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Tables For Correcting Airfoil Data Obtained in the Langley 0.3-Meter Transonic Cryogenic Tunnel For Sidewall Boundary Layer Effects

(NASA-TM-87723) TABLES FOR CORRECTING AIRFOIL DATA OBTAINED IN THE LANGLEY 0.3-METER TRANSCNIC CRYOGENIC TUNNEL FOR SIDEWALL BOUNDARY-LAYER EFFECTS (NASA) 16 p HC A02/MF A01 CSCL 01A G3/02

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INTRODUCTION

One of the test sections for the 0.3-Meter Transonic Cryogenic Tunnel is a two-dimensional slotted wall configuration which was designed according to the classical linear wall interference precepts and empirical data of reference 1. The slotted top and bottom walls of the 0.3-m TCT are designed to have nearly zero blockage and the corrections to the Mach number and flow curvature, for their effect should be minimal. The solid sidewalls, on the other hand, have boundary layers which interact with the model pressure field and must be taken into account. As with all transonic two-dimensional tunnels, the data from this tunnel is subject to corrections for wall interference. A partial list of current wall correction procedures is as follows:

1. Sidewalls only (refs. 2 and 3)
2. Top and bottom walls only (refs. 4 and 5)
3. All four walls (refs. 6 and 7)

During the time period from mid 1978 to the fall of 1984, a large number of airfoils were tested in the 0.3-m TCT to obtain aerodynamic data over a large range of Reynolds number. Much of the data from the 0.3-m TCT have been published without wall corrections and, in this regard, is comparable to the data previously published from other facilities.

Experience with correcting two-dimensional data from this tunnel indicates (ref. 8) that the data should at least be corrected for the significant Mach number change due to the sidewall boundary-layer effects. In addition, if an angle-of-attack correction is desired, the data must be corrected for top and bottom wall effects (ref. 9). The present paper provides tables for the 0.3-m TCT that can be used to correct airfoil data for the effects of the sidewalls based on the method of reference 3.

WIND TUNNEL AND DATA

The 0.3-m TCT is a continuous flow, fan driven, transonic tunnel which uses nitrogen gas as the test medium. As detailed in reference 10, the tunnel with the two-dimensional insert is capable of operating at temperatures from about 78K to about 327K and stagnation pressures from slightly greater than 1.0 atmosphere to 6.0 atmospheres. Mach number can be varied from about 0.20 to 0.90. The ability to operate at cryogenic temperatures combined with the six atmosphere pressure capability provides a high Reynolds number capability at relatively low model loading. More information on the design and operational capabilities of the 0.3-m TCT can be found in references 10 and 11. Information on the use of nitrogen as a test gas can be found in reference 12.

The 0.3-m TCT operating conditions can be controlled to the following accuracies:

Total temperature	± 0.10K
Total pressure	± 0.007 atm
Free-stream Mach number	± 0.003

A momentum rake is located downstream of the airfoil and provides up to six total pressure measurements across the span of the model and can traverse vertically from about one chord above to about one-half chord below the model. Integration of these pressure measurements provides the profile-drag coefficients. Integration of the measured airfoil model surface pressures provides normal-force coefficients and quarter-chord pitching-moment coefficients.

METHOD

The correction tables in this report are based on the theory of reference 3. For our present purpose, equations 14 and 16 of reference 3, which give the relationships between the measured Mach number and pressure coefficient, and an interference-free equivalent Mach number and pressure coefficient are the most important. Those equations in full form are:

$$\frac{\text{Mdbar}}{\text{(SQRT(1-Mdbar**2))**(3/4)}} = \frac{\text{M}}{\text{(SQRT(1-M**2+2*ds/b*(2+1/H-M**2))**(3/2)}}$$

and

$$\text{Cpdbar} = \frac{\text{(SQRT(1-M+2*ds/b*(2+1/H-M**2))*Cp}}{\text{SQRT(1-Mdbar**2)}}$$

where:

b	= model span (8 inches)
ds	= boundary layer displacement thickness in inches
H	= boundary layer shape factor
M	= measured free-stream Mach number
Mdbar	= interference-free equivalent free-stream Mach number
Cp	= measured pressure coefficient
Cpdbar	= interference-free equivalent pressure coefficient

This theory requires a knowledge of the boundary layer displacement thickness (delta star) and shape factor on the tunnel sidewalls. Delta star must be measured directly or indirectly calculated. Measuring the delta star for every test combination of Reynolds and Mach number is a tremendous task; thus, the ability to calculate delta star is very helpful.

