NASA TECHNICAL NOTE

NASA TN D-8121

NASA TN D-8121

INLET NOISE OF 0.5-METER-DIAMETER NASA QF-1 FAN AS MEASURED IN AN UNMODIFIED COMPRESSOR AERODYNAMIC TEST FACILITY AND IN AN ANECHOIC CHAMBER

Thomas F. Gelder and Richard F. Soltis

Lewis Research Center

Cleveland, Ohio 44135

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION • WASHINGTON, D. C. • DECEMBER 1975

1. Report No. NASA TN D-8121	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle INLET NOISE OF 0.5-METER-DIAMETER NASA QF-1 FAN AS MEASURED IN AN UNMODIFIED COMPRESSOR AERODYNAMIC TEST FACILITY AND IN AN ANECHOIC CHAMBER		5. Report Date December 1975
		6. Performing Organization Code
7. Author(s) Thomas F. Gelder and Richard F. Soltis		8. Performing Organization Report No. E-8201
		10. Work Unit No. 505-04
9. Performing Organization Name and Address Lewis Research Center National Aeronautics and Space Administration Cleveland, Ohio 44135		11. Contract or Grant No.
		13. Type of Report and Period Covered Technical Note
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

Narrowband analyses revealed grossly similar sound pressure level spectra in each facility. Blade passing frequency (BPF) noise and multiple pure tone (MPT) noise were superimposed on a broadband (BB) base noise. From one-third octave bandwidth sound power analyses the BPF noise (harmonics combined), and the MPT noise (harmonics combined, excepting BPF's) agreed between facilities within 1.5 dB or less over the range of speeds and flows tested. Detailed noise and aerodynamic performance is also presented.

17. Key Words (Suggested by Author(s)) Low speed fan noise; Compressor noise; Low speed fan aero		18. Distribution Statement Unclassified - unlimited STAR Category 71 (rev.)	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 98	22. Price* $4.75

* For sale by the National Technical Information Service, Springfield, Virginia 22161

CONTENTS

INLET NOISE OF 0.5-METER-DIAMETER NASA QF-1 FAN AS MEASURED IN AN UNMODIFIED COMPRESSOR AERODYNAMIC TEST FACILITY AND IN AN ANECHOIC CHAMBER

by Thomas F. Gelder and Richard F. Soltis

Lewis Research Center

SUMMARY

The inlet noise from a 0.271-scale model (0.5-m or 20-in. diameter) of the NASA QF-1 fan was determined from measurements in the reverberant plenum chamber of an unmodified (i.e., no acoustic treatment) compressor aerodynamic test facility and from measurements in an anechoic chamber. These noise results are presented along with detailed aerodynamic performance recently published. Narrowband (50-Hz) noise analyses revealed grossly similar sound pressure level spectra in each facility. Blade passing frequency (BPF) noise and, at the higher tip speeds, multiple pure tone (MPT) noise were superimposed on a broadband (BB) base noise. Sound power levels were determined from one-third octave bandwidth analyses. On that basis the BPF noise (harmonics combined) and the MPT noise (harmonics combined, excepting BPF's) agreed between facilities within 1.5 dB or less over the range of speeds and flows tested. Trends in the total broadband noise with changes in speed and flow were similar in each facility but comparisons of the absolute power levels are questionable because of differing frequency spectra and maximum frequency limits analyzed.

The satisfactory determination of one-third octave based inlet tone power levels in the same installation and time period that the detailed aerodynamic performance is obtained allows early screening of designs. And coupled with narrowband spectra that are representative of free and far field spectra it also offers the potential for cause and effect relationships between aerodynamic and noise performance.

In the anechoic chamber the BPF noise was highest near peak efficiency operation. It propagated at all speeds despite a design to cut it off at low speeds and despite inlet flow with low free stream turbulence intensity and flow distortion. The MPT noise was only significant at 100 percent design speed where it dominated the spectrum. The broadband noise increased about 6 dB from 60 to 80 percent design speed then decreased about 1 dB from 80 to 90 percent speed, all on a calculated operating line passing through the design point.

INTRODUCTION

Facilities utilized to determine the detailed aerodynamic performance of a fan or compressor are generally unsuitable for free and far field noise measurements. The test package is usually installed between an upstream plenum chamber and a downstream collector and exhaust system which have hard, noise reflecting walls throughout. However, it has been demonstrated (ref. 1) that the usual noise components of blade passing frequency tones, multiple pure tones, and broadband noise can be identified and sound power levels determined from noise measurements in the reverberant field environment of the inlet plenum chamber of an unmodified (i.e., no acoustic treatment) compressor aerodynamic test facility. These data contained no directivity information, no downstream or exit noise measurements, and were for rotors with blade passing frequencies at design speed of at least 10 kilohertz which eliminated any significant standing wave problems.

There is a real incentive to obtain meaningful noise data in the same installation and time period that the detailed aerodynamic data are obtained. Early screening of designs and the potential for cause and effect relationships between the aerodynamic and noise performance is thereby possible.

A 0.271-scale model (0.5-m or 20-in. diameter) of the NASA QF-1 fan has been tested for noise and aerodynamic performance in an unmodified compressor test facility. The detailed aerodynamic performance has been recently reported (ref. 2). In addition, the same QF-1 scale model, renamed stage 15-9 (rotor 15 - stator 9) for convenient reference, was recently tested for inlet noise in an anechoic chamber. This anechoic chamber is a new facility which belongs to the General Electric Co. It was designed and developed by them and is located at their Corporate Research and Development Center, Schenectady, New York. The cooperation of the General Electric Company and particularly that of C. T. Savell and R. J. Wells is gratefully acknowledged.

The purposes of this report are the following: (1) to compare the inlet sound pressure level spectra and the absolute sound power levels in each noise component as determined in an unmodified compressor aerodynamic test facility with that determined in an anechoic chamber and thereby establish the validity and limitations of the non-anechoic facility and (2) to document the inlet acoustic performance of a 0.271-scale model of NASA QF-1 fan over a wide range of speeds and flows for which detailed aerodynamic data are also available.

The design tip speed of the NASA QF-1 fan is 337 meters per second (1107 ft/sec) and design total pressure ratio is 1.50. The fan was tested over a range of speeds from 50 to 100 percent of design and weight flows between near choke and near stall. One-third octave bandwidth sound power spectra for all test conditions and narrowband (50-Hz) sound pressure spectra for selected conditions are presented.

All symbols and equations are defined in appendixes A and B, respectively. Abbreviations and units for the tabular data are defined in appendix C.

APPARATUS

Test Stage Design

The overall aerodynamic design parameters for stage 15-9 are listed in table I. Design total pressure ratio, efficiency, and weight flow per unit annulus area were 1.499, 0.848, and 201.8 kilograms per second per square meter (41.3 lb/(sec)(ft^2)), respectively, at a tip speed of 337 meters per second (1107 ft/sec). There were 53 rotor blades and 112 stator blades spaced 3.5 rotor chords downstream of the rotor trailing edge. The flow path through the blading and aerodynamic instrumentation stations are shown in figure 1. A view of the stage with outer casing removed is shown in figure 2.

The blade element design parameters for rotor 15 and stator 9 are presented in tables II and III, respectively. The blade geometry is presented in table IV for the rotor and in table V for the stator. Both rotor and stator used multiple circular arc blade shapes. Further details of the aerodynamic and mechanical designs appear in reference 2. Stage 15-9 is a 0.271-scale model (0.5-m or 20-in. diameter) of the NASA QF-1 fan (refs. 3 and 4).

Test Facilities

Compressor aerodynamic test facility and instrumentation. - The compressor test facility has been previously described (e.g., refs. 2 and 5), but pertinent features are repeated here for convenience. An overall schematic view is shown in figure 3(a) while rotor and microphone locations are detailed in figure 3(b). The drive system consists of a 3000-hp electric motor with a variable-frequency speed control. The drive motor is coupled to a 5.521-to-1 ratio speed-increaser gearbox that drives the test rotor.

Atmospheric air enters through a filter house (not shown) into a line on the roof of the building. The air passes successively through a flow measuring orifice, inlet throttle valves, two cascades of turning vanes which reverses the direction of flow, and then into the 183-centimeter- (72-in. -) diameter plenum chamber. As shown by figure 3(b), the air then enters a 122-centimeter- (48-in. -) diameter pipe leading to a bellmouth which then reduces the flow path to the 49.5-centimeter (19.49-in.) diameter of the rotor tip. Downstream of the stator, the air is turned into a toroid-shaped collector. A cylindrically shaped and translatable sleeve valve at the collector entrance was used exclusively to throttle the airflow for the present tests. The air is finally exhausted to either a low- or high-vacuum receiver, as required.

The walls of the plenum chamber and all piping to and from it are rolled steel plate about 1.3 cm (1/2 in.) thick with no acoustic treatment. The volume of the chamber between the rotor and the turning vanes in the first 90° bend upstream is about 13.3 cubic meters (470 ft^3). The corresponding wall surface area is about 36 square meters (388 ft^2).

Hereafter, noise data from the microphone locations of figure 3(b) are referred to as those from the plenum chamber.

The acoustic instrumentation was the same as that detailed in reference 1. A 0.64-centimeter- (1/4-in.-) diameter condenser-type microphone was positioned by remote control to two different radii in the plenum chamber in a plane 236 centimeters (93 in.) upstream of the rotor as shown in figure 3(b). A pistonphone-type microphone calibrator was routinely used. The microphone signal was recorded in the FM-mode at a tape speed of 19.05 centimeters per second ($7\frac{1}{2}$ in./sec) with a frequency capability to 25 kilohertz. Playback from the tape recorder was connected to either a continuous 50 hertz constant bandwidth wave analyzer geared to its graphic level recorder, or to a continuous one-third octave constant percentage bandwidth analyzer geared to its graphic level recorder.

The aerodynamic instrumentation is pictured in figure 4(a) and its location is given in figure 4(b). The wedge probes were used to determine static pressure and the combination probes were used to determine total pressure, total temperature, and flow angle. These probes were automatically alined with the direction of flow. Radial traverses of the flow were made at three axial stations labeled 1, 2a or 2b, and 3 in figure 1. Further downstream at station 4 were four fixed rakes for measuring total pressure. Each fixed rake contained five radially spaced tubes with equal circumferential spacing between rakes. Two combination probes and two 8° wedge probes (fig. 4) were radially traversed at each of the stations 1 to 3. The combination probes at station 3 were also circumferentially traversed across one stator blade gap (3.2°) from the nominal values shown in figure 4(b). Calibrated transducers were used to measure all pressures. The total pressures at station 4 were used to monitor online overall performance. The traversable probes at station 1 to 3 were used for more accurate determination of overall performance and for the blade element performance. The data were recorded by a central data recording system.

Anechoic chamber test facility and instrumentation. - A three view schematic of the General Electric Company's anechoic chamber is shown in figure 5. The structural enclosure of the chamber is approximately 10.4 meters (34 ft) wide, 7.2 meters (23.5 ft) long, and 4.1 meters (13.5 ft) high. All enclosing surfaces are covered with an array of polyurethane foam wedges about 0.7 meter (2.3 ft) long. A photograph of the anechoic chamber taken from the air intake opening is shown in figure 6. The anechoic chamber was designed to test fans in both intake and exhaust modes. In the intake mode the test fan is mounted so that air flows into the anechoic chamber and out through the muffler and inlet noise may be measured. In the exhaust mode the test fan and airflow are reversed and exhaust noise may be measured. For the present tests only the intake mode was used. All the anechoic chamber walls were made porous by leaving small spaces between the foam wedges. By distributing the intake air with ducting to all the porous walls, spherical sink-type flow was simulated in the intake mode of operation. This was to minimize inlet flow distortion and turbulence level.

Test fans in the anechoic chamber are driven by a constant speed motor of 2500 hp. A gearbox for speeds to 19 000 rpm was used for stage 15-9. The airflow was throttled about 43 meters (141 ft) downstream of the fan (fig. 5), and a muffler was installed about 2 meters (6.5 ft) upstream of this throttle. A flow measuring orifice was 7.6 meters (25 ft) upstream of the muffler.

Acoustic calibration tests of the chamber utilized a horn driver with pure tone inputs. Microphone traverses were made from about 1 to 6 meters (3 to 20 ft) along different azimuthal rays emanating from the fan inlet location. Results of these tests indicated a standing wave ratio of ±1 dB or less for frequencies from about 400 to 40 000 hertz and for azimuthal angles from 0° to 90°. Fan far field noise measurements were made at a fixed radius of 5.18 meters (17 ft) (~7 bellmouth diameters) at driveshaft height and for azimuthal angles from 0° to 120°.

The acoustic instrumentation utilized in the anechoic chamber consisted of the following: Thirteen 0.64-centimeter- (1/4-in. -) diameter condenser-type microphones and pistonphone-type microphone calibrator. The acoustic data were recorded in the FM-mode at 152.4 centimeters per second (60 in./sec). The tape recorder was calibrated over the frequency range from 0 to 80 kilohertz. Only above 40 kilohertz were significant corrections to the data necessary and these have been incorporated in the data presented. These data were all processed by a one-third octave bandwidth analyzer with digital output. Selected data were further reduced by a 50 hertz constant bandwidth analyzer and corresponding graphic level recorder. Computers were utilized to process the digital one-third octave data into various standardized formats and also to calculate the sound power levels from the sound pressure levels measured by the azimuthal array of 13 inlet microphones.

The aerodynamic instrumentation in the anechoic chamber was minimal. It consisted of two five-element total pressure rakes at station 4 (fig. 1). These were two of the four rakes utilized in the compressor aerodynamic test facility to monitor overall performance. Only two rakes, 180° apart, were used in the anechoic chamber due to limitations in available data channels. Inlet total pressure was taken equal to anechoic chamber static pressure. Mass flow was measured by a 55.9-centimeter- (22-in. -) diameter orifice. Inlet mean velocity and turbulence intensity were measured by a radially traversable single-wire hot film probe in a plane 26.8 centimeters (10.6 in.)

upstream of the rotor (fig. 7). Four circumferential locations, 90° apart were surveyed with the hot film. The fluctuating velocity was measured by a true rms meter. All hot film data were recorded on tape for later processing.

Comparison of fan inlet configurations. - Above the fan centerline in figure 7 is shown the anechoic chamber inlet and below the fan centerline is shown the unmodified compressor test facility inlet. A nearly spherical screen encloses the well rounded bellmouth in the anechoic chamber for most of the tests. The purpose of the screen was to homogenize the inflow to the fan and thus produce lower turbulence intensity levels. There is a flat screen in the plenum chamber of the other facility (figs. 7 and 3(b)). The screens for each facility utilized different wire and mesh sizes but the ratio of screen distance from rotor to mesh size was comparable. The unmodified compressor facility also utilizes four support struts in a relatively low velocity section about 60 centimeters (23.6 in.) upstream of the rotor. These struts are equally spaced, airfoil shaped, and have maximum thickness to chord ratio of about 23 percent. The contour of the case between the support struts and the rotor was designed to minimize boundary layer growth and prevent separation. The centerbody in the compressor test facility was fixed and longer than the rotating spinner utilized in the anechoic chamber.

PROCEDURES

Test

In both facilities the fan was tested over a range of speeds from 50 to 100 percent of design and weight flows between near choke and near stall. Fan rotative speed and temperatures were allowed to stabilize before any aerodynamic or acoustic measurements were made. Downstream throttle valves were then adjusted to the several desired weight flows. In the unmodified compressor test facility the aerodynamic data at stations 1 to 3 (fig. 1) were obtained at nine radial positions for each speed and weight flow tested. All the aerodynamic performance data presented herein are from mass weighted integrations of the traverse data taken in the non-anechoic facility. The anechoic chamber aerodynamic performance was related to this traverse data performance through the common rake measurements at station 4 and the respective flow measurements.

Hot film measurements in the anechoic chamber were recorded for 2 minutes at each location. Corrections for any temperature and pressure changes during testing were made from manufacturers' calibrations.

All 13-arc microphones in the anechoic chamber were calibrated with a pistonphone before and after each test. If these levels differed for any microphone, its average level was used to reduce the data from that microphone. Frequency response of the acoustic data acquisition system was calibrated by inserting constant amplitude sine waves at each one-third octave center frequency. Anechoic chamber acoustic data from all microphones were recorded simultaneously for at least 1 minute at each operating point. No inlet probes (hot film) were in place during acoustic tests.

The plenum chamber microphone was calibrated with a pistonphone before each test. About 2 minutes of data at each operating point and for each of two radial positions (fig. 3(b)) were recorded.

Prior to taking noise data in the plenum chamber, all the aerodynamic probes at stations 1 to 4 were withdrawn from the flow path and the holes in the outer case smoothly plugged. Aerodynamic probes in the flow path can create extraneous noise sources as demonstrated in reference 1. Except for adding a microphone in the plenum chamber and the removal of all aerodynamic probes (except for a single pitot tube at station 4 for monitoring purposes), the compressor test facility was not otherwise modified for the present noise tests.

Noise Data Reduction

General. - Sound power levels (PWL) rather than sound pressure levels (SPL) must be utilized for absolute value comparisons of stage 15-9 inlet noise determined in the anechoic chamber with those determined in the reverberant environment of the untreated plenum chamber in the compressor test facility. Inlet noise directivity is measured in the anechoic chamber but cannot be measured in the plenum chamber. In the latter a diffuse sound field exists (ref. 1). Thus a different calculation for inlet PWL from the measured SPL values will be described for each facility.

Fan noise is usually subdivided into the following three components (refs. 6 and 7): (1) the fundamental blade passing frequency (1×BPF) and its harmonics (2×BPF, etc.), (2) multiple pure tones (MPT), and (3) broadband (BB). One-third octave bandwidth analysis is most commonly used to display the spectra of fan noise and determine its noise components. However, MPT noise is generally not obvious from one-third octave bandwidth spectra alone. Significant MPT noise is usually associated with rotor blade relative Mach numbers that are supersonic. These MPT occur at harmonics of rotor speed frequency (rotor RPM/60, Hz) which usually cannot be identified without narrow (~50-Hz), constant bandwidth analysis. These narrowband analyses provide a continuous trace of the sound pressure level with frequency as measured at a particular microphone location. Such narrowband traces are rarely used to calculate a sound power level which would require a large amount of detailed interpretation and calculation.

A typical compromise in reducing fan noise data (refs. 4 and 8) is to process all of the data by one-third octave bandwidth SPL and PWL analyses. Then data from selected microphone locations are further reduced by narrowband analysis to continuous SPL against frequency traces. The narrowband results are then used to guide the interpretation of the one-third octave bandwidth SPL and PWL spectra. Such a procedure was adopted for reducing the noise data from both the anechoic chamber and the plenum chamber as illustrated next.

Anechoic chamber. - Sample narrowband and one-third octave bandwidth noise spectra are shown in figure 8 for a speed high enough to generate all three noise components - BPF, MPT, and BB. In figures 8(a) and (b), the SPL from the 60° microphone are shown. But in figure 8(c), the inlet PWL based on all microphones is presented for one-third octave bandwidths. These PWL were obtained by assuming symmetry above and below the plane of the microphones (fig. 5) and integrating the SPL over the nearly hemispherical surface that could be generated by rotating the arc of 13 microphones through 180°. (The SPL from the 100° to 120° microphones was included in the PWL calculation but that sector had an insignificant influence on the overall level from 0° to 90°, the hemisphere of interest herein.)

In figure 8(a) the 50-hertz analysis extends from 0 to 25 kilohertz and the 1×BPF tone is clearly shown by the peak in SPL at about 11.6-kilohertz. The MPT noise is at integral multiples of rotor speed frequency of 219 hertz and is most significant at frequencies below 1×BPF. Peak MPT values are higher than values of 1×BPF and appear between 4 and 8 kilohertz. In figure 8(b) the one-third octave SPL analysis of the same data also shows a significant peak in the 4- to 8-kilohertz range. With the previous narrowband detail (fig. 8(a)) this hump in the one-third octave band data (fig. 8(b)) can be identified as MPT noise. Similarly, in the PWL spectrum from all inlet microphones (fig. 8(c)) the powerpeak in the 4- to 8-kilohertz range is attributed to MPT noise.

The 1×BPF noise at 11.6 kilohertz (fig. 8(a)) is near the dividing frequency of 11.3 kilohertz which separates adjacent one-third octave bands (indicated along abscissa of figs. 8(b) and (c)). To account for this adjacent band sharing or band splitting of the 1×BPF noise, the sound energy in the two bands is added. As will be evident in subsequent plots, when 1×BPF falls near the center frequency of the one-third octave band, band sharing does not occur. In the sample shown (fig. 8), 2×BPF noise is insignificant (at least 10 dB lower) relative to 1×BPF. At lower speeds it is not. For all speeds and weight flows, the 1×BPF and 2×BPF noise are added together in subsequent comparison plots of BPF noise from each facility.

A broadband noise base is indicated on all parts of figure 8. In figure 8(a) it is estimated to be along a line connecting the low points of the narrowband spectrum as shown. From this narrowband estimate a one-third octave bandwidth broadband level is calculated for figure 8(b) as indicated on the figure and discussed next.

A spectrum level (SL) for the broadband base is determined from the 50-hertz analysis at each one-third octave center frequency which are indicated along the abscissa of figure 8(a). The spectrum level, SL, is defined as the average sound pressure level of the broadband base in decibels referred to a 1-hertz-wide bandwidth. To each SL the corresponding one-third octave bandwidth, $(bw)_{1/3\ oct}$, allowance was added to yield the broadband SPL in that band (fig. 8(b)).

The indicated broadband base in the one-third octave PWL spectrum (fig. 8(c)) is obtained by joining the low points in the PWL spectrum underlying the BPF's and MPT's which have been previously identified in narrowband SPL analyses like figure 8(a). The reasonably close agreement of the broadband base levels between figures 8(b) and (c) supports this technique.

All levels above the calculated broadband base in figures 8(b) or (c) are interpreted as the total noise in either (MPT + BB) or (BPF + BB). The MPT or BPF noise is determined by decibel subtraction of the underlying BB energy contribution from the total SPL or PWL values at that frequency.

The tabulations on figure 8(c) show a sample breakdown of the noise components and the broadband corrections to the indicated tones. The total BB noise indicated in figure 8(c), 135.8 dB, resulted from adding the energy at the centerline frequencies of each one-third octave band between 100 and 80 000 hertz. Also tone indications, if any, below about 250 hertz were generally ignored because of poor narrowband resolution there and possible starting transient errors in the graphic level recorders.

Plenum chamber. - These noise data were reduced in a manner similar to the anechoic chamber data with the following exceptions: (1) the upper limit of frequency analysis was 20 kilohertz (instead of 80 kHz) because of tape recorder limitations, and (2) the calculation of PWL from SPL measurements was based on reverberant chamber relations (instead of free and far field integrations over a hemisphere) because of the diffuse sound field in the plenum. These relations are developed in reference 1 and result in the following equation:

$$PWL = SPL + 10 \log (v) - 10 \log (\tau) - 19\ dB \tag{1}$$

where PWL is in dB (referenced to 10^{-13} W), SPL is in dB (referenced to 0.0002 μbar), v is chamber volume in cubic feet (470 ft^3), and τ is reverberation time in seconds. The experimentally determined reverberation time is shown in figure 9(a) taken from reference 1. (The microphone locations in fig. 9(a) encompass those utilized in the present study (fig. 3(b)). Because reverberation time is a function of frequency and chamber volume is a known constant, the PWL-SPL relation can be plotted as shown in figure 9(b). Further details of this procedure are given in reference 1. An average SPL from the two radial positions in the plenum was utilized to calculate the one-third octave PWL spectra presented although such radial differences were usually within 1 dB for all conditions and center frequencies. Finally, separating out the MPT and BPF noise from the BB and adjusting the tone levels for the broadband contribution was exactly the same for the plenum chamber data as for the anechoic chamber data previously illustrated (fig. 8(c)).

RESULTS AND DISCUSSION

Aerodynamic as well as acoustic results are presented in this section. Some of the data are tabulated as well as plotted. The overall aerodynamic performance for eleven representative operating points with stage 15-9 are given in table VI. Blade element performance for these operating points is presented in table VII for the rotor and table VIII for the stator. These and other aerodynamic data for the stage can be found in reference 2 and are repeated here for convenience. Operating points for the acoustic data will be indicated. In general they are close to but not identical to those in table VI.

Acoustic data from each of the 13 microphones in the anechoic chamber reduced to one-third octave bandwidth spectra from 100 to 80 000 hertz and adjusted to standard day conditions at 30.48 meters (100 ft) are presented in table IX along with the acoustic power levels calculated from the microphone array. Subsequent plots will present all of the anechoic and plenum chamber results from one-third octave bandwidth analyses as well as narrowband (50-Hz) analyses for selected operating conditions and microphone locations.

Aerodynamic Performance

Overall pressure ratio and efficiency. - An overall performance map for stage 15-9 is presented in figure 10. The solid lines are fairings through the data of reference 2. Operating points for the acoustic data are indicated by arrowheads. At design speed and on an operating line calculated to pass through the design point with a fixed fan exhaust nozzle (see ref. 2), the stage pressure ratio, efficiency, and percent design weight flow were 1.475, 0.835, and 98.0, respectively; these compare favorably with design values of 1.499, 0.848, and 100.0 (table I). The near stall or near surge lines indicated are not much removed from the calculated operating line, particularly in the anechoic chamber installation. The near surge line in the anechoic chamber occurs at higher weight flows than in the compressor aerodynamic facility. This is believed related to the much larger volume between the stator trailing edge and the throttling valve in the anechoic facility (fig. 5) compared with the sleeve valve located in the collector inlet in the compressor test facility (fig. 3(a)). Also, the increased exit ducting and muffler in the anechoic chamber installation caused its minimum resistance line (wide open throttle) to occur at lower weight flows than that for the other facility. The combined result was a relatively narrow flow range of operation at a given speed in the anechoic chamber facility. Flow range was less than half that available in the compressor test facility. Power and vibration limits at design speed caused an additional restriction to the anechoic chamber operating range.

Rotor tip Mach number. - Speed is a primary variable in evaluating acoustic as well as aerodynamic performance. For convenient reference the Mach number relative to the rotor blade leading edge at 5 percent span from the tip, ($M'_{1,05}$), is presented in figure 11 for all conditions tested. These data along with loadings (diffusion factor D), loss coefficients, incidence angles, and so forth, are available at nine spanwise locations for both rotor and stator blades in tables VII and VIII, respectively.

Inlet flow mean velocity and turbulence intensity in anechoic chamber. - These data were obtained from radial surveys with a hot film at four equally spaced circumferential locations, 26.8 centimeters (10.6 in.) upstream of the rotor in the anechoic chamber installation both with and without the inlet turbulence screen as indicated in figure 7. Comparable data were not taken in the compressor test facility. Results of the hot film surveys are shown in figure 12. A circumferentially averaged mean velocity without the turbulence screen is presented in figure 12(a). Circumferential variations were less than ±2 percent (within accuracy of measurement) and nonsystematic. (Hot film calibration problems with the screen in place made that data unreliable thus it is not shown). As indicated by the radial profile of mean velocity, the boundary layer from the well-rounded bellmouth inlet did not extend beyond a radius ratio of about 0.98 at the measuring station. Also, the free stream average velocity of about 97.5 meters per second (320 ft/sec) (fig. 12(a)) agrees within a few percent of an average value that was calculated from the measured flow, the cross-sectional area in the hot wire plane, and the local density deduced from static conditions measured in the anechoic chamber.

