.03700	505.56	20.62	505.56	20.64
6.41	0.029281	0.93000	-0.03400	537.41	20.73	537.41	20.75
6.79	0.031017	0.94000	-0.03200	569.27	20.95	569.27	20.97
6.94	0.031729	0.95000	-0.02600	582.33	21.18	582.33	21.19
7.14	0.032619	0.95500	-0.02400	598.67	21.29	598.67	21.30
7.32	0.033464	0.95500	-0.02200	614.19	21.29	614.19	21.29
7.50	0.034265	0.96000	-0.02000	628.89	21.40	628.89	21.41
7.70	0.035200	0.96500	-0.01600	646.04	21.51	646.04	21.52
7.89	0.036045	0.97000	-0.01400	661.56	21.62	661.56	21.63
8.05	0.036802	0.97000	-0.01500	675.44	21.52	675.44	21.63
8.24	0.037647	0.97500	-0.01200	690.96	21.74	690.96	21.74
8.42	0.038493	0.98400	-0.00800	706.48	21.94	706.48	21.94
8.63	0.039427	0.98500	-0.00800	723.63	21.96	723.63	21.96
8.91	0.040718	0.98600	-0.00600	747.31	21.98	747.31	21.98
10.71	0.048950	1.00000	0.00000	898.41	22.29	898.41	22.29

CHAM,515 RPM ROTATING DISC IDENT 40.

PROFILE NUMBER 3 X = 0.333 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.10	0.000494	0.31000	-0.08600	10.03	7.08	10.09	7.31
0.27	0.001334	0.55500	-0.09600	27.08	12.58	27.25	12.79
0.31	0.001531	0.57000	-0.10800	31.09	13.03	31.28	13.18
0.34	0.001680	0.58500	-0.11300	34.10	13.37	34.31	13.53
0.40	0.001976	0.60500	-0.11700	40.12	13.83	40.36	14.00
0.50	0.002519	0.63500	-0.11900	51.16	14.51	51.46	14.68
0.60	0.003013	0.65500	-0.11800	61.19	14.97	61.55	15.12
0.95	0.004743	0.70500	-0.11900	96.30	16.11	96.88	16.24
1.12	0.005582	0.72500	-0.11600	113.35	16.57	114.03	15.68
1.62	0.008102	0.76000	-0.11000	164.50	17.37	165.49	17.44
1.97	0.009831	0.78500	-0.10800	199.61	17.94	200.81	18.00
2.48	0.012350	0.81500	-0.10300	250.77	18.63	252.27	18.66
3.06	0.015265	0.83500	-0.09200	309.95	19.08	311.81	19.08
3.49	0.017438	0.85500	-0.08600	354.08	19.54	356.21	19.52
4.02	0.020056	0.87000	-0.07400	407.24	19.88	409.69	19.83
4.55	0.022724	0.88500	-0.06700	461.41	20.22	464.18	20.16
5.56	0.027763	0.92000	-0.04800	563.72	21.02	567.11	20.93
6.57	0.032802	0.94500	-0.03500	666.03	21.60	670.03	21.48
7.12	0.035519	0.95000	-0.02700	721.20	21.71	725.53	21.59
7.63	0.038087	0.95500	-0.02200	773.36	21.82	778.00	21.70
8.14	0.040607	0.96500	-0.02000	824.52	22.05	829.47	21.93
8.48	0.042336	0.97000	-0.01800	859.62	22.17	864.79	22.04
8.65	0.043176	0.97500	-0.01400	876.67	22.28	881.94	22.15
8.84	0.044114	0.97500	-0.01100	895.73	22.28	901.11	22.15
9.00	0.044905	0.98000	-0.01100	911.78	22.40	917.26	22.26
9.16	0.045695	0.98300	-0.00700	927.83	22.46	933.40	22.33
9.36	0.046683	0.98500	-0.00600	947.89	22.51	953.59	22.38
9.52	0.047523	0.98700	-0.00600	964.94	22.56	970.74	22.42
10.89	0.054340	1.00000	0.00000	1103.37	22.85	1109.99	22.72

TITLE: Cham Rotating Disc, 1000 RPM, Flow 42

REFERENCES: Cham, T., "Turbulent boundary layers in rotating flows," Ph.D. dissertation, Department of Engineering, University of Cambridge, May 1968, Partially available in JFM, 37, p. 129.

DESCRIPTION: Boundary layer measurements were made above the surface of a 36 inch diameter steel disc rotating in still room air. Velocity direction was measured with a single wire hot anemometer rotated at two different angles (90° apart) until the same reading was obtained. The direction was then taken as the mean of the two angles. The velocity magnitudes were measured with the central hole on a three hole yaw probe (dimensions not given). No turbulence quantities were measured. The radius to the first velocity profile is 0.75 feet.

EDITORS' COMMENTS: The originator was unable to supply tabulations of his velocity profiles. Hence, the tabulations provided here were read from graphs contained in the dissertation. Some loss of accuracy is to be expected.

PRESSURE GRADIENT: The external pressure is constant and the velocity is zero outside the boundary layer.

CHAM,1000 RPM ROTATING DISC

IDENT =42. KIN. VISC= 0.0001630

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	1123.2	1.442	0.004333	0.003942	0.004429	-19.53	11.94	0.003375	0.002341
0.33300	2718.2	1.346	0.003745	0.003613	0.003776	-17.57	7.31	0.005278	0.003921
0.66600	4100.4	1.337	0.003386	0.003285	0.003442	-11.31	10.33	0.006035	0.004516

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	-0.001121	0.000082	-0.000862	-0.000259	0.000	0.000	0.000	0.000	78.20	90.0
0.33300	-0.002251	0.000174	-0.001823	-0.000428	0.112	0.120	0.369	0.364	113.00	90.0
0.66600	-0.002712	0.000214	-0.002218	-0.000494	0.301	0.257	0.932	0.962	148.00	90.0

CHAM,1000 RPM ROTATING DISC IDENT 42.

PROFILE NUMBER 1 X = 0.000 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.10	0.000226	0.20800	-0.07400	5.05	4.47	5.10	4.69
0.15	0.000362	0.32500	-0.09900	8.07	6.98	8.16	7.22
0.30	0.000701	0.46500	-0.11700	15.55	9.99	15.82	10.19
0.49	0.001153	0.55800	-0.11800	25.74	11.99	26.02	12.12
0.70	0.001627	0.62400	-0.11500	36.34	13.41	36.74	13.48
1.04	0.002441	0.68100	-0.10800	54.51	14.63	55.11	14.65
1.55	0.003639	0.73500	-0.09600	81.25	15.79	82.15	15.75
1.93	0.004520	0.76000	-0.08900	100.94	16.33	102.05	16.26
2.61	0.006102	0.81100	-0.07300	136.27	17.42	137.76	17.30
3.35	0.007842	0.84200	-0.06400	175.13	18.09	177.05	17.94
4.04	0.009469	0.87000	-0.05200	211.46	18.69	213.79	18.52
4.76	0.011142	0.89800	-0.04300	248.81	19.29	251.54	19.10
5.47	0.012814	0.91200	-0.03600	286.16	19.59	289.30	19.40
6.18	0.014464	0.94500	-0.02600	323.00	20.30	326.55	20.09
6.91	0.016182	0.95600	-0.01900	361.36	20.54	365.33	20.32
7.25	0.016973	0.95600	-0.01900	379.02	20.54	383.18	20.32
7.61	0.017809	0.96800	-0.01700	397.69	20.80	402.06	20.57
7.97	0.018668	0.97200	-0.01300	416.87	20.88	421.45	20.66
8.30	0.019436	0.97600	-0.01100	434.03	20.97	438.80	20.74
8.60	0.020137	0.97800	-0.01200	449.68	21.01	454.62	20.78
9.06	0.021199	0.97900	-0.01100	473.40	21.03	478.60	20.81
9.40	0.022012	0.98800	-0.00500	491.56	21.23	496.97	21.00
10.62	0.024860	1.00000	0.00000	555.16	21.48	561.26	21.25

CHAM,1000 RPM ROTATING DISC IDENT 42.

PROFILE NUMBER 2 X = 0.333 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.09	0.000344	0.30000	-0.09500	10.31	6.93	10.36	7.24
0.20	0.000802	0.51500	-0.10600	24.07	11.90	24.15	12.10
0.33	0.001299	0.58500	-0.11600	38.96	13.52	39.12	13.73
0.46	0.001795	0.62500	-0.11700	53.86	14.44	54.08	14.63
0.66	0.002598	0.67000	-0.11500	77.93	15.48	78.25	15.65
1.08	0.004240	0.72500	-0.11000	127.21	16.75	127.73	16.88
1.72	0.006761	0.77500	-0.10000	202.84	17.91	203.67	17.98
2.13	0.008366	0.80500	-0.09500	250.97	18.60	252.00	18.66
2.80	0.010963	0.83500	-0.08600	328.90	19.30	330.25	19.32
3.42	0.013408	0.85500	-0.07600	402.25	19.76	403.89	19.75
4.08	0.016006	0.88000	-0.06600	480.17	20.34	482.14	20.31
4.71	0.018451	0.89500	-0.05600	553.52	20.68	555.78	20.64
5.35	0.020972	0.91000	-0.04600	629.15	21.03	631.73	20.97
5.99	0.023493	0.92500	-0.03800	704.79	21.38	707.67	21.31
6.63	0.026014	0.93500	-0.03400	780.43	21.61	783.62	21.53
7.27	0.028497	0.94500	-0.03200	854.92	21.84	858.41	21.76
7.71	0.030216	0.96000	-0.02600	906.49	22.18	910.19	22.10
8.13	0.031859	0.96500	-0.02300	955.76	22.30	959.67	22.22
8.55	0.033540	0.97000	-0.01900	1006.19	22.42	1010.30	22.33
8.96	0.035144	0.97500	-0.01600	1054.32	22.53	1058.63	22.44
9.19	0.036023	0.98000	-0.01400	1080.68	22.65	1085.10	22.56
9.39	0.036825	0.98400	-0.01100	1104.74	22.74	1109.26	22.65
9.63	0.037742	0.98600	-0.00900	1132.25	22.78	1136.88	22.69
9.84	0.038582	0.99000	-0.00600	1157.46	22.88	1162.19	22.78
10.72	0.042020	1.00000	0.00000	1260.60	23.11	1265.76	23.01

CHAM,1000 RPM ROTATING DISC IDENT 42.

PROFILE NUMBER 3 X = 0.666 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.11	0.000496	0.39500	-0.07900	18.54	9.50	18.69	9.71
0.19	0.000857	0.51500	-0.10600	32.02	12.52	32.28	12.67
0.30	0.001353	0.58500	-0.11600	50.55	14.22	50.97	14.38
0.47	0.002120	0.63500	-0.11400	79.20	15.43	79.85	15.55
0.77	0.003473	0.68500	-0.11300	129.75	16.65	130.81	15.73
1.11	0.005006	0.72500	-0.11000	187.04	17.62	188.57	17.68
1.47	0.006630	0.76500	-0.10500	247.70	18.59	249.73	18.61
2.05	0.009245	0.80000	-0.10000	345.43	19.44	348.27	19.43
2.59	0.011681	0.82500	-0.09300	436.42	20.05	440.00	20.01
3.14	0.014161	0.84500	-0.08700	529.10	20.54	533.44	20.48
3.71	0.016732	0.86500	-0.07500	625.14	21.02	630.28	20.93
4.24	0.019168	0.88500	-0.06900	716.14	21.51	722.01	21.40
4.83	0.021828	0.90000	-0.06200	815.55	21.87	822.25	21.75
5.38	0.024309	0.91000	-0.04900	908.23	22.11	915.68	21.97
5.92	0.026744	0.92000	-0.04300	999.22	22.36	1007.42	22.20
6.47	0.029225	0.93000	-0.03800	1091.90	22.60	1100.86	22.44
7.03	0.031750	0.94500	-0.03400	1186.26	22.97	1196.00	22.79
7.60	0.034321	0.96000	-0.02700	1282.30	23.33	1292.83	23.15
8.16	0.036847	0.97000	-0.02300	1376.67	23.57	1387.97	23.39
8.71	0.039327	0.97300	-0.01800	1469.34	23.65	1481.40	23.46
9.09	0.041041	0.97500	-0.01700	1533.37	23.69	1545.96	23.51
9.26	0.041808	0.98000	-0.01400	1562.02	23.82	1574.84	23.62
9.64	0.043522	0.98200	-0.01200	1626.05	23.86	1639.40	23.67
9.84	0.044424	0.98400	-0.01100	1659.75	23.91	1573.38	23.72
9.99	0.045100	0.98500	-0.00900	1685.02	23.94	1598.86	23.74
10.10	0.045596	0.99000	-0.00800	1703.56	24.06	1717.55	23.86
10.19	0.046002	0.99500	-0.00500	1718.72	24.18	1732.84	23.98
10.99	0.049610	1.00000	0.00000	1853.53	24.30	1868.74	24.10

TITLE: Cham Rotating Disc, 1550 RPM, Flow 44

REFERENCE: Cham, T., "Turbulent boundary layers in rotating flow," Ph.D. dissertation, Department of Engineering, University of Cambridge, May 1968. Partially available in JFM 37, p. 129

DESCRIPTION: Boundary layer measurements were made above the surface of a 36 inch diameter steel disc rotating in still room air. Velocity direction was measured with a single wire hot wire anemometer rotated at two different angles (90° apart) until the same reading was obtained. The direction was then the mean of these two angles. The velocity magnitudes were measured with the central hole on a three hole yaw probe. No turbulence quantities were measured. The radius to the first velocity profile is 0.625 feet.

EDITORS' COMMENTS: The originator was unable to supply tabulations of his velocity profiles. Hence, the tabulations provided here were read from graphs contained in the dissertation. Some loss in accuracy is to be expected.

PRESSURE GRADIENT: The external pressure is constant and the velocity is zero outside the boundary layer.

CHAM 1550 RPM ROTATING DISC

IDENT =44. KIN. VISC= 0.0001630

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	1274.3	1.451	0.004113	0.003757	0.004258	-15.52	14.99	0.002984	0.002056
0.37500	3329.1	1.346	0.003545	0.003421	0.003618	-10.87	11.54	0.004510	0.003350
0.79100	6226.3	1.316	0.003090	0.003032	0.003158	-9.63	11.98	0.005807	0.004413

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	-0.001124	0.000089	-0.000883	-0.000241	0.000	0.000	0.000	0.000	101.00	90.0
0.37500	-0.002065	0.000164	-0.001696	-0.000369	0.102	0.069	0.308	0.316	162.00	90.0
0.79100	-0.002614	0.000200	-0.002155	-0.000458	0.312	0.188	0.950	0.982	230.00	90.0

CHAM 1550 RPM ROTATING DISC IDENT 44.

PROFILE NUMBER 1 X = 0.000 FT

Y/THIC	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.20	0.000412	0.33500	-0.09300	11.58	7.39	11.78	7.54
0.26	0.000536	0.43500	-0.10500	15.05	9.59	15.31	9.70
0.44	0.000906	0.54500	-0.11400	25.47	12.02	25.91	12.07
0.60	0.001236	0.61000	-0.11800	34.73	13.45	35.34	13.47
0.83	0.001710	0.65000	-0.11900	48.04	14.33	48.88	14.32
1.15	0.002369	0.69500	-0.11700	66.56	15.33	67.73	15.28
1.73	0.003564	0.74500	-0.10800	100.14	16.43	101.89	15.32
2.13	0.004388	0.78500	-0.09800	123.29	17.31	125.44	17.15
2.54	0.005232	0.80500	-0.09000	147.02	17.75	149.59	17.56
2.94	0.006036	0.82500	-0.08300	169.59	18.19	172.56	17.97
3.78	0.007766	0.86000	-0.06500	218.22	18.97	222.03	18.69
4.56	0.009373	0.89500	-0.05400	263.36	19.74	267.96	19.43
5.40	0.011103	0.92000	-0.04000	311.98	20.29	317.43	19.96
6.20	0.012751	0.94500	-0.02800	358.29	20.84	364.55	20.49
7.00	0.014399	0.95000	-0.02800	404.60	20.95	411.66	20.60
7.81	0.016068	0.96500	-0.02000	451.48	21.28	459.37	20.92
8.22	0.016913	0.97000	-0.01800	475.21	21.39	483.51	21.03
8.60	0.017695	0.97500	-0.01600	497.21	21.50	505.89	21.13
9.02	0.018540	0.98000	-0.01400	520.94	21.61	530.04	21.24
9.43	0.019385	0.98500	-0.01000	544.67	21.72	554.19	21.35
9.82	0.020188	0.99000	-0.00600	567.25	21.83	577.15	21.46
11.02	0.022660	1.00000	0.00000	636.70	22.05	647.83	21.67

CHAM 1550 RPM ROTATING DISC IDENT 44.

PROFILE NUMBER 2 X = 0.375 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.17	0.000571	0.50000	-0.09600	23.90	11.88	24.14	11.97
0.26	0.000874	0.55500	-0.10400	36.55	13.18	36.93	13.28
0.33	0.001109	0.58000	-0.11400	46.39	13.78	46.87	13.90
0.51	0.001714	0.64500	-0.11400	71.70	15.32	72.43	15.40
0.62	0.002083	0.67000	-0.11600	87.16	15.91	88.06	15.99
0.90	0.003024	0.70000	-0.11500	126.53	16.53	127.82	16.68
1.27	0.004267	0.74000	-0.11200	178.54	17.58	180.37	17.60
1.75	0.005846	0.78000	-0.10600	244.62	18.53	247.13	18.51
2.23	0.007459	0.81000	-0.10000	312.10	19.24	315.30	19.19
3.00	0.010046	0.84000	-0.08800	420.35	19.95	424.66	19.86
3.76	0.012600	0.87000	-0.07500	527.19	20.67	532.60	20.53
4.48	0.015019	0.89000	-0.06800	628.41	21.14	634.86	20.99
5.23	0.017506	0.91000	-0.05500	732.44	21.62	739.96	21.44
5.98	0.020026	0.93000	-0.04400	837.88	22.09	846.48	21.89
6.74	0.022579	0.94500	-0.03700	944.72	22.45	954.42	22.24
7.48	0.025066	0.95500	-0.03000	1048.76	22.68	1059.52	22.47
8.21	0.027485	0.96500	-0.02300	1149.98	22.92	1161.78	22.70
8.71	0.029165	0.97000	-0.02100	1220.27	23.04	1232.79	22.81
8.96	0.030005	0.97000	-0.02200	1255.42	23.04	1268.30	22.81
9.16	0.030677	0.97500	-0.01800	1283.53	23.16	1296.71	22.93
9.43	0.031584	0.98000	-0.01700	1321.49	23.28	1335.05	23.05
9.68	0.032424	0.98000	-0.01200	1356.64	23.28	1370.55	23.04
9.95	0.033331	0.98000	-0.01100	1394.59	23.28	1408.91	23.04
10.1	0.034138	0.98500	-0.01100	1428.33	23.40	1442.9	23.16
10.49	0.035011	0.99000	-0.00800	1464.89	23.52	1479	23.28
11.03	0.036960	1.00000	0.00000	1546.42	23.75	1562.3	23.51

CHAM 1550 RPM ROTATING DISC IDENT 44.

