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PERFORMANCE WITH AND WITHOUT INLET RADIAL DISTORTION OF A TRANSONIC FAN STAGE DESIGNED FOR REDUCED LOADING IN THE TIP REGION

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SUMMARY

A transonic compressor stage designed for a reduced loading in the tip region of the rotor blades was tested with and without inlet radial distortion. Three levels of tip radial distortion and one level of hub radial distortion produced by inlet screens were imposed on the inlet flow. The rotor was 50 centimeters in diameter and designed for an operating tip speed of 420 meters per second. For clean inlet flow, overall performance data is presented at 60, 70, 80, 90, and 100 percent of equivalent design speed. With distortion, overall performance data is presented at 70 and 100 percent of equivalent design speed. Blade-element performance parameters are presented for selected operating conditions at 100 percent design speed.

The clean inlet performance of rotor 21 and stage 21-18 compared favorably with design specifications. At design flow, a stage overall pressure ratio of 1.595 at an efficiency of 0.814 was achieved. The stage stall margin was only 8 percent and analysis of the data indicates that the flow around the damper appears to be critical and limited the stable operating range of this range.

With either tip or hub radial distortion, the overall pressure ratios for the rotor and stage were less than the undistorted values at any given flow rate and very little change in overall efficiency was noted. There was essentially no change in performance with radial distortion at 70 percent speed. For all levels of tip and hub radial distortion, there was a large reduction in the rotor stall margin.

INTRODUCTION

The stable operating range of a stage is limited by the breakdown of flow in one or more blade elements of the stage. Experience has indicated that the flow breakdown usually occurs first in the blade end regions (critical flow regions), particularly the rotor tip and the stator hub. For a given overall pressure ratio and speed, one potential method for increasing flow range is to decrease the blade loading of one or more of the critical blade elements. Such a reduction of design loading in a rotor tip region, for example, could also provide a greater tolerance to tip radial distortion.

The investigation reported herein studies the experimental performances of a stage when the design blade loading in the rotor tip region has been substantially reduced. In order to produce the same overall pressure ratio as a reference stage (ref. 1, which was designed for a constant spanwise pressure ratio), the blade loading (pressure ratio) levels in the midspan portion of the present rotor blade had to be relatively high, compared to the overall pressure ratio. Both stages were designed for an overall pressure ratio of 1.57 at a weight flow of 29.5 kilograms per second. The design rotor blade tip speed was 424.6 meters per second and rotor diameter was 50 centimeters. The subject stage was tested with inlet conditions of uniform (undistorted) flow, with just the backup or support screen (BUS), and with three levels of tip radial distortion. The tolerance of the new loading distribution to a hub radial distortion was also evaluated by testing with one magnitude of hub radial distortion. All distortion patterns covered approximately 40 percent of the annulus area at the fan face.

In this report the clean inlet performance is presented and discussed first. Particular attention is addressed to radial distributions of blade-element parameters and to the stable operating range limitations. Performance with the backup screen in place is presented, and differences between the backup screen and clean inlet performance are briefly considered. Distortion screens are attached to the backup screen so distortion performance is compared to the backup screen as reference, rather than to the clean inlet performance. The effects of three levels of tip radial distortion and one level of hub radial distortion are evaluated, and particular attention is given to the operation near stall in an attempt to identify the critical blade elements. This study was conducted at the NASA Lewis Research Center.

STAGE DESIGN

The overall design parameters for the test fan stage (designated stage 21-18) are listed in table I. The stage was designed for an overall pressure ratio of 1.57, a weight flow of 29.5 kilograms per second, and a specific flow of 198.4 kg/sec/m^2 of annulus area. The design blade tip speed was 424.6 meters per second. The stage was designed for rotor and stator tip solidities of 1.28 and 1.29, respectively. This resulted in 44 rotor blades having an aspect ratio of 2.5 and 48 stator blades of 2.4 aspect ratio. The inlet hub-tip ratio was 0.5. The design values of blade-element parameters for rotor 21 and stator 18 are presented in tables II and III, respectively. The rotor blade geometry is presented in table IV and the stator geometry in table V.

The area ratios less than 1.0 indicated in the rotor hub region from table IV were due to an error in the early design calculations. However, the aerodynamic performance data does not appear to be affected by this error. The rotor utilized a multiple circular arc (MCA) blade shape and the stator a double circular arc (DCA) blade shape.

Stage 21-18 design parameters were maintained as closely as possible with those of the reference stage (stage 11-4, ref. 1). The design overall flow, stage pressure ratio, and blade tip speed were the same. Both stages utilized the same annulus flow path (see fig. 1); hence the outer casing and certain other hardware were the same for both investigations. Blade chord length, aspect ratios, and solidity were very similar.

The most notable design feature of stage 21-18 is the radial distributions of design pressure ratio (blade loading). Design total pressure ratio for rotor 21 varied from 1.324 at the tip to a maximum of 1.721 at approximately 60 percent of the blade span from the tip, and then decreased to 1.458 at the hub; the corresponding aerodynamic blade loadings, in terms of diffusion factor D, were 0.27, 0.54, and 0.42, respectively. These rotor hub loadings were set in order to maintain stator hub loadings within acceptable levels.

The computer codes used to design stage 21-18 are described in references 2 and 3. A complete list of symbols is presented in appendix A. Equations for calculating overall and blade-element parameters are present in appendix B, and definitions and units of the parameters shown in the tables are listed in appendix C.

APPARATUS AND PROCEDURE

Compressor Test Facility

The compressor test facility is the same as that described in reference 1. A schematic view of the facility is shown in figure 2. For the present study, atmospheric air entered the test facility at an inlet on the roof of the building, flowed through the compressor test stage and was exhausted to a low pressure (6.754 newtons/cm^2 vacuum) exhaust system.

Test Stage

Rotor 21 is shown in figure 3(a)). The rotor has 44 blades and each blade is made with a vibration damper located at about 49 percent of span from the tip (see fig. 3(b)). The 48 cantilevered stator blades (fig. 4) are mounted to the outer casing.

Instrumentation

The compressor stage weight flow was determined from measurements on a calibrated thin-plate orifice. The orifice temperature was determined from an average of two Chromel-Alumel thermocouples. Orifice pressures were measured by calibrated transducers.

Radial surveys of the flow were made at three axial locations: about 2.3 centimeters upstream of the rotor, about half the distance (2.4 cm) between the rotor and stator, and approximately 50 percent of the stator chord downstream of the stator (see fig. 1). Two combination probes (fig. 5(a)) and two 8° C-shaped wedge probes (fig. 5(b)) were used at each axial measuring station. The probes are located 90° apart, with the two like probes located opposite each other (see fig. 6). The wedge probes were used to determine static pressure, and the combination probes were used to determine total pressure, total temperature, and flow angle. Each probe had associated null-balancing equipment that automatically alined the probe to the direction of flow. Iron-constantan thermocouples were used in the combination probe to determine stream temperatures. Calibrated transducers were used to measure all pressures.

Static pressure taps were also installed on both the outer and inner walls of the compressor casing. These static pressure taps were in stalled at the same axial and circumferential location as the probes (see fig. 6). The rotative speed of the test rotor was determined by an electronic speed counter. The test data were recorded by a central data recording system.

The estimated errors of the data, based on the inherent accuracies of the instrumentation and recording system, are as follows:

Weight flow, kg/sec	±0.3
Rotative speed, rpm	±30
Flow angle, deg	±1
Temperature, K	±0.6
Rotor inlet total pressure, N/cm^2	±0.01
Rotor outlet total pressure, N/cm^2	±0.10
Stator outlet total pressure, N/cm^2	±0.10
Rotor inlet static pressure, N/cm^2	±0.04
Rotor outlet static pressure, N/cm^2	±0.07
Stator outlet static pressure, N/cm^2	±0.07

Distortion Screens

The radial distortion screens used in this investigation were mounted on a backup screen and located in the inlet flow path about 35 centimeters upstream of the rotor, as shown in figure 1. This backup screen has a 0.037-centimeter wire diameter and a 1.9- by 1.9-centimeter clear opening. The eight support struts of the backup screen, which supports the distortion screens, are shown in figure 7. The radial distortion screens (see fig. 7) were designed to produce distortion over 40 percent of the area at the fan face. The distortion screens consist of a 7-mesh screen (seven wires per 2.54 cm) with a 0.081-centimeter wire diameter and a 20-mesh screen (twenty wires per 2.54 cm) with a 0.043-centimeter wire diameter. Only the 20-mesh screen was used for the hub distortion flow. In addition to the 7-mesh screen and the 20-mesh screen used for the tip distortion flows, a double screen combination consisting of both the 7-mesh and 20-mesh screens was also used. Different screen porosities produced by the different size mesh screens were picked to provide various magnitudes of radial distortion as defined by the usual distortion parameter:

$$(\text{Distortion parameter})_{\text{radial}} = \left(\frac{P_{max} - P_{min}}{P_{max}}\right)$$

Test and Calculation Procedures

With clean inlet flow, compressor test data were taken over a range of weight flows from maximum flow to stall at blade speeds of 70, 90, and 100 percent of equivalent design speed. At 50, 60, and 80 percent of design speed, radial surveys were made at the near-stall weight flow only. With distortion, test data were taken over a range of weight flows from maximum flow to stall at blade speeds of 70 and 100 percent of equivalent design speed. At 60, 80, and 90 percent of the design speed, radial surveys were made at the near-stall weight flow only. Data were recorded at 11 radial positions for each speed and weight flow. At each radial position the two combination probes were traversed across one blade passage to nine circumferentially different locations; values of total pressure, total temperature, and flow angle were recorded at each circumferential location.

Compressor stall points were established by increasing the back pressure on the compressor until an abrupt drop in total pressure ratio occurred. Also, fluctuations in compressor discharge pressure and blade stress were observed when stall was encountered. When the stall conditions were noted, the discharge throttle was immediately opened. The weight flow was then set close to the weight flow at which stall occurred, the radial survey data was taken at this near-stall condition. With the stall weight flow already known, the stall total pressure ratio was approximately by equating the ratio of the near-stall pressure ratio divided by the stall pressure ratio equal to the ratio of the near stall weight flow divided by the stall weight flow. From this relationship and the near-stall data the stall pressure ratio was easily obtained.

The data presented herein have been corrected to standard-day conditions. Measured outlet total temperatures and total pressures were corrected for Mach number and streamline slope according to the calibrations given in reference 4. Static pressure was also corrected for Mach number and streamline slope.

At the stator exit, circumferentially averaged values of the nine measurements of total pressure, total temperature, and flow angle were obtained for each radial position. The nine values of total temperature were mass averaged to obtain the total-temperature rise. The nine values of total pressure were energy averaged. The measured values of pressure, temperature, and flow angle were used to calculate axial and tangential velocities. To obtain the overall performance, the values of total temperature were radially mass-averaged, and the values of total pressure were energy averaged.

Blade-element and overall performance parameters were calculated in accordance with the equations defined in appendix B. The blade-element data have been translated from measurement stations along design streamlines to locations on the blade leading and trailing edges. The translation procedure described in reference 2 was used. In addition to translating the flow measurements along design streamlines, this translation procedure also assumes that angular momentum is conserved, that total pressure and total temperature is constant, and that the ratio of the product of the local density and axial velocity at the measuring station to its value at the blade edge is constant along the design streamlines.

RESULTS AND DISCUSSION

The overall performance data for the rotor and stage with clean inlet flow are presented first. (These data are tabulated in table VI for convenience). Radial distributions of various performance parameters are presented graphically and complete blade-element data are also tabulated in tables VII to XII. Some of these data for the rotor and stator are also presented in graphical form along with a short discussion.

With the backup screen in place the overall performance data for the rotor and stator are presented only in plotted form. The effect of the backup screen is briefly presented.

Finally, the overall performance data for the rotor and stage with three levels of tip radial distortion and one level of hub radial distortion are presented. (Complete tabulations are included as tables XIII to XVI). Radial distributions of various blade-element performance parameters are presented, and a general discussion of the radial distortion effects on the rotor and stage performance is then given. The performance with the backup screen (BUS) in the inlet (without the distortion screens) is used as a reference condition for assessing the effect of distortion on rotor and stage performance.

The abbreviations and units used for the tabular data are defined in appendix C.

Performance With Clean Inlet Flow

Overall performance. - The overall performance for rotor 21 is presented in figure 8, and the overall performance for the stage 21-18 is presented in figure 9. The total pressure, total temperature ratio, and efficiency are plotted as a function of equivalent weight flow for rotative speeds of 60, 70, 80, 90, and 100 percent of design speed. At 60 and 80 percent of design speed, data are presented only for the near-stall condition. The design point is indicated by the solid symbol.

The overall performance of rotor 21 and stage 21-18 compared very well with the design specifications. Specifically, the peak efficiency for rotor 21 at design speed is 0.847, compared to the design value of 0.854. At the 100 percent weight flow (29.47 (29.47 kg/sec), which was also very close to peak efficiency, the measured total pressure ratio of 1.632 is greater than the design value of 1.606.

For stage 21-18 the overall performance trends with respect to design values are similar to those for rotor 21. At design flow, the stage efficiency is 0.814, compared to the design value of 0.816. At this weight flow, the measured total pressure ratio of 1.595 is greater than the design values of 1.574. Peak stage efficiency of about 83 percent occurred at a flow (106 percent design flow) where the stage produced a pressure ratio of 1.557. This 83 percent peak efficiency is one point greater than design and two points higher than the maximum stage efficiency (0.81) measured from the reference stage, 11-4 (see ref. 1). Based on design flow, the stage stall margin is a little over 8 percent while, based on the peak efficiency operating point ($W = 1.06\ W_{des}$), the stall margin is about 14 percent. These values are disappointing as regards to the design intent of providing an increased stable operating range and do not represent any improvement over stall margin levels of the reference stage (11-4). Evidently, the spanwise loading used in this design results in flow across elements other than the tip reaching a critical flow state and limiting the useful flow range.

Radial distributions. - The radial distributions of several blade-element performance parameters for 100 percent of design speed are presented in figure 10 for rotor 21 and figure 11 for stator 18. In each figure, data are presented for the three weight flows: maximum flow, peak efficiency, and near stall. The design distributions of the blade-element performance parameters are shown by the solid symbols.

From figure 10(d) the entering flow to the rotor for the weight flow (29.47 kg/sec), as indicated by the measured incidence angle from hub to tip, is very close to the design calculations. However, all the outlet measurements presented in figure 10 show significant deviations from design in the flow across the midspan damper and tip regions. Plausible reasons for the large deviations from design are as follows: first, the damper results in a flow blockage and high loss flow region which is probably traceable to rather high suction surface Mach numbers in this region. The damper also results in a redistribution of flow in the hub and tip regions. A second factor affecting performance in the tip region is the significantly lower deviation angle than the deviation angle predicted by the design method. The higher-than-design turning of fluid is reflected in the increased levels of energy addition (total temperature ratio and total pressure ratio). However, the increased throughflow indicated by the meridional velocity ratio keeps the blade loading D relatively close to design values. One possible reason for the large differences between the measured and design deviation angles is that the prediction methods for deviation angle do not reflect all the real flows, particularly the shock patterns and secondary flows occurring in the tip region. In addition, the data reduction procedure (translation along design streamlines) and the effect of blade on twist may also contribute to the questionable condition of negative deviation angle.

For the near design weight flow (29.47 kg/sec), the flow conditions entering the stator are similar to the design prediction except for the extreme tip region and a localized midspan region (see fig. 11(a)). This difference between the measured and design incidence angle in the midspan region is probably caused by the rotor damper. From the outlet measurements, the stator operated reasonably close to design. The total pressure loss coefficient $\overline{\omega}$ was somewhat higher than design, most notably in elements closest to end walls.

Stable operating range. - The performance distributions near stall are of interest because they indicate where the flow breakdown probably occurred, thereby limiting stable operation of this stage. Values of diffusion factor are indicated in the following table at near-stall operation for stage 21-18 and stage 11-4 (ref. 1):

Stage	Diffusion factors				
	Rotor tip, D_{10}	Rotor damper, D_{dam}	Rotor hub, D_{90}	Stator tip, D_{10}	Stator hub, D_{90}
21-18	0.390	0.629	0.515	0.399	0.500
11-4	.518	.593	.539	.466	.509

The data in this table seem to indicate that (for stage 21-18) the rotor tip element did not reach stalling values. Because of the increased loading in midspan of the rotor, flow separation about the damper may have occurred and limited the stable operating range. A second critical flow region may have been the stator hub for both stages. In reference 5, where it was known that the stator hub flow limited the stage operating range, a stator hub diffusion factor D_{90} of about 0.50 was measured as it was in the subject stator. However, the flow Mach number entering the stator of stage (15-9) (ref. 5) was somewhat higher (~0.85) and the meridional velocity ratio was somewhat higher (~1.0) than the same parameter values for stator 18 presented in this report, so the comparison is not exact, the possible critical flow region (hub of stator 18) is therefore not certain.

The design objective of increasing the stable operating range by using a reduced level of design blade loading in the rotor tip region was greatly restricted by a resulting critical flow region around the rotor blade. The increased loading over the remaining portion of the blade span (to attain a given overall pressure ratio) resulted in a critical stall-inducing flow across the blade section before an improved stable operating range could be realized. For this stage the flow across the part-span damper is most suspect as the critical flow region. A careful tailoring of the radial distribution of design blade loading to allow the blade elements to approach a stalling flow together must be considered to optimize the stable operating range.

Performance With Backup Screen

The effect of the backup screen on the overall performance for rotor 21 is presented in figure 12(a), and for the stage 21-18 is presented in figure 12(b). The overall performance with and without the backup screen is presented for speeds of 70 and 100 percent of design speed. From figure 12(a) the effect of the backup screen at 100 percent speed is seen to generally produce a higher overall total pressure ratio and efficiency from stall to choke condition. At 70 percent speed this effect is seen to be greatly reduced (see fig. 12(a)). One possible reason for this increased total pressure ratio and efficiency at the 100 percent speed is that the backup screen may significantly increase the flow turbulence level. This increased turbulence level could energize the the rotor and damper turbulent boundary layers and move the separation point further toward the trailing edge of the rotor blade and/or damper.

Similarly, figure 12(b) shows that for the stage 21-18 the effect of the backup screen was to increase the total pressure ratio and efficiency above the clean inlet flow measurements. The backup screen had no apparent effect on the stable operating range or stall weight flow.

Performance With Tip and Hub Radial Distortion

Before discussing the effects of radial distortion on a particular compressor stage, a measure of distortion produced by a distortion screen is needed. The distortion parameter (same as ref. 6), used in this report, is defined by

$$\frac{P_{max} - P_{min}}{P_{max}} \tag{1}$$

Calculated values from measured pressures at the rotor inlet station are presented in table XVII for the distortion parameter over a range of weight flows. Three different magnitudes of tip radial distortion and one magnitude of hub radial distortion were produced by the radial distortion screens.

Overall performance. - The overall performance for rotor 21 and stage 21-18 with various types of inlet flow distortions is presented in figures 13 and 14. The overall total pressure ratio and efficiency are plotted as a function of the equivalent weight flow for rotative speeds of 70 and 100 percent of equivalent design speed. At 60, 80, and 90 percent of design speed, data are presented only for the near-stall condition. To aid in assessing stall margin, a fan operating line was imposed on the rotor overall performance plots. The method used for constructing the fan operating line (see appendix D) is the same as described in reference 6. With inlet radial distortion the operating line differed from the undistorted operating line, tending to move the distorted operating line closer to the stall line (see fig. 13). Values of the radial distortion parameter index defined by equation (1) near design speed weight flow are given for identification on all the performance figures with radial distortion.

The overall performance with radial distortion will be discussed with reference to backup screen (BUS) performance. From figures 13 and 14, the first result is that there is a decrease in the rotor and stage stall pressure ratio from the undistorted flow results, except for the lowest level of tip radial distortion at 100 percent design speed. For all levels of tip radial distortion, there is a significant reduction in the rotor stall margin. At the higher levels of tip radial distortion the stall margin is reduced to zero based on the operating line passing through the peak efficiency point of the BUS data.

For the lowest level of tip radial distortion (0.127), distortion has little effect on the overall pressure ratio and efficiency of the rotor or stage (speed lines are almost identical, see figs. 13(a) and 14(a)). For the tip radial distortion index of 0.164 and above (at design speed), figures 13(b) to (c) and 14(b) to (c) show that there is a significant decrease in total pressure ratio across the rotor and stage but relatively small change in efficiency. Also, at 70 percent design speed only a slight increase occurs in the total pressure ratio and no change in efficiency. These observations indicate that the changes in pressure ratio due to distortion are primarily due to changes in energy addition.

With hub radial distortion, figure 13(d) indicates a large decrease in stall total pressure ratio and flow at design speed, but a small increase in stall total pressure ratio at 70 percent speed. At both speeds, hub distortion for the rotor and stage affects a significant loss in total pressure ratio but with a small or no decrease in efficiency (see figs. 13(d) and 14(d)).

In figures 15 and 16, relative effects of tip radial and hub radial distortion on overall performance of rotor and stage at design speed are shown. Evident in figure 15 was a sharp drop off in stable operating range with both hub and tip radial distortion. At design speed with distortion, the rotor stalls at higher weight flows and has a lower maximum flow. At a given weight flow the total pressure ratio decreases with distortion. From figures 15 and 16, it can be seen that data points are available at approximately the same flow ($W \approx 1.005\ W_{des}$) for undistorted tip radial and hub radial distortion. Therefore, the radial distributions of performance and flow parameters can be compared at the same flow ($W = 1.005\ W_{des}$) for undistorted, tip radial and hub radial distortion.

Radial distributions. - The effects of radial distortion on the spanwise distributions of flow and performance parameters are examined in this section. Before presenting these radial distributions, the method of defining the streamlines of flow across the blade rows should be assessed. In figure 17, the large differences between the calculated streamlines and the design streamlines are shown graphically for tip radial and hub radial distortions. The greatest difference between the calculated and design streamlines occurs at the 30 percent spanwise location from the tip for tip radial distortion.

The calculated streamlines are determined by passing a linear line through equal weight flow points calculated on the rotor blade leading and trailing edges. The radial locations for the streamlines at the blade trailing edge are held fixed and the radial locations at the leading edge are easily calculated on the basis of equal weight flows.

These streamline comparisons (fig. 17) indicate that actual streamlines can significantly deviate from design streamlines under off-design operating conditions. All the blade-element parameters presented in figures 18 and 19 for the backup screen (BUS), tip radial, and hub radial distortion are obtained by using the calculated streamlines across the rotor. These plots will be used, as needed, to discuss the effects of distortion on the flow and performance changes (from the BUS values).

Figure 18 shows redistributions of flow caused by radial distortion at the rotor inlet. In the distorted flow regions total pressure and axial velocity are lower than BUS levels, and in undistorted regions they are higher (figs. 18(a) and (c)). The distributions of the incidence angle (fig. 18(b)) indicate the new radial matching of blade elements; the higher incidence angle tending to load up blade sections in distorted flow regions and reduced incidence angle tending to unload the blade sections in undistorted flow.

The blade-element parameters across the rotor and at the rotor exit seem to indicate the occurrence of the following general flow process as was also observed in reference 7. In distorted flow regions the blade elements operate at higher loading (see diffusion factor and total temperature ratio in figs. 18(k) and (h)) and produces a total pressure ratio greater than the BUS value. However, in the distorted region the inlet total pressure is lower than the BUS value and the higher total pressure ratio only results in exit total pressures being almost equal to or lower than the BUS level. In undistorted flow regions, blade elements operate unloaded, that is, the work input and total pressure ratio is down and the outlet total pressure is less than the BUS level. Thus, over the entire rotor blade span the outlet total pressure level is lower than the corresponding BUS level, and therefore the overall pressure ratio is lower. This in turn tends to decrease the energy addition. This general flow process is descriptive of both types of radial distortion, although specific details maybe modified somewhat by loss, radial equilibrium, and relative response of different blade elements.

The stator blade row performance responds to the new incidence angle and Mach number distribution fed by the rotor, that is, stator blade loading and loss generally follow the incidence angle and Mach number changes.

Near-Stall Operation

One of the primary effects of radial distortion on stage performance is loss in stall pressure ratio or loss in stall margin. It is assumed that stall is initiated by flow breakdown in one or more of the flow regions near the rotor or stator end walls and near the rotor part span damper. Previous sections discussed the flow redistributions and radial rematching of blade-element performance (compared to clean inlet flow) as a radial distortion was applied. This section summarizes selected parameters with and without distortion at the near-stall operating condition.

The principal indicator of stall used herein is the blade loading parameter, diffusion factor D. The diffusion factors across the blade elements 10 percent from the hub D_{90} and 10 percent from the tip D_{10} and across the damper D_{dam} are summarized in the following table:

Operating mode	Distortion level	Diffusion factors - near-stall operation stage 21-18 (100 percent of design speed)				
		Rotor tip, D_{10}	Rotor damper, D_{dam}	Rotor hub, D_{90}	Stator tip, D_{10}	Stator hub, D_{90}
Clean inlet	0	0.390	0.629	0.515	0.399	0.500
BUS	0	.417	.613	.517	.413	.501
Tip radial	.127	.413	.540	.501	.450	.421
Tip radial	.164	.424	.542	.501	.401	.389
Hub radial	.133	.293	.522	.520	.359	.368

These diffusion factors are calculated using actual streamlines for 100 percent design speed at the near-stall operation. For undistorted flow (clean inlet and BUS) high diffusion factors in the damper and stator hub regions indicate that flow separation in one or both of these regions may initiate stage stall. For the other regions, diffusion factors higher than the shown levels have been noted without stall (see ref. 1). With distorted inlet flow, the values for the diffusion factor at all blade elements appear low (compared with experience) for initiating blade stall. The damper region flow is most suspect as the critical flow region because the diffusion factor level for near stall does show some consistency and there are flow features (which can become adverse) in damper regions that probably are not fully reflected in the diffusion factor.

Two of these flow features are angle of attack of the flow over the damper and the flow Mach number at the damper leading edge. Another useful parameter, the cone angle, is the angle for a cone on which the surface calculated streamline lies, based on the radius at which an equal flow streamline crosses blade leading and trailing edges and the distance in a meridional plane. These flow features are summarized in the following table which compares parameters for the streamline that crosses the blade trailing edge at a radius of 18.672 centimeters (in damper flow region) when operating with and without distortion:

Flow features - near-stall operation - stage 21-18

Operating mode	Distortion level	Cone angle, α_c, deg	Damper angle of attack, α_{dam}, deg	Suction-surface Mach number, M_{ss}	Total temperature ratio, T_2/T_1
Design	-----	2.26	0	----	-----
Clean inlet	-----	9.30	7.04	1.73	1.210
Tip radial	0.127	12.40	10.14	1.58	1.178
Tip radial	.164	13.48	11.22	1.56	1.172
Hub radial	.133	1.76	.50	1.65	1.179

For reference, the design cone angle (on which damper is located) is given in the aforementioned table. The difference between the cone angle of the actual streamline (for particular operating mode) and the design value is assumed to provide an approximate angle of attack for the damper.

A calculated blade suction-surface Mach number M_{ss} is based on a model described in reference 8 and depends on the inlet Mach number, incidence angle i_{ss} and camber turning of the suction surface. This model should provide an approximate level of the suction surface Mach number M_{ss} and a consistent method for showing relative change in M_{ss} as distortion is applied. Values of the suction surface Mach number indicate that shocks from the damper could be a factor in the rotor and stage performance.

A comparison of radial distortion and clean inlet values from the foregoing chart shows that with radial distortion parameters such as diffusion factor, temperature ratio, and suction surface Mach numbers in the damper region (which are indicators of a critical operating condition), do not exceed clean inlet values. However, the damper angles of attack with distortion do differ considerably from clean inlet conditions which indicates significant variations in local flow about the damper.

Although the evidence is not definitive, the high levels of diffusion factor and suction surface Mach number, coupled with relatively high and low angle of attack to the damper, suggest that with radial distortion the flow in the damper region initiates stall and thereby limits the flow operating range.

SUMMARY OF RESULTS

A transonic fan stage was designed with reduced rotor tip loading in an attempt to improve both stable operating range and tolerance to tip radial distortion. This stage was tested with clean inlet flow, with three magnitudes of tip radial distortion, and with one magnitude of hub radial distortion. The distortions were produced by wire screens placed in the inlet flow. The rotor was 50 centimeters in diameter and designed for an operating tip speed of 420 meters per second. Overall performance data for rotor speeds from 60 to 100 percent of equivalent design speed were measured. Also, the blade-element performance parameters were determined for selected operating conditions at 100 percent of equivalent design speed. The following results were obtained:
For clean inlet flow,

1. The measured performance of rotor 21 and stage 21-18 compared favorably with design. At design flow the overall stage pressure ratio (1.595) and efficiency (0.814) are very close to design values. The part-span damper caused some radial redistributions of flow not accounted for in design, in particular, high flow losses around the damper.

2. The design objective of increasing the stable operating range by using a reduced level of design blade loading in the rotor tip region was greatly restricted by a resulting critical flow region around the blade. The increased loading over the rest of the blade span (to achieve the desired overall pressure ratio) resulted in a critical stall-inducing flow across the blade section before an improved stable operating range could be realized. For this stage the flow across the part-span damper is most suspect as the critical flow region. The measured rotor stall margin of 14 percent based on the maximum efficiency operating point was acceptable but does not represent improvement over conventional designs.

For distorted flow,

1. For all levels of tip radial distortion there was a significant reduction (from undistorted flow) in the stall margin. At distortion levels greater than a distortion index of 0.127, there was a sharp decrease in the pressure ratio but little change in efficiency at design flow. Even with distorted inlet flow the stable operating range was apparently controlled by the flow across the part-span damper.

2. For the hub radial distortion (index of 0.133) there was a sharp decrease in the stall margin and pressure ratio at design speed, but essentially no change in efficiency. At 70 percent speed there was essentially no change in stall margin or performance parameters.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, April 10, 1978,
505-04.