Circumferentially averaged turbulence intensities with and without the screen in place are presented in figure 12(b). With screen, the midstream levels are quite low, about 0.0045. (Nonsystematic circumferential variations ranged from 0.0035 to 0.0055). Similar midstream levels have been measured in outdoor model tests. Turbulence intensities within the boundary layer were much higher than in midstream, ranging from 2 to over 6 percent. Tests without the inlet screen show an average midstream intensity level of about 0.007. (Midstream circumferential variations ranged from 0.0065 to 0.0085.) Also without the screen, the region of intense turbulence near the case wall was thickened. There were no measurable differences in overall pressure ratio or weight flow in the anechoic chamber with or without the turbulence screen. The effects of the screen on the acoustic results are discussed next.

Inlet Noise Performance

Effect of turbulence screen. - As shown by one-third octave band sound power spectra in figures 13(a) to (d) for speeds of 70 to 100 percent of design, respectively, the screen in the anechoic chamber reduced the high frequency broadband noise (above about 2×10^4 Hz) at all speeds by 3 to 5 dB. In general as speed was increased, the effectiveness of the screen spread to lower frequencies. Blade passing tone levels were generally affected less than 2 dB. At design speed (fig. 13(d)) the screen was not effective in reducing the multiple pure tone noise occurring in the frequency range from 4 to 8 kilohertz. Because the screen was found from calibrations not to have significantly altered the sound from a speaker source, and because the screen was located in a low velocity region, the broadband noise reduction is believed to be a result of a reduction in the noise source levels. As previously discussed, the screen reduced the inlet free-stream turbulence intensity and reduced the thickness of intense turbulence near the case wall.

The flat screen half way through the plenum chamber of the compressor test facility (fig. 3(b)) was not removed thus comparable data from that facility are not available.

As shown in figure 7, the distance between the screen and the rotor, divided by the mesh size (wire center to center distance) was about 960 for the anechoic chamber and about 850 for the compressor test facility with plenum chamber. Such large and comparable distance to mesh size ratios are an indication of comparable turbulence intensities at the rotor face (ref. 9). Thus the noise data from the two facilities, discussed next, is with their respective screens in place.

Typical noise spectra in each facility. - In the anechoic chamber the effect of speed on narrowband and on one-third octave band SPL from the 60° microphone is shown in figures 14 and 15, respectively. Comparable results from a microphone in the plenum chamber of the aerodynamic test facility are shown in figures 16 and 17. The 60° angle SPL was selected for comparison because it is generally at or near the peak azimuthal value for all operating conditions (see table IX) and is representative of the spectra which has the major influence on the inlet sound power.

The narrowband results from the anechoic chamber (fig. 14) show prominent 1×BPF tones at all speeds despite a design that should cut them off at low speeds (refs. 4 and 10). The MPT content increases as the speed is increased from 70 to 100 percent speed. High levels of MPT noise relative to the 1×BPF noise in the far field have been related to supersonic relative blade speeds (refs. 7 and 11). The blade relative Mach number (at 5 percent span from tip) at 100 percent design speed is about 1.15 and that at 70 percent speed is about 0.75 (see fig. 11). Also, figure 14 shows the 2×BPF tone decreasing relative to the 1×BPF level as speed is increased.

At 70 percent speed (fig. 14(c)), there is an extraneous tone near 2000 hertz, the source of which is unknown. Other fan designs tested in this anechoic chamber have not displayed such a tone. Also, at comparable speed and flow conditions, the same fan tested for noise in the compressor aerodynamic facility did not generate the stray tone (see fig. 16(c)). Fortunately the 2000-hertz tone is not a factor in evaluating the three noise components of interest.

Also at 70 percent speed in the anechoic chamber (fig. 14(c)) the 2×BPF and 3×BPF tones appear split into two discrete tones about 600 hertz (4 rev/sec) apart. This phenomena also did not appear in the narrowband analyses of the plenum chamber data (fig. 16(c)) nor at any of the higher speeds in either facility. Reasons for the split are unknown. However, it is not a factor in the one-third octave analyses (fig. 15(c)) where the wider bandwidths automatically combine the aforementioned tone splits.

Direct graphic comparison of the 50-hertz spectra from each facility (figs. 14 and 16) is a little difficult because of the different scales utilized by the different graphic level recorders. To eliminate that difficulty and also to illustrate that MPT's (including the BPF's) occur at multiples of the engine order E (rev/sec of the rotor shaft), figures 18 and 19 were constructed. Figure 18 is for 70 percent speed, and figure 19 is for 100 percent speed. Part (a) of each figure represents the anechoic chamber traces of figures 14 (a) and (c); part (b) represents the plenum chamber traces of figures 16(a) and (c). The peaks and valleys of each MPT, relative to the level of 1×BPF, were read from the graphic traces. The peaks were plotted at the appropriate engine orders and the valleys half way between. Straight lines were drawn between them. In regions without MPT clusters (mainly the 70 percent speed data) the SPL at each engine order was read from the respective analyzer traces then these levels were joined by straight lines. Exact correspondence of noise spectra from any single microphone in an anechoic chamber with that from any microphone in a reverberant chamber is of course not expected or even possible. However, there are enough similarities in the narrowband spectra between the plenum chamber data and the anechoic chamber data to make the former a helpful representation of the free and far field frequency content and of relative dB levels. For example, in either facility, the MPT's are similar in frequency content and in level (relative to 1×BPF) at 100 percent speed (fig. 19). At this speed the MPT's dominate the spectrum. Likewise in either facility the MPT's are equally insignificant at 70 percent speed (fig. 18).

With regard to 1×BPF at 70 percent speed, (fig. 18) similar patterns are evident in either facility although the tone is wider at the broadband base level in the plenum chamber. Also at 70 percent speed, the 2×BPF tone is lower relative to the 1×BPF tone in the plenum chamber than in the anechoic chamber. At 100 percent speed (fig. 19), the 1×BPF tone level is less above the broadband base in the plenum chamber data than in the anechoic chamber data.

There are gross similarities in the narrowband (50-Hz) spectra from each facility at comparable operating conditions. However, some of the finer details differ.

The one-third octave band results from either the anechoic chamber (fig. 15) or the plenum chamber (fig. 17) are much easier to interpret when their corresponding narrowband results (figs. 14 and 16, respectively) are available. The MPT noise at 100 percent design speed (figs. 15(a) or 17(a)) is mainly clustered in the one-third octave bands centered at 4, 5, 6.3, and 8 kHz. The 1×BPF noise at 100 percent speed is shared by the 10 and 12.5 kilohertz centered bands and the 2×BPF by the 20 and 25 kilohertz centered bands. At 70 percent speed (figs. 15(c) or 17(c)) the 1×BPF is near the center of the one-third octave band centered at 8 kilohertz and no band sharing of this tone or its second harmonic is apparent. The one-third octave broadband base calculated from the narrowband analyses (fig. 14) agrees with the direct one-third octave analysis for all speeds (fig. 15).

In the plenum chamber at 70 percent speed and 67 percent flow (figs. 16(c) and 17(c)) there is a broadband hump in the SPL spectra extending from about 500 to about 3000 hertz that is not present for comparable conditions in the anechoic chamber (figs. 14(c) and 15(c)). This is believed due to exit throttle generated noise in the compressor test facility discussed later.

One-third octave band power spectra comparisons. - As previously discussed, the flow range at each speed is much less in the anechoic chamber installation than in the compressor test facility. Thus, in general there was only one flow at a given speed that was nearly the same in each facility. These four directly comparable operating conditions are shown in figures 20(a), (b), (c), and (d) for 70, 80, 90, and 100 percent speed, respectively.

In general, the broadband spectra are somewhat different between the two facilities as is the upper frequency limit of the analysis. There is the previously indicated low speed (70 and 80 percent), low frequency range (500- to 3000-Hz) hump in the plenum data. Also, above 1×BPF, the plenum broadband is less than the anechoic data. At 90 and 100 percent speed (figs. 20(c) and (d)), the plenum broadband is higher under the MPT noise than in the anechoic chamber. Above 1×BPF, the broadband noise switches to higher in the plenum at 90 percent speed and about equal at 100 percent speed relative to the anechoic chamber levels. Substantially different downstream throttle systems are believed responsible for the broadband differences below about 3000 hertz (see later discussion). Reasons for the inconsistent broadband relation between facilities above 1×BPF are not apparent. The overall result is that absolute value comparisons of broadband noise power are questionable because of the aforementioned differences. However, the broadband contribution to the indicated 1×BPF tone levels is not significantly different between facilities to adversely affect that tone noise comparison described next.

The 1×BPF noise component is nearly the same in both facilities for all speeds shown (fig. 20). At 70 and 80 percent speed the 2×BPF noise is higher in the anechoic chamber than in the plenum but the combined BPF noise agrees within less than 1.5 dB for speeds from 70 to 100 percent.

The MPT spectra are quite similar at 90 and 100 percent speed and the absolute values are in close agreement at 100 percent speed where the MPT component is dominant.

The satisfactory determination of one-third octave based inlet tone power levels (BPF's and MPT's) in the same installation and time period that the detailed aerodynamic performance is obtained allows early screening of designs. And coupled with narrowband spectra that are representative of free and far field spectra it also offers the potential for cause and effect relations between the aerodynamic and noise performance.

All of the one-third octave band power spectra from each facility are presented in figures 21 to 26 for speeds of 50 to 100 percent of design, respectively. At 50 and 60 percent speed directly comparable data are not available as it is for 70, 80, 90, and 100 percent speed. The weight flows at each speed are shown and the absolute value of each noise component tabulated.

In the anechoic chamber at 60 and 70 percent speed (figs. 22 and 23(a)) the second harmonic (2×BPF) is about equal to the fundamental (1×BPF). In the aerodynamic test facility at 70 percent speed (fig. 23(b)), the 2×BPF noise level is 7 to 9 dB below 1×BPF for all weight flows tested. This implies that the stage 15-9 waveforms measured in the reverberant plenum chamber are shaped nearly like sine waves while those in the anechoic chamber are more irregular in shape. However the combined acoustic power in 1×BPF and 2×BPF in one chamber is nearly equal to that in the other at comparable operating conditions. Also, at the higher speeds (figs. 24 to 26), the 2×BPF noise levels are nearly 10 dB lower than 1×BPF in both facilities.

Crossplots summarizing each of the noise components are presented and discussed next. Following that, the throttle noise in the compressor aerodynamic test facility is examined.

Noise components as functions of speed and flow. - The inlet sound power in blade passing frequencies (BPF), in multiple pure tones (MPT), and in the broadband (BB) noise are shown in figures 27, 28, and 29, respectively, for both test facilities. These results are from the previously presented one-third octave analyses (figs. 21 to 26) and cover the range of speeds and flows tested.

The levels of BPF noise (fig. 27) represent the combined power of 1×BPF and 2×BPF. On this basis there is very good agreement between the two facilities over the entire range studied. At a midthrottle setting, the BPF levels generally increase with increasing tip speed from 50 to 80 percent speed and remain near the later level at 90 and 100 percent speed. The effect of flow or loading at a fixed speed on BPF levels is mixed. At speeds between 70 and 100 percent the midthrottle settings associated with near peak efficiency operation (fig. 10) produce the highest level of BPF noise. Also, the near stall flows in the aerodynamic test facility generally result in the lowest levels of BPF at a given speed. Reasons for this unexpected behavior of BPF noise are not presently known.

The levels of the multiple pure tones are shown in figure 28 against a background of blade passing frequency levels. Only at 100 percent speed are the MPT a significant noise source (relative to the BPF) and there the agreement between the two facilities is very good. There is some MPT contribution at 90 percent speed where the relative Mach number is near 1.0 but it is less than the BPF. The MPT levels at 90 percent speed are about 5 dB less in the anechoic chamber than in the plenum for unknown reasons. At 100 percent speed the combined MPT levels exceed the combined BPF levels. It appears that some of the acoustic energy in the blade passing frequency is increasingly shifted into multiple pure tones as the blade relative Mach number increases above unity. Evidence for this is the leveling off of the BPF noise near 1.0 relative Mach number concurrent with increasing MPT noise as Mach number increases beyond about 1.0. At design speed there is no effect of loading (flow changes) on the MPT levels for the range of flows that could be tested.

The broadband noise levels for each facility are presented in figure 29. As previously discussed, the plenum chamber data show a broadband frequency spectra that generally differs from the anechoic chamber data as does the upper frequency limit analyzed thus absolute value comparisons of total broadband power are questionable. However, trends with speed and flow may be valid and are similar in each facility. At constant speed, the broadband noise increases steadily with decreases in flow. Such flow decreases mean increased blade loading with possibly increased flow separation and thus increased turbulence from blade and wall boundary layers. The allowable flow range at constant speed was small in the anechoic chamber thus the range of broadband noise was only a few dB. The broadband noise in the anechoic chamber increased about 6 dB from 60 to 80 percent design speed (about fifth power of speed dependence) then decreased about 1 dB from 80 to 90 percent speed. These values apply along a fan operating line calculated to pass through the design point with a fixed fan exhaust nozzle. Design speed data could not be run at this throttle setting (fig. 10). Reasons for the lower broadband noise at 90 percent speed are not known.

A summary of the one-third octave based inlet sound power from the 0.271-scale model of the NASA QF-1 fan tested in an anechoic chamber revealed the following: the blade passing frequency noise was highest near a midthrottle, peak efficiency, setting. It propagated to the far field at all speeds despite a stator to rotor blade number ratio satisfying the cutoff criteria (ref. 10) and despite low levels of free stream inlet turbulence intensity and flow distortion. The MPT noise was not significant at 90 percent speed (takeoff condition, ref. 3) but was dominant at 100 percent speed. And the broadband noise increased with speed between 60 and 80 percent design speed but declined about 1 dB from 80 to 90 percent speed.

Throttle noise in unmodified compressor test facility. - As previously mentioned there is a broadband hump in the noise spectra from about 500 to 3000 hertz for the midthrottle data at 70 and 80 percent speed (figs. 20(a) and (b)) that is not apparent from the anechoic chamber data. The source of this broadband hump is believed to be the sleeve throttle valve at the entrance to the collector about 60 centimeters (23.6-in.) downstream of the stator in the compressor test facility (fig. 3(b)). At maximum flow, the sleeve valve is translated forward and completely out of the flow path. Under these conditions (see figs. 23(b) to 26(b)), the plenum chamber noise spectra do not show a low frequency hump and are similar to the anechoic chamber spectra. However, to reduce weight flow, the sleeve valve must be translated rearward and into the flow path. Then the broadband noise hump is present as shown (figs. 23(b) to 26(b)). On the other hand in the anechoic chamber installation, the throttle valve is remote from the stator and also there is a muffler in the line to reduce its upstream noise (fig. 5).

To further identify possible secondary noise sources, additional data from the aerodynamic compressor test facility without stage 15-9 installed is presented in figure 30. A range of weight flows was drawn by vacuum exhaust equipment (fig. 3(a)) through the compressor flow path and throttled by the collector entrance sleeve valve. The overall sound powers measured in the plenum as a function of flow are shown in figure 30(a). In figure 30(c) are the one-third octave power spectra for a range of flows, while figure 30(b) presents the average Mach number of the flow in the minimum area section (station 3 of fig. 1). Noise levels increased with increasing flow until the annulus was nearly choked and then the noise dropped off over 10 dB when the average Mach number approached 0.9. The noise spectra were similarly shaped for all flows with the highest levels in the range of frequencies between about 500 and 3000 hertz. These highest absolute levels are about the same as those with stage 15-9 operating at conditions resulting in about the same average Mach number at station 3 (fig. 1). By choking the flow at station 3 in the vacuum exhaust tests without stage 15-9 installed, the noise decrease extends across most of the spectrum (fig. 30(c)). In particular, the broadband noise between about 500 and 3000 hertz is substantially reduced. Thus the noise that has been choked off is believed to originate from the partly closed sleeve throttle.

The high broadband noise at the near stall flows in the aerodynamic test facility (figs. 21 to 26) are believed generated by stage 15-9. The continuously increasing level with increasing frequency (up to 1×BPF) is not characteristic of the facility operated without the stage (fig. 30(c)). Increased regions of flow separation from the highly loaded rotor and stator blades is a possible source of the increased broadband noise. In the anechoic chamber, similarly low weight flows and the correspondingly high blade loadings were not attainable thus acquiring noise data under such conditions was not possible.

CONCLUDING REMARKS

There are some obvious limitations to the noise measurements taken in the reverberant inlet plenum chamber of the present or any similar aerodynamic compressor test facility. No noise directivity information is possible from reverberant facilities which is required for effective perceived noise level or noise footprint calculations. Also, fan exit as well as inlet noise data are essential in evaluating its overall noise performance and these are not reported herein. Although 1.32-centimeter- (1/8-in.-) diameter microphones were radially traversed behind the stators of stage 15-9 (and others), there are presently no anechoic or other free and far field data with which to compare and thus evaluate it.

The high blade passing frequencies of stage 15-9 (about 11 kHz at design speed) eliminated any significant standing wave problems in the symmetrical plenum chamber (ref. 1). Rotors with much lower blade passing frequencies (due to lower numbers of blades or lower tip speeds) may introduce such problems. Then modifications to the plenum or to the method of acquiring a good space average of the noise level will probably be required. Finally, the presently described contamination by exit throttle noise may be reduced by using a more remote and perhaps muffled throttle than one at the collector entrance.

SUMMARY OF RESULTS

The inlet noise from a 0.271-scale model (0.5-m or 20-in. diameter) of the NASA QF-1 fan was determined from measurements in the reverberant plenum chamber of an unmodified compressor aerodynamic test facility and from measurements in an anechoic chamber. The principle results of the study were the following:

1. Narrowband (50-Hz) analyses revealed grossly similar sound pressure level spectra in each facility. Blade passing frequency (BPF) noise and, at the higher tip speeds, multiple pure tone (MPT) noise were superimposed on a broadband (BB) based noise.

2. Sound power levels were determined from one-third octave bandwidth analysis. On that basis the BPF noise (harmonics combined) and the MPT noise (harmonics combined excepting BPF's) agreed between facilities within 1.5 dB or less over the range of speeds and flows tested. However, the sound power difference between 1×BPF and 2×BPF was not the same in each facility at low speed. Trends in the total broadband noise with changes in speed and flow were similar in each facility but comparisons of the absolute power levels are questionable because of differing frequency spectra and maximum frequency limit analyzed.

3. The satisfactory determination of one-third octave based inlet tone power levels in the same installation and time period that the detailed aerodynamic performance is obtained allows early screening of designs. And coupled with narrowband spectra that are representative of free and far field spectra it also offers the potential for cause and effect relations between the aerodynamic and noise performance.

4. In the anechoic chamber the BPF noise was highest near peak efficiency operation. It propagated at all speeds despite a design to cut it off at low speeds and despite free stream inlet flow with low turbulence intensity and flow distortion. Also the MPT noise was only significant at 100 percent design speed (tip relative Mach number of about 1.10) where it dominated the spectrum. The broadband noise increased about 6 dB from

60 to 80 percent design speed then decreased about 1 dB from 80 to 90 percent speed, all on a calculated operating line passing through the design point.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, August 22, 1975,
505-04.

APPENDIX A

SYMBOLS

A_{an} annulus area at rotor leading edge, 0.144 m^2; 1.55 ft^2

A_f frontal area at rotor leading edge, 0.192 m^2; 2.07 ft^2

C_p specific heat at constant pressure, 1004 J/(kg)(K); 0.24 Btu/(lb)(^oR)

c aerodynamic chord, cm; in.

D diffusion factor

E engine order, rev/sec

i_{mc} mean incidence angle, angle between inlet air 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

N_D design rotative speed, 13 020 rpm

P total pressure, N/cm^2; psia

PWL sound power level, dB (referenced to 10^{-13} W)

p static pressure, N/cm^2; psia

r radius, cm; in.

SM stall margin

SPL sound pressure level, dB (referenced to 0.0002 μbar)

T total temperature, K; ^oR

U wheel speed, m/sec; ft/sec

U' fluctuating velocity from hot film probe, m/sec; ft/sec

$\bar{U}$ mean velocity from hot film probe, m/sec; ft/sec

V air velocity, m/sec; ft/sec

W weight flow, kg/sec; lb/sec

W_D design weight flow, 29.16 kg/sec; (64.3 lb/sec)

Z axial distance referenced from rotor blade hub leading edge, cm; in.

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 ($\tan \beta'_m \cos \alpha_c / \cos \alpha_s$), deg

γ ratio of specific heats (1.40)

δ ratio of rotor inlet total pressure to standard pressure of 10.13 N/cm^2 (14.69 lb/in.^{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 (518.7^o R)

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

κ_{ss} angle between blade suction surface at leading edge and meridional plane, deg

σ solidity, ratio of chord to spacing

$\bar{\omega}$ total loss coefficient

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

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

Subscripts:

ad adiabatic (temperature rise)

id ideal

LE blade leading edge

m meridional direction

mom momentum rise

p polytropic

R rotor

ref reference

stall stall

TE blade trailing edge

tip tip

z	axial direction
θ	tangential direction
05	5 percent span from tip of rotor
1	instrumentation plane upstream of rotor (fig. 1)
2a	instrumentation plane nearest rotor trailing edge (fig. 1)
2b	instrumentation plane nearest stator leading edge (fig. 1)
3,4	instrumentation planes downstream of stator (fig. 1)

Superscript:

'	relative to blade

APPENDIX B

EQUATIONS

Suction-surface incidence angle

$$i_{ss} = \left(\beta_c'\right)_{LE} - \kappa_{ss} \tag{B1}$$

Mean incidence angle

$$i_{mc} = \left(\beta_c'\right)_{LE} - \left(\kappa_{mc}\right)_{LE} \tag{B2}$$

Deviation angle

$$\delta^{o} = \left(\beta_c'\right)_{TE} - \left(\kappa_{mc}\right)_{TE} \tag{B3}$$

Diffusion factor

$$D = 1 - \frac{V_{TE}'}{V_{LE}'} + \left| \frac{\left(rV_\theta\right)_{TE} - \left(rV_\theta\right)_{LE}}{\left(r_{TE} + r_{LE}\right)\sigma\left(V_{LE}'\right)} \right| \tag{B4}$$

Total loss coefficient

$$\bar{\omega} = \frac{\left(P_{id}'\right)_{TE} - \left(P'\right)_{TE}}{\left(P'\right)_{LE} - \left(p\right)_{LE}} \tag{B5}$$

Profile loss coefficient

$$\bar{\omega}_p = \bar{\omega} - \bar{\omega}_s \tag{B6}$$

Total loss parameter

$$\frac{\bar{\omega} \cos\left(\beta_m'\right)_{TE}}{2\sigma} \tag{B7}$$

Profile loss parameter

$$\frac{\bar{\omega}_p \cos \left(\beta_m'\right)_{TE}}{2\sigma} \tag{B8}$$

Adiabatic (temperature-rise) efficiency

$$\eta_{ad} = \frac{\left(\frac{P_{TE}}{P_{LE}}\right)^{(\gamma-1)/\gamma} - 1}{\frac{T_{TE}}{T_{LE}} - 1} \tag{B9}$$

Momentum-rise efficiency

$$\eta_{mom} = \frac{\left(\frac{P_{TE}}{P_{LE}}\right)^{(\gamma-1)/\gamma} - 1}{\frac{\left(UV_\theta\right)_{TE} - \left(UV_\theta\right)_{LE}}{T_{LE}C_p}} \tag{B10}$$

Equivalent weight flow

$$\frac{w\sqrt{\theta}}{\delta} \tag{B11}$$

Equivalent rotative speed

$$\frac{N}{\sqrt{\theta}} \tag{B12}$$

Weight flow per unit annulus area

$$\frac{\frac{w\sqrt{\theta}}{\delta}}{A_{an}} \tag{B13}$$

Weight flow per unit frontal area

$$\frac{\left(\frac{W\sqrt{\theta}}{\delta}\right)}{A_f} \tag{B14}$$

Head-rise coefficient

$$\frac{C_p T_{LE}}{U_{tip}^2}\left[\left(\frac{P_{TE}}{P_{LE}}\right)^{(\gamma-1)/\gamma} - 1\right] \tag{B15}$$

Flow coefficient

$$\left(\frac{V_z}{U_{tip}}\right)_{LE} \tag{B16}$$

Stall margin

$$SM = \left[\frac{\left(\frac{P_{TE}}{P_{LE}}\right)_{stall}}{\left(\frac{P_{TE}}{P_{LE}}\right)_{ref}} \times \frac{\left(\frac{W\sqrt{\theta}}{\delta}\right)_{ref}}{\left(\frac{W\sqrt{\theta}}{\delta}\right)_{stall}} - 1\right] \times 100 \tag{B17}$$

Polytropic efficiency

$$\eta_p = \frac{\ln\left(\frac{P_{TE}}{P_{LE}}\right)^{(\gamma-1)/\gamma}}{\ln \frac{T_{TE}}{T_{LE}}} \tag{B18}$$

APPENDIX C

ABBREVIATIONS AND UNITS USED IN TABLES

(Aerodynamic and acoustic parameters listed separately)

Aerodynamic Parameters

ABS	absolute
AERO CHORD	aerodynamic chord, cm
AREA RATIO	ratio of actual flow area to critical area (where local Mach number is 1)
BETAM	meridional air angle, deg
CONE ANGLE	angle between axial direction and conical surface representing blade element, deg
DELTA INC	difference between mean camber blade angle and suction-surface blade angle at leading edge, 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 (suction surface defined by eq. (B1) and 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 trailing edge and meridional plane, deg
KTC	angle between blade mean camber line at transition point and meridional plane, deg
LOSS COEFF	loss coefficient (total defined by eq. (B5) and profile defined by eq. (B6))
LOSS PARAM	loss parameter (total defined by eq. (B7) and profile defined 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 trailing edge for design streamlines
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 a multiple-circular-arc blade section to that of a double-circular-arc blade section

ZIC	axial distance to blade leading edge from rotor hub leading edge, cm
ZMC	axial distance to blade maximum thickness point from rotor hub leading edge, cm
ZOC	axial distance to blade trailing edge from rotor hub leading edge, cm
ZTC	axial distance to transition point from rotor hub leading edge, cm

Acoustic Parameters

BAR	barometric pressure, in. Hg
DBA	decibels using A weighted frequency response network (ref. 12)
DBB	decibels using B weighted frequency response network (ref. 12)
DBC	decibels using C weighted frequency response network (ref. 12)
HACT	absolute moisture content of inlet air, g/m^3
NFA	actual rotative speed, rpm
NFK	equivalent (corrected rotative speed, NFA/$\sqrt{\theta}$), rpm
NFD	design rotative speed, rpm
PERC RH	percent relative humidity
PNL	perceived noise level, PN dB
PNLT	tone corrected perceived noise level
PWL	sound power level, dB (referenced to 10^{-13} W)
SPLS	sound pressure level, dB (referenced to 0.0002 μbar)
TAMB	ambient temperature, ^{o}F
TWET	wet bulb temperature, ^{o}F

REFERENCES

1. Gelder, Thomas F.; and Soltis, Richard F.: Inlet Plenum Chamber Noise Measurement Comparison of 20-Inch Diameter Fan Rotors with Aspect Ratios 3.6 and 6.6. NASA TM X-2191, 1971.
2. Gelder, Thomas F.; and Lewis, George W., Jr.: Aerodynamic Performance of a 0.5-Meter Diameter, 337-Meters-Per-Second Tip Speed, 1.5-Pressure Ratio, Single Stage Fan Designed for Low Noise Aircraft Engines. NASA TN D-7836, 1974.
3. Leonard, Bruce R.; Schmiedlin, Ralph F.; Stakolich, Edward G.; and Neumann, Harvey E.: Acoustic and Aerodynamic Performance of a 6-Foot-Diameter Fan for Turbofan Engines. I - Design of Facility and QF-1 Fan. NASA TN D-5877, 1970.
4. Goldstein, Arthur W.; Lucas, James G.; and Balombin, Joseph R.: Acoustic and Aerodynamic Performance of a 6-Foot-Diameter Fan for Turbofan Engines. II - Performance of QF-1 Fan in Nacelle Without Acoustic Suppression. NASA TN D-6080, 1970.
5. Urasek, Donald C.; and Janetzke, David C.: Performance of Tandem-Bladed Transonic Compressor Rotor with Tip Speed of 1375 Feet per Second. NASA TM X-2484, 1972.
6. Kester, J. D.; and Slaiby, T. G.: Designing the JT9D Engine to Meet Low Noise Requirements for Future Transports. SAE Paper 670331, April 1967.
7. Kramer, James J.; Hartmann, Melvin J.; Leonard, Bruce R.; Klapproth, Jack F.; and Sofrin, Thomas G.: Fan Noise and Performance. Section II of Aircraft Engine Noise Reduction. NASA SP-311, 1972, pp. 7-61.
8. Montegani, Francis J.: Noise Generated by Quiet Engine Fans. I - Fan B. NASA TM X-2528, 1972.
9. Hinze, J. O.: Turbulence; An Introduction to its Mechanism and Theory. McGraw-Hill Book Co., Inc., 1959, (p. 217 and figs. 3-19).
10. Tyler, J. M.; and Sofrin, T. G.: Axial Flow Compressor Noise Studies. SAE Trans., vol. 70, 1962, pp. 309-332.
11. Burdsall, E. A.; and Urban, R. H.: Fan-Compressor Noise: Prediction, Research, and Reduction Studies. Pratt and Whitney Aircraft (FAA-RD-71-73), 1971.
12. Beranek, Leo L.; ed: Noise Reduction. McGraw-Hill Book Co., Inc., 1960.