PROFILE NUMBER 3 X = 0.791 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.14	0.000636	0.54500	-0.09300	35.27	13.87	35.66	13.91
0.28	0.001230	0.61000	-0.10500	68.19	15.52	68.95	15.58
0.41	0.001823	0.64000	-0.11000	101.11	16.28	102.23	16.34
0.54	0.002374	0.65500	-0.11200	131.68	16.66	133.14	16.72
0.72	0.003180	0.69000	-0.11400	176.36	17.56	178.31	17.60
0.92	0.004070	0.71500	-0.11000	225.74	18.19	228.24	18.20
1.28	0.005639	0.75000	-0.10700	312.75	19.08	316.21	19.06
1.67	0.007378	0.77500	-0.10300	409.16	19.72	413.69	19.67
2.21	0.009752	0.81000	-0.09500	540.85	20.61	546.83	20.52
2.79	0.012296	0.84000	-0.08700	681.94	21.37	689.48	21.25
3.35	0.014798	0.85500	-0.08000	820.58	21.75	829.75	21.61
3.93	0.017342	0.87500	-0.07000	961.77	22.26	972.41	22.09
4.50	0.019843	0.89000	-0.06200	1100.51	22.64	1112.68	22.45
5.04	0.022218	0.90500	-0.05400	1232.19	23.03	1245.82	22.81
5.64	0.024889	0.91500	-0.04800	1380.34	23.28	1395.60	23.06
6.20	0.027348	0.93500	-0.04400	1516.72	23.79	1533.50	23.55
6.75	0.029765	0.94000	-0.03800	1650.76	23.92	1669.02	23.67
7.30	0.032224	0.94500	-0.03300	1787.15	24.04	1806.92	23.79
7.86	0.034683	0.96000	-0.02700	1923.53	24.42	1944.81	24.17
8.45	0.037270	0.96500	-0.02200	2066.98	24.55	2089.84	24.29
8.81	0.038881	0.97000	-0.01900	2156.33	24.68	2180.19	24.41
9.17	0.040450	0.97500	-0.01500	2243.34	24.81	2268.15	24.54
9.55	0.042146	0.97800	-0.01200	2337.40	24.88	2363.26	24.61
9.73	0.042951	0.98100	-0.01100	2382.08	24.96	2408.43	24.69
9.93	0.043799	0.98400	-0.00800	2429.11	25.04	2455.98	24.76
10.13	0.044690	0.98800	-0.00800	2478.49	25.14	2505.91	24.86
10.33	0.045580	0.99100	-0.00400	2527.87	25.21	2555.83	24.94
10.57	0.046640	1.00000	0.00000	2586.66	25.44	2615.27	25.16

TITLE: Bradshaw and Terrell, Flow 48

REFERENCE: Bradshaw, P. and Terrell, "The response of a turbulent boundary layer on an 'infinite' swept wing to the sudden removal of pressure gradient," NPL Aero Report 1305, Oct. 1969

DESCRIPTION: Boundary layer measurements were made on a flat plate attached to the trailing edge of an infinite swept wing (Figure 48.1). The boundary layer relaxed from a moderately skewed form to an almost two-dimensional form. The velocity direction in the boundary layer was measured with a two hole yawmeter and the velocities measured with a single hole pitot probe. The probe dimensions were not reported. Wall shear stresses were indirectly measured by allowing the pitot probe to rest on the surface and thereby act as a Preston tube. Turbulence quantities were also measured by hot wire anemometers. Only the shear stress profiles τ_x and τ_z are reported here, but other turbulence quantities are given in the reference.

EDITORS' COMMENTS: Some scatter in the integral parameters appears to be a consequence of the data having been taken at various spanwise position, the flow being slightly non-uniform in the spanwise direction.

PRESSURE GRADIENT: The external pressure was constant and the free stream velocity uniform at 129 feet/second.

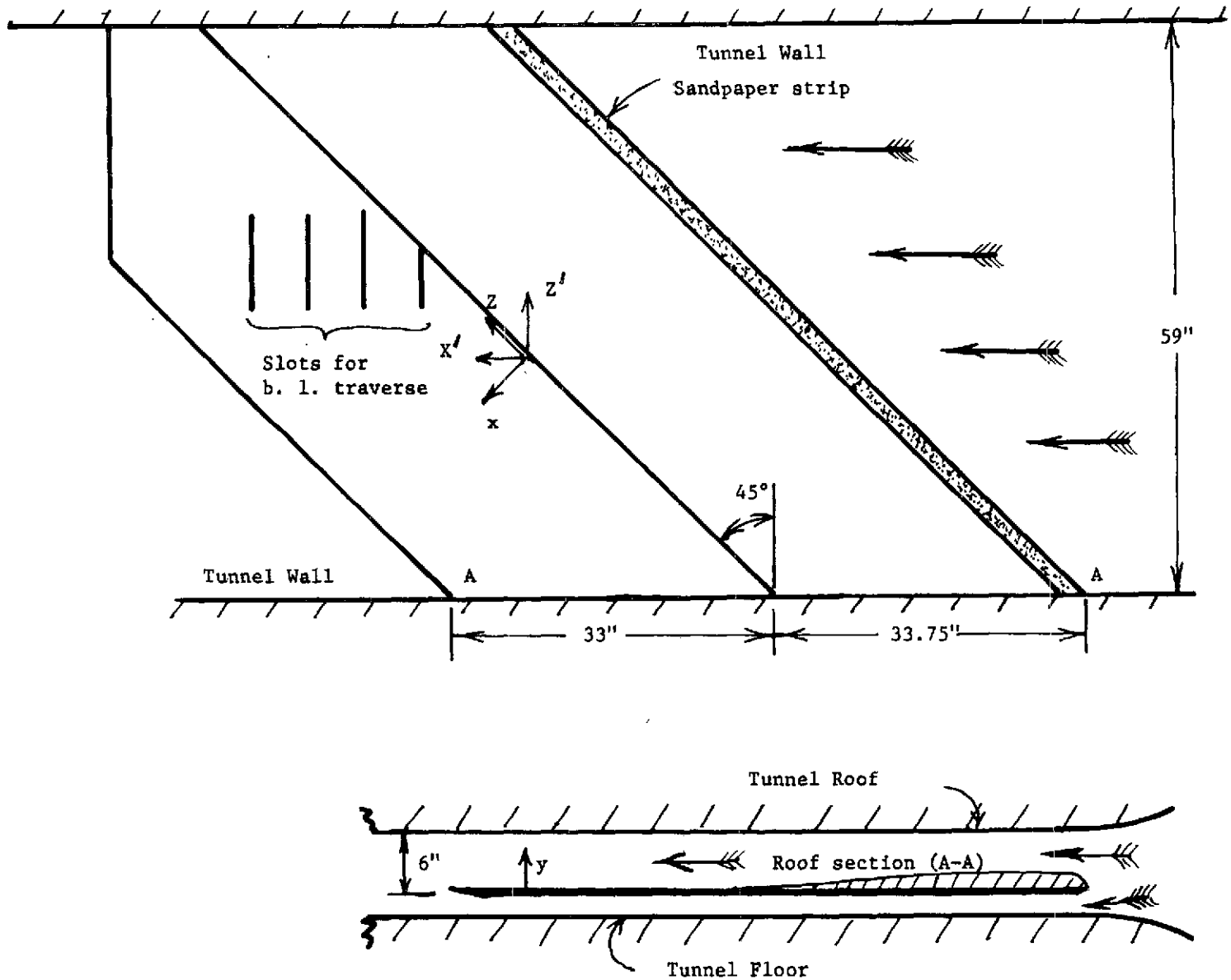


Figure 48.1 - Configuration of Bradshaw and Terrell Flow

Bradshaw and Terrell - Shear Stress Profiles IDENT = 48

Notes: x' along tunnel centerline (Fig. 48.1).
z' normal to tunnel centerline (Fig. 48.1).
$\tau_{x'}$ streamwise and $\tau_{z'}$ crossflow components since external flow streamlines very close to tunnel centerline direction.
$\tau_{x'}$ and $\tau_{z'}$ are dimensionless, normalized on ρQ_∞^2 .

y	Profile No. 1 x = 0(ft)		Profile No. 2 x = 0.059(ft)		Profile No. 3 x = 0.118(ft)	
(inches)	$\tau_{x'}$	$\tau_{z'}$	$\tau_{x'}$	$\tau_{z'}$	$\tau_{x'}$	$\tau_{z'}$
0.020	+1.436E-03	+5.715E-05	+1.326E-03	+9.524E-05	+1.363E-03	+1.179E-04
0.025	+1.459E-03	+3.972E-05	+1.397E-03	+9.319E-05	+1.394E-03	+1.103E-04
0.030	+1.471E-03	+1.963E-05	+1.408E-03	+7.890E-05	+1.405E-03	+1.059E-04
0.040	+1.515E-03	-7.660E-06	+1.440E-03	+6.127E-05	+1.426E-03	+9.278E-05
0.050	+1.547E-03	-2.631E-05	+1.473E-03	+3.827E-05	+1.447E-03	+8.420E-05
0.060	+1.578E-03	-4.145E-05	+1.505E-03	+1.989E-05	+1.469E-03	+6.990E-05
0.080	+1.651E-03	-7.355E-05	+1.559E-03	-1.686E-05	+1.522E-03	+4.797E-05
0.100	+1.724E-03	-1.016E-04	+1.622E-03	-4.877E-05	+1.574E-03	+2.548E-05
0.120	+1.795E-03	-1.252E-04	+1.685E-03	-8.334E-05	+1.626E-03	+5.615E-07
0.150	+1.887E-03	-1.586E-04	+1.778E-03	-1.351E-04	+1.688E-03	-3.778E-05
0.200	+2.017E-03	-2.014E-04	+1.921E-03	-2.031E-04	+1.812E-03	-1.013E-04
0.250	+2.146E-03	-2.463E-04	+2.062E-03	-2.652E-04	+1.934E-03	-1.678E-04
0.300	+2.174E-03	-2.961E-04	+2.100E-03	-3.060E-04	+2.005E-03	-2.346E-04
0.350	+2.119E-03	-3.263E-04	+2.046E-03	-3.202E-04	+1.994E-03	-2.706E-04
0.400	+1.993E-03	-3.488E-04	+1.941E-03	-3.350E-04	+1.939E-03	-2.942E-04
0.500	+1.714E-03	-3.334E-04	+1.662E-03	-2.803E-04	+1.742E-03	-2.774E-04
0.600	+1.406E-03	-2.656E-04	+1.336E-03	-2.666E-04	+1.495E-03	-2.129E-04
0.700	+1.022E-03	-1.900E-04	+9.619E-04	-1.907E-04	+1.112E-03	-1.536E-04
0.800	+6.301E-04	-5.355E-05	+5.901E-04	-7.895E-05	+7.102E-04	-9.322E-05
0.900	+2.200E-04	-5.257E-06	+2.600E-04	-2.054E-05	+3.099E-04	-2.569E-05
1.000	+2.001E-05	+4.954E-06	+6.000E-05	-1.731E-07	+6.000E-05	-1.255E-06

Bradshaw and Terrell - Shear Stress Profiles (Continued)

INDENT = 48

y (inches)	Profile No. 4 x = 0.235(ft) $\tau_{x'}$	Profile No. 4 x = 0.235(ft) $\tau_{z'}$	Profile No. 5 x = 0.352(ft) $\tau_{x'}$	Profile No. 5 x = 0.352(ft) $\tau_{z'}$	Profile No. 6 x = 0.589(ft) $\tau_{x'}$	Profile No. 6 x = 0.589(ft) $\tau_{z'}$
0.020	+1.413E-03	-1.108E-05	+1.391E-03	+1.071E-04	+1.451E-03	+9.813E-05
0.025	+1.411E-03	+1.141E-04	+1.401E-03	+1.060E-04	+1.461E-03	+9.413E-05
0.030	+1.422E-03	+1.115E-04	+1.411E-03	+1.035E-04	+1.472E-03	+9.190E-05
0.040	+1.442E-03	+1.079E-04	+1.422E-03	+9.967E-05	+1.482E-03	+8.478E-05
0.050	+1.463E-03	+1.028E-04	+1.432E-03	+9.662E-05	+1.503E-03	+7.686E-05
0.060	+1.473E-03	+9.558E-05	+1.443E-03	+9.125E-05	+1.513E-03	+7.122E-05
0.080	+1.514E-03	+8.232E-05	+1.473E-03	+8.449E-05	+1.535E-03	+5.348E-05
0.100	+1.545E-03	+6.690E-05	+1.494E-03	+7.400E-05	+1.567E-03	+1.754E-05
0.120	+1.576E-03	+4.932E-05	+1.525E-03	+6.324E-05	+1.587E-03	+1.812E-05
0.150	+1.618E-03	+2.236E-05	+1.566E-03	+4.621E-05	+1.638E-03	-4.951E-06
0.200	+1.617E-03	-2.839E-05	+1.607E-03	+1.365E-05	+1.720E-03	-4.320E-05
0.250	+1.703E-03	-8.365E-05	+1.638E-03	-2.311E-05	+1.751E-03	-8.522E-05
0.300	+1.725E-03	-1.518E-04	+1.660E-03	-7.771E-05	+1.762E-03	-1.204E-04
0.350	+1.729E-03	-2.569E-04	+1.671E-03	-1.376E-04	+1.752E-03	-1.508E-04
0.400	+1.717E-03	-2.882E-04	+1.661E-03	-1.849E-04	+1.732E-03	-1.808E-04
0.500	+1.633E-03	-3.068E-04	+1.570E-03	-2.440E-04	+1.650E-03	-2.185E-04
0.600	+1.408E-03	-2.942E-04	+1.385E-03	-2.134E-04	+1.498E-03	-2.353E-04
0.700	+1.034E-03	-2.423E-04	+1.092E-03	-1.698E-04	+1.265E-03	-2.027E-04
0.800	+6.615E-04	-1.819E-04	+7.406E-04	-1.152E-04	+9.620E-04	-1.406E-04
0.900	+3.603E-04	-1.140E-04	+4.200E-04	-5.788E-05	+6.407E-04	-8.320E-05
1.000	+1.401E-04	-4.383E-05	+1.800E-04	+5.760E-06	+3.401E-04	-3.367E-05
1.100	+4.995E-05	+3.008E-05	+5.000E-05	-3.412E-08	+1.100E-04	-4.775E-06
1.200	+1.996E-05	+2.004E-05	+2.000E-05	-6.167E-09		
1.300	+9.983E-06	+1.002E-05	+1.000E-05	-3.083E-09		

Bradshaw and Terrell - Shear Stress Profiles (Continued)

IDENT = 48

y (inches)	Profile No. 7 x = 0.707(ft) $\tau_{x'}$	$\tau_{z'}$	Profile No. 8 x = 0.820(ft) $\tau_{x'}$	$\tau_{z'}$	Profile No. 9 x = 0.940(ft) $\tau_{x'}$	$\tau_{z'}$
0.020	+1.431E-03	+8.534E-05	+1.511E-03	+7.592E-05	+1.451E-03	+6.990E-05
0.025	+1.442E-03	+8.231E-05	+1.511E-03	+7.292E-05	+1.451E-03	+6.690E-05
0.030	+1.452E-03	+7.652E-05	+1.511E-03	+7.092E-05	+1.461E-03	+6.546E-05
0.040	+1.463E-03	+6.863E-05	+1.511E-03	+6.592E-09	+1.461E-03	+6.046E-05
0.050	+1.463E-03	+5.930E-05	+1.522E-03	+6.051E-05	+1.472E-03	+5.514E-05
0.060	+1.474E-03	+5.079E-05	+1.522E-03	+5.651E-05	+1.472E-03	+5.070E-05
0.080	+1.495E-03	+3.336E-05	+1.533E-03	+4.609E-05	+1.482E-03	+3.974E-05
0.100	+1.516E-03	+1.701E-05	+1.533E-03	+3.520E-05	+1.483E-03	+2.797E-05
0.120	+1.527E-03	-2.381E-06	+1.544E-03	+2.444E-05	+1.494E-03	+1.678E-05
0.150	+1.559E-03	-3.462E-05	+1.555E-03	+7.364E-06	+1.504E-03	-1.317E-06
0.200	+1.611E-03	-8.090E-05	+1.586E-03	-2.035E-05	+1.516E-03	-3.041E-05
0.250	+1.652E-03	-1.206E-04	+1.607E-03	-5.221E-05	+1.547E-03	-6.054E-05
0.300	+1.693E-03	-1.510E-04	+1.628E-03	-8.674E-05	+1.558E-03	-9.357E-05
0.350	+1.723E-03	-1.785E-04	+1.639E-03	-1.173E-04	+1.588E-03	-1.219E-04
0.400	+1.732E-03	-2.150E-04	+1.639E-03	-1.474E-04	+1.588E-03	-1.508E-04
0.500	+1.660E-03	-2.427E-04	+1.608E-03	-1.979E-04	+1.538E-03	-1.885E-04
0.600	+1.518E-03	-2.643E-04	+1.466E-03	-2.154E-04	+1.406E-03	-2.066E-04
0.700	+1.335E-03	-2.466E-04	+1.244E-03	-1.990E-04	+1.224E-03	-1.882E-04
0.800	+1.092E-03	-1.960E-04	+9.915E-04	-1.483E-04	+9.918E-04	-1.499E-04
0.900	+8.106E-04	-1.314E-04	+7.204E-04	-7.946E-05	+7.506E-04	-8.855E-05
1.000	+5.100E-04	-6.562E-05	+4.500E-04	-9.967E-06	+5.001E-04	-2.989E-05
1.100	+2.100E-04	-1.821E-05	+2.200E-04	+2.315E-05	+2.500E-04	+1.398E-05
1.200	+5.998E-05	-8.117E-06	+8.001E-05	+2.097E-05	+9.005E-05	+3.789E-05
1.300			+4.002E-05	+1.595E-05	+2.004E-05	+3.798E-05
1.400			+4.003E-05	+1.593E-05	+1.831E-08	+3.600E-05
1.500			+4.004E-05	+1.992E-05	+5.747E-09	+3.600E-05

y (inches)	Profile No. 10 x = 1.060(ft) $\tau_{x'}$	Profile No. 10 x = 1.060(ft) $\tau_{z'}$	Profile No. 11 x = 1.180(ft) $\tau_{x'}$	Profile No. 11 x = 1.180(ft) $\tau_{z'}$
0.020	+1.421E-03	+7.210E-05	+1.441E-03	+7.108E-05
0.025	+1.421E-03	+6.811E-05	+1.441E-03	+6.908E-05
0.030	+1.431E-03	+6.551E-05	+1.441E-03	+6.719E-05
0.040	+1.432E-03	+5.819E-05	+1.451E-03	+6.231E-05
0.050	+1.432E-03	+5.169E-05	+1.451E-03	+5.669E-05
0.060	+1.442E-03	+4.552E-05	+1.452E-03	+5.126E-05
0.080	+1.453E-03	+3.327E-05	+1.462E-03	+4.302E-05
0.100	+1.454E-03	+1.901E-05	+1.463E-03	+3.259E-05
0.120	+1.464E-03	+5.080E-06	+1.473E-03	+2.362E-05
0.150	+1.475E-03	-1.582E-05	+1.484E-03	+8.497E-06
0.200	+1.487E-03	-5.238E-05	+1.495E-03	-1.604E-05
0.250	+1.498E-03	-8.851E-05	+1.526E-03	-4.222E-05
0.300	+1.509E-03	-1.223E-04	+1.547E-03	-7.000E-05
0.350	+1.509E-03	-1.511E-04	+1.558E-03	-9.811E-05
0.400	+1.499E-03	-1.773E-04	+1.558E-03	-1.309E-04
0.500	+1.479E-03	-2.105E-04	+1.549E-03	-1.804E-04
0.600	+1.397E-03	-2.221E-04	+1.488E-03	-2.114E-04
0.700	+1.265E-03	-2.167E-04	+1.365E-03	-2.097E-04
0.800	+1.093E-03	-1.852E-04	+1.203E-03	-1.842E-04
0.900	+8.813E-04	-1.457E-04	+1.002E-03	-1.488E-04
1.000	+6.503E-04	-9.775E-05	+7.806E-04	-1.035E-04
1.100	+4.100E-04	-5.262E-05	+5.302E-04	-5.654E-05
1.200	+2.000E-04	-1,596E-05	+3.200E-04	-3.616E-06
1.300	+7.000E-05	+9.998E-06	+1.600E-04	+2.714E-05
1.400	+1.001E-05	+2.000E-05	+1.200E-04	+3.504E-05
1.500	+4.065E-09	+2.000E-05	+1.200E-04	+3.498E-05