APPENDIX A

SYMBOLS

A_{an} annulus area at rotor leading edge, m^2

A_f frontal area at rotor leading edge, m^2

C_p specific heat at constant pressure, J/kg-K

c aerodynamic chord, cm

D diffusion factor

i_{mc} mean incidence angle, angle between inlet area direction and line tangent to blade mean camber line at leading edge, deg

i_{ss} suction-surface incidence angle, angle between inlet air direction and line tangent to blade suction surface at leading edge, deg

M Mach number

N rotative speed, rpm

P total pressure, N/cm^2

p static pressure, N/cm^2

r radius, cm

T total temperature, K

U wheel speed, m/sec

V air velocity, m/sec

W weight flow, kg/sec

Z axial distance references from rotor blade hub leading edge, cm

α_c cone angle, deg

α_s slope of streamline, deg

β air angle, angle between air velocity and axial direction, deg

β'_c relative meridional air angle based on cone angle, arctan $(\tan \beta'_m \cos \alpha_c / \cos \alpha_2)$, deg

γ ratio of specific heats

δ ratio of rotor inlet total pressure to standard pressure of 10.13 N/cm^2

δ^o deviation angle, angle between exit air direction and tangent to blade mean camber line at trailing edge, deg

η efficiency

θ ratio of rotor inlet total temperature to standard temperature of 288.2 K

κ_{mc} angle between the blade mean camber line and the meridional plane, deg

σ solidity, ratio of chord to spacing

$\overline{\omega}$ total loss coefficient

$\overline{\omega}_p$ profile loss coefficient

$\overline{\omega}_s$ shock loss coefficient

Subscripts:

ad adiabatic (temperature rise)

dam damper

des design

h hub

id ideal

LE blade leading edge

m meridional direction

max maximum

min minimum

mom momentum rise

p polytropic

ss suction surface

TE blade trailing edge

t tip

z axial direction

θ tangential direction

1 intrumentation plane upstream of rotor

2 instrumentation plane between rotor and stator

3 instrumentation plane downstream of stator

10 element location (10 percent from tip)

90 element location (90 percent from tip)

Superscript:

' relative to blade

APPENDIX B

EQUATIONS

Mean incidence angle:

$$i_{mc} = (\beta'_c)_{LE} - (\kappa_{mc})_{LE} \tag{B1}$$

Deviation angle:

$$\delta^o = (\beta'_c)_{TE} - (\kappa_{mc})_{TE} \tag{B2}$$

Diffusion factor:

$$D = 1 - \frac{V'_{TE}}{V'_{LE}} + \left| \frac{(rV_\theta)_{TE} - (rV_\theta)_{LE}}{(r_{TE} + r_{LE})\sigma V'_{LE}} \right| \tag{B3}$$

Total loss coefficient:

$$\omega = \frac{(P'_{id})_{TE} - P'_{TE}}{P'_{LE} - p_{LE}} \tag{B4}$$

Profile loss coefficient:

$$\overline{\omega}_p = \overline{\omega} - \overline{\omega}_s \tag{B5}$$

Total loss parameter:

$$\frac{\overline{\omega} \cos (\beta'_m)_{TE}}{2\sigma} \tag{B6}$$

Profile loss parameter:

$$\frac{\overline{\omega}_p \cos (\beta'_m)_{TE}}{2\sigma} \tag{B7}$$

Adiabatic (temperature rise) efficiency:

$$\eta_{ad} = \frac{\left(\frac{P_{TE}}{P_{LE}}\right)^{(\gamma-1)/\gamma} - 1}{\frac{T_{TE}}{T_{LE}} - 1} \tag{B8}$$

Momentum-rise efficiency:

$$\eta_{mom} = \frac{\left(\frac{P_{TE}}{P_{LE}}\right)^{(\gamma-1)/\gamma} - 1}{\frac{(UV_\theta)_{TE} - (UV_\theta)_{LE}}{T_{LE}C_p}} \tag{B9}$$

Equivalent weight flow:

$$\frac{w\sqrt{\theta}}{\delta} \tag{B10}$$

Equivalent rotative speed:

$$\frac{N}{\sqrt{\theta}} \tag{B11}$$

Weight flow per unit annulus area:

$$\frac{\left(\frac{w\sqrt{\theta}}{\delta}\right)}{A_{an}} \tag{B12}$$

Weight flow per unit frontal area:

$$\frac{\left(\frac{w\sqrt{\theta}}{\delta}\right)}{A_f} \tag{B13}$$

Head-rise coefficient:

$$\frac{C_p T_{LE}}{U_{tip}^2}\left[\left(\frac{P_{TE}}{P_{LE}}\right)^{(\gamma-1)/\gamma} - 1\right] \qquad \text{(B14)}$$

Flow coefficient:

$$\left(\frac{V_z}{U_{tip}}\right)_{LE} \qquad \text{(B15)}$$

Polytropic efficiency:

$$\eta_p = \frac{\ln\left(\frac{P_{TE}}{P_{LE}}\right)^{(\gamma-1)/\gamma}}{\ln\left(\frac{T_{TE}}{T_{LE}}\right)} \qquad \text{(B16)}$$

APPENDIX C

DEFINITIONS AND UNITS USED IN TABLES

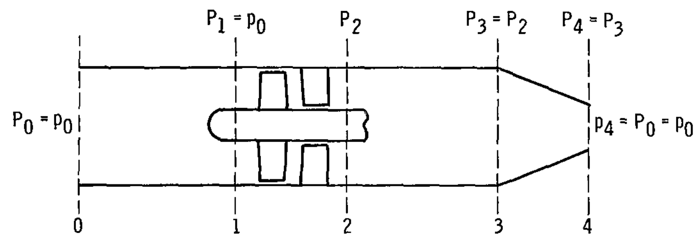
ABS	absolute
AERO CHORD	straight line between blade leading and trailing edges along design streamline, cm
AREA RATIO	ratio of actual flow area to critical area (where local Mach number is one)
BETAM	meridional air angle, deg
CONE ANGLE	angle between axial direction and conical surface representing blade element, deg
DEV	deviation angle (defined by eq. (B3)), deg
D-FACT	diffusion factor (defined by eq. (B4))
EFF	adiabatic efficiency (defined by eq. (B9))
IN	inlet (leading edge of blade)
INCIDENCE	incidence angle (mean defined by eq. (B2)), deg
KIC	angle between blade mean camber line at leading edge and meridional plane, deg
KOC	angle between blade mean camber line at transition point and meridional plane, deg
KTC	angle between blade mean camber line at trailing edge and meridional plane, deg
LOSS COEFF	loss coefficient (total defined by eq. (B5) and profile by eq. (B6))
LOSS PARAM	loss parameter (total defined by eq. (B7) and profile by eq. (B8))
MERID	meridional
MERID VEL R	meridional velocity ratio
OUT	outlet (trailing edge of blade)
PERCENT SPAN	percent of blade span from tip at rotor outlet
PHISS	suction-surface camber ahead of assumed shock location, deg
PRESS	pressure, N/cm^2

PROF	profile
RADII	radius, cm
REL	relative to blade
RI	inlet radius (leading edge of blade), cm
RO	outlet radius (trailing edge of blade), cm
RP	radial position
RPM	equivalent rotative speed, rpm
SETTING ANGLE	angle between aerodynamic chord and meridional plane, deg
SOLIDITY	ratio of aerodynamic chord to blade spacing
SPEED	speed, m/sec
SS	suction surface
STREAMLINE SLOPE	slope of streamline, deg
TANG	tangential
TEMP	temperature, K
TI	thickness of blade at leading edge, cm
TM	thickness of blade at maximum thickness, cm
TO	thickness of blade at trailing edge, cm
TOT	total
TOTAL CAMBER	difference between inlet and outlet blade mean camber lines, deg
VEL	velocity, m/sec
WT FLOW	equivalent weight flow, kg/sec
X FACTOR	ratio of suction-surface camber ahead of assumed shock location of multiple-circular-arc blade section to that of double circular-arc blade section
ZIC	axial distance to blade leading edge from inlet, cm
ZMC	axial distance to blade maximum thickness point from inlet, cm
ZOC	axial distance to blade trailing edge from inlet, cm
ZTC	axial distance to transition point from inlet, cm

APPENDIX D

DETERMINATION OF THE OPERATING LINE

In order to help in assessing the stall margin, a fan operating line (calculated by the following procedure) was imposed on the rotor overall performance plots. A relatively simple flow model (ref. 6), used to construct the operating line, assumes that the exit flow nozzle expands to ambient pressure and there is no loss in total pressure from the fan rotor outlet to the nozzle exit (see sketch):



With the assumption of pressures as indicated in the sketch the following expression results:

$$\frac{p_4}{P_4} = \frac{p_0}{P_3} = \frac{K}{\frac{P_2}{P_1}} \tag{D1}$$

where

$$K = \frac{1}{K'} \tag{D2}$$

and

$$K' = \frac{P_1}{P_0} \tag{D3}$$

with distortion, $K' < 1.0$.

The following procedure was used to obtain an operating line:

1. A reference operating point (with known P_2/P_1, $W\sqrt{\theta/\delta}$, and η) is selected through which the operating line must pass. The peak efficiency operating point for the

backup screen (BUS) data at 100 percent speed was chosen as the reference operating point.

2. From the nozzle weight flow equation, an equation for the exit nozzle flow area is given by

$$A = \frac{\sqrt{T_0}\left(W\sqrt{\theta/\delta}\right)\left(\sqrt{\frac{T_2}{T_1}}\right)(K)}{\sqrt{\frac{\gamma}{R}}\left(P_0\right)\left(\frac{P_2}{P_1}\right)\left(\frac{\rho}{\rho_t}\right)\left(\frac{a}{a_t}\right)(M)} \tag{D4}$$

where M (the Mach number) is determined from the known P_2/P_1, ρ/ρ_t and a/a_t are determined using the calculated M, and T_2/T_1 is given by

$$\frac{T_2}{T_1} = 1 + \frac{1}{\eta}\left[\left(\frac{P_2}{P_1}\right)^{\gamma-1/\gamma} - 1\right] \tag{D5}$$

After equation (D4) is solved for the reference point, the exit nozzle flow area for the reference point is obtained. This area remains constant throughout the calculation of the operating line.

3. For each speed line which has four or five operating points of P_2/P_1, $W\sqrt{\theta/\delta} + \eta$, a nozzle exit flow area can be calculated from equation (D4) for each operating point. Then a graph of P_2/P_1 versus the nozzle exit flow area can be made and using the constant reference nozzle area the correct value of P_2/P_1 for each speed line is obtained.

4. Finally, the operating line is obtained by drawing a curve through these calculated points (one for each speed line). Generally, at least three speed lines are needed to define an operating line.

REFERENCES

1. Kovich, George; Moore, Royce D.; and Urasek, Donald C.: Performance of Transonic Fan Stage with Weight Flow per Unit Annulus Area of 198 Kilograms per Second per Square Meter (40.6 (Lb/Sec)/Ft^2). NASA TM X-2905, 1973.
2. Ball, Calvin L.; Janetzke, David C.; and Reid, Lonnie: Performance of 1380-Foot-Per-Second-Tip-Speed Axial-Flow Compressor Rotor with Blade Tip Solidity of 1.5. NASA TM X-2379, 1972.
3. Crouse, James E.; Janetzke, David C.; and Schwirian, Richard E.: A Computer Program for Composing Compressor Blading from Simulated Circular-Arc Elements on Conical Surfaces. NASA TN D-5437, 1969.
4. Glawe, George E.; Krause, Lloyd N.; and Dudzinski, Thomas J.: A Small Combination Sensing Probe for Measurement of Temperature, Pressure, and Flow Direction. NASA TN D-4816, 1968.
5. Gelder, Thomas F.; and Lewis, George W., Jr.: Aerodynamic Performance of a 0.5 Meter Diameter, 337-Meter-Per-Second Tip Speed, 1.5-Perssure Ratio, Single Stage Fan Designed for Low Noise Aircraft Engines. NASA TN D-7836, 1974.
6. Sandercock, Donald M.; and Sanger, Nelson L.: Some Observations of the Effects of Radial Distortions on Performance of a Translating Rotating Blade Row. NASA TN D-7824, Dec. 1974.
7. Sanger, Nelson L.: Effect of Rotor Meridional Velocity Ratio on Response to Inlet Radial and Circumferential Distortion. NASA TP-1278, 1978.
8. Schwenk, Francis C.; Lewis, George W.; and Hartmann, Melvin J.: A Preliminary Analysis of the Magnitude of Shock Losses in Transonic Compressors. NACA RM E57A30, 1957.

TABLE I. - DESIGN OVERALL PARAMETERS

FOR STAGE 21-18

ROTOR TOTAL PRESSURE RATIO................	1.606
STAGE TOTAL PRESSURE RATIO	1.574
ROTOR TOTAL TEMPERATURE RATIO.............	1.170
STAGE TOTAL TEMPERATURE RATIO	1.170
ROTOR ADIABATIC EFFICIENCY................	0.854
STAGE ADIABATIC EFFICIENCY	0.816
ROTOR POLYTROPIC EFFICIENCY...............	0.863
STAGE POLYTROPIC EFFICIENCY	0.827
ROTOR HEAD RISE COEFFICIENT...............	0.232
STAGE HEAD RISE COEFFICIENT	0.222
FLOW COEFFICIENT..........................	0.475
WT FLOW PER UNIT FRONTAL AREA	147.971
WT FLOW PER UNIT ANNULUS AREA............	198.434
WT FLOW	29.484
RPM....................................	16100.000
TIP SPEED	424.601

TABLE II. - DESIGN BLADE-ELEMENT PARAMETERS FOR ROTOR 21

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
TIP	25.184	24.859	-0.	32.4	69.2	69.8	287.8	1.115	10.14	1.324
1	24.720	24.321	0.	32.7	67.9	67.0	287.8	1.125	10.14	1.371
2	24.209	23.785	0.	33.1	66.5	64.1	287.8	1.134	10.14	1.418
3	21.977	21.630	-0.	37.5	61.1	53.3	287.8	1.167	10.14	1.585
4	19.509	19.478	-0.	42.1	56.7	41.3	287.8	1.189	10.14	1.698
5	19.186	19.209	-0.	42.6	56.3	39.7	287.8	1.191	10.14	1.706
6	18.861	18.940	-0.	43.1	55.8	38.1	287.8	1.192	10.14	1.713
7	18.534	18.671	-0.	43.5	55.3	36.4	287.8	1.193	10.14	1.718
8	18.204	18.402	-0.	43.9	54.9	34.8	287.8	1.193	10.14	1.721
9	16.863	17.326	-0.	45.1	53.1	28.7	287.8	1.191	10.14	1.713
10	14.112	15.173	-0.	43.5	49.1	21.8	287.8	1.159	10.14	1.583
11	13.420	14.635	-0.	41.8	47.8	22.2	287.8	1.145	10.14	1.524
HUB	12.700	14.097	0.	39.7	46.4	23.2	287.8	1.129	10.14	1.458

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
TIP	161.4	148.2	454.2	362.1	161.4	125.2	-0.	79.3	424.6	419.1
1	169.4	162.8	449.9	350.1	169.4	137.0	0.	87.9	416.8	410.0
2	177.8	176.7	445.2	338.5	177.8	148.0	0.	96.5	408.2	401.0
3	204.3	217.8	423.1	289.2	204.3	172.7	-0.	132.7	370.5	364.7
4	215.7	248.4	393.3	245.4	215.7	184.4	-0.	166.5	328.9	328.4
5	216.1	251.6	389.0	240.7	216.1	185.2	-0.	170.2	323.5	323.9
6	216.2	254.5	384.5	236.1	216.2	185.9	-0.	173.8	318.0	319.3
7	216.1	257.2	379.9	231.8	216.1	186.5	-0.	177.1	312.5	314.8
8	215.9	259.7	375.3	227.9	215.9	187.1	-0.	180.1	306.9	310.3
9	213.6	266.9	355.6	214.9	213.6	188.6	-0.	188.9	284.3	292.1
10	206.4	261.4	315.0	204.4	206.4	189.8	-0.	179.8	257.9	255.8
11	205.0	254.0	305.3	204.6	205.0	189.4	-0.	169.3	226.3	246.7
HUB	203.7	245.4	295.5	205.5	203.7	188.8	0.	156.7	214.1	237.7

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	STREAMLINE SLOPE IN	STREAMLINE SLOPE OUT	MERID VEL R	PEAK SS MACH NO
TIP	0.486	0.420	1.367	1.026	0.486	0.355	-10.49	-10.43	0.775	1.431
1	0.511	0.461	1.357	0.991	0.511	0.388	-9.42	-9.48	0.809	1.450
2	0.538	0.500	1.347	0.958	0.538	0.419	-8.22	-8.50	0.832	1.474
3	0.624	0.615	1.292	0.816	0.624	0.488	-2.56	-3.92	0.845	1.573
4	0.662	0.702	1.206	0.694	0.662	0.521	4.05	1.38	0.855	1.660
5	0.663	0.711	1.193	0.681	0.663	0.524	4.91	2.07	0.857	1.666
6	0.663	0.720	1.180	0.668	0.663	0.526	5.78	2.76	0.860	1.672
7	0.663	0.729	1.165	0.657	0.663	0.528	6.65	3.45	0.863	1.676
8	0.662	0.736	1.151	0.646	0.662	0.530	7.51	4.14	0.866	1.679
9	0.655	0.760	1.090	0.612	0.655	0.537	10.97	6.88	0.883	1.673
10	0.631	0.753	0.962	0.589	0.631	0.547	17.61	12.10	0.919	1.517
11	0.626	0.735	0.932	0.592	0.626	0.548	19.17	13.32	0.924	1.426
HUB	0.622	0.713	0.902	0.597	0.622	0.549	20.77	14.51	0.927	1.324

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
TIP	0.	2.0	-0.5	3.2	0.271	0.724	0.141	0.079	0.019	0.011
1	5.00	2.2	-0.4	3.2	0.296	0.757	0.133	0.069	0.020	0.010
2	10.00	2.6	-0.3	3.2	0.320	0.783	0.128	0.061	0.021	0.010
3	30.00	4.0	0.0	3.1	0.422	0.840	0.120	0.041	0.024	0.008
4	50.00	5.1	-0.0	3.9	0.505	0.864	0.125	0.039	0.028	0.009
5	52.50	5.3	-0.0	4.0	0.512	0.865	0.126	0.041	0.029	0.010
6	55.00	5.4	-0.0	4.2	0.519	0.866	0.128	0.044	0.030	0.010
7	57.50	5.6	-0.0	4.3	0.525	0.867	0.130	0.047	0.030	0.011
8	60.00	5.7	-0.0	4.5	0.530	0.868	0.132	0.050	0.031	0.012
9	70.00	6.3	0.0	5.2	0.538	0.870	0.138	0.067	0.032	0.016
10	90.00	7.4	0.0	5.7	0.482	0.880	0.132	0.106	0.027	0.022
11	95.00	7.7	0.0	5.4	0.452	0.883	0.125	0.112	0.024	0.022
HUB	100.00	7.9	-0.1	5.0	0.416	0.884	0.118	0.114	0.022	0.021

TABLE III. - DESIGN BLADE-ELEMENT PARAMETERS FOR STATOR 18

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
TIP	24.399	24.384	32.9	-0.	32.9	-0.	321.0	1.001	13.42	0.995
1	23.893	23.865	32.2	0.	32.2	0.	323.7	1.000	13.90	0.992
2	23.393	23.305	31.8	0.	31.8	0.	326.3	1.000	14.37	0.992
3	21.468	21.358	33.5	-0.	33.5	-0.	335.9	1.000	16.06	0.987
4	19.588	19.591	36.6	-0.	36.6	-0.	342.2	1.000	17.21	0.980
5	19.354	19.379	37.0	-0.	37.0	-0.	342.6	1.000	17.29	0.979
6	19.119	19.169	37.4	-0.	37.4	-0.	343.0	1.000	17.36	0.978
7	18.884	18.961	37.8	-0.	37.8	-0.	343.3	1.000	17.41	0.977
8	18.648	18.755	38.2	-0.	38.2	-0.	343.4	1.000	17.44	0.976
9	17.706	17.949	39.3	-0.	39.3	-0.	342.7	1.000	17.36	0.972
10	15.828	16.382	37.2	-0.	37.2	-0.	333.6	1.000	16.04	0.970
11	15.372	15.976	35.4	-0.	35.4	-0.	329.4	1.000	15.44	0.971
HUB	14.595	15.240	31.7	0.	31.7	0.	321.8	0.999	14.35	0.968

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
TIP	148.6	93.6	148.6	93.6	124.8	93.6	80.8	-0.	0.	0.
1	168.0	117.0	168.0	117.0	142.2	117.0	89.5	0.	0.	0.
2	186.4	140.7	186.4	140.7	158.5	140.7	98.2	0.	0.	0.
3	242.2	197.9	242.2	197.9	202.0	197.9	133.7	-0.	0.	0.
4	277.7	227.3	277.7	227.3	222.9	227.3	165.6	-0.	0.	0.
5	280.6	229.8	280.6	229.8	224.1	229.8	168.9	-0.	0.	0.
6	283.2	232.0	283.2	232.0	224.9	232.0	172.2	-0.	0.	0.
7	285.5	233.9	285.5	233.9	225.4	233.9	175.1	-0.	0.	0.
8	287.4	235.4	287.4	235.4	225.8	235.4	177.8	-0.	0.	0.
9	291.7	237.8	291.7	237.8	225.6	237.8	184.9	-0.	0.	0.
10	285.1	209.5	285.1	209.5	227.1	209.5	172.3	-0.	0.	0.
11	278.4	196.3	278.4	196.3	227.0	196.3	161.1	-0.	0.	0.
HUB	266.4	171.1	266.4	171.1	226.5	171.1	140.1	0.	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	STREAMLINE SLOPE IN	STREAMLINE SLOPE OUT	MERID VEL R	PEAK SS MACH NO
TIP	0.421	0.262	0.421	0.262	0.354	0.262	-0.24	0.17	0.750	0.659
1	0.476	0.328	0.476	0.328	0.403	0.328	0.19	0.38	0.823	0.709
2	0.529	0.395	0.529	0.395	0.450	0.395	0.64	0.63	0.888	0.777
3	0.690	0.555	0.690	0.555	0.575	0.555	2.69	1.76	0.980	1.020
4	0.795	0.637	0.795	0.637	0.638	0.637	5.00	3.03	1.020	1.205
5	0.804	0.644	0.804	0.644	0.642	0.644	5.30	3.19	1.025	1.223
6	0.812	0.651	0.812	0.651	0.644	0.651	5.60	3.36	1.032	1.239
7	0.819	0.656	0.819	0.656	0.646	0.656	5.89	3.52	1.037	1.254
8	0.825	0.661	0.825	0.661	0.648	0.661	6.19	3.68	1.043	1.266
9	0.840	0.669	0.840	0.669	0.649	0.669	7.36	4.33	1.054	1.294
10	0.831	0.592	0.831	0.592	0.662	0.592	9.57	5.55	0.922	1.209
11	0.814	0.556	0.814	0.556	0.664	0.556	10.09	5.84	0.865	1.149
HUB	0.785	0.487	0.785	0.487	0.668	0.487	10.95	6.35	0.755	1.039

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
TIP	0.	3.4	-2.9	7.6	0.582	0.	0.066	0.066	0.026	0.026
1	5.00	3.1	-3.1	7.4	0.506	0.	0.053	0.053	0.020	0.020
2	10.00	3.0	-3.0	7.2	0.441	0.	0.043	0.043	0.016	0.016
3	30.00	2.4	-3.0	7.4	0.372	0.	0.046	0.046	0.016	0.016
4	50.00	1.8	-3.0	8.0	0.367	0.	0.058	0.058	0.018	0.018
5	52.50	1.8	-2.9	8.0	0.367	0.	0.060	0.060	0.019	0.019
6	55.00	1.8	-2.8	8.1	0.366	0.	0.062	0.062	0.019	0.019
7	57.50	1.8	-2.8	8.2	0.365	0.	0.065	0.064	0.019	0.019
8	60.00	1.8	-2.7	8.2	0.364	0.	0.067	0.066	0.020	0.020
9	70.00	1.7	-2.5	8.3	0.363	0.	0.075	0.074	0.021	0.021
10	90.00	1.6	-2.1	7.3	0.416	0.	0.083	0.083	0.021	0.021
11	95.00	1.6	-2.0	6.7	0.435	0.	0.084	0.084	0.021	0.021
HUB	100.00	1.4	-2.0	5.7	0.478	0.	0.082	0.082	0.019	0.019

TABLE IV. - BLADE GEOMETRY FOR ROTOR 21

RP	PERCENT SPAN	RADII RI	RO	BLADE ANGLES KIC	KTC	KOC	DELTA INC	CONE ANGLE
TIP	0.	25.184	24.859	67.16	68.45	66.50	2.49	-10.943
1	5.	24.720	24.321	65.46	66.09	63.55	2.68	-12.184
2	10.	24.209	23.783	63.63	63.54	60.68	2.91	-11.940
3	30.	21.977	21.630	57.00	53.33	50.06	3.95	-7.386
4	50.	19.509	19.478	51.69	43.35	37.36	5.12	-0.536
5	53.	19.186	19.209	51.09	42.21	35.65	5.27	0.386
6	55.	18.861	18.940	50.51	41.10	33.91	5.41	1.320
7	58.	18.534	18.671	49.93	40.04	32.15	5.56	2.257
8	60.	18.204	18.402	49.36	39.03	30.36	5.70	3.194
9	70.	16.863	17.326	47.12	35.49	23.43	6.26	6.996
10	90.	14.112	15.173	42.06	31.67	15.87	7.39	14.856
11	95.	13.420	14.635	40.49	31.40	16.47	7.70	16.870
HUB	100.	12.700	14.097	38.77	31.28	17.72	8.03	19.264

RP	BLADE THICKNESSES TI	TM	TO	AXIAL DIMENSIONS ZIC	ZMC	ZTC	ZOC
TIP	0.051	0.149	0.051	1.100	1.947	2.326	2.782
1	0.051	0.157	0.051	1.033	1.949	2.314	2.880
2	0.051	0.166	0.051	0.960	1.951	2.296	2.976
3	0.051	0.208	0.051	0.661	1.943	2.109	3.334
4	0.051	0.255	0.051	0.379	1.925	1.766	3.663
5	0.051	0.261	0.051	0.347	1.923	1.716	3.699
6	0.051	0.268	0.051	0.315	1.921	1.664	3.735
7	0.051	0.274	0.051	0.285	1.919	1.612	3.769
8	0.051	0.280	0.051	0.255	1.917	1.560	3.801
9	0.051	0.306	0.051	0.148	1.910	1.350	3.915
10	0.051	0.361	0.051	0.018	1.911	0.989	4.020
11	0.051	0.375	0.051	0.007	1.912	0.918	4.013
HUB	0.051	0.391	0.051	0.000	1.914	0.850	3.997

RP	AERO CHORD	SETTING ANGLE	TOTAL CAMBER	SOLIDITY	X FACTOR	PHISS	AREA RATIO
TIP	4.567	67.72	0.66	1.278	0.693	2.33	1.019
1	4.604	65.49	1.90	1.315	0.727	3.13	1.026
2	4.606	63.10	2.95	1.344	0.768	4.00	1.033
3	4.598	53.64	6.94	1.477	0.980	8.09	1.047
4	4.585	43.59	14.32	1.647	1.124	12.91	1.070
5	4.585	42.32	15.44	1.672	1.135	13.43	1.072
6	4.585	41.04	16.60	1.699	1.146	13.93	1.074
7	4.587	39.76	17.79	1.727	1.156	14.38	1.076
8	4.589	38.50	19.00	1.756	1.164	14.78	1.077
9	4.609	33.63	23.69	1.888	1.195	15.87	1.075
10	4.708	27.27	26.19	2.252	1.237	14.15	1.024
11	4.746	26.92	24.02	2.369	1.245	12.75	0.993
HUB	4.800	26.92	21.05	2.509	1.253	11.07	0.956

TABLE V. - BLADE GEOMETRY FOR STATOR 18

RP	PERCENT SPAN	RADII RI	RADII RO	BLADE ANGLES KIC	BLADE ANGLES KTC	BLADE ANGLES KOC	DELTA INC	CONE ANGLE
TIP	0.	24.399	24.384	29.57	17.96	-7.59	6.29	-0.219
1	5.	23.893	23.865	29.07	18.02	-7.36	6.16	-0.400
2	10.	23.393	23.305	28.76	18.15	-7.18	6.04	-1.270
3	30.	21.468	21.358	31.09	19.85	-7.42	5.43	-1.577
4	50.	19.588	19.591	34.88	22.21	-7.99	4.79	0.057
5	53.	19.354	19.379	35.33	22.52	-8.05	4.71	0.372
6	55.	19.119	19.169	35.77	22.82	-8.10	4.63	0.735
7	58.	18.884	18.961	36.20	23.11	-8.15	4.56	1.129
8	60.	18.648	18.755	36.60	23.41	-8.20	4.48	1.556
9	70.	17.706	17.949	37.83	24.48	-8.26	4.20	3.556
10	90.	15.828	16.382	35.68	24.77	-7.27	3.72	8.014
11	95.	15.372	15.976	33.86	24.17	-6.75	3.62	8.708
HUB	100.	14.595	15.240	30.45	22.98	-5.74	3.47	9.242

RP	BLADE THICKNESSES TI	BLADE THICKNESSES TM	BLADE THICKNESSES TO	AXIAL DIMENSIONS ZIC	AXIAL DIMENSIONS ZMC	AXIAL DIMENSIONS -ZTC	AXIAL DIMENSIONS ZOC
TIP	0.051	0.282	0.051	6.784	8.713	7.963	10.769
1	0.051	0.277	0.051	6.781	8.714	7.926	10.768
2	0.051	0.272	0.051	6.780	8.714	7.896	10.768
3	0.051	0.251	0.051	6.795	8.711	7.883	10.769
4	0.051	0.228	0.051	6.822	8.706	7.898	10.770
5	0.051	0.225	0.051	6.825	8.706	7.898	10.770
6	0.051	0.223	0.051	6.829	8.705	7.898	10.770
7	0.051	0.220	0.051	6.832	8.705	7.897	10.771
8	0.051	0.217	0.051	6.835	8.704	7.895	10.771
9	0.051	0.207	0.051	6.845	8.702	7.876	10.770
10	0.051	0.189	0.051	6.831	8.703	7.738	10.764
11	0.051	0.186	0.051	6.817	8.704	7.677	10.762
HUB	0.051	0.179	0.051	6.792	8.707	7.566	10.757

RP	AERO CHORD	SETTING ANGLE	TOTAL CAMBER	SOLIDITY	X FACTOR	PHISS	AREA RATIO
TIP	4.111	10.99	37.16	1.287	1.000	15.37	1.590
1	4.111	10.85	36.43	1.315	1.000	14.63	1.455
2	4.112	10.79	35.94	1.345	1.000	14.03	1.335
3	4.112	11.84	38.51	1.467	1.000	14.26	1.122
4	4.111	13.45	42.86	1.603	1.000	15.33	1.062
5	4.111	13.64	43.38	1.622	1.000	15.44	1.059
6	4.111	13.84	43.87	1.640	1.000	15.53	1.057
7	4.111	14.02	44.35	1.660	1.000	15.61	1.055
8	4.112	14.20	44.79	1.680	1.000	15.66	1.053
9	4.118	14.78	46.09	1.765	1.000	15.62	1.050
10	4.148	14.19	42.96	1.968	1.000	12.69	1.044
11	4.155	13.53	40.61	2.025	1.000	11.32	1.044
HUB	4.164	12.42	36.18	2.132	1.000	8.85	1.045

TABLE VI. - OVERALL PERFORMANCE FOR STAGE 21-18

(CLEAN INLET FLOW)

(a) 100 Percent of design speed

Parameter	Reading				
	2586	2585	2584	2583	2582
ROTOR TOTAL PRESSURE RATIO	1.440	1.574	1.632	1.652	1.667
STAGE TOTAL PRESSURE RATIO	1.408	1.557	1.595	1.612	1.611
ROTOR TOTAL TEMPERATURE RATIO	1.134	1.163	1.177	1.185	1.193
STAGE TOTAL TEMPERATURE RATIO	1.134	1.163	1.175	1.184	1.192
ROTOR TEMP. RISE EFFICIENCY	0.821	0.847	0.847	0.834	0.816
STAGE TEMP. RISE EFFICIENCY	0.769	0.828	0.814	0.793	0.761
ROTOR MOMENTUM RISE EFFICIENCY	0.790	0.848	0.853	0.844	0.826
ROTOR HEAD RISE COEFFICIENT	0.176	0.221	0.240	0.245	0.250
STAGE HEAD RISE COEFFICIENT	0.165	0.215	0.228	0.232	0.232
FLOW COEFFICIENT	0.442	0.433	0.416	0.400	0.378
WT FLOW PER UNIT FRONTAL AREA	154.46	152.40	147.89	144.31	137.97
WT FLOW PER UNIT ANNULUS AREA	207.14	204.37	198.32	193.52	185.03
WT FLOW AT ORIFICE	30.78	30.37	29.47	28.75	27.49
WT FLOW AT ROTOR INLET	30.72	30.33	29.47	28.76	27.53
WT FLOW AT ROTOR OUTLET	30.56	30.00	29.54	28.88	27.92
WT FLOW AT STATOR OUTLET	30.90	30.39	29.70	29.46	28.76
ROTATIVE SPEED	16114.4	16132.3	16129.8	16183.4	16168.4
PERCENT OF DESIGN SPEED	100.1	100.2	100.2	100.5	100.4

(b) 90 Percent of design speed

Parameter	Reading			
	2571	2581	2580	2579
ROTOR TOTAL PRESSURE RATIO	1.390	1.456	1.490	1.513
STAGE TOTAL PRESSURE RATIO	1.361	1.438	1.470	1.483
ROTOR TOTAL TEMPERATURE RATIO	1.113	1.128	1.136	1.145
STAGE TOTAL TEMPERATURE RATIO	1.111	1.127	1.136	1.144
ROTOR TEMP. RISE EFFICIENCY	0.877	0.885	0.886	0.863
STAGE TEMP. RISE EFFICIENCY	0.828	0.863	0.854	0.850
ROTOR MOMENTUM RISE EFFICIENCY	0.866	0.879	0.887	0.871
ROTOR HEAD RISE COEFFICIENT	0.195	0.225	0.239	0.247
STAGE HEAD RISE COEFFICIENT	0.182	0.217	0.231	0.234
FLOW COEFFICIENT	0.452	0.433	0.414	0.392
WT FLOW PER UNIT FRONTAL AREA	145.71	140.88	136.03	130.80
WT FLOW PER UNIT ANNULUS AREA	195.41	188.93	182.43	175.41
WT FLOW AT ORIFICE	29.03	28.07	27.10	26.06
WT FLOW AT ROTOR INLET	29.02	28.08	27.15	26.10
WT FLOW AT ROTOR OUTLET	29.27	28.01	27.26	26.31
WT FLOW AT STATOR OUTLET	28.84	28.04	27.31	26.37
ROTATIVE SPEED	14508.9	14487.2	14490.4	14548.1
PERCENT OF DESIGN SPEED	90.1	90.0	90.0	90.4