TABLE I. - OVERALL AERODYNAMIC DESIGN

PARAMETERS FOR STAGE 15-9

ROTOR TOTAL PRESSURE RATIO................	1.541
STAGE TOTAL PRESSURE RATIO	1.499
ROTOR TOTAL TEMPERATURE RATIO.............	1.145
STAGE TOTAL TEMPERATURE RATIO	1.145
ROTOR ADIABATIC EFFICIENCY................	0.909
STAGE ADIABATIC EFFICIENCY	0.848
ROTOR POLYTROPIC EFFICIENCY...............	0.915
STAGE POLYTROPIC EFFICIENCY	0.856
ROTOR HEAD RISE COEFFICIENT...............	0.334
STAGE HEAD RISE COEFFICIENT	0.312
FLOW COEFFICIENT..........................	0.581
WT FLOW PER UNIT FRONTAL AREA	151.534
WT FLOW PER UNIT ANNULUS AREA............	201.797
WT FLOW	29.161
RPM..................................	13020.000
TIP SPEED	337.451

TABLE II. - DESIGN BLADE-ELEMENT PARAMETERS FOR ROTOR 15

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	24.750	23.962	0.	40.8	63.6	45.6	288.2	1.169	10.13	1.541
1	24.132	23.424	0.	38.9	61.6	44.9	288.2	1.158	10.13	1.541
2	23.510	22.886	-0.	37.6	59.8	44.1	288.2	1.149	10.13	1.541
3	22.884	22.347	-0.	36.9	58.3	43.0	288.2	1.143	10.13	1.541
4	21.021	20.732	-0.	38.2	54.7	37.6	288.2	1.139	10.13	1.541
5	18.560	18.579	-0.	41.5	50.9	27.1	288.2	1.141	10.13	1.541
6	16.075	16.425	-0.	45.3	47.2	11.7	288.2	1.144	10.13	1.541
7	14.192	14.810	-0.	48.6	44.0	-3.0	288.2	1.148	10.13	1.541
8	13.573	14.272	-0.	49.9	42.7	-8.3	288.2	1.149	10.13	1.541
9	12.960	13.734	-0.	51.3	41.5	-13.8	288.2	1.151	10.13	1.541
HUB	12.352	13.195	0.	52.6	40.1	-19.2	288.2	1.152	10.13	1.541

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	167.3	229.2	376.6	247.7	167.3	173.4	0.	149.8	337.5	326.7
1	177.8	227.4	374.0	249.9	177.8	176.9	0.	142.9	329.0	319.4
2	186.3	226.5	370.7	249.8	186.3	179.4	-0.	138.2	320.5	312.0
3	192.7	226.3	366.7	247.4	192.7	180.9	-0.	135.9	312.0	304.7
4	203.0	230.9	351.2	229.1	203.0	181.5	-0.	142.7	286.6	282.7
5	205.7	242.4	326.1	203.9	205.7	181.6	-0.	160.6	253.1	253.3
6	203.2	261.7	298.9	188.0	203.2	184.2	-0.	185.9	219.2	224.0
7	200.7	282.0	278.8	186.6	200.7	186.3	-0.	211.7	193.5	201.9
8	200.2	290.1	272.7	188.7	200.2	186.8	-0.	221.9	185.1	194.6
9	200.0	298.8	266.9	192.5	200.0	187.0	-0.	233.1	176.7	187.3
HUB	200.1	308.3	261.5	198.1	200.1	187.1	0.	245.0	168.4	179.9

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	STREAMLINE SLOPE IN	STREAMLINE SLOPE OUT	MERID VEL R	PEAK SS MACH NO
TIP	0.504	0.649	1.135	0.701	0.504	0.491	-19.40	-14.51	1.037	1.448
1	0.537	0.646	1.130	0.710	0.537	0.503	-16.77	-12.48	0.995	1.455
2	0.565	0.646	1.124	0.713	0.565	0.512	-14.29	-10.63	0.963	1.455
3	0.585	0.648	1.114	0.708	0.585	0.518	-11.97	-8.97	0.939	1.448
4	0.619	0.663	1.071	0.658	0.619	0.521	-5.98	-4.78	0.894	1.451
5	0.628	0.699	0.995	0.588	0.628	0.523	0.30	-0.20	0.883	1.475
6	0.620	0.759	0.911	0.546	0.620	0.534	5.93	4.15	0.906	1.405
7	0.611	0.825	0.849	0.546	0.611	0.545	10.16	7.57	0.928	1.324
8	0.610	0.851	0.831	0.554	0.610	0.548	11.61	8.79	0.933	1.292
9	0.609	0.880	0.813	0.567	0.609	0.551	13.07	10.05	0.935	1.258
HUB	0.609	0.911	0.797	0.586	0.609	0.553	14.55	11.34	0.935	1.222

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.	3.3	-0.0	7.0	0.488	0.778	0.189	0.154	0.049	0.040
1	5.00	3.4	-0.0	6.4	0.469	0.834	0.136	0.100	0.035	0.026
2	10.00	3.5	0.0	5.9	0.458	0.883	0.093	0.059	0.024	0.015
3	15.00	3.6	-0.0	5.7	0.453	0.919	0.063	0.031	0.016	0.008
4	30.00	4.2	-0.0	5.8	0.479	0.944	0.046	0.018	0.012	0.005
5	50.00	5.5	0.0	6.4	0.517	0.936	0.058	0.035	0.015	0.009
6	70.00	7.8	-0.0	7.4	0.529	0.914	0.090	0.081	0.022	0.020
7	85.00	10.3	0.0	8.1	0.504	0.890	0.131	0.129	0.029	0.029
8	90.00	11.6	0.0	8.2	0.486	0.882	0.148	0.147	0.031	0.031
9	95.00	13.1	0.0	8.3	0.462	0.873	0.166	0.165	0.033	0.033
HUB	100.00	14.9	-0.0	8.5	0.430	0.864	0.185	0.185	0.034	0.034

TABLE III. - DESIGN BLADE-ELEMENT PARAMETERS FOR STATOR 9

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	23.414	23.409	37.5	0.	37.5	0.	336.9	1.000	15.61	0.952
1	22.943	22.945	35.5	0.	35.5	0.	333.6	1.000	15.61	0.961
2	22.478	22.475	33.8	-0.	33.8	-0.	331.1	1.000	15.61	0.969
3	22.004	21.999	32.9	-0.	32.9	-0.	329.4	1.000	15.61	0.975
4	20.577	20.575	33.4	-0.	33.4	-0.	328.3	1.000	15.61	0.983
5	18.632	18.718	36.1	-0.	36.1	-0.	328.7	1.000	15.61	0.986
6	16.735	16.916	40.2	-0.	40.2	-0.	329.6	1.000	15.61	0.983
7	15.343	15.622	45.4	-0.	45.4	-0.	330.7	1.000	15.61	0.979
8	14.848	15.165	47.2	-0.	47.2	-0.	331.1	1.000	15.61	0.951
9	14.344	14.685	49.0	-0.	49.0	-0.	331.6	1.000	15.61	0.899
HUB	13.853	14.181	50.8	-0.	50.8	-0.	332.0	1.000	15.61	0.821

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	252.0	187.1	252.0	187.1	199.9	187.1	153.4	0.	0.	0.
1	252.2	190.9	252.2	190.9	205.7	190.9	145.9	0.	0.	0.
2	253.0	193.8	253.0	193.8	210.3	193.8	140.7	-0.	0.	0.
3	254.3	195.9	254.3	195.9	213.6	195.9	138.0	-0.	0.	0.
4	261.2	198.7	261.2	198.7	218.1	198.7	143.8	-0.	0.	0.
5	271.2	199.1	271.2	199.1	219.2	199.1	159.7	-0.	0.	0.
6	281.8	198.5	281.8	198.5	215.1	198.5	181.9	-0.	0.	0.
7	287.2	195.2	287.2	195.2	201.8	195.2	204.4	-0.	0.	0.
8	289.9	188.7	289.9	188.7	196.9	188.7	212.7	-0.	0.	0.
9	293.5	177.7	293.5	177.7	192.5	177.7	221.5	-0.	0.	0.
HUB	297.8	162.0	297.8	162.0	188.3	162.0	230.7	-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	0.719	0.522	0.719	0.522	0.571	0.522	-0.01	0.00	0.936	1.261
1	0.724	0.536	0.724	0.536	0.591	0.536	0.01	0.01	0.928	1.212
2	0.730	0.547	0.730	0.547	0.606	0.547	0.02	0.01	0.922	1.181
3	0.738	0.555	0.738	0.555	0.618	0.555	0.03	0.00	0.917	1.165
4	0.760	0.564	0.760	0.564	0.634	0.564	0.27	0.18	0.911	1.196
5	0.792	0.565	0.792	0.565	0.640	0.565	1.39	1.25	0.908	1.274
6	0.825	0.563	0.825	0.563	0.630	0.563	3.69	3.59	0.923	1.377
7	0.842	0.551	0.842	0.551	0.592	0.551	6.87	7.40	0.937	1.469
8	0.850	0.532	0.850	0.532	0.578	0.532	7.91	9.04	0.958	1.506
9	0.862	0.499	0.862	0.499	0.565	0.499	8.84	10.85	0.923	1.546
HUB	0.876	0.453	0.876	0.453	0.554	0.453	9.67	12.83	0.860	1.589

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.	13.7	0.0	5.3	0.474	0.	0.165	0.165	0.059	0.059
1	5.00	14.1	0.0	4.8	0.445	0.	0.131	0.131	0.046	0.046
2	10.00	14.3	0.0	4.5	0.424	0.	0.103	0.103	0.035	0.035
3	15.00	14.3	0.0	4.3	0.411	0.	0.082	0.082	0.027	0.027
4	30.00	13.1	-0.0	4.5	0.412	0.	0.053	0.053	0.017	0.017
5	50.00	11.2	0.0	5.1	0.433	0.	0.040	0.040	0.011	0.011
6	70.00	9.4	0.0	5.9	0.460	0.	0.048	0.045	0.012	0.011
7	85.00	8.1	0.0	6.8	0.485	0.	0.056	0.046	0.013	0.011
8	90.00	7.6	0.0	7.1	0.513	0.	0.130	0.116	0.029	0.026
9	95.00	7.2	0.0	7.4	0.557	0.	0.264	0.245	0.057	0.053
HUB	100.00	6.8	-0.0	7.6	0.616	0.	0.455	0.428	0.095	0.090

TABLE IV. - BLADE GEOMETRY FOR ROTOR 15

RP	PERCENT SPAN	RADII RI	RO	BLADE ANGLES KIC	KTC	KOC	DELTA INC	CONE ANGLE
TIP	0.	24.750	23.962	60.18	56.04	37.62	3.32	-20.376
1	5.	24.132	23.424	58.16	53.63	37.89	3.37	-17.429
2	10.	23.510	22.886	56.33	51.57	37.68	3.46	-14.752
3	15.	22.884	22.347	54.69	49.88	37.00	3.58	-12.262
4	30.	21.021	20.732	50.52	45.02	31.80	4.17	-5.998
5	50.	18.560	18.579	45.41	38.87	20.63	5.49	0.349
6	70.	16.075	16.425	39.39	32.45	4.28	7.78	5.833
7	85.	14.192	14.810	33.67	27.61	-11.12	10.32	9.632
8	90.	13.573	14.272	31.22	26.10	-16.53	11.60	10.738
9	95.	12.960	13.734	28.47	24.63	-22.01	13.13	11.756
HUB	100.	12.352	13.195	25.42	23.22	-27.59	14.88	12.727

RP	BLADE THICKNESSES TI	TM	TO	AXIAL DIMENSIONS ZIC	ZMC	ZTC	ZOC
TIP	0.036	0.143	0.032	0.711	1.655	1.926	2.831
1	0.036	0.145	0.031	0.666	1.683	1.914	2.920
2	0.037	0.147	0.032	0.620	1.700	1.886	2.990
3	0.038	0.151	0.032	0.573	1.706	1.841	3.042
4	0.042	0.167	0.034	0.448	1.673	1.674	3.196
5	0.050	0.199	0.039	0.313	1.624	1.408	3.407
6	0.062	0.246	0.045	0.203	1.625	1.114	3.638
7	0.074	0.295	0.052	0.082	1.631	0.825	3.723
8	0.079	0.315	0.055	0.048	1.637	0.731	3.734
9	0.084	0.337	0.058	0.022	1.648	0.641	3.738
HUB	0.090	0.360	0.061	0.000	1.664	0.554	3.734

RP	AERO CHORD	SETTING ANGLE	TOTAL CAMBER	SOLIDITY	X FACTOR	PHISS	AREA RATIO
TIP	3.880	53.99	22.56	1.344	0.500	8.34	1.005
1	3.863	51.91	20.27	1.370	0.578	8.62	1.014
2	3.851	50.05	18.65	1.400	0.638	8.76	1.021
3	3.838	48.36	17.69	1.431	0.681	8.78	1.024
4	3.812	42.94	18.72	1.540	0.780	9.66	1.036
5	3.802	34.58	24.78	1.727	0.858	11.38	1.046
6	3.820	23.56	35.11	1.983	0.920	13.11	1.047
7	3.858	13.29	44.80	2.244	0.963	13.64	1.029
8	3.872	9.62	47.75	2.346	0.976	13.54	1.015
9	3.887	5.85	50.48	2.456	0.989	13.30	0.996
HUB	3.906	1.98	53.02	2.579	1.000	12.92	0.972

TABLE V. - BLADE GEOMETRY FOR STATOR 9

RP	PERCENT SPAN	RADII RI	RADII RO	BLADE ANGLES KIC	BLADE ANGLES KTC	BLADE ANGLES KOC	DELTA INC	CONE ANGLE
TIP	0.	23.414	23.409	23.77	14.42	-5.26	13.73	-0.162
1	5.	22.943	22.943	21.22	14.42	-4.82	14.11	-0.100
2	10.	22.478	22.475	19.49	14.48	-4.49	14.30	-0.125
3	15.	22.004	21.999	18.58	14.59	-4.29	14.30	-0.180
4	30.	20.577	20.575	20.32	15.70	-4.50	13.09	-0.060
5	50.	18.682	18.718	24.83	17.85	-5.14	11.19	1.156
6	70.	16.783	16.916	30.81	20.69	-5.94	9.39	4.176
7	85.	15.345	15.622	37.14	23.74	-6.78	8.06	9.026
8	90.	14.848	15.165	39.39	24.91	-7.08	7.64	10.248
9	95.	14.344	14.683	41.60	26.13	-7.35	7.22	10.973
HUB	100.	13.833	14.181	43.80	27.41	-7.62	6.83	11.305

RP	BLADE THICKNESSES TI	BLADE THICKNESSES TM	BLADE THICKNESSES TO	AXIAL DIMENSIONS ZIC	AXIAL DIMENSIONS ZMC	AXIAL DIMENSIONS ZTC	AXIAL DIMENSIONS ZOC
TIP	0.037	0.184	0.028	17.366	18.159	17.771	19.162
1	0.036	0.181	0.028	17.365	18.161	17.740	19.163
2	0.035	0.177	0.028	17.366	18.163	17.718	19.164
3	0.035	0.173	0.028	17.367	18.165	17.705	19.166
4	0.032	0.162	0.028	17.369	18.164	17.709	19.165
5	0.030	0.147	0.028	17.375	18.161	17.731	19.164
6	0.028	0.132	0.028	17.382	18.154	17.750	19.159
7	0.028	0.122	0.028	17.393	18.146	17.767	19.155
8	0.028	0.118	0.028	17.399	18.145	17.773	19.154
9	0.028	0.115	0.028	17.407	18.145	17.777	19.155
HUB	0.028	0.110	0.028	17.416	18.146	17.781	19.157

RP	AERO CHORD	SETTING ANGLE	TOTAL CAMBER	SOLIDITY	X FACTOR	PHISS	AREA RATIO
TIP	1.846	7.93	29.03	1.406	1.300	19.35	1.123
1	1.845	7.61	26.04	1.434	1.300	17.05	1.095
2	1.845	7.41	23.98	1.463	1.300	15.39	1.074
3	1.845	7.36	22.87	1.495	1.300	14.36	1.061
4	1.844	8.02	24.82	1.597	1.300	14.11	1.052
5	1.843	9.48	30.02	1.757	1.300	15.13	1.054
6	1.846	11.46	36.75	1.953	1.300	16.87	1.078
7	1.863	13.62	43.93	2.145	1.300	19.13	1.124
8	1.869	14.43	46.47	2.220	1.300	19.88	1.140
9	1.873	15.24	48.96	2.301	1.300	20.55	1.157
HUB	1.875	16.07	51.42	2.386	1.300	21.15	1.173

TABLE VI. - OVERALL AERODYNAMIC PERFORMANCE OF STAGE 15-9

Percent design speed	Percent design flow	Stage pressure ratio	Stage efficiency	Reading number
100	100.3	1.397	0.763	558
100	98.2	1.463	.830	539
100	94.8	1.484	.821	551
90	94.9	1.320	.806	564
90	88.4	1.377	.852	567
90	75.5	1.334	.715	545
80	60.4	1.243	.657	572
70	79.9	1.177	.855	573
70	67.0	1.211	.851	575
70	52.7	1.185	.673	550
50	36.3	1.090	.771	579

TABLE VII. - BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 15

(a) 100 Percent of design speed; intrablade row instrumentation at station 2a; reading number 558

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	24.133	23.424	-0.1	31.4	60.8	48.5	288.7	1.123	10.06	1.401
2	23.510	22.885	-0.1	31.4	58.8	46.8	288.5	1.122	10.13	1.409
3	22.883	22.347	-0.2	31.5	57.4	45.1	288.3	1.122	10.13	1.420
4	21.026	20.731	-0.5	34.2	54.0	39.0	288.1	1.125	10.14	1.447
5	18.560	18.578	-0.8	38.0	50.2	27.5	288.0	1.131	10.14	1.470
6	16.076	16.426	-0.4	41.4	46.3	12.0	288.0	1.137	10.14	1.505
7	14.194	14.811	-0.5	45.3	43.7	-3.8	288.0	1.149	10.14	1.567
8	13.574	14.272	-0.5	46.8	42.6	-8.6	287.9	1.152	10.14	1.573
9	12.959	13.734	-0.8	48.9	41.8	-13.3	287.7	1.151	10.11	1.551

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	184.6	215.6	378.6	277.9	184.6	184.0	-0.3	112.3	330.2	320.5
2	194.8	218.9	376.2	272.9	194.8	186.9	-0.4	114.0	321.4	312.9
3	200.5	221.9	372.3	267.9	200.5	189.1	-0.6	116.0	313.1	305.7
4	210.0	230.1	357.4	244.8	210.0	190.3	-1.9	129.3	287.3	283.3
5	213.6	247.6	333.7	220.1	213.6	195.3	-2.9	152.3	253.5	253.8
6	211.2	273.2	305.6	209.6	211.2	205.0	-1.4	180.7	219.5	224.3
7	205.3	305.2	283.9	215.1	205.3	214.6	-1.9	217.0	194.2	202.7
8	203.7	311.9	276.8	215.7	203.7	213.3	-1.8	227.5	185.7	195.3
9	200.8	312.8	269.5	211.1	200.8	205.5	-3.0	235.8	176.8	187.3

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	0.558	0.620	1.146	0.799	0.558	0.529			0.997	1.439
2	0.592	0.631	1.143	0.786	0.592	0.539			0.959	1.434
3	0.611	0.640	1.134	0.773	0.611	0.546			0.943	1.432
4	0.642	0.665	1.093	0.708	0.642	0.550			0.906	1.442
5	0.654	0.719	1.022	0.639	0.654	0.567			0.914	1.463
6	0.646	0.800	0.935	0.614	0.646	0.600			0.971	1.414
7	0.627	0.905	0.867	0.636	0.627	0.635			1.045	1.343
8	0.621	0.925	0.845	0.640	0.621	0.632			1.047	1.311
9	0.612	0.928	0.822	0.626	0.612	0.610			1.023	1.282

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	2.6	-0.8	10.0	0.373	0.824	0.114	0.080	0.028	0.019
2	10.00	2.4	-1.0	8.6	0.382	0.844	0.101	0.068	0.025	0.017
3	15.00	2.7	-0.9	7.8	0.389	0.862	0.091	0.059	0.022	0.014
4	30.00	3.5	-0.7	7.1	0.433	0.888	0.081	0.052	0.020	0.013
5	50.00	4.8	-0.7	6.8	0.475	0.890	0.090	0.065	0.023	0.017
6	70.00	6.9	-0.9	7.7	0.466	0.905	0.093	0.081	0.023	0.020
7	85.00	10.1	-0.3	7.3	0.418	0.920	0.095	0.092	0.021	0.020
8	90.00	11.5	-0.1	8.0	0.402	0.912	0.109	0.108	0.023	0.023
9	95.00	13.5	0.4	8.8	0.402	0.883	0.151	0.150	0.030	0.030

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

EDGES FOR ROTOR 15

(b) 100 Percent of design speed; intrablade row instrumentation at station 2a; reading number 539

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	24.133	23.424	-0.1	34.3	61.5	48.3	288.9	1.136	10.03	1.457
2	23.510	22.885	0.5	33.2	59.2	46.1	288.6	1.135	10.11	1.477
3	22.883	22.347	-0.2	33.6	57.9	44.0	288.4	1.135	10.13	1.494
4	21.026	20.731	-0.2	36.6	54.3	38.1	288.1	1.136	10.14	1.500
5	18.560	18.578	-1.1	39.6	50.8	26.8	288.0	1.137	10.15	1.520
6	16.076	16.426	-1.0	43.3	47.9	12.3	287.9	1.140	10.15	1.534
7	14.194	14.811	-1.2	47.2	46.5	-2.1	287.9	1.146	10.14	1.552
8	13.574	14.272	-0.3	49.4	45.0	-8.3	288.0	1.148	10.14	1.566
9	12.959	13.734	-1.0	51.4	44.0	-13.7	288.0	1.149	10.12	1.563

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	179.8	215.1	376.3	267.1	179.8	177.7	-0.3	121.2	330.3	320.6
2	190.7	220.7	372.2	266.2	190.7	184.6	1.6	121.0	321.3	312.7
3	196.7	224.7	369.7	260.3	196.7	187.2	-0.5	124.3	312.5	305.1
4	206.7	231.0	354.6	235.7	206.7	185.4	-0.8	137.8	287.3	283.3
5	210.2	247.5	332.6	213.6	210.2	190.8	-4.1	157.7	253.7	253.9
6	201.6	266.0	301.0	198.3	201.6	193.7	-3.6	182.3	219.9	224.6
7	188.2	286.1	273.2	194.7	188.2	194.5	-3.9	209.7	194.2	202.7
8	187.0	294.3	264.3	193.6	187.0	191.6	-1.0	223.3	185.7	195.3
9	186.9	298.4	259.7	191.6	185.8	186.2	-3.2	233.2	177.3	187.6

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	0.543	0.614	1.137	0.763	0.543	0.507	0.988	1.454
2	0.578	0.632	1.129	0.762	0.578	0.529	0.968	1.436
3	0.598	0.645	1.124	0.747	0.598	0.537	0.952	1.445
4	0.631	0.665	1.083	0.678	0.631	0.533	0.897	1.446
5	0.643	0.717	1.017	0.618	0.643	0.552	0.908	1.483
6	0.615	0.775	0.918	0.578	0.615	0.565	0.961	1.438
7	0.571	0.839	0.829	0.571	0.571	0.571	1.034	1.363
8	0.567	0.866	0.801	0.570	0.567	0.564	1.025	1.307
9	0.567	0.879	0.788	0.565	0.567	0.549	0.997	1.286

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	3.2	-0.2	9.8	0.406	0.835	0.118	0.082	0.029	0.020
2	10.00	2.8	-0.7	7.9	0.398	0.874	0.091	0.059	0.023	0.015
3	15.00	3.1	-0.4	6.7	0.412	0.899	0.074	0.042	0.019	0.011
4	30.00	3.8	-0.3	6.3	0.461	0.900	0.078	0.049	0.020	0.013
5	50.00	5.4	-0.1	6.1	0.499	0.927	0.063	0.037	0.016	0.009
6	70.00	8.6	0.8	8.0	0.499	0.931	0.071	0.058	0.017	0.014
7	85.00	12.8	2.5	9.1	0.465	0.918	0.101	0.098	0.022	0.022
8	90.00	13.8	2.2	8.2	0.453	0.922	0.103	0.102	0.022	0.022
9	95.00	15.7	2.5	8.4	0.453	0.914	0.118	0.118	0.023	0.023

TABLE VII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 15

(c) 100 Percent of design speed; intrablade row instrumentation at station 2a; reading number 551

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	24.133	23.424	0.5	39.2	62.7	45.9	289.1	1.159	10.06	1.569
2	23.510	22.885	0.6	37.9	60.7	44.3	288.9	1.154	10.11	1.571
3	22.883	22.347	0.1	38.2	59.1	42.6	288.4	1.151	10.13	1.568
4	21.026	20.731	-0.8	39.7	55.5	37.5	288.0	1.146	10.14	1.547
5	18.560	18.578	-1.2	41.3	51.7	27.0	287.9	1.140	10.15	1.532
6	16.076	16.426	-1.0	44.2	48.7	13.0	287.8	1.139	10.14	1.525
7	14.194	14.811	-0.6	48.5	47.0	-2.5	287.9	1.146	10.14	1.545
8	13.574	14.272	-0.5	50.1	45.9	-8.3	287.8	1.150	10.14	1.560
9	12.959	13.734	-0.7	51.8	44.6	-13.7	288.0	1.150	10.13	1.562

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	169.3	223.1	368.7	248.3	169.2	172.9	1.5	141.1	329.1	319.4
2	178.9	225.4	365.4	248.4	178.9	177.8	1.9	138.6	320.5	312.0
3	186.6	227.4	363.8	242.8	186.6	178.6	0.2	140.7	312.5	305.2
4	198.8	230.4	351.3	223.2	198.8	177.2	-2.7	147.2	287.0	283.0
5	203.7	243.5	328.4	205.3	203.6	183.0	-4.1	160.6	253.5	253.7
6	195.7	259.7	296.4	191.2	195.7	166.3	-3.5	180.9	219.2	224.0
7	182.4	280.6	267.2	186.2	182.4	186.1	-1.8	210.1	193.6	202.0
8	180.9	288.8	259.9	187.2	180.9	185.2	-1.4	221.6	185.1	194.7
9	181.1	294.3	254.5	187.2	181.1	181.9	-2.3	231.3	176.5	187.1