The approach used here, to calculate delta star, is primarily based on empirical relationships which originate in the T'(T-prime) method of reference 13. The original work of reference 13 is expanded and cast in a slightly different form in reference 14.

Empirical relationships (ref. 14) between skin friction and Reynolds number and Mach number and shape factor can be combined with the relationship between shape factor, skin friction, and the distance from the beginning of the boundary layer to calculate delta star. It will be noted that a procedure that uses this approach requires a prior knowledge of the origin of the boundary layer. The sidewall boundary layer in the test section is a continuation of the boundary layer of the rest of the tunnel, and the origin is not directly discernible as with a flat plate where the leading edge is the origin.

This difficulty was attacked in the following manner. Early in the test series, the sidewall boundary layer thickness was measured for several test conditions with solid sidewalls at a location ahead of the airfoil and extrapolated to the center of the turntables. With these values in hand, a program was developed to determine the values of distance from the origin that produced the indicated delta stars at the center of the turntable. The virtual origin distance, determined in an iterative fashion, can then be used to calculate delta star at other test conditions.

RESULTS AND DISCUSSION

The average distance from the virtual origin (XJ) was found to be 49.5 inches, and it was permanently included in the program. The theory of reference 3 was then combined with the boundary layer displacement thickness calculation of the program to generate the correction tables given in Table I. This table contains measured Mach number (MACH NUMBER), the corrected Mach number (EFF. MACH), the change in Mach number (DELMACH), the correction factor (CFACTOR), and the calculated boundary layer displacement thickness in inches (DELSTAR).

As mentioned earlier, the virtual origin distance was indirectly determined from measurement of the boundary layer displacement thickness (delta star) in the test section, and it in effect averages sidewall differences due to different Reynolds number and Mach numbers. This averaging may give rise to questions regarding how accurate the virtual distance value must be to get good correction tables. Table II was produced to determine what effect a 20-percent error in the virtual origin distance has on the correction values. It can be determined from Table II that a 20-percent decrease in the virtual origin distance from 49.5 inches to 39.6 inches produces a decrease of less than 0.3 percent in the correction factor and a 16- to 20-percent decrease in the boundary layer displacement thickness. On the other hand, an increase of 20 percent to a value of 59.4 inches results in an increase of less than 0.3 percent for the correction factor and an increase of 16 to 18 percent in the boundary layer displacement thickness. In both cases, the change in effective Mach number is within 0.003 or the Mach number control error. Both effective Mach number and the correction factor value, which are used for the sidewall correction, are relatively unaffected by a $\pm$20-percent change in the virtual origin distance. Table II is for a Reynolds number of 30 million only; however, calculations for the other values of Reynolds number show similar results.

Table I is arranged in the order of increasing Reynolds number. Tables are presented for typical test Reynolds number values of 4, 6, 10, 15, 20, 30, 40, 45, and 47.6 million.

Table I is applied as follows:

1. Find the table for the tested Reynolds number.
2. Find the measured test Mach number and read the corresponding values for EFF. MACH, and CFACTOR.
3. The corrected Mach number is now known, and any measured pressure coefficient or value based on pressure coefficient can be corrected by multiplying the measured value by CFACTOR (i.e., the corrected normal-force, pitching moment, and drag force coefficients are the measured values multiplied by CFACTOR).

Data for measured Mach numbers that do not appear in the tables can be corrected by linear interpolation in the tables.

Some of the tests included in the airfoil test series (for example ref. 15) were conducted with perforated sidewall inserts installed upstream of the airfoil in the test section. The purpose of the perforated inserts was to enable removal of a portion of the sidewall boundary layer. Tests have been conducted to determine if the presence of the perforated inserts affected the displacement thickness of the sidewall boundary layer. Table III give comparisons of boundary layer displacement thickness (delta star) measured for various Reynolds and Mach numbers with perforated sidewalls but no boundary layer removal to values calculated for solid sidewalls. The agreement between the measured and calculated values suggests that the presence of the perforated sidewalls without boundary layer removal does not alter the sidewall boundary layer displacement thickness. If boundary layer removal is actually employed, an additional correction is required to account for the change in test section mass flow (ref. 16).