BRADSHAW AND TERRELL

IDENT =48. KIN. VISC= 0.0001560

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THET11 (FT)
0.00000	7912.9	1.458	0.002380	0.002277	0.002423	7.61	10.81	0.013955	0.009569
0.05890	7694.9	1.440	0.002488	0.002362	0.002510	6.47	7.58	0.013398	0.009305
0.11800	7906.4	1.438	0.002477	0.002351	0.002499	6.47	7.59	0.013750	0.009561
0.23500	7649.8	1.402	0.002655	0.002508	0.002655	5.23	0.00	0.012972	0.009251
0.35200	7985.5	1.402	0.002621	0.002480	0.002632	4.89	5.30	0.013541	0.009657
0.58900	8043.2	1.376	0.002700	0.002577	0.002712	4.18	5.26	0.013387	0.009727
0.70700	8438.3	1.380	0.002632	0.002529	0.002644	4.34	5.29	0.014085	0.010204
0.82000	7622.0	1.365	0.002815	0.002662	0.002827	3.45	5.20	0.012579	0.009217
0.94000	8082.8	1.357	0.002792	0.002652	0.002792	3.24	0.00	0.013266	0.009775
1.06000	8835.6	1.371	0.002666	0.002533	0.002666	3.44	0.00	0.014651	0.010685
1.18000	9050.2	1.358	0.002689	0.002570	0.002689	3.19	0.00	0.014861	0.010944

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.003152	0.000172	0.002369	0.000783	0.000	0.000	0.000	0.000	129.00	44.7
0.05890	0.002794	0.000142	0.002112	0.000682	-0.144	0.028	0.023	0.036	129.00	44.8
0.11800	0.002832	0.000147	0.002129	0.000704	-0.046	0.058	0.092	0.073	129.00	44.7
0.23500	0.002453	0.000101	0.001908	0.000546	-0.209	0.119	0.104	0.147	129.00	45.0
0.35200	0.002371	0.000097	0.001825	0.000546	-0.086	0.182	0.256	0.222	129.00	44.9
0.58900	0.002121	0.000080	0.001644	0.000477	-0.152	0.312	0.356	0.375	129.00	45.2
0.70700	0.002551	0.000094	0.002019	0.000532	0.177	0.378	0.370	0.451	129.00	44.8
0.82000	0.002317	0.000077	0.001889	0.000429	-0.161	0.442	0.127	0.525	129.00	44.9
0.94000	0.002057	0.000064	0.001650	0.000408	-0.068	0.513	0.384	0.605	129.00	45.0
1.06000	0.002099	0.000062	0.001664	0.000435	0.218	0.583	0.660	0.683	129.00	45.0
1.18000	0.002301	0.000070	0.001847	0.000454	0.350	0.651	0.681	0.759	129.00	45.0

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 1 X = 0.000 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.17	0.001667	0.48735	0.06514	47.54	14.13	47.97	14.13
0.22	0.002083	0.50794	0.06790	59.43	14.72	59.96	14.72
0.26	0.002500	0.53113	0.07048	71.31	15.40	71.95	15.39
0.35	0.003333	0.55322	0.07253	95.08	16.04	95.94	16.03
0.44	0.004166	0.57091	0.07395	118.85	16.55	119.92	16.54
0.52	0.005000	0.58561	0.07438	142.62	16.98	143.90	16.96
0.70	0.006666	0.61460	0.07594	190.16	17.82	191.87	17.79
0.87	0.008333	0.63500	0.07610	237.70	18.41	239.84	18.37
1.05	0.010000	0.65050	0.07549	285.24	18.86	287.81	18.81
1.31	0.012499	0.67361	0.07394	356.56	19.53	359.76	19.47
1.74	0.016666	0.70632	0.07106	475.41	20.48	479.68	20.40
2.18	0.020832	0.73705	0.06638	594.26	21.37	599.60	21.26
2.61	0.024999	0.76468	0.06084	713.11	22.17	719.52	22.04
3.05	0.029165	0.79171	0.05488	831.96	22.95	839.44	22.80
3.48	0.033332	0.81675	0.04630	950.82	23.68	959.36	23.50
4.35	0.041665	0.86481	0.03590	1188.52	25.07	1199.20	24.87
5.23	0.049998	0.91147	0.02397	1426.22	26.42	1439.04	26.20
6.10	0.058331	0.94992	0.01435	1663.93	27.54	1678.88	27.30
6.97	0.066664	0.97976	0.00745	1901.63	28.40	1918.73	28.15
7.84	0.074997	0.99498	0.00411	2139.34	28.84	2158.57	28.59
8.71	0.083330	0.99888	0.00301	2377.04	28.96	2398.41	28.70
9.58	0.091663	0.99999	0.00266	2614.75	28.99	2638.25	28.73
10.45	0.099996	0.99999	0.00201	2852.45	28.99	2878.09	28.73
11.32	0.108329	0.99999	0.00156	3090.15	28.99	3117.93	28.73
12.19	0.116662	0.99999	0.00105	3327.86	28.99	3357.77	28.73
13.06	0.124995	1.00000	-0.00000	3565.56	28.99	3597.61	28.73

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 2 X = 0.059 FT

Y/THIL	Y (FT)	LS/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.18	0.001667	0.50991	0.05783	48.61	14.46	48.82	14.49
0.22	0.002083	0.53150	0.06037	60.76	15.07	61.03	15.10
0.27	0.002500	0.54549	0.06180	72.91	15.47	73.23	15.50
0.36	0.003333	0.57348	0.06461	97.22	16.26	97.65	16.29
0.45	0.004166	0.58738	0.06566	121.52	16.65	122.06	16.68
0.54	0.005000	0.60178	0.06661	145.83	17.06	146.47	17.09
0.72	0.006666	0.63177	0.06906	194.44	17.91	195.29	17.94
0.90	0.008333	0.64667	0.06937	243.05	18.33	244.11	18.36
1.07	0.010000	0.66477	0.06899	291.65	18.85	292.94	18.87
1.34	0.012499	0.68278	0.06663	364.57	19.36	366.17	19.36
1.79	0.016666	0.71819	0.06392	486.09	20.36	488.23	20.35
2.24	0.020832	0.74620	0.05942	607.61	21.16	610.28	21.13
2.69	0.024999	0.77382	0.05456	729.14	21.94	732.34	21.90
3.13	0.029165	0.80083	0.05019	850.66	22.71	854.40	22.65
3.58	0.033332	0.82585	0.04361	972.18	23.41	976.46	23.34
4.48	0.041665	0.87248	0.03449	1215.23	24.74	1220.57	24.65
5.37	0.049998	0.91652	0.02263	1458.27	25.99	1464.68	25.88
6.27	0.058331	0.95296	0.01243	1701.32	27.02	1708.80	26.90
7.16	0.066664	0.98078	0.00502	1944.37	27.81	1952.91	27.69
8.06	0.074997	0.99430	0.00127	2187.41	28.19	2197.03	28.07
8.96	0.083330	0.99900	0.00046	2430.46	28.32	2441.14	28.20
9.85	0.091663	1.00000	0.00083	2673.50	28.35	2685.26	28.23
10.75	0.099996	1.00000	0.00083	2916.55	28.35	2929.37	28.23
11.64	0.108329	1.00000	0.00090	3159.59	28.35	3173.48	28.23
12.54	0.116662	1.00000	0.00070	3402.64	28.35	3417.59	28.23
13.43	0.124995	1.00000	0.00000	3645.69	28.35	3661.71	28.23

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 3 X = 0.118 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.17	0.001667	0.51213	0.05812	48.50	14.55	48.72	14.58
0.22	0.002083	0.52602	0.05938	60.63	14.95	60.89	14.98
0.26	0.002500	0.54122	0.06091	72.75	15.38	73.07	15.41
0.35	0.003333	0.56800	0.06380	97.00	16.14	97.43	16.17
0.44	0.004166	0.58869	0.06582	121.26	16.73	121.79	16.76
0.52	0.005000	0.60569	0.06713	145.51	17.21	146.15	17.24
0.70	0.006666	0.63168	0.06907	194.01	17.95	194.86	17.98
0.87	0.008333	0.64877	0.06980	242.51	18.43	243.58	18.46
1.05	0.010000	0.66208	0.06915	291.01	18.81	292.30	18.83
1.31	0.012499	0.68169	0.06738	363.77	19.37	365.37	19.38
1.74	0.016666	0.71470	0.06471	485.02	20.31	487.16	20.30
2.18	0.020832	0.74172	0.06065	606.28	21.08	608.95	21.05
2.61	0.024999	0.76724	0.05606	727.53	21.80	730.74	21.76
3.05	0.029165	0.79476	0.05191	848.79	22.58	852.53	22.53
3.49	0.033332	0.81879	0.04469	970.05	23.27	974.32	23.20
4.36	0.041665	0.86483	0.03535	1212.56	24.57	1217.90	24.49
5.23	0.049998	0.90809	0.02381	1455.07	25.80	1461.48	25.70
6.10	0.058331	0.94793	0.01418	1697.58	26.93	1705.06	26.82
6.97	0.066664	0.97677	0.00701	1940.09	27.75	1948.64	27.63
7.84	0.074997	0.99399	0.00242	2182.60	28.24	2192.22	28.12
8.72	0.083330	0.99880	0.00042	2425.12	28.38	2435.80	28.26
9.59	0.091663	1.00000	-0.00040	2667.63	28.41	2679.38	28.29
10.46	0.099996	1.00000	-0.00060	2910.14	28.41	2922.96	28.29
11.33	0.108329	1.00000	-0.00098	3152.65	28.41	3166.54	28.29
12.20	0.116662	1.00000	-0.00070	3395.16	28.41	3410.12	28.29
13.07	0.124995	1.00000	-0.00000	3637.67	28.41	3653.70	28.29

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 4 X = 0.235 FT

Y/THIC	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.18	0.001667	0.54703	0.05005	50.21	15.01	50.21	15.08
0.23	0.002083	0.56093	0.05143	62.76	15.40	62.76	15.46
0.27	0.002500	0.57363	0.05239	75.32	15.74	75.32	15.81
0.36	0.003333	0.59713	0.05437	100.42	16.39	100.42	16.46
0.45	0.004166	0.61513	0.05559	125.53	16.88	125.53	16.95
0.54	0.005000	0.62763	0.05581	150.63	17.23	150.63	17.29
0.72	0.006666	0.65003	0.05615	200.85	17.84	200.85	17.91
0.90	0.008333	0.67303	0.05638	251.06	18.47	251.06	18.54
1.08	0.010000	0.68623	0.05569	301.27	18.83	301.27	18.90
1.35	0.012499	0.70803	0.05472	376.59	19.43	376.59	19.49
1.80	0.016666	0.73643	0.05264	502.12	20.21	502.12	20.26
2.25	0.020832	0.76153	0.04928	627.65	20.90	627.65	20.95
2.70	0.024999	0.78603	0.04584	753.17	21.57	753.17	21.61
3.15	0.029165	0.80822	0.04261	878.70	22.18	878.70	22.21
3.60	0.033332	0.83052	0.03754	1004.23	22.80	1004.23	22.82
4.50	0.041665	0.87602	0.03096	1255.29	24.04	1255.29	24.06
5.40	0.049998	0.91061	0.02210	1506.35	24.99	1506.35	25.00
6.31	0.058331	0.94631	0.01388	1757.41	25.97	1757.41	25.98
7.21	0.066664	0.97490	0.00701	2008.47	26.76	2008.47	26.76
8.11	0.074997	0.99100	0.00214	2259.52	27.20	2259.52	27.20
9.01	0.083330	0.99790	0.00066	2510.58	27.39	2510.58	27.39
9.91	0.091663	0.99900	0.00106	2761.64	27.42	2761.64	27.42
10.81	0.099996	1.00000	0.00158	3012.70	27.45	3012.70	27.45
11.71	0.108329	1.00000	0.00109	3263.76	27.45	3263.76	27.45
12.61	0.116662	1.00000	0.00052	3514.81	27.45	3514.81	27.45
13.51	0.124995	1.00000	0.00000	3765.87	27.45	3765.87	27.45

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 5 X = 0.352 FT

Y/THI1	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.17	0.001667	0.53134	0.04543	49.89	14.68	50.00	14.70
0.22	0.002083	0.54844	0.04688	62.36	15.15	62.50	15.17
0.26	0.002500	0.56594	0.04839	74.84	15.63	75.00	15.66
0.35	0.003333	0.58794	0.05026	99.78	16.24	100.00	16.27
0.43	0.004166	0.60694	0.05194	124.73	16.77	124.99	16.79
0.52	0.005000	0.62494	0.05338	149.67	17.26	149.99	17.29
0.69	0.006666	0.64473	0.05451	199.56	17.81	199.99	17.83
0.86	0.008333	0.66643	0.05539	249.46	18.41	249.99	18.43
1.04	0.010000	0.68113	0.05517	299.35	18.82	299.99	18.84
1.29	0.012499	0.70433	0.05468	374.18	19.46	374.98	19.47
1.73	0.016666	0.73094	0.05282	498.91	20.19	499.98	20.20
2.16	0.020832	0.75794	0.04970	623.64	20.94	624.97	20.94
2.59	0.024999	0.78144	0.04561	748.37	21.59	749.97	21.58
3.02	0.029165	0.80465	0.04189	873.09	22.23	874.96	22.21
3.45	0.033332	0.82496	0.03654	997.82	22.79	999.96	22.76
4.31	0.041665	0.86756	0.02995	1247.28	23.96	1249.95	23.93
5.18	0.049998	0.90187	0.02108	1496.73	24.91	1499.94	24.87
6.04	0.058331	0.93698	0.01333	1746.19	25.88	1749.93	25.83
6.90	0.066664	0.96549	0.00619	1995.65	26.67	1999.92	26.61
7.77	0.074997	0.98550	0.00148	2245.10	27.22	2249.91	27.16
8.63	0.083330	0.99560	-0.00012	2494.56	27.50	2499.90	27.44
9.49	0.091663	0.99900	0.00053	2744.01	27.60	2749.89	27.54
10.35	0.099996	0.99900	0.00090	2993.47	27.60	2999.88	27.54
11.22	0.108329	1.00000	0.00090	3242.92	27.62	3249.87	27.56
12.08	0.116662	1.00000	0.00070	3492.38	27.62	3499.86	27.56
12.94	0.124995	1.00000	0.00000	3741.84	27.62	3749.85	27.56

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 6 X = 0.589 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.17	0.001667	0.56715	0.04150	50.64	15.44	50.75	15.44
0.21	0.002083	0.58215	0.04259	63.30	15.84	63.43	15.85
0.26	0.002500	0.59516	0.04354	75.96	16.20	76.12	16.21
0.34	0.003333	0.61316	0.04490	101.28	16.69	101.49	16.70
0.43	0.004166	0.62817	0.04582	126.60	17.10	126.86	17.11
0.51	0.005000	0.63907	0.04644	151.92	17.39	152.24	17.40
0.69	0.006666	0.66027	0.04744	202.56	17.97	202.98	17.98
0.86	0.008333	0.67827	0.04820	253.19	18.46	253.73	18.47
1.03	0.010000	0.69467	0.04808	303.83	18.91	304.47	18.91
1.29	0.012499	0.71217	0.04724	379.79	19.38	380.59	19.38
1.71	0.016666	0.74217	0.04582	506.39	20.20	507.46	20.19
2.14	0.020832	0.76516	0.04330	632.99	20.82	634.32	20.81
2.57	0.024999	0.78655	0.04057	759.58	21.41	761.19	21.39
3.00	0.029165	0.80674	0.03797	886.18	21.96	888.05	21.93
3.43	0.033332	0.82712	0.03410	1012.78	22.51	1014.92	22.48
4.28	0.041665	0.86650	0.02881	1265.97	23.58	1268.65	23.55
5.14	0.049998	0.90278	0.02201	1519.17	24.57	1522.37	24.53
6.00	0.058331	0.93456	0.01538	1772.36	25.43	1776.10	25.38
6.85	0.066664	0.95703	0.00884	2025.56	26.05	2029.83	25.99
7.71	0.074997	0.97831	0.00380	2278.75	26.63	2283.56	26.57
8.57	0.083330	0.99200	0.00029	2531.95	27.00	2537.29	26.94
9.42	0.091663	0.99789	-0.00157	2785.14	27.16	2791.02	27.10
10.28	0.099996	0.99899	-0.00312	3038.34	27.19	3044.75	27.13
11.14	0.108329	0.99999	-0.00317	3291.53	27.22	3298.48	27.16
11.99	0.116662	0.99999	-0.00227	3544.73	27.22	3552.21	27.16
12.85	0.124995	1.00000	-0.00000	3797.92	27.22	3805.94	27.16

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 7 X = 0.707 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.16	0.001667	0.55784	0.04236	50.00	15.38	50.10	15.39
0.20	0.002083	0.57084	0.04345	62.50	15.73	62.63	15.75
0.24	0.002500	0.58584	0.04439	75.00	16.15	75.16	16.16
0.33	0.003333	0.60383	0.04549	100.00	16.64	100.21	16.66
0.41	0.004166	0.61983	0.04656	124.99	17.09	125.26	17.10
0.49	0.005000	0.63283	0.04744	149.99	17.44	150.31	17.46
0.65	0.006666	0.65282	0.04857	199.99	17.99	200.42	18.01
0.82	0.008333	0.67132	0.04916	249.99	18.50	250.52	18.51
0.98	0.010000	0.68642	0.04932	299.99	18.92	300.63	18.93
1.22	0.012499	0.70422	0.04911	374.98	19.41	375.79	19.42
1.63	0.016666	0.73282	0.04854	499.98	20.20	501.05	20.20
2.04	0.020832	0.75753	0.04637	624.97	20.88	626.31	20.88
2.45	0.024999	0.77904	0.04367	749.97	21.47	751.57	21.46
2.86	0.029165	0.79945	0.04151	874.96	22.04	876.83	22.02
3.27	0.033332	0.81786	0.03773	999.96	22.54	1002.10	22.52
4.08	0.041665	0.85748	0.03293	1249.95	23.64	1252.62	23.60
4.90	0.049998	0.89190	0.02611	1499.94	24.58	1503.14	24.54
5.72	0.058331	0.92363	0.01966	1749.93	25.46	1753.67	25.41
6.53	0.066664	0.95395	0.01315	1999.92	26.29	2004.19	26.24
7.35	0.074997	0.97077	0.00788	2249.91	26.76	2254.72	26.70
8.17	0.083330	0.98798	0.00435	2499.90	27.23	2505.24	27.18
8.98	0.091663	0.99579	0.00265	2749.89	27.45	2755.77	27.39
9.80	0.099996	0.99899	0.00171	2999.88	27.54	3006.29	27.48
10.62	0.108329	1.00000	0.00084	3249.87	27.56	3256.81	27.51
11.43	0.116662	1.00000	0.00017	3499.86	27.56	3507.33	27.51
12.25	0.124995	1.00000	0.00000	3749.85	27.56	3757.86	27.51