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	0.509	0.632	1.110	0.703	0.509	0.490	1.021	1.476
2	0.540	0.641	1.104	0.706	0.540	0.505	0.994	1.469
3	0.565	0.648	1.102	0.692	0.565	0.509	0.957	1.469
4	0.605	0.659	1.070	0.639	0.605	0.507	0.891	1.480
5	0.622	0.703	1.002	0.592	0.621	0.528	0.898	1.508
6	0.596	0.755	0.902	0.556	0.595	0.542	0.952	1.436
7	0.552	0.821	0.809	0.545	0.552	0.544	1.020	1.345
8	0.548	0.847	0.787	0.549	0.548	0.543	1.024	1.308
9	0.548	0.865	0.770	0.550	0.548	0.535	1.005	1.275

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	1.1	7.3	0.463	0.866	0.113	0.077	0.029	0.020
2	10.00	4.3	0.8	6.1	0.452	0.896	0.087	0.052	0.022	0.013
3	15.00	4.4	0.8	5.3	0.466	0.908	0.076	0.042	0.020	0.011
4	30.00	5.0	0.9	5.6	0.502	0.910	0.076	0.044	0.020	0.011
5	50.00	6.3	0.8	6.3	0.520	0.926	0.067	0.038	0.017	0.010
6	70.00	9.3	1.5	8.7	0.513	0.919	0.085	0.073	0.021	0.018
7	85.00	13.3	3.0	8.6	0.483	0.906	0.121	0.119	0.027	0.027
8	90.00	14.8	3.2	8.3	0.467	0.906	0.129	0.129	0.027	0.027
9	95.00	16.3	3.2	8.4	0.457	0.907	0.132	0.132	0.026	0.026

TABLE VII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 15

(d) 90 Percent of design speed; intrablade row instrumentation at station 2a; reading number 564

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	24.133	23.424	-0.4	27.9	60.5	48.2	288.7	1.089	10.07	1.295
2	23.510	22.885	-0.6	27.6	58.6	46.6	288.4	1.090	10.14	1.299
3	22.883	22.347	-0.6	28.1	57.3	44.8	288.2	1.091	10.13	1.312
4	21.026	20.731	-0.8	30.8	53.8	38.7	288.1	1.096	10.14	1.346
5	18.560	18.578	-0.9	34.7	49.7	27.3	288.0	1.102	10.14	1.376
6	16.076	16.426	-0.5	38.8	45.8	12.6	288.0	1.109	10.14	1.404
7	14.194	14.811	-0.6	43.4	43.2	-2.0	288.0	1.117	10.14	1.429
8	13.574	14.272	-0.4	45.7	42.1	-7.9	288.0	1.120	10.14	1.446
9	12.959	13.734	-1.0	47.2	41.4	-12.5	288.0	1.124	10.11	1.454

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	167.9	197.4	341.3	261.6	167.9	174.4	-1.0	92.5	296.1	287.5
2	177.3	200.2	340.0	258.5	177.3	177.4	-1.8	92.8	288.4	280.7
3	181.7	203.4	336.0	253.0	181.7	179.4	-1.9	95.8	280.7	274.1
4	191.5	212.3	324.0	233.9	191.5	182.5	-2.8	108.6	258.6	255.0
5	195.4	229.6	302.4	212.3	195.4	188.7	-2.9	130.8	227.9	228.1
6	193.5	251.8	277.8	201.0	193.5	196.1	-1.7	158.0	197.5	201.8
7	187.6	274.6	257.3	199.5	187.6	199.4	-1.9	188.8	174.2	181.8
8	186.2	283.4	250.8	199.9	186.2	198.0	-1.2	202.8	166.8	175.4
9	184.2	289.4	245.7	201.4	184.2	196.6	-3.3	212.4	159.3	168.8

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	0.505	0.573	1.027	0.760	0.505	0.506	1.039	1.356
2	0.536	0.582	1.027	0.751	0.535	0.516	1.001	1.355
3	0.550	0.592	1.017	0.736	0.550	0.522	0.987	1.360
4	0.581	0.619	0.984	0.681	0.581	0.532	0.953	1.370
5	0.594	0.671	0.920	0.621	0.594	0.552	0.966	1.327
6	0.588	0.741	0.844	0.591	0.588	0.577	1.014	1.263
7	0.569	0.813	0.780	0.590	0.569	0.590	1.063	1.196
8	0.565	0.841	0.761	0.593	0.565	0.588	1.063	1.166
9	0.558	0.860	0.744	0.598	0.558	0.584	1.067	1.151

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	2.3	-1.1	9.6	0.332	0.859	0.079	0.066	0.019	0.016
2	10.00	2.2	-1.3	8.5	0.338	0.859	0.080	0.067	0.020	0.017
3	15.00	2.5	-1.0	7.5	0.348	0.884	0.068	0.055	0.017	0.014
4	30.00	3.3	-0.9	6.9	0.389	0.927	0.047	0.036	0.012	0.009
5	50.00	4.3	-1.2	6.6	0.426	0.941	0.045	0.041	0.012	0.010
6	70.00	6.5	-1.3	8.3	0.423	0.937	0.058	0.058	0.014	0.014
7	85.00	9.6	-0.8	9.1	0.393	0.920	0.089	0.089	0.020	0.020
8	90.00	10.9	-0.7	8.7	0.381	0.924	0.090	0.090	0.019	0.019
9	95.00	13.1	-0.0	9.6	0.364	0.913	0.110	0.110	0.022	0.022

TABLE VII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 15

(e) 90 Percent of design speed; intrablade row instrumentation at station 2a; reading number 567

	RADII		ABS BETAM		REL BETAM		TOTAL TEMP		TOTAL PRESS	
RP	IN	OUT	IN	OUT	IN	OUT	IN	RATIO	IN	RATIO
1	24.133	23.424	-0.4	35.1	62.7	45.8	288.8	1.114	10.07	1.418
2	23.510	22.885	-0.5	34.6	60.7	44.5	288.4	1.113	10.13	1.412
3	22.883	22.347	-0.8	35.1	59.4	43.1	288.3	1.112	10.14	1.410
4	21.026	20.731	-1.4	37.1	56.2	37.8	288.1	1.110	10.14	1.412
5	18.560	18.578	-1.2	40.3	52.4	27.8	288.0	1.109	10.14	1.401
6	16.076	16.426	-0.6	43.7	49.2	14.1	287.9	1.111	10.13	1.404
7	14.194	14.811	-0.4	48.3	47.0	-2.9	288.0	1.119	10.14	1.438
8	13.574	14.272	-0.5	49.7	45.9	-8.8	288.0	1.122	10.14	1.457
9	12.959	13.734	-0.7	51.1	44.9	-13.7	288.0	1.123	10.12	1.458

	ABS VEL		REL VEL		MERID VEL		TANG VEL		WHEEL SPEED	
RP	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
1	153.7	203.7	335.4	238.7	153.7	166.5	-1.0	117.2	297.0	288.3
2	163.3	204.6	333.4	236.1	163.2	168.4	-1.4	116.2	289.3	281.6
3	168.3	205.3	330.3	230.2	168.2	168.0	-2.3	117.9	281.9	275.3
4	176.0	208.8	316.4	210.8	176.0	166.6	-4.2	125.9	258.7	255.1
5	178.6	217.8	292.9	188.0	178.6	166.2	-3.8	140.8	228.4	228.6
6	172.9	232.3	264.4	175.1	172.9	167.9	-1.8	160.6	198.3	202.6
7	164.4	255.9	241.0	170.4	164.4	170.2	-1.2	191.2	175.0	182.7
8	163.5	265.9	235.1	173.9	163.5	171.8	-1.4	202.9	167.6	176.2
9	162.4	271.1	229.3	175.3	162.4	170.3	-1.9	210.9	159.9	169.5

	ABS MACH NO		REL MACH NO		MERID MACH NO		MERID PEAK SS	
RP	IN	OUT	IN	OUT	IN	OUT	VEL R	MACH NO
1	0.461	0.586	1.005	0.686	0.461	0.479	1.083	1.426
2	0.491	0.589	1.003	0.680	0.491	0.485	1.032	1.422
3	0.507	0.592	0.995	0.664	0.507	0.484	0.999	1.423
4	0.532	0.603	0.956	0.609	0.532	0.481	0.946	1.410
5	0.540	0.632	0.886	0.545	0.540	0.482	0.931	1.359
6	0.522	0.677	0.798	0.504	0.522	0.489	0.971	1.284
7	0.495	0.750	0.726	0.499	0.495	0.499	1.035	1.206
8	0.492	0.782	0.707	0.511	0.492	0.505	1.051	1.177
9	0.489	0.799	0.690	0.516	0.489	0.502	1.048	1.148

	PERCENT	INCIDENCE		DEV	D-FACT	EFF	LOSS COEFF		LOSS PARAM	
RP	SPAN	MEAN	SS				TOT	PROF	TOT	PROF
1	5.00	4.5	1.1	7.2	0.415	0.920	0.058	0.039	0.015	0.010
2	10.00	4.3	0.8	6.3	0.416	0.919	0.058	0.041	0.015	0.010
3	15.00	4.7	1.1	5.8	0.429	0.924	0.055	0.038	0.014	0.010
4	30.00	5.7	1.5	5.9	0.466	0.938	0.047	0.035	0.012	0.009
5	50.00	7.0	1.5	7.2	0.501	0.926	0.063	0.058	0.016	0.015
6	70.00	9.8	2.0	9.8	0.502	0.918	0.084	0.083	0.020	0.020
7	85.00	13.4	3.0	8.3	0.475	0.918	0.104	0.104	0.023	0.023
8	90.00	14.8	3.2	7.7	0.450	0.932	0.092	0.092	0.019	0.019
9	95.00	16.6	3.4	8.4	0.430	0.927	0.103	0.103	0.020	0.020

TABLE VII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 15

(f) 90 Percent of design speed; intrablade row instrumentation at station 2a; reading number 545

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	24.133	23.424	-0.6	46.4	67.9	48.3	289.0	1.134	10.07	1.389
2	23.510	22.885	-0.5	43.1	65.8	46.2	288.5	1.130	10.12	1.391
3	22.883	22.347	-0.9	41.8	64.5	44.5	288.3	1.127	10.14	1.394
4	21.026	20.731	-1.8	43.2	61.7	39.9	288.1	1.120	10.14	1.382
5	18.560	18.578	-1.8	46.8	58.2	29.3	288.1	1.117	10.14	1.378
6	16.076	16.426	-1.0	47.0	54.0	14.0	287.9	1.114	10.14	1.396
7	14.194	14.811	-0.4	49.6	50.9	-2.4	287.9	1.121	10.14	1.429
8	13.574	14.272	-0.2	50.5	49.6	-8.5	287.8	1.123	10.14	1.455
9	12.959	13.734	-0.2	51.5	48.3	-13.5	287.9	1.124	10.12	1.464

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	121.0	192.1	321.8	199.2	121.0	132.4	-1.3	139.2	296.8	288.1
2	130.1	194.2	317.2	204.9	130.1	141.8	-1.0	132.7	288.3	280.6
3	134.7	195.8	313.1	204.6	134.7	145.8	-2.0	130.6	280.6	274.0
4	141.6	196.5	298.3	186.7	141.5	143.2	-4.5	134.6	258.0	254.4
5	144.3	205.2	273.7	161.1	144.2	140.5	-4.5	149.6	228.1	228.3
6	144.9	223.5	246.6	157.1	144.9	152.4	-2.5	163.4	197.0	201.3
7	142.4	247.5	225.8	160.5	142.3	160.3	-1.1	188.6	174.1	181.7
8	142.0	258.7	219.3	166.4	142.0	164.6	-0.6	199.6	166.5	175.1
9	141.9	266.0	213.3	170.5	141.9	165.8	-0.5	208.0	158.7	168.2

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	0.360	0.545	0.956	0.565	0.360	0.375	1.094	1.532
2	0.388	0.553	0.946	0.583	0.388	0.404	1.090	1.508
3	0.402	0.559	0.935	0.584	0.402	0.416	1.083	1.500
4	0.423	0.563	0.892	0.535	0.423	0.410	1.012	1.482
5	0.432	0.590	0.819	0.463	0.432	0.404	0.974	1.417
6	0.434	0.648	0.739	0.455	0.434	0.442	1.052	1.310
7	0.426	0.722	0.676	0.468	0.426	0.468	1.126	1.214
8	0.425	0.758	0.657	0.488	0.425	0.482	1.159	1.175
9	0.425	0.782	0.638	0.501	0.425	0.487	1.168	1.136

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	9.7	6.3	9.8	0.538	0.732	0.234	0.206	0.057	0.050
2	10.00	9.4	6.0	8.1	0.503	0.760	0.209	0.186	0.052	0.046
3	15.00	9.8	6.2	7.2	0.493	0.787	0.185	0.164	0.046	0.041
4	30.00	11.2	7.0	8.1	0.524	0.808	0.172	0.157	0.043	0.039
5	50.00	12.8	7.3	8.6	0.574	0.819	0.182	0.177	0.046	0.045
6	70.00	14.6	6.9	9.7	0.535	0.875	0.146	0.146	0.036	0.036
7	85.00	17.3	7.0	8.7	0.480	0.888	0.160	0.160	0.036	0.036
8	90.00	18.5	6.9	8.1	0.441	0.922	0.119	0.119	0.025	0.025
9	95.00	20.0	6.8	8.6	0.405	0.930	0.113	0.113	0.022	0.022

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

EDGES FOR ROTOR 15

(g) 80 Percent of design speed; intrablade row instrumentation at station 2a; reading number 572

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	24.133	23.424	-0.5	52.8	70.7	52.2	288.6	1.111	10.09	1.283
2	23.510	22.885	-0.6	47.8	68.9	48.7	288.3	1.106	10.13	1.289
3	22.883	22.347	-0.6	45.8	67.9	46.5	288.3	1.102	10.13	1.294
4	21.026	20.731	-1.1	49.9	65.4	42.1	288.1	1.098	10.14	1.280
5	18.560	18.578	-1.8	53.3	62.2	30.3	288.0	1.096	10.13	1.278
6	16.076	16.426	-1.7	51.2	57.9	12.3	288.0	1.094	10.14	1.306
7	14.194	14.811	-0.8	50.9	54.2	-3.1	288.0	1.096	10.14	1.337
8	13.574	14.272	-0.5	51.9	52.7	-9.4	287.9	1.097	10.13	1.352
9	12.959	13.734	-0.6	52.8	51.3	-14.8	288.1	1.098	10.13	1.363

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	92.7	162.7	280.7	160.4	92.7	98.4	-0.9	129.6	264.1	256.3
2	99.7	166.4	277.0	169.5	99.7	111.9	-1.0	123.2	257.4	250.6
3	102.2	168.6	271.8	170.9	102.2	117.5	-1.1	120.8	250.8	244.9
4	106.4	168.3	255.4	146.3	106.4	108.5	-2.1	128.7	230.2	226.9
5	108.6	176.4	233.1	122.0	108.5	105.3	-3.4	141.6	202.9	203.1
6	112.3	196.0	211.3	125.7	112.3	122.8	-3.3	152.7	175.7	179.5
7	113.0	218.3	193.4	137.9	113.0	137.7	-1.7	169.5	155.2	162.0
8	113.7	227.6	187.6	142.5	113.7	140.6	-1.0	179.0	148.2	155.9
9	114.4	235.6	183.2	147.2	114.4	142.4	-1.3	187.8	141.8	150.2

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	0.274	0.463	0.831	0.456	0.274	0.280	1.061	1.410
2	0.296	0.475	0.821	0.484	0.296	0.319	1.122	1.396
3	0.303	0.483	0.806	0.489	0.303	0.336	1.150	1.386
4	0.316	0.483	0.758	0.420	0.316	0.311	1.020	1.355
5	0.322	0.508	0.692	0.351	0.322	0.303	0.970	1.294
6	0.334	0.568	0.628	0.365	0.334	0.356	1.094	1.199
7	0.336	0.638	0.575	0.403	0.336	0.402	1.218	1.099
8	0.338	0.667	0.558	0.417	0.338	0.412	1.237	1.058
9	0.340	0.692	0.544	0.432	0.340	0.418	1.244	1.027

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	12.5	9.1	13.6	0.596	0.662	0.306	0.301	0.068	0.067
2	10.00	12.5	9.1	10.6	0.546	0.707	0.261	0.257	0.061	0.061
3	15.00	13.2	9.6	9.2	0.526	0.747	0.225	0.222	0.054	0.053
4	30.00	14.9	10.7	10.3	0.592	0.743	0.245	0.244	0.059	0.059
5	50.00	16.8	11.3	9.7	0.657	0.754	0.270	0.270	0.067	0.067
6	70.00	18.5	10.7	8.0	0.593	0.842	0.201	0.201	0.050	0.050
7	85.00	20.6	10.3	8.0	0.488	0.902	0.150	0.150	0.033	0.033
8	90.00	21.6	10.0	7.2	0.450	0.927	0.119	0.119	0.025	0.025
9	95.00	23.0	9.9	7.3	0.412	0.944	0.097	0.097	0.019	0.019

TABLE VII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 15

(h) 70 Percent of design speed; intrablade row instrumentation at station 2a; reading number 573

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	24.133	23.424	0.4	20.5	60.0	47.7	288.5	1.043	10.08	1.141
2	23.510	22.885	0.0	20.5	57.8	46.4	288.3	1.043	10.14	1.142
3	22.883	22.347	-0.1	21.3	56.6	44.9	288.3	1.044	10.13	1.148
4	21.026	20.731	-0.4	24.4	53.0	39.3	288.1	1.048	10.14	1.170
5	18.560	18.578	-0.9	29.5	49.1	28.2	288.1	1.055	10.14	1.196
6	16.076	16.426	-0.9	34.7	45.4	13.8	288.0	1.063	10.14	1.224
7	14.194	14.811	-0.6	40.5	42.4	-1.2	288.0	1.072	10.14	1.255
8	13.574	14.272	-0.8	42.8	41.5	-7.0	288.0	1.074	10.13	1.268
9	12.959	13.734	-0.6	44.8	40.3	-12.3	288.1	1.077	10.12	1.275

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	132.4	161.6	264.7	225.1	132.4	151.4	0.8	56.7	230.0	223.3
2	141.0	163.8	264.9	222.4	141.0	153.4	0.1	57.5	224.4	218.4
3	144.3	165.4	262.2	217.6	144.3	154.1	-0.2	60.0	218.7	213.6
4	151.9	170.5	252.4	200.8	151.9	155.3	-1.1	70.5	200.6	197.8
5	155.4	184.5	237.3	182.2	155.3	160.6	-2.4	90.9	176.9	177.1
6	153.6	202.9	218.6	171.8	153.6	166.8	-2.4	115.5	153.3	156.6
7	149.4	222.8	202.5	169.5	149.4	169.5	-1.4	144.6	135.2	141.1
8	148.6	231.2	198.6	171.1	148.6	169.8	-2.1	157.0	129.6	136.2
9	147.5	238.2	193.4	173.1	147.5	169.1	-1.6	167.8	123.4	130.8

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	0.475	0.789	0.662	0.395	0.445	1.143	1.050
2	0.422	0.482	0.792	0.654	0.422	0.451	1.088	1.047
3	0.432	0.487	0.785	0.640	0.432	0.453	1.068	1.046
4	0.455	0.502	0.757	0.591	0.455	0.457	1.023	1.034
5	0.466	0.543	0.712	0.537	0.466	0.473	1.034	1.012
6	0.461	0.599	0.656	0.507	0.461	0.492	1.086	0.971
7	0.448	0.660	0.607	0.502	0.448	0.502	1.134	0.915
8	0.446	0.686	0.595	0.507	0.445	0.504	1.142	0.902
9	0.442	0.708	0.580	0.514	0.442	0.502	1.146	0.874

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	1.7	-1.6	9.2	0.226	0.894	0.045	0.045	0.011	0.011
2	10.00	1.5	-2.0	8.2	0.237	0.893	0.045	0.045	0.011	0.011
3	15.00	1.9	-1.7	7.6	0.250	0.913	0.038	0.038	0.009	0.009
4	30.00	2.5	-1.7	7.5	0.296	0.953	0.024	0.024	0.006	0.006
5	50.00	3.7	-1.8	7.6	0.346	0.951	0.031	0.031	0.008	0.008
6	70.00	6.0	-1.8	9.5	0.352	0.944	0.047	0.047	0.011	0.011
7	85.00	8.8	-1.5	9.9	0.327	0.934	0.070	0.070	0.016	0.016
8	90.00	10.4	-1.2	9.6	0.314	0.943	0.065	0.065	0.014	0.014
9	95.00	12.0	-1.2	9.8	0.288	0.935	0.080	0.080	0.016	0.016

TABLE VII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 15

(i) 70 Percent of design speed; intrablade row instrumentation at station 2a; reading number 575

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	24.133	23.424	0.0	34.0	64.7	47.0	288.6	1.066	10.10	1.222
2	23.510	22.885	0.2	33.2	62.8	45.9	288.3	1.065	10.13	1.220
3	22.883	22.347	-0.1	33.6	61.6	44.5	288.1	1.063	10.13	1.219
4	21.026	20.731	-0.5	36.2	58.5	39.7	288.2	1.063	10.13	1.220
5	18.560	18.578	-1.3	39.8	55.2	29.5	288.1	1.064	10.14	1.225
6	16.076	16.426	-0.8	43.4	51.6	15.1	288.0	1.066	10.14	1.230
7	14.194	14.811	-0.7	47.5	48.9	-1.0	288.0	1.072	10.14	1.251
8	13.574	14.272	-0.5	48.9	47.6	-7.6	288.0	1.074	10.13	1.265
9	12.959	13.734	-1.0	50.2	46.5	-12.5	287.9	1.074	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	109.1	154.4	255.1	187.8	109.1	128.0	0.0	86.4	230.5	223.8
2	115.3	155.0	252.4	186.4	115.3	129.6	0.3	85.0	224.9	218.9
3	118.0	155.5	248.4	181.7	118.0	129.5	-0.1	86.0	218.4	213.3
4	123.8	156.9	236.8	164.8	123.8	126.7	-1.1	92.6	200.7	197.9
5	125.7	165.8	220.1	146.4	125.6	127.5	-2.9	106.1	177.9	178.1
6	123.5	178.1	198.6	134.1	123.5	129.5	-1.7	122.3	153.8	157.2
7	119.9	195.6	182.5	132.2	119.9	132.2	-1.5	144.2	136.0	141.9
8	119.7	205.1	177.4	135.9	119.7	134.7	-1.0	154.6	129.9	136.6
9	119.3	209.5	173.4	137.5	119.3	134.2	-2.1	160.9	123.8	131.2

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	0.324	0.448	0.757	0.545	0.324	0.371	1.173	1.130
2	0.343	0.450	0.750	0.541	0.343	0.377	1.124	1.121
3	0.351	0.452	0.739	0.528	0.351	0.377	1.098	1.114
4	0.369	0.456	0.705	0.479	0.369	0.369	1.024	1.095
5	0.375	0.483	0.656	0.427	0.374	0.372	1.015	1.068
6	0.368	0.521	0.592	0.392	0.368	0.379	1.049	1.000
7	0.357	0.573	0.543	0.388	0.357	0.388	1.103	0.938
8	0.356	0.602	0.528	0.399	0.356	0.396	1.125	0.908
9	0.355	0.617	0.516	0.405	0.355	0.395	1.125	0.888

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	6.4	3.1	8.5	0.386	0.896	0.070	0.070	0.017	0.017
2	10.00	6.4	3.0	7.8	0.380	0.904	0.064	0.064	0.016	0.016
3	15.00	6.9	3.3	7.2	0.388	0.923	0.052	0.052	0.013	0.013
4	30.00	8.0	3.8	7.9	0.432	0.927	0.053	0.053	0.013	0.013
5	50.00	9.8	4.3	8.8	0.478	0.926	0.062	0.062	0.016	0.016
6	70.00	12.2	4.4	10.8	0.484	0.920	0.083	0.083	0.020	0.020
7	85.00	15.3	5.0	10.2	0.457	0.925	0.097	0.097	0.022	0.022
8	90.00	16.4	4.8	9.0	0.426	0.944	0.078	0.078	0.016	0.016
9	95.00	18.2	5.1	9.6	0.404	0.939	0.088	0.088	0.018	0.018

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

EDGES FOR ROTOR 15

(j) 70 Percent of design speed; intrablade row instrumentation at station 2a; reading number 550

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	24.133	23.424	-0.1	51.6	71.1	51.9	288.6	1.084	10.10	1.214
2	23.510	22.885	0.3	46.2	69.1	48.9	288.3	1.080	10.12	1.217
3	22.893	22.347	0.2	44.0	68.0	46.8	288.4	1.076	10.13	1.219
4	21.026	20.731	-0.2	47.8	65.3	42.3	288.2	1.074	10.13	1.212
5	18.560	18.578	-0.7	51.4	62.1	31.1	288.0	1.073	10.13	1.208
6	16.076	16.426	-1.0	50.3	58.0	13.1	288.0	1.072	10.14	1.228
7	14.194	14.811	-0.3	50.1	54.3	-3.1	287.9	1.074	10.14	1.261
8	13.574	14.272	-0.4	50.8	53.0	-8.2	287.8	1.074	10.13	1.264
9	12.959	13.734	-0.8	51.5	51.9	-12.7	287.9	1.073	10.13	1.263

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	78.7	141.2	242.4	142.2	78.7	87.8	-0.1	110.6	229.2	222.5
2	85.0	143.7	238.8	151.2	85.0	99.4	0.5	103.8	223.7	217.7
3	87.8	145.4	234.1	152.6	87.8	104.5	0.4	101.1	217.4	212.3
4	92.2	146.1	220.7	132.7	92.2	98.2	-0.3	108.2	200.2	197.4
5	94.1	152.6	201.0	111.2	94.1	95.2	-1.2	119.2	176.5	176.6
6	96.8	170.5	182.6	111.9	96.8	109.0	-1.7	131.1	155.1	156.4
7	97.5	192.8	167.2	123.8	97.5	123.6	-0.5	148.0	135.3	141.2
8	97.6	198.3	162.3	126.7	97.6	125.4	-0.6	153.6	129.0	135.6
9	97.7	202.8	158.2	129.3	97.7	126.1	-1.3	158.8	123.1	130.5

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	0.232	0.405	0.716	0.407	0.232	0.252	1.116	1.224
2	0.251	0.413	0.706	0.435	0.251	0.286	1.169	1.207
3	0.260	0.419	0.692	0.440	0.260	0.301	1.190	1.192
4	0.273	0.422	0.653	0.383	0.273	0.283	1.065	1.166
5	0.279	0.441	0.596	0.322	0.279	0.276	1.012	1.110
6	0.287	0.496	0.541	0.325	0.287	0.317	1.126	1.034
7	0.289	0.564	0.496	0.362	0.289	0.361	1.267	0.950
8	0.289	0.581	0.481	0.371	0.289	0.368	1.285	0.918
9	0.290	0.596	0.469	0.380	0.290	0.370	1.291	0.893