CONCLUSIONS

Tables to correct 0.3-m TCT airfoil data for the presence of the sidewall boundary layer have been presented. Significant conclusions are:

1. The corrected Mach number and the correction factor are minutely changed by a 20-percent change in the virtual origin distance.

2. The sidewall boundary layer displacement thicknesses measured with perforated sidewall inserts and without boundary layer removal agree with the values calculated for solid sidewalls.

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TABLE I.-DATA CORRECTION TABLES.

(a) REYNOLDS NUMBER = 4.00 MILLION; XJ = 49.5 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.600	0.582	0.018	1.021	0.085
0.610	0.592	0.018	1.021	0.085
0.620	0.601	0.019	1.020	0.085
0.630	0.611	0.019	1.020	0.086
0.640	0.621	0.019	1.020	0.086
0.650	0.631	0.019	1.020	0.086
0.660	0.641	0.019	1.020	0.086
0.670	0.651	0.019	1.020	0.087
0.680	0.661	0.019	1.019	0.087
0.690	0.671	0.019	1.019	0.087
0.700	0.681	0.019	1.019	0.087
0.710	0.690	0.020	1.019	0.088
0.720	0.700	0.020	1.019	0.088
0.730	0.710	0.020	1.018	0.088
0.740	0.720	0.020	1.018	0.088
0.750	0.730	0.020	1.018	0.089
0.760	0.740	0.020	1.018	0.089
0.770	0.750	0.020	1.018	0.089
0.780	0.760	0.020	1.017	0.090
0.790	0.770	0.020	1.017	0.090
0.800	0.780	0.020	1.017	0.090
0.810	0.790	0.020	1.017	0.091
0.820	0.800	0.020	1.017	0.091
0.830	0.810	0.020	1.016	0.091
0.840	0.820	0.020	1.016	0.091
0.850	0.830	0.020	1.016	0.092
0.860	0.840	0.020	1.016	0.092
0.870	0.850	0.020	1.016	0.092
0.880	0.860	0.020	1.015	0.093
0.890	0.870	0.020	1.015	0.093
0.900	0.880	0.020	1.015	0.093

TABLE I.-Continued.

(b) REYNOLDS NUMBER = 6.00 MILLION; XJ = 49.5 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.600	0.583	0.017	1.020	0.080
0.610	0.593	0.017	1.019	0.080
0.620	0.602	0.018	1.019	0.080
0.630	0.612	0.018	1.019	0.081
0.640	0.622	0.018	1.019	0.081
0.650	0.632	0.018	1.019	0.081
0.660	0.642	0.018	1.019	0.081
0.670	0.652	0.018	1.018	0.081
0.680	0.662	0.018	1.018	0.082
0.690	0.672	0.018	1.018	0.082
0.700	0.682	0.018	1.018	0.082
0.710	0.692	0.018	1.018	0.082
0.720	0.701	0.019	1.018	0.083
0.730	0.711	0.019	1.017	0.083
0.740	0.721	0.019	1.017	0.083
0.750	0.731	0.019	1.017	0.084
0.760	0.741	0.019	1.017	0.084
0.770	0.751	0.019	1.017	0.084
0.780	0.761	0.019	1.016	0.084
0.790	0.771	0.019	1.016	0.085
0.800	0.781	0.019	1.016	0.085
0.810	0.791	0.019	1.016	0.085
0.820	0.801	0.019	1.016	0.086
0.830	0.811	0.019	1.015	0.086
0.840	0.821	0.019	1.015	0.086
0.850	0.831	0.019	1.015	0.086
0.860	0.841	0.019	1.015	0.087
0.870	0.851	0.019	1.015	0.087
0.880	0.861	0.019	1.014	0.087
0.890	0.871	0.019	1.014	0.088
0.900	0.881	0.019	1.014	0.088

TABLE I.-Continued.