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 8 X = 0.820 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.18	0.001667	0.56263	0.03391	51.71	15.00	51.81	14.99
0.23	0.002083	0.58233	0.03510	64.63	15.52	64.77	15.52
0.27	0.002500	0.60183	0.03628	77.56	16.04	77.72	16.04
0.36	0.003333	0.62022	0.03738	103.41	16.53	103.63	16.53
0.45	0.004166	0.64082	0.03862	129.27	17.08	129.54	17.08
0.54	0.005000	0.65392	0.03941	155.12	17.43	155.44	17.42
0.72	0.006666	0.67892	0.04092	206.83	18.10	207.26	18.09
0.90	0.008333	0.69721	0.04207	258.54	18.58	259.07	18.58
1.08	0.010000	0.71081	0.04274	310.24	18.95	310.88	18.94
1.36	0.012499	0.73201	0.04370	387.80	19.51	388.61	19.50
1.81	0.016666	0.75601	0.04396	517.07	20.15	518.14	20.14
2.26	0.020832	0.78001	0.04293	646.34	20.79	647.68	20.78
2.71	0.024999	0.80192	0.04087	775.61	21.37	777.21	21.36
3.16	0.029165	0.82112	0.03880	904.88	21.89	906.75	21.86
3.62	0.033332	0.84103	0.03556	1034.15	22.42	1036.28	22.39
4.52	0.041665	0.87594	0.03088	1292.68	23.35	1295.35	23.31
5.42	0.049998	0.91065	0.02467	1551.22	24.27	1554.42	24.23
6.33	0.058331	0.94096	0.01783	1809.76	25.08	1813.49	25.03
7.23	0.066664	0.96688	0.01145	2068.29	25.77	2072.57	25.72
8.14	0.074997	0.97899	0.00681	2326.83	26.09	2331.64	26.04
9.04	0.083330	0.99189	0.00430	2585.37	26.44	2590.71	26.38
9.94	0.091663	0.99789	0.00273	2843.90	26.60	2849.78	26.54
10.85	0.099996	0.99890	0.00171	3102.44	26.62	3108.85	26.57
11.75	0.108329	1.00000	0.00084	3360.97	26.65	3367.92	26.60
12.66	0.116662	1.00000	0.00017	3619.51	26.65	3626.99	26.60
13.56	0.124995	1.00000	0.00000	3878.05	26.65	3886.06	26.60

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 9 X = 0.940 FT

Y/THI1	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.17	0.001667	0.57399	0.03251	51.49	15.36	51.49	15.39
0.21	0.002083	0.58849	0.03333	64.37	15.75	64.37	15.78
0.26	0.002500	0.59919	0.03394	77.24	16.04	77.24	16.06
0.34	0.003333	0.61699	0.03495	102.99	16.51	102.99	16.54
0.43	0.004166	0.63629	0.03608	128.73	17.03	128.73	17.06
0.51	0.005000	0.65259	0.03681	154.48	17.47	154.48	17.49
0.68	0.006666	0.67599	0.03790	205.97	18.09	205.97	18.12
0.85	0.008333	0.69299	0.03849	257.47	18.55	257.47	18.58
1.02	0.010000	0.70959	0.03906	308.96	18.99	308.96	19.02
1.28	0.012499	0.72579	0.03916	386.20	19.42	386.20	19.45
1.71	0.016666	0.75399	0.03936	514.94	20.18	514.94	20.21
2.13	0.020832	0.77609	0.03865	643.67	20.77	643.67	20.80
2.56	0.024999	0.79559	0.03731	772.40	21.29	772.40	21.32
2.98	0.029165	0.81259	0.03570	901.14	21.75	901.14	21.77
3.41	0.033332	0.83099	0.03285	1029.87	22.24	1029.87	22.26
4.26	0.041665	0.86670	0.02873	1287.34	23.20	1287.34	23.21
5.12	0.049998	0.89840	0.02286	1544.81	24.04	1544.81	24.05
5.97	0.058331	0.92700	0.01670	1802.28	24.81	1802.28	24.81
6.82	0.066664	0.96160	0.01097	2059.75	25.74	2059.75	25.74
7.67	0.074997	0.97000	0.00591	2317.21	25.96	2317.21	25.96
8.53	0.083330	0.98590	0.00235	2574.68	26.39	2574.68	26.39
9.38	0.091663	0.99460	0.00006	2832.15	26.62	2832.15	26.62
10.23	0.099996	0.99800	-0.00103	3089.62	26.71	3089.62	26.71
11.08	0.108329	0.99900	-0.00081	3347.09	26.74	3347.09	26.74
11.94	0.116662	1.00000	-0.00035	3604.55	26.76	3604.55	26.76
12.79	0.124995	1.00000	0.00000	3862.02	26.76	3862.02	26.76

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 10 X = 1.060 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.16	0.001667	0.53399	0.03211	50.32	14.63	50.32	14.65
0.19	0.002083	0.55699	0.03310	62.90	15.26	62.90	15.28
0.23	0.002500	0.56799	0.03369	75.48	15.56	75.48	15.58
0.31	0.003333	0.59899	0.03539	100.64	16.41	100.64	16.43
0.39	0.004166	0.61399	0.03606	125.80	16.82	125.80	16.85
0.47	0.005000	0.63159	0.03676	150.96	17.30	150.96	17.33
0.62	0.006666	0.65579	0.03779	201.27	17.96	201.27	17.99
0.78	0.008333	0.67439	0.03828	251.59	18.47	251.59	18.50
0.94	0.010000	0.69119	0.03853	301.91	18.93	301.91	18.96
1.17	0.012499	0.71099	0.03844	377.39	19.47	377.39	19.50
1.56	0.016666	0.73709	0.03781	503.18	20.19	503.18	20.21
1.95	0.020832	0.75759	0.03650	628.98	20.75	628.98	20.77
2.34	0.024999	0.77899	0.03532	754.78	21.34	754.78	21.36
2.73	0.029165	0.80019	0.03424	880.57	21.92	880.57	21.94
3.12	0.033332	0.81669	0.03180	1006.37	22.37	1006.37	22.38
3.90	0.041665	0.85129	0.02826	1257.96	23.32	1257.96	23.33
4.68	0.049998	0.88270	0.02301	1509.55	24.18	1509.55	24.18
5.46	0.058331	0.91370	0.01778	1761.15	25.02	1761.15	25.03
6.24	0.066664	0.93900	0.01293	2012.74	25.72	2012.74	25.72
7.02	0.074997	0.95980	0.00812	2264.33	26.29	2264.33	26.29
7.80	0.083330	0.97900	0.00360	2515.92	26.81	2515.92	26.81
8.58	0.091663	0.99090	0.00112	2767.52	27.14	2767.52	27.14
9.36	0.099996	0.99690	0.00038	3019.11	27.30	3019.11	27.30
10.14	0.108329	0.99890	0.00018	3270.70	27.36	3270.70	27.36
10.92	0.116662	1.00000	-0.00017	3522.29	27.39	3522.29	27.39
11.70	0.124995	1.00000	0.00000	3773.89	27.39	3773.89	27.39

BRADSHAW AND TERRELL IDENT 48.

PROFILE NUMBER 11 X = 1.180 FT

Y/TH11	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.15	0.001667	0.55799	0.03112	50.53	15.22	50.53	15.24
0.19	0.002083	0.57699	0.03218	63.17	15.74	63.17	15.76
0.23	0.002500	0.58699	0.03278	75.80	16.01	75.80	16.03
0.30	0.003333	0.60999	0.03388	101.06	16.64	101.06	16.66
0.38	0.004166	0.62339	0.03436	126.33	17.00	126.33	17.03
0.46	0.005000	0.63849	0.03500	151.60	17.41	151.60	17.44
0.61	0.006666	0.66409	0.03651	202.13	18.11	202.13	18.14
0.76	0.008333	0.67839	0.03709	252.66	18.50	252.66	18.53
0.91	0.010000	0.69639	0.03783	303.19	18.99	303.19	19.02
1.14	0.012499	0.71139	0.03832	378.99	19.40	378.99	19.43
1.52	0.016666	0.73699	0.03917	505.32	20.10	505.32	20.13
1.90	0.020832	0.75999	0.03901	631.65	20.73	631.65	20.75
2.28	0.024999	0.77839	0.03803	757.98	21.23	757.98	21.25
2.66	0.029165	0.79759	0.03713	884.31	21.75	884.31	21.78
3.05	0.033332	0.81499	0.03488	1010.64	22.23	1010.64	22.25
3.81	0.041665	0.84799	0.03133	1263.30	23.13	1263.30	23.14
4.57	0.049998	0.88100	0.02606	1515.96	24.03	1515.96	24.04
5.33	0.058331	0.90820	0.02039	1768.62	24.77	1768.62	24.78
6.09	0.066664	0.93450	0.01481	2021.29	25.49	2021.29	25.49
6.85	0.074997	0.95340	0.00983	2273.95	26.00	2273.95	26.00
7.61	0.083330	0.97280	0.00571	2526.61	26.53	2526.61	26.53
8.38	0.091663	0.98680	0.00287	2779.27	26.91	2779.27	26.91
9.14	0.099996	0.99490	0.00135	3031.93	27.13	3031.93	27.13
9.90	0.108329	0.99800	0.00101	3284.59	27.22	3284.59	27.22
10.66	0.116662	0.99900	0.00052	3537.25	27.25	3537.25	27.25
11.42	0.124995	1.00000	0.00000	3789.91	27.27	3789.91	27.27

TITLE: East and Hoxey Plane of Symmetry, Flow 50

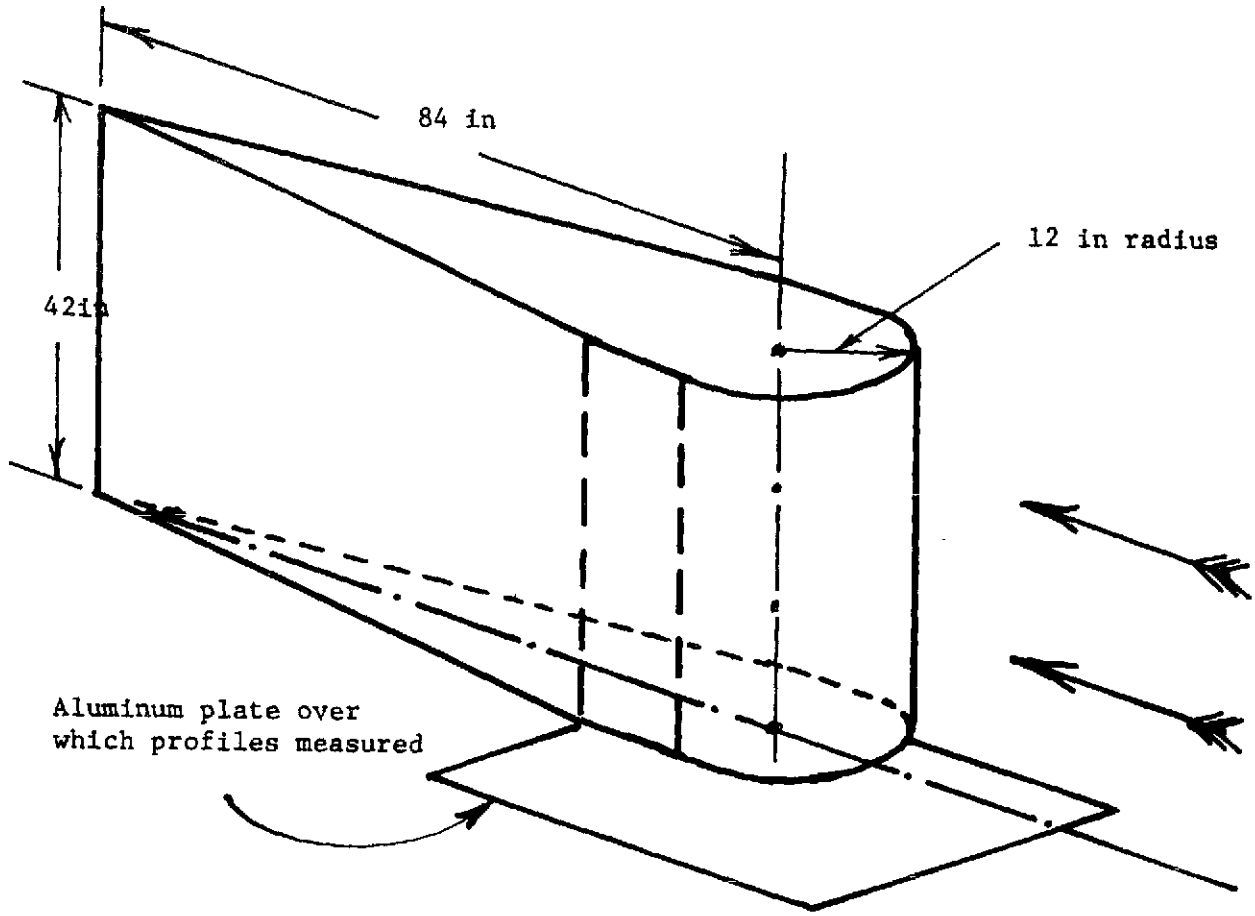
REFERENCE: East, L., and Hoxey, R. "Low-speed three-dimensional turbulent layer data," Royal Aircraft Establishment Technical Report 69041, March 1969.

DESCRIPTION: The three-dimensional turbulent boundary layer development was measured in the vicinity of a wing body junction (Figure 50.1). Measurements were made on the flat surface (body) at many points both on and off the plane of symmetry. Velocity direction and magnitude were measured with a three hole probe constructed from three pieces of 0.020 inch OD tubing. Some static pressure profiles were measured. Indirect measurements of the wall shear stress were made using a Preston tube (0.080 inch OD) and a razor blade. No turbulence data were taken.

EDITORS' COMMENTS: The values of $\partial W_\infty/\partial z$ and the profiles of $\partial W/\partial z$ on the plane of symmetry were computed using smoothed and corrected values of the velocity direction in the free stream. These smoothed and corrected values were used as supplied by the originators. It was noted by the editors in attempts to predict the development of this flow that there exists a high gradient of shear stress normal to the wall (see: Wheeler and Johnston, 1971, pp. 76,77). It is thought that the form of the law of the wall (Equation 4) used to estimate C_f overestimates the actual wall shear stress for this flow.

PRESSURE GRADIENT:

x feet	Q_∞ (ft/sec)	$\partial Q_\infty/\partial x$ (sec^{-1})	$\partial W_\infty/\partial z$ (sec^{-1})	$\frac{\partial}{\partial x}(\partial W_\infty/\partial z)$ $(sec\text{-}ft)^{-1}$
0.000	167.7	-21.5	15.5	16.8
0.083	165.8	-24.5	17.0	21.0
0.167	163.6	-27.5	19.2	31.2
0.250	161.2	-31.3	22.5	46.5
0.333	158.4	-34.8	26.7	55.1
0.417	155.4	-37.9	31.6	62.0
0.500	152.1	-41.5	37.1	69.0
0.583	148.4	-48.1	43.0	72.9
0.667	144.0	-59.0	49.2	75.4
0.750	138.2	-79.6	55.5	75.4



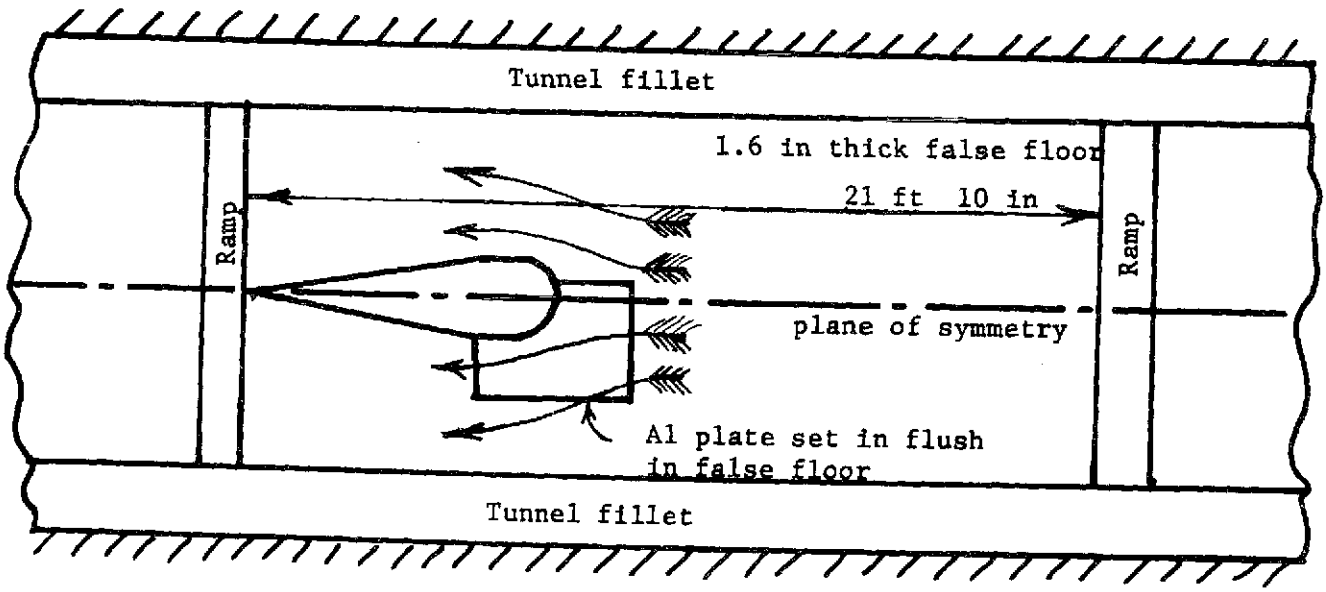


Figure 50.1 - Configuration of East and Hoxey Flow

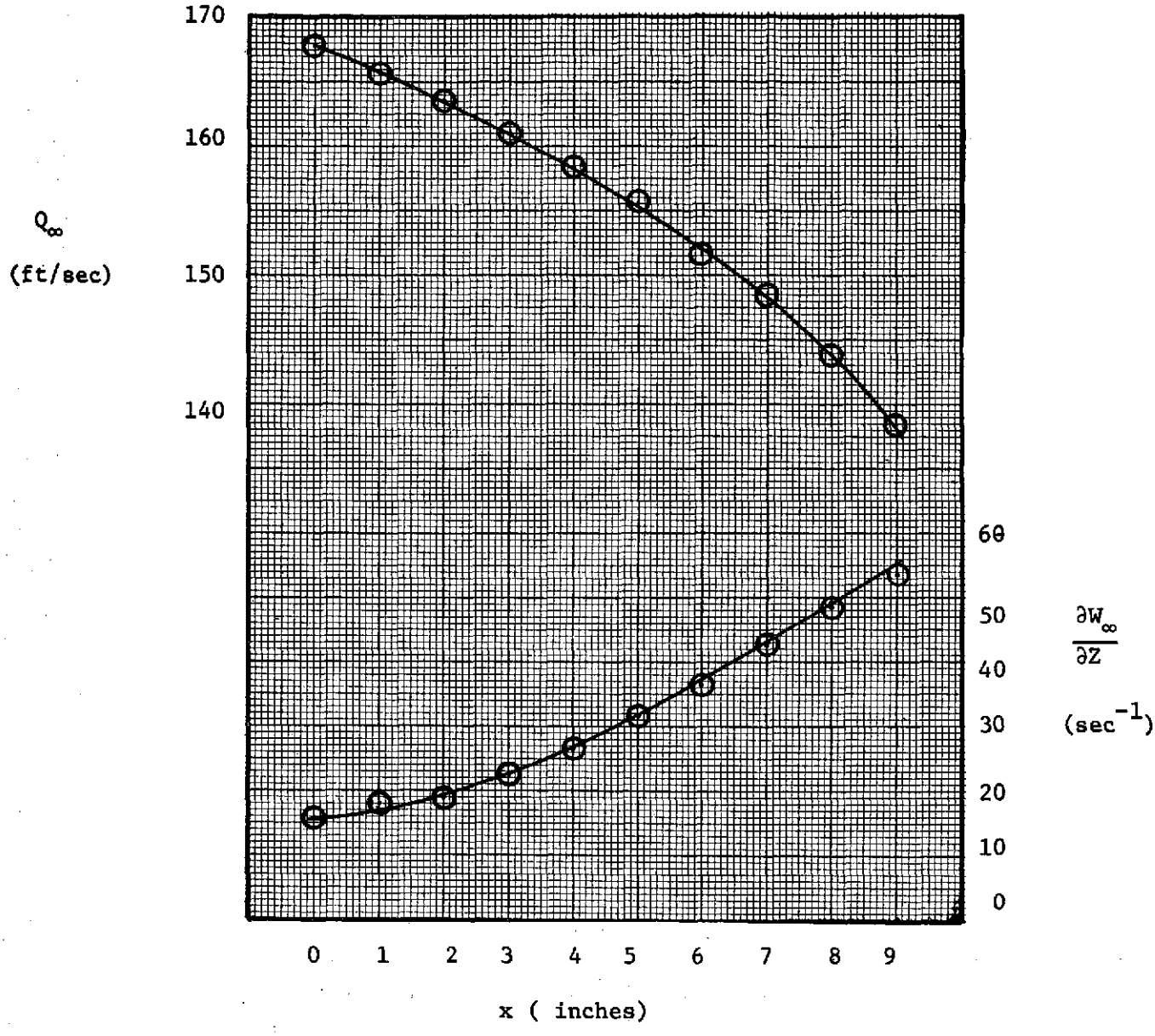


Figure 50.2 - East and Hoxey Q_∞ and $\partial W_\infty/\partial Z$ Distributions

EAST AND HOXEY, PLANE OF SYMMETRY IDENT 50. KIN. VISC 0.0001530

X (FT)	RTHETA	H	CFXLW	CFXLT	DELTA1	THET11	THTWZZ
0.00000	52049.7	1.396	0.001436	0.001516	0.066325	0.047524	0.010312
0.08333	52069.3	1.408	0.001398	0.001489	0.067699	0.048093	0.011722
0.16660	54107.0	1.435	0.001260	0.001412	0.072704	0.050682	0.014542
0.25000	54837.3	1.456	0.001181	0.001361	0.075907	0.052142	0.017329
0.33330	55386.5	1.488	0.001043	0.001291	0.079740	0.053595	0.021938
0.41666	56628.7	1.520	0.000901	0.001221	0.084701	0.055732	0.027663
0.50000	56168.6	1.587	0.000709	0.001101	0.089723	0.056567	0.035851
0.58333	56794.8	1.679	0.000480	0.000951	0.098300	0.058532	0.045915

X	PLX	PPX
0.00000	0.000	0.000
0.08333	-1.346	0.206
0.16660	3.115	0.392
0.25000	3.656	0.559
0.33330	3.309	0.706
0.41666	6.255	0.831
0.50000	2.949	0.930
0.58333	4.477	1.000

FAST AND HOXEY, PLANE OF SYMMETRY IDENT 50.