(c) 70 Percent of design speed

Parameter	Reading				
	2563	2564	2565	2566	2567
ROTOR TOTAL PRESSURE RATIO	1.193	1.239	1.257	1.268	1.283
STAGE TOTAL PRESSURE RATIO	1.177	1.229	1.246	1.253	1.253
ROTOR TOTAL TEMPERATURE RATIO	1.057	1.069	1.077	1.085	1.096
STAGE TOTAL TEMPERATURE RATIO	1.057	1.069	1.077	1.085	1.096
ROTOR TEMP. RISE EFFICIENCY	0.913	0.912	0.875	0.823	0.773
STAGE TEMP. RISE EFFICIENCY	0.842	0.882	0.846	0.786	0.690
ROTOR MOMENTUM RISE EFFICIENCY	0.910	0.920	0.889	0.827	0.763
ROTOR HEAD RISE COEFFICIENT	0.169	0.208	0.221	0.229	0.241
STAGE HEAD RISE COEFFICIENT	0.156	0.200	0.213	0.218	0.217
FLOW COEFFICIENT	0.455	0.414	0.379	0.342	0.301
WT FLOW PER UNIT FRONTAL AREA	119.75	110.00	102.34	93.73	83.02
WT FLOW PER UNIT ANNULUS AREA	160.59	147.51	137.24	125.70	111.34
WT FLOW AT ORIFICE	23.86	21.92	20.39	18.68	16.54
WT FLOW AT ROTOR INLET	23.91	22.02	20.45	18.67	16.59
WT FLOW AT ROTOR OUTLET	23.84	22.17	20.73	19.11	17.03
WT FLOW AT STATOR OUTLET	23.71	21.80	20.34	18.94	17.94
ROTATIVE SPEED	11264.8	11246.1	11267.2	1286.9	1302.8
PERCENT OF DESIGN SPEED	70.0	69.9	70.0	70.1	70.2

TABLE VII. - BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21

(CLEAN INLET FLOW); 100 PERCENT OF DESIGN SPEED

(a) Reading 2586

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	0.0	21.0	68.4	63.6	289.8	1.087	9.86	1.237
2	24.209	23.782	-0.0	20.0	65.5	60.7	289.3	1.094	10.14	1.263
3	21.976	21.631	-0.0	25.9	59.9	51.1	288.6	1.129	10.14	1.447
4	19.510	19.477	-0.0	37.4	54.7	44.9	287.9	1.148	10.15	1.424
5	19.187	19.210	-0.0	38.2	54.1	45.2	287.9	1.150	10.15	1.406
6	18.862	18.941	-0.0	38.6	53.4	43.8	287.8	1.154	10.15	1.415
7	18.534	18.672	-0.0	37.7	52.9	39.4	287.8	1.158	10.15	1.488
8	18.204	18.402	-0.0	37.1	52.2	36.7	287.8	1.159	10.15	1.529
9	16.863	17.325	-0.0	37.8	50.1	29.1	287.5	1.161	10.15	1.607
10	14.112	15.174	0.0	36.3	45.3	24.7	287.1	1.136	10.15	1.497
11	13.421	14.635	0.0	36.2	43.3	24.2	287.1	1.128	10.12	1.438

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	165.0	183.4	448.2	384.5	165.0	171.2	0.0	65.8	416.8	410.1
2	185.9	199.1	448.6	382.1	185.9	187.2	-0.0	68.0	408.3	401.1
3	214.4	235.2	428.0	336.8	214.4	211.7	-0.0	102.6	370.4	364.6
4	233.0	234.9	403.2	263.5	233.0	186.7	-0.0	142.6	329.1	328.6
5	234.8	230.2	400.1	256.4	234.8	180.8	-0.0	142.5	323.9	324.3
6	236.2	233.0	396.5	252.4	236.2	182.2	-0.0	145.2	318.5	319.8
7	237.2	250.1	392.7	256.0	237.2	197.9	-0.0	153.0	313.0	315.3
8	237.9	259.1	388.5	258.0	237.9	206.7	-0.0	156.2	307.2	310.5
9	238.3	277.9	371.2	251.1	238.3	219.5	-0.0	170.4	284.6	292.4
10	235.5	266.1	334.8	236.1	235.5	214.6	0.0	157.4	238.0	255.9
11	240.4	259.5	330.6	229.6	240.4	209.4	0.0	153.3	226.9	247.4

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.495	0.530	1.345	1.111	0.495	0.495	1.038	1.457
2	0.562	0.577	1.357	1.107	0.562	0.542	1.007	1.451
3	0.656	0.679	1.310	0.973	0.656	0.611	0.987	1.549
4	0.719	0.673	1.245	0.755	0.719	0.535	0.801	1.624
5	0.726	0.658	1.237	0.733	0.726	0.517	0.770	1.629
6	0.731	0.665	1.227	0.721	0.731	0.520	0.771	1.632
7	0.734	0.718	1.216	0.735	0.734	0.568	0.834	1.634
8	0.737	0.746	1.203	0.743	0.737	0.595	0.869	1.631
9	0.738	0.807	1.150	0.729	0.738	0.637	0.921	1.613
10	0.729	0.778	1.037	0.691	0.729	0.628	0.911	1.459
11	0.746	0.760	1.026	0.672	0.746	0.613	0.871	1.382

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	2.8	0.1	-0.2	0.197	0.716	0.114	0.051	0.019	0.009
2	10.00	1.6	-1.3	-0.3	0.204	0.732	0.114	0.050	0.021	0.009
3	30.00	2.8	-1.2	0.8	0.293	0.862	0.082	0.005	0.017	0.001
4	50.00	3.1	-2.0	7.5	0.454	0.718	0.198	0.115	0.043	0.025
5	52.50	3.1	-2.2	9.5	0.466	0.681	0.229	0.146	0.048	0.031
6	55.00	3.1	-2.3	9.9	0.472	0.678	0.238	0.155	0.050	0.033
7	57.50	3.1	-2.5	7.3	0.461	0.763	0.183	0.102	0.041	0.023
8	60.00	3.1	-2.6	6.4	0.451	0.812	0.150	0.072	0.034	0.016
9	70.00	3.3	-3.0	5.6	0.447	0.900	0.087	0.020	0.020	0.005
10	90.00	3.6	-3.8	8.5	0.403	0.897	0.090	0.065	0.018	0.013
11	95.00	3.2	-4.5	7.4	0.408	0.853	0.124	0.109	0.024	0.021

TABLE VII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR

ROTOR 21 (CLEAN INLET FLOW); 100 PERCENT OF DESIGN SPEED

(b) Reading 2585

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	-0.0	32.6	68.5	60.7	289.7	1.151	9.89	1.503
2	24.209	23.782	0.0	30.6	65.9	59.4	289.2	1.148	10.13	1.489
3	21.976	21.631	-0.0	34.2	60.4	51.6	288.5	1.165	10.14	1.595
4	19.510	19.477	-0.0	42.1	55.3	44.1	288.0	1.175	10.15	1.590
5	19.187	19.210	0.0	43.1	54.7	44.2	287.9	1.175	10.15	1.567
6	18.862	18.941	-0.0	43.9	54.2	43.5	287.8	1.176	10.15	1.561
7	18.534	18.672	-0.0	43.9	53.6	41.1	287.8	1.178	10.15	1.584
8	18.204	18.402	-0.0	43.3	53.0	38.1	287.7	1.180	10.15	1.619
9	16.863	17.325	-0.0	42.9	50.9	30.6	287.5	1.178	10.15	1.672
10	14.112	15.174	-0.0	41.4	46.4	27.5	287.2	1.144	10.14	1.536
11	13.421	14.635	0.0	41.3	44.6	23.5	287.2	1.143	10.12	1.527

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	164.1	201.3	448.5	346.6	164.1	169.6	-0.0	108.4	417.4	410.7
2	182.6	204.2	447.8	345.7	182.6	175.7	0.0	104.0	408.9	401.7
3	210.3	226.9	426.0	302.3	210.3	187.6	-0.0	127.7	370.5	364.7
4	228.0	236.7	400.7	244.4	228.0	175.5	-0.0	158.8	329.5	329.0
5	229.4	233.0	397.4	237.5	229.4	170.1	0.0	159.2	324.5	324.9
6	230.1	232.4	393.1	230.8	230.1	167.5	-0.0	161.1	318.6	320.0
7	231.1	238.5	389.2	228.1	231.1	171.8	-0.0	165.5	313.2	315.5
8	231.5	247.5	384.9	228.6	231.5	180.0	-0.0	169.8	307.4	310.8
9	231.5	263.4	367.4	224.1	231.5	193.0	-0.0	179.2	285.3	293.1
10	226.8	243.9	329.1	206.3	226.8	183.0	-0.0	161.2	238.5	256.5
11	229.9	250.7	322.9	205.4	229.9	188.4	0.0	165.4	226.7	247.2

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.492	0.567	1.346	0.977	0.492	0.478	1.034	1.463
2	0.552	0.577	1.353	0.978	0.552	0.497	0.962	1.462
3	0.642	0.642	1.302	0.856	0.642	0.531	0.892	1.558
4	0.703	0.670	1.235	0.692	0.703	0.497	0.770	1.636
5	0.707	0.659	1.225	0.671	0.707	0.481	0.742	1.642
6	0.710	0.657	1.213	0.653	0.710	0.473	0.728	1.645
7	0.713	0.675	1.201	0.646	0.713	0.486	0.744	1.646
8	0.715	0.702	1.188	0.649	0.715	0.511	0.777	1.646
9	0.715	0.753	1.135	0.641	0.715	0.552	0.834	1.632
10	0.699	0.704	1.015	0.595	0.699	0.528	0.807	1.491
11	0.710	0.726	0.997	0.595	0.710	0.545	0.819	1.415

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	2.9	0.2	-3.1	0.318	0.820	0.118	0.053	0.022	0.010
2	10.00	2.1	-0.9	-1.5	0.314	0.815	0.118	0.052	0.022	0.010
3	30.00	3.2	-0.7	1.4	0.391	0.866	0.099	0.022	0.021	0.005
4	50.00	3.7	-1.4	6.8	0.510	0.809	0.159	0.074	0.035	0.016
5	52.50	3.8	-1.5	8.6	0.522	0.781	0.183	0.099	0.039	0.021
6	55.00	3.8	-1.6	9.6	0.534	0.773	0.192	0.109	0.041	0.023
7	57.50	3.8	-1.7	9.0	0.537	0.791	0.181	0.100	0.040	0.022
8	60.00	3.9	-1.8	7.7	0.532	0.822	0.159	0.080	0.036	0.018
9	70.00	4.1	-2.1	7.1	0.521	0.887	0.109	0.040	0.025	0.009
10	90.00	4.8	-2.6	11.3	0.486	0.907	0.068	0.060	0.017	0.012
11	95.00	4.5	-3.2	6.6	0.477	0.899	0.097	0.081	0.019	0.016

TABLE VII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21 (CLEAN INLET FLOW); 100 PERCENT OF DESIGN SPEED

(c) Reading 2584

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	-0.0	37.6	69.3	59.8	289.5	1.182	9.90	1.589
2	24.209	23.782	-0.0	33.8	66.7	58.3	289.2	1.170	10.13	1.577
3	21.976	21.631	0.0	38.1	61.4	51.6	288.5	1.181	10.14	1.652
4	19.510	19.477	0.0	44.8	56.8	44.1	288.0	1.187	10.15	1.642
5	19.187	19.210	-0.0	46.3	56.2	43.8	287.9	1.187	10.15	1.628
6	18.862	18.941	-0.0	47.2	55.7	42.2	287.8	1.189	10.15	1.631
7	18.534	18.672	-0.0	47.1	55.1	39.6	287.8	1.192	10.15	1.656
8	18.204	18.402	0.0	46.6	54.6	36.7	287.7	1.193	10.15	1.683
9	16.863	17.325	-0.0	45.3	52.6	30.6	287.6	1.184	10.15	1.706
10	14.112	15.174	-0.0	44.0	48.3	27.1	287.3	1.150	10.14	1.569
11	13.421	14.635	-0.0	43.8	46.4	22.6	287.4	1.149	10.12	1.568

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	157.5	208.3	446.0	327.8	157.5	164.9	-0.0	127.2	417.3	410.6
2	175.8	211.3	444.7	333.6	175.8	175.5	-0.0	117.6	408.5	401.3
3	202.4	226.9	422.5	287.1	202.4	178.4	0.0	140.1	370.9	365.1
4	215.9	236.1	393.9	233.3	215.9	167.4	0.0	166.4	329.5	328.9
5	216.8	234.1	389.9	224.2	216.8	161.8	-0.0	169.2	324.1	324.4
6	217.5	237.2	385.8	217.6	217.5	161.3	-0.0	173.9	318.6	319.9
7	218.2	243.7	381.8	215.3	218.2	165.9	-0.0	178.5	313.3	315.6
8	218.2	251.0	377.1	215.1	218.2	172.4	0.0	182.3	307.5	310.9
9	218.0	260.0	358.9	212.2	218.0	182.7	-0.0	184.9	285.1	292.9
10	212.8	241.1	319.6	194.7	212.8	173.3	-0.0	167.6	238.4	256.3
11	216.2	249.3	313.5	194.9	216.2	179.9	-0.0	172.6	227.0	247.5

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.472	0.580	1.337	0.913	0.472	0.459	1.047	1.480
2	0.530	0.593	1.341	0.936	0.530	0.493	0.999	1.477
3	0.617	0.638	1.287	0.807	0.617	0.502	0.881	1.577
4	0.662	0.665	1.208	0.657	0.662	0.471	0.776	1.661
5	0.665	0.658	1.196	0.631	0.665	0.455	0.746	1.667
6	0.667	0.667	1.184	0.612	0.667	0.454	0.741	1.672
7	0.670	0.687	1.172	0.606	0.670	0.468	0.760	1.675
8	0.670	0.709	1.158	0.607	0.670	0.487	0.790	1.676
9	0.669	0.740	1.102	0.604	0.669	0.520	0.838	1.664
10	0.652	0.693	0.980	0.559	0.652	0.498	0.814	1.518
11	0.664	0.719	0.962	0.562	0.664	0.519	0.832	1.424

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	3.7	1.0	-4.0	0.373	0.776	0.172	0.105	0.033	0.020
2	10.00	2.8	-0.1	-2.7	0.347	0.820	0.131	0.064	0.026	0.013
3	30.00	4.2	0.2	1.4	0.432	0.853	0.118	0.039	0.025	0.008
4	50.00	5.1	0.0	6.8	0.536	0.817	0.164	0.078	0.036	0.017
5	52.50	5.2	-0.1	8.2	0.555	0.797	0.184	0.099	0.040	0.021
6	55.00	5.3	-0.1	8.3	0.569	0.792	0.193	0.108	0.042	0.024
7	57.50	5.4	-0.2	7.4	0.572	0.807	0.184	0.101	0.041	0.022
8	60.00	5.5	-0.2	6.4	0.568	0.829	0.167	0.085	0.038	0.020
9	70.00	5.8	-0.5	7.1	0.547	0.894	0.108	0.037	0.025	0.009
10	90.00	6.6	-0.8	11.0	0.512	0.919	0.083	0.055	0.016	0.011
11	95.00	6.3	-1.4	5.8	0.500	0.918	0.086	0.072	0.017	0.014

TABLE VII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21 (CLEAN INLET FLOW); 100 PERCENT OF DESIGN SPEED

(d) Reading 2583

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	0.0	39.4	70.0	59.2	289.7	1.191	9.90	1.635
2	24.209	23.782	-0.0	36.0	67.5	58.7	289.1	1.179	10.13	1.595
3	21.976	21.631	-0.0	40.2	62.5	52.3	288.5	1.189	10.14	1.665
4	19.510	19.477	-0.0	47.1	57.9	44.2	288.0	1.195	10.15	1.667
5	19.187	19.210	0.0	48.6	57.4	43.7	287.9	1.196	10.15	1.650
6	18.862	18.941	-0.0	49.4	56.9	42.1	287.8	1.198	10.15	1.655
7	18.534	18.672	-0.0	49.6	56.4	39.4	287.8	1.201	10.15	1.677
8	18.204	18.402	-0.0	48.9	55.8	36.5	287.7	1.202	10.15	1.705
9	16.863	17.325	0.0	46.6	53.7	30.1	287.6	1.192	10.15	1.731
10	14.112	15.174	-0.0	45.0	49.5	27.2	287.3	1.154	10.14	1.586
11	13.421	14.635	0.0	45.0	47.5	22.2	287.4	1.154	10.12	1.587

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	152.2	213.3	445.6	322.1	152.2	164.9	0.0	135.3	418.8	412.0
2	169.3	209.4	443.0	326.5	169.3	169.5	-0.0	123.0	409.4	402.2
3	194.3	224.4	420.0	280.3	194.3	171.5	-0.0	144.8	372.4	366.5
4	207.1	236.6	390.2	224.6	207.1	160.9	-0.0	173.4	330.7	330.1
5	207.2	235.1	385.1	215.1	207.2	155.4	0.0	176.3	324.6	325.0
6	208.5	238.1	381.5	208.9	208.5	155.0	-0.0	180.7	319.5	320.8
7	209.0	244.6	377.2	205.0	209.0	158.5	-0.0	186.4	314.0	316.4
8	209.6	251.8	373.2	205.7	209.6	165.4	-0.0	189.9	308.8	312.2
9	209.9	261.5	354.9	207.5	209.9	179.6	0.0	190.1	286.2	294.0
10	204.9	240.6	315.2	191.3	204.9	170.1	-0.0	170.1	239.5	257.5
11	208.5	249.5	308.7	190.5	208.5	176.4	0.0	176.4	227.7	248.3

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.455	0.593	1.333	0.895	0.455	0.458	1.083	1.501
2	0.510	0.585	1.333	0.912	0.510	0.473	1.001	1.498
3	0.590	0.628	1.276	0.784	0.590	0.480	0.883	1.603
4	0.633	0.664	1.192	0.630	0.633	0.451	0.777	1.688
5	0.633	0.659	1.177	0.603	0.633	0.436	0.750	1.693
6	0.638	0.668	1.167	0.586	0.638	0.435	0.743	1.699
7	0.639	0.687	1.154	0.575	0.639	0.445	0.758	1.702
8	0.641	0.709	1.142	0.579	0.641	0.465	0.789	1.705
9	0.642	0.742	1.086	0.589	0.642	0.510	0.856	1.693
10	0.626	0.690	0.963	0.548	0.626	0.488	0.830	1.531
11	0.638	0.718	0.945	0.548	0.638	0.507	0.846	1.434

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	4.4	1.7	-4.6	0.392	0.791	0.167	0.096	0.032	0.019
2	10.00	3.7	0.8	-2.2	0.365	0.799	0.153	0.083	0.029	0.016
3	30.00	5.3	1.3	2.1	0.448	0.831	0.141	0.058	0.029	0.012
4	50.00	6.3	1.2	6.9	0.559	0.806	0.182	0.092	0.040	0.020
5	52.50	6.5	1.2	8.1	0.578	0.785	0.206	0.117	0.044	0.025
6	55.00	6.5	1.1	8.2	0.592	0.783	0.211	0.123	0.046	0.027
7	57.50	6.6	1.0	7.2	0.600	0.794	0.207	0.120	0.046	0.027
8	60.00	6.7	1.0	6.2	0.594	0.814	0.192	0.106	0.044	0.024
9	70.00	6.9	0.7	6.6	0.559	0.883	0.126	0.051	0.029	0.012
10	90.00	7.8	0.4	11.1	0.517	0.914	0.092	0.064	0.018	0.013
11	95.00	7.4	-0.3	5.4	0.509	0.913	0.097	0.082	0.019	0.016

TABLE VII. - Concluded. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21 (CLEAN INLET FLOW); 100 PERCENT OF DESIGN SPEED

(e) Reading 2582

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	-0.0	42.2	71.0	59.4	289.5	1.207	9.93	1.654
2	24.209	23.782	-0.0	38.7	68.8	58.7	289.2	1.191	10.11	1.625
3	21.976	21.631	0.0	43.1	64.0	52.4	288.4	1.198	10.15	1.681
4	19.510	19.477	-0.0	50.4	59.7	44.8	287.9	1.204	10.15	1.673
5	19.187	19.210	-0.0	51.0	59.2	43.7	287.9	1.204	10.15	1.668
6	18.862	18.941	0.0	52.5	58.7	40.8	287.8	1.207	10.15	1.686
7	18.534	18.672	0.0	52.2	58.1	38.3	287.8	1.210	10.15	1.704
8	18.204	18.402	-0.0	51.3	57.6	35.5	287.8	1.210	10.15	1.723
9	16.863	17.325	-0.0	47.8	55.5	30.1	287.6	1.194	10.15	1.737
10	14.112	15.174	-0.0	45.7	51.2	27.0	287.5	1.156	10.15	1.594
11	13.421	14.635	0.0	45.2	49.1	22.3	287.5	1.154	10.13	1.592

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	143.9	214.1	442.4	311.3	143.9	158.7	-0.0	143.8	416.4	411.6
2	158.9	210.8	439.3	316.6	158.9	164.5	-0.0	131.8	409.5	402.3
3	181.6	224.3	414.0	268.8	181.6	163.9	0.0	153.1	372.0	366.1
4	193.0	234.9	382.4	211.0	193.0	149.8	-0.0	181.0	330.2	329.6
5	194.0	235.9	378.5	205.5	194.0	148.5	-0.0	183.3	325.0	325.4
6	194.5	243.1	374.0	195.7	194.5	148.1	0.0	192.8	319.5	320.8
7	195.1	248.3	369.6	193.9	195.1	152.3	0.0	196.1	313.9	316.2
8	195.5	254.1	365.0	195.2	195.5	158.9	-0.0	198.2	308.2	311.6
9	196.2	260.0	346.7	201.8	196.2	174.7	-0.0	192.6	285.9	293.7
10	192.4	239.9	306.8	188.2	192.4	167.7	-0.0	171.6	239.0	257.0
11	196.7	248.1	300.5	189.1	196.7	175.0	0.0	175.9	227.1	247.7

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.430	0.591	1.321	0.859	0.430	0.438	1.103	1.523
2	0.477	0.586	1.318	0.880	0.477	0.457	1.035	1.526
3	0.549	0.625	1.252	0.749	0.549	0.457	0.902	1.633
4	0.587	0.656	1.162	0.589	0.587	0.418	0.776	1.724
5	0.590	0.659	1.151	0.574	0.590	0.415	0.766	1.731
6	0.591	0.680	1.138	0.547	0.591	0.414	0.761	1.738
7	0.594	0.695	1.124	0.543	0.594	0.426	0.781	1.741
8	0.595	0.713	1.111	0.548	0.595	0.446	0.813	1.743
9	0.597	0.737	1.056	0.572	0.597	0.495	0.890	1.737
10	0.585	0.687	0.933	0.539	0.585	0.480	0.871	1.537
11	0.599	0.713	0.915	0.544	0.599	0.503	0.889	1.439

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	5.4	2.7	-4.4	0.419	0.747	0.216	0.143	0.042	0.028
2	10.00	4.9	2.0	-2.3	0.390	0.778	0.179	0.106	0.035	0.020
3	30.00	6.8	2.9	2.2	0.475	0.807	0.171	0.085	0.035	0.017
4	50.00	8.1	2.9	7.4	0.592	0.777	0.221	0.127	0.048	0.027
5	52.50	8.2	2.9	8.1	0.602	0.770	0.233	0.139	0.050	0.030
6	55.00	8.3	2.9	7.0	0.629	0.776	0.233	0.139	0.052	0.031
7	57.50	8.4	2.8	6.1	0.629	0.782	0.234	0.141	0.053	0.032
8	60.00	8.4	2.7	5.2	0.621	0.800	0.218	0.128	0.051	0.030
9	70.00	8.7	2.5	6.6	0.567	0.879	0.136	0.055	0.031	0.013
10	90.00	9.5	2.1	10.9	0.515	0.916	0.095	0.070	0.019	0.014
11	95.00	9.0	1.3	5.5	0.500	0.923	0.089	0.077	0.017	0.015

TABLE VIII. - BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18

(CLEAN INLET FLOW); 100 PERCENT OF DESIGN SPEED

(a) Reading 2586

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	21.2	-1.8	21.2	-1.8	315.1	1.001	12.19	0.979
2	23.393	23.304	19.5	-2.3	19.5	-2.3	316.5	0.999	12.80	0.973
3	21.468	21.359	21.9	-1.0	21.9	-1.0	325.9	1.004	14.68	0.990
4	19.588	19.591	31.1	-2.7	31.1	-2.7	330.5	0.997	14.45	0.997
5	19.355	19.380	32.0	-3.0	32.0	-3.0	331.1	0.997	14.28	1.011
6	19.119	19.169	32.0	-2.9	32.0	-2.9	332.1	0.995	14.36	1.014
7	18.882	18.961	30.2	-2.3	30.2	-2.3	333.2	0.995	15.11	0.984
8	18.649	18.755	28.5	-1.6	28.5	-1.6	333.5	0.997	15.52	0.976
9	17.706	17.950	27.0	-0.3	27.0	-0.3	333.9	0.999	16.31	0.975
10	15.829	16.383	27.5	-0.8	27.5	-0.8	326.2	1.000	15.19	0.960
11	15.372	15.977	29.0	0.0	29.0	0.0	324.0	0.998	14.56	0.909

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	185.0	175.7	185.0	175.7	172.5	175.6	67.0	-5.4	0.	0.
2	207.2	194.1	207.2	194.1	195.3	194.0	69.1	-7.6	0.	0.
3	277.6	245.9	277.6	245.9	257.6	245.9	103.4	-4.1	0.	0.
4	274.5	239.9	274.5	239.9	235.1	239.6	141.7	-11.4	0.	0.
5	267.2	240.5	267.2	240.5	226.7	240.2	141.4	-12.7	0.	0.
6	271.3	243.7	271.3	243.7	230.0	243.4	143.9	-12.4	0.	0.
7	301.1	250.1	301.1	250.1	260.4	249.9	151.2	-9.9	0.	0.
8	323.3	256.4	323.3	256.4	284.1	256.3	154.1	-7.1	0.	0.
9	367.4	273.5	367.4	273.5	327.4	273.5	166.8	-1.5	0.	0.
10	327.1	296.0	327.1	296.0	290.2	295.9	150.9	-3.9	0.	0.
11	301.2	272.7	301.2	272.7	263.5	272.7	146.0	0.0	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.535	0.506	0.535	0.506	0.498	0.506	1.018	0.566
2	0.602	0.562	0.602	0.562	0.567	0.561	0.993	0.602
3	0.817	0.712	0.817	0.712	0.758	0.712	0.955	0.817
4	0.800	0.690	0.800	0.690	0.685	0.689	1.019	1.060
5	0.775	0.691	0.775	0.691	0.658	0.690	1.059	1.044
6	0.787	0.701	0.787	0.701	0.668	0.700	1.058	1.055
7	0.885	0.720	0.885	0.720	0.765	0.719	0.960	1.116
8	0.961	0.739	0.961	0.739	0.845	0.738	0.902	1.139
9	1.122	0.793	1.122	0.793	1.000	0.793	0.835	1.156
10	0.988	0.878	0.988	0.878	0.876	0.878	1.020	1.060
11	0.900	0.804	0.900	0.804	0.787	0.804	1.035	1.056

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	-7.9	-14.0	5.6	0.199	0.	0.120	0.120	0.046	0.046
2	10.00	-9.3	-15.3	4.9	0.201	0.	0.127	0.127	0.047	0.047
3	30.00	-9.2	-14.6	6.5	0.246	0.	0.029	0.029	0.010	0.010
4	50.00	-3.7	-8.5	5.3	0.300	0.	0.008	0.008	0.002	0.002
5	52.50	-3.3	-8.0	5.0	0.278	0.	-0.034	-0.034	-0.010	-0.010
6	55.00	-3.6	-8.3	5.2	0.277	0.	-0.043	-0.043	-0.013	-0.013
7	57.50	-5.9	-10.5	5.9	0.330	0.	0.041	0.041	0.012	0.012
8	60.00	-8.0	-12.5	6.6	0.355	0.	0.054	0.053	0.016	0.016
9	70.00	-10.7	-14.9	7.9	0.385	0.	0.046	0.041	0.013	0.012
10	90.00	-8.1	-11.8	6.5	0.213	0.	0.086	0.086	0.022	0.022
11	95.00	-4.8	-8.4	6.8	0.212	0.	0.223	0.223	0.055	0.055

TABLE VIII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR

STATOR 18 (CLEAN INLET FLOW); 100 PERCENT OF DESIGN SPEED

(b) Reading 2585

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	32.8	0.1	32.8	0.1	333.4	1.001	14.87	0.977
2	23.393	23.304	30.0	-0.3	30.0	-0.3	332.0	1.000	15.09	0.993
3	21.468	21.359	30.3	-0.2	30.3	-0.2	336.1	1.001	16.17	0.992
4	19.588	19.591	36.1	-1.3	36.1	-1.3	338.4	0.996	16.14	0.990
5	19.355	19.380	37.0	-1.5	37.0	-1.5	338.4	0.997	15.91	1.003
6	19.119	19.169	37.7	-1.4	37.7	-1.4	338.3	0.998	15.85	1.011
7	18.882	18.961	37.4	-1.2	37.4	-1.2	338.9	0.997	16.08	1.008
8	18.649	18.755	36.4	-0.4	36.4	-0.4	339.3	0.997	16.44	0.993
9	17.706	17.950	34.8	0.5	34.8	0.5	338.7	0.996	16.97	0.984
10	15.829	16.383	34.5	-1.8	34.5	-1.8	328.5	1.005	15.58	0.987
11	15.372	15.977	34.8	-1.5	34.8	-1.5	328.3	1.001	15.46	0.942

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	203.6	165.9	203.6	165.9	171.1	165.9	110.4	0.2	0.	0.
2	211.4	180.6	211.4	180.6	183.1	180.6	105.7	-1.1	0.	0.
3	254.6	206.2	254.6	206.2	219.7	206.2	128.6	-0.6	0.	0.
4	268.1	203.8	268.1	203.8	216.6	203.8	157.9	-4.7	0.	0.
5	262.5	203.7	262.5	203.7	209.6	203.7	158.0	-5.4	0.	0.
6	261.1	205.5	261.1	205.5	206.7	205.5	159.6	-4.9	0.	0.
7	269.3	210.6	269.3	210.6	213.9	210.5	163.6	-4.6	0.	0.
8	282.6	214.0	282.6	214.0	227.5	214.0	167.6	-1.6	0.	0.
9	307.1	225.8	307.1	225.8	252.2	225.8	175.3	1.9	0.	0.
10	272.6	212.5	272.6	212.5	224.5	212.4	154.6	-6.5	0.	0.
11	275.7	194.8	275.7	194.8	226.3	194.7	157.5	-5.2	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.574	0.462	0.574	0.462	0.483	0.462	0.970	0.868
2	0.599	0.507	0.599	0.507	0.519	0.507	0.987	0.844
3	0.729	0.580	0.729	0.580	0.629	0.580	0.939	0.998
4	0.769	0.572	0.769	0.572	0.621	0.571	0.941	1.152
5	0.751	0.571	0.751	0.571	0.600	0.571	0.972	1.142
6	0.747	0.576	0.747	0.576	0.591	0.576	0.994	1.146
7	0.772	0.591	0.772	0.591	0.613	0.591	0.984	1.17[illegible]
8	0.814	0.601	0.814	0.601	0.656	0.601	0.941	1.199
9	0.897	0.638	0.897	0.638	0.736	0.638	0.895	1.243
10	0.796	0.604	0.796	0.604	0.656	0.604	0.946	1.086
11	0.807	0.552	0.807	0.552	0.663	0.552	0.860	1.124

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	3.8	-2.4	7.4	0.391	0.	0.113	0.113	0.043	0.043
2	10.00	1.2	-4.8	6.8	0.334	0.	0.030	0.030	0.011	0.011
3	30.00	-0.7	-6.2	7.3	0.363	0.	0.025	0.025	0.009	0.009
4	50.00	1.3	-3.5	6.7	0.429	0.	0.032	0.032	0.010	0.010
5	52.50	1.8	-2.9	6.5	0.416	0.	-0.011	-0.011	-0.003	-0.003
6	55.00	2.0	-2.6	6.7	0.405	0.	-0.035	-0.035	-0.011	-0.011
7	57.50	1.3	-3.2	6.9	0.406	0.	-0.026	-0.026	-0.008	-0.008
8	60.00	-0.1	-4.6	7.8	0.420	0.	0.019	0.019	0.006	0.006
9	70.00	-2.8	-7.0	8.7	0.424	0.	0.040	0.039	0.011	0.011
10	90.00	-1.0	-4.7	5.5	0.368	0.	0.038	0.038	0.010	0.010
11	95.00	1.1	-2.5	5.2	0.437	0.	0.165	0.165	0.041	0.041

TABLE VIII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18 (CLEAN INLET FLOW); 100 PERCENT OF DESIGN SPEED

(c) Reading 2584

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	37.9	2.3	37.9	2.3	342.3	0.993	15.72	0.981
2	23.393	23.304	33.2	0.9	33.2	0.9	338.2	0.997	15.97	0.984
3	21.468	21.359	34.3	0.5	34.3	0.5	340.6	0.998	16.76	0.981
4	19.588	19.591	39.0	-0.5	39.0	-0.5	341.7	0.998	16.67	0.977
5	19.355	19.380	40.4	-0.8	40.4	-0.8	341.9	0.998	16.52	0.989
6	19.119	19.169	41.1	-0.9	41.1	-0.9	342.4	0.997	16.56	0.990
7	18.882	18.961	40.7	-0.1	40.7	-0.1	343.1	0.996	16.81	0.985
8	18.649	18.755	39.9	0.6	39.9	0.6	343.3	0.996	17.08	0.980
9	17.706	17.950	37.8	1.7	37.8	1.7	340.6	0.997	17.31	0.970
10	15.829	16.383	37.5	-1.3	37.5	-1.3	330.3	1.005	15.92	0.971
11	15.372	15.977	37.6	-1.3	37.6	-1.3	330.4	0.999	15.87	0.933