(c) REYNOLDS NUMBER = 10.00 MILLION; XJ = 49.5 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.600	0.584	0.016	1.018	0.074
0.610	0.594	0.016	1.018	0.074
0.620	0.604	0.016	1.018	0.075
0.630	0.614	0.016	1.018	0.075
0.640	0.623	0.017	1.018	0.075
0.650	0.633	0.017	1.017	0.075
0.660	0.643	0.017	1.017	0.075
0.670	0.653	0.017	1.017	0.076
0.680	0.663	0.017	1.017	0.076
0.690	0.673	0.017	1.017	0.076
0.700	0.683	0.017	1.017	0.076
0.710	0.693	0.017	1.016	0.077
0.720	0.703	0.017	1.016	0.077
0.730	0.713	0.017	1.016	0.077
0.740	0.723	0.017	1.016	0.077
0.750	0.733	0.017	1.016	0.078
0.760	0.743	0.017	1.016	0.078
0.770	0.753	0.017	1.015	0.078
0.780	0.763	0.017	1.015	0.078
0.790	0.773	0.017	1.015	0.079
0.800	0.782	0.018	1.015	0.079
0.810	0.792	0.018	1.015	0.079
0.820	0.802	0.018	1.015	0.079
0.830	0.812	0.018	1.014	0.080
0.840	0.822	0.018	1.014	0.080
0.850	0.833	0.017	1.014	0.080
0.860	0.843	0.017	1.014	0.080
0.870	0.853	0.017	1.014	0.081
0.880	0.863	0.017	1.013	0.081
0.890	0.873	0.017	1.013	0.081
0.900	0.883	0.017	1.013	0.082

TABLE I.-Continued.

(d) REYNOLDS NUMBER = 15.00 MILLION; XJ = 49.5 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.600	0.585	0.015	1.017	0.070
0.610	0.595	0.015	1.017	0.070
0.620	0.605	0.015	1.017	0.070
0.630	0.614	0.016	1.017	0.071
0.640	0.624	0.016	1.017	0.071
0.650	0.634	0.016	1.016	0.071
0.660	0.644	0.016	1.016	0.071
0.670	0.654	0.016	1.016	0.071
0.680	0.664	0.016	1.016	0.072
0.690	0.674	0.016	1.016	0.072
0.700	0.684	0.016	1.016	0.072
0.710	0.694	0.016	1.016	0.072
0.720	0.704	0.016	1.015	0.073
0.730	0.714	0.016	1.015	0.073
0.740	0.724	0.016	1.015	0.073
0.750	0.734	0.016	1.015	0.073
0.760	0.744	0.016	1.015	0.073
0.770	0.754	0.016	1.015	0.074
0.780	0.763	0.017	1.014	0.074
0.790	0.773	0.017	1.014	0.074
0.800	0.783	0.017	1.014	0.074
0.810	0.793	0.017	1.014	0.075
0.820	0.803	0.017	1.014	0.075
0.830	0.813	0.017	1.014	0.075
0.840	0.823	0.017	1.013	0.075
0.850	0.833	0.017	1.013	0.076
0.860	0.843	0.017	1.013	0.076
0.870	0.854	0.016	1.013	0.076
0.880	0.864	0.016	1.013	0.077
0.890	0.874	0.016	1.012	0.077
0.900	0.884	0.016	1.012	0.077

TABLE I.-Continued.

(e) REYNOLDS NUMBER = 20.00 MILLION; XJ = 49.5 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.600	0.585	0.015	1.017	0.067
0.610	0.595	0.015	1.016	0.067
0.620	0.605	0.015	1.016	0.068
0.630	0.615	0.015	1.016	0.068
0.640	0.625	0.015	1.016	0.068
0.650	0.635	0.015	1.016	0.068
0.660	0.645	0.015	1.016	0.068
0.670	0.655	0.015	1.016	0.069
0.680	0.665	0.015	1.015	0.069
0.690	0.675	0.015	1.015	0.069
0.700	0.684	0.016	1.015	0.069
0.710	0.694	0.016	1.015	0.070
0.720	0.704	0.016	1.015	0.070
0.730	0.714	0.016	1.015	0.070
0.740	0.724	0.016	1.014	0.070
0.750	0.734	0.016	1.014	0.070
0.760	0.744	0.016	1.014	0.071
0.770	0.754	0.016	1.014	0.071
0.780	0.764	0.016	1.014	0.071
0.790	0.774	0.016	1.014	0.071
0.800	0.784	0.016	1.013	0.072
0.810	0.794	0.016	1.013	0.072
0.820	0.804	0.016	1.013	0.072
0.830	0.814	0.016	1.013	0.072
0.840	0.824	0.016	1.013	0.073
0.850	0.834	0.016	1.013	0.073
0.860	0.844	0.016	1.012	0.073
0.870	0.854	0.016	1.012	0.073
0.880	0.864	0.016	1.012	0.074
0.890	0.874	0.016	1.012	0.074
0.900	0.884	0.016	1.012	0.074

TABLE I.-Continued.