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	12.8	9.5	13.3	0.578	0.676	0.291	0.291	0.065	0.065
2	10.00	12.8	9.3	10.8	0.519	0.721	0.245	0.245	0.058	0.058
3	15.00	13.3	9.7	9.5	0.497	0.763	0.208	0.208	0.050	0.050
4	30.00	14.8	10.6	10.4	0.557	0.764	0.222	0.222	0.053	0.053
5	50.00	16.7	11.2	10.5	0.620	0.765	0.256	0.256	0.064	0.064
6	70.00	18.6	10.8	8.8	0.573	0.841	0.205	0.205	0.050	0.050
7	85.00	20.7	10.4	8.0	0.462	0.918	0.129	0.129	0.029	0.029
8	90.00	21.9	10.3	8.4	0.427	0.935	0.108	0.108	0.023	0.023
9	95.00	23.5	10.4	9.4	0.395	0.942	0.099	0.099	0.020	0.020

TABLE VII. - Concluded. BLADE-ELEMENT DATA AT BLADE EDGES FOR ROTOR 15

(k) 50 Percent of design speed; intrablade row instrumentation at station 2a; reading number 579

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	24.133	23.424	37.7	55.5	78.9	53.2	290.9	1.030	10.09	1.110
2	23.510	22.885	48.5	57.7	79.2	51.7	292.2	1.024	10.06	1.106
3	22.883	22.347	29.0	54.6	71.3	49.6	291.2	1.025	10.08	1.101
4	21.026	20.731	4.6	50.2	63.6	44.1	288.8	1.029	10.08	1.086
5	18.560	18.578	-1.1	46.5	60.1	31.6	287.3	1.034	10.15	1.093
6	16.076	16.426	-1.2	46.6	56.5	15.7	286.9	1.036	10.17	1.100
7	14.194	14.811	-1.3	47.3	53.1	-1.0	286.7	1.039	10.18	1.113
8	13.574	14.272	-1.3	48.0	51.8	-6.9	286.6	1.040	10.18	1.121
9	12.959	13.734	-1.7	49.7	50.7	-12.7	287.0	1.042	10.17	1.124

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	35.2	100.7	145.3	95.3	27.9	57.0	21.5	83.0	164.2	159.3
2	37.9	102.5	134.1	88.2	25.1	54.7	28.4	86.6	160.1	155.8
3	50.7	101.5	138.2	90.7	44.4	58.8	24.6	82.7	155.4	151.8
4	68.2	101.2	153.0	90.2	68.0	64.8	5.5	77.8	142.6	140.6
5	73.7	110.3	147.6	89.1	73.6	75.9	-1.4	80.0	126.5	126.7
6	73.5	121.8	133.2	86.9	73.5	83.7	-1.5	88.5	109.5	111.9
7	73.6	139.2	122.7	94.3	73.6	94.3	-1.7	102.3	96.5	100.7
8	73.9	146.6	119.6	98.8	73.9	98.1	-1.7	108.9	92.3	97.1
9	74.2	151.8	117.0	100.7	74.1	98.3	-2.2	115.8	88.3	93.6

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	0.103	0.293	0.426	0.277	0.082	0.166	2.044	0.845
2	0.111	0.298	0.392	0.257	0.073	0.159	2.181	0.809
3	0.149	0.295	0.405	0.264	0.130	0.171	1.326	0.743
4	0.201	0.295	0.451	0.263	0.200	0.189	0.953	0.779
5	0.218	0.322	0.436	0.260	0.218	0.222	1.030	0.783
6	0.218	0.357	0.394	0.255	0.218	0.245	1.138	0.733
7	0.218	0.409	0.363	0.277	0.218	0.277	1.281	0.680
8	0.219	0.431	0.354	0.291	0.219	0.289	1.328	0.661
9	0.219	0.447	0.346	0.296	0.219	0.289	1.325	0.645

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	20.7	17.4	14.7	0.495	1.001	-0.001	-0.001	-0.000	-0.000
2	10.00	22.9	19.4	13.5	0.493	1.209	-0.172	-0.172	-0.038	-0.038
3	15.00	16.6	13.0	12.3	0.487	1.094	-0.076	-0.076	-0.017	-0.017
4	30.00	13.1	8.9	12.3	0.563	0.810	0.145	0.145	0.034	0.034
5	50.00	14.7	9.2	11.0	0.556	0.756	0.227	0.227	0.056	0.056
6	70.00	17.1	9.3	11.3	0.520	0.762	0.283	0.283	0.069	0.069
7	85.00	19.5	9.2	10.1	0.424	0.789	0.321	0.321	0.071	0.071
8	90.00	20.7	9.1	9.7	0.376	0.821	0.291	0.291	0.061	0.061
9	95.00	22.3	9.2	9.4	0.350	0.810	0.334	0.334	0.066	0.066

TABLE VIII. - BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 9

(a) 100 Percent of design speed; intrablade row instrumentation at station 2a; reading number 558

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	22.949	22.944	27.8	7.5	27.8	7.5	324.2	0.997	14.10	0.925
2	22.479	22.474	27.5	3.9	27.5	3.9	323.7	0.999	14.27	0.970
3	22.004	21.999	27.4	3.1	27.4	3.1	323.5	0.999	14.38	0.973
4	20.577	20.574	29.3	5.4	29.3	5.4	324.2	1.000	14.67	0.960
5	18.682	18.717	32.2	5.8	32.2	5.8	325.7	1.000	14.91	0.952
6	16.787	16.916	35.9	2.6	35.9	2.6	327.4	1.000	15.26	0.946
7	15.342	15.624	41.9	1.5	41.9	1.5	330.9	0.999	15.89	0.926
8	14.849	15.164	44.5	1.8	44.5	1.8	331.6	1.001	15.95	0.940
9	14.343	14.684	47.8	3.7	47.8	3.7	331.2	0.999	15.69	0.904

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	245.5	206.5	245.5	206.5	217.1	204.8	114.7	26.9	0.	0.
2	251.1	228.7	251.1	228.7	222.6	228.2	116.1	15.7	0.	0.
3	255.9	231.1	255.9	231.1	227.1	230.8	117.8	12.6	0.	0.
4	266.4	228.7	266.4	228.7	232.4	227.7	130.3	21.4	0.	0.
5	284.4	230.2	284.4	230.2	240.8	229.0	151.4	23.4	0.	0.
6	301.7	234.6	301.7	234.6	244.5	234.4	176.8	10.8	0.	0.
7	313.9	244.1	313.9	244.1	233.8	244.1	209.5	6.4	0.	0.
8	311.9	248.9	311.9	248.9	222.4	248.7	218.7	7.7	0.	0.
9	304.7	232.1	304.7	232.1	204.6	231.6	225.8	14.9	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	0.714	0.593	0.714	0.593	0.631	0.588	0.943	1.014
2	0.733	0.662	0.733	0.662	0.650	0.660	1.025	1.029
3	0.748	0.669	0.748	0.669	0.664	0.668	1.016	1.045
4	0.782	0.661	0.782	0.661	0.682	0.658	0.980	1.122
5	0.840	0.664	0.840	0.664	0.711	0.660	0.951	1.241
6	0.896	0.676	0.896	0.676	0.726	0.675	0.959	1.363
7	0.933	0.702	0.933	0.702	0.695	0.702	1.044	2.568
8	0.925	0.716	0.925	0.716	0.659	0.715	1.119	0.015
9	0.900	0.664	0.900	0.664	0.605	0.663	1.132	2.745

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	6.6	-7.5	12.3	0.283	0.	0.261	0.261	0.090	0.090
2	10.00	8.0	-6.3	8.4	0.226	0.	0.100	0.100	0.034	0.034
3	15.00	8.8	-5.5	7.4	0.234	0.	0.087	0.087	0.029	0.029
4	30.00	9.0	-4.1	9.9	0.269	0.	0.120	0.120	0.037	0.037
5	50.00	7.3	-3.9	11.0	0.319	0.	0.130	0.130	0.037	0.037
6	70.00	5.0	-4.3	8.6	0.363	0.	0.132	0.126	0.034	0.032
7	85.00	4.6	-3.5	8.3	0.372	0.	0.172	-0.213	0.040	-0.050
8	90.00	4.9	-2.7	8.8	0.353	0.	0.142	0.142	0.032	0.032
9	95.00	6.0	-1.2	11.0	0.387	0.	0.234	-0.249	0.051	-0.054

TABLE VIII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 9

(b) 100 Percent of design speed; intrablade row instrumentation at station 2a; reading number 539

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	22.949	22.944	30.7	7.7	30.7	7.7	328.2	0.998	14.62	0.942
2	22.479	22.474	29.3	5.4	29.3	5.4	327.5	1.000	14.94	0.966
3	22.004	21.999	29.4	3.8	29.4	3.8	327.3	1.000	15.14	0.969
4	20.577	20.574	31.7	3.1	31.7	3.1	327.4	0.999	15.22	0.977
5	18.682	18.717	33.9	3.1	33.9	3.1	327.4	1.000	15.42	0.969
6	16.787	16.916	38.1	1.2	38.1	1.2	328.1	0.999	15.57	0.974
7	15.342	15.624	44.0	1.9	44.0	1.9	329.8	1.001	15.75	0.968
8	14.849	15.164	47.2	3.7	47.2	3.7	330.7	0.999	15.89	0.945
9	14.343	14.684	50.3	4.5	50.3	4.5	330.9	0.999	15.83	0.919

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	242.2	178.1	242.2	178.1	208.2	176.5	123.7	23.9	0.	0.
2	251.5	199.0	251.5	199.0	219.2	198.1	123.2	18.9	0.	0.
3	257.2	205.2	257.2	205.2	224.1	204.7	126.2	13.7	0.	0.
4	264.1	207.2	264.1	207.2	224.6	206.9	138.8	11.1	0.	0.
5	281.0	206.1	281.0	206.1	233.2	205.8	156.9	11.0	0.	0.
6	288.8	207.6	288.8	207.6	227.2	207.6	178.4	4.2	0.	0.
7	291.6	210.8	291.6	210.8	209.8	210.6	202.5	7.1	0.	0.
8	292.7	206.0	292.7	206.0	198.9	205.6	214.7	13.4	0.	0.
9	290.4	194.3	290.4	194.3	185.7	193.7	223.3	15.3	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	0.699	0.503	0.699	0.503	0.601	0.499	0.848	1.061
2	0.729	0.566	0.729	0.566	0.636	0.563	0.904	1.069
3	0.748	0.585	0.748	0.585	0.652	0.583	0.913	1.095
4	0.770	0.591	0.770	0.591	0.655	0.590	0.921	1.169
5	0.826	0.587	0.826	0.587	0.685	0.587	0.883	1.269
6	0.851	0.592	0.851	0.592	0.669	0.592	0.914	1.360
7	0.858	0.599	0.858	0.599	0.617	0.599	1.004	1.457
8	0.860	0.584	0.860	0.584	0.585	0.583	1.033	1.522
9	0.852	0.549	0.852	0.549	0.545	0.547	1.043	1.566

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	9.5	-4.6	12.5	0.408	0.	0.207	0.207	0.071	0.071
2	10.00	9.8	-4.5	9.9	0.350	0.	0.114	0.114	0.039	0.039
3	15.00	10.8	-3.5	8.1	0.349	0.	0.099	0.099	0.033	0.033
4	30.00	11.4	-1.7	7.6	0.367	0.	0.069	0.069	0.022	0.022
5	50.00	9.0	-2.1	8.2	0.414	0.	0.087	0.086	0.025	0.025
6	70.00	7.3	-2.1	7.1	0.435	0.	0.069	0.066	0.018	0.017
7	85.00	6.7	-1.4	8.7	0.432	0.	0.083	0.073	0.019	0.017
8	90.00	7.6	-0.0	10.8	0.449	0.	0.145	0.128	0.032	0.029
9	95.00	8.5	1.2	11.9	0.485	0.	0.214	0.192	0.046	0.042

TABLE VIII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 9

(c) 100 Percent of design speed; intrablade row instrumentation at station 2a; reading number 551

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	22.949	22.944	35.5	6.1	35.5	6.1	334.9	0.998	15.78	0.936
2	22.479	22.474	33.9	4.5	33.9	4.5	333.3	0.998	15.89	0.950
3	22.004	21.999	34.0	4.1	34.0	4.1	332.0	1.000	15.88	0.951
4	20.577	20.574	34.9	3.9	34.9	3.9	330.1	1.000	15.69	0.963
5	18.682	18.717	35.8	3.1	35.8	3.1	328.2	1.001	15.54	0.971
6	16.787	16.916	39.2	1.3	39.2	1.3	328.0	1.000	15.47	0.975
7	15.342	15.624	45.4	2.1	45.4	2.1	329.9	0.999	15.68	0.965
8	14.849	15.164	48.0	3.9	48.0	3.9	330.9	0.997	15.82	0.938
9	14.343	14.684	50.7	4.1	50.7	4.1	331.1	0.997	15.82	0.928

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	247.9	186.7	247.9	186.7	201.8	185.7	144.0	19.7	0.	0.
2	252.7	195.9	252.7	195.9	209.6	195.3	141.1	15.3	0.	0.
3	255.5	195.5	255.5	195.5	211.8	195.0	142.9	14.1	0.	0.
4	259.1	195.1	259.1	195.1	212.4	194.7	148.4	13.1	0.	0.
5	272.7	198.6	272.7	198.6	221.1	198.3	159.7	10.8	0.	0.
6	279.9	198.4	279.9	198.4	216.8	198.3	177.0	4.4	0.	0.
7	284.8	202.6	284.8	202.6	200.0	202.5	202.8	7.6	0.	0.
8	286.9	196.6	286.9	196.6	192.1	196.1	213.0	13.2	0.	0.
9	286.4	192.3	286.4	192.3	181.5	191.8	221.5	13.9	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	0.709	0.523	0.709	0.523	0.577	0.520	0.920	1.192
2	0.726	0.552	0.726	0.552	0.602	0.550	0.932	1.178
3	0.737	0.551	0.737	0.551	0.611	0.550	0.920	1.194
4	0.750	0.552	0.750	0.552	0.615	0.551	0.917	1.220
5	0.797	0.564	0.797	0.564	0.646	0.563	0.897	1.277
6	0.821	0.564	0.821	0.564	0.636	0.564	0.915	1.343
7	0.835	0.575	0.835	0.575	0.586	0.574	1.012	1.459
8	0.841	0.556	0.841	0.556	0.563	0.555	1.021	1.510
9	0.839	0.543	0.839	0.543	0.531	0.542	1.056	1.553

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	14.3	0.2	10.9	0.422	0.	0.225	0.225	0.078	0.078
2	10.00	14.4	0.1	9.0	0.395	0.	0.169	0.169	0.058	0.058
3	15.00	15.4	1.1	8.4	0.404	0.	0.162	0.162	0.054	0.054
4	30.00	14.6	1.5	8.4	0.410	0.	0.118	0.118	0.037	0.037
5	50.00	11.0	-0.2	8.3	0.427	0.	0.085	0.085	0.024	0.024
6	70.00	8.4	-1.0	7.2	0.449	0.	0.069	0.067	0.018	0.017
7	85.00	8.1	0.1	8.9	0.447	0.	0.096	0.087	0.022	0.020
8	90.00	8.4	0.7	10.9	0.470	0.	0.167	0.153	0.037	0.034
9	95.00	8.9	1.7	11.5	0.484	0.	0.196	0.178	0.043	0.039

TABLE VIII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 9

(d) 90 Percent of design speed; intrablade row instrumentation at station 2a; reading number 564

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	22.949	22.944	24.8	6.0	24.8	6.0	314.5	0.999	13.04	0.936
2	22.479	22.474	24.3	2.5	24.3	2.5	314.4	1.000	13.17	0.978
3	22.004	21.999	24.5	1.6	24.5	1.6	314.5	1.000	13.29	0.983
4	20.577	20.574	26.4	2.5	26.4	2.5	315.7	1.000	13.65	0.974
5	18.682	18.717	29.4	3.7	29.4	3.7	317.3	0.999	13.96	0.963
6	16.787	16.916	33.7	1.6	33.7	1.6	319.3	1.001	14.24	0.961
7	15.342	15.624	40.1	0.8	40.1	0.8	321.7	1.001	14.49	0.964
8	14.849	15.164	43.3	1.2	43.3	1.2	322.6	1.002	14.66	0.969
9	14.343	14.684	45.9	3.3	45.9	3.3	323.7	1.000	14.70	0.932

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	224.8	191.8	224.8	191.8	204.0	190.7	94.4	20.2	0.	0.
2	229.8	212.7	229.8	212.7	209.5	212.5	94.5	9.4	0.	0.
3	234.4	216.9	234.4	216.9	213.3	216.8	97.3	6.0	0.	0.
4	246.3	219.0	246.3	219.0	220.7	218.8	109.4	9.6	0.	0.
5	264.9	221.0	264.9	221.0	230.7	220.5	130.1	14.1	0.	0.
6	278.6	226.3	278.6	226.3	231.9	226.2	154.6	6.5	0.	0.
7	283.1	236.7	283.1	236.7	216.5	236.7	182.3	3.3	0.	0.
8	284.2	241.5	284.2	241.5	206.8	241.5	194.9	5.2	0.	0.
9	283.1	229.9	283.1	229.9	197.0	229.5	203.4	13.3	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	0.659	0.556	0.659	0.556	0.598	0.553	0.935	0.866
2	0.675	0.621	0.675	0.621	0.616	0.621	1.014	0.871
3	0.690	0.634	0.690	0.634	0.628	0.634	1.016	0.893
4	0.727	0.640	0.727	0.640	0.652	0.639	0.991	0.969
5	0.786	0.644	0.786	0.644	0.685	0.643	0.956	1.087
6	0.830	0.658	0.830	0.658	0.690	0.658	0.976	1.201
7	0.841	0.688	0.841	0.688	0.644	0.688	1.093	1.318
8	0.844	0.702	0.844	0.702	0.614	0.702	1.168	1.382
9	0.839	0.665	0.839	0.665	0.583	0.664	1.165	1.416

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	3.6	-10.5	10.9	0.262	0.	0.252	0.252	0.087	0.087
2	10.00	4.8	-9.5	7.0	0.201	0.	0.082	0.082	0.028	0.028
3	15.00	5.9	-8.4	5.9	0.205	0.	0.064	0.064	0.021	0.021
4	30.00	6.1	-7.0	7.0	0.238	0.	0.089	0.089	0.028	0.028
5	50.00	4.5	-6.6	8.8	0.290	0.	0.109	0.109	0.031	0.031
6	70.00	2.9	-6.5	7.6	0.323	0.	0.107	0.107	0.027	0.027
7	85.00	2.8	-5.3	7.6	0.310	0.	0.096	0.095	0.022	0.022
8	90.00	3.7	-3.9	8.3	0.299	0.	0.083	0.079	0.019	0.018
9	95.00	4.1	-3.1	10.7	0.332	0.	0.185	0.179	0.040	0.039

TABLE VIII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 9

(e) 90 Percent of design speed; intrablade row instrumentation at station 2a; reading number 567

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	22.949	22.944	31.7	6.8	31.7	6.8	321.7	1.000	14.28	0.943
2	22.479	22.474	31.0	4.6	31.0	4.6	320.8	1.001	14.30	0.975
3	22.004	21.999	31.2	3.6	31.2	3.6	320.5	0.999	14.30	0.979
4	20.577	20.574	32.7	3.1	32.7	3.1	319.9	1.000	14.31	0.980
5	18.682	18.717	35.3	3.0	35.3	3.0	319.4	1.001	14.21	0.984
6	16.787	16.916	39.2	1.5	39.2	1.5	319.9	0.999	14.23	0.979
7	15.342	15.624	45.3	2.0	45.3	2.0	322.3	0.999	14.57	0.974
8	14.849	15.164	47.5	3.5	47.5	3.5	323.1	0.998	14.78	0.955
9	14.343	14.684	49.8	4.5	49.8	4.5	323.3	0.999	14.75	0.935

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	227.6	169.8	227.6	169.8	193.6	168.6	119.7	20.0	0.	0.
2	230.0	185.5	230.0	185.5	197.2	184.9	118.3	14.9	0.	0.
3	231.0	187.2	231.0	187.2	197.5	186.9	119.8	11.7	0.	0.
4	235.0	186.1	235.0	186.1	197.8	185.8	126.9	10.0	0.	0.
5	242.2	185.6	242.2	185.6	197.7	185.4	140.0	9.7	0.	0.
6	248.8	184.3	248.8	184.3	192.9	184.3	157.1	4.9	0.	0.
7	259.5	194.7	259.5	194.7	182.5	194.6	184.6	6.8	0.	0.
8	264.4	193.5	264.4	193.5	178.5	193.1	195.0	11.9	0.	0.
9	264.4	184.7	264.4	184.7	170.7	184.1	201.9	14.6	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	0.660	0.483	0.660	0.483	0.561	0.480	0.871	1.024
2	0.669	0.531	0.669	0.531	0.573	0.529	0.938	1.018
3	0.672	0.537	0.672	0.537	0.575	0.536	0.946	1.027
4	0.686	0.534	0.686	0.534	0.577	0.533	0.939	1.063
5	0.709	0.532	0.709	0.532	0.579	0.532	0.938	1.123
6	0.730	0.529	0.730	0.529	0.566	0.528	0.955	1.192
7	0.762	0.558	0.762	0.558	0.536	0.557	1.066	1.329
8	0.777	0.554	0.777	0.554	0.524	0.553	1.082	1.384
9	0.777	0.527	0.777	0.527	0.501	0.525	1.079	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	10.5	-3.6	11.6	0.407	0.	0.225	0.225	0.078	0.078
2	10.00	11.5	-2.8	9.1	0.347	0.	0.098	0.098	0.033	0.033
3	15.00	12.7	-1.6	7.9	0.346	0.	0.080	0.080	0.027	0.027
4	30.00	12.4	-0.7	7.6	0.364	0.	0.075	0.075	0.023	0.023
5	50.00	10.4	-0.8	8.1	0.387	0.	0.056	0.056	0.016	0.016
6	70.00	8.3	-1.1	7.5	0.415	0.	0.072	0.072	0.018	0.018
7	85.00	8.0	-0.0	8.8	0.408	0.	0.081	0.081	0.019	0.019
8	90.00	8.0	0.3	10.6	0.422	0.	0.138	0.136	0.031	0.031
9	95.00	8.0	0.8	11.9	0.453	0.	0.198	0.195	0.043	0.042

TABLE VIII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 9

(f) 90 Percent of design speed; intrablade row instrumentation at station 2a; reading number 545

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	22.949	22.944	43.2	4.4	43.2	4.4	327.9	0.997	13.99	0.938
2	22.479	22.474	39.6	3.5	39.6	3.5	326.0	0.998	14.08	0.941
3	22.004	21.999	38.1	3.2	38.1	3.2	324.8	0.999	14.13	0.941
4	20.577	20.574	39.0	3.3	39.0	3.3	322.6	1.000	14.01	0.955
5	18.682	18.717	42.2	2.7	42.2	2.7	321.8	0.998	13.97	0.960
6	16.787	16.916	42.7	2.8	42.7	2.8	320.8	0.999	14.16	0.967
7	15.342	15.624	46.7	2.2	46.7	2.2	322.7	0.998	14.49	0.969
8	14.849	15.164	48.3	3.5	48.3	3.5	323.1	0.998	14.75	0.944
9	14.343	14.684	50.2	4.4	50.2	4.4	323.5	0.998	14.83	0.932

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	207.4	149.7	207.4	9.7	151.1	149.3	142.1	11.4	0.	0.
2	211.9	155.5	211.9	55.5	163.2	155.2	135.1	9.4	0.	0.
3	214.7	156.7	214.7	156.7	168.9	156.5	132.6	8.8	0.	0.
4	215.2	158.6	215.2	158.6	167.2	158.4	135.6	9.1	0.	0.
5	221.4	156.2	221.4	156.2	163.9	156.0	148.8	7.5	0.	0.
6	235.9	164.8	235.9	164.8	173.4	164.6	159.9	8.0	0.	0.
7	250.1	180.1	250.1	180.1	171.5	180.0	182.0	6.8	0.	0.
8	257.0	178.2	257.0	178.2	170.9	177.9	191.9	10.8	0.	0.
9	259.5	175.0	259.5	175.0	166.2	174.5	199.2	13.4	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	0.591	0.420	0.591	0.420	0.431	0.419	0.988	1.152
2	0.607	0.438	0.607	0.438	0.467	0.437	0.951	1.102
3	0.617	0.442	0.617	0.442	0.485	0.442	0.927	1.086
4	0.620	0.449	0.620	0.449	0.482	0.449	0.947	1.096
5	0.640	0.443	0.640	0.443	0.474	0.443	0.952	1.165
6	0.687	0.469	0.687	0.469	0.505	0.469	0.949	1.204
7	0.731	0.514	0.731	0.514	0.501	0.513	1.050	1.309
8	0.752	0.508	0.752	0.508	0.501	0.507	1.041	1.361
9	0.760	0.498	0.760	0.498	0.487	0.496	1.050	1.394

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	22.0	7.9	9.2	0.498	0.	0.294	0.294	0.102	0.102
2	10.00	20.1	5.8	8.0	0.469	0.	0.267	0.267	0.091	0.091
3	15.00	19.6	5.3	7.5	0.463	0.	0.261	0.261	0.087	0.087
4	30.00	18.7	5.6	7.8	0.447	0.	0.196	0.196	0.061	0.061
5	50.00	17.3	6.2	7.9	0.476	0.	0.165	0.165	0.047	0.047
6	70.00	11.9	2.5	8.7	0.465	0.	0.122	0.122	0.031	0.031
7	85.00	9.4	1.4	8.9	0.441	0.	0.105	0.105	0.024	0.024
8	90.00	8.7	1.1	10.5	0.463	0.	0.178	0.177	0.040	0.040
9	95.00	8.4	1.2	11.8	0.479	0.	0.215	0.213	0.046	0.046

TABLE VIII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 9

(g) 80 Percent of design speed; intrablade row instrumentation at station 2a; reading number 572

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	22.949	22.944	50.0	2.3	50.0	2.3	320.7	0.995	12.95	0.945
2	22.479	22.474	44.6	1.6	44.6	1.6	319.0	0.998	13.06	0.936
3	22.004	21.999	42.4	2.1	42.4	2.1	317.8	1.000	13.11	0.933
4	20.577	20.574	46.1	3.2	46.1	3.2	316.4	1.000	12.97	0.953
5	18.682	18.717	49.3	2.5	49.3	2.5	315.8	0.999	12.96	0.962
6	16.787	16.916	47.3	2.5	47.3	2.5	315.1	1.001	13.24	0.980
7	15.342	15.624	48.1	1.4	48.1	1.4	315.6	0.997	13.56	0.961
8	14.849	15.164	49.7	3.1	49.7	3.1	315.9	0.996	13.71	0.946
9	14.343	14.684	51.5	4.7	51.5	4.7	316.4	0.998	13.80	0.939

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	172.7	115.2	172.7	115.2	111.0	115.1	132.3	4.6	0.	0.
2	178.7	115.0	178.7	115.0	127.3	115.0	125.4	3.2	0.	0.
3	182.0	115.5	182.0	115.5	134.4	115.4	122.7	4.3	0.	0.
4	180.0	122.7	180.0	122.7	124.8	122.5	129.7	6.8	0.	0.
5	185.7	127.1	185.7	127.1	121.1	126.9	140.8	5.6	0.	0.
6	203.5	149.9	203.5	149.9	138.2	149.7	149.5	6.5	0.	0.
7	219.9	155.0	219.9	155.0	146.9	154.9	163.6	3.9	0.	0.
8	225.7	153.8	225.7	153.8	146.0	153.6	172.1	8.3	0.	0.
9	229.9	154.5	229.9	154.5	143.2	154.0	179.8	12.7	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	0.493	0.325	0.493	0.325	0.317	0.325	1.037	1.004
2	0.512	0.325	0.512	0.325	0.365	0.325	0.903	1.020
3	0.523	0.327	0.523	0.327	0.386	0.326	0.859	0.999
4	0.518	0.348	0.518	0.348	0.359	0.348	0.982	1.044
5	0.536	0.361	0.536	0.361	0.349	0.361	1.048	1.111
6	0.592	0.429	0.592	0.429	0.402	0.428	1.084	1.131
7	0.642	0.444	0.642	0.444	0.429	0.444	1.055	1.182
8	0.660	0.441	0.660	0.441	0.427	0.440	1.052	1.226
9	0.673	0.442	0.673	0.442	0.420	0.441	1.075	1.266