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	210.8	170.4	210.8	170.4	166.4	170.3	129.5	6.8	0.	0.
2	218.5	178.0	218.5	178.0	182.9	178.0	119.5	2.8	0.	0.
3	250.7	194.3	250.7	194.3	207.2	194.3	141.2	1.7	0.	0.
4	263.1	191.2	263.1	191.2	204.6	191.2	165.4	-1.7	0.	0.
5	259.2	192.8	259.2	192.8	197.4	192.8	168.0	-2.7	0.	0.
6	262.1	194.8	262.1	194.8	197.5	194.8	172.3	-2.9	0.	0.
7	270.5	199.4	270.5	199.4	204.9	199.4	176.5	-0.2	0.	0.
8	280.5	204.8	280.5	204.8	215.2	204.7	179.9	2.2	0.	0.
9	295.1	209.5	295.1	209.5	233.1	209.4	181.0	6.3	0.	0.
10	264.2	189.5	264.2	189.5	209.7	189.4	160.6	-4.3	0.	0.
11	269.4	173.3	269.4	-173.3	213.5	173.2	164.3	-4.0	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.588	0.471	0.588	0.471	0.464	0.471	1.023	0.989
2	0.615	0.495	0.615	0.495	0.515	0.495	0.973	0.932
3	0.711	0.541	0.711	0.541	0.588	0.541	0.938	1.070
4	0.749	0.531	0.749	0.531	0.582	0.531	0.935	1.195
5	0.736	0.536	0.736	0.536	0.561	0.535	0.977	1.204
6	0.745	0.541	0.745	0.541	0.561	0.541	0.986	1.229
7	0.770	0.554	0.770	0.554	0.584	0.554	0.973	1.255
8	0.802	0.570	0.802	0.570	0.616	0.570	0.951	1.278
9	0.854	0.586	0.854	0.586	0.675	0.586	0.898	1.272
10	0.767	0.533	0.767	0.533	0.609	0.533	0.903	1.123
11	0.784	0.487	0.784	0.487	0.621	0.487	0.811	1.165

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	8.8	2.7	9.6	0.413	0.	0.093	0.093	0.035	0.035
2	10.00	4.4	-1.6	8.1	0.384	0.	0.073	0.073	0.027	0.027
3	30.00	3.2	-2.2	7.9	0.415	0.	0.066	0.066	0.023	0.023
4	50.00	4.2	-0.6	7.5	0.471	0.	0.073	0.073	0.023	0.023
5	52.50	5.2	0.5	7.2	0.459	0.	0.035	0.035	0.011	0.011
6	55.00	5.5	0.8	7.2	0.460	0.	0.032	0.032	0.010	0.010
7	57.50	4.7	0.1	8.1	0.459	0.	0.047	0.047	0.014	0.014
8	60.00	3.4	-1.0	8.8	0.458	0.	0.058	0.058	0.017	0.017
9	70.00	0.2	-4.0	10.0	0.457	0.	0.078	0.077	0.022	0.022
10	90.00	1.9	-1.8	6.0	0.439	0.	0.089	0.089	0.023	0.023
11	95.00	3.8	0.2	5.4	0.508	0.	0.201	0.201	0.050	0.050

TABLE VIII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18 (CLEAN INLET FLOW); 100 PERCENT OF DESIGN SPEED

(d) Reading 2583

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	39.6	3.2	39.6	3.2	344.9	0.997	16.19	0.974
2	23.393	23.304	35.3	1.4	35.3	1.4	340.8	1.000	16.15	0.994
3	21.468	21.359	36.4	1.8	36.4	1.8	342.9	0.999	16.88	0.984
4	19.588	19.591	41.4	-0.2	41.4	-0.2	344.2	0.998	16.93	0.972
5	19.355	19.380	42.9	-0.5	42.9	-0.5	344.4	0.998	16.75	0.981
6	19.119	19.169	43.5	-0.3	43.5	-0.3	344.7	0.997	16.80	0.987
7	18.882	18.961	43.5	0.3	43.5	0.3	345.5	0.996	17.02	0.981
8	18.649	18.755	42.5	0.6	42.5	0.6	345.9	0.996	17.31	0.972
9	17.706	17.950	39.3	2.5	39.3	2.5	342.9	0.997	17.57	0.959
10	15.829	16.383	38.5	-1.2	38.5	-1.2	331.6	1.004	16.08	0.965
11	15.372	15.977	38.9	-1.0	38.9	-1.0	331.8	0.998	16.06	0.929

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	216.0	172.3	216.0	172.3	166.5	172.0	137.7	9.6	0.	0.
2	216.3	179.6	216.3	179.6	176.5	179.6	125.1	4.4	0.	0.
3	246.0	191.2	246.0	191.2	198.1	191.1	145.9	6.1	0.	0.
4	260.5	187.6	260.5	187.6	195.3	187.6	172.4	-0.8	0.	0.
5	257.3	187.6	257.3	187.6	188.5	187.6	175.0	-1.8	0.	0.
6	260.1	192.2	260.1	192.2	188.6	192.2	179.1	-0.9	0.	0.
7	267.6	195.8	267.6	195.8	194.1	195.8	184.3	0.9	0.	0.
8	277.4	199.8	277.4	199.8	204.5	199.8	187.4	1.9	0.	0.
9	293.9	203.6	293.9	203.6	227.6	203.5	186.0	8.9	0.	0.
10	262.0	181.0	262.0	181.0	205.1	180.9	163.0	-3.7	0.	0.
11	267.7	164.9	267.7	164.9	208.4	164.9	168.0	-2.8	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.601	0.474	0.601	0.474	0.463	0.473	1.033	1.046
2	0.606	0.497	0.606	0.497	0.494	0.497	1.018	0.963
3	0.694	0.530	0.694	0.530	0.559	0.530	0.965	1.093
4	0.738	0.518	0.738	0.518	0.553	0.518	0.961	1.239
5	0.727	0.518	0.727	0.518	0.533	0.518	0.995	1.251
6	0.736	0.532	0.736	0.532	0.534	0.532	1.019	1.275
7	0.759	0.542	0.759	0.542	0.550	0.542	1.009	1.308
8	0.789	0.553	0.789	0.553	0.582	0.553	0.977	1.326
9	0.847	0.567	0.847	0.567	0.656	0.566	0.894	1.302
10	0.758	0.507	0.758	0.507	0.593	0.507	0.882	1.136
11	0.776	0.462	0.776	0.462	0.604	0.462	0.791	1.188

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	10.5	4.4	10.5	0.428	0.	0.121	0.121	0.046	0.046
2	10.00	6.6	0.5	8.6	0.377	0.	0.028	0.028	0.010	0.010
3	30.00	5.3	-0.1	9.2	0.417	0.	0.059	0.059	0.020	0.020
4	50.00	6.7	1.9	7.7	0.487	0.	0.092	0.092	0.029	0.029
5	52.50	7.7	3.0	7.5	0.482	0.	0.065	0.065	0.020	0.020
6	55.00	7.9	3.2	7.8	0.472	0.	0.044	0.044	0.013	0.013
7	57.50	7.5	2.9	8.4	0.474	0.	0.060	0.060	0.018	0.018
8	60.00	6.1	1.6	8.8	0.478	0.	0.083	0.083	0.025	0.025
9	70.00	1.6	-2.6	10.8	0.476	0.	0.109	0.108	0.031	0.031
10	90.00	2.9	-0.8	6.1	0.468	0.	0.109	0.109	0.028	0.028
11	95.00	5.1	1.5	5.8	0.539	0.	0.216	0.216	0.053	0.053

TABLE VIII. - Concluded. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18 (CLEAN INLET FLOW); 100 PERCENT OF DESIGN SPEED

(e) Reading 2582

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	42.4	2.7	42.4	2.7	349.4	0.993	16.42	0.972
2	23.393	23.304	38.1	2.7	38.1	2.7	344.5	1.000	16.43	0.982
3	21.468	21.359	39.3	2.6	39.3	2.6	345.5	1.000	17.05	0.970
4	19.588	19.591	45.0	-0.6	45.0	-0.6	346.5	0.998	16.97	0.970
5	19.355	19.380	45.4	0.0	45.4	0.0	346.8	0.998	16.93	0.979
6	19.119	19.169	46.8	0.8	46.8	0.8	347.5	0.997	17.12	0.976
7	18.882	18.961	46.3	0.4	46.3	0.4	348.3	0.994	17.30	0.966
8	18.649	18.755	45.1	1.7	45.1	1.7	348.3	0.994	17.49	0.959
9	17.706	17.950	40.6	2.9	40.6	2.9	343.6	0.997	17.64	0.949
10	15.829	16.383	39.2	-1.6	39.2	-1.6	332.2	1.001	16.17	0.956
11	15.372	15.977	39.0	-0.6	39.0	-0.6	331.8	0.999	16.12	0.929

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	217.0	174.1	217.0	174.1	160.2	173.9	146.3	8.1	0.	0.
2	217.4	177.4	217.4	177.4	171.2	177.2	134.0	8.4	0.	0.
3	243.5	185.3	243.5	185.3	188.4	185.2	154.3	8.4	0.	0.
4	254.5	183.8	254.5	183.8	180.0	183.8	179.9	-2.0	0.	0.
5	255.3	186.9	255.3	186.9	179.1	186.9	181.9	0.0	0.	0.
6	261.8	191.3	261.8	191.3	179.1	191.3	191.0	2.8	0.	0.
7	268.3	192.0	268.3	192.0	185.3	192.0	193.9	1.3	0.	0.
8	276.2	194.1	276.2	194.1	195.0	194.0	195.6	5.9	0.	0.
9	289.3	195.6	289.3	195.6	219.5	195.3	188.4	10.0	0.	0.
10	260.1	172.5	260.1	172.5	201.5	172.4	164.5	-4.8	0.	0.
11	265.9	161.1	265.9	161.1	206.5	161.1	167.5	-1.6	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.600	0.477	0.600	0.477	0.443	0.476	1.085	1.102
2	0.605	0.488	0.605	0.488	0.477	0.487	1.035	1.078
3	0.683	0.510	0.683	0.510	0.529	0.510	0.983	1.145
4	0.716	0.506	0.716	0.506	0.507	0.506	1.021	1.290
5	0.718	0.514	0.718	0.514	0.504	0.514	1.044	1.299
6	0.738	0.527	0.738	0.527	0.505	0.527	1.068	1.363
7	0.757	0.529	0.757	0.529	0.523	0.529	1.036	1.378
8	0.782	0.535	0.782	0.535	0.552	0.535	0.995	1.384
9	0.831	0.543	0.831	0.543	0.630	0.542	0.890	1.317
10	0.751	0.483	0.751	0.483	0.582	0.483	0.856	1.145
11	0.770	0.450	0.770	0.450	0.598	0.450	0.780	1.184

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	13.3	7.2	10.0	0.440	0.	0.130	0.130	0.049	0.049
2	10.00	9.3	3.2	9.9	0.399	0.	0.081	0.081	0.030	0.030
3	30.00	8.2	2.8	10.0	0.444	0.	0.110	0.110	0.037	0.037
4	50.00	10.2	5.4	7.4	0.501	0.	0.102	0.102	0.032	0.032
5	52.50	10.2	5.5	8.1	0.487	0.	0.073	0.073	0.023	0.023
6	55.00	11.2	6.6	8.9	0.488	0.	0.080	0.079	0.024	0.024
7	57.50	10.2	5.7	8.5	0.500	0.	0.107	0.106	0.032	0.032
8	60.00	8.6	4.2	9.9	0.501	0.	0.124	0.122	0.037	0.036
9	70.00	3.0	-1.2	11.2	0.497	0.	0.140	0.139	0.040	0.039
10	90.00	3.7	-0.1	5.7	0.500	0.	0.142	0.142	0.036	0.036
11	95.00	5.3	1.7	6.2	0.548	0.	0.218	0.218	0.054	0.054

TABLE IX. - BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21

(CLEAN INLET FLOW); 90 PERCENT OF DESIGN SPEED

(a) Reading 2571

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	0.0	20.2	68.0	61.6	289.6	1.078	9.90	1.239
2	24.209	23.782	0.0	19.6	65.3	59.6	289.2	1.082	10.12	1.249
3	21.976	21.631	0.0	26.1	59.6	50.4	288.5	1.108	10.15	1.377
4	19.510	19.477	0.0	35.1	54.5	41.1	287.9	1.128	10.15	1.422
5	19.187	19.210	-0.0	35.2	53.9	40.5	287.7	1.129	10.15	1.422
6	18.862	18.941	-0.0	35.4	53.3	39.8	287.8	1.129	10.15	1.420
7	18.534	18.672	0.0	34.8	52.7	36.9	287.7	1.130	10.15	1.464
8	18.204	18.402	0.0	34.8	52.2	35.5	287.6	1.130	10.15	1.472
9	16.863	17.325	0.0	36.5	50.0	29.1	287.6	1.130	10.15	1.499
10	14.112	15.174	0.0	35.6	45.4	23.6	287.4	1.114	10.14	1.419
11	13.421	14.635	0.0	35.6	43.8	22.4	287.4	1.109	10.12	1.389

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	151.6	177.6	405.1	350.5	151.6	166.7	0.0	61.2	375.6	369.6
2	169.6	186.3	405.4	346.7	169.6	175.5	0.0	62.7	368.2	361.7
3	195.7	215.6	387.0	303.7	195.7	193.7	0.0	94.7	333.9	328.6
4	211.0	229.6	363.8	249.1	211.0	187.7	0.0	132.1	296.3	295.8
5	212.5	229.2	361.0	246.2	212.5	187.2	-0.0	132.2	291.9	292.2
6	213.8	229.1	357.9	243.1	213.8	186.8	-0.0	132.6	287.0	288.2
7	214.8	239.6	354.6	246.1	214.8	196.9	0.0	136.6	282.2	284.3
8	214.7	241.9	350.1	243.8	214.7	198.6	0.0	138.1	276.5	279.6
9	214.3	252.0	333.5	231.8	214.3	202.6	0.0	149.8	255.5	262.5
10	210.8	245.4	300.4	217.9	210.8	199.6	0.0	142.8	214.1	230.2
11	212.8	242.3	294.7	213.2	212.8	197.1	0.0	141.0	203.8	222.2

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.453	0.515	1.212	1.016	0.453	0.483	1.100	1.318
2	0.510	0.540	1.220	1.006	0.510	0.509	1.034	1.313
3	0.595	0.624	1.176	0.880	0.595	0.561	0.990	1.420
4	0.646	0.663	1.113	0.719	0.646	0.542	0.889	1.514
5	0.651	0.662	1.106	0.711	0.651	0.540	0.881	1.522
6	0.655	0.661	1.097	0.702	0.655	0.539	0.874	1.528
7	0.658	0.694	1.087	0.713	0.658	0.570	0.917	1.533
8	0.659	0.702	1.074	0.707	0.659	0.576	0.925	1.535
9	0.657	0.734	1.022	0.675	0.657	0.590	0.945	1.535
10	0.646	0.719	0.920	0.638	0.646	0.585	0.947	1.338
11	0.652	0.710	0.903	0.625	0.652	0.578	0.926	1.255

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	2.4	-0.3	-2.2	0.192	0.813	0.076	0.051	0.014	0.009
2	10.00	1.4	-1.5	-1.4	0.202	0.795	0.087	0.062	0.016	0.012
3	30.00	2.4	-1.5	0.1	0.297	0.884	0.067	0.032	0.014	0.007
4	50.00	2.9	-2.2	3.7	0.425	0.829	0.123	0.080	0.028	0.018
5	52.50	3.0	-2.3	4.9	0.428	0.821	0.131	0.087	0.030	0.020
6	55.00	2.9	-2.5	5.9	0.430	0.817	0.135	0.092	0.031	0.021
7	57.50	3.0	-2.6	4.7	0.418	0.887	0.086	0.043	0.020	0.010
8	60.00	3.0	-2.7	5.1	0.417	0.898	0.079	0.038	0.018	0.009
9	70.00	3.2	-3.1	5.6	0.425	0.941	0.049	0.014	0.011	0.003
10	90.00	3.8	-3.6	7.5	0.384	0.920	0.070	0.065	0.014	0.013
11	95.00	3.6	-4.1	5.6	0.382	0.903	0.084	0.082	0.016	0.016

TABLE IX. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21 (CLEAN INLET FLOW); 90 PERCENT OF DESIGN SPEED

(b) Reading 2581

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	0.0	30.9	68.7	61.1	289.5	1.116	9.92	1.358
2	24.209	23.782	-0.0	28.0	66.2	58.9	289.3	1.111	10.11	1.366
3	21.976	21.631	-0.0	32.1	60.7	51.6	288.5	1.126	10.15	1.445
4	19.510	19.477	0.0	38.6	55.9	41.0	287.9	1.142	10.15	1.502
5	19.187	19.210	-0.0	39.5	55.3	40.3	287.8	1.142	10.15	1.495
6	18.862	18.941	0.0	40.1	54.8	39.8	287.8	1.140	10.15	1.486
7	18.534	18.672	-0.0	39.6	54.2	37.4	287.7	1.140	10.15	1.511
8	18.204	18.402	-0.0	39.6	53.7	35.6	287.7	1.141	10.15	1.525
9	16.863	17.325	-0.0	40.8	51.6	29.8	287.6	1.138	10.15	1.531
10	14.112	15.174	0.0	40.5	47.3	24.4	287.4	1.118	10.14	1.442
11	13.421	14.635	-0.0	40.2	45.5	22.1	287.4	1.115	10.13	1.423

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	146.0	178.1	401.9	316.4	146.0	152.8	0.0	91.4	374.5	368.4
2	162.1	186.2	401.1	318.5	162.1	164.4	-0.0	87.5	366.8	360.4
3	187.4	205.0	382.6	279.6	187.4	173.6	-0.0	109.1	333.6	328.3
4	200.7	227.1	357.9	234.9	200.7	177.3	0.0	141.8	296.4	295.9
5	201.4	225.8	354.0	228.5	201.4	174.2	-0.0	143.6	291.1	291.4
6	202.0	224.3	350.1	223.3	202.0	171.7	0.0	144.3	286.0	287.2
7	202.8	230.9	346.9	224.2	202.8	178.0	-0.0	147.1	281.4	283.5
8	203.4	235.0	343.3	222.7	203.4	181.0	-0.0	149.9	276.6	279.6
9	202.2	241.4	325.8	210.5	202.2	182.6	-0.0	157.8	255.5	262.5
10	197.4	231.6	291.2	193.3	197.4	176.1	0.0	150.4	214.1	230.2
11	200.0	232.4	285.5	191.8	200.0	177.6	-0.0	149.9	203.8	222.2

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.436	0.507	1.201	0.900	0.436	0.435	1.047	1.333
2	0.487	0.533	1.204	0.911	0.487	0.470	1.014	1.331
3	0.568	0.587	1.159	0.800	0.568	0.497	0.926	1.443
4	0.612	0.651	1.091	0.673	0.612	0.508	0.883	1.545
5	0.614	0.647	1.079	0.654	0.614	0.499	0.865	1.552
6	0.616	0.643	1.068	0.640	0.616	0.492	0.850	1.563
7	0.619	0.663	1.059	0.644	0.619	0.511	0.878	1.567
8	0.621	0.676	1.048	0.640	0.621	0.521	0.890	1.572
9	0.617	0.697	0.994	0.608	0.617	0.528	0.903	1.577
10	0.602	0.673	0.888	0.562	0.602	0.512	0.892	1.347
11	0.610	0.677	0.871	0.558	0.610	0.517	0.888	1.264

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	3.1	0.4	-2.6	0.299	0.790	0.123	0.097	0.023	0.018
2	10.00	2.3	-0.6	-2.0	0.286	0.837	0.093	0.067	0.018	0.013
3	30.00	3.5	-0.5	1.4	0.365	0.882	0.079	0.042	0.016	0.009
4	50.00	4.3	-0.9	3.6	0.464	0.868	0.107	0.061	0.024	0.014
5	52.50	4.3	-0.9	4.7	0.476	0.856	0.118	0.073	0.027	0.017
6	55.00	4.4	-1.0	5.9	0.484	0.852	0.122	0.077	0.028	0.017
7	57.50	4.4	-1.1	5.3	0.477	0.891	0.091	0.046	0.021	0.011
8	60.00	4.5	-1.2	5.3	0.476	0.906	0.080	0.036	0.019	0.008
9	70.00	4.8	-1.4	6.4	0.484	0.936	0.059	0.020	0.013	0.005
10	90.00	5.7	-1.7	8.3	0.455	0.932	0.065	0.061	0.013	0.012
11	95.00	5.4	-2.3	5.3	0.444	0.924	0.073	0.072	0.014	0.014

TABLE IX. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21 (CLEAN INLET FLOW); 90 PERCENT OF DESIGN SPEED

(c) Reading 2580

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	0.0	32.0	69.5	59.6	289.7	1.123	9.93	1.443
2	24.209	23.782	0.0	31.8	67.0	59.1	289.3	1.124	10.11	1.421
3	21.976	21.631	-0.0	35.5	61.8	52.0	288.4	1.137	10.15	1.484
4	19.510	19.477	0.0	41.8	57.2	41.5	287.9	1.150	10.15	1.533
5	19.187	19.210	0.0	42.5	56.7	40.5	287.8	1.150	10.15	1.527
6	18.862	18.941	0.0	42.9	56.2	39.8	287.8	1.149	10.15	1.521
7	18.534	18.672	0.0	42.8	55.7	37.7	287.7	1.149	10.15	1.537
8	18.204	18.402	-0.0	42.6	55.2	35.7	287.7	1.149	10.15	1.549
9	16.863	17.325	-0.0	43.3	53.2	30.5	287.6	1.144	10.15	1.548
10	14.112	15.174	-0.0	42.8	49.0	25.1	287.4	1.121	10.14	1.458
11	13.421	14.635	0.0	42.5	47.1	22.1	287.5	1.119	10.12	1.443

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	140.2	186.8	400.5	313.3	140.2	158.5	0.0	98.9	375.2	369.1
2	155.9	185.4	399.1	306.8	155.9	157.6	0.0	97.7	367.4	360.9
3	178.9	202.2	378.6	267.7	178.9	164.7	-0.0	117.4	333.7	328.5
4	190.8	223.5	352.6	222.4	190.8	166.7	0.0	148.8	296.5	296.0
5	190.8	223.2	347.8	216.1	190.8	164.4	0.0	150.9	290.8	291.2
6	191.8	222.7	344.4	212.2	191.8	163.1	0.0	151.6	286.1	287.3
7	192.0	227.2	340.3	210.8	192.0	166.8	0.0	154.2	281.0	283.0
8	192.1	231.2	336.2	209.6	192.1	170.1	-0.0	156.6	275.9	278.9
9	191.6	236.0	319.8	199.2	191.6	171.7	-0.0	161.9	256.0	263.0
10	186.3	225.1	283.9	182.4	186.3	165.1	-0.0	152.9	214.2	230.3
11	189.3	227.7	278.1	181.2	189.3	167.8	0.0	153.9	203.7	222.2

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.418	0.531	1.194	0.890	0.418	0.451	1.131	1.357
2	0.467	0.527	1.196	0.872	0.467	0.448	1.011	1.354
3	0.541	0.575	1.144	0.762	0.541	0.468	0.921	1.470
4	0.580	0.637	1.071	0.634	0.580	0.475	0.874	1.578
5	0.580	0.636	1.057	0.616	0.580	0.469	0.862	1.587
6	0.583	0.635	1.047	0.605	0.583	0.465	0.850	1.596
7	0.584	0.649	1.034	0.602	0.584	0.477	0.869	1.604
8	0.584	0.662	1.022	0.600	0.584	0.487	0.886	1.612
9	0.583	0.678	0.972	0.572	0.583	0.493	0.896	1.592
10	0.565	0.651	0.862	0.528	0.565	0.478	0.886	1.356
11	0.575	0.661	0.845	0.526	0.575	0.487	0.887	1.271

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	3.9	1.2	-4.2	0.311	0.896	0.066	0.037	0.013	0.007
2	10.00	3.1	0.2	-1.9	0.321	0.855	0.091	0.063	0.017	0.012
3	30.00	4.6	0.7	1.8	0.397	0.873	0.092	0.053	0.019	0.011
4	50.00	5.6	0.5	4.1	0.497	0.866	0.116	0.068	0.027	0.015
5	52.50	5.7	0.5	4.8	0.508	0.856	0.127	0.078	0.029	0.018
6	55.00	5.8	0.4	5.9	0.514	0.854	0.130	0.081	0.029	0.018
7	57.50	5.9	0.3	5.6	0.512	0.875	0.113	0.064	0.026	0.015
8	60.00	6.0	0.3	5.4	0.510	0.896	0.096	0.048	0.022	0.011
9	70.00	6.4	0.1	7.0	0.513	0.923	0.075	0.036	0.017	0.008
10	90.00	7.3	-0.1	9.0	0.482	0.936	0.065	0.061	0.013	0.012
11	95.00	7.0	-0.7	5.3	0.470	0.932	0.070	0.069	0.014	0.014

TABLE IX. - Concluded. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21 (CLEAN INLET FLOW); 90 PERCENT OF DESIGN SPEED

(d) Reading 2579

	RADII		ABS BETAM		REL BETAM		TOTAL TEMP		TOTAL PRESS	
RP	IN	OUT	IN	OUT	IN	OUT	IN	RATIO	IN	RATIO
1	24.719	24.320	0.0	39.3	70.5	60.5	289.9	1.149	9.95	1.462
2	24.209	23.782	-0.0	35.0	68.1	59.1	289.6	1.137	10.10	1.454
3	21.976	21.631	0.0	38.2	63.1	51.9	288.4	1.147	10.15	1.520
4	19.510	19.477	0.0	43.8	58.8	42.3	287.8	1.156	10.15	1.551
5	19.187	19.210	-0.0	45.0	58.3	41.2	287.8	1.157	10.15	1.546
6	18.862	18.941	-0.0	46.1	57.8	40.0	287.7	1.158	10.15	1.543
7	18.534	18.672	-0.0	46.2	57.3	37.9	287.6	1.159	10.15	1.554
8	18.204	18.402	-0.0	45.7	56.7	36.0	287.7	1.158	10.15	1.566
9	16.863	17.325	0.0	45.9	54.9	31.0	287.5	1.151	10.15	1.560
10	14.112	15.174	0.0	44.4	50.8	25.9	287.4	1.123	10.14	1.470
11	13.421	14.635	0.0	43.6	48.8	22.4	287.4	1.121	10.13	1.461

	ABS VEL		REL VEL		MERID VEL		TANG VEL		WHEEL SPEED	
RP	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
1	132.8	184.3	397.9	290.0	132.8	142.7	0.0	116.7	375.1	369.1
2	147.6	186.0	396.3	296.8	147.6	152.4	-0.0	106.6	367.8	361.3
3	169.8	203.2	375.3	259.0	169.8	159.8	0.0	125.6	334.7	329.5
4	180.0	220.1	347.5	214.6	180.0	158.8	0.0	152.4	297.2	296.7
5	180.8	220.6	343.7	207.5	180.8	156.1	-0.0	155.9	292.2	292.6
6	181.4	221.8	340.0	200.5	181.4	153.7	-0.0	159.9	287.5	288.7
7	181.6	225.6	335.9	198.2	181.6	156.3	-0.0	162.8	282.5	284.6
8	182.0	229.5	332.0	197.9	182.0	160.2	-0.0	164.3	277.6	280.6
9	181.0	232.7	314.6	188.8	181.0	161.8	0.0	167.1	257.4	264.4
10	175.8	221.3	277.9	175.8	175.8	158.2	0.0	154.7	215.3	231.5
11	179.2	226.0	272.2	177.0	179.2	163.6	0.0	155.9	204.9	223.4

	ABS MACH NO		REL MACH NO		MERID MACH NO		MERID PEAK SS	
RP	IN	OUT	IN	OUT	IN	OUT	VEL R	MACH NO
1	0.395	0.517	1.184	0.814	0.395	0.400	1.075	1.383
2	0.441	0.525	1.184	0.838	0.441	0.430	1.033	1.384
3	0.512	0.576	1.131	0.734	0.512	0.453	0.941	1.505
4	0.545	0.625	1.052	0.610	0.545	0.451	0.882	1.621
5	0.547	0.626	1.040	0.589	0.547	0.443	0.863	1.631
6	0.549	0.630	1.030	0.569	0.549	0.436	0.847	1.642
7	0.550	0.641	1.018	0.563	0.550	0.444	0.860	1.652
8	0.551	0.653	1.006	0.564	0.551	0.456	0.880	1.661
9	0.548	0.666	0.953	0.540	0.548	0.463	0.894	1.616
10	0.532	0.639	0.841	0.508	0.532	0.457	0.900	1.373
11	0.543	0.654	0.824	0.512	0.543	0.474	0.913	1.288

	PERCENT	INCIDENCE		DEV	D-FACT	EFF	LOSS COEFF		LOSS PARAM	
RP	SPAN	MEAN	SS				TOT	PROF	TOT	PROF
1	5.00	4.9	2.2	-3.3	0.382	0.767	0.172	0.141	0.032	0.026
2	10.00	4.3	1.4	-1.9	0.350	0.822	0.124	0.093	0.024	0.018
3	30.00	5.9	2.0	1.7	0.422	0.863	0.108	0.064	0.023	0.013
4	50.00	7.2	2.1	4.9	0.515	0.858	0.130	0.075	0.029	0.017
5	52.50	7.3	2.0	5.6	0.532	0.844	0.146	0.091	0.033	0.020
6	55.00	7.4	2.0	6.1	0.549	0.833	0.159	0.104	0.036	0.023
7	57.50	7.5	1.9	5.8	0.551	0.845	0.151	0.095	0.034	0.022
8	60.00	7.6	1.9	5.6	0.545	0.865	0.134	0.078	0.031	0.018
9	70.00	8.1	1.8	7.6	0.542	0.896	0.108	0.067	0.025	0.015
10	90.00	9.1	1.7	9.8	0.495	0.945	0.059	0.056	0.012	0.011
11	95.00	8.7	1.0	5.6	0.476	0.941	0.064	0.063	0.012	0.012

TABLE X. - BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18

(CLEAN INLET FLOW); 90 PERCENT OF DESIGN SPEED

(a) Reading 2571

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	20.4	0.8	20.4	0.8	312.0	1.001	12.26	0.968
2	23.393	23.304	19.2	-0.2	19.2	-0.2	313.1	0.999	12.64	0.979
3	21.468	21.359	22.6	-0.8	22.6	-0.8	319.8	0.998	13.98	0.975
4	19.588	19.591	28.9	-0.2	28.9	-0.2	324.7	0.998	14.43	0.988
5	19.355	19.380	28.9	-0.7	28.9	-0.7	324.7	0.999	14.43	0.994
6	19.119	19.169	28.8	-0.8	28.8	-0.8	324.9	0.999	14.41	0.999
7	18.882	18.961	27.5	-0.8	27.5	-0.8	325.1	0.999	14.85	0.977
8	18.649	18.755	27.2	-0.6	27.2	-0.6	325.0	1.000	14.95	0.981
9	17.706	17.950	27.7	0.1	27.7	0.1	325.0	1.000	15.21	0.988
10	15.829	16.383	28.2	-0.0	28.2	-0.0	320.2	0.998	14.39	0.980
11	15.372	15.977	29.0	0.3	29.0	0.3	318.8	0.996	14.06	0.927

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	179.1	159.8	179.1	159.8	167.9	159.8	62.3	2.3	0.	0.
2	193.5	179.9	193.5	179.9	182.7	179.9	63.7	-0.7	0.	0.
3	248.3	214.1	248.3	214.1	229.3	214.1	95.4	-3.1	0.	0.
4	271.4	227.8	271.4	227.8	237.5	227.8	131.4	-0.8	0.	0.
5	271.8	229.7	271.8	229.7	238.0	229.7	131.2	-2.9	0.	0.
6	272.5	231.3	272.5	231.3	238.8	231.3	131.4	-3.2	0.	0.
7	293.0	233.8	293.0	233.8	260.0	233.8	135.1	-3.1	0.	0.
8	298.3	237.7	298.3	237.7	265.3	237.7	136.3	-2.7	0.	0.
9	315.1	249.3	315.1	249.3	279.0	249.3	146.6	0.6	0.	0.
10	289.6	260.3	289.6	260.3	255.1	260.3	136.9	-0.1	0.	0.
11	276.9	242.4	276.9	242.4	242.2	242.4	134.2	1.1	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.519	0.461	0.519	0.461	0.487	0.461	0.952	0.519
2	0.562	0.521	0.562	0.521	0.531	0.521	0.984	0.562
3	0.729	0.621	0.729	0.621	0.673	0.621	0.934	0.758
4	0.798	0.658	0.798	0.658	0.698	0.658	0.959	0.993
5	0.799	0.664	0.799	0.664	0.700	0.664	0.965	0.985
6	0.801	0.668	0.801	0.668	0.702	0.668	0.969	0.978
7	0.870	0.676	0.870	0.676	0.772	0.676	0.899	1.002
8	0.888	0.688	0.888	0.688	0.790	0.688	0.896	1.002
9	0.947	0.725	0.947	0.725	0.838	0.725	0.894	1.048
10	0.866	0.768	0.866	0.768	0.763	0.768	1.020	0.964
11	0.825	0.712	0.825	0.712	0.721	0.712	1.001	0.968