(f) REYNOLDS NUMBER = 30.00 MILLION; XJ = 49.5 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.600	0.586	0.014	1.016	0.064
0.610	0.596	0.014	1.016	0.064
0.620	0.606	0.014	1.015	0.064
0.630	0.616	0.014	1.015	0.064
0.640	0.626	0.014	1.015	0.064
0.650	0.636	0.014	1.015	0.065
0.660	0.646	0.014	1.015	0.065
0.670	0.655	0.015	1.015	0.065
0.680	0.665	0.015	1.015	0.065
0.690	0.675	0.015	1.014	0.065
0.700	0.685	0.015	1.014	0.066
0.710	0.695	0.015	1.014	0.066
0.720	0.705	0.015	1.014	0.066
0.730	0.715	0.015	1.014	0.066
0.740	0.725	0.015	1.014	0.066
0.750	0.735	0.015	1.014	0.067
0.760	0.745	0.015	1.013	0.067
0.770	0.755	0.015	1.013	0.067
0.780	0.765	0.015	1.013	0.067
0.790	0.775	0.015	1.013	0.068
0.800	0.785	0.015	1.013	0.068
0.810	0.795	0.015	1.013	0.068
0.820	0.805	0.015	1.012	0.068
0.830	0.815	0.015	1.012	0.068
0.840	0.825	0.015	1.012	0.069
0.850	0.835	0.015	1.012	0.069
0.860	0.845	0.015	1.012	0.069
0.870	0.855	0.015	1.012	0.069
0.880	0.865	0.015	1.012	0.070
0.890	0.875	0.015	1.011	0.070
0.900	0.885	0.015	1.011	0.070

TABLE I.-Continued.

(g) REYNOLDS NUMBER = 40.00 MILLION; XJ = 49.5 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.600	0.587	0.013	1.015	0.061
0.610	0.597	0.013	1.015	0.062
0.620	0.606	0.014	1.015	0.062
0.630	0.616	0.014	1.015	0.062
0.640	0.626	0.014	1.015	0.062
0.650	0.636	0.014	1.014	0.062
0.660	0.646	0.014	1.014	0.062
0.670	0.656	0.014	1.014	0.063
0.680	0.666	0.014	1.014	0.063
0.690	0.676	0.014	1.014	0.063
0.700	0.686	0.014	1.014	0.063
0.710	0.696	0.014	1.014	0.063
0.720	0.706	0.014	1.013	0.064
0.730	0.716	0.014	1.013	0.064
0.740	0.726	0.014	1.013	0.064
0.750	0.736	0.014	1.013	0.064
0.760	0.746	0.014	1.013	0.064
0.770	0.756	0.014	1.013	0.065
0.780	0.765	0.015	1.013	0.065
0.790	0.775	0.015	1.012	0.065
0.800	0.785	0.015	1.012	0.065
0.810	0.795	0.015	1.012	0.065
0.820	0.805	0.015	1.012	0.066
0.830	0.815	0.015	1.012	0.066
0.840	0.825	0.015	1.012	0.066
0.850	0.835	0.015	1.012	0.066
0.860	0.846	0.014	1.011	0.067
0.870	0.856	0.014	1.011	0.067
0.880	0.866	0.014	1.011	0.067
0.890	0.876	0.014	1.011	0.067
0.900	0.886	0.014	1.011	0.067

TABLE I.-Continued.