PROFILE NUMBER 1 X = 0.000 FT

Y/THIL	Y. (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.02	0.000833	0.35400	1.95735	24.45	13.21
0.02	0.001167	0.37400	1.86197	34.24	13.96
0.04	0.001667	0.39800	1.92103	48.91	14.87
0.05	0.002333	0.41600	1.97759	68.47	15.53
0.07	0.003333	0.43400	2.01809	97.82	16.20
0.10	0.004750	0.45900	2.06436	139.39	17.13
0.14	0.006666	0.47500	2.10126	195.63	17.73
0.20	0.009416	0.50300	2.03431	276.33	18.77
0.28	0.013333	0.53100	2.02048	391.27	19.82
0.40	0.018833	0.55900	2.00950	552.67	20.86
0.56	0.026666	0.59500	1.92594	782.54	22.21
0.79	0.037748	0.62500	1.91102	1107.78	23.33
1.12	0.053331	0.65900	1.77900	1565.08	24.59
1.59	0.075414	0.70900	1.63317	2213.12	26.46
2.24	0.106662	0.75700	1.55893	3130.16	28.25
2.63	0.124995	0.77900	1.59231	3668.15	29.07
3.51	0.166660	0.83500	1.55813	4890.87	31.16
4.38	0.208325	0.87800	1.41919	6113.59	32.77
5.26	0.249990	0.92100	1.37144	7336.30	34.37
6.14	0.291655	0.94900	1.31612	8559.02	35.42
7.01	0.333320	0.97200	1.25221	9781.73	36.28
7.89	0.374985	0.98700	1.14010	11004.45	36.84
8.77	0.416650	0.99600	1.07283	12227.17	37.17
9.64	0.458315	0.99700	0.99677	13449.89	37.21
10.52	0.499980	0.99900	0.99826	14672.61	37.28
11.40	0.541645	1.00000	0.99851	15895.32	37.32
12.27	0.583310	1.00000	1.00000	17118.04	37.32

EAST AND HOXEY, PLANE OF SYMMETRY IDENT 50.

PROFILE NUMBER 2 X = 0.083 FT

Y/TH11	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.02	0.000833	0.35100	1.86510	23.86	13.27
0.02	0.001167	0.37300	1.93067	33.40	14.11
0.03	0.001667	0.38400	1.96909	47.71	14.52
0.05	0.002333	0.40500	2.01478	66.79	15.32
0.07	0.003333	0.42200	2.02162	95.42	15.96
0.10	0.004750	0.44600	2.01310	135.97	16.87
0.14	0.006666	0.46500	1.98986	190.84	17.59
0.20	0.009416	0.49100	1.96046	269.56	18.57
0.28	0.013333	0.51900	1.94187	381.68	19.63
0.39	0.018833	0.54400	1.90570	539.13	20.57
0.55	0.026666	0.58200	1.83789	763.37	22.01
0.78	0.037748	0.61800	1.77467	1080.64	23.37
1.11	0.053331	0.65400	1.72668	1526.74	24.73
1.57	0.075414	0.70300	1.68343	2158.90	26.59
2.22	0.106662	0.75300	1.59228	3053.47	28.48
2.60	0.124995	0.77500	1.48779	3578.29	29.31
3.47	0.166660	0.83000	1.44882	4771.05	31.39
4.33	0.208325	0.87700	1.31230	5963.81	33.17
5.20	0.249990	0.91800	1.25137	7156.57	34.72
6.06	0.291655	0.94700	1.20557	8349.33	35.82
6.93	0.333320	0.97200	1.13585	9542.09	36.76
7.80	0.374985	0.98600	1.14320	10734.96	37.29
8.66	0.416650	0.99500	1.05208	11927.62	37.63
9.53	0.458315	0.99900	1.00834	13120.38	37.78
10.40	0.499980	1.00000	1.01102	14313.14	37.82
11.26	0.541645	1.00000	1.01870	15505.91	37.82
12.13	0.583310	1.00000	1.00303	16698.67	37.82

EAST AND HOXEY, PLANE OF SYMMETRY IDENT 50.

PROFILE NUMBER 3 X = 0.167 FT

Y/THIL	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.02	0.000833	0.32600	2.02484	22.33	12.9[illegible]
0.02	0.001167	0.35000	2.08612	31.26	13.94
0.03	0.001667	0.35800	2.19032	44.66	14.26
0.05	0.002333	0.37900	2.12250	62.52	15.10
0.07	0.003333	0.40600	2.25036	89.32	16.17
0.09	0.004750	0.41900	2.24097	127.28	16.69
0.13	0.006666	0.44100	2.28325	178.64	17.57
0.18	0.009416	0.46700	2.27939	252.33	18.60
0.26	0.013333	0.49500	2.21726	357.28	19.72
0.37	0.018833	0.53000	2.11336	504.66	21.11
0.53	0.026666	0.56000	2.04309	714.57	22.31
0.74	0.037748	0.59400	1.96566	1011.56	23.66
1.05	0.053331	0.63200	1.93749	1429.14	25.18
1.49	0.075414	0.68300	1.88190	2020.89	27.21
2.10	0.106662	0.73000	1.73757	2858.27	29.08
2.47	0.124995	0.76500	1.73027	3349.54	30.48
3.29	0.166660	0.82000	1.61271	4466.05	32.67
4.11	0.208325	0.86200	1.49315	5582.56	34.34
4.93	0.249990	0.91200	1.42743	6699.07	36.33
5.75	0.291655	0.93900	1.33841	7815.58	37.41
6.58	0.333320	0.96600	1.21603	8932.10	38.48
7.40	0.374985	0.98400	1.17208	10048.61	39.20
8.22	0.416650	0.99300	1.13033	11165.13	39.56
9.04	0.458315	0.99800	1.07115	12281.63	39.76
9.87	0.499980	0.99900	1.07297	13398.15	39.80
10.69	0.541645	1.00000	1.01362	14514.66	39.84
11.51	0.583310	1.00000	1.00000	15631.18	39.84

EAST AND HOXEY, PLANE OF SYMMETRY IDENT 50.

PROFILE NUMBER 4 X = 0.250 FT

Y/THI1	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.02	0.000833	0.31568	1.90783	21.30	12.99
0.02	0.001167	0.33067	1.95628	29.81	13.61
0.03	0.001667	0.35465	2.02942	42.59	14.59
0.04	0.002333	0.36363	2.05155	59.63	14.96
0.06	0.003333	0.38562	2.09739	85.18	15.87
0.09	0.004750	0.40260	2.05540	121.39	16.57
0.13	0.006666	0.42357	2.05761	170.36	17.43
0.18	0.009416	0.45654	2.05845	240.64	18.79
0.26	0.013333	0.47552	2.03230	340.73	19.57
0.36	0.018833	0.50949	2.00265	481.28	20.97
0.51	0.026666	0.54546	1.99451	681.45	22.45
0.72	0.037748	0.57243	1.91243	964.68	23.56
1.02	0.053331	0.62138	1.80964	1362.91	25.57
1.45	0.075414	0.66833	1.75137	1927.24	27.50
2.05	0.106662	0.72128	1.63872	2725.81	29.68
2.40	0.124995	0.74625	1.57721	3194.31	30.71
3.20	0.166660	0.80819	1.53752	4259.09	33.26
4.00	0.208325	0.86413	1.38119	5323.86	35.55
4.79	0.249990	0.90309	1.27144	6388.63	37.17
5.59	0.291655	0.94206	1.21584	7453.40	38.77
6.39	0.333320	0.96504	1.11991	8518.17	39.71
7.19	0.374985	0.97902	1.09186	9582.94	40.29
7.99	0.416650	0.99201	1.05372	10647.71	40.82
8.79	0.458315	0.99600	0.99967	11712.48	40.99
9.59	0.499980	0.99800	1.00035	12777.26	41.07
10.39	0.541645	0.99900	1.00102	13842.03	41.11
11.19	0.583310	1.00000	1.00000	14906.80	41.15

EAST AND HOXEY, PLANE OF SYMMETRY IDENT 59.

PROFILE NUMBER 5 X = 0.333 FT

Y/TH11	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.02	0.000833	0.28200	1.86159	19.66	12.35
0.02	0.001167	0.29400	2.02203	27.53	12.96
0.03	0.001667	0.31700	2.10462	39.32	13.99
0.04	0.002333	0.34200	2.13604	55.05	14.98
0.06	0.003333	0.35400	2.09269	78.65	15.50
0.09	0.004750	0.37400	2.08190	112.07	16.38
0.12	0.006666	0.40100	2.11747	157.29	17.56
0.18	0.009416	0.42000	2.05666	222.17	18.40
0.25	0.013333	0.44400	2.00999	314.58	19.45
0.35	0.018833	0.48300	2.02581	444.35	21.15
0.50	0.026666	0.52000	1.94891	629.17	22.78
0.70	0.037748	0.55700	1.88047	890.67	24.40
1.00	0.053331	0.59900	1.82678	1258.34	26.24
1.41	0.075414	0.65400	1.72086	1779.37	28.64
1.99	0.106662	0.71400	1.60937	2516.67	31.27
2.33	0.124995	0.73400	1.60422	2949.23	32.15
3.11	0.166660	0.80100	1.48446	3932.30	35.08
3.89	0.208325	0.84800	1.38153	4915.38	37.14
4.66	0.249990	0.90000	1.23022	5898.45	39.42
5.44	0.291655	0.93200	1.13678	6881.52	40.82
6.22	0.333320	0.96300	1.14394	7864.60	42.18
7.00	0.374985	0.98100	1.07965	8847.68	42.97
7.77	0.416650	0.99100	1.04251	9830.75	43.40
8.55	0.458315	0.99600	0.99775	10813.83	43.62
9.33	0.499980	1.00000	0.98772	11796.91	43.80
10.11	0.541645	1.00000	0.97472	12779.98	43.80
10.88	0.583310	1.00300	1.00000	13763.06	43.93

FAST AND HOXEY, PLANE OF SYMMETRY IDENT 50.

PROFILE NUMBER 6 X = 0.417 FT

Y/THIL	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.01	0.000833	0.25574	1.95023	17.97	12.05
0.02	0.001167	0.28072	2.07752	25.16	13.22
0.03	0.001667	0.29071	2.06082	35.95	13.70
0.04	0.002333	0.30669	2.11203	50.32	14.45
0.06	0.003333	0.32068	2.11475	71.89	15.11
0.09	0.004750	0.34766	2.12020	102.45	16.38
0.12	0.006666	0.36663	2.01012	143.79	17.27
0.17	0.009416	0.39461	1.99462	203.10	18.59
0.24	0.013333	0.41958	1.97416	287.57	19.77
0.34	0.018833	0.45954	1.91131	406.19	21.65
0.48	0.026666	0.48951	1.86216	575.14	23.06
0.68	0.037748	0.53147	1.80690	814.18	25.04
0.96	0.053331	0.57943	1.74937	1150.28	27.30
1.35	0.075414	0.63537	1.68407	1626.57	29.93
1.91	0.106662	0.69531	1.58233	2300.56	32.76
2.24	0.124995	0.72228	1.53109	2695.97	34.03
2.99	0.166660	0.79621	1.44613	3594.63	37.51
3.74	0.208325	0.83817	1.32583	4493.23	39.48
4.49	0.249990	0.88512	1.23782	5391.94	41.70
5.23	0.291655	0.92507	1.13646	6290.59	43.59
5.98	0.333320	0.95505	1.12395	7189.25	44.99
6.73	0.374985	0.97902	1.05940	8087.90	46.12
7.48	0.416650	0.99101	1.03783	8986.56	46.69
8.22	0.458315	0.99601	0.98159	9885.22	46.92
8.97	0.499980	0.99801	0.96412	10783.87	47.00
9.72	0.541645	0.99900	0.97425	11682.54	47.06
10.47	0.583310	1.00000	1.00000	12581.19	47.11

FAST AND HOXEY, PLANE OF SYMMETRY IDENT ED.

PROFILE NUMBER 7 X = 0.500 FT

Y/THTA	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.01	0.000833	0.21200	2.15756	15.58	11.28
0.02	0.001167	0.23500	2.22404	21.81	12.48
0.03	0.001667	0.25100	2.22398	31.15	13.33
0.04	0.002333	0.26900	2.25615	43.61	14.29
0.06	0.003333	0.28300	2.29610	62.31	15.03
0.08	0.004750	0.30400	2.21171	88.78	16.15
0.12	0.006666	0.32600	2.18293	124.61	17.32
0.17	0.009416	0.34800	2.16482	176.02	18.49
0.24	0.013333	0.37300	2.08068	249.23	19.81
0.33	0.018833	0.40400	2.02859	352.03	21.46
0.47	0.026666	0.45100	1.94519	498.45	23.96
0.67	0.037748	0.50000	1.90587	705.62	26.56
0.94	0.053331	0.54600	1.78955	996.91	29.00
1.33	0.075414	0.61000	1.71521	1409.69	32.40
1.88	0.106662	0.66600	1.63736	1993.82	35.38
2.21	0.124995	0.70500	1.58357	2336.51	37.45
2.95	0.166660	0.78000	1.47331	3115.34	41.43
3.48	0.209325	0.83700	1.36144	3814.19	44.44
4.42	0.249990	0.88300	1.24003	4673.31	45.90
5.16	0.291655	0.92700	1.16989	5451.25	49.24
5.89	0.333320	0.95500	1.11106	6230.63	50.73
6.63	0.374985	0.97700	1.07380	7009.52	51.90
7.37	0.416650	0.99100	1.04504	7788.35	52.64
8.10	0.458315	0.99700	1.01329	8567.18	52.95
8.74	0.499980	1.00000	1.00160	9346.02	53.12
9.58	0.541645	1.00000	1.04237	10124.86	53.12
10.31	0.583310	1.00000	1.00000	10903.69	53.12

EAST AND HOXSEY, PLANE OF SYMMETRY IDENT 50.

PROFILE NUMBER F X = 9.583 FT

Y/THICK	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.01	0.000833	0.17200	2.37033	12.53	11.10
0.02	0.001167	0.18700	2.38234	17.54	12.07
0.03	0.001667	0.19300	2.40722	25.05	12.46
0.04	0.002333	0.21500	2.37743	35.07	13.88
0.06	0.003333	0.22200	2.36231	50.11	14.33
0.08	0.004750	0.24400	2.36521	71.40	15.75
0.11	0.006666	0.26100	2.28956	100.21	16.85
0.16	0.009416	0.27900	2.15925	141.55	18.01
0.23	0.013333	0.31100	2.15023	200.43	20.07
0.32	0.018833	0.34200	2.10791	283.10	22.08
0.46	0.026666	0.40600	1.96387	400.86	26.21
0.64	0.037749	0.43500	1.82330	567.46	28.08
0.91	0.053331	0.49800	1.75443	801.71	32.21
1.29	0.075414	0.55400	1.65224	1133.67	36.40
1.82	0.106662	0.64300	1.56003	1603.42	41.50
2.14	0.124995	0.69600	1.51414	1879.01	44.94
2.85	0.166660	0.76200	1.40370	2505.35	49.17
3.56	0.208325	0.82400	1.25734	3131.68	53.19
4.27	0.249990	0.87200	1.13072	3756.02	56.24
4.98	0.291655	0.92000	1.12991	4384.35	59.33
5.69	0.333320	0.95300	1.08276	5010.69	61.32
6.41	0.374985	0.97500	1.05702	5637.03	62.93
7.12	0.416650	0.98700	1.00723	6263.36	63.71
7.83	0.458315	0.99400	1.03133	6889.70	64.16
8.54	0.499980	0.99900	1.00214	7516.03	64.49
9.25	0.541645	1.00100	0.99111	8142.37	64.61
9.97	0.583310	1.00000	1.00000	8768.70	64.55

TITLE: Johnston Plane of Symmetry, Flow 52

REFERENCE: Johnston, J., "Three-dimensional turbulent boundary layer," Gas Turbine Lab. Report 39, Massachusetts Institute of Technology, May 1957,also TASME 82, Series D, 1960, p. 233-248.

DESCRIPTION: The boundary layer development was measured at points both on and off the plane of symmetry on the walls of a confined jet which impinged on a back wall (see Figure 52.1). The velcoity magnitude and direction in the boundary layers were measured with a three-holed cobra probe constructed from three pieces of 0.024 inch outside diameter tubing. No turbulence data were measured.

EDITORS' COMMENTS: No measurements were made at points off the plane of symmetry except at values of x greater than 24 inches. Since $\partial W_\infty/\partial z$ is required for plane of symmetry prediction methods it was estimated by indirect. If one assumes that on the centerline of the flow $\partial V/\partial y$ as well as V is zero, conservation of mass yields.

$$-\frac{\partial W_\infty}{\partial z} = \frac{\partial U_\infty}{\partial x} = \frac{\partial Q_\infty}{\partial x}$$

This relation has been used to compute $\partial W_\infty/\partial z$ up to $x = 24$ inches after which data is available. The results by this procedure merge with the direct data at $x = 24$ inches but at larger values of x (closer to separation) a definite divergence appeared between the direct data and the results from the equation above. Due to an inconsistency between original tabular and graphical results, the shape of the Q_∞ vs x curve on Figure 10.2 is uncertain near $x = 30$ inches and hence the pressure gradient is a bit uncertain in this region. Due to the absence of cross flow data in the early part of the flow, momentum integral were not performed for this flow.