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	-8.7	-14.9	8.2	0.235	0.	0.191	0.191	0.073	0.073
2	10.00	-9.5	-15.6	7.0	0.194	0.	0.107	0.107	0.040	0.040
3	30.00	-8.5	-13.9	6.6	0.273	0.	0.084	0.084	0.029	0.029
4	50.00	-5.8	-10.6	7.8	0.313	0.	0.035	0.035	0.011	0.011
5	52.50	-6.4	-11.1	7.3	0.307	0.	0.018	0.018	0.005	0.005
6	55.00	-6.8	-11.5	7.3	0.302	0.	0.002	0.002	0.001	0.001
7	57.50	-8.6	-13.2	7.4	0.344	0.	0.060	0.060	0.018	0.018
8	60.00	-9.3	-13.8	7.6	0.341	0.	0.048	0.048	0.014	0.014
9	70.00	-10.0	-14.2	8.4	0.339	0.	0.026	0.026	0.007	0.007
10	90.00	-7.4	-11.1	7.2	0.219	0.	0.053	0.053	0.013	0.013
11	95.00	-4.8	-8.4	7.0	0.241	0.	0.202	0.202	0.050	0.050

TABLE X. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18 (CLEAN INLET FLOW); 90 PERCENT OF DESIGN SPEED

(c) Reading 2580

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	32.2	1.7	32.2	1.7	325.4	1.005	14.33	0.969
2	23.393	23.304	31.2	-0.1	31.2	-0.1	325.0	1.000	14.37	0.994
3	21.468	21.359	32.0	0.0	32.0	0.0	327.9	1.001	15.06	0.997
4	19.588	19.591	35.9	0.2	35.9	0.2	331.1	0.997	15.56	0.985
5	19.355	19.380	36.6	-0.2	36.6	-0.2	331.0	0.997	15.50	0.988
6	19.119	19.169	36.8	-0.0	36.8	-0.0	330.7	0.998	15.44	0.995
7	18.882	18.961	36.4	0.4	36.4	0.4	330.6	0.999	15.60	0.990
8	18.649	18.755	36.0	0.2	36.0	0.2	330.4	0.999	15.72	0.985
9	17.706	17.950	36.2	0.7	36.2	0.7	329.0	0.998	15.72	0.981
10	15.829	16.383	36.4	-1.5	36.4	-1.5	322.3	1.003	14.79	0.985
11	15.372	15.977	36.5	-1.7	36.5	-1.7	321.6	1.001	14.61	0.946

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	188.8	148.9	188.8	148.9	159.8	148.8	100.7	4.4	0.	0.
2	191.5	163.5	191.5	163.5	163.7	163.5	99.3	-0.3	0.	0.
3	223.4	183.3	223.4	183.3	189.6	183.3	118.3	0.1	0.	0.
4	252.0	192.0	252.0	192.0	204.0	192.0	147.9	0.5	0.	0.
5	251.2	192.3	251.2	192.3	201.7	192.3	149.8	-0.7	0.	0.
6	250.7	194.1	250.7	194.1	200.7	194.1	150.2	-0.1	0.	0.
7	257.1	196.4	257.1	196.4	207.0	196.4	152.5	1.2	0.	0.
8	262.9	198.3	262.9	198.3	212.7	198.3	154.5	0.8	0.	0.
9	268.1	200.2	268.1	200.2	216.3	200.2	158.5	2.5	0.	0.
10	247.1	192.9	247.1	192.9	198.9	192.8	146.6	-5.0	0.	0.
11	246.2	172.2	246.2	172.2	197.9	172.2	146.5	-5.1	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.537	0.418	0.537	0.418	0.454	0.418	0.932	0.800
2	0.545	0.462	0.545	0.462	0.466	0.462	0.998	0.791
3	0.640	0.518	0.640	0.518	0.543	0.518	0.967	0.913
4	0.727	0.543	0.727	0.543	0.588	0.543	0.941	1.085
5	0.724	0.543	0.724	0.543	0.581	0.543	0.953	1.091
6	0.723	0.549	0.723	0.549	0.579	0.549	0.967	1.088
7	0.743	0.556	0.743	0.556	0.598	0.556	0.949	1.101
8	0.762	0.561	0.762	0.561	0.617	0.561	0.932	1.113
9	0.781	0.569	0.781	0.569	0.630	0.569	0.926	1.121
10	0.721	0.551	0.721	0.551	0.581	0.551	0.969	1.030
11	0.720	0.490	0.720	0.490	0.578	0.490	0.870	1.044

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	3.1	-3.0	9.1	0.406	0.	0.176	0.176	0.067	0.067
2	10.00	2.5	-3.6	7.1	0.340	0.	0.033	0.033	0.012	0.012
3	30.00	0.9	-4.5	7.4	0.360	0.	0.013	0.013	0.004	0.004
4	50.00	1.2	-3.6	8.1	0.421	0.	0.051	0.051	0.016	0.016
5	52.50	1.4	-3.3	7.8	0.419	0.	0.042	0.042	0.013	0.013
6	55.00	1.2	-3.5	8.1	0.408	0.	0.017	0.017	0.005	0.005
7	57.50	0.3	-4.2	8.5	0.413	0.	0.032	0.032	0.010	0.010
8	60.00	-0.5	-4.9	8.4	0.419	0.	0.047	0.047	0.014	0.014
9	70.00	-1.4	-5.6	9.0	0.417	0.	0.056	0.056	0.016	0.016
10	90.00	0.8	-2.9	5.8	0.373	0.	0.053	0.053	0.013	0.013
11	95.00	2.8	-0.8	5.1	0.450	0.	0.185	0.185	0.046	0.046

TABLE X. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18 (CLEAN INLET FLOW); 90 PERCENT OF DESIGN SPEED

(b) Reading 2579

	RADII		ABS BETAM		REL BETAM		TOTAL TEMP		TOTAL PRESS	
RP	IN	OUT	IN	OUT	IN	OUT	IN	RATIO	IN	RATIO
1	23.894	23.866	39.5	2.5	39.5	2.5	333.2	0.992	14.55	0.985
2	23.393	23.304	34.4	1.4	34.4	1.4	329.3	0.997	14.68	0.993
3	21.468	21.359	34.6	0.5	34.6	0.5	330.8	0.999	15.42	0.988
4	19.588	19.591	38.2	0.2	38.2	0.2	332.6	0.997	15.74	0.975
5	19.355	19.380	39.2	0.1	39.2	0.1	333.0	0.997	15.69	0.979
6	19.119	19.169	40.2	0.2	40.2	0.2	333.2	0.996	15.65	0.983
7	18.882	18.961	40.0	0.3	40.0	0.3	333.3	0.996	15.78	0.978
8	18.649	18.755	39.4	0.6	39.4	0.6	333.2	0.996	15.90	0.971
9	17.706	17.950	39.1	0.8	39.1	0.8	330.9	0.998	15.83	0.972
10	15.829	16.383	38.1	-1.3	38.1	-1.3	322.7	1.006	14.91	0.982
11	15.372	15.977	37.7	-1.2	37.7	-1.2	322.3	1.003	14.80	0.950

	ABS VEL		REL VEL		MERID VEL		TANG VEL		WHEEL SPEED	
RP	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
1	186.6	151.4	186.6	151.4	143.9	151.2	118.7	6.5	0.	0.
2	191.8	158.9	191.8	158.9	158.3	158.9	108.4	3.9	0.	0.
3	222.8	175.4	222.8	175.4	183.4	175.4	126.5	1.6	0.	0.
4	245.2	179.3	245.2	179.3	192.8	179.3	151.5	0.7	0.	0.
5	244.9	180.5	244.9	180.5	189.9	180.5	154.7	0.3	0.	0.
6	245.3	181.4	245.3	181.4	187.3	181.4	158.4	0.7	0.	0.
7	250.2	183.2	250.2	183.2	191.5	183.2	160.9	1.0	0.	0.
8	255.7	183.9	255.7	183.9	197.7	183.9	162.2	2.0	0.	0.
9	259.2	185.3	259.2	185.3	201.1	185.3	163.6	2.6	0.	0.
10	240.5	178.6	240.5	178.6	189.3	178.6	148.3	-4.0	0.	0.
11	242.8	162.8	242.8	162.8	192.2	162.8	148.4	-3.3	0.	0.

	ABS MACH NO		REL MACH NO		MERID MACH NO		MERID VEL R	PEAK SS MACH NO
RP	IN	OUT	IN	OUT	IN	OUT		
1	0.524	0.423	0.524	0.423	0.404	0.422	1.051	0.910
2	0.543	0.446	0.543	0.446	0.448	0.446	1.004	0.846
3	0.635	0.493	0.635	0.493	0.523	0.493	0.956	0.963
4	0.703	0.503	0.703	0.503	0.553	0.503	0.930	1.103
5	0.702	0.507	0.702	0.507	0.544	0.507	0.951	1.119
6	0.703	0.509	0.703	0.509	0.537	0.509	0.969	1.139
7	0.718	0.515	0.718	0.515	0.550	0.515	0.956	1.153
8	0.736	0.517	0.736	0.517	0.569	0.517	0.931	1.158
9	0.750	0.522	0.750	0.522	0.582	0.522	0.921	1.150
10	0.700	0.507	0.700	0.507	0.551	0.507	0.943	1.039
11	0.708	0.461	0.708	0.461	0.560	0.461	0.847	1.055

	PERCENT	INCIDENCE		DEV	D-FACT	EFF	LOSS COEFF		LOSS PARAM	
RP	SPAN	MEAN	SS				TOT	PROF	TOT	PROF
1	5.00	10.5	4.3	9.8	0.418	0.	0.086	0.086	0.033	0.033
2	10.00	5.6	-0.4	8.6	0.375	0.	0.039	0.039	0.014	0.014
3	30.00	3.5	-1.9	7.9	0.404	0.	0.052	0.052	0.018	0.018
4	50.00	3.4	-1.4	8.2	0.461	0.	0.090	0.090	0.028	0.028
5	52.50	4.0	-0.8	8.2	0.457	0.	0.074	0.074	0.023	0.023
6	55.00	4.6	-0.0	8.3	0.456	0.	0.060	0.060	0.018	0.018
7	57.50	4.0	-0.6	8.5	0.460	0.	0.076	0.076	0.023	0.023
8	60.00	2.9	-1.6	8.8	0.467	0.	0.096	0.096	0.028	0.028
9	70.00	1.5	-2.7	9.1	0.460	0.	0.091	0.091	0.026	0.026
10	90.00	2.5	-1.2	6.0	0.416	0.	0.065	0.065	0.017	0.017
11	95.00	3.9	0.3	5.6	0.481	0.	0.175	0.175	0.043	0.043

TABLE X. - Concluded. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18 (CLEAN INLET FLOW); 90 PERCENT OF DESIGN SPEED

(d) Reading 2581

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	31.2	0.7	31.2	0.7	323.0	0.997	13.48	0.988
2	23.393	23.304	27.5	-0.5	27.5	-0.5	321.5	0.998	13.81	0.989
3	21.468	21.359	28.6	-1.2	28.6	-1.2	324.7	0.999	14.66	0.991
4	19.588	19.591	32.6	-0.4	32.6	-0.4	328.8	0.997	15.24	0.986
5	19.355	19.380	33.4	-0.6	33.4	-0.6	328.7	0.998	15.17	0.993
6	19.119	19.169	33.8	-0.7	33.8	-0.7	328.2	0.999	15.08	1.001
7	18.882	18.961	32.9	-0.6	32.9	-0.6	328.1	1.000	15.34	0.989
8	18.649	18.755	32.7	-0.5	32.7	-0.5	328.4	1.000	15.48	0.989
9	17.706	17.950	33.3	-0.1	33.3	-0.1	327.3	0.999	15.53	0.992
10	15.829	16.383	33.9	-1.8	33.9	-1.8	321.3	1.001	14.62	0.986
11	15.372	15.977	34.0	-1.9	34.0	-1.9	320.4	1.000	14.42	0.946

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	179.9	155.2	179.9	155.2	154.0	155.2	93.1	1.8	0.	0.
2	192.7	166.8	192.7	166.8	170.9	166.8	89.0	-1.3	0.	0.
3	229.2	190.9	229.2	190.9	201.2	190.9	109.9	-3.9	0.	0.
4	261.4	204.8	261.4	204.8	220.1	204.8	141.0	-1.5	0.	0.
5	259.2	205.7	259.2	205.7	216.5	205.7	142.6	-2.2	0.	0.
6	257.1	206.8	257.1	206.8	213.6	206.7	143.0	-2.4	0.	0.
7	267.6	208.6	267.6	208.6	224.6	208.6	145.5	-2.1	0.	0.
8	273.7	212.3	273.7	212.3	230.3	212.3	147.9	-2.0	0.	0.
9	281.0	218.0	281.0	218.0	234.8	218.0	154.4	-0.5	0.	0.
10	258.7	213.2	258.7	213.2	214.8	213.1	144.2	-6.6	0.	0.
11	255.3	195.8	255.3	195.8	211.6	195.6	142.8	-6.4	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.512	0.440	0.512	0.440	0.438	0.440	1.008	0.745
2	0.552	0.475	0.552	0.475	0.490	0.475	0.979	0.729
3	0.662	0.544	0.662	0.544	0.581	0.544	0.949	0.866
4	0.760	0.583	0.760	0.583	0.640	0.583	0.930	1.048
5	0.753	0.586	0.753	0.586	0.629	0.586	0.950	1.051
6	0.746	0.589	0.746	0.589	0.620	0.589	0.968	1.046
7	0.781	0.595	0.781	0.595	0.655	0.595	0.929	1.064
8	0.800	0.606	0.800	0.606	0.673	0.606	0.922	1.077
9	0.826	0.624	0.826	0.624	0.690	0.624	0.929	1.101
10	0.761	0.615	0.761	0.615	0.632	0.615	0.992	1.019
11	0.750	0.563	0.750	0.563	0.622	0.562	0.924	1.023

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	2.1	-4.1	8.0	0.331	0.	0.071	0.071	0.027	0.027
2	10.00	-1.3	-7.3	6.7	0.309	0.	0.060	0.060	0.022	0.022
3	30.00	-2.4	-7.9	6.3	0.337	0.	0.037	0.037	0.013	0.013
4	50.00	-2.1	-6.9	7.6	0.386	0.	0.043	0.043	0.013	0.013
5	52.50	-1.9	-6.6	7.4	0.379	0.	0.021	0.021	0.006	0.006
6	55.00	-1.9	-6.5	7.4	0.368	0.	-0.004	-0.004	-0.001	-0.001
7	57.50	-3.1	-7.7	7.6	0.386	0.	0.034	0.034	0.010	0.010
8	60.00	-3.8	-8.2	7.7	0.387	0.	0.032	0.032	0.010	0.010
9	70.00	-4.3	-8.5	8.1	0.379	0.	0.023	0.023	0.006	0.006
10	90.00	-1.7	-5.4	5.5	0.322	0.	0.043	0.043	0.011	0.011
11	95.00	0.2	-3.4	4.9	0.375	0.	0.172	0.172	0.042	0.042

TABLE XI. - BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21 (CLEAN INLET FLOW); 70 PERCENT OF DESIGN SPEED

(a) Reading 2563

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	0.0	11.5	68.1	62.4	289.1	1.030	9.97	1.085
2	24.209	23.782	0.0	11.7	65.1	60.5	288.8	1.032	10.13	1.089
3	21.976	21.631	0.0	17.8	59.9	52.1	288.3	1.048	10.14	1.164
4	19.510	19.477	0.0	27.6	55.3	41.0	288.0	1.068	10.14	1.224
5	19.187	19.210	0.0	29.4	54.6	39.5	288.0	1.070	10.14	1.226
6	18.862	18.941	0.0	30.2	54.1	38.5	288.0	1.071	10.14	1.226
7	18.534	18.672	0.0	29.7	53.5	37.0	287.7	1.070	10.14	1.238
8	18.204	18.402	0.0	29.6	53.0	35.4	287.9	1.070	10.14	1.253
9	16.863	17.325	0.0	31.7	50.8	29.8	287.8	1.072	10.14	1.262
10	14.112	15.174	0.0	31.9	46.3	22.5	287.6	1.063	10.14	1.233
11	13.421	14.635	0.0	31.6	44.4	21.9	287.6	1.059	10.13	1.215

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	117.2	138.2	314.5	292.7	117.2	135.5	0.0	27.6	291.8	287.1
2	132.2	145.2	314.6	288.5	132.2	142.2	0.0	29.4	285.5	280.4
3	150.1	166.7	299.4	258.5	150.1	158.7	0.0	50.9	259.1	255.0
4	160.2	186.8	281.0	219.4	160.2	165.6	0.0	86.5	230.9	230.5
5	161.0	188.1	278.2	212.3	161.0	163.9	0.0	92.3	226.9	227.2
6	161.3	187.9	275.0	207.5	161.3	162.4	0.0	94.5	222.7	223.6
7	161.6	191.6	271.9	208.4	161.6	166.4	0.0	94.9	218.7	220.3
8	161.8	195.4	268.9	208.3	161.8	169.9	0.0	96.6	214.8	217.1
9	161.9	201.7	256.3	197.7	161.9	171.6	0.0	105.9	198.7	204.1
10	158.8	202.9	229.7	186.4	158.8	172.3	0.0	107.1	165.9	178.4
11	161.4	198.9	225.8	182.6	161.4	169.4	0.0	104.2	157.9	172.2

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.348	0.406	0.934	0.860	0.348	0.398	1.156	1.096
2	0.394	0.427	0.938	0.849	0.394	0.418	1.075	1.077
3	0.450	0.490	0.897	0.760	0.450	0.466	1.057	1.189
4	0.482	0.547	0.845	0.642	0.482	0.485	1.034	1.254
5	0.484	0.550	0.837	0.621	0.484	0.480	1.018	1.253
6	0.485	0.550	0.827	0.607	0.485	0.475	1.007	1.250
7	0.487	0.562	0.818	0.611	0.487	0.488	1.030	1.246
8	0.487	0.573	0.809	0.611	0.487	0.499	1.050	1.241
9	0.487	0.593	0.771	0.581	0.487	0.504	1.060	1.202
10	0.478	0.599	0.691	0.551	0.478	0.509	1.085	1.023
11	0.486	0.588	0.680	0.540	0.486	0.501	1.050	0.959

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	2.5	-0.2	-1.3	0.102	0.780	0.051	0.051	0.009	0.009
2	10.00	1.3	-1.6	-0.5	0.117	0.774	0.055	0.055	0.010	0.010
3	30.00	2.7	-1.2	1.9	0.194	0.932	0.026	0.026	0.005	0.005
4	50.00	3.6	-1.5	3.7	0.313	0.870	0.077	0.077	0.018	0.018
5	52.50	3.7	-1.6	3.8	0.336	0.853	0.091	0.091	0.021	0.021
6	55.00	3.7	-1.7	4.6	0.347	0.846	0.098	0.097	0.022	0.022
7	57.50	3.8	-1.8	4.9	0.335	0.899	0.065	0.065	0.015	0.015
8	60.00	3.8	-1.9	5.0	0.328	0.938	0.041	0.041	0.009	0.009
9	70.00	4.0	-2.2	6.3	0.339	0.957	0.031	0.031	0.007	0.007
10	90.00	4.6	-2.8	6.4	0.296	0.979	0.016	0.016	0.003	0.003
11	95.00	4.2	-3.5	5.1	0.293	0.971	0.022	0.022	0.004	0.004

TABLE XI. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21 (CLEAN INLET FLOW); 70 PERCENT OF DESIGN SPEED

(b) Reading 2564

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	0.0	21.7	69.9	60.5	288.9	1.052	10.00	1.183
2	24.209	23.782	0.0	22.1	67.1	59.7	288.7	1.054	10.13	1.175
3	21.976	21.631	0.0	26.2	62.2	52.7	288.3	1.064	10.14	1.222
4	19.510	19.477	-0.0	34.4	57.8	41.9	288.0	1.079	10.14	1.263
5	19.187	19.210	0.0	36.1	57.4	40.5	287.9	1.080	10.14	1.263
6	18.862	18.941	-0.0	36.6	56.8	39.6	288.1	1.081	10.14	1.262
7	18.534	18.672	0.0	36.0	56.3	38.4	288.1	1.079	10.14	1.268
8	18.204	18.402	0.0	35.9	55.8	36.9	288.0	1.078	10.14	1.274
9	16.863	17.325	0.0	37.3	53.9	30.7	287.8	1.080	10.14	1.287
10	14.112	15.174	0.0	37.5	49.6	23.0	287.7	1.069	10.14	1.257
11	13.421	14.635	0.0	37.2	47.5	21.8	287.8	1.067	10.13	1.241

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	106.7	142.4	310.0	268.4	106.7	132.2	0.0	52.7	291.0	286.3
2	120.8	142.9	309.8	262.4	120.8	132.4	0.0	53.7	285.2	280.2
3	136.4	157.4	292.7	233.0	136.4	141.2	0.0	69.6	258.9	254.9
4	144.2	175.5	270.9	194.4	144.2	144.8	-0.0	99.2	229.3	228.9
5	144.6	176.5	268.0	187.5	144.6	142.6	0.0	104.1	225.6	225.9
6	145.4	176.8	265.3	184.3	145.4	142.0	-0.0	105.4	222.0	222.9
7	145.5	179.1	262.5	184.7	145.5	144.8	0.0	105.4	218.4	220.0
8	145.5	181.5	259.1	183.8	145.5	147.0	0.0	106.4	214.4	216.7
9	145.1	189.4	246.0	175.1	145.1	150.6	0.0	114.8	198.7	204.1
10	141.8	189.3	218.6	163.2	141.8	150.2	0.0	115.2	166.4	178.9
11	144.9	187.1	214.6	160.4	144.9	149.0	0.0	113.1	158.3	172.6

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.316	0.414	0.919	0.781	0.316	0.385	1.239	1.143
2	0.359	0.416	0.921	0.763	0.359	0.385	1.096	1.131
3	0.407	0.458	0.874	0.677	0.407	0.411	1.035	1.230
4	0.432	0.509	0.811	0.564	0.432	0.420	1.004	1.274
5	0.433	0.512	0.802	0.544	0.433	0.414	0.986	1.275
6	0.435	0.513	0.794	0.535	0.435	0.412	0.977	1.272
7	0.436	0.520	0.786	0.536	0.436	0.420	0.995	1.27[illegible]
8	0.436	0.528	0.776	0.535	0.436	0.428	1.010	1.265
9	0.435	0.552	0.737	0.510	0.435	0.439	1.038	1.224
10	0.424	0.555	0.654	0.478	0.424	0.440	1.059	1.042
11	0.434	0.548	0.643	0.470	0.434	0.437	1.028	0.976

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	4.2	1.5	-3.3	0.198	0.944	0.023	0.022	0.004	0.004
2	10.00	3.2	0.3	-1.3	0.217	0.867	0.056	0.056	0.010	0.010
3	30.00	5.0	1.1	2.5	0.284	0.917	0.044	0.044	0.009	0.009
4	50.00	6.2	1.1	4.5	0.393	0.871	0.093	0.093	0.021	0.021
5	52.50	6.4	1.1	4.9	0.416	0.859	0.105	0.104	0.024	0.024
6	55.00	6.4	1.0	5.7	0.422	0.853	0.112	0.112	0.025	0.025
7	57.50	6.6	1.0	6.3	0.413	0.883	0.090	0.090	0.020	0.020
8	60.00	6.7	1.0	6.6	0.408	0.916	0.065	0.065	0.015	0.015
9	70.00	7.0	0.8	7.2	0.413	0.935	0.056	0.056	0.013	0.013
10	90.00	7.9	0.5	6.9	0.375	0.978	0.021	0.021	0.004	0.004
11	95.00	7.4	-0.3	5.0	0.369	0.957	0.039	0.039	0.008	0.008

TABLE XI. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21 (CLEAN INLET FLOW); 70 PERCENT OF DESIGN SPEED

(c) Reading 2565

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	0.0	27.5	71.3	60.6	289.0	1.065	10.02	1.215
2	24.209	23.782	0.0	27.1	68.7	60.1	288.8	1.064	10.13	1.206
3	21.976	21.631	0.0	31.8	64.3	54.0	288.2	1.074	10.14	1.237
4	19.510	19.477	0.0	40.2	60.3	42.5	288.0	1.087	10.14	1.279
5	19.187	19.210	0.0	41.8	59.8	41.4	288.0	1.089	10.14	1.276
6	18.862	18.941	0.0	43.2	59.3	40.3	288.0	1.089	10.14	1.274
7	18.534	18.672	0.0	42.1	58.8	38.0	288.0	1.089	10.14	1.284
8	18.204	18.402	0.0	41.9	58.3	36.7	288.0	1.088	10.14	1.289
9	16.863	17.325	0.0	40.9	56.3	30.2	287.8	1.086	10.14	1.305
10	14.112	15.174	0.0	39.5	51.8	23.9	297.7	1.072	10.13	1.267
11	13.421	14.635	0.0	39.6	49.5	22.0	287.8	1.068	10.13	1.253

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	98.7	140.8	307.3	254.2	98.7	124.9	0.0	65.0	291.0	286.3
2	111.2	139.8	306.1	249.7	111.2	124.5	0.0	63.6	285.2	280.1
3	124.7	150.5	287.7	217.6	124.7	128.0	0.0	79.2	259.3	255.2
4	131.4	171.0	265.1	177.1	131.4	130.7	0.0	110.3	230.3	229.9
5	131.6	171.2	261.8	170.0	131.6	127.6	0.0	114.2	226.3	226.6
6	132.1	171.8	258.9	164.1	132.1	125.2	0.0	117.6	222.7	223.6
7	132.4	176.2	255.6	165.8	132.4	130.7	0.0	118.2	218.7	220.3
8	132.7	178.0	252.9	165.3	132.7	132.6	0.0	118.8	215.3	217.6
9	132.4	186.5	238.8	163.2	132.4	141.0	0.0	122.1	198.8	204.2
10	130.9	183.2	211.9	154.6	130.9	141.4	0.0	116.5	166.6	179.1
11	135.2	182.4	208.4	151.7	135.2	140.7	0.0	116.2	158.6	172.9

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.292	0.407	0.909	0.735	0.292	0.361	1.266	1.180
2	0.330	0.404	0.908	0.722	0.330	0.360	1.119	1.172
3	0.371	0.435	0.857	0.628	0.371	0.370	1.027	1.268
4	0.392	0.494	0.791	0.511	0.392	0.377	0.995	1.309
5	0.393	0.494	0.781	0.491	0.393	0.368	0.969	1.306
6	0.394	0.495	0.773	0.473	0.394	0.361	0.948	1.305
7	0.395	0.509	0.763	0.479	0.395	0.378	0.987	1.298
8	0.396	0.515	0.755	0.478	0.396	0.383	0.999	1.295
9	0.395	0.542	0.713	0.474	0.395	0.409	1.065	1.244
10	0.391	0.535	0.633	0.452	0.391	0.413	1.080	1.056
11	0.404	0.534	0.623	0.444	0.404	0.411	1.040	0.988

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	5.7	3.0	-3.2	0.253	0.881	0.060	0.059	0.011	0.011
2	10.00	4.8	1.9	-0.8	0.261	0.853	0.073	0.073	0.014	0.014
3	30.00	7.2	3.2	3.8	0.336	0.846	0.096	0.095	0.019	0.019
4	50.00	8.7	3.6	5.1	0.458	0.834	0.136	0.135	0.030	0.030
5	52.50	8.8	3.6	5.8	0.481	0.811	0.160	0.159	0.036	0.036
6	55.00	8.9	3.5	6.4	0.500	0.801	0.172	0.172	0.039	0.039
7	57.50	9.0	3.5	5.9	0.486	0.833	0.147	0.147	0.034	0.033
8	60.00	9.2	3.5	6.4	0.481	0.852	0.133	0.133	0.030	0.030
9	70.00	9.5	3.2	6.8	0.454	0.918	0.079	0.079	0.018	0.018
10	90.00	10.2	2.8	7.8	0.397	0.974	0.026	0.026	0.005	0.005
11	95.00	9.4	1.7	5.2	0.395	0.974	0.026	0.026	0.005	0.005

TABLE XI. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR

ROTOR 21 (CLEAN INLET FLOW); 70 PERCENT OF DESIGN SPEED

(d) Reading 2566

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	0.0	34.3	73.2	61.8	289.0	1.077	10.04	1.226
2	24.209	23.782	0.0	33.2	70.9	61.2	288.7	1.076	10.13	1.218
3	21.976	21.631	0.0	40.1	66.8	54.1	288.3	1.087	10.14	1.252
4	19.510	19.477	0.0	45.3	63.0	43.1	288.0	1.093	10.14	1.283
5	19.187	19.210	0.0	47.2	62.5	42.2	288.1	1.095	10.14	1.281
6	18.862	18.941	0.0	48.6	62.0	40.5	288.0	1.096	10.14	1.282
7	18.534	18.672	0.0	48.7	61.5	38.1	288.0	1.097	10.14	1.290
8	18.204	18.402	0.0	47.6	61.0	35.6	288.0	1.097	10.14	1.300
9	16.863	17.325	0.0	43.8	58.8	29.1	287.7	1.092	10.14	1.322
10	14.112	15.174	0.0	42.1	54.2	24.5	287.8	1.073	10.14	1.270
11	13.421	14.635	0.0	41.6	51.6	21.9	287.9	1.070	10.13	1.261

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	88.4	136.5	305.2	238.9	88.4	112.8	0.0	76.9	292.2	287.4
2	99.3	136.2	303.2	236.1	99.3	113.9	0.0	74.6	286.5	281.5
3	111.4	150.7	283.0	196.5	111.4	115.3	0.0	97.0	260.1	256.1
4	117.2	167.8	258.4	161.7	117.2	118.0	0.0	119.3	230.3	229.9
5	117.8	168.1	255.5	154.3	117.8	114.3	0.0	123.3	226.7	227.0
6	118.1	169.9	252.1	148.0	118.1	112.5	0.0	127.4	222.7	223.6
7	118.7	173.9	249.1	145.8	118.7	114.7	0.0	130.7	219.0	220.6
8	119.1	178.0	245.9	147.6	119.1	120.0	0.0	131.5	215.1	217.5
9	120.5	187.1	233.0	154.6	120.5	135.0	0.0	129.6	199.4	204.9
10	120.5	178.0	205.9	145.2	120.5	132.1	0.0	119.3	166.9	179.5
11	125.7	179.2	202.3	144.4	125.7	133.9	0.0	119.0	158.5	172.9

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.261	0.392	0.902	0.686	0.261	0.324	1.276	1.232
2	0.294	0.391	0.898	0.679	0.294	0.327	1.148	1.231
3	0.331	0.433	0.841	0.564	0.331	0.331	1.035	1.315
4	0.349	0.483	0.769	0.465	0.349	0.339	1.007	1.343
5	0.350	0.483	0.760	0.443	0.350	0.328	0.970	1.341
6	0.352	0.488	0.750	0.425	0.352	0.323	0.952	1.336
7	0.353	0.500	0.741	0.419	0.353	0.330	0.967	1.331
8	0.354	0.513	0.732	0.425	0.354	0.345	1.007	1.322
9	0.359	0.542	0.694	0.448	0.359	0.391	1.120	1.271
10	0.359	0.519	0.613	0.423	0.359	0.385	1.096	1.072
11	0.375	0.523	0.603	0.422	0.375	0.391	1.066	0.999

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	7.6	4.9	-1.9	0.312	0.777	0.132	0.131	0.024	0.024
2	10.00	7.1	4.1	0.2	0.312	0.763	0.138	0.137	0.025	0.025
3	30.00	9.7	5.7	3.8	0.421	0.761	0.175	0.174	0.035	0.035
4	50.00	11.4	6.3	5.8	0.514	0.791	0.188	0.188	0.042	0.042
5	52.50	11.5	6.3	6.6	0.541	0.777	0.207	0.207	0.046	0.046
6	55.00	11.7	6.2	6.7	0.562	0.766	0.224	0.224	0.050	0.050
7	57.50	11.8	6.2	6.0	0.567	0.780	0.218	0.218	0.050	0.050
8	60.00	11.8	6.1	5.3	0.553	0.803	0.201	0.201	0.046	0.046
9	70.00	12.0	5.7	5.7	0.486	0.900	0.107	0.107	0.025	0.025
10	90.00	12.5	5.1	8.4	0.428	0.969	0.033	0.033	0.007	0.007
11	95.00	11.5	3.8	5.1	0.416	0.984	0.017	0.017	0.003	0.003