(h) REYNOLDS NUMBER = 45.00 MILLION; XJ = 49.5 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.600	0.587	0.013	1.015	0.060
0.610	0.597	0.013	1.015	0.061
0.620	0.607	0.013	1.015	0.061
0.630	0.617	0.013	1.014	0.061
0.640	0.626	0.014	1.014	0.061
0.650	0.636	0.014	1.014	0.061
0.660	0.646	0.014	1.014	0.061
0.670	0.656	0.014	1.014	0.062
0.680	0.666	0.014	1.014	0.062
0.690	0.676	0.014	1.014	0.062
0.700	0.686	0.014	1.014	0.062
0.710	0.696	0.014	1.013	0.062
0.720	0.706	0.014	1.013	0.063
0.730	0.716	0.014	1.013	0.063
0.740	0.726	0.014	1.013	0.063
0.750	0.736	0.014	1.013	0.063
0.760	0.746	0.014	1.013	0.063
0.770	0.756	0.014	1.013	0.064
0.780	0.766	0.014	1.012	0.064
0.790	0.776	0.014	1.012	0.064
0.800	0.786	0.014	1.012	0.064
0.810	0.796	0.014	1.012	0.064
0.820	0.806	0.014	1.012	0.065
0.830	0.816	0.014	1.012	0.065
0.840	0.826	0.014	1.012	0.065
0.850	0.836	0.014	1.011	0.065
0.860	0.846	0.014	1.011	0.065
0.870	0.856	0.014	1.011	0.066
0.880	0.866	0.014	1.011	0.066
0.890	0.876	0.014	1.011	0.066
0.900	0.886	0.014	1.011	0.066

TABLE I.-Concluded.

(i) REYNOLDS NUMBER = 47.60 MILLION; XJ = 49.5 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.600	0.587	0.013	1.015	0.060
0.610	0.597	0.013	1.015	0.060
0.620	0.607	0.013	1.014	0.060
0.630	0.617	0.013	1.014	0.060
0.640	0.627	0.013	1.014	0.061
0.650	0.636	0.014	1.014	0.061
0.660	0.646	0.014	1.014	0.061
0.670	0.656	0.014	1.014	0.061
0.680	0.666	0.014	1.014	0.061
0.690	0.676	0.014	1.014	0.062
0.700	0.686	0.014	1.013	0.062
0.710	0.696	0.014	1.013	0.062
0.720	0.706	0.014	1.013	0.062
0.730	0.716	0.014	1.013	0.062
0.740	0.726	0.014	1.013	0.062
0.750	0.736	0.014	1.013	0.063
0.760	0.746	0.014	1.013	0.063
0.770	0.756	0.014	1.012	0.063
0.780	0.766	0.014	1.012	0.063
0.790	0.776	0.014	1.012	0.063
0.800	0.786	0.014	1.012	0.064
0.810	0.796	0.014	1.012	0.064
0.820	0.806	0.014	1.012	0.064
0.830	0.816	0.014	1.012	0.064
0.840	0.826	0.014	1.011	0.065
0.850	0.836	0.014	1.011	0.065
0.860	0.846	0.014	1.011	0.065
0.870	0.856	0.014	1.011	0.065
0.880	0.866	0.014	1.011	0.065
0.890	0.876	0.014	1.011	0.066
0.900	0.886	0.014	1.011	0.066

TABLE II-EFFECTS OF A 20 PERCENT ERROR IN THE VIRTUAL DISTANCE FROM THE ORIGIN.

(a) REYNOLDS NUMBER = 30.00 MILLION; XJ = 39.6 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.700	0.688	0.012	1.012	0.054
0.710	0.698	0.012	1.012	0.054
0.720	0.708	0.012	1.012	0.054
0.730	0.718	0.012	1.011	0.055
0.740	0.728	0.012	1.011	0.055
0.750	0.738	0.012	1.011	0.055
0.760	0.748	0.012	1.011	0.055
0.770	0.758	0.012	1.011	0.055
0.780	0.768	0.012	1.011	0.055
0.790	0.778	0.012	1.011	0.056
0.800	0.788	0.012	1.011	0.056
0.810	0.798	0.012	1.010	0.056
0.820	0.808	0.012	1.010	0.056
0.830	0.818	0.012	1.010	0.056
0.840	0.828	0.012	1.010	0.057
0.850	0.838	0.012	1.010	0.057
0.860	0.848	0.012	1.010	0.057
0.870	0.858	0.012	1.010	0.057
0.880	0.868	0.012	1.009	0.057
0.890	0.878	0.012	1.009	0.058
0.900	0.888	0.012	1.009	0.058

TABLE II-Continued.