PRESSURE GRADIENT:

x (feet)	Q_∞ (ft/sec)	$\frac{\partial Q_\infty}{\partial x}$ (sec^{-1})	$\frac{\partial W_\infty}{\partial z}$ (sec^{-1})	$\frac{\partial}{\partial x}\frac{\partial W_\infty}{\partial z}$ $(sec\text{-}ft)^{-1}$
0.000	102.3	0.00	0.00	2.00
0.104	102.2	-0.21	0.21	2.00
0.208	102.2	-0.65	0.42	2.00
0.312	102.1	-0.86	0.62	2.00
0.416	102.0	-1.05	0.86	2.52
0.520	101.9	-1.37	1.14	2.85
0.625	101.7	-1.58	1.46	3.36
0.729	101.6	-1.90	1.81	3.44
0.833	101.3	-2.32	2.20	4.03
0.937	101.1	-2.75	2.61	4.20
1.041	100.8	-3.22	3.19	6.74
1.145	100.4	-3.90	3.97	8.55

(con't next page)

PRESSURE GRADIENT (con't)

1.249	100.0	-4.80	5.02	11.72
1.353	99.4	-6.52	6.44	15.60
1.457	98.6	-8.10	8.30	20.38
1.561	97.6	-10.62	10.73	25.63
1.666	96.4	-12.91	13.47	26.83
1.770	94.9	-16.21	16.31	27.83
1.874	93.1	-18.70	19.26	28.73
1.978	90.9	-22.28	22.22	29.41
2.082	88.5	-24.71	25.75	37.50
2.186	85.7	-28.40	29.77	39.60
2.290	82.7	-28.27	33.95	41.10
2.394	79.9	-25.60	38.45	44.90
2.498	77.3	-24.50	43.20	46.30

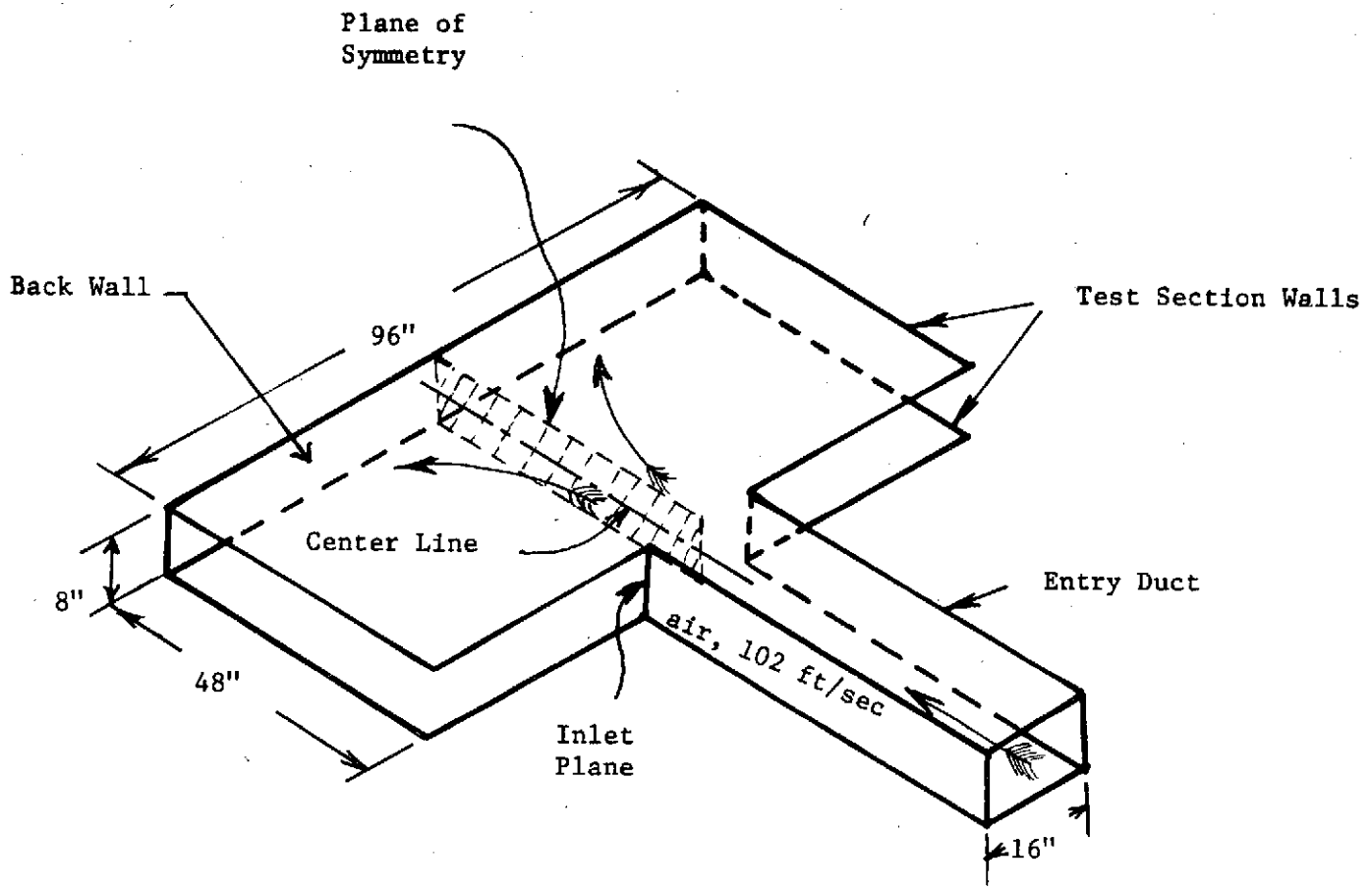


Figure 52.1 - Configuration of Johnston Plane of Symmetry Flow

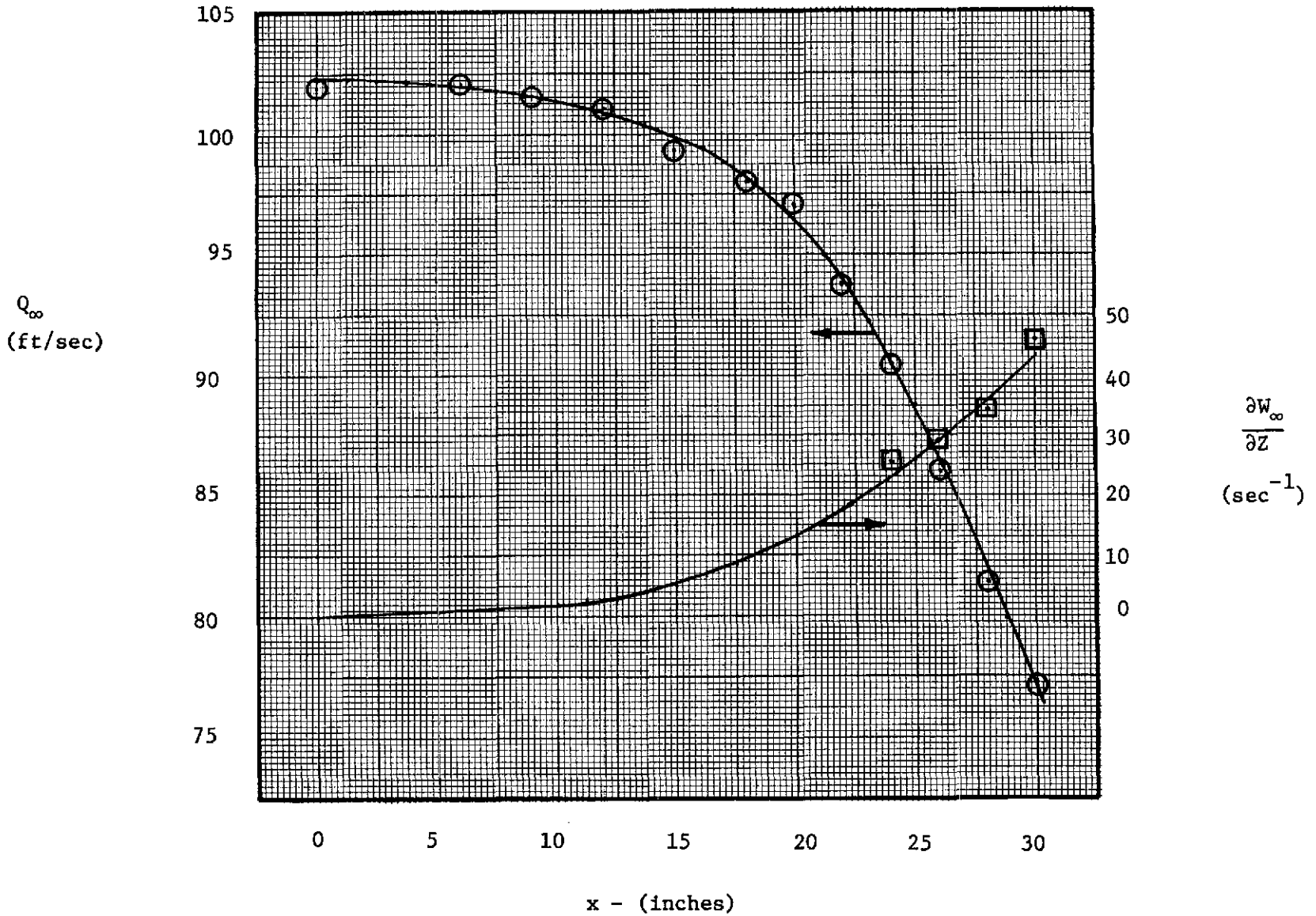


Figure 52.2 - Johnston Plane of Symmetry Q_∞ and $\partial W_\infty/\partial Z$ Distribution

JOHNSTON, PLANE OF SYMMETRY IDENT 52. KIN. VISC 0.0001700

X (FT)	RTHETA	H	CFXLW	CFXLT	DELTA1	THET11	THTWZZ
0.00000	5690.8	1.336	0.003050	0.003013	0.012681	0.009494	0.000000
0.50000	6100.3	1.337	0.002952	0.002953	0.013549	0.010137	0.000000
0.75000	6323.6	1.344	0.002903	0.002890	0.014223	0.010581	0.000000
1.00000	6516.5	1.343	0.002875	0.002874	0.014697	0.010947	0.000000
1.25000	6771.7	1.358	0.002747	0.002776	0.015746	0.011593	0.000000
1.50000	7155.9	1.363	0.002681	0.002714	0.016922	0.012413	0.000000
1.66600	7456.5	1.371	0.002610	0.002652	0.017858	0.013028	0.000000
1.83300	7654.9	1.400	0.002435	0.002516	0.019344	0.013815	0.000000
2.00000	7879.7	1.448	0.002183	0.002319	0.021356	0.014753	0.006552
2.16600	8142.3	1.517	0.001800	0.002063	0.024271	0.015002	0.010024
2.33300	8413.2	1.631	0.001447	0.001711	0.028516	0.017485	0.014564
2.50000	8851.4	1.793	0.001051	0.001310	0.034953	0.019491	0.022799

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 1 X = 0.000 FT

Y/THI1	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.11	0.001000	0.49400	0.00000	23.41	12.65
0.18	0.001667	0.55000	0.00000	39.01	14.09
0.26	0.002500	0.58900	0.00000	58.51	15.08
0.35	0.003333	0.61100	0.00000	78.02	15.65
0.44	0.004167	0.63300	0.00000	97.52	16.21
0.53	0.005000	0.65000	0.00000	117.03	16.65
0.70	0.006667	0.67300	0.00000	156.04	17.24
0.88	0.008333	0.69300	0.00000	195.05	17.75
1.05	0.010000	0.71200	0.00000	234.06	18.23
1.32	0.012500	0.73400	0.00000	292.57	18.80
1.76	0.016667	0.76300	0.00000	390.10	19.54
2.19	0.020833	0.78600	0.00000	487.62	20.13
2.63	0.025000	0.81100	0.00000	585.14	20.77
3.51	0.033333	0.84600	0.00000	780.19	21.67
4.39	0.041667	0.87700	0.00000	975.24	22.46
5.27	0.050000	0.90900	0.00000	1170.29	23.28
6.14	0.058333	0.93500	0.00000	1365.34	23.94
7.02	0.066666	0.95700	0.00000	1560.39	24.51
7.90	0.075000	0.97100	0.00000	1755.43	24.87
8.78	0.083333	0.98200	0.00000	1950.48	25.15
9.66	0.091666	0.99400	0.00000	2145.53	25.46
10.53	0.100000	0.99800	0.00000	2340.58	25.56
13.17	0.125000	1.00000	0.00000	2925.72	25.61
17.55	0.166666	1.00000	0.00000	3900.97	25.61

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 2 X = 0.500 FT

Y/THII	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.10	0.001000	0.48300	0.00000	23.12	12.57
0.16	0.001667	0.53500	0.00000	38.53	13.93
0.25	0.002500	0.57100	0.00000	57.79	14.86
0.33	0.003333	0.60100	0.00000	77.06	15.64
0.41	0.004167	0.61900	0.00000	96.32	16.11
0.49	0.005000	0.63700	0.00000	115.59	16.58
0.66	0.006667	0.66400	0.00000	154.12	17.28
0.82	0.008333	0.68600	0.00000	192.65	17.86
0.99	0.010000	0.70200	0.00000	231.18	18.27
1.23	0.012500	0.72100	0.00000	288.97	18.77
1.64	0.016667	0.75700	0.00000	385.29	19.71
2.06	0.020833	0.78200	0.00000	481.62	20.36
2.47	0.025000	0.80200	0.00000	577.94	20.88
3.29	0.033333	0.84200	0.00000	770.58	21.92
4.11	0.041667	0.87100	0.00000	963.23	22.67
4.93	0.050000	0.89800	0.00000	1155.88	23.38
5.75	0.058333	0.92200	0.00000	1348.52	24.00
6.59	0.066666	0.94600	0.00000	1541.17	24.62
7.40	0.075000	0.96400	0.00000	1733.82	25.09
8.22	0.083333	0.97800	0.00000	1926.46	25.46
9.04	0.091666	0.98400	0.00000	2119.11	25.61
9.86	0.100000	0.99400	0.00000	2311.75	25.87
12.33	0.125000	1.00000	0.00000	2889.69	26.03
16.44	0.166666	1.00000	0.00000	3852.93	26.03

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 3 X = 0.750 FT

Y/TH11	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.11	0.001167	0.49200	0.00000	26.59	12.90
0.16	0.001667	0.53600	0.00000	37.98	14.06
0.24	0.002500	0.57200	0.00000	56.97	15.00
0.32	0.003333	0.59500	0.00000	75.96	15.60
0.39	0.004167	0.61400	0.00000	94.95	16.10
0.47	0.005000	0.62900	0.00000	113.94	16.50
0.63	0.006667	0.65600	0.00000	151.92	17.20
0.79	0.008333	0.68000	0.00000	189.90	17.83
0.95	0.010000	0.69300	0.00000	227.88	18.17
1.18	0.012500	0.71500	0.00000	284.85	18.75
1.58	0.016667	0.75200	0.00000	379.80	19.72
1.97	0.020833	0.77200	0.00000	474.75	20.25
2.36	0.025000	0.79500	0.00000	569.70	20.85
3.15	0.033333	0.83100	0.00000	759.60	21.79
3.94	0.041667	0.86300	0.00000	949.51	22.63
4.73	0.050000	0.89100	0.00000	1139.41	23.37
5.51	0.058333	0.91600	0.00000	1329.31	24.02
6.30	0.066666	0.93800	0.00000	1519.21	24.60
7.09	0.075000	0.95700	0.00000	1709.11	25.10
7.88	0.083333	0.97300	0.00000	1899.01	25.52
8.66	0.091666	0.98400	0.00000	2088.91	25.81
9.45	0.100000	0.99300	0.00000	2278.81	26.04
11.81	0.125000	1.00000	0.00000	2848.52	26.23
15.75	0.166666	1.00000	0.00000	3798.02	26.23

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 4 X = 1.000 FT

Y/THI1	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.09	0.001000	0.47500	0.00000	22.57	12.53
0.15	0.001667	0.53400	0.00000	37.62	14.08
0.23	0.002500	0.56700	0.00000	56.43	14.95
0.30	0.003333	0.59000	0.00000	75.23	15.56
0.38	0.004167	0.60900	0.00000	94.04	16.06
0.46	0.005000	0.62800	0.00000	112.85	16.56
0.61	0.006667	0.65200	0.00000	150.47	17.20
0.76	0.008333	0.67300	0.00000	188.09	17.75
0.91	0.010000	0.68600	0.00000	225.70	18.09
1.14	0.012500	0.71200	0.00000	282.13	18.78
1.52	0.016667	0.74300	0.00000	376.17	19.60
1.90	0.020833	0.76700	0.00000	470.22	20.23
2.28	0.025000	0.78700	0.00000	564.26	20.76
3.05	0.033333	0.82600	0.00000	752.35	21.79
3.81	0.041667	0.85600	0.00000	940.44	22.58
4.57	0.050000	0.88500	0.00000	1128.52	23.34
5.33	0.058333	0.91000	0.00000	1316.61	24.00
6.09	0.066666	0.93400	0.00000	1504.70	24.63
6.85	0.075000	0.95100	0.00000	1692.79	25.08
7.61	0.083333	0.97000	0.00000	1880.88	25.58
8.37	0.091666	0.98200	0.00000	2068.96	25.90
9.14	0.100000	0.99100	0.00000	2257.05	26.14
9.90	0.108333	0.99600	0.00000	2445.14	26.27
11.42	0.125000	1.00000	0.00000	2821.31	26.37
15.23	0.166666	1.00000	0.00000	3761.75	26.37

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 5 X = 1.250 FT

Y/TH11	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.10	0.001167	0.49800	0.00000	25.25	13.44
0.14	0.001667	0.52500	0.00000	36.08	14.17
0.22	0.002500	0.55500	0.00000	54.12	14.98
0.29	0.003333	0.57600	0.00000	72.16	15.54
0.36	0.004167	0.59600	0.00000	90.20	16.08
0.43	0.005000	0.60800	0.00000	108.23	16.41
0.58	0.006667	0.63300	0.00000	144.31	17.08
0.72	0.008333	0.65600	0.00000	180.39	17.70
0.86	0.010000	0.67000	0.00000	216.47	18.08
1.08	0.012500	0.69700	0.00000	270.59	18.81
1.44	0.016667	0.73000	0.00000	360.78	19.70
1.80	0.020833	0.75000	0.00000	450.98	20.24
2.16	0.025000	0.77700	0.00000	541.17	20.97
2.88	0.033333	0.81200	0.00000	721.57	21.91
3.59	0.041667	0.84300	0.00000	901.96	22.75
4.31	0.050000	0.87500	0.00000	1082.35	23.61
5.03	0.058333	0.90200	0.00000	1262.74	24.34
5.75	0.066666	0.92200	0.00000	1443.13	24.88
6.47	0.075000	0.94500	0.00000	1623.52	25.50
7.19	0.083333	0.96400	0.00000	1803.91	26.01
7.91	0.091666	0.97900	0.00000	1984.31	26.42
8.63	0.100000	0.98800	0.00000	2164.70	26.66
9.34	0.108333	0.99600	0.00000	2345.09	26.88
10.78	0.125000	1.00000	0.00000	2705.87	26.99
14.38	0.166666	1.00000	0.00000	3607.83	26.99

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 6 X = 1.500 FT

Y/THI1	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.07	0.001167	0.48700	0.00000	24.62	13.36
0.13	0.001667	0.51300	0.00000	35.18	14.01
0.20	0.002500	0.54500	0.00000	52.76	14.89
0.27	0.003333	0.56700	0.00000	70.35	15.49
0.34	0.004167	0.58300	0.00000	87.94	15.92
0.40	0.005000	0.59900	0.00000	105.53	16.36
0.54	0.006667	0.62600	0.00000	140.71	17.10
0.67	0.008333	0.64500	0.00000	175.88	17.62
0.81	0.010000	0.66000	0.00000	211.06	18.03
1.01	0.012500	0.68100	0.00000	263.82	18.60
1.34	0.016667	0.71200	0.00000	351.76	19.45
1.68	0.020833	0.74500	0.00000	439.70	20.35
2.01	0.025000	0.76100	0.00000	527.64	20.79
2.69	0.033333	0.80100	0.00000	703.53	21.88
3.36	0.041667	0.83300	0.00000	879.41	22.75
4.03	0.050000	0.86100	0.00000	1055.29	23.52
4.70	0.058333	0.88100	0.00000	1231.17	24.34
5.37	0.066666	0.91500	0.00000	1407.05	24.99
6.04	0.075000	0.93600	0.00000	1582.93	25.57
6.71	0.083333	0.95600	0.00000	1758.82	26.11
7.38	0.091666	0.97100	0.00000	1934.70	26.52
8.06	0.100000	0.98100	0.00000	2110.58	26.79
8.73	0.108333	0.99100	0.00000	2286.46	27.07
10.07	0.125000	0.99800	0.00000	2638.23	27.26
13.43	0.166666	1.00000	0.00000	3517.63	27.31