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	28.8	14.7	7.1	0.591	0.	0.363	0.363	0.126	0.126
2	10.00	25.1	10.8	6.1	0.590	0.	0.389	0.389	0.133	0.133
3	15.00	23.8	9.5	6.4	0.583	0.	0.391	0.391	0.131	0.131
4	30.00	25.8	12.7	7.7	0.532	0.	0.279	0.279	0.087	0.087
5	50.00	24.4	13.2	7.7	0.523	0.	0.215	0.215	0.061	0.061
6	70.00	16.4	7.0	8.4	0.443	0.	0.097	0.097	0.025	0.025
7	85.00	10.8	2.7	8.2	0.463	0.	0.160	0.160	0.037	0.037
8	90.00	10.1	2.5	10.2	0.480	0.	0.214	0.214	0.048	0.048
9	95.00	9.7	2.5	12.1	0.484	0.	0.233	0.233	0.051	0.051

TABLE VIII. - Continued. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 9

(h) 70 Percent of design speed; intrablade row instrumentation at station 2a; reading number 573

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	22.949	22.944	18.4	2.4	18.4	2.4	300.9	1.000	11.50	0.963
2	22.479	22.474	18.2	0.1	18.2	0.1	300.8	1.000	11.58	0.989
3	22.004	21.999	18.8	-0.8	18.8	-0.8	301.0	1.000	11.64	0.992
4	20.577	20.574	21.2	-0.9	21.2	-0.9	302.0	1.000	11.86	0.990
5	18.682	18.717	25.4	-1.1	25.4	-1.1	304.0	1.000	12.12	0.987
6	16.787	16.916	30.4	-1.3	30.4	-1.3	306.1	1.000	12.41	0.987
7	15.342	15.624	37.4	-1.1	37.4	-1.1	308.7	0.998	12.72	0.977
8	14.849	15.164	40.3	0.3	40.3	0.3	309.4	1.000	12.85	0.980
9	14.343	14.684	43.2	2.3	43.2	2.3	310.2	1.001	12.91	0.963

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	183.5	155.0	183.5	155.0	174.2	154.8	57.9	6.4	0.	0.
2	187.1	170.6	187.1	170.6	177.8	170.6	58.5	0.3	0.	0.
3	189.5	174.0	189.5	174.0	179.4	174.0	61.0	-2.3	0.	0.
4	196.3	179.4	196.3	179.4	183.0	179.3	71.0	-2.7	0.	0.
5	210.9	185.4	210.9	185.4	190.5	185.3	90.3	-3.4	0.	0.
6	223.2	193.4	223.2	193.4	192.5	193.3	113.1	-4.4	0.	0.
7	230.1	202.0	230.1	202.0	182.9	202.0	139.6	-3.8	0.	0.
8	233.1	208.1	233.1	208.1	177.7	208.1	150.9	1.0	0.	0.
9	234.5	203.9	234.5	203.9	170.8	203.7	160.6	8.3	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	0.543	0.455	0.543	0.455	0.515	0.454	0.889	0.553
2	0.555	0.503	0.555	0.503	0.527	0.503	0.960	0.555
3	0.562	0.513	0.562	0.513	0.532	0.513	0.970	0.580
4	0.582	0.529	0.582	0.529	0.543	0.529	0.980	0.657
5	0.627	0.546	0.627	0.546	0.566	0.546	0.973	0.774
6	0.664	0.569	0.664	0.569	0.572	0.569	1.005	0.885
7	0.683	0.594	0.683	0.594	0.543	0.594	1.104	1.007
8	0.692	0.612	0.692	0.612	0.527	0.612	1.171	1.064
9	0.695	0.598	0.695	0.598	0.507	0.597	1.193	1.111

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	-16.9	7.2	0.254	0.	0.202	0.202	0.070	0.070
2	10.00	-1.3	-15.6	4.6	0.195	0.	0.061	0.061	0.021	0.021
3	15.00	0.2	-14.1	3.5	0.193	0.	0.041	0.041	0.014	0.014
4	30.00	0.9	-12.2	3.6	0.204	0.	0.047	0.047	0.015	0.015
5	50.00	0.5	-10.7	4.1	0.247	0.	0.054	0.054	0.015	0.015
6	70.00	-0.4	-9.8	4.6	0.268	0.	0.051	0.051	0.013	0.013
7	85.00	0.1	-8.0	5.7	0.266	0.	0.086	0.086	0.020	0.020
8	90.00	0.8	-6.9	7.4	0.251	0.	0.073	0.073	0.016	0.016
9	95.00	1.5	-5.8	9.7	0.270	0.	0.134	0.134	0.029	0.029

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

EDGES FOR STATOR 9

(i) 70 Percent of design speed; intrablade row instrumentation at station 2a; reading number 575

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	22.949	22.944	31.2	6.1	31.2	6.1	307.6	1.001	12.34	0.966
2	22.479	22.474	30.2	4.0	30.2	4.0	307.0	1.001	12.36	0.984
3	22.004	21.999	30.4	2.8	30.4	2.8	306.3	1.000	12.36	0.989
4	20.577	20.574	32.4	2.3	32.4	2.3	306.3	1.000	12.36	0.991
5	18.692	18.717	35.5	2.5	35.5	2.5	306.6	1.000	12.41	0.988
6	16.787	16.916	39.3	1.3	39.3	1.3	307.1	0.999	12.47	0.986
7	15.342	15.624	44.6	1.9	44.6	1.9	308.6	1.000	12.69	0.987
8	14.849	15.164	46.7	3.3	46.7	3.3	309.2	1.000	12.82	0.978
9	14.343	14.684	48.6	4.6	48.6	4.6	309.1	1.000	12.79	0.964

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	170.3	128.1	170.3	128.1	145.6	127.4	88.2	13.7	0.	0.
2	171.7	140.3	171.7	140.3	148.3	139.9	86.5	9.8	0.	0.
3	172.5	142.2	172.5	142.2	148.8	142.0	87.3	7.0	0.	0.
4	173.9	142.0	173.9	142.0	146.7	141.9	93.3	5.7	0.	0.
5	181.7	142.9	181.7	142.9	148.0	142.8	105.5	6.3	0.	0.
6	189.1	145.1	189.1	145.1	146.3	145.1	119.7	3.2	0.	0.
7	198.3	156.2	198.3	156.2	141.3	156.1	139.2	5.1	0.	0.
8	204.3	158.2	204.3	158.2	140.2	157.9	148.6	9.2	0.	0.
9	205.2	150.4	205.2	150.4	135.6	149.9	154.0	12.1	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	0.496	0.369	0.496	0.369	0.424	0.367	0.875	0.761
2	0.501	0.406	0.501	0.406	0.433	0.405	0.943	0.751
3	0.504	0.412	0.504	0.412	0.435	0.412	0.955	0.756
4	0.508	0.412	0.508	0.412	0.429	0.411	0.967	0.784
5	0.532	0.414	0.532	0.414	0.433	0.414	0.965	0.846
6	0.554	0.421	0.554	0.421	0.429	0.420	0.992	0.907
7	0.582	0.452	0.582	0.452	0.415	0.452	1.104	1.000
8	0.600	0.458	0.600	0.458	0.412	0.457	1.126	1.051
9	0.603	0.435	0.603	0.435	0.398	0.433	1.105	1.074

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	10.0	-4.1	11.0	0.400	0.	0.217	0.217	0.075	0.075
2	10.00	10.8	-3.5	8.5	0.336	0.	0.100	0.100	0.034	0.034
3	15.00	11.8	-2.5	7.1	0.331	0.	0.071	0.071	0.024	0.024
4	30.00	12.1	-1.0	6.8	0.341	0.	0.058	0.058	0.018	0.018
5	50.00	10.6	-0.6	7.7	0.369	0.	0.071	0.071	0.020	0.020
6	70.00	8.5	-0.9	7.2	0.389	0.	0.073	0.073	0.019	0.019
7	85.00	7.3	-0.8	8.6	0.369	0.	0.065	0.065	0.015	0.015
8	90.00	7.1	-0.6	10.4	0.378	0.	0.100	0.100	0.022	0.022
9	95.00	6.9	-0.4	12.0	0.415	0.	0.164	0.164	0.035	0.035

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

EDGES FOR STATOR 9

(j) 70 Percent of design speed; intrablade row instrumentation at station 2a; reading number 550

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	22.949	22.944	48.8	2.4	48.8	2.4	312.9	0.996	12.26	0.958
2	22.479	22.474	43.2	2.0	43.2	2.0	311.4	0.998	12.32	0.953
3	22.004	21.999	40.8	2.7	40.8	2.7	310.4	1.001	12.35	0.952
4	20.577	20.574	44.1	3.5	44.1	3.5	309.5	1.000	12.28	0.966
5	18.682	18.717	47.3	2.8	47.3	2.8	308.9	1.000	12.25	0.974
6	16.787	16.916	46.4	2.7	46.4	2.7	308.7	1.000	12.45	0.984
7	15.342	15.624	47.3	2.1	47.3	2.1	309.4	0.997	12.78	0.966
8	14.849	15.164	48.5	3.7	48.5	3.7	309.1	0.997	12.81	0.956
9	14.343	14.684	50.0	5.0	50.0	5.0	309.0	1.000	12.80	0.955

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	150.0	100.3	150.0	100.3	98.8	100.2	112.9	4.2	0.	0.
2	154.4	100.8	154.4	100.8	112.6	100.7	105.7	3.5	0.	0.
3	157.1	101.8	157.1	101.8	118.9	101.7	102.6	4.7	0.	0.
4	156.7	108.7	156.7	108.7	112.6	108.5	109.0	6.6	0.	0.
5	161.2	112.2	161.2	112.2	109.2	112.1	118.5	5.5	0.	0.
6	177.2	129.8	177.2	129.8	122.2	129.7	128.3	6.2	0.	0.
7	194.4	136.1	194.4	136.1	131.8	136.0	142.8	5.0	0.	0.
8	197.0	132.9	197.0	132.9	130.4	132.7	147.7	8.5	0.	0.
9	198.4	133.5	198.4	133.5	127.4	133.0	152.0	11.7	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	0.431	0.286	0.431	0.286	0.284	0.286	1.014	0.928
2	0.445	0.288	0.445	0.288	0.324	0.287	0.895	0.864
3	0.454	0.290	0.454	0.290	0.344	0.290	0.855	0.842
4	0.453	0.311	0.453	0.311	0.326	0.311	0.963	0.880
5	0.467	0.322	0.467	0.322	0.317	0.321	1.026	0.935
6	0.516	0.374	0.516	0.374	0.356	0.373	1.061	0.971
7	0.569	0.392	0.569	0.392	0.386	0.392	1.032	1.031
8	0.577	0.383	0.577	0.383	0.382	0.382	1.017	1.049
9	0.582	0.384	0.582	0.384	0.374	0.383	1.044	1.064

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	27.6	13.5	7.2	0.584	0.	0.353	0.353	0.123	0.123
2	10.00	23.7	9.4	6.5	0.573	0.	0.370	0.370	0.126	0.126
3	15.00	22.2	7.9	7.0	0.560	0.	0.365	0.365	0.122	0.122
4	30.00	23.8	10.7	8.0	0.511	0.	0.258	0.258	0.081	0.081
5	50.00	22.5	11.3	7.9	0.503	0.	0.187	0.187	0.053	0.053
6	70.00	15.6	6.2	8.7	0.443	0.	0.098	0.098	0.025	0.025
7	85.00	10.0	1.9	8.9	0.464	0.	0.174	0.174	0.041	0.041
8	90.00	9.0	1.3	10.8	0.482	0.	0.219	0.219	0.049	0.049
9	95.00	8.3	1.0	12.4	0.479	0.	0.217	0.217	0.047	0.047

TABLE VIII. - Concluded. BLADE-ELEMENT DATA AT BLADE EDGES FOR STATOR 9

(k) 50 Percent of design speed; intrablade row instrumentation at station 2a; reading number 579

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	22.949	22.944	53.0	2.6	53.0	2.6	299.6	0.999	11.20	0.979
2	22.479	22.474	55.1	3.2	55.1	3.2	299.2	0.997	11.13	0.981
3	22.004	21.999	51.7	3.1	51.7	3.1	298.7	0.997	11.10	0.986
4	20.577	20.574	46.8	3.1	46.8	3.1	297.4	0.998	10.95	1.002
5	18.682	18.717	42.6	2.6	42.6	2.6	297.1	0.999	11.09	0.999
6	16.787	16.916	42.8	2.2	42.8	2.2	297.2	0.999	11.18	0.997
7	15.342	15.624	44.5	3.1	44.5	3.1	298.0	0.998	11.33	0.984
8	14.849	15.164	45.7	4.0	45.7	4.0	298.2	0.998	11.41	0.972
9	14.343	14.684	48.0	3.1	48.0	3.1	299.0	0.997	11.43	0.964

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	106.0	69.1	106.0	69.1	63.8	69.0	84.7	3.1	0.	0.
2	107.5	69.4	107.5	69.4	61.5	69.3	88.2	3.8	0.	0.
3	107.0	72.3	107.0	72.3	66.3	72.2	84.0	3.9	0.	0.
4	107.6	77.0	107.6	77.0	73.7	76.9	78.4	4.1	0.	0.
5	117.6	85.1	117.6	85.1	86.6	85.0	79.6	3.9	0.	0.
6	127.4	91.2	127.4	91.2	93.5	91.1	86.6	3.5	0.	0.
7	141.0	93.4	141.0	93.4	100.5	93.3	98.8	5.0	0.	0.
8	146.3	89.6	146.3	89.6	102.2	89.4	104.7	6.3	0.	0.
9	149.1	85.2	149.1	85.2	99.7	85.0	110.8	4.6	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	0.308	0.200	0.308	0.200	0.186	0.200	1.083	0.715
2	0.313	0.201	0.313	0.201	0.179	0.201	1.128	0.751
3	0.312	0.210	0.312	0.210	0.193	0.210	1.088	0.704
4	0.314	0.224	0.314	0.224	0.215	0.224	1.043	0.641
5	0.344	0.248	0.344	0.248	0.254	0.248	0.981	0.631
6	0.374	0.266	0.374	0.266	0.274	0.266	0.974	0.657
7	0.414	0.272	0.414	0.272	0.295	0.272	0.928	0.711
8	0.430	0.261	0.430	0.261	0.301	0.260	0.875	0.740
9	0.438	0.248	0.438	0.248	0.293	0.247	0.853	0.772

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	31.8	17.7	7.4	0.616	0.	0.336	0.336	0.117	0.117
2	10.00	35.6	21.3	7.6	0.623	0.	0.289	0.289	0.099	0.099
3	15.00	33.1	18.8	7.4	0.575	0.	0.214	0.214	0.071	0.071
4	30.00	26.5	13.4	7.6	0.501	0.	-0.033	-0.033	-0.010	-0.010
5	50.00	17.7	6.5	7.7	0.460	0.	0.018	0.018	0.005	0.005
6	70.00	12.0	2.6	8.1	0.451	0.	0.037	0.037	0.009	0.009
7	85.00	7.2	-0.9	9.8	0.491	0.	0.147	0.147	0.034	0.034
8	90.00	6.1	-1.5	11.1	0.537	0.	0.235	0.235	0.053	0.053
9	95.00	6.3	-1.0	10.5	0.581	0.	0.287	0.287	0.062	0.062

TABLE IX. - NOISE OF STAGE 15-9 IN ANECHOIC CHAMBER

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

(a) Percent speed, 60; fan actual rotative speed, 7730 rpm; percent weight flow, 62.5

Frequency	Angle from inlet, deg: 0	10	20	30	40	50	60	70	80	90	100	110	120	PWL, dB (re 10^{-13} W)
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	59.6	59.3	58.5	57.6	56.5	57.7	60.2	59.3	58.5	58.5	58.6	56.7	52.3	107.0
125	62.5	62.0	59.2	58.3	58.9	59.2	62.2	63.8	64.4	65.6	66.8	63.9	58.0	112.3
160	60.2	59.5	60.4	60.7	58.6	57.1	58.1	56.7	56.9	56.9	57.0	55.1	52.0	106.4
200	65.2	66.5	66.3	64.7	62.6	62.1	60.8	59.2	58.1	56.9	55.7	54.3	52.5	109.4
250	69.4	68.2	68.3	67.2	66.3	64.5	63.5	60.9	60.3	59.5	58.7	55.5	52.9	111.9
315	68.6	68.9	68.0	67.1	65.5	64.2	63.0	61.4	59.2	58.4	57.6	54.7	51.6	111.6
400	64.1	64.1	63.7	62.8	61.0	60.2	58.7	56.1	54.5	53.8	53.1	50.7	47.3	107.2
500	61.5	61.5	61.1	60.8	59.7	58.4	57.9	55.5	54.7	52.8	51.0	48.2	45.3	105.7
630	63.9	64.2	64.3	63.2	62.4	60.9	59.1	56.5	55.6	54.2	52.7	49.6	46.5	107.9
800	63.1	63.4	63.5	63.2	62.0	60.0	58.5	55.7	53.8	53.2	52.7	49.8	46.4	107.4
1000	59.8	60.6	60.7	60.1	58.5	57.0	55.5	52.1	49.5	47.0	47.6	45.0	42.3	104.1
1250	62.0	61.8	61.4	59.8	58.2	56.7	54.9	51.5	49.2	47.2	46.0	43.2	39.8	104.1
1600	76.4	72.8	67.8	67.3	67.9	66.1	63.3	59.2	55.9	52.1	51.0	48.6	48.2	112.7
2000	86.8	83.2	77.5	76.7	78.5	76.5	73.2	69.1	65.5	61.8	59.9	58.0	57.9	122.9
2500	65.2	64.4	63.2	62.9	62.2	60.4	59.1	55.0	51.7	49.2	48.0	46.4	43.3	107.5
3150	68.3	69.8	67.5	65.8	64.8	63.5	61.2	57.1	53.8	51.8	51.3	49.3	47.4	110.9
4000	69.3	72.0	70.3	69.0	67.3	68.0	65.0	60.4	57.0	54.8	54.3	53.0	50.6	114.3
5000	68.8	70.2	69.6	69.1	68.9	67.3	65.0	61.2	56.9	55.1	55.4	53.1	51.5	114.4
6300	77.2	80.1	79.7	79.0	79.4	79.0	76.3	71.8	68.1	67.6	66.6	63.1	62.0	125.5
8000	76.5	80.7	78.0	74.9	78.5	79.2	74.6	68.3	65.6	68.2	65.2	60.5	62.1	125.0
10000	72.0	72.4	70.8	71.9	72.4	71.6	68.5	63.9	59.3	57.6	57.6	56.7	54.6	119.4
12500	72.2	74.8	74.8	76.1	78.1	76.7	77.0	73.5	66.0	65.5	63.1	60.8	60.6	126.5
16000	67.6	69.5	69.9	72.3	74.0	72.6	73.0	69.6	62.2	61.0	59.1	57.3	56.7	124.4
20000	67.0	66.9	66.7	68.0	68.4	69.4	68.5	64.7	57.7	54.9	54.4	53.3	52.2	122.6
25000	60.9	61.8	61.3	62.3	63.6	62.6	63.7	57.4	51.1	48.6	48.8	47.7	46.4	120.6
31500	52.4	53.9	54.3	55.9	56.1	55.9	57.1	51.0	43.9	41.3	43.3	41.0	39.4	119.2
40000	41.8	44.8	45.1	46.0	47.4	46.1	47.6	42.7	34.6	33.0	34.2	32.1	31.5	118.0
50000	28.2	32.3	32.2	32.5	34.5	32.9	34.9	30.8	22.4	21.9	20.2	19.1	19.7	115.9
63000	11.9	16.0	16.4	15.8	18.8	16.1	18.2	15.5	7.2	7.6	2.6	2.8	5.1	115.5
80000	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	114.4
DBA	89.2	87.6	84.5	83.6	84.8	84.1	81.2	76.8	72.9	72.2	70.6	67.5	66.9	
DBD	88.0	86.3	83.3	82.4	83.4	82.6	79.8	75.7	72.3	71.7	70.6	67.6	66.2	
DBC	87.9	86.2	83.3	82.4	83.4	82.6	79.9	75.9	73.0	72.6	71.8	69.0	66.8	
PNL	101.4	99.9	97.8	96.9	97.2	96.5	93.9	89.8	86.6	85.7	84.8	81.8	80.3	
PNLT	108.2	106.5	102.7	101.9	103.0	102.3	99.1	94.9	91.5	89.4	88.9	86.0	85.5	

NFA 7730 RPM
NFK 7809 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 48 DEG F TWET 45 DEG F
HACT 7.36 GM/M3
BAR 29.2 HG

TABLE IX. - Continued.

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

(b) Percent speed, 60; fan actual rotative speed, 7724 rpm; percent weight flow, 55.7

Frequency	Angle from inlet, deg													PWL, dB (re 10^{-13} W)
	0	10	20	30	40	50	60	70	80	90	100	110	120	
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	57.8	57.8	57.0	55.8	54.7	55.5	58.0	57.3	56.7	56.6	56.6	54.7	50.6	105.1
125	61.5	61.0	57.7	57.0	58.4	58.2	61.4	63.5	63.7	65.0	66.3	63.7	58.0	111.8
160	57.2	57.2	57.4	57.5	56.1	54.6	56.6	54.0	54.1	54.3	54.5	52.6	49.5	103.8
200	62.5	64.2	63.6	62.0	60.1	59.8	59.1	57.0	55.6	54.1	52.7	51.8	50.5	107.0
250	65.9	65.4	64.8	64.4	63.0	62.0	60.8	58.2	56.8	56.1	55.4	53.0	50.2	108.9
315	65.6	65.9	65.0	64.1	63.0	61.0	59.7	58.4	56.0	55.0	54.1	51.7	48.6	108.6
400	60.8	60.8	60.4	59.3	57.5	56.7	55.7	52.8	52.0	50.9	49.8	47.7	44.3	103.9
500	59.0	59.3	58.6	58.5	57.2	55.4	55.2	52.8	51.9	50.2	48.5	45.7	42.5	103.1
630	61.7	62.2	62.1	61.5	60.4	58.6	56.9	54.7	52.9	51.7	50.5	47.1	44.2	105.8
800	60.4	61.2	61.5	60.9	59.5	57.8	56.5	53.4	51.3	50.6	49.9	47.0	44.2	105.1
1000	59.5	59.8	59.7	59.6	57.7	56.2	55.0	51.8	49.0	47.0	46.6	44.2	41.3	103.4
1250	61.0	62.8	63.1	62.3	59.9	58.7	56.4	53.5	50.7	48.9	47.8	45.2	41.5	105.9
1600	78.9	82.0	83.3	80.8	77.6	75.3	72.8	69.2	63.9	61.9	59.0	57.6	55.5	124.1
2000	79.8	80.7	81.2	79.2	76.5	74.7	72.0	68.6	64.3	61.8	59.1	57.5	56.4	122.8
2500	67.2	68.2	67.4	66.9	66.0	63.9	62.4	58.5	54.7	52.4	51.3	50.2	47.3	111.3
3150	69.3	69.8	69.8	69.8	68.6	66.7	64.0	60.4	56.8	54.3	54.3	53.0	50.4	113.8
4000	70.5	71.5	72.3	71.5	70.8	68.7	66.2	61.9	59.0	56.5	56.8	55.5	52.9	116.2
5000	72.8	73.7	74.3	73.6	73.2	70.6	68.0	63.7	60.6	58.8	58.9	57.4	55.7	118.4
6300	77.7	80.3	81.0	80.0	78.9	77.0	75.0	71.8	68.6	65.8	65.8	63.6	62.0	125.2
8000	73.2	75.2	75.7	75.9	75.0	73.5	70.1	66.1	63.1	61.4	60.9	59.5	57.6	121.4
10000	71.7	72.9	73.8	74.4	74.9	73.3	71.3	65.9	61.5	59.8	60.3	58.9	57.3	121.6
12500	73.2	74.1	74.8	76.6	75.9	77.7	76.3	72.7	66.5	64.5	65.4	61.8	59.4	126.1
16000	67.9	69.0	69.9	70.8	70.5	70.1	71.0	65.6	60.5	57.2	57.4	56.1	54.2	122.0
20000	68.5	68.1	68.0	68.5	68.6	67.9	68.5	62.2	56.2	53.7	54.4	53.3	52.2	122.3
25000	62.9	63.3	62.8	63.3	64.1	62.9	63.5	57.4	51.1	48.3	49.8	48.7	46.9	121.0
31500	53.6	55.2	55.5	56.4	57.1	55.9	57.1	50.5	43.6	40.8	43.3	41.5	39.9	119.6
40000	44.3	46.6	46.9	46.7	48.7	46.9	48.9	43.2	34.6	33.5	35.2	33.1	32.3	119.1
50000	30.9	34.3	34.5	33.5	36.0	32.9	35.9	31.3	22.4	22.4	21.2	20.3	20.9	116.9
63000	14.9	20.3	19.2	17.8	20.3	17.1	18.9	16.0	7.7	8.1	3.4	3.8	5.8	116.7
80000	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	115.5
DBA	85.7	87.6	88.4	86.9	85.1	83.4	81.1	77.4	73.4	71.1	70.5	68.6	66.7	
DBB	84.5	86.4	87.2	85.6	83.7	82.0	79.7	76.2	72.4	70.6	70.1	68.1	65.7	
DBC	84.5	86.3	87.1	85.5	83.6	81.9	79.7	76.4	72.9	71.4	71.2	69.1	66.3	
PNL	97.7	99.1	99.6	98.7	97.5	95.6	93.6	90.2	87.1	84.8	84.5	82.5	80.5	
PNLT	103.0	102.5	102.8	102.0	100.6	98.7	96.8	93.5	91.0	88.0	87.8	85.6	84.5	

NFA 7724 RPM
NFK 7803 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 48 DEG F THET 45 DEG F
HACT 7.36 GM/M3
BAR 29.2 HG

TABLE IX. - Continued.