(b) REYNOLDS NUMBER = 30.00 MILLION; XJ = 49.5 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.700	0.685	0.015	1.014	0.066
0.710	0.695	0.015	1.014	0.066
0.720	0.705	0.015	1.014	0.066
0.730	0.715	0.015	1.014	0.066
0.740	0.725	0.015	1.014	0.066
0.750	0.735	0.015	1.014	0.067
0.760	0.745	0.015	1.013	0.067
0.770	0.755	0.015	1.013	0.067
0.780	0.765	0.015	1.013	0.067
0.790	0.775	0.015	1.013	0.068
0.800	0.785	0.015	1.013	0.068
0.810	0.795	0.015	1.013	0.068
0.820	0.805	0.015	1.012	0.068
0.830	0.815	0.015	1.012	0.068
0.840	0.825	0.015	1.012	0.069
0.850	0.835	0.015	1.012	0.069
0.860	0.845	0.015	1.012	0.069
0.870	0.855	0.015	1.012	0.069
0.880	0.865	0.015	1.012	0.070
0.890	0.875	0.015	1.011	0.070
0.900	0.885	0.015	1.011	0.070

TABLE II-Concluded.

(c) REYNOLDS NUMBER = 30.00 MILLION; XJ = 59.4 INCHES.

MACH NUMBER	EFF. MACH	DELMACH	CFACTOR	DELSTAR (inches)
0.700	0.683	0.017	1.017	0.077
0.710	0.693	0.017	1.017	0.077
0.720	0.703	0.017	1.016	0.077
0.730	0.713	0.017	1.016	0.078
0.740	0.723	0.017	1.016	0.078
0.750	0.733	0.017	1.016	0.078
0.760	0.742	0.018	1.016	0.078
0.770	0.752	0.018	1.015	0.079
0.780	0.762	0.018	1.015	0.079
0.790	0.772	0.018	1.015	0.079
0.800	0.782	0.018	1.015	0.079
0.810	0.792	0.018	1.015	0.080
0.820	0.802	0.018	1.015	0.080
0.830	0.812	0.018	1.014	0.080
0.840	0.822	0.018	1.014	0.080
0.850	0.832	0.018	1.014	0.081
0.860	0.842	0.018	1.014	0.081
0.870	0.852	0.018	1.014	0.081
0.880	0.863	0.017	1.013	0.081
0.890	0.873	0.017	1.013	0.082
0.900	0.883	0.017	1.013	0.082

TABLE III.-COMPARISON OF THE MEASURED AND CALCULATED BOUNDARY LAYER DISPLACEMENT THICKNESS.

Mach Number	Measured* Delta Star (inches)	Calculated Delta Star (inches)
Reynolds number = 6 million		
0.730	0.078	0.083
0.765	0.081	0.084
Reynolds number = 10 million		
0.730	0.076	0.077
0.765	0.076	0.078
Reynolds number = 15 million		
0.600	0.068	0.070
0.700	0.072	0.072
0.730	0.072	0.073
0.750	0.071	0.073
0.765	0.073	0.074
0.780	0.071	0.074
0.790	0.072	0.074
0.800	0.076	0.074
0.820	0.074	0.075
0.840	0.076	0.075
0.860	0.074	0.076
Reynolds number = 20 million		
0.730	0.071	0.070
Reynolds number = 30 million		
0.600	0.067	0.064
0.700	0.070	0.066
0.730	0.067	0.066
0.750	0.069	0.067
0.765	0.069	0.067
0.780	0.069	0.067
0.790	0.070	0.067
0.800	0.072	0.068

*These measurements were performed with the perforated inserts in place but without boundary layer removal by Murthy and Johnson, senior authors of references 15, and 16.

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16. Abstract

This report presents tables for correcting airfoil data taken in the Langley 0.3-meter Transonic Cryogenic Tunnel for the presence of sidewall boundary layer. The corrected Mach number and the correction factor are minutely changed by a 20 percent change in the boundary layer virtual origin distance. The sidewall boundary layer displacement thicknesses measured for perforated sidewall inserts and without boundary layer removal agree with the values calculated for solid sidewalls.

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