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 7 X = 1.666 FT

Y/THI1	Y (FT)	U/QINF	W/W7INF	Y+ (S)	U+
0.09	0.001167	0.48500	0.00000	24.12	13.43
0.13	0.001667	0.51000	0.00000	34.46	14.12
0.19	0.002500	0.53800	0.00000	51.69	14.89
0.26	0.003333	0.56500	0.00000	68.92	15.64
0.32	0.004167	0.57300	0.00000	86.15	15.86
0.38	0.005000	0.59000	0.00000	103.38	16.33
0.51	0.006667	0.61400	0.00000	137.84	17.00
0.64	0.008333	0.63400	0.00000	172.30	17.55
0.77	0.010000	0.65300	0.00000	206.76	18.08
0.96	0.012500	0.67200	0.00000	258.45	18.60
1.28	0.016667	0.70000	0.00000	344.61	19.38
1.60	0.020833	0.72700	0.00000	430.76	20.12
1.92	0.025000	0.75100	0.00000	516.91	20.79
2.56	0.033333	0.78000	0.00000	689.21	21.64
3.20	0.041667	0.82200	0.00000	861.52	22.75
3.84	0.050000	0.85400	0.00000	1033.82	23.64
4.48	0.058333	0.88300	0.00000	1206.12	24.44
5.12	0.066666	0.90800	0.00000	1378.43	25.13
5.76	0.075000	0.92900	0.00000	1550.73	25.72
6.40	0.083333	0.94700	0.00000	1723.03	26.21
7.04	0.091666	0.96500	0.00000	1895.34	26.71
7.68	0.100000	0.97200	0.00000	2067.64	27.07
8.32	0.108333	0.98700	0.00000	2239.94	27.32
9.59	0.125000	0.99800	0.00000	2584.55	27.63
12.79	0.166666	1.00000	0.00000	3446.07	27.69

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 8 X = 1.833 FT

Y/TH11	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.08	0.001167	0.47400	0.00000	22.56	13.58
0.12	0.001667	0.49600	0.00000	32.23	14.21
0.18	0.002500	0.51200	0.00000	48.34	14.67
0.24	0.003333	0.53200	0.00000	64.45	15.25
0.30	0.004167	0.55100	0.00000	80.56	15.79
0.36	0.005000	0.56000	0.00000	96.68	16.05
0.48	0.006667	0.58800	0.00000	128.90	16.86
0.60	0.008333	0.61000	0.00000	161.13	17.48
0.72	0.010000	0.62700	0.00000	193.35	17.97
0.90	0.012500	0.64700	0.00000	241.69	18.54
1.21	0.016667	0.67500	0.00000	322.25	19.34
1.51	0.020833	0.70100	0.00000	402.82	20.09
1.81	0.025000	0.72700	0.00000	483.38	20.83
2.41	0.033333	0.75900	0.00000	644.51	22.04
3.02	0.041667	0.80600	0.00000	805.63	23.10
3.62	0.050000	0.84100	0.00000	966.76	24.10
4.22	0.058333	0.87100	0.00000	1127.89	24.96
4.83	0.066666	0.89500	0.00000	1289.01	25.65
5.43	0.075000	0.92100	0.00000	1450.14	26.39
6.03	0.083333	0.94100	0.00000	1611.27	26.97
6.64	0.091666	0.96300	0.00000	1772.40	27.60
7.24	0.100000	0.97600	0.00000	1933.52	27.97
7.84	0.108333	0.98700	0.00000	2094.65	28.28
9.05	0.125000	0.99800	0.00000	2416.90	28.60
10.25	0.141666	0.99800	0.00000	2739.15	28.60
12.06	0.166666	1.00000	0.00000	3222.54	28.66

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 9 X = 2.000 FT

Y/TH11	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.08	0.001167	0.39000	1.25204	20.59	11.80
0.11	0.001667	0.43000	1.34910	29.41	13.01
0.17	0.002500	0.47400	1.39772	44.12	14.35
0.23	0.003333	0.48600	1.40746	58.82	14.71
0.28	0.004167	0.50800	1.41716	73.53	15.38
0.34	0.005000	0.53000	1.41720	88.23	16.04
0.45	0.006667	0.54600	1.41716	117.65	16.53
0.56	0.008333	0.57100	1.40746	147.06	17.28
0.68	0.010000	0.58600	1.38806	176.47	17.74
0.85	0.012500	0.61300	1.39781	220.59	18.55
1.13	0.016667	0.64500	1.34923	294.12	19.52
1.41	0.020833	0.67900	1.34927	367.65	20.55
1.69	0.025000	0.70300	1.30079	441.17	21.28
2.26	0.033333	0.74600	1.22317	588.23	22.59
2.82	0.041667	0.78600	1.18433	735.29	23.79
3.39	0.050000	0.82100	1.13589	882.35	24.85
3.95	0.058333	0.85400	1.10676	1029.41	25.85
4.52	0.066666	0.88400	1.06792	1176.47	26.76
5.08	0.075000	0.91200	1.07767	1323.52	27.60
5.65	0.083333	0.93300	1.07771	1470.53	28.24
6.21	0.091666	0.95700	1.06806	1617.64	28.97
6.78	0.100000	0.97200	1.05336	1764.70	29.42
8.47	0.125000	0.99700	1.06306	2205.87	30.18
11.30	0.166666	1.00000	1.00000	2941.17	30.27

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 10 X = 2.166 FT

Y/TH11	Y (FT)	U/QINF	W/QINF	Y+ (S)	U+
0.07	0.001167	0.35200	1.11182	17.81	11.73
0.10	0.001667	0.38600	1.19737	25.44	12.87
0.16	0.002500	0.41000	1.23682	38.16	13.67
0.21	0.003333	0.43900	1.25000	50.88	14.63
0.26	0.004167	0.45300	1.26315	63.60	15.10
0.31	0.005000	0.46600	1.25659	76.32	15.53
0.42	0.006667	0.49200	1.25659	101.76	16.40
0.52	0.008333	0.51100	1.25659	127.21	17.03
0.62	0.010000	0.53500	1.24344	152.65	17.83
0.78	0.012500	0.55800	1.23685	190.81	18.60
1.04	0.016667	0.59500	1.22367	254.41	19.83
1.30	0.020833	0.63100	1.18422	318.01	21.03
1.56	0.025000	0.66000	1.16448	381.62	22.00
2.09	0.033333	0.71300	1.11841	508.82	23.77
2.60	0.041667	0.75600	1.10526	636.03	25.20
3.12	0.050000	0.79600	1.07237	763.23	26.53
3.65	0.058333	0.83400	1.06579	890.44	27.80
4.17	0.066666	0.87100	1.04604	1017.64	29.03
4.69	0.075000	0.89500	1.03289	1144.85	29.83
5.21	0.083333	0.92300	0.99341	1272.05	30.77
5.73	0.091666	0.94600	1.00659	1399.26	31.53
6.25	0.100000	0.96900	0.99344	1526.46	32.30
6.77	0.108333	0.97800	0.98029	1653.67	32.60
7.81	0.125000	0.99400	0.95386	1908.08	33.13
10.42	0.166666	1.00000	1.00000	2544.11	33.33

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 11 X = 2.233 FT

Y/TH11	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.07	0.001167	0.27600	1.18257	15.10	10.26
0.10	0.001667	0.30000	1.29756	21.57	11.15
0.14	0.002500	0.33300	1.32234	32.35	12.38
0.19	0.003333	0.35400	1.33984	43.14	13.16
0.24	0.004167	0.37300	1.35165	53.92	13.87
0.29	0.005000	0.39100	1.37503	64.71	14.54
0.38	0.006667	0.40900	1.35733	86.27	15.21
0.48	0.008333	0.44100	1.36322	107.84	16.40
0.57	0.010000	0.45600	1.36313	129.41	16.95
0.71	0.012500	0.48600	1.36893	161.76	18.07
0.95	0.016667	0.53400	1.35721	215.69	19.86
1.19	0.020833	0.56500	1.33972	269.61	21.01
1.43	0.025000	0.60100	1.31613	323.53	22.35
1.91	0.033333	0.66100	1.29872	431.37	24.58
2.39	0.041667	0.71200	1.22241	539.21	26.47
2.86	0.050000	0.75900	1.19731	647.06	28.22
3.34	0.058333	0.80400	1.15209	754.90	29.89
3.81	0.066666	0.83700	1.12269	862.74	31.12
4.29	0.075000	0.87400	1.09343	970.58	32.50
4.77	0.083333	0.90900	1.08190	1078.43	33.80
5.24	0.091666	0.93200	1.04067	1186.27	34.65
5.72	0.100000	0.95400	1.03487	1294.11	35.47
6.20	0.108333	0.97200	1.02309	1401.96	36.14
7.15	0.125000	0.99300	1.01749	1617.64	36.92
9.53	0.166666	1.00000	1.00000	2156.85	37.18

JOHNSTON PLANE OF SYMMETRY IDENT 52.

PROFILE NUMBER 12 X = 2.500 FT

Y/TH11	Y (FT)	U/QINF	WZ/WZINF	Y+ (S)	U+
0.06	0.001167	0.15200	1.06052	12.15	6.53
0.09	0.001667	0.19500	1.11503	17.35	8.31
0.13	0.002500	0.24900	1.17631	26.03	10.36
0.17	0.003333	0.26300	1.18046	34.71	11.47
0.21	0.004167	0.27800	1.13342	43.38	12.13
0.26	0.005000	0.29200	1.15569	52.06	12.74
0.34	0.006667	0.32900	1.15513	69.41	14.35
0.43	0.008333	0.35100	1.15541	86.76	15.31
0.51	0.010000	0.37200	1.14326	104.12	16.23
0.64	0.012500	0.39200	1.15146	130.15	17.10
0.86	0.016667	0.43800	1.13113	173.53	19.10
1.07	0.020833	0.48100	1.13545	216.91	20.98
1.29	0.025000	0.52600	1.13122	260.29	22.94
1.71	0.033333	0.59500	1.13104	347.06	25.95
2.14	0.041667	0.64400	1.12699	433.82	28.09
2.57	0.050000	0.70100	1.09423	520.59	30.57
2.99	0.058333	0.75000	1.09423	607.35	32.71
3.42	0.066666	0.79400	1.08203	694.11	34.63
3.85	0.075000	0.83200	1.06563	780.88	36.29
4.28	0.083333	0.86800	1.06975	867.64	37.86
4.70	0.091666	0.90300	1.04519	954.41	39.39
5.13	0.100000	0.92800	1.03693	1041.17	40.48
5.56	0.108333	0.95300	1.02474	1127.94	41.57
6.41	0.125000	0.98400	1.01655	1301.47	42.92
7.27	0.141666	0.99600	0.99189	1474.99	43.44
8.55	0.166666	1.00000	1.00000	1735.29	43.62

TITLE: Johnston Infinite Swept Step, Flow 56

REFERENCE: Johnston, J., "Measurements in a three-dimensional turbulent boundary layer induced by a swept, forward facing step," JFM 42, p. 823-844.

DESCRIPTION: The boundary layer development was measured on the floor of a wind tunnel immediately upstream of a step swept 45° to the tunnel centerline (Figure 56.1). The velocity direction was measured with a two-hole yaw meter. The yawmeter was assembled from two tubes, each 0.025 inches in diameter. The velocity magnitude was measured with a single hole pitot probe of the same diameter. Static pressure profiles were also made using a disc type probe. Turbulent shear stresses and other quantities were measured using a special crossed wire hot wire anemometer. Only profiles of τ and its angle, θ_τ are given here.

PRESSURE GRADIENT: As shown in Figure 56.2, the pressure was not constant through the boundary layer. Derivatives with respect to x have been obtained from the curves in Figure 56.2 as a function of both x and y.

$\frac{1}{\rho}\frac{\partial P}{\partial x}$ (ft/sec^2) as a function of x (inches) and y (inches)

x \ y →	0	0.6	1.0	1.5	2.0	2.5	3.0	3.5
0	186.7	211.2	124.6	90.9	79.1	0.	0.	0.
1	259.5	238.	162.2	142.8	133.7	45.1	0	0
2	362.7	330.2	277.8	251.8	227.1	172.6	48.	0
3	509.	511.	446.5	360.	350.	291.	103	0
4	802.	749.	704.8	614.	550.	375.	148.	0
5	1151.	1118.	1014.	876.	645.	447.	74.0	0
6	1444.	1389.	1302.	1089.	723.	472.	277.	-79.2
7	1950.	1846.	1698.	1258.	782.	297.	45.4	-462.
8	2350.	2150.	1961.	1545.	940.	337.	-607.	-1010.
9	2714.	2412.	1969.	1440.	577.	-447.	-1655.	-2431.
9.75	1440.	2075.	1780.	1125.	205.	-840.	-2905.	-6100.

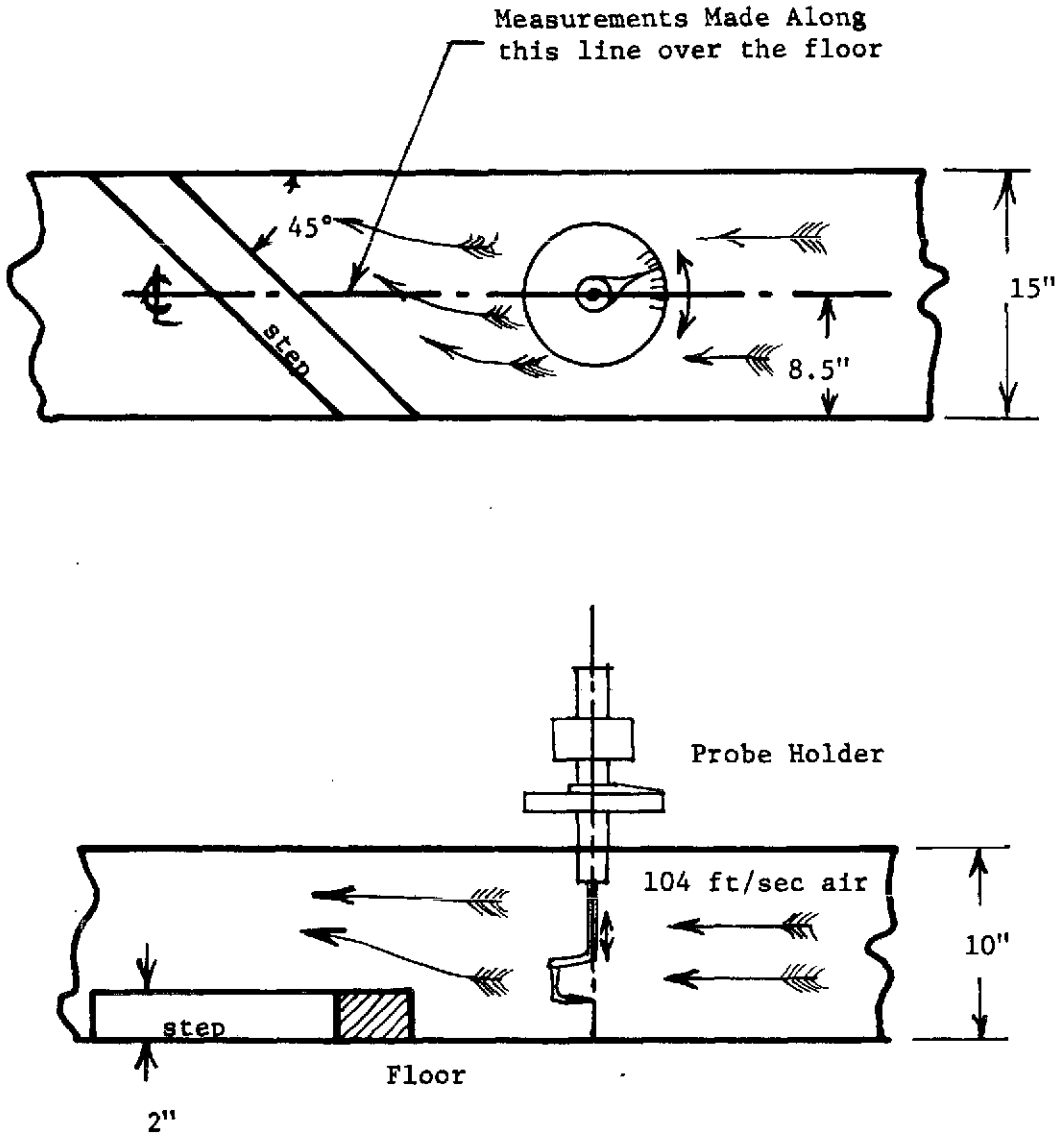


Figure 56.1 - Sketch of Johnston Infinite Step

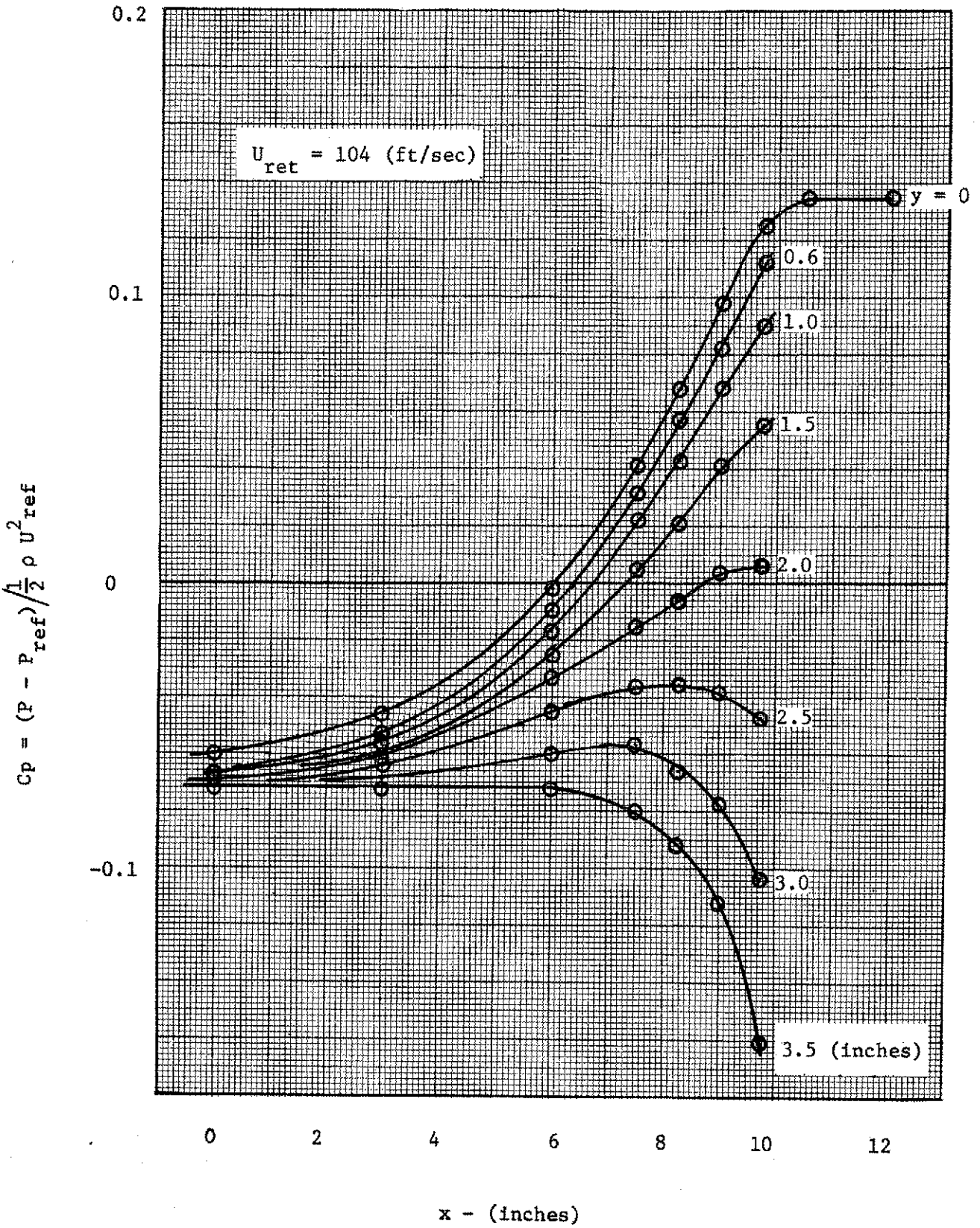


Figure 56.2 - Johnston Infinite Step Distribution of Pressure Coefficent

JOHNSTON INFINITE STEP FLOW 56

SHEAR STRESS PROFILES

y (in.)	x = 0.0 ft θ_τ (deg.)	x = 0.0 ft $\frac{\tau}{\rho U^2_{ref}}$	x = 0.625 ft θ_τ (deg.)	x = 0.625 ft $\frac{\tau}{\rho U^2_{ref}}$	x = 0.75 ft θ_τ (deg.)	x = 0.75 ft $\frac{\tau}{\rho U^2_{ref}}$
2.50		2.232E-06		1.245E-05		7.298E-05
2.00		2.617E-05	-2.93	1.537E-04	-1.87	3.795E-04
1.50	0.93	2.157E-04	1.20	5.652E-04	0.19	8.171E-04
1.25	1.98	3.725E-04	0.98	8.097E-04	0.23	1.094E-03
1.00	2.22	6.754E-04	2.19	9.508E-04	0.88	1.336E-03
0.80	2.01	8.283E-04	2.62	1.205E-03	3.07	1.414E-03
0.60	2.19	9.653E-04	3.87	1.327E-04	3.76	1.655E-03
0.50	2.03	1.146E-03	3.91	1.424E-03	5.16	1.722E-03
0.40	2.01	1.249E-03	4.39	1.419E-03	4.16	1.722E-03
0.30	1.71	1.320E-03	4.43	1.459E-03	6.52	1.634E-03
0.20	2.38	1.380E-03	4.62	1.454E-03	8.21	1.477E-03
0.10	2.68	1.278E-03	9.06	1.485E-03	15.35	1.451E-03
0.05	5.46	1.210E-03	14.19	1.422E-03	24.44	1.191E-03