TABLE XI. - Concluded. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 21 (CLEAN INLET FLOW); 70 PERCENT OF DESIGN SPEED

(e) Reading 2567

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	24.719	24.320	0.0	55.3	75.9	66.0	288.8	1.108	10.05	1.251
2	24.209	23.782	0.0	49.2	73.6	63.1	288.7	1.102	10.13	1.241
3	21.976	21.631	0.0	48.4	69.8	54.3	288.3	1.100	10.14	1.269
4	19.510	19.477	0.0	51.2	66.0	43.0	288.1	1.101	10.14	1.294
5	19.187	19.210	0.0	52.5	65.5	42.7	288.1	1.101	10.14	1.288
6	18.862	18.941	0.0	53.7	65.0	41.5	287.9	1.100	10.14	1.286
7	18.534	18.672	0.0	54.1	64.4	39.1	288.2	1.102	10.14	1.293
8	18.204	18.402	0.0	53.1	63.9	35.6	287.8	1.104	10.14	1.304
9	16.863	17.325	0.0	46.0	61.6	27.6	287.9	1.097	10.14	1.337
10	14.112	15.174	0.0	42.7	56.7	25.2	287.8	1.074	10.13	1.276
11	13.421	14.635	0.0	42.3	53.8	22.6	287.9	1.070	10.13	1.264

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	73.3	137.3	301.9	191.9	73.3	78.2	0.0	112.9	292.9	288.2
2	84.4	137.6	298.8	198.9	84.4	90.0	0.0	104.1	286.6	281.6
3	95.9	153.3	277.5	174.5	95.9	101.8	0.0	114.6	260.4	256.3
4	102.7	168.9	252.6	144.7	102.7	105.8	0.0	131.7	230.8	230.4
5	103.2	167.7	249.4	138.8	103.2	102.0	0.0	133.1	227.0	227.3
6	103.8	168.2	245.7	132.8	103.8	99.4	0.0	135.6	222.7	223.6
7	105.0	171.8	243.2	129.9	105.0	100.8	0.0	139.1	219.4	221.0
8	105.4	177.1	239.9	130.8	105.4	106.3	0.0	141.7	215.5	217.9
9	108.1	189.4	227.0	148.3	108.1	131.4	0.0	136.3	199.6	205.1
10	109.8	175.6	200.0	142.5	109.8	129.0	0.0	119.1	167.1	179.7
11	116.5	176.6	197.0	141.5	116.5	130.6	0.0	118.9	158.9	173.3

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.216	0.389	0.890	0.543	0.216	0.221	1.067	1.302
2	0.249	0.391	0.883	0.565	0.249	0.255	1.066	1.293
3	0.284	0.438	0.822	0.498	0.284	0.291	1.062	1.369
4	0.305	0.484	0.749	0.415	0.305	0.303	1.030	1.387
5	0.306	0.481	0.740	0.398	0.306	0.292	0.988	1.383
6	0.308	0.482	0.729	0.381	0.308	0.285	0.958	1.373
7	0.311	0.492	0.721	0.372	0.311	0.289	0.961	1.367
8	0.313	0.508	0.712	0.375	0.313	0.305	1.008	1.359
9	0.321	0.547	0.674	0.429	0.321	0.380	1.216	1.299
10	0.326	0.511	0.594	0.415	0.326	0.375	1.174	1.091
11	0.347	0.515	0.586	0.413	0.347	0.381	1.121	1.014

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	10.4	7.7	2.2	0.505	0.611	0.310	0.308	0.048	0.048
2	10.00	9.8	6.9	2.2	0.463	0.623	0.290	0.288	0.049	0.049
3	30.00	12.7	8.7	4.1	0.510	0.705	0.251	0.248	0.050	0.049
4	50.00	14.4	9.3	5.7	0.585	0.755	0.246	0.245	0.055	0.054
5	52.50	14.5	9.3	7.1	0.603	0.743	0.262	0.262	0.058	0.057
6	55.00	14.6	9.2	7.6	0.622	0.743	0.268	0.268	0.059	0.059
7	57.50	14.6	9.1	7.0	0.632	0.746	0.275	0.274	0.062	0.062
8	60.00	14.7	9.0	5.3	0.624	0.761	0.268	0.268	0.062	0.062
9	70.00	14.7	8.4	4.2	0.508	0.895	0.123	0.123	0.029	0.029
10	90.00	15.0	7.6	9.0	0.425	0.969	0.036	0.036	0.007	0.007
11	95.00	13.6	5.9	5.8	0.415	0.984	0.018	0.018	0.004	0.004

TABLE XII. - BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18

(CLEAN INLET FLOW); 70 PERCENT OF DESIGN SPEED

(a) Reading 2563

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	11.7	0.5	11.7	0.5	297.8	1.001	10.82	0.988
2	23.393	23.304	11.5	-0.9	11.5	-0.9	298.0	1.001	11.03	0.996
3	21.468	21.359	15.7	-1.1	15.7	-1.1	302.1	1.001	11.80	0.990
4	19.588	19.591	22.9	0.2	22.9	0.2	307.6	0.998	12.41	0.987
5	19.355	19.380	24.4	0.1	24.4	0.1	308.3	0.997	12.44	0.989
6	19.119	19.169	25.0	0.1	25.0	0.1	308.3	0.998	12.43	0.993
7	18.882	18.961	24.3	-0.1	24.3	-0.1	307.9	1.000	12.56	0.986
8	18.649	18.755	24.0	-0.3	24.0	-0.3	308.1	1.000	12.68	0.980
9	17.706	17.950	25.4	-0.4	25.4	-0.4	308.5	1.000	12.80	0.997
10	15.829	16.383	25.9	0.0	25.9	0.0	305.7	1.002	12.50	0.995
11	15.372	15.977	26.1	0.3	26.1	0.3	304.6	1.002	12.30	0.959

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	139.1	142.4	139.1	142.4	136.3	142.4	28.1	1.3	0.	0.
2	150.3	155.6	150.3	155.6	147.3	155.6	29.9	-2.4	0.	0.
3	189.5	179.3	189.5	179.3	182.4	179.3	51.3	-3.5	0.	0.
4	221.0	196.8	221.0	196.8	203.6	196.8	86.0	0.5	0.	0.
5	221.9	198.6	221.9	198.6	202.2	198.6	91.6	0.4	0.	0.
6	221.7	199.9	221.7	199.9	200.9	199.9	93.6	0.4	0.	0.
7	228.1	201.0	228.1	201.0	207.9	201.0	93.8	-0.5	0.	0.
8	234.4	202.7	234.4	202.7	214.1	202.7	95.3	-1.2	0.	0.
9	241.8	212.3	241.8	212.3	218.4	212.3	103.7	-1.6	0.	0.
10	234.9	232.4	234.9	232.4	211.3	232.4	102.7	0.1	0.	0.
11	225.2	223.5	225.2	223.5	202.2	223.5	99.2	1.0	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.409	0.418	0.409	0.418	0.400	0.418	1.045	0.409
2	0.443	0.459	0.443	0.459	0.434	0.459	1.056	0.443
3	0.561	0.529	0.561	0.529	0.540	0.529	0.983	0.561
4	0.655	0.579	0.655	0.579	0.603	0.579	0.967	0.655
5	0.657	0.584	0.657	0.584	0.599	0.584	0.983	0.657
6	0.656	0.588	0.656	0.588	0.595	0.588	0.995	0.675
7	0.678	0.591	0.678	0.591	0.618	0.591	0.967	0.678
8	0.698	0.596	0.698	0.596	0.637	0.596	0.947	0.698
9	0.721	0.626	0.721	0.626	0.652	0.626	0.972	0.721
10	0.703	0.693	0.703	0.693	0.632	0.693	1.100	0.703
11	0.672	0.666	0.672	0.666	0.603	0.666	1.105	0.680

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	-17.4	-23.6	7.9	0.050	0.	0.111	0.111	0.042	0.042
2	10.00	-17.3	-23.3	6.3	0.045	0.	0.035	0.035	0.013	0.013
3	30.00	-15.4	-20.8	6.3	0.152	0.	0.052	0.052	0.018	0.018
4	50.00	-11.9	-16.7	8.1	0.230	0.	0.051	0.051	0.016	0.016
5	52.50	-10.9	-15.6	8.2	0.232	0.	0.042	0.042	0.013	0.013
6	55.00	-10.7	-15.3	8.2	0.226	0.	0.027	0.027	0.008	0.008
7	57.50	-11.8	-16.4	8.0	0.243	0.	0.054	0.054	0.016	0.016
8	60.00	-12.5	-17.0	7.9	0.257	0.	0.071	0.071	0.021	0.021
9	70.00	-12.3	-16.5	7.8	0.245	0.	0.045	0.045	0.013	0.013
10	90.00	-9.7	-13.4	7.3	0.120	0.	0.019	0.019	0.005	0.005
11	95.00	-7.6	-11.3	7.0	0.113	0.	0.158	0.158	0.039	0.039

TABLE XII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18 (CLEAN INLET FLOW); 70 PERCENT OF DESIGN SPEED

(b) Reading 2564

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	22.0	1.6	22.0	1.6	304.0	1.003	11.83	0.982
2	23.393	23.304	21.7	-0.0	21.7	-0.0	304.4	1.000	11.90	0.995
3	21.468	21.359	23.6	-0.4	23.6	-0.4	306.9	1.000	12.40	0.996
4	19.588	19.591	29.5	0.4	29.5	0.4	310.8	0.998	12.81	0.991
5	19.355	19.380	31.0	0.6	31.0	0.6	311.0	0.997	12.81	0.994
6	19.119	19.169	31.2	0.5	31.2	0.5	311.4	0.998	12.80	0.996
7	18.882	18.961	30.6	0.2	30.6	0.2	311.0	0.999	12.86	0.994
8	18.649	18.755	30.2	-0.0	30.2	-0.0	310.5	1.000	12.92	0.991
9	17.706	17.950	31.1	0.3	31.1	0.3	310.8	0.999	13.05	0.994
10	15.829	16.383	31.6	0.1	31.6	0.1	307.6	1.000	12.74	0.992
11	15.372	15.977	31.7	-0.4	31.7	-0.4	306.9	1.001	12.57	0.970

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	143.5	124.4	143.5	124.4	133.1	124.3	53.7	3.4	0.	0.
2	147.6	135.1	147.6	135.1	137.1	135.1	54.6	-0.0	0.	0.
3	175.4	154.8	175.4	154.8	160.7	154.8	70.1	-1.2	0.	0.
4	200.4	167.9	200.4	167.9	174.4	167.9	98.6	1.2	0.	0.
5	200.8	169.4	200.8	169.4	172.2	169.4	103.3	1.7	0.	0.
6	201.2	170.5	201.2	170.5	172.0	170.5	104.4	1.5	0.	0.
7	205.0	171.6	205.0	171.6	176.5	171.6	104.2	0.7	0.	0.
8	208.5	172.8	208.5	172.8	180.1	172.8	105.0	-0.1	0.	0.
9	217.5	181.0	217.5	181.0	186.3	181.0	112.4	0.8	0.	0.
10	211.0	186.1	211.0	186.1	179.8	186.1	110.4	0.2	0.	0.
11	205.0	175.6	205.0	175.6	174.5	175.6	107.7	-1.2	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.418	0.360	0.418	0.360	0.387	0.360	0.934	0.460
2	0.430	0.392	0.430	0.392	0.399	0.392	0.985	0.464
3	0.512	0.450	0.512	0.450	0.470	0.450	0.963	0.563
4	0.586	0.487	0.586	0.487	0.510	0.487	0.963	0.742
5	0.587	0.491	0.587	0.491	0.504	0.491	0.984	0.770
6	0.588	0.494	0.588	0.494	0.503	0.494	0.991	0.772
7	0.600	0.498	0.600	0.498	0.517	0.498	0.972	0.766
8	0.612	0.501	0.612	0.501	0.529	0.501	0.959	0.768
9	0.640	0.527	0.640	0.527	0.548	0.527	0.972	0.801
10	0.623	0.545	0.623	0.545	0.531	0.545	1.035	0.782
11	0.605	0.513	0.605	0.513	0.515	0.513	1.007	0.774

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	-7.1	-13.3	8.9	0.266	0.	0.158	0.158	0.060	0.060
2	10.00	-7.0	-13.1	7.2	0.222	0.	0.043	0.043	0.016	0.016
3	30.00	-7.5	-12.9	7.0	0.256	0.	0.022	0.022	0.008	0.008
4	50.00	-5.3	-10.1	8.4	0.314	0.	0.043	0.043	0.013	0.013
5	52.50	-4.3	-9.0	8.6	0.312	0.	0.029	0.029	0.009	0.009
6	55.00	-4.4	-9.0	8.6	0.308	0.	0.018	0.018	0.006	0.006
7	57.50	-5.5	-10.1	8.4	0.315	0.	0.028	0.028	0.009	0.009
8	60.00	-6.2	-10.7	8.2	0.321	0.	0.039	0.039	0.011	0.011
9	70.00	-6.6	-10.8	8.5	0.312	0.	0.024	0.024	0.007	0.007
10	90.00	-4.0	-7.7	7.3	0.249	0.	0.034	0.034	0.009	0.009
11	95.00	-2.1	-5.7	6.4	0.272	0.	0.138	0.138	0.034	0.034

TABLE XII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18 (CLEAN INLET FLOW); 70 PERCENT OF DESIGN SPEED

(c) Reading 2565

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	27.8	2.3	27.8	2.3	307.8	1.002	12.18	0.983
2	23.393	23.304	26.7	0.5	26.7	0.5	307.4	1.001	12.21	0.998
3	21.468	21.359	28.9	0.2	28.9	0.2	309.6	1.000	12.55	0.998
4	19.588	19.591	35.1	1.2	35.1	1.2	313.2	0.996	12.97	0.989
5	19.355	19.380	36.6	1.1	36.6	1.1	313.6	0.996	12.93	0.993
6	19.119	19.169	37.8	1.0	37.8	1.0	313.7	0.996	12.92	0.996
7	18.882	18.961	36.6	0.9	36.6	0.9	313.6	0.997	13.02	0.990
8	18.649	18.755	36.1	0.9	36.1	0.9	313.4	0.998	13.07	0.990
9	17.706	17.950	34.7	1.2	34.7	1.2	312.5	0.999	13.23	0.987
10	15.829	16.383	33.6	0.5	33.6	0.5	308.4	1.002	12.84	0.993
11	15.372	15.977	34.0	-0.4	34.0	-0.4	307.5	1.003	12.69	0.970

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	142.0	115.0	142.0	115.0	125.7	114.9	66.1	4.5	0.	0.
2	144.1	125.9	144.1	125.9	128.8	125.9	64.7	1.1	0.	0.
3	165.4	139.4	165.4	139.4	144.8	139.4	79.8	0.5	0.	0.
4	190.5	152.5	190.5	152.5	155.8	152.5	109.7	3.2	0.	0.
5	190.0	153.4	190.0	153.4	152.4	153.3	113.3	2.8	0.	0.
6	189.9	154.3	189.9	154.3	149.9	154.3	116.5	2.8	0.	0.
7	196.2	156.1	196.2	156.1	157.6	156.1	116.9	2.5	0.	0.
8	198.7	158.0	198.7	158.0	160.5	158.0	117.2	2.5	0.	0.
9	210.0	164.7	210.0	164.7	172.7	164.6	119.5	3.4	0.	0.
10	201.8	166.7	201.8	166.7	168.0	166.7	111.7	1.4	0.	0.
11	197.7	152.9	197.7	152.9	163.8	152.9	110.6	-1.1	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.411	0.330	0.411	0.330	0.363	0.330	0.914	0.548
2	0.417	0.363	0.417	0.363	0.373	0.363	0.978	0.538
3	0.479	0.402	0.479	0.402	0.420	0.402	0.963	0.631
4	0.553	0.439	0.553	0.439	0.452	0.439	0.979	0.811
5	0.551	0.441	0.551	0.441	0.442	0.441	1.006	0.831
6	0.551	0.444	0.551	0.444	0.435	0.444	1.029	0.849
7	0.570	0.449	0.570	0.449	0.458	0.449	0.991	0.849
8	0.578	0.455	0.578	0.455	0.467	0.455	0.984	0.847
9	0.615	0.475	0.615	0.475	0.505	0.475	0.953	0.849
10	0.593	0.484	0.593	0.484	0.494	0.484	0.992	0.789
11	0.581	0.443	0.581	0.443	0.482	0.443	0.934	0.793

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	-1.3	-7.5	9.6	0.356	0.	0.155	0.155	0.059	0.059
2	10.00	-2.1	-8.1	7.7	0.291	0.	0.022	0.022	0.008	0.008
3	30.00	-2.2	-7.6	7.6	0.321	0.	0.017	0.017	0.006	0.006
4	50.00	0.4	-4.4	9.2	0.374	0.	0.059	0.059	0.018	0.018
5	52.50	1.4	-3.3	9.1	0.372	0.	0.039	0.039	0.012	0.012
6	55.00	2.2	-2.4	9.1	0.370	0.	0.023	0.023	0.007	0.007
7	57.50	0.5	-4.0	9.1	0.380	0.	0.049	0.049	0.015	0.015
8	60.00	-0.3	-4.8	9.1	0.376	0.	0.048	0.048	0.014	0.014
9	70.00	-3.0	-7.2	9.5	0.371	0.	0.059	0.059	0.017	0.017
10	90.00	-2.0	-5.7	7.8	0.310	0.	0.032	0.032	0.008	0.008
11	95.00	0.3	-3.3	6.4	0.363	0.	0.146	0.146	0.036	0.036

TABLE XII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18 (CLEAN INLET FLOW); 70 PERCENT OF DESIGN SPEED

(d) Reading 2566

	RADII		ABS BETAM		REL BETAM		TOTAL TEMP		TOTAL PRESS	
RP	IN	OUT	IN	OUT	IN	OUT	IN	RATIO	IN	RATIO
1	23.894	23.866	34.6	3.2	34.6	3.2	311.3	1.001	12.31	0.987
2	23.393	23.304	32.8	3.1	32.8	3.1	310.6	1.001	12.34	0.996
3	21.468	21.359	36.9	2.3	36.9	2.3	313.4	0.998	12.70	0.992
4	19.588	19.591	40.3	2.0	40.3	2.0	314.9	0.998	13.01	0.988
5	19.355	19.380	42.1	1.4	42.1	1.4	315.3	0.997	12.99	0.991
6	19.119	19.169	43.3	1.5	43.3	1.5	315.6	0.996	12.99	0.992
7	18.882	18.961	43.3	1.4	43.3	1.4	315.8	0.996	13.08	0.988
8	18.649	18.755	42.0	1.5	42.0	1.5	315.9	0.996	13.18	0.986
9	17.706	17.950	37.6	2.5	37.6	2.5	314.3	0.999	13.40	0.980
10	15.829	16.383	36.2	0.6	36.2	0.6	308.8	1.004	12.87	0.993
11	15.372	15.977	36.1	-0.4	36.1	-0.4	307.9	1.004	12.77	0.969

	ABS VEL		REL VEL		MERID VEL		TANG VEL		WHEEL SPEED	
RP	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
1	137.9	105.7	137.9	105.7	113.5	105.5	78.2	5.9	0.	0.
2	140.1	113.4	140.1	113.4	117.8	113.3	75.9	6.0	0.	0.
3	162.6	128.7	162.6	128.7	130.0	128.6	97.7	5.3	0.	0.
4	183.3	140.6	183.3	140.6	139.7	140.5	118.6	4.9	0.	0.
5	182.6	141.5	182.6	141.5	135.6	141.4	122.4	3.5	0.	0.
6	183.9	142.6	183.9	142.6	133.8	142.5	126.2	3.7	0.	0.
7	188.3	144.1	188.3	144.1	137.0	144.0	129.2	3.6	0.	0.
8	193.8	147.4	193.8	147.4	144.0	147.3	129.8	4.0	0.	0.
9	207.7	155.0	207.7	155.0	164.5	154.9	126.8	6.9	0.	0.
10	193.5	152.4	193.5	152.4	156.1	152.4	114.3	1.6	0.	0.
11	192.3	136.2	192.3	136.2	155.4	136.2	113.3	-0.8	0.	0.

	ABS MACH NO		REL MACH NO		MERID MACH NO		MERID VEL R	PEAK SS MACH NO
RP	IN	OUT	IN	OUT	IN	OUT		
1	0.396	0.301	0.396	0.301	0.326	0.301	0.929	0.622
2	0.403	0.324	0.403	0.324	0.339	0.324	0.962	0.606
3	0.468	0.368	0.468	0.368	0.374	0.367	0.989	0.747
4	0.529	0.402	0.529	0.402	0.404	0.402	1.005	0.869
5	0.527	0.404	0.527	0.404	0.391	0.404	1.043	0.893
6	0.531	0.408	0.531	0.408	0.386	0.408	1.065	0.916
7	0.544	0.412	0.544	0.412	0.396	0.412	1.051	0.934
8	0.561	0.422	0.561	0.422	0.417	0.422	1.023	0.933
9	0.606	0.445	0.606	0.445	0.480	0.445	0.941	0.898
10	0.567	0.440	0.567	0.440	0.457	0.440	0.976	0.806
11	0.564	0.393	0.564	0.393	0.456	0.393	0.877	0.810

	PERCENT	INCIDENCE		DEV	D-FACT	EFF	LOSS COEFF		LOSS PARAM	
RP	SPAN	MEAN	SS				TOT	PROF	TOT	PROF
1	5.00	5.5	-0.7	10.6	0.433	0.	0.124	0.124	0.047	0.047
2	10.00	4.0	-2.0	10.2	0.376	0.	0.042	0.042	0.015	0.015
3	30.00	5.9	0.4	9.8	0.403	0.	0.056	0.056	0.019	0.019
4	50.00	5.6	0.8	10.0	0.427	0.	0.071	0.071	0.022	0.022
5	52.50	6.9	2.2	9.5	0.426	0.	0.055	0.055	0.017	0.017
6	55.00	7.7	3.1	9.6	0.428	0.	0.046	0.046	0.014	0.014
7	57.50	7.3	2.7	9.6	0.436	0.	0.067	0.067	0.020	0.020
8	60.00	5.6	1.1	9.7	0.432	0.	0.075	0.075	0.022	0.022
9	70.00	-0.0	-4.2	10.8	0.416	0.	0.090	0.090	0.025	0.025
10	90.00	0.6	-3.1	7.9	0.358	0.	0.033	0.033	0.008	0.008
11	95.00	2.4	-1.3	6.4	0.435	0.	0.162	0.162	0.040	0.040

TABLE XII. - Concluded. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 18 (CLEAN INLET FLOW); 70 PERCENT OF DESIGN SPEED

(e) Reading 2567

RP	RADII IN	RADII OUT	ABS BETAM IN	ABS BETAM OUT	REL BETAM IN	REL BETAM OUT	TOTAL TEMP IN	TOTAL TEMP RATIO	TOTAL PRESS IN	TOTAL PRESS RATIO
1	23.894	23.866	55.6	-0.4	55.6	-0.4	320.0	0.998	12.57	0.975
2	23.393	23.304	48.7	2.1	48.7	2.1	318.2	1.001	12.57	0.978
3	21.468	21.359	45.3	3.9	45.3	3.9	317.1	0.999	12.86	0.974
4	19.588	19.591	46.4	1.7	46.4	1.7	317.2	0.999	13.11	0.974
5	19.355	19.380	47.7	1.5	47.7	1.5	317.1	0.999	13.05	0.980
6	19.119	19.169	48.8	1.3	48.8	1.3	316.7	1.000	13.03	0.983
7	18.882	18.961	49.0	1.5	49.0	1.5	317.7	0.997	13.11	0.980
8	18.649	18.755	47.8	2.2	47.8	2.2	317.6	0.996	13.23	0.981
9	17.706	17.950	39.9	3.8	39.9	3.8	315.7	0.999	13.56	0.966
10	15.829	16.383	36.9	1.2	36.9	1.2	309.2	1.005	12.93	0.993
11	15.372	15.977	36.8	-0.1	36.8	-0.1	308.2	1.005	12.80	0.973

RP	ABS VEL IN	ABS VEL OUT	REL VEL IN	REL VEL OUT	MERID VEL IN	MERID VEL OUT	TANG VEL IN	TANG VEL OUT	WHEEL SPEED IN	WHEEL SPEED OUT
1	139.3	102.9	139.3	102.9	78.8	102.9	114.9	-0.7	0.	0.
2	140.9	105.0	140.9	105.0	92.9	105.0	105.9	3.8	0.	0.
3	162.5	120.0	162.5	120.0	114.3	119.7	115.5	8.2	0.	0.
4	180.7	133.0	180.7	133.0	124.5	132.9	130.9	3.9	0.	0.
5	178.7	133.7	178.7	133.7	120.4	133.6	132.1	3.6	0.	0.
6	178.6	135.0	178.6	135.0	117.6	135.0	134.3	3.0	0.	0.
7	182.3	137.0	182.3	137.0	119.7	137.0	137.5	3.6	0.	0.
8	188.7	142.8	188.7	142.8	126.7	142.7	139.8	5.5	0.	0.
9	208.0	149.7	208.0	149.7	159.6	149.4	133.4	9.8	0.	0.
10	190.2	149.0	190.2	149.0	152.1	149.0	114.2	3.1	0.	0.
11	188.9	134.8	188.9	134.8	151.2	134.8	113.2	-0.2	0.	0.

RP	ABS MACH NO IN	ABS MACH NO OUT	REL MACH NO IN	REL MACH NO OUT	MERID MACH NO IN	MERID MACH NO OUT	MERID VEL R	PEAK SS MACH NO
1	0.395	0.290	0.395	0.290	0.223	0.290	1.307	0.918
2	0.400	0.296	0.400	0.296	0.264	0.296	1.129	0.823
3	0.465	0.340	0.465	0.340	0.327	0.339	1.047	0.875
4	0.519	0.378	0.519	0.378	0.358	0.378	1.067	0.962
5	0.514	0.380	0.514	0.380	0.346	0.380	1.110	0.969
6	0.514	0.384	0.514	0.384	0.338	0.384	1.148	0.984
7	0.524	0.390	0.524	0.390	0.344	0.390	1.144	1.003
8	0.544	0.407	0.544	0.407	0.365	0.407	1.126	1.013
9	0.605	0.428	0.605	0.428	0.464	0.427	0.936	0.943
10	0.556	0.429	0.556	0.429	0.445	0.429	0.980	0.804
11	0.553	0.388	0.553	0.388	0.443	0.388	0.892	0.808

RP	PERCENT SPAN	INCIDENCE MEAN	INCIDENCE SS	DEV	D-FACT	EFF	LOSS COEFF TOT	LOSS COEFF PROF	LOSS PARAM TOT	LOSS PARAM PROF
1	5.00	26.5	20.3	7.0	0.577	0.	0.242	0.242	0.092	0.092
2	10.00	20.0	13.9	9.3	0.524	0.	0.209	0.209	0.078	0.078
3	30.00	14.2	8.8	11.3	0.487	0.	0.192	0.192	0.065	0.065
4	50.00	11.7	6.9	9.7	0.483	0.	0.153	0.153	0.048	0.048
5	52.50	12.5	7.8	9.6	0.474	0.	0.124	0.124	0.038	0.038
6	55.00	13.2	8.5	9.4	0.468	0.	0.104	0.104	0.032	0.032
7	57.50	12.9	8.4	9.7	0.469	0.	0.117	0.117	0.035	0.035
8	60.00	11.4	6.9	10.4	0.455	0.	0.106	0.106	0.032	0.032
9	70.00	2.2	-2.0	12.0	0.447	0.	0.156	0.156	0.044	0.044
10	90.00	1.3	-2.4	8.4	0.362	0.	0.039	0.039	0.010	0.010
11	95.00	3.1	-0.6	6.7	0.432	0.	0.143	0.143	0.035	0.035

TABLE XIII. - OVERALL PERFORMANCE FOR STAGE 21-18;

7-MESH SCREEN (TIP RADIAL DISTORTION)

(a) 100 Percent of design speed; tip radial distortion, 0.127

Parameter	Reading		
	2687	2686	2685
ROTOR TOTAL PRESSURE RATIO	1.510	1.615	1.663
STAGE TOTAL PRESSURE RATIO	1.483	1.582	1.621
ROTOR TOTAL TEMPERATURE RATIO	1.153	1.171	1.180
STAGE TOTAL TEMPERATURE RATIO	1.149	1.166	1.175
ROTOR TEMP. RISE EFFICIENCY	0.817	0.859	0.868
STAGE TEMP. RISE EFFICIENCY	0.801	0.844	0.846
ROTOR MOMENTUM RISE EFFICIENCY	0.808	0.857	0.863
ROTOR HEAD RISE COEFFICIENT	0.201	0.237	0.252
STAGE HEAD RISE COEFFICIENT	0.191	0.226	0.238
FLOW COEFFICIENT	0.449	0.445	0.438
WT FLOW PER UNIT FRONTAL AREA	152.72	151.51	149.41
WT FLOW PER UNIT ANNULUS AREA	204.80	203.18	200.36
WT FLOW AT ORIFICE	30.43	30.19	29.77
WT FLOW AT ROTOR INLET	30.47	30.24	29.95
WT FLOW AT ROTOR OUTLET	30.11	29.99	29.72
WT FLOW AT STATOR OUTLET	30.09	30.04	30.03
ROTATIVE SPEED	16096.9	16042.9	16072.6
PERCENT OF DESIGN SPEED	100.0	99.6	99.8

(b) 70 Percent of design speed; tip radial distortion, 0.044

Parameter	Reading		
	2699	2698	2697
ROTOR TOTAL PRESSURE RATIO	1.246	1.276	1.287
STAGE TOTAL PRESSURE RATIO	1.237	1.264	1.266
ROTOR TOTAL TEMPERATURE RATIO	1.072	1.082	1.091
STAGE TOTAL TEMPERATURE RATIO	1.072	1.081	1.089
ROTOR TEMP. RISE EFFICIENCY	0.901	0.877	0.824
STAGE TEMP. RISE EFFICIENCY	0.870	0.856	0.784
ROTOR MOMENTUM RISE EFFICIENCY	0.894	0.885	0.825
ROTOR HEAD RISE COEFFICIENT	0.212	0.236	0.246
STAGE HEAD RISE COEFFICIENT	0.204	0.227	0.230
FLOW COEFFICIENT	0.435	0.396	0.352
WT FLOW PER UNIT FRONTAL AREA	113.28	104.03	93.57
WT FLOW PER UNIT ANNULUS AREA	151.91	139.50	125.48
WT FLOW AT ORIFICE	22.57	20.73	18.64
WT FLOW AT ROTOR INLET	22.65	20.87	18.70
WT FLOW AT ROTOR OUTLET	22.41	20.78	18.69
WT FLOW AT STATOR OUTLET	22.25	20.56	19.13
ROTATIVE SPEED	11292.3	11275.9	11246.3
PERCENT OF DESIGN SPEED	70.1	70.0	69.9

TABLE XIV. - OVERALL PERFORMANCE FOR STAGE 21-18;

20-MESH SCREEN (TIP RADIAL DISTORTION)

(a) 100 Percent of design speed; tip radial distortion, 0.164

Parameter	Reading		
	2646	2645	2644
ROTOR TOTAL PRESSURE RATIO	1.460	1.563	1.629
STAGE TOTAL PRESSURE RATIO	1.442	1.549	1.607
ROTOR TOTAL TEMPERATURE RATIO	1.137	1.160	1.178
STAGE TOTAL TEMPERATURE RATIO	1.136	1.160	1.180
ROTOR TEMP. RISE EFFICIENCY	0.835	0.848	0.842
STAGE TEMP. RISE EFFICIENCY	0.810	0.833	0.808
ROTOR MOMENTUM RISE EFFICIENCY	0.800	0.832	0.847
ROTOR HEAD RISE COEFFICIENT	0.184	0.220	0.240
STAGE HEAD RISE COEFFICIENT	0.178	0.215	0.233
FLOW COEFFICIENT	0.459	0.455	0.444
WT FLOW PER UNIT FRONTAL AREA	149.74	148.32	146.52
WT FLOW PER UNIT ANNULUS AREA	200.81	198.90	196.49
WT FLOW AT ORIFICE	29.84	29.55	29.19
WT FLOW AT ROTOR INLET	30.39	30.13	29.64
WT FLOW AT ROTOR OUTLET	29.89	29.44	29.19
WT FLOW AT STATOR OUTLET	30.10	29.96	30.30
ROTATIVE SPEED	16058.4	16047.6	16115.4
PERCENT OF DESIGN SPEED	99.7	99.7	100.1