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

(c) Percent speed, 60; fan actual rotative speed, 7749 rpm; percent weight flow, 51.2

Frequency	Angle from inlet, deg													PWL, dB (re 10^{-13} W)
	0	10	20	30	40	50	60	70	80	90	100	110	120	
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	57.3	58.3	56.5	55.1	54.0	55.0	57.5	56.3	55.7	55.8	55.8	54.0	49.3	104.3
125	60.0	61.3	57.7	57.3	57.7	57.9	61.7	63.3	62.9	64.6	66.3	63.9	58.5	111.7
160	57.0	57.5	57.1	57.0	55.6	53.6	56.1	53.7	53.6	53.8	54.0	51.9	49.5	103.3
200	62.5	63.7	63.8	62.0	60.1	59.1	58.3	56.2	55.3	53.9	52.5	51.3	50.5	106.7
250	64.7	64.2	64.0	63.2	62.0	60.5	59.5	56.9	55.8	54.8	53.9	51.8	48.9	107.7
315	64.1	64.6	63.7	63.1	61.2	59.7	58.5	57.4	54.7	53.7	52.6	51.0	47.4	107.3
400	60.1	61.3	59.4	58.8	58.0	56.5	55.2	52.3	51.0	49.9	48.8	46.7	43.6	103.5
500	58.7	62.3	59.1	58.5	56.9	55.9	54.7	52.6	51.9	50.0	48.0	45.7	42.5	103.4
630	61.4	62.2	62.1	61.2	60.1	58.6	57.1	54.7	53.1	51.9	50.7	47.4	44.5	105.7
800	61.6	62.4	62.8	61.9	60.0	58.8	57.8	53.9	52.3	51.9	51.4	48.3	45.2	106.1
1000	61.5	.0	63.0	62.9	61.0	59.5	58.0	54.8	52.3	50.5	49.9	47.2	44.3	106.3
1250	64.0	68.8	66.6	65.3	63.4	62.7	61.2	58.0	55.5	52.7	51.5	49.2	45.3	109.9
1600	79.1	83.0	84.3	81.8	79.1	76.8	75.6	72.2	68.9	66.1	60.7	60.8	57.0	125.5
2000	79.5	81.5	81.7	79.7	77.8	76.2	75.0	71.1	68.3	64.8	60.1	60.3	56.1	124.0
2500	71.7	72.9	72.7	71.9	70.7	69.2	68.1	64.3	60.7	58.2	57.3	55.7	52.3	116.5
3150	73.8	74.3	74.0	73.8	72.3	70.7	68.7	64.6	61.3	59.5	58.3	57.5	54.1	118.0
4000	73.8	75.5	75.8	75.5	74.6	72.2	70.7	66.4	63.0	60.8	60.3	59.3	57.1	120.0
5000	75.3	76.9	77.3	76.1	76.2	73.8	71.3	67.4	63.9	62.1	62.4	60.9	59.0	121.4
6300	77.2	79.6	80.7	79.2	79.2	77.2	74.8	71.1	68.1	65.6	65.6	63.6	62.2	125.0
8000	73.2	75.2	76.2	75.7	75.5	73.7	71.1	67.1	63.6	61.7	61.2	60.5	58.3	121.8
10000	72.0	73.9	74.6	74.7	75.4	74.3	73.3	67.9	63.5	60.8	61.3	59.9	58.1	122.6
12500	73.2	74.8	75.0	75.1	75.6	75.5	75.8	69.7	64.5	62.2	62.1	60.3	59.6	124.9
16000	69.4	70.7	71.4	71.3	71.0	70.6	70.0	64.4	59.5	57.2	57.1	56.1	54.7	122.1
20000	70.8	70.9	70.2	69.5	68.6	68.6	68.5	61.9	56.7	53.9	54.4	53.9	52.5	122.9
25000	64.1	65.3	64.8	64.8	65.4	64.4	64.5	57.1	51.4	49.3	50.6	49.4	47.9	122.3
31500	55.4	57.5	57.8	57.2	57.9	56.7	57.6	51.0	44.4	41.3	44.0	42.5	40.9	120.5
40000	45.9	46.6	49.1	47.7	49.4	47.7	48.9	43.0	35.1	34.1	35.4	33.9	32.8	119.8
50000	33.2	36.6	36.8	35.0	37.3	34.2	36.5	32.1	22.9	22.2	22.0	20.9	21.5	118.0
63000	17.4	22.8	21.7	19.3	21.8	18.3	19.7	16.3	7.7	7.9	4.4	5.0	6.8	118.0
80000	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	116.5
DBA	86.4	88.8	89.5	87.8	86.5	84.7	83.1	79.2	75.9	73.3	71.6	70.4	68.0	
DBB	85.1	87.5	88.2	86.5	85.1	83.3	81.8	77.9	74.8	72.4	70.9	69.6	66.9	
DBC	85.0	87.4	88.1	86.4	85.1	83.2	81.7	78.0	74.9	72.9	71.8	70.3	67.3	
PNL	98.3	100.1	100.7	99.2	98.6	96.7	94.9	91.2	88.3	86.0	85.3	83.7	81.5	
PNLT	102.5	106.7	104.1	102.3	101.5	99.8	98.1	94.4	91.4	89.2	88.5	86.8	84.2	

NFA 7748 RPM
NFK 7825 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAM_B 48 DEG F TWET 46 DEG F
$HACT_T$ 7.35 GM/M3
BAR 29.2 HG

TABLE IX. - Continued.

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

(d) Percent speed, 70; fan actual rotative speed, 8976 rpm; percent weight flow, 72.8

Frequency	Angle from inlet, deg: 0	10	20	30	40	50	60	70	80	90	100	110	120	PWL, dB (re 10^{-13} W)
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	61.1	61.1	60.7	59.3	58.5	59.5	61.7	61.3	61.0	61.0	61.1	58.7	54.3	109.1
125	62.0	61.5	59.4	58.8	58.7	59.2	59.7	60.5	62.2	61.0	59.8	60.4	53.3	108.9
160	63.2	61.7	63.6	66.0	64.4	62.9	59.9	66.2	70.6	68.6	66.5	67.1	55.5	115.4
200	67.7	68.7	68.3	66.5	64.8	63.8	63.1	61.0	60.3	59.3	58.2	57.1	54.7	111.5
250	72.4	71.2	71.3	70.4	68.8	67.8	67.0	64.2	63.3	62.1	60.9	58.3	55.9	114.9
315	70.9	71.1	70.0	68.9	67.2	66.0	64.7	63.6	61.2	60.0	58.9	57.2	53.9	113.5
400	67.6	67.3	66.4	65.8	64.5	63.0	62.0	59.6	57.5	56.6	55.8	53.4	50.6	110.3
500	64.7	64.5	64.1	63.8	62.4	60.9	60.7	58.8	57.4	55.6	53.8	51.2	48.0	108.5
630	66.4	67.5	67.3	66.5	65.4	64.4	62.4	60.0	58.9	57.6	56.2	52.9	50.0	111.1
800	66.1	66.7	66.8	66.2	65.3	63.5	61.8	59.2	57.3	56.5	55.7	52.8	49.7	110.6
1000	63.0	63.6	63.5	63.1	62.0	60.2	58.0	55.3	52.8	51.0	51.6	48.7	46.1	107.2
1250	62.5	64.1	63.6	62.6	60.7	59.2	57.7	54.8	51.5	49.7	48.8	45.9	42.8	106.6
1600	63.1	63.3	62.6	61.8	60.4	58.8	57.1	53.0	50.4	48.6	47.7	45.8	43.0	106.0
2000	67.8	68.5	69.0	69.5	68.0	66.7	63.7	59.9	56.0	53.8	54.1	50.3	48.4	113.1
2500	65.2	65.2	64.4	64.6	63.7	62.4	61.1	57.0	53.2	51.4	50.5	48.7	45.3	109.2
3150	72.3	70.3	69.8	67.5	67.6	65.2	64.5	60.9	56.5	55.3	53.8	53.0	50.9	113.2
4000	77.0	76.5	75.5	73.5	72.6	70.5	70.0	66.4	62.5	59.5	59.6	58.0	55.9	118.9
5000	71.1	71.9	71.8	70.6	70.2	69.6	68.3	63.9	60.4	57.6	57.7	55.1	53.5	116.5
6300	70.9	72.6	72.0	72.2	72.4	71.2	69.5	65.3	61.6	59.6	58.6	56.9	55.2	118.3
8000	77.5	80.2	79.2	81.2	81.5	80.5	79.4	75.3	71.6	68.9	67.4	66.5	63.3	128.0
10000	74.7	74.9	74.1	74.7	74.4	73.8	71.8	67.4	62.5	60.3	60.1	59.2	57.3	122.0
12500	74.0	75.1	75.0	75.1	74.4	74.2	74.3	68.5	63.5	60.7	60.9	59.3	58.4	124.0
16000	72.4	73.7	76.2	77.3	77.5	79.1	78.0	75.9	68.5	65.7	65.4	64.1	63.4	129.7
20000	66.8	67.9	67.0	70.0	70.4	70.6	71.5	65.9	61.0	57.2	57.2	55.4	54.0	124.5
25000	63.4	65.8	65.0	66.3	68.1	68.1	70.7	64.6	59.4	55.1	55.3	53.7	52.4	126.4
31500	54.6	57.0	57.3	59.4	59.9	59.9	61.9	55.8	50.7	45.8	47.3	45.0	43.9	123.4
40000	45.4	48.1	48.6	49.2	51.2	49.9	52.4	47.5	40.4	37.1	38.4	36.1	35.6	122.2
50000	31.5	35.8	35.8	36.2	39.3	37.2	40.0	36.1	28.4	24.7	24.5	23.9	24.2	120.5
63000	15.4	21.0	20.5	20.1	22.8	20.8	23.7	21.0	12.5	9.1	6.6	7.5	9.1	120.2
80000	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	117.6
DBA	83.3	84.0	83.4	83.6	83.4	82.3	81.2	77.1	73.5	71.1	70.2	68.7	66.1	
DBB	82.6	83.1	82.5	82.6	82.2	81.1	79.9	76.4	74.1	72.1	70.9	69.8	65.8	
DBC	82.8	83.3	82.7	82.7	82.3	81.2	80.1	76.8	75.3	73.4	72.2	71.3	66.6	
PNL	97.7	97.7	97.0	97.0	96.8	95.6	94.4	90.8	87.7	85.4	84.3	82.9	79.8	
PNLT	101.0	101.0	100.3	100.4	100.0	98.9	97.7	94.1	91.0	88.7	87.6	86.1	83.1	

NFA 8976 RPM
NFK 9065 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 48 DEG F TWET 46 DEG F
HACT 7.35 GM/M3
BAR 29.2 HG

TABLE IX. - Continued.

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

(e) Percent speed, 70; fan actual rotative speed, 8991 rpm; percent weight flow, 66.8

Frequency	Angle from inlet, deg													PWL, dB (re 10^{-13} W)
	0	10	20	30	40	50	60	70	80	90	100	110	120	
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	59.6	59.1	59.5	57.8	57.2	57.7	60.2	59.3	58.7	58.8	58.8	57.0	52.3	107.2
125	60.8	60.0	58.9	58.0	57.9	57.2	58.4	60.0	61.2	60.9	60.5	59.7	52.0	108.3
160	62.0	61.2	63.1	66.7	65.1	59.9	62.4	67.0	70.1	69.3	68.5	67.1	53.5	115.8
200	64.7	66.5	65.8	64.7	62.1	61.8	60.8	59.2	58.3	57.0	55.7	54.8	52.7	109.3
250	69.7	68.9	68.0	67.9	66.8	65.0	64.0	61.7	60.3	59.6	58.9	56.3	53.7	112.3
315	68.9	69.1	67.7	67.1	66.0	63.7	63.0	61.6	59.0	58.2	57.4	55.2	52.6	111.6
400	64.8	64.3	63.9	62.8	61.5	60.5	59.0	56.8	54.7	54.0	53.3	50.9	48.1	107.8
500	62.0	62.3	62.1	61.5	60.2	59.2	58.2	56.3	55.2	53.2	51.3	48.9	45.5	106.3
630	65.2	65.7	65.6	65.0	64.4	62.1	60.6	58.2	56.9	55.4	54.0	51.1	47.7	109.4
800	64.1	65.2	64.5	64.7	63.3	62.0	60.3	57.4	55.1	54.5	53.9	50.8	47.9	108.8
1000	61.5	62.6	62.2	61.6	60.7	59.0	57.5	54.3	51.0	49.7	50.1	47.0	44.3	106.0
1250	62.7	63.3	63.1	62.6	60.9	59.4	58.2	54.8	52.0	49.9	49.0	45.9	42.5	106.6
1600	71.4	68.3	67.1	67.5	67.9	67.8	64.8	60.2	56.1	54.1	52.0	49.8	47.5	112.8
2000	83.8	79.2	77.5	79.0	80.5	80.0	77.2	72.6	67.8	66.0	62.9	60.0	58.6	124.9
2500	67.9	67.9	67.2	67.1	66.7	64.9	63.6	59.8	55.7	53.2	52.8	50.7	47.8	111.9
3150	68.8	70.0	68.8	69.0	68.6	66.7	66.0	61.6	58.3	55.3	54.8	53.5	50.1	114.0
4000	74.0	73.5	72.8	72.3	72.1	70.2	69.5	65.4	61.3	58.8	58.6	57.0	54.6	117.7
5000	73.8	73.7	74.1	73.6	73.2	71.6	69.3	65.2	61.1	59.3	58.9	57.9	56.2	118.7
6300	75.2	76.1	76.2	76.7	76.2	74.0	70.8	67.1	64.1	62.1	61.6	60.1	59.0	121.6
8000	77.7	80.2	80.5	82.7	81.0	81.2	78.4	76.3	71.8	68.4	68.2	66.5	64.6	128.4
10000	76.2	76.9	75.6	77.2	76.7	75.3	72.5	67.9	64.0	61.5	61.8	60.9	59.3	123.7
12500	74.7	75.8	75.5	77.1	76.3	75.5	75.2	69.7	64.8	62.2	62.6	60.8	59.3	125.3
16000	71.4	73.5	74.4	76.8	77.0	77.9	78.3	74.3	68.7	63.9	64.6	62.3	60.2	129.0
20000	69.3	69.6	68.7	70.8	71.9	71.6	72.2	66.9	61.0	57.4	57.1	55.8	54.2	125.5
25000	64.8	66.0	65.5	66.8	67.6	67.8	69.5	63.8	57.9	54.3	54.6	53.4	51.9	125.8
31500	56.1	57.9	58.0	60.1	60.6	60.2	61.8	56.0	49.4	45.5	47.0	45.4	44.1	123.7
40000	46.6	49.3	49.4	50.4	51.6	50.9	52.8	47.9	40.1	36.8	38.7	36.8	35.5	122.8
50000	33.7	37.8	36.7	37.7	39.7	37.4	40.9	36.5	27.9	24.6	24.7	24.6	24.7	121.2
63000	17.4	23.0	22.2	21.3	24.0	21.0	24.4	21.0	11.7	9.6	6.8	8.2	10.3	120.9
80000	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	118.6
DBA	87.3	85.7	85.1	86.3	86.1	85.4	82.9	79.3	75.0	72.6	71.6	69.8	67.9	
DBB	86.1	84.5	83.8	84.9	84.7	84.0	81.5	78.1	74.8	72.8	71.9	70.1	66.9	
DBC	86.1	84.5	83.9	84.9	84.7	83.9	81.6	78.3	75.6	73.9	73.1	71.4	67.2	
PNL	100.3	98.1	97.5	98.7	98.3	97.4	95.1	92.0	88.3	85.8	85.2	83.4	80.9	
PNLT	106.2	101.8	101.0	102.6	103.6	103.0	100.2	96.2	92.3	89.9	88.7	86.6	85.1	

NFA 8991 RPM
NFK 9087 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 48 DEG F TWET 45 DEG F
HACT 7.39 GM/M3
BAR 29.2 HG

TABLE IX. - Continued.

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

(f) Percent speed, 70; fan actual rotative speed, 9017 rpm; percent weight flow, 62.7

Frequency	Angle from inlet, deg: 0	10	20	30	40	50	60	70	80	90	100	110	120	PWL, dB (re 10^{-13} W)
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	59.1	58.8	58.0	57.1	57.0	56.7	59.2	58.6	57.7	57.8	57.8	56.2	51.8	106.3
125	60.0	59.5	58.2	58.3	58.7	56.7	58.4	59.5	60.4	60.6	60.8	59.2	51.8	108.0
160	61.7	61.5	63.4	67.0	66.6	59.6	63.9	67.2	69.9	69.7	69.5	66.9	55.7	116.2
200	65.0	66.2	66.1	64.5	62.8	61.6	61.1	59.2	57.8	56.8	55.7	54.6	52.7	109.3
250	68.7	67.7	67.3	66.7	65.8	63.8	63.0	60.4	59.3	58.6	57.9	55.3	52.7	111.2
315	67.4	67.6	66.5	66.1	64.7	62.7	62.0	61.1	58.2	57.0	55.9	54.0	51.1	110.5
400	63.1	63.1	62.9	61.6	60.5	59.5	58.2	55.3	54.0	53.0	52.1	49.9	46.8	106.4
500	61.5	61.8	61.4	60.8	59.7	58.4	57.7	55.5	54.2	52.2	50.3	48.7	45.3	105.6
630	64.4	64.7	64.8	64.2	63.1	61.1	59.9	57.2	55.6	54.4	53.2	50.1	47.0	108.5
800	64.1	64.9	64.5	64.4	63.3	61.5	59.8	56.9	54.8	54.2	53.7	50.0	47.7	108.6
1000	62.8	63.1	63.5	62.6	61.7	59.7	58.2	55.1	52.8	50.7	50.9	47.7	45.1	106.9
1250	64.7	65.6	65.9	64.8	63.7	62.7	61.2	58.0	55.0	52.9	52.3	49.2	45.5	109.4
1600	76.6	74.5	69.8	68.8	68.9	68.3	65.8	62.2	58.6	56.9	54.7	53.3	49.7	114.6
2000	89.3	87.0	80.2	79.5	80.3	80.5	77.5	73.6	68.8	67.5	64.1	63.8	60.1	126.2
2500	72.4	72.2	71.4	70.9	70.2	69.4	67.9	63.8	59.9	57.7	56.8	55.2	51.8	118.9
3150	72.3	73.5	73.0	72.5	72.6	71.2	69.5	65.4	61.3	59.0	58.8	57.0	54.4	117.8
4000	75.0	76.0	75.8	75.3	74.8	73.0	71.2	66.6	63.0	61.8	60.8	60.0	57.6	120.3
5000	76.3	77.2	77.3	76.9	76.7	74.3	71.8	68.2	64.6	62.6	62.7	61.4	59.2	121.9
6300	78.7	78.6	79.0	79.0	78.9	77.2	73.8	69.3	66.1	64.8	64.6	63.6	61.5	124.3
8000	79.4	80.4	80.5	81.7	82.3	81.0	78.9	75.3	71.3	68.1	67.7	66.2	63.6	128.4
10000	76.5	76.9	76.6	78.2	78.9	77.1	75.0	69.6	65.5	63.0	63.3	62.2	60.1	125.3
12500	75.2	75.8	75.8	77.4	77.6	77.5	76.7	71.2	66.3	64.0	63.9	62.3	60.6	126.5
16000	72.1	74.2	74.4	76.8	77.5	77.9	77.8	72.1	67.2	64.9	64.9	62.6	60.4	128.7
20000	72.0	71.8	70.7	71.3	72.1	72.1	72.5	65.9	60.7	57.4	57.4	56.6	55.2	125.9
25000	66.8	67.8	66.7	67.8	68.8	68.1	69.0	62.6	57.1	54.3	54.1	53.2	51.9	126.0
31500	58.1	60.2	59.5	60.6	61.9	60.9	61.8	56.0	49.1	45.8	48.3	46.4	44.9	124.3
40000	48.8	50.8	51.1	51.9	53.4	51.9	53.1	48.4	40.6	37.8	39.9	37.8	36.8	123.8
50000	35.9	39.0	39.0	38.4	41.7	39.1	41.4	37.3	28.9	25.6	26.0	25.8	25.7	122.4
63000	19.9	25.5	23.9	22.5	25.8	23.0	24.4	22.0	12.2	10.1	8.3	9.0	10.5	122.1
80000	.0	.8	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	120.1
DBA	91.8	90.3	87.2	87.2	87.5	86.5	84.1	80.0	76.0	74.1	73.0	71.8	69.1	
DBB	90.5	89.0	85.8	85.8	86.0	85.0	82.7	78.8	75.4	73.9	73.0	71.4	68.0	
DBC	90.4	88.9	85.8	85.8	86.0	85.0	82.6	79.0	76.1	74.8	74.0	72.3	68.2	
PNL	104.2	103.0	99.4	99.2	99.3	98.5	96.1	92.4	88.8	87.1	86.0	84.6	81.8	
PNLT	110.7	108.7	102.6	102.4	102.8	102.4	99.7	96.0	92.0	90.5	89.0	87.8	85.1	

NFA 9017 RPM
NFK 9113 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 48 DEG F TWET 45 DEG F
HACT 7.39 GM/M3
BAR 29.2 HG

TABLE IX. - Continued.

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

(g) Percent speed, 80; fan actual rotative speed, 10 287 rpm; percent weight flow, 83.4

Frequency	Angle from inlet, deg: 0	10	20	30	40	50	60	70	80	90	100	110	120	PWL, dB (re 10^{-13} W)
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	61.3	61.0	61.5	61.3	59.2	60.5	62.7	62.3	62.0	62.1	62.3	60.0	55.1	110.1
125	62.3	62.0	60.4	58.3	59.7	59.2	60.2	60.5	59.9	59.9	59.8	58.7	54.0	108.4
160	64.2	63.5	63.6	67.2	65.9	66.9	62.1	64.2	63.4	64.3	65.2	64.1	63.2	113.7
200	69.5	70.7	69.3	68.0	67.1	66.3	64.1	63.2	62.6	61.8	61.0	59.6	58.0	113.4
250	73.7	72.7	72.5	71.9	70.5	68.8	68.0	65.4	64.3	63.6	62.9	59.8	57.4	116.3
315	71.9	72.1	71.0	70.6	69.2	67.5	66.2	64.9	62.2	61.5	60.9	58.5	55.1	114.9
400	69.1	58.8	67.7	67.3	66.0	64.2	63.5	61.1	59.2	58.5	57.8	55.9	52.1	111.7
500	66.5	56.6	66.4	65.8	64.9	63.7	62.9	61.0	59.9	58.1	56.3	53.9	50.3	110.9
630	66.4	69.2	69.1	68.5	67.6	66.1	64.4	61.7	60.6	59.1	57.5	54.6	51.7	113.0
800	68.1	68.7	66.5	66.2	66.8	65.0	63.5	60.2	58.6	57.9	57.2	54.0	51.2	112.2
1000	64.5	65.3	65.5	64.6	63.7	62.5	60.2	57.1	55.0	53.0	53.4	50.2	47.6	109.1
1250	64.7	65.8	65.9	65.3	63.7	62.2	60.4	57.8	55.0	52.7	51.8	49.2	45.3	109.3
1600	65.4	65.3	64.3	63.3	62.4	61.1	59.6	56.2	52.9	51.4	50.2	48.3	44.5	108.0
2000	66.0	66.2	65.5	65.5	64.0	62.5	61.7	57.9	54.0	52.0	51.4	50.0	45.9	109.7
2500	66.9	66.9	66.9	67.4	66.2	64.9	63.6	60.0	56.4	53.9	53.8	52.7	48.3	111.8
3150	70.0	69.3	69.3	68.3	68.1	67.0	66.2	62.6	59.1	56.5	55.1	54.3	50.7	114.0
4000	75.0	73.5	74.0	72.8	72.1	70.2	69.0	65.6	62.0	60.0	59.1	58.8	54.9	118.0
5000	71.6	72.7	73.1	71.6	71.9	71.3	70.8	68.2	64.1	60.8	60.4	59.1	55.5	118.5
6300	70.4	72.1	72.7	73.0	72.7	72.5	71.3	66.3	64.8	62.6	60.4	58.9	57.3	119.5
8000	75.2	75.9	76.2	77.4	77.0	77.5	76.4	75.1	70.4	66.9	64.4	63.0	62.1	125.0
10000	77.7	79.2	79.1	80.2	79.9	80.6	79.8	78.6	73.5	70.3	67.9	66.5	65.6	129.0
12500	73.2	72.6	73.0	73.4	73.4	73.5	74.0	70.5	65.0	63.0	61.6	59.0	57.4	123.3
16000	68.9	69.7	70.4	72.5	72.5	72.1	73.3	68.9	64.2	60.7	59.4	58.3	56.4	124.1
20000	67.1	67.9	69.2	72.0	71.6	72.1	72.8	68.9	64.2	59.7	58.7	57.6	56.0	126.2
25000	61.4	63.1	63.8	65.9	66.6	65.9	67.5	62.4	58.2	53.3	52.8	51.2	49.9	124.2
31500	53.6	55.5	56.3	57.9	58.7	58.0	59.6	55.6	50.4	45.6	45.8	44.2	42.2	121.9
40000	45.1	48.4	48.7	49.0	51.7	49.9	51.9	48.0	41.9	37.3	37.5	35.9	35.1	122.2
50000	32.5	36.3	36.8	36.2	39.0	35.9	39.5	36.1	29.7	25.4	23.8	23.9	23.7	120.3
63000	15.8	21.9	20.8	20.5	23.2	19.7	23.1	21.4	14.3	10.0	6.3	7.9	9.0	120.2
80000	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	118.2
DBA	82.8	83.2	83.3	83.4	82.9	82.8	81.9	80.0	75.6	72.8	71.1	69.6	67.7	
DBB	82.5	82.8	82.7	82.7	82.1	81.7	80.8	78.9	75.1	73.0	71.8	70.1	68.0	
DBC	82.8	83.1	83.0	82.9	82.3	81.9	80.9	79.1	75.6	73.8	72.9	71.2	69.1	
PNL	97.0	96.6	96.7	96.1	95.4	95.1	94.1	92.2	88.3	85.8	84.3	82.8	80.6	
PNLT	100.3	99.9	100.0	99.4	98.7	98.4	97.4	95.5	91.6	89.2	87.6	86.2	83.9	

NFA 10287 RPM
NFK 10404 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 47 DEG F TWET 44 DEG F
HACT 7.15 GM/M3
BAR 29.2 HG

TABLE IX. - Continued.