Θ_τ is measured relative to tunnel centerline and is positive when rotated in same direction as velocity vector $\vec{Q}$

U_{ref} = 104 ft/sec

JOHNSTON INFINITE SWEPT STEP

IDENT =56. KIN. VISC= 0.0001700

X (FT)	RTHETA	H	CFSLW	CFSLT	CFMLW	BETAFP	BETASF	DELTA1 (FT)	THETI1 (FT)
0.00000	10043.7	1.288	0.002902	0.002788	0.002902	0.60	0.00	0.020426	0.015862
0.25000	11434.0	1.293	0.002656	0.002672	0.002656	1.60	0.00	0.023301	0.018025
0.50000	13948.4	1.325	0.002330	0.002410	0.002343	5.60	5.97	0.029217	0.022054
0.62500	17254.9	1.377	0.001962	0.002098	0.001997	11.41	10.74	0.037430	0.027182
0.69000	19177.8	1.421	0.001696	0.001904	0.001772	15.60	16.86	0.042825	0.030136
0.75000	22101.9	1.490	0.001335	0.001647	0.001522	25.09	28.68	0.051465	0.034549
0.81100	26102.6	1.614	0.000908	0.001297	0.001190	35.70	40.25	0.064957	0.040240

X (FT)	DELTA2 (FT)	THET22 (FT)	THET21 (FT)	THET12 (FT)	PLX	PRX	PLT	PRT	QINF FT/SEC	PSI
0.00000	0.000564	0.000002	0.000500	0.000064					107.64	0.0
0.25000	0.001304	0.000009	0.001121	0.000183					107.84	0.0
0.50000	0.004941	0.000122	0.004095	0.000847					107.52	0.0
0.62500	0.009957	0.000478	0.007898	0.002060					107.91	0.0
0.69000	0.014347	0.000957	0.011076	0.003270					108.18	0.0
0.75000	0.019355	0.001821	0.013996	0.005359					108.75	0.0
0.81100	0.025934	0.003232	0.017206	0.008727					110.27	0.0

JOHNSTON INFINITE SWEPT STEP IDENT 56.

PROFILE NUMBER 1 X = 0.000 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.06	0.CC1000	C.50048	0.00522	24.12	13.14	24.12	13.14
0.12	0.001833	C.54783	0.00570	44.21	14.38	44.21	14.38
0.17	0.CC2667	0.57295	0.00502	64.31	15.04	64.31	15.04
0.27	0.CC4333	0.61836	0.00541	104.51	16.23	104.51	16.23
0.38	0.CC6000	C.63768	0.00560	144.70	16.74	144.70	16.74
0.59	0.CC9333	0.67633	0.00473	225.09	17.76	225.09	17.76
0.85	0.013499	0.70918	0.00493	325.57	18.62	325.57	18.62
1.11	0.017666	0.73623	0.00386	426.06	19.33	426.06	19.33
1.64	0.025999	0.77295	0.00271	627.03	20.29	627.03	20.29
2.16	0.034332	C.80290	0.00280	828.01	21.08	828.01	21.08
2.69	0.042665	C.82802	0.00145	1028.98	21.74	1028.98	21.74
3.22	0.C5C998	0.84638	0.00145	1229.95	22.22	1229.95	22.22
4.27	0.C67664	C.88309	0.00155	1631.89	23.18	1631.89	23.18
5.32	0.C84330	0.91401	0.00319	2033.84	24.00	2033.84	24.00
6.63	0.1C5162	0.94300	0.00329	2536.27	24.76	2536.27	24.76
7.94	0.125995	0.96618	0.00338	3038.70	25.37	3038.70	25.37
9.26	0.146827	C.98164	0.00174	3541.13	25.77	3541.13	25.77
10.57	0.167660	0.99227	0.00174	4043.56	26.05	4043.56	26.05
13.20	0.2C9325	C.99903	0.00174	5048.42	26.23	5048.42	26.23
15.82	0.250990	C.99903	0.00000	6053.28	26.23	6053.28	26.23
18.45	0.292655	1.00000	0.00000	7058.14	26.25	7058.14	26.25

JOHNSTON INFINITE SWEPT STEP IDENT 56.

PROFILE NUMBER 2 X = 0.250 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.06	0.001000	0.48300	0.01353	23.12	13.25	23.12	13.26
0.11	0.002000	0.52158	0.01279	46.23	14.31	46.23	14.32
0.16	0.002833	0.56594	0.01281	65.50	15.53	65.50	15.53
0.25	0.004500	0.60259	0.01371	104.03	16.53	104.03	16.54
0.34	0.006166	0.62381	0.01309	142.55	17.12	142.55	17.12
0.43	0.007833	0.64222	0.01229	181.08	17.62	181.08	17.63
0.52	0.009333	0.65862	0.01033	215.76	18.07	215.76	18.07
0.75	0.013499	0.68466	0.01077	312.08	18.79	312.08	18.79
0.98	0.017666	0.72420	0.01012	408.40	19.87	408.40	19.87
1.44	0.025999	0.75602	0.00795	601.03	20.74	601.03	20.75
1.90	0.034332	0.78302	0.00684	793.67	21.49	793.67	21.49
2.37	0.042665	0.80809	0.00708	986.31	22.17	986.31	22.17
2.83	0.050998	0.82844	0.00579	1178.95	22.73	1178.95	22.73
3.75	0.067664	0.86982	0.00611	1564.23	23.87	1564.23	23.87
4.68	0.084330	0.89971	0.00625	1949.51	24.69	1949.51	24.69
5.83	0.105162	0.92961	0.00649	2431.11	25.51	2431.11	25.51
6.99	0.125995	0.95275	0.00500	2912.71	26.14	2912.71	26.14
8.15	0.146827	0.97108	0.00507	3394.30	26.65	3394.30	26.65
9.30	0.167660	0.98361	0.00340	3875.90	26.99	3875.90	26.99
10.46	0.188492	0.98843	0.00349	4357.50	27.12	4357.50	27.12
11.61	0.209325	0.99422	0.00348	4839.10	27.28	4839.10	27.28
13.92	0.250990	0.99807	0.00000	5802.29	27.39	5802.29	27.39
16.24	0.292655	1.00000	0.00000	6765.49	27.44	6765.49	27.44

JOHNSTON INFINITE SWEPT STEP IDENT 56.

PROFILE NUMBER 3 X = 0.500 FT

Y/THIL	Y (FT)	LS/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.05	0.001000	0.43706	0.04289	21.59	12.80	21.65	12.83
0.08	0.001833	0.48852	0.04272	39.58	14.31	39.68	14.33
0.12	0.002667	0.51658	0.04431	57.57	15.13	57.72	15.15
0.20	0.004333	0.54984	0.04133	93.55	16.11	93.80	16.11
0.27	0.006000	0.57499	0.04120	129.52	16.84	129.88	16.84
0.35	0.007666	0.59249	0.04043	165.50	17.36	165.95	17.35
0.42	0.009333	0.61290	0.04071	201.48	17.96	202.03	17.95
0.61	0.013499	0.64703	0.03734	291.43	18.96	292.22	18.94
0.80	0.017666	0.67034	0.03635	381.38	19.64	382.42	19.61
1.18	0.025999	0.71202	0.03362	561.27	20.86	562.80	20.83
1.56	0.034332	0.74209	0.03240	741.17	21.74	743.19	21.70
1.93	0.042665	0.76927	0.03090	921.06	22.54	923.57	22.49
2.31	0.050998	0.79731	0.02921	1100.96	23.36	1103.96	23.31
3.07	0.067664	0.83124	0.02468	1460.74	24.35	1464.72	24.30
3.82	0.084330	0.86799	0.02429	1820.53	25.43	1825.49	25.37
4.77	0.105162	0.90183	0.02044	2270.27	26.42	2276.46	26.36
5.71	0.125995	0.93066	0.02116	2720.01	27.26	2727.42	27.20
6.66	0.146827	0.95384	0.01504	3169.74	27.94	3178.38	27.87
7.60	0.167660	0.96922	0.01525	3619.48	28.39	3629.34	28.32
8.55	0.188492	0.97984	0.01026	4069.22	28.71	4080.31	28.63
9.49	0.209325	0.98659	0.00694	4518.95	28.90	4531.27	28.83
11.38	0.250990	0.99421	0.00351	5418.43	29.13	5433.19	29.05
13.27	0.292655	1.00000	0.00000	6317.90	29.30	6335.11	29.22

JOHNSTON INFINITE SWEPT STEP IDENT 56.

PROFILE NUMBER 4 X = 0.625 FT

Y/THIC	Y (FT)	US/QINF	WS/QINF	Y+ (S)	U+	Y+ (M)	Q+
0.04	0.001000	0.39116	0.07892	19.88	12.49	20.06	12.63
0.07	0.001833	0.43984	0.08070	36.45	14.04	36.77	14.15
0.10	0.002667	0.46078	0.08373	53.02	14.71	53.49	14.82
0.16	0.004333	0.49605	0.08387	86.15	15.84	86.92	15.92
0.22	0.006000	0.52053	0.08342	119.29	16.62	120.35	16.68
0.28	0.007666	0.53931	0.08155	152.43	17.22	153.78	17.26
0.34	0.009333	0.55355	0.07779	185.56	17.67	187.21	17.69
0.50	0.013499	0.58504	0.07497	268.40	18.68	270.78	18.67
0.65	0.017666	0.61538	0.07235	351.24	19.65	354.36	19.61
0.96	0.025999	0.65668	0.06561	516.92	20.97	521.51	20.88
1.26	0.034332	0.68605	0.06126	682.60	21.90	688.66	21.80
1.57	0.042665	0.71880	0.05910	848.28	22.95	855.81	22.82
1.88	0.050998	0.74315	0.05460	1013.96	23.73	1022.96	23.58
2.49	0.067664	0.78678	0.05092	1345.32	25.12	1357.26	24.95
3.10	0.084330	0.82242	0.04749	1676.68	26.26	1691.56	26.07
3.87	0.105162	0.86180	0.04221	2090.88	27.51	2109.43	27.31
4.64	0.125995	0.89434	0.03755	2505.08	28.55	2527.31	28.33
5.40	0.146827	0.92312	0.03224	2919.27	29.47	2945.18	29.23
6.17	0.167660	0.95367	0.03164	3333.47	30.45	3363.06	30.20
6.93	0.188492	0.96720	0.02365	3747.67	30.88	3780.93	30.62
7.70	0.209325	0.97392	0.01878	4161.87	31.09	4198.81	30.83
9.23	0.250990	0.98925	0.00692	4990.27	31.58	5034.56	31.31
10.77	0.292655	1.00000	0.00000	5818.66	31.93	5870.31	31.65

JOHNSTON INFINITE SWEPT STEP IDENT 56.

PROFILE NUMBER 5 X = C.690 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.03	0.0C1000	0.35467	0.09903	18.53	12.18	18.94	12.37
0.06	0.001833	C.40318	0.10725	33.97	13.85	34.72	14.02
0.09	0.002667	0.42359	0.11268	49.41	14.55	50.51	14.73
0.14	0.004333	0.45541	0.11265	80.29	15.64	82.08	15.76
0.20	0.C06000	0.48108	0.11285	111.17	16.52	113.64	16.60
0.25	0.007666	0.49856	0.10956	142.05	17.12	145.21	17.15
0.31	0.009333	C.51730	0.10904	172.93	17.77	176.78	17.76
0.39	0.011833	0.53554	0.10603	219.26	18.39	224.13	18.34
0.48	0.014333	0.55456	0.10378	265.58	19.05	271.48	18.96
0.59	0.017666	0.57715	0.10276	327.34	19.82	334.61	19.70
0.86	0.025999	C.61746	0.09334	481.74	21.21	492.45	20.98
1.14	0.034332	C.65299	0.08713	636.15	22.43	650.29	22.13
1.42	0.042665	0.68631	0.08180	790.56	23.57	808.12	23.22
1.69	0.C50998	0.70956	0.07952	944.96	24.37	965.96	23.99
2.25	0.067664	C.75045	0.07087	1253.77	25.77	1281.63	25.33
2.80	0.084330	C.79157	0.06780	1562.58	27.19	1597.31	26.69
3.49	0.105162	0.8368C	0.05998	1948.60	28.74	1991.90	28.19
4.18	0.125995	C.87581	0.05663	2334.61	30.08	2386.49	29.49
4.87	0.146827	C.90862	0.04756	2720.62	31.21	2781.08	30.57
5.56	0.167660	0.93434	0.04074	3106.64	32.09	3175.68	31.42
6.25	0.188492	C.95438	0.03329	3492.65	32.78	3570.27	32.08
6.95	0.209325	C.96962	0.02703	3878.67	33.30	3964.86	32.59
8.33	0.250990	C.98713	0.01547	4650.69	33.90	4754.04	33.17
9.71	0.292655	1.C000C	0.00000	5422.72	34.34	5543.23	33.60

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JOHNSTON INFINITE SWEPT STEP IDENT 56.

PROFILE NUMBER 6 X = 0.750 FT

Y/THIL	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.03	0.001000	0.30395	0.14234	16.53	11.76	17.65	12.17
0.05	0.001833	0.34477	0.15427	30.30	13.34	32.35	13.69
0.08	0.002667	0.36743	0.15746	44.08	14.22	47.06	14.49
0.13	0.004333	0.39889	0.15628	71.62	15.44	76.47	15.53
0.17	0.006000	0.42184	0.15775	99.17	16.33	105.88	16.33
0.22	0.007666	0.44164	0.15635	126.72	17.09	135.29	16.98
0.27	0.009333	0.45943	0.15456	154.27	17.78	164.70	17.57
0.34	0.011833	0.47961	0.15116	195.59	18.56	208.82	18.23
0.41	0.014333	0.49855	0.14765	236.91	19.29	252.93	18.85
0.51	0.017666	0.52332	0.14415	292.01	20.25	311.75	19.68
0.63	0.021832	0.54667	0.13731	360.88	21.16	385.28	20.43
0.75	0.025999	0.56944	0.13142	429.75	22.04	458.80	21.19
0.99	0.034332	0.60283	0.12488	567.49	23.33	605.86	22.32
1.23	0.042665	0.63325	0.11508	705.23	24.51	752.91	23.33
1.48	0.050998	0.66176	0.10958	842.97	25.61	899.96	24.32
1.72	0.059331	0.68500	0.10599	980.71	26.51	1047.02	25.13
1.96	0.067664	0.71035	0.10106	1118.44	27.49	1194.07	26.01
2.20	0.075997	0.72872	0.09717	1256.18	28.20	1341.12	26.65
2.44	0.084330	0.74881	0.09195	1393.92	28.98	1488.17	27.35
3.04	0.105162	0.79349	0.08342	1738.27	30.71	1855.81	28.92
3.65	0.125995	0.83472	0.07297	2082.62	32.31	2223.44	30.37
4.25	0.146827	0.87280	0.06251	2426.97	33.78	2591.07	31.72
4.85	0.167660	0.90342	0.05205	2771.32	34.96	2958.70	32.80
6.06	0.209325	0.95136	0.03482	3460.02	36.82	3693.97	34.51
7.26	0.250990	0.98945	0.01547	4148.71	38.29	4429.23	35.87
8.47	0.292655	1.00000	0.00000	4837.41	38.70	5164.50	36.25

JOHNSTON INFINITE SWEPT STEP IDENT 56.

PROFILE NUMBER 7 X = 0.811 FT

Y/THIC	Y (FT)	US/QINF	WS/QINF	Y+ (S)	US+	Y+ (M)	Q+
0.02	0.CC1000	0.23207	0.16676	13.82	10.89	15.82	11.72
0.05	0.CC1833	0.27416	0.19054	25.34	12.86	29.01	13.69
0.07	0.002667	C.29324	0.19935	36.86	13.76	42.19	14.54
0.11	0.004333	C.31640	0.20545	59.90	14.85	68.57	15.47
0.15	0.CC6CCO	C.33526	0.20549	82.94	15.73	94.94	16.12
0.19	0.CC7666	0.35121	0.20438	105.98	16.48	121.31	16.66
0.23	0.CC9333	0.36659	0.20401	129.01	17.20	147.68	17.20
0.27	0.C11000	C.38150	0.20204	152.05	17.90	174.05	17.70
0.36	0.014333	0.40775	0.19798	198.13	19.13	226.79	18.58
0.44	0.017666	C.42939	0.19115	244.21	20.15	279.54	19.27
0.54	0.021832	0.45405	0.18529	301.80	21.31	345.47	20.10
0.65	0.025999	C.48079	0.17783	359.40	22.56	411.39	21.01
0.85	0.034332	C.52087	0.16519	474.59	24.44	543.25	22.40
1.06	0.042665	C.55801	0.15479	589.78	26.18	675.11	23.74
1.27	0.050998	C.58788	0.14444	704.97	27.59	806.97	24.82
1.68	0.067664	0.64021	0.13377	935.35	30.04	1070.68	26.81
2.10	C.C84330	0.68517	0.12324	1165.74	32.15	1334.40	28.54
2.61	0.105162	0.73647	0.11134	1453.72	34.56	1664.04	30.53
3.13	0.125995	C.77995	0.09712	1741.69	36.60	1993.68	32.22
3.65	0.146827	0.82521	0.08527	2029.67	38.72	2323.33	34.01
4.17	0.167660	0.86293	0.07242	2317.65	40.49	2652.97	35.50
4.68	0.188492	0.90037	0.05976	2605.63	42.25	2982.61	36.99
5.20	0.209325	C.92884	0.04704	2893.61	43.59	3312.26	38.13
6.24	0.250990	C.97004	0.02205	3469.57	45.52	3971.54	39.78
7.27	0.292655	1.00000	-0.00000	4045.52	46.93	4630.83	40.99