(b) 70 Percent of design speed; tip radial distortion, 0.070

Parameter	Reading		
	2640	2639	2638
ROTOR TOTAL PRESSURE RATIO	1.235	1.268	1.282
STAGE TOTAL PRESSURE RATIO	1.225	1.258	1.267
ROTOR TOTAL TEMPERATURE RATIO	1.068	1.078	1.085
STAGE TOTAL TEMPERATURE RATIO	1.068	1.078	1.086
ROTOR TEMP. RISE EFFICIENCY	0.910	0.899	0.863
STAGE TEMP. RISE EFFICIENCY	0.875	0.873	0.817
ROTOR MOMENTUM RISE EFFICIENCY	0.905	0.907	0.868
ROTOR HEAD RISE COEFFICIENT	0.203	0.228	0.239
STAGE HEAD RISE COEFFICIENT	0.195	0.220	0.227
FLOW COEFFICIENT	0.466	0.432	0.398
WT FLOW PER UNIT FRONTAL AREA.	116.30	108.83	100.85
WT FLOW PER UNIT ANNULUS AREA	155.96	145.95	135.25
WT FLOW AT ORIFICE	23.17	21.68	20.09
WT FLOW AT ROTOR INLET	23.53	22.12	20.48
WT FLOW AT ROTOR OUTLET	23.13	21.83	20.03
WT FLOW AT STATOR OUTLET	22.93	21.56	20.41
ROTATIVE SPEED	11283.4	11320.7	11314.4
PERCENT OF DESIGN SPEED	70.1	70.3	70.3

TABLE XV. - OVERALL PERFORMANCE FOR STAGE 21-18;

7- AND 20-MESH SCREENS (TIP RADIAL DISTORTION)

(a) 100 Percent of design speed; tip radial distortion, 0.189

Parameter	Reading		
	2626	2625	2624
ROTOR TOTAL PRESSURE RATIO	1.465	1.556	1.604
STAGE TOTAL PRESSURE RATIO	1.447	1.544	1.587
ROTOR TOTAL TEMPERATURE RATIO	1.140	1.160	1.175
STAGE TOTAL TEMPERATURE RATIO	1.140	1.160	1.175
ROTOR TEMP. RISE EFFICIENCY	0.825	0.840	0.827
STAGE TEMP. RISE EFFICIENCY	0.799	0.828	0.804
ROTOR MOMENTUM RISE EFFICIENCY	0.801	0.824	0.832
ROTOR HEAD RISE COEFFICIENT	0.186	0.215	0.231
STAGE HEAD RISE COEFFICIENT	0.180	0.211	0.226
FLOW COEFFICIENT	0.464	0.460	0.455
WT FLOW PER UNIT FRONTAL AREA	149.25	148.86	147.19
WT FLOW PER UNIT ANNULUS AREA	200.14	199.62	197.39
WT FLOW AT ORIFICE	29.74	29.66	29.33
WT FLOW AT ROTOR INLET	30.28	30.23	29.91
WT FLOW AT ROTOR OUTLET	29.74	29.51	29.13
WT FLOW AT STATOR OUTLET	29.95	30.08	30.09
ROTATIVE SPEED	16063.4	16146.2	16130.8
PERCENT OF DESIGN SPEED	99.8	100.3	100.2

(b) 70 Percent of design speed; tip radial distortion, 0.082

Parameter	Reading		
	2618	2620	2621
ROTOR TOTAL PRESSURE RATIO	1.243	1.268	1.279
STAGE TOTAL PRESSURE RATIO	1.234	1.259	1.264
ROTOR TOTAL TEMPERATURE RATIO	1.069	1.078	1.084
STAGE TOTAL TEMPERATURE RATIO	1.070	1.078	1.083
ROTOR TEMP. RISE EFFICIENCY	0.931	0.899	0.871
STAGE TEMP. RISE EFFICIENCY	0.880	0.873	0.833
ROTOR MOMENTUM RISE EFFICIENCY	0.924	0.905	0.873
ROTOR HEAD RISE COEFFICIENT	0.209	0.229	0.238
STAGE HEAD RISE COEFFICIENT	0.202	0.221	0.226
FLOW COEFFICIENT	0.473	0.442	0.415
WT FLOW PER UNIT FRONTAL AREA	115.99	109.06	102.46
WT FLOW PER UNIT ANNULUS AREA	155.55	146.25	137.40
WT FLOW AT ORIFICE	23.11	21.73	20.41
WT FLOW AT ROTOR INLET	23.38	22.20	20.95
WT FLOW AT ROTOR OUTLET	23.12	21.76	20.38
WT FLOW AT STATOR OUTLET	22.93	21.64	20.73
ROTATIVE SPEED	11303.1	11304.4	11296.6
PERCENT OF DESIGN SPEED	70.2	70.2	70.2

TABLE XVI. - OVERALL PERFORMANCE FOR STAGE 21-18;

20-MESH SCREEN (HUB RADIAL DISTORTION)

(a) 100 Percent of design speed; hub radial distortion, 0.133

Parameter	Reading		
	2666	2665	2664
ROTOR TOTAL PRESSURE RATIO	1.449	1.501	1.558
STAGE TOTAL PRESSURE RATIO	1.423	1.483	1.536
ROTOR TOTAL TEMPERATURE RATIO	1.134	1.146	1.158
STAGE TOTAL TEMPERATURE RATIO	1.133	1.147	1.160
ROTOR TEMP. RISE EFFICIENCY	0.832	0.843	0.854
STAGE TEMP. RISE EFFICIENCY	0.794	0.812	0.816
ROTOR MOMENTUM RISE EFFICIENCY	0.798	0.826	0.849
ROTOR HEAD RISE COEFFICIENT	0.180	0.197	0.216
STAGE HEAD RISE COEFFICIENT	0.170	0.191	0.209
FLOW COEFFICIENT	0.446	0.441	0.430
WT FLOW PER UNIT FRONTAL AREA	151.53	150.47	148.35
WT FLOW PER UNIT ANNULUS AREA	203.21	201.79	198.94
WT FLOW AT ORIFICE	30.19	29.98	29.56
WT FLOW AT ROTOR INLET	30.28	30.05	29.55
WT FLOW AT ROTOR OUTLET	29.86	29.79	29.66
WT FLOW AT STATOR OUTLET	30.10	29.84	29.96
ROTATIVE SPEED	16098.2	16120.7	16127.2
PERCENT OF DESIGN SPEED	100.0	100.1	100.2

(b) 70 Percent of design speed; hub radial distortion, 0.027

Parameter	Reading				
	2662	2661	2660	2659	2658
ROTOR TOTAL PRESSURE RATIO	1.203	1.226	1.245	1.256	1.275
STAGE TOTAL PRESSURE RATIO	1.193	1.217	1.229	1.235	1.237
ROTOR TOTAL TEMPERATURE RATIO	1.060	1.068	1.077	1.085	1.098
STAGE TOTAL TEMPERATURE RATIO	1.059	1.068	1.077	1.086	1.099
ROTOR TEMP. RISE EFFICIENCY	0.906	0.887	0.840	0.796	0.734
STAGE TEMP. RISE EFFICIENCY	0.873	0.852	0.794	0.726	0.633
ROTOR MOMENTUM RISE EFFICIENCY	0.873	0.857	0.821	0.777	0.706
ROTOR HEAD RISE COEFFICIENT	0.178	0.196	0.212	0.221	0.237
STAGE HEAD RISE COEFFICIENT	0.169	0.189	0.199	0.205	0.206
FLOW COEFFICIENT	0.435	0.397	0.358	0.318	0.271
WT FLOW PER UNIT FRONTAL AREA.	112.80	104.39	95.19	85.49	73.97
WT FLOW PER UNIT ANNULUS AREA	151.27	139.99	127.65	114.64	99.19
WT FLOW AT ORIFICE	22.48	20.80	18.97	17.03	14.74
WT FLOW AT ROTOR INLET	22.58	20.86	19.04	17.10	14.86
WT FLOW AT ROTOR OUTLET	22.47	20.95	19.34	17.49	15.04
WT FLOW AT STATOR OUTLET	22.30	20.69	19.08	17.71	16.76
ROTATIVE SPEED	11267.1	11273.1	11263.7	11245.9	11251.4
PERCENT OF DESIGN SPEED	70.0	70.0	70.0	69.9	69.9

TABLE XVII. - DISTORTION PARAMETER VALUES OVER OPERATING RANGE

Rotor speed, N, percent of design	Corrected weight flow, $W\sqrt{\theta}/\delta$, kg/sec	Ratio of equivalent weight flow to design, $\frac{W\sqrt{\theta}/\delta}{(W\sqrt{\theta}/\delta)_{des}}$	Maximum total pressure, P_{max}, N/cm^2	Minimum total pressure, P_{min}, N/cm^2	Distortion index, $\frac{P_{max} - P_{min}}{P_{max}}$
Tip radial distortion, 0.127					
100	30.43	1.032	10.590	9.191	0.132
	29.77	1.010	10.571	9.225	.127
90	26.42	.897	10.432	9.432	.096
80	22.43	.760	10.328	9.653	.065
70	22.57	.765	10.335	9.670	.064
	18.64	.632	10.259	9.811	.044
Tip radial distortion, 0.164					
100	29.84	1.012	10.806	8.942	0.173
	29.19	0.990	10.772	9.004	.164
90	27.56	.935	10.688	9.163	.143
80	24.31	.824	10.550	9.420	.107
70	23.17	.786	10.494	9.503	.094
	20.09	.682	10.411	9.683	.070
Tip radial distortion, 0.189					
100	29.74	1.009	10.804	8.694	0.195
	29.33	.995	10.777	8.743	.189
90	27.59	.936	10.701	8.929	.166
80	24.72	.838	10.563	9.191	.130
70	23.11	.784	10.487	9.322	.111
	20.41	.692	10.390	9.542	.082
Hub radial distortion, 0.133					
100	30.19	1.024	10.639	9.154	0.139
	29.56	1.002	10.618	9.205	.133
70	22.48	.762	10.377	9.694	.066
	14.74	.500	10.232	9.956	.027

Flow path coordinates			
Axial distance, z, cm	Radius, r, cm	Axial distance, z, cm	Radius, r, cm
Hub surface		Tip surface	
-34.892	7.328	-34.892	25.400
-26.518	7.328	-16.358	25.400
-23.978	7.671	[a]-2.304	25.400
-18.898	8.484	-1.260	25.395
-11.278	9.830	.0	25.352
-6.198	10.767	1.270	25.210
[a]-2.304	11.760	2.540	24.981
.0	12.573	3.810	24.727
4.770	14.107	5.080	24.526
[a]5.596	14.351	[a]5.596	24.460
8.580	14.782	6.350	24.427
9.850	15.113	6.985	24.402
11.120	15.240	8.255	24.384
[a]13.246	15.240	[a]13.246	24.384
17.238	15.240	17.238	24.384

[a]Instrumentation survey station.

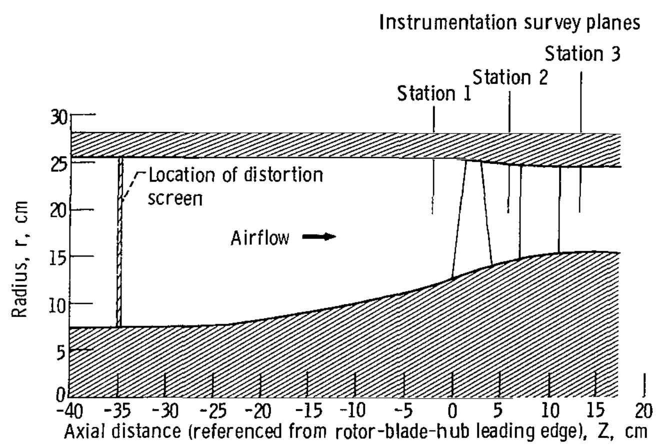


Figure 1. - Flow path for stage 21-18, showing axial location of instrumentation.

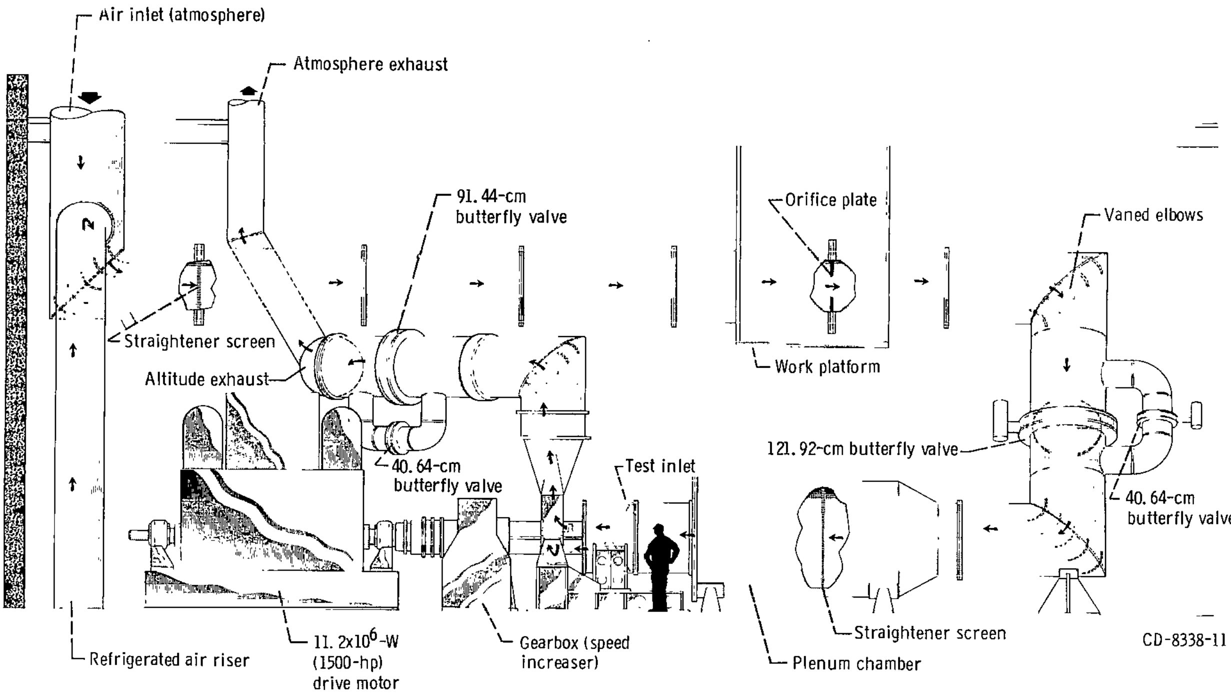
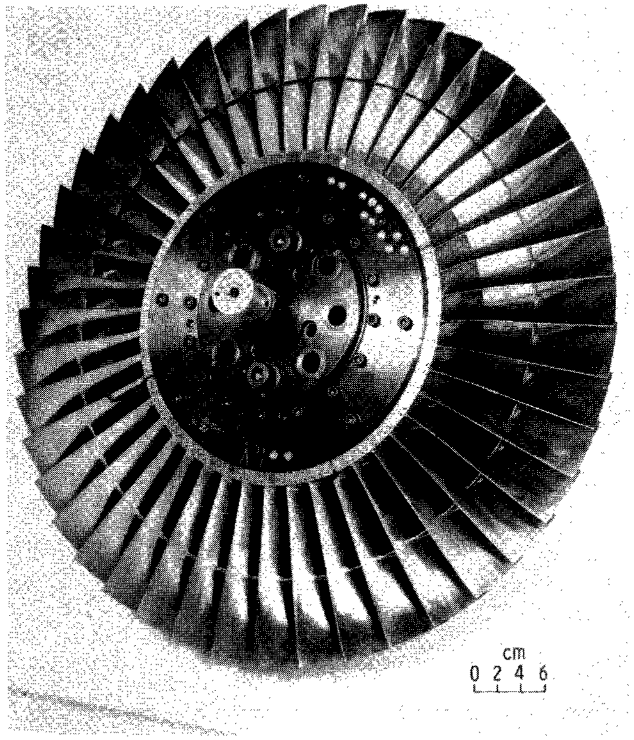
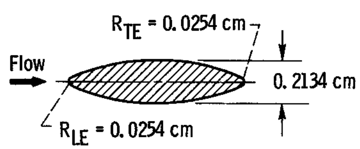


Figure 2. - Compressor test facility.



(a) Rotor 21.



(b) Rotor damper.

Figure 3. - Rotor 21 and damper cross section.

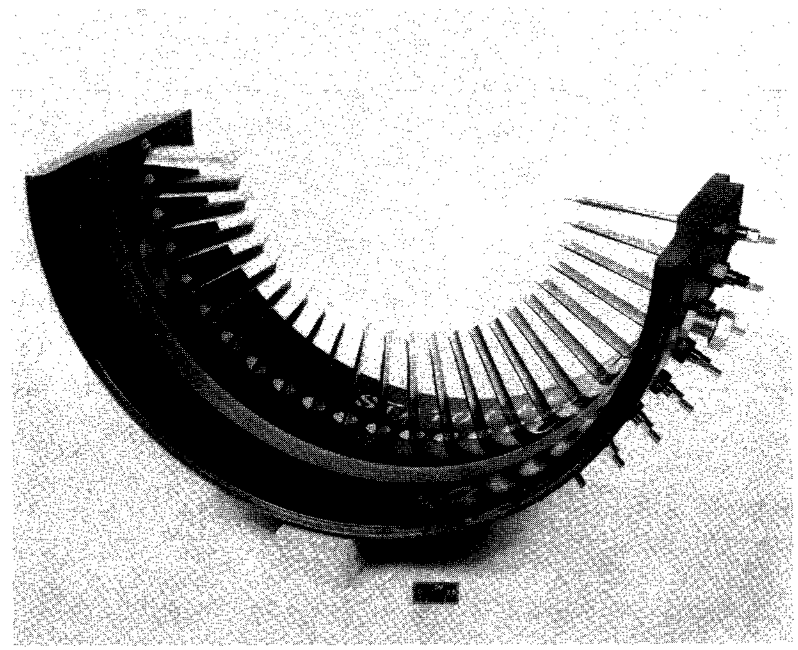
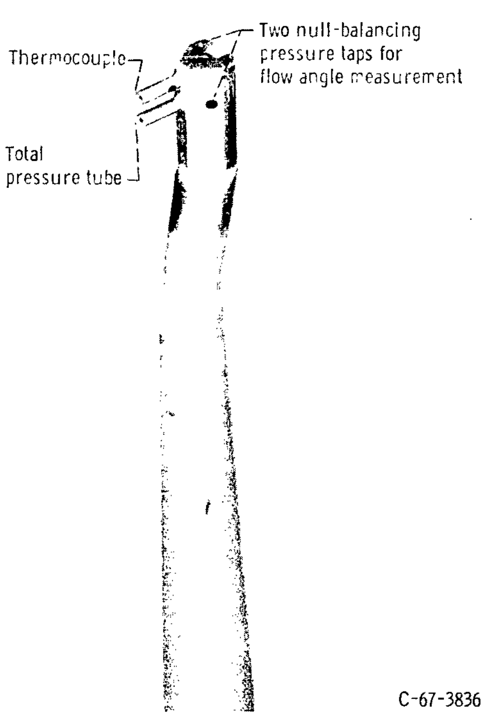
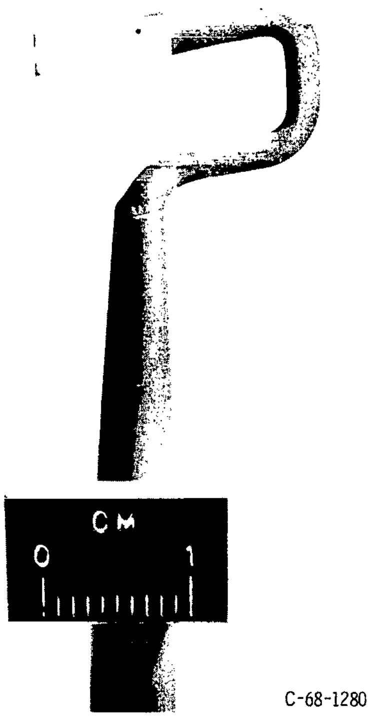


Figure 4. - Stator 18.



(a) Combination total pressure, total temperature, and flow angle probe (double barrel probe).



(b) Static pressure probe (8^0 wedge).

Figure 5. - Sensing probes.

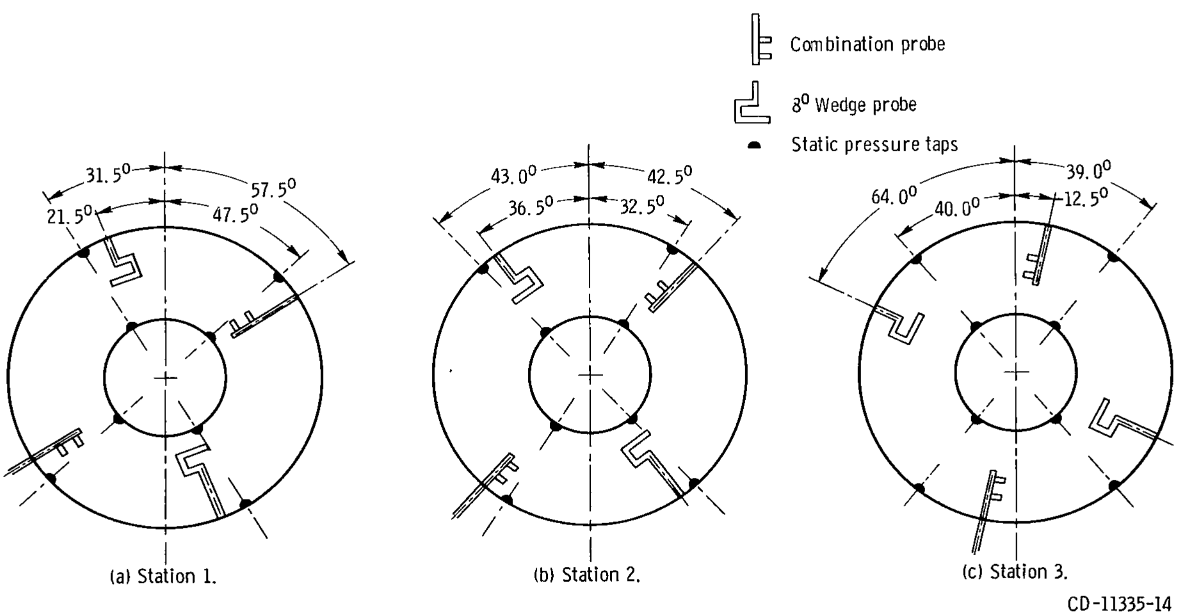


Figure 6. - Circumferential location of instrumentation at measuring stations - facing downstream.

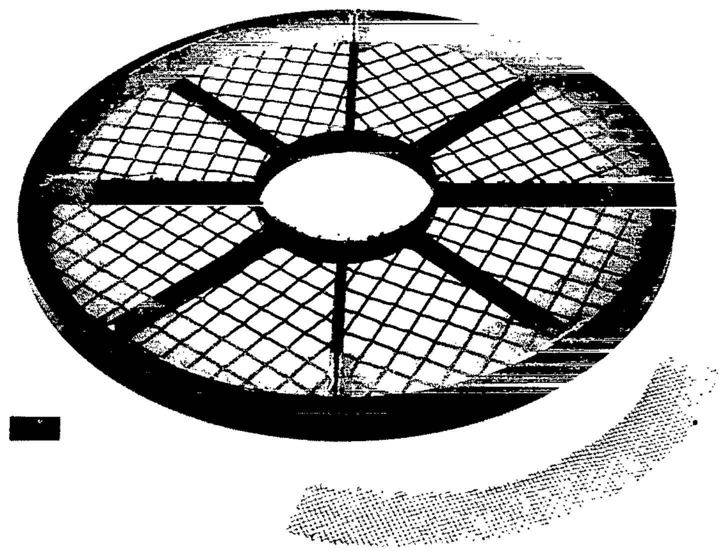


Figure 7. - Backup screen and distortion screens.

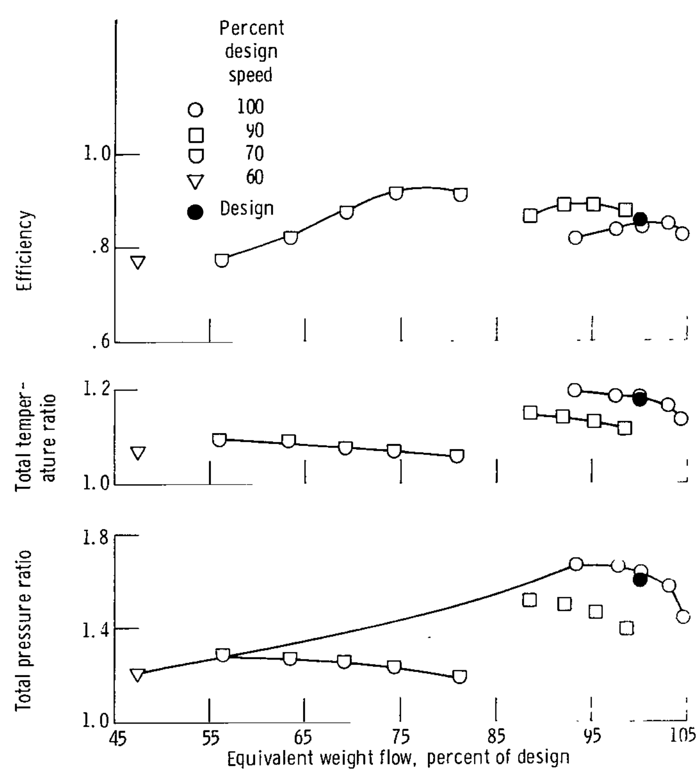


Figure 8. - Overall performance for rotor 21. Clean inlet flow.

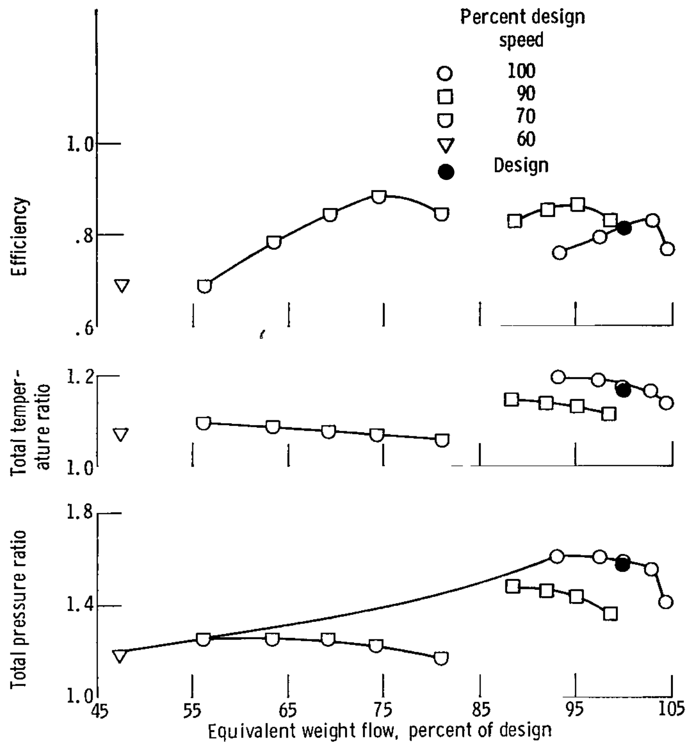
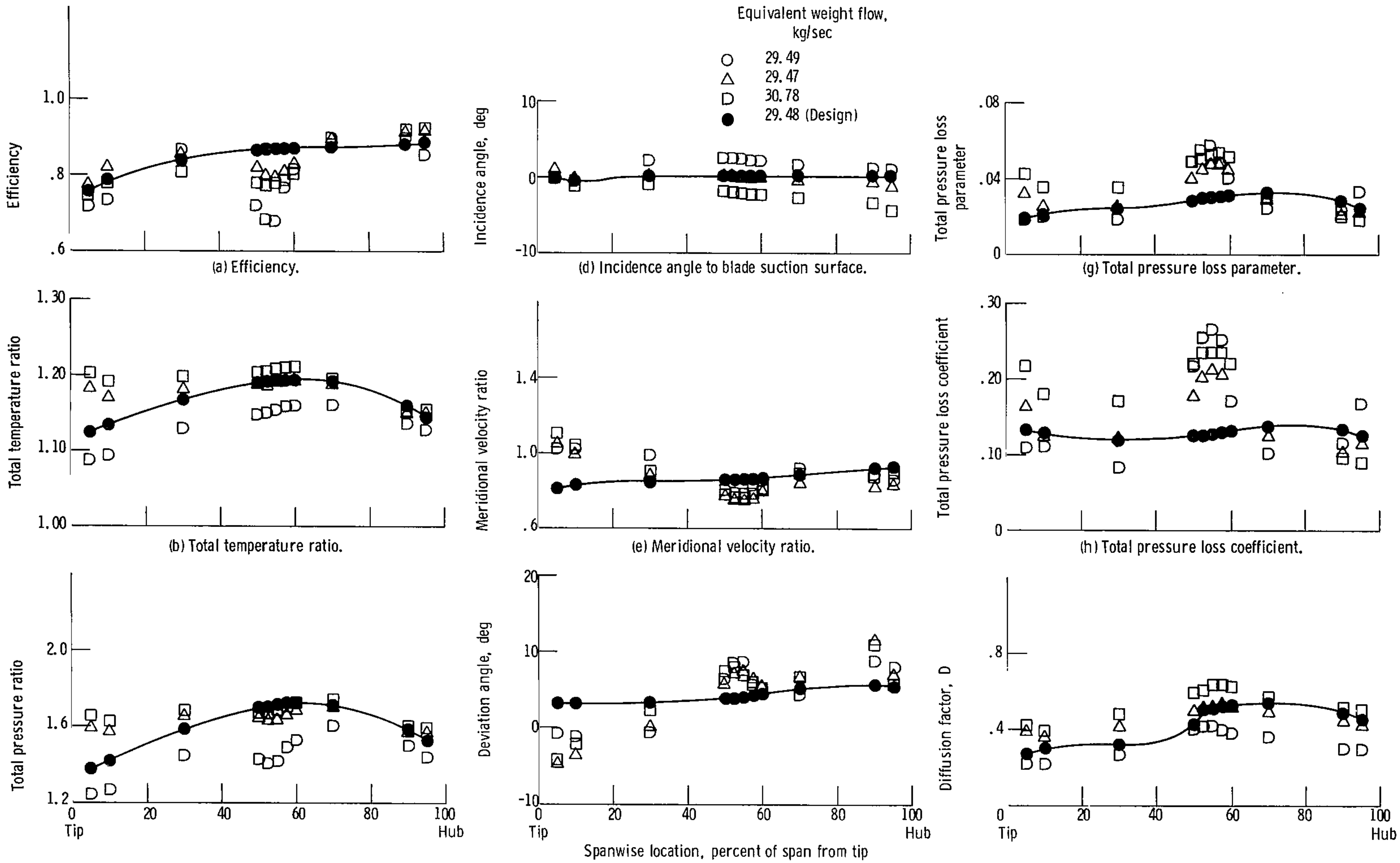


Figure 9. - Overall performance for stage 21-18. Clean inlet flow.



(a) Efficiency.

(d) Incidence angle to blade suction surface.

(g) Total pressure loss parameter.

(b) Total temperature ratio.

(e) Meridional velocity ratio.

(h) Total pressure loss coefficient.

(c) Total pressure ratio.

(f) Deviation angle.

(i) Diffusion factor.

Figure 10. - Radial distribution of rotor 21 performance for 100 percent design speed. Clean inlet flow.

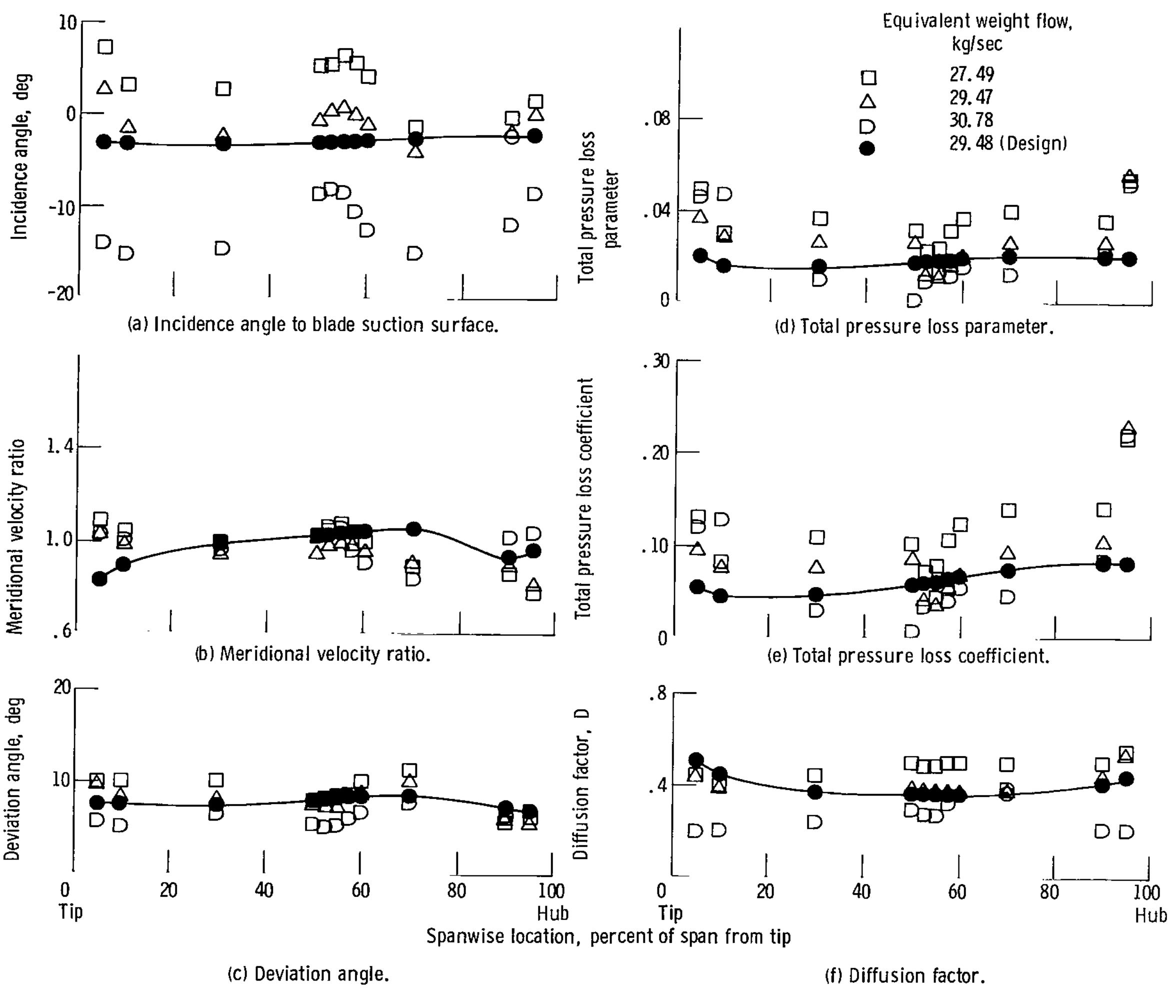
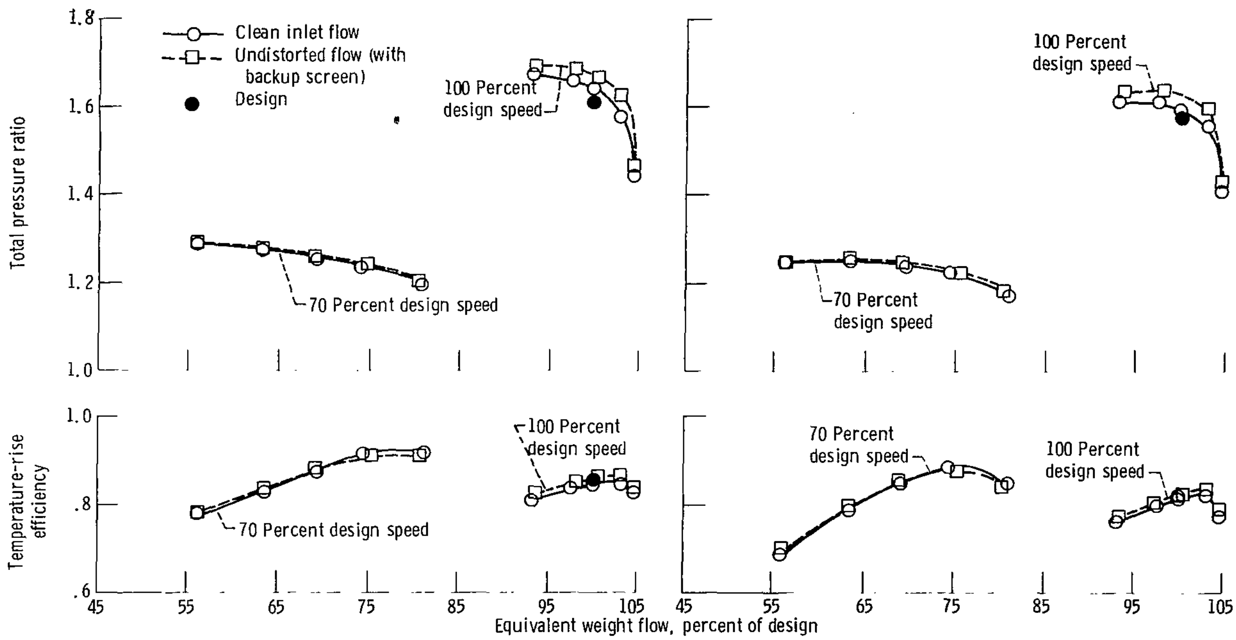


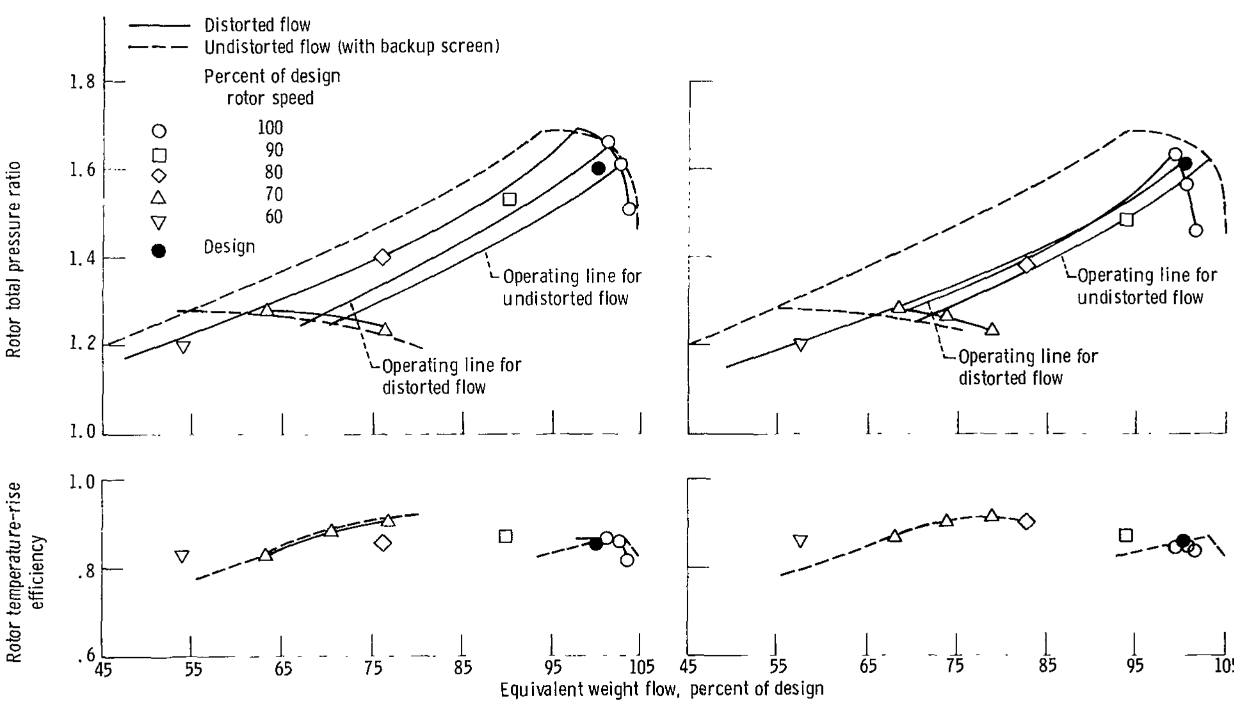
Figure 11. - Radial distribution of stator performance for 100 percent design speed. Clean inlet flow.



(a) Rotor 21.

(b) Stage.

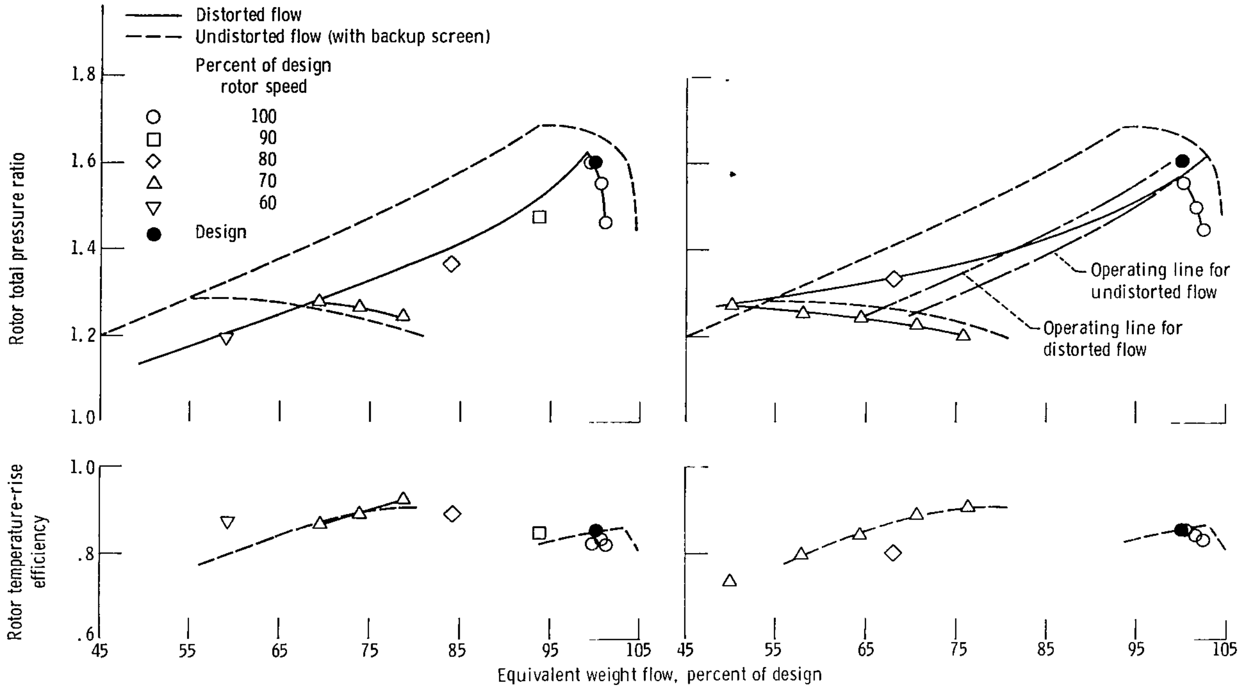
Figure 12. - Effect of backup screen on clean inlet overall performance.



(a) Tip distortion, 0.127.

(b) Tip distortion, 0.164.

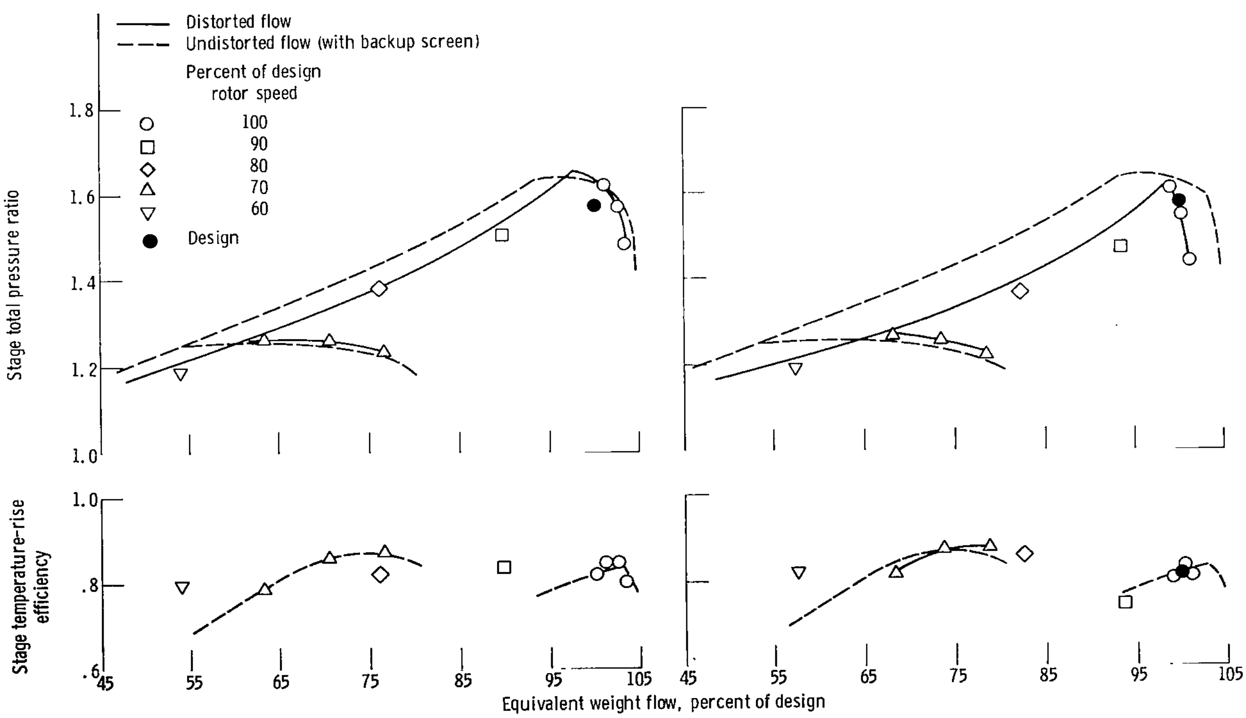
Figure 13. - Effect of radial distortion on overall rotor performance.



(c) Tip distortion, 0.189.

(d) Hub distortion, 0.133.

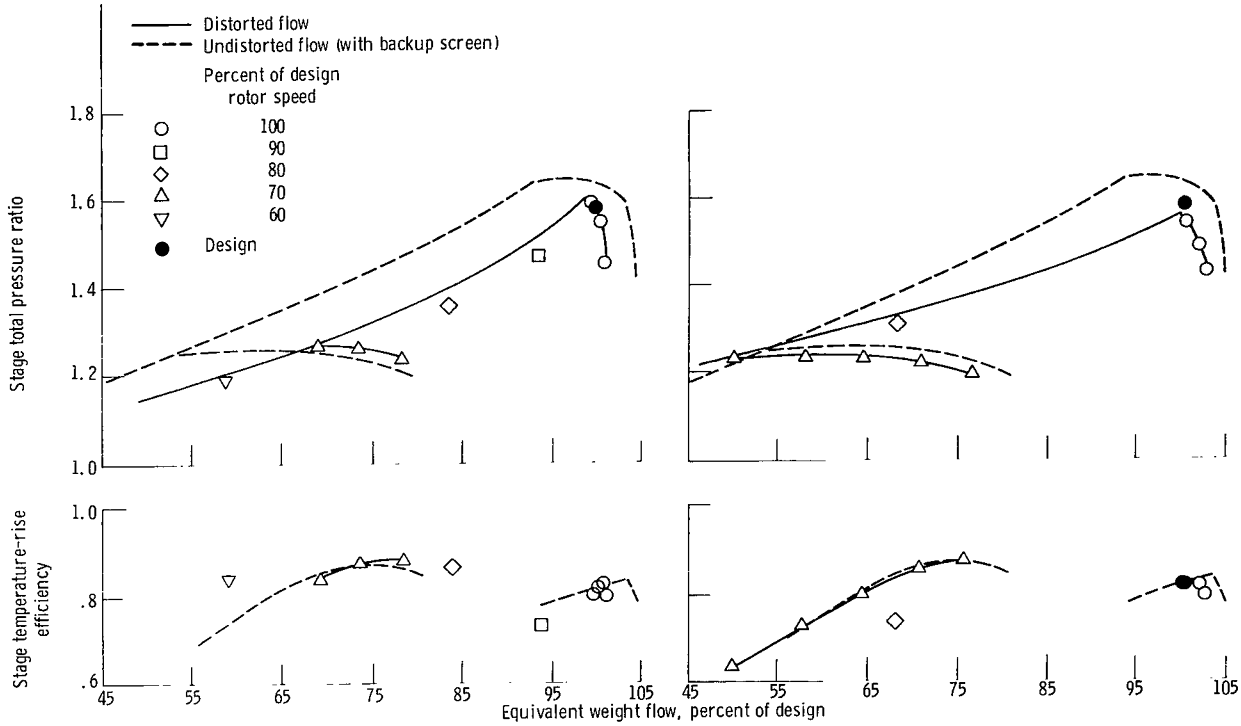
Figure 13. - Concluded.



(a) Tip distortion, 0.127.

(b) Tip distortion, 0.164.

Figure 14. - Effect of radial distortion on overall stage performance.



(c) Tip distortion, 0.189.

(d) Hub distortion, 0.133.

Figure 14. - Concluded.

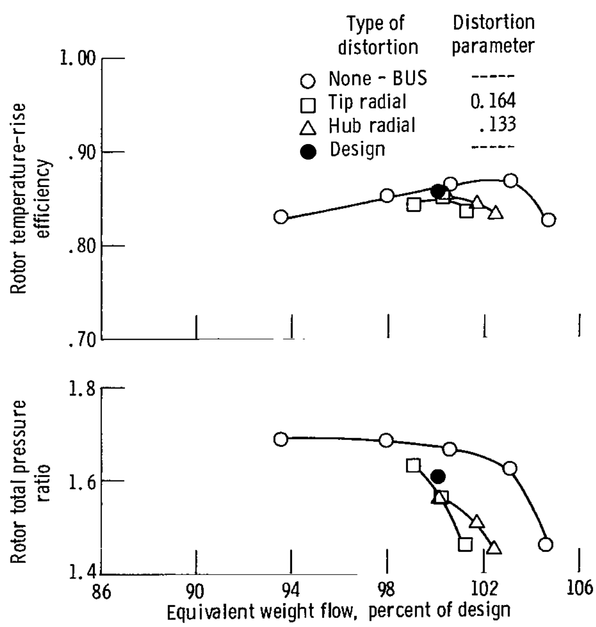


Figure 15. - Comparison of overall rotor performance with and without distortion (design speed).

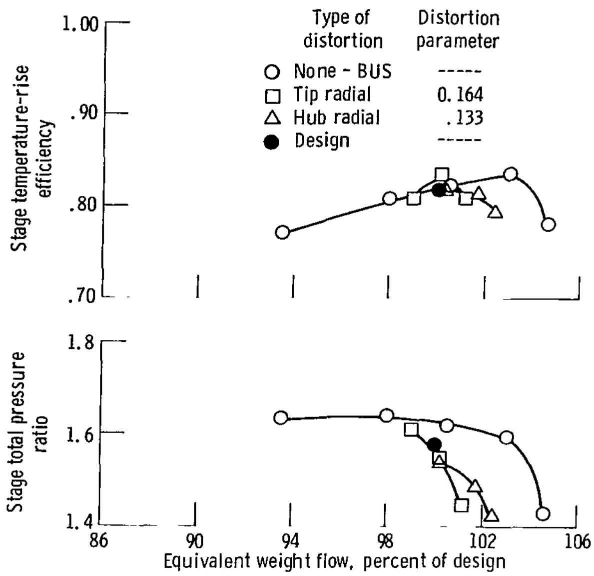


Figure 16. - Comparison of overall stage performance with and without distortion (design speed).

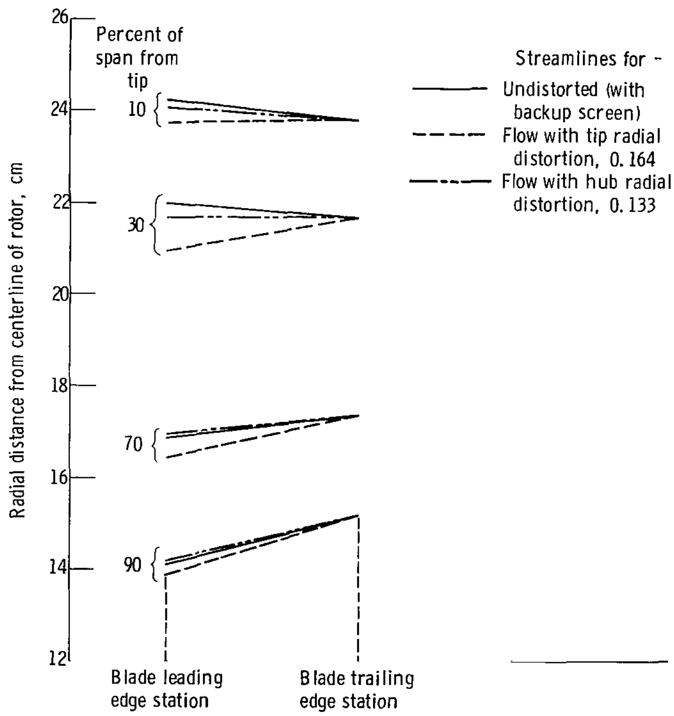


Figure 17. - Spanwise location of streamlines entering and leaving rotor blade row with and without distortion at same weight flow and at design speed.

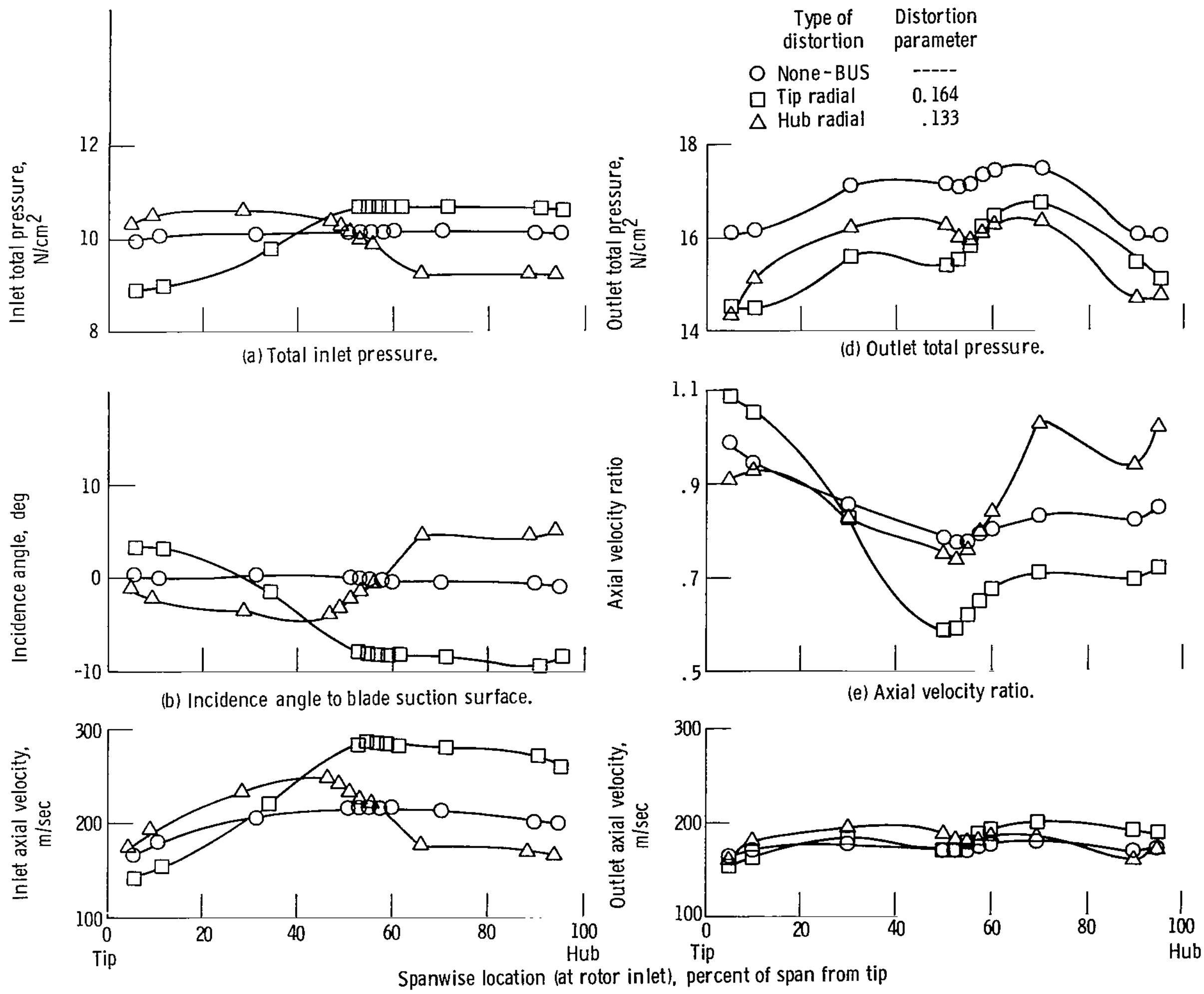


Figure 18. - Radial distributions of rotor blade - element parameters (using actual streamlines) at same flow with and without distortion (design speed). Corrected weight flow, $(W\sqrt{\theta}/\delta)/(W\sqrt{\theta}/\delta)_{des}$, 1.005.

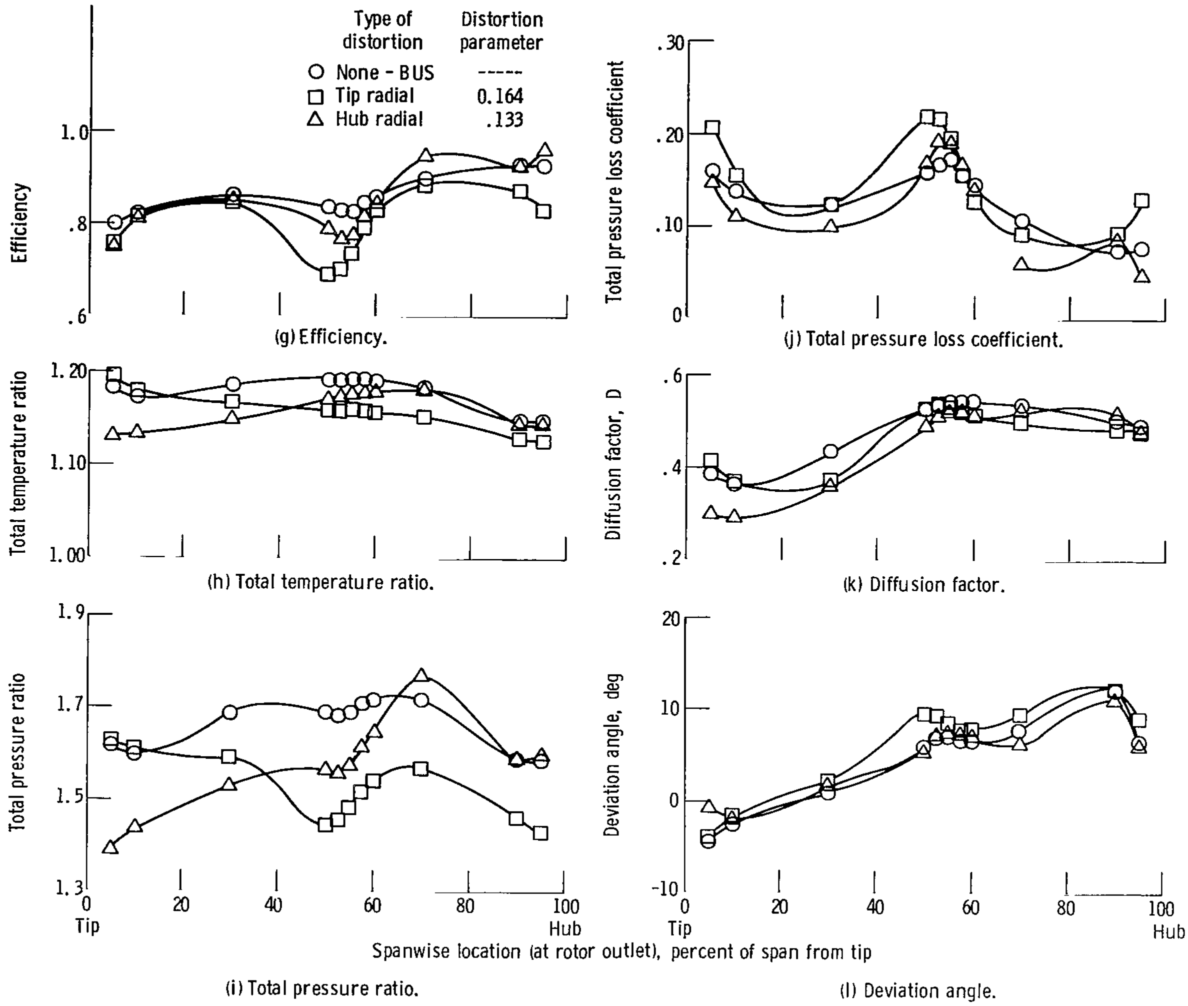


Figure 18. - Concluded.

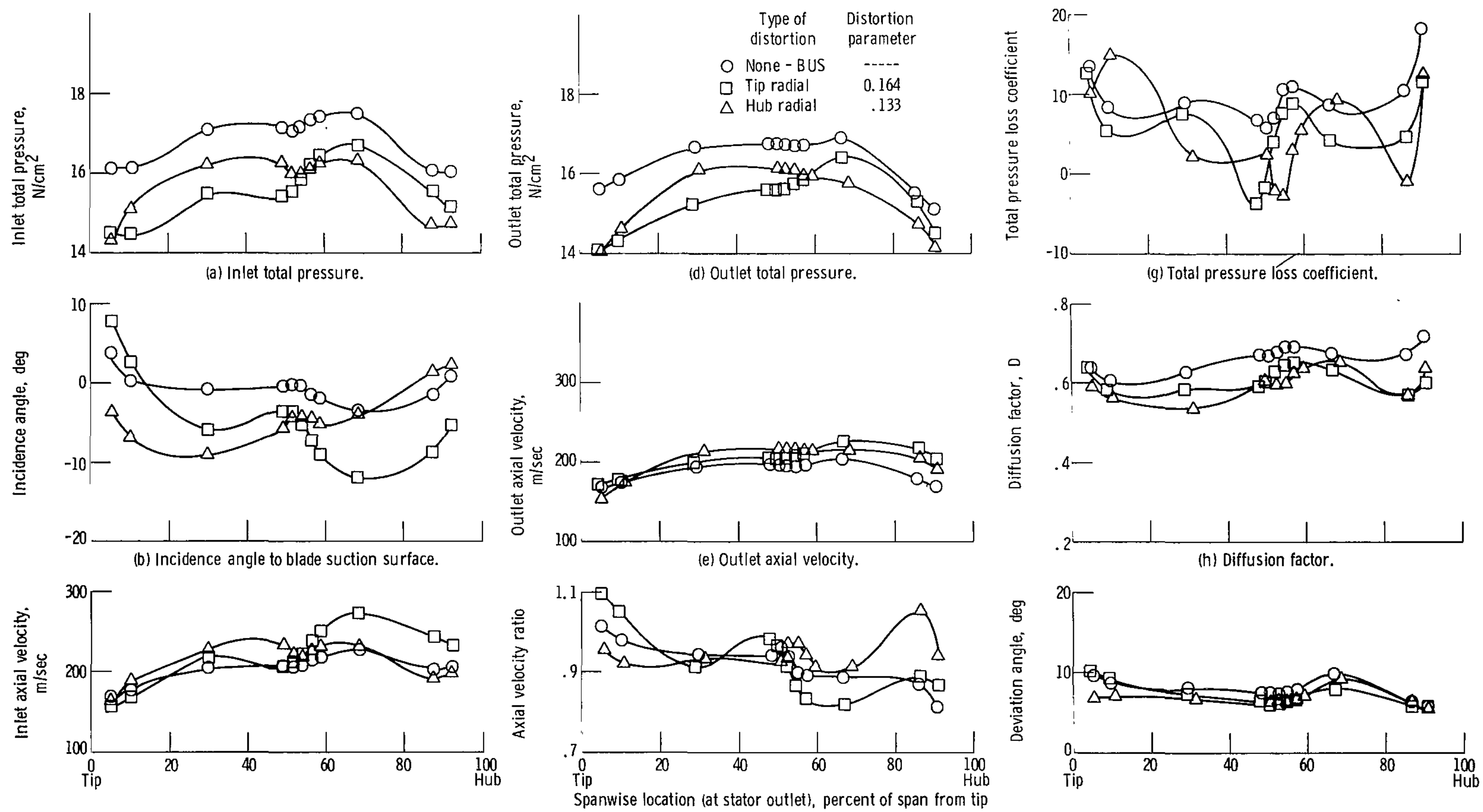


Figure 19. - Radial distributions of stator blade element parameters (using actual streamlines) at same flow with and without distortion (design speed). Corrected weight flow, $(W\sqrt{\theta}/\delta)/(W\sqrt{\theta}/\delta)_{des}$, 1.005.

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16. Abstract

A transonic compressor stage designed for a reduced loading in the tip region of the rotor blades was tested with and without inlet radial distortion. The rotor was 50 cm in diameter and designed for an operating tip speed of 420 m/sec. Although the rotor blade loading in the tip region was reduced to provide additional operating range, analysis of the data indicates that the flow around the damper appears to be critical and limited the stable operating range of this stage. For all levels of tip and hub radial distortion, there was a large reduction in the rotor stall margin.

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