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

(h) Percent speed, 80; fan actual rotative speed, 10 280 rpm; percent weight flow, 76.4

Frequency	Angle from inlet, deg													PWL, dB (re 10^{-13} W)
	0	10	20	30	40	50	60	70	80	90	100	110	120	
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	61.1	61.1	60.7	59.3	59.0	60.5	61.7	61.3	60.7	60.8	60.8	59.2	54.3	109.2
125	61.0	61.0	58.9	56.8	58.7	58.7	59.2	59.3	58.9	59.0	59.0	57.9	53.3	107.5
160	63.0	62.7	64.4	66.7	65.9	66.6	60.6	63.0	62.4	63.4	64.5	64.1	63.7	113.2
200	66.7	68.5	67.1	66.0	65.3	64.6	62.3	61.0	60.1	59.5	59.0	57.8	56.7	111.4
250	71.9	70.9	70.8	69.9	68.5	67.5	66.3	63.7	62.5	62.0	61.4	58.5	55.7	114.5
315	70.6	70.9	69.7	68.6	67.7	66.0	64.7	63.1	61.0	60.0	59.1	56.7	54.6	113.4
400	66.8	66.3	65.4	65.1	63.2	62.7	61.0	58.8	57.0	56.0	55.1	52.9	49.8	109.4
500	64.0	64.5	64.1	63.3	62.7	61.2	60.4	58.5	57.2	55.5	53.8	51.2	48.0	108.4
630	66.9	67.5	67.3	67.2	66.4	64.6	63.1	60.5	58.6	57.3	56.0	53.4	49.7	111.5
800	67.1	67.9	67.5	67.2	65.5	64.3	62.3	59.4	57.6	56.7	55.9	53.0	49.9	111.2
1000	64.5	65.3	64.7	64.4	63.0	61.7	59.7	56.3	54.3	51.7	52.4	50.0	46.8	108.5
1250	64.7	65.3	65.4	64.8	63.4	62.4	60.9	57.3	54.5	52.2	51.5	49.2	45.0	109.1
1600	65.1	65.5	64.6	63.5	62.9	61.8	59.8	56.5	53.4	51.4	51.0	48.8	45.2	108.4
2000	67.8	68.7	68.7	68.7	67.0	65.5	63.2	59.9	56.5	54.5	53.6	51.5	47.4	112.5
2500	67.7	67.9	67.9	67.6	67.0	65.7	65.1	61.3	57.7	55.2	54.3	52.7	48.3	112.6
3150	69.3	70.3	69.8	69.0	69.1	68.8	67.5	63.4	60.1	57.8	56.6	54.5	51.4	115.0
4000	71.0	72.5	72.5	72.0	70.8	70.7	69.2	64.9	61.5	59.3	58.6	57.5	54.1	117.4
5000	73.6	74.2	73.6	73.9	72.7	72.6	72.0	68.7	64.6	61.6	61.7	60.1	56.5	119.6
6300	73.9	75.6	75.0	75.5	74.7	73.7	72.3	68.1	63.8	62.1	61.6	59.6	58.0	121.0
8000	77.7	79.2	79.0	80.4	81.8	81.5	80.6	77.3	72.1	69.2	68.4	66.0	64.3	128.6
10000	80.5	80.2	79.4	81.7	84.4	83.9	84.3	80.9	75.3	70.8	70.6	68.5	67.4	132.0
12500	77.2	77.8	76.8	77.9	76.6	75.7	75.3	69.7	65.3	63.0	63.6	61.5	60.1	125.8
16000	72.9	74.7	75.7	76.8	79.0	76.6	77.0	71.6	66.7	63.2	63.9	62.8	60.4	128.6
20000	70.6	71.6	71.7	74.8	75.1	75.6	75.5	71.4	66.0	61.7	61.7	60.4	58.8	129.2
25000	66.1	66.8	66.8	69.1	70.1	70.1	71.2	66.1	60.7	56.3	56.6	55.2	53.7	127.9
31500	57.6	60.0	59.6	60.9	61.9	62.2	63.4	58.3	52.4	47.6	49.3	47.2	45.4	125.4
40000	48.9	50.9	51.9	52.2	54.4	53.4	55.4	50.7	44.4	39.8	41.0	39.6	37.8	125.3
50000	35.5	39.1	39.5	39.5	42.3	40.2	43.0	39.3	31.9	26.9	27.3	26.6	26.5	123.6
63000	18.8	24.7	23.8	23.5	26.2	23.7	26.3	24.1	15.3	10.7	8.5	10.4	11.5	123.2
80000	.0	.0	.0	.0	.0	1.1	.0	.0	.0	.0	.0	.0	.0	120.9
DBA	83.9	84.7	84.2	85.1	86.0	85.5	85.1	81.6	76.6	73.4	73.0	70.9	69.0	
DBB	83.0	83.7	83.2	83.9	84.5	84.0	83.5	80.1	75.6	72.9	72.5	70.6	68.7	
DBC	83.2	83.8	83.3	83.9	84.6	84.0	83.5	80.2	75.9	73.5	73.2	71.4	69.6	
PNL	96.2	97.2	96.9	97.5	97.9	97.4	96.6	93.3	89.0	86.5	85.8	83.7	81.4	
PNLT	99.5	100.5	100.2	100.8	101.2	100.7	100.0	96.7	92.3	89.8	89.2	87.0	84.7	

NFA 10280 RPM
NFK 10397 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 47 DEG F THET 44 DEG F
HACT 7.15 GM/M3
BAR 29.2 HG

TABLE IX. - Continued.

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

(i) Percent speed, 90; fan actual rotative speed, 11 564 rpm; percent weight flow, 93.8

Frequency	Angle from inlet, deg													PWL, dB (re 10^{-13} W)
	0	10	20	30	40	50	60	70	80	90	100	110	120	
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	56.8	57.1	56.7	55.8	56.7	57.7	58.7	58.3	58.2	58.1	58.1	55.7	51.8	106.3
125	58.8	58.8	56.9	54.8	56.9	57.4	57.4	57.5	57.4	58.0	58.5	57.7	53.0	106.2
160	56.5	57.0	56.4	57.2	57.6	58.4	58.4	58.2	58.4	59.2	60.0	58.6	55.0	107.3
200	67.2	68.7	68.1	66.7	66.1	66.1	63.6	62.7	62.8	62.8	62.7	65.1	60.0	113.4
250	66.9	66.4	66.0	65.7	64.0	63.0	61.5	59.4	58.5	57.7	56.9	54.5	52.4	110.1
315	65.9	66.1	64.7	64.4	62.7	62.0	61.5	59.1	57.0	56.8	56.6	54.5	51.6	109.3
400	63.1	62.8	61.9	61.3	60.2	59.0	58.2	55.1	54.0	53.6	53.3	52.9	49.8	106.3
500	58.7	59.0	58.9	58.5	57.9	57.2	56.7	54.0	53.4	52.0	50.5	47.4	44.8	104.1
630	62.2	62.5	62.1	62.0	60.9	59.6	57.9	55.2	54.9	54.2	53.5	49.4	47.0	106.6
800	60.1	61.2	61.3	61.9	61.8	60.5	58.8	55.7	53.3	54.0	54.7	52.3	48.7	107.0
1000	60.8	61.1	61.2	60.1	59.5	58.0	56.5	53.3	51.8	50.2	50.3	48.5	44.6	105.0
1250	64.5	65.1	64.4	64.8	63.7	62.7	61.7	59.0	56.7	53.7	52.5	49.2	46.8	109.4
1600	68.4	68.3	66.1	65.0	64.1	63.8	62.6	60.2	56.4	53.6	53.5	50.8	47.7	110.5
2000	63.8	65.2	64.5	64.5	63.5	62.7	62.5	59.6	56.0	53.5	52.9	51.3	46.4	109.7
2500	66.7	65.9	66.7	67.1	66.5	66.2	65.9	63.5	59.4	56.9	55.0	52.9	48.6	112.8
3150	68.3	67.8	68.8	69.8	69.1	69.8	70.2	68.1	64.1	61.3	59.9	58.3	53.2	116.5
4000	68.8	69.3	69.3	70.0	69.8	69.7	71.0	68.9	65.0	61.8	61.6	59.3	54.4	117.4
5000	71.1	72.4	72.6	72.9	73.4	75.8	76.3	72.9	68.4	66.6	66.4	62.6	58.7	122.0
6300	70.2	70.9	70.7	71.5	71.9	74.0	74.0	72.3	68.6	65.6	63.1	60.6	57.8	120.8
8000	69.7	70.7	70.5	71.7	72.8	72.7	72.9	70.1	66.1	62.9	61.2	59.2	56.1	120.4
10000	80.2	80.2	80.9	82.0	82.4	82.9	84.0	80.1	76.0	72.8	70.9	69.2	67.4	131.5
12500	69.7	70.3	70.8	71.9	72.4	73.2	74.8	72.2	67.8	64.0	61.6	60.3	57.9	123.4
16000	66.4	67.2	67.2	68.5	69.5	70.1	71.0	68.9	64.7	60.5	58.4	56.1	54.7	122.0
20000	67.1	68.1	69.0	70.3	71.1	71.4	71.5	66.9	62.7	58.2	56.4	55.9	54.8	125.1
25000	60.1	61.3	62.0	62.4	64.1	63.6	65.2	60.9	56.7	52.1	50.8	49.7	48.2	122.0
31500	54.9	56.7	57.3	57.7	58.7	58.0	59.9	55.1	50.7	45.3	46.0	43.7	42.2	122.0
40000	45.4	48.1	48.1	48.2	49.9	48.9	49.9	46.7	41.1	36.1	36.7	34.9	33.3	120.8
50000	32.2	36.1	36.5	35.5	37.7	36.1	37.7	35.3	28.6	24.4	23.0	22.6	22.7	119.3
63000	16.2	21.1	20.3	18.9	22.1	19.9	21.3	20.1	13.1	9.2	5.5	6.4	7.9	119.1
80000	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	118.0
DBA	81.5	81.8	82.0	82.8	83.0	83.8	84.5	81.3	77.3	74.5	73.2	70.9	68.0	
DBB	80.4	80.7	80.8	81.5	81.6	82.3	82.9	79.8	76.0	73.4	72.3	70.6	67.3	
DBC	80.5	80.8	80.9	81.5	81.6	82.3	82.9	79.8	76.1	73.8	72.8	71.3	67.9	
PNL	94.3	94.5	94.7	95.4	95.4	95.8	96.3	93.2	89.6	87.3	86.7	83.9	80.8	
PNLT	97.3	97.6	97.8	98.7	98.5	99.2	99.7	96.5	92.9	90.6	89.9	86.9	83.6	

NFA 11564 RPM
NFK 11702 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 46 DEG F TWET 44 DEG F
HACT 7.10 GM/M3
BAR 29.2 HG

TABLE IX. - Continued.

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

(j) Percent speed, 90; fan actual rotative speed, 11 570 rpm; percent weight flow, 89.4

Frequency	Angle from inlet, deg 0	10	20	30	40	50	60	70	80	90	100	110	120	PWL, dB (re 10^{-13} W)
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	61.3	61.1	61.2	60.3	60.0	61.0	62.5	62.8	62.5	62.8	63.1	60.0	55.1	110.5
125	62.0	61.5	59.7	57.5	59.4	59.7	59.9	60.8	60.2	60.1	60.0	58.9	55.0	108.5
160	62.2	61.5	62.4	63.0	61.9	60.9	60.6	61.0	60.6	60.9	61.2	59.9	55.7	109.8
200	69.7	70.7	70.3	69.2	68.1	67.8	65.6	65.2	64.1	64.3	64.5	65.3	60.5	115.2
250	73.4	72.2	71.8	71.2	69.8	68.3	67.5	65.2	64.0	63.3	62.7	59.3	57.2	115.7
315	71.6	71.9	70.7	69.9	68.5	67.2	66.0	64.4	61.5	60.8	60.1	58.2	55.6	114.4
400	67.3	67.1	66.7	65.6	64.5	62.7	61.5	59.6	57.5	56.8	56.1	54.2	51.3	110.2
500	65.5	66.0	65.1	64.8	63.4	62.9	62.2	59.8	58.9	57.0	55.0	52.7	49.3	109.8
630	68.2	69.2	68.6	68.5	67.1	65.9	64.1	61.7	60.1	58.8	57.5	54.4	51.2	112.7
800	68.4	68.9	69.0	68.4	67.3	65.5	64.0	60.9	58.6	58.2	57.9	55.0	52.4	112.7
1000	64.0	65.3	65.4	65.1	64.2	62.2	60.2	57.6	54.8	53.2	53.8	51.0	48.3	109.3
1250	64.7	66.1	65.9	65.6	64.7	63.4	61.9	59.0	56.7	54.2	53.0	50.2	47.3	110.1
1600	67.4	67.3	66.1	64.8	64.4	64.6	63.3	60.7	57.6	54.6	54.2	51.8	48.7	110.8
2000	66.5	67.2	65.7	65.0	64.5	64.2	63.5	60.9	57.3	54.5	53.1	52.0	47.1	110.9
2500	67.7	68.2	67.2	67.1	67.0	66.9	66.9	63.8	59.9	57.4	56.0	53.9	49.8	113.4
3150	69.0	70.0	70.5	70.3	70.1	69.7	70.2	66.9	63.5	59.8	60.3	58.3	53.4	116.7
4000	70.8	71.8	71.3	71.5	70.8	70.2	71.0	68.4	65.5	62.0	61.6	59.5	55.6	118.0
5000	73.1	74.7	74.6	74.4	75.4	76.1	76.8	74.7	70.6	66.3	67.2	63.1	59.5	123.1
6300	72.4	73.4	73.7	73.7	74.4	74.7	75.3	72.8	69.3	65.3	64.6	61.6	59.3	122.2
8000	73.0	73.2	73.5	74.7	74.8	75.0	74.9	72.1	67.9	64.2	62.9	61.5	58.6	122.6
10000	80.0	80.9	81.8	83.4	85.9	84.8	86.0	81.1	76.5	73.6	72.6	70.9	68.6	133.4
12500	73.5	73.6	73.5	74.4	75.1	75.2	76.8	73.0	68.5	65.0	63.6	61.5	59.6	125.3
16000	69.9	71.0	70.9	71.8	72.2	72.6	74.3	70.9	66.5	63.0	61.4	58.3	57.4	124.8
20000	68.8	70.6	70.5	72.0	72.9	72.9	72.5	67.7	63.5	59.4	58.4	57.6	56.2	126.5
25000	61.9	63.3	64.3	64.8	65.9	66.1	67.0	61.9	57.1	53.3	52.6	51.2	49.7	123.8
31500	56.6	58.2	59.0	59.4	61.1	60.4	60.8	56.5	51.4	46.6	47.3	45.7	43.9	123.7
40000	47.1	49.6	50.1	50.2	52.1	51.1	52.3	47.7	42.6	38.0	38.9	36.9	35.8	122.8
50000	33.7	38.3	38.5	37.2	39.7	37.9	39.9	37.0	30.6	25.9	24.7	24.8	24.4	121.2
63000	17.5	23.6	22.5	21.2	24.4	21.9	23.8	22.6	14.8	10.2	7.0	8.6	9.9	121.3
80000	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	119.8
DBA	82.9	83.7	83.9	84.5	85.8	85.2	86.1	82.3	78.3	75.0	74.5	72.2	69.3	
DBB	82.4	83.1	83.1	83.5	84.5	83.9	84.5	81.0	77.2	74.5	74.0	71.9	68.8	
DBC	82.7	83.3	83.3	83.6	84.5	83.9	84.5	81.1	77.5	75.0	74.6	72.7	69.4	
PNL	95.8	96.8	96.7	97.3	98.3	97.6	98.1	94.8	91.2	88.0	88.0	85.3	82.3	
PNLT	99.1	100.1	100.0	100.6	101.7	100.9	101.5	98.1	94.5	91.4	91.3	88.6	85.7	

NFA 11570 RPM
NFK 11710 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 46 DEG F TWET 44 DEG F
HACT 7.15 GM/M3
BAR 29.2 HG

TABLE IX. - Continued.

[Model SPLS for standard day (59° F; 70 percen RH) at 100-ft radius.]

(k) Percent speed, 100; *fan actual rotative speed*, 12 800 rpm; percent weight flow, 99.8

Fre-quency	Angle from inlet, deg													PWL, dB (re 10^{-13} W)
	0	10	20	30	40	50	60	70	80	90	100	110	120	
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	49.3	49.8	50.5	50.6	53.7	54.7	59.0	55.6	55.7	56.0	56.3	54.2	50.1	104.2
125	53.0	52.5	52.4	50.5	52.9	54.7	57.9	56.8	57.4	58.6	59.8	58.2	54.0	106.0
160	53.2	53.5	51.9	54.2	57.6	57.6	62.6	59.0	60.1	60.7	61.2	58.9	55.2	108.4
200	59.7	61.5	56.6	62.5	60.1	64.8	60.8	62.7	67.1	67.5	68.0	65.6	64.5	114.2
250	52.4	53.2	51.8	54.9	53.8	56.0	56.0	53.9	56.8	57.5	58.2	55.8	54.4	105.0
315	55.1	55.9	56.0	54.4	56.5	57.2	57.2	53.6	52.7	53.2	53.6	52.0	50.4	103.7
400	54.3	55.6	55.4	55.6	54.5	55.5	56.2	52.3	50.7	50.8	50.8	49.2	46.8	102.2
500	53.2	53.5	53.1	51.8	51.9	51.2	55.2	49.3	48.4	48.0	47.5	44.2	41.0	99.5
630	72.7	72.2	70.6	67.7	66.1	62.1	60.6	56.5	55.4	55.4	55.5	51.1	51.5	111.8
800	60.9	60.9	61.5	62.2	61.5	59.8	59.5	55.9	54.3	54.0	53.7	49.0	46.7	106.9
1000	60.5	60.1	59.2	60.4	59.5	58.0	57.5	54.1	52.3	52.2	51.1	47.7	45.1	105.0
1250	62.7	62.8	61.6	61.6	61.7	60.9	59.7	57.0	55.0	53.4	51.8	48.2	44.5	107.3
1600	65.1	65.8	66.8	65.8	63.9	63.1	63.1	61.2	58.6	55.6	53.7	51.8	47.5	110.7
2000	61.5	62.7	64.2	62.7	62.0	62.5	63.0	61.4	58.8	55.0	55.6	52.8	47.1	109.7
2500	62.2	62.4	63.9	64.9	64.5	65.4	67.1	65.5	62.2	58.9	58.0	55.4	50.6	112.8
3150	66.5	69.5	67.3	68.3	68.3	69.5	74.5	74.1	71.3	69.0	66.1	65.8	60.2	120.2
4000	71.8	72.3	70.5	71.5	73.3	80.7	86.0	84.4	81.0	79.0	79.8	73.5	67.6	130.7
5000	71.3	76.2	74.3	74.4	75.4	81.1	88.8	88.9	83.4	84.3	80.9	80.1	73.7	134.3
6300	74.9	75.9	75.2	75.7	77.9	81.2	88.8	90.1	84.8	83.6	82.1	78.1	73.3	135.2
8000	72.2	71.9	74.0	72.7	73.8	76.7	82.2	82.3	78.1	74.4	71.7	70.0	64.1	128.6
10000	76.7	77.7	77.6	78.5	78.9	79.4	82.8	82.6	79.3	75.3	73.9	72.0	65.9	130.8
12500	78.7	79.3	79.5	80.6	81.1	81.2	83.3	83.0	79.3	74.7	72.9	69.0	66.1	132.7
16000	68.1	69.2	69.4	70.1	72.0	71.7	74.3	73.4	69.7	65.2	63.4	60.1	57.7	125.2
20000	68.3	68.4	69.0	68.8	70.1	69.9	71.8	71.4	66.7	61.9	59.9	57.4	56.3	125.7
25000	65.9	66.1	65.8	65.6	66.6	66.1	68.3	65.9	61.9	57.4	55.3	53.5	51.4	125.4
31500	56.7	57.2	57.6	57.7	58.9	57.2	60.1	58.8	54.7	49.3	47.6	45.0	43.4	122.9
40000	47.4	49.1	49.4	48.2	49.9	48.4	51.1	49.5	46.1	40.3	38.7	36.1	34.3	122.0
50000	34.5	37.6	37.3	35.7	38.5	35.4	39.0	38.1	33.7	28.9	25.3	23.6	23.0	120.7
63000	18.0	23.1	21.5	19.6	23.1	19.9	23.5	23.1	18.5	14.9	9.0	7.6	8.7	121.0
80000	.0	.0	.0	.0	.0	.0	3.7	.0	.0	.0	.0	.0	.0	122.1
DBA	82.1	83.4	82.9	83.2	84.2	87.6	93.9	94.1	89.3	88.4	86.6	83.7	77.9	
DBB	80.8	82.0	81.4	81.7	82.5	86.0	92.2	92.4	87.6	86.7	84.9	82.0	76.4	
DBC	80.8	82.0	81.3	81.6	82.5	85.9	92.1	92.3	87.5	86.6	84.9	82.0	76.5	
PNL	94.0	95.7	94.6	94.9	96.1	99.7	105.6	105.5	101.0	100.6	98.3	96.4	90.7	
PNLT	99.2	100.7	99.0	98.4	99.4	103.1	109.0	108.6	104.0	103.6	101.2	99.2	93.2	

NFA 12800 RPM
NFK 12956 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 46 DEG F TWET 44 DEG F
HACT 7.09 GM/M3
BAR 29.2 HG

TABLE IX. - Concluded.

[Model SPLS for standard day (59° F; 70 percent RH) at 100-ft radius.]

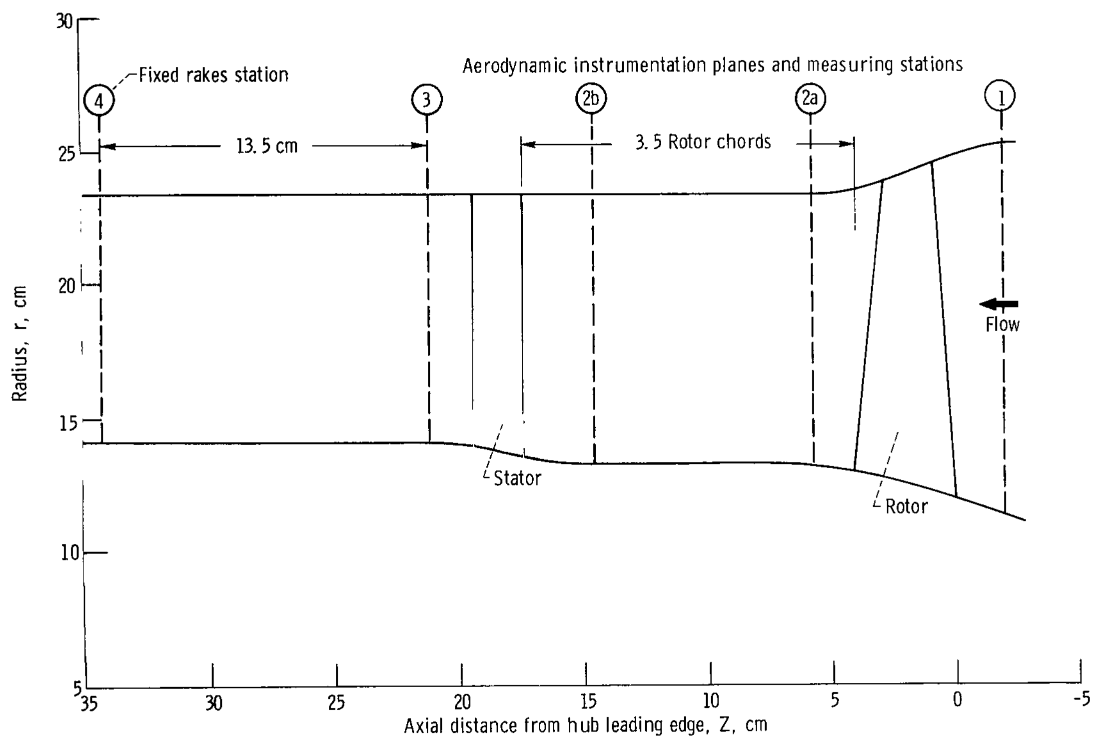
(l) Percent speed, 100; fan actual rotative speed, 12 737 rpm; percent weight flow, 99.5

Frequency	Angle from inlet, deg: 0	10	20	30	40	50	60	70	80	90	100	110	120	PWL, dB (re 10^{-13} W)
	One-third octave band sound pressure level, dB (re 0.0002 μbar)													
100	53.1	53.3	53.2	53.6	55.0	56.0	59.7	56.6	56.7	56.9	57.1	54.7	50.6	105.1
125	55.8	55.6	53.9	53.3	54.9	56.2	58.7	57.5	57.9	58.9	59.8	58.7	54.0	106.5
160	54.5	54.5	53.9	54.7	57.4	57.6	62.4	59.0	59.4	60.1	60.7	58.9	55.0	108.1
200	63.2	64.7	64.8	61.5	62.1	62.6	62.3	65.2	66.8	66.9	67.0	64.6	64.0	114.0
250	61.4	60.7	60.3	59.9	59.3	58.5	58.5	56.7	56.8	56.8	56.9	54.5	52.7	106.5
315	60.6	61.4	60.5	60.1	59.7	59.5	59.2	56.1	54.7	54.8	54.9	53.2	51.4	106.3
400	58.8	59.1	58.4	57.8	56.7	56.2	57.0	53.8	52.5	52.8	53.1	50.7	47.8	103.9
500	56.2	56.5	56.4	55.8	54.9	54.7	55.4	52.0	50.9	50.2	49.5	45.9	43.0	101.8
630	70.7	69.2	67.6	64.7	62.6	59.4	58.9	54.5	55.1	54.7	54.2	51.6	49.7	109.1
800	59.9	59.9	61.0	61.9	61.5	61.0	59.8	57.2	56.1	55.2	54.4	52.0	48.9	107.4
1000	61.5	61.1	60.7	60.9	60.5	60.0	59.5	56.8	54.5	53.5	53.1	50.0	46.6	106.6
1250	64.0	63.6	63.1	63.1	62.4	62.2	60.9	58.3	56.2	53.9	52.3	49.4	46.0	108.4
1600	67.9	66.8	68.1	67.3	66.9	66.6	65.8	64.0	60.9	58.6	56.0	54.3	50.5	113.1
2000	62.0	63.0	64.2	64.2	63.5	63.5	64.0	61.6	58.3	55.8	55.1	52.3	47.4	110.4
2500	63.7	63.4	66.4	66.1	66.5	66.9	68.4	65.8	62.4	59.7	58.0	54.9	50.6	113.9
3150	66.8	67.8	68.5	68.3	68.1	70.3	69.2	66.9	62.8	61.0	59.6	57.5	52.9	115.9
4000	70.5	70.6	68.8	68.5	68.8	69.8	72.7	71.6	70.5	65.8	66.1	63.5	57.4	119.1
5000	72.1	74.7	74.6	76.4	76.4	81.3	87.1	85.7	83.9	78.6	78.4	77.1	69.0	132.1
6300	74.2	74.4	75.5	76.7	76.9	80.0	90.1	88.6	86.8	81.6	82.1	80.4	73.8	135.2
8000	71.0	73.2	74.0	73.9	73.0	75.2	84.2	83.6	79.4	73.9	73.7	70.0	67.1	129.8
10000	77.5	78.4	78.4	79.5	79.9	79.9	82.1	80.4	77.0	73.1	71.1	69.0	65.9	129.9
12500	76.7	78.4	78.8	79.9	80.4	80.3	81.8	80.8	77.0	72.7	71.9	69.1	66.9	131.3
16000	68.2	68.8	69.2	70.1	71.0	70.7	73.1	71.4	68.3	63.7	61.7	58.6	57.2	124.0
20000	68.8	68.9	69.3	69.6	69.9	70.2	70.8	69.2	66.0	61.0	58.5	56.9	55.5	125.0
25000	65.4	66.1	65.8	66.1	66.9	66.2	67.3	64.7	61.2	56.6	54.9	53.0	51.5	125.0
31500	56.4	58.3	57.8	58.0	58.7	58.0	59.4	57.1	54.2	48.9	47.6	45.3	42.7	122.5
40000	47.1	49.4	49.4	49.0	50.5	48.7	51.2	48.0	45.4	40.1	39.2	35.9	34.6	121.9
50000	34.9	38.0	37.7	36.7	38.4	36.1	38.4	37.0	33.1	28.6	25.7	23.5	23.4	120.5
63000	17.4	22.7	21.9	20.5	23.3	19.8	23.2	22.2	18.2	14.8	9.1	7.2	8.5	120.8
80000	.0	.0	.0	.0	.0	.0	3.5	.0	.0	.0	.0	.0	.0	121.9
DBA	81.8	82.7	83.0	83.8	83.9	86.2	93.0	91.6	89.4	84.3	84.4	82.7	76.3	
DBB	80.5	81.3	81.6	82.3	82.3	84.5	91.2	89.9	87.7	82.7	82.8	81.0	74.8	
DBC	80.5	81.3	81.5	82.2	82.3	84.5	91.1	89.8	87.6	82.7	82.8	81.0	74.9	
PNL	94.1	95.0	95.2	96.0	95.9	99.0	105.1	103.5	101.5	97.0	97.1	95.2	89.3	
PNLT	98.3	98.7	98.1	99.3	99.3	102.1	108.6	106.9	105.8	100.4	100.4	99.0	92.1	

NFA 12737 RPM
NFK 12912 RPM
NFD 13020 RPM

NUMBER OF BLADES 53

TAMB 45 DEG F TWET 43 DEG F
HACT 6.77 GM/M3
BAR 29.2 HG



Flow path coordinates		
Axial distance, Z, cm	Radius, r, cm,	
	Inner	Outer
-10.183	9.611	25.412
-5.365	10.909	25.412
-3.300	11.468	25.412
[a]-1.916	11.843	25.385
-1.235	12.027	25.311
0.314	12.443	24.917
3.411	13.132	23.792
4.961	13.365	23.528
[a]5.628	13.437	23.475
7.025	13.503	23.426
10.467	13.597	23.421
13.908	13.600	
[a]14.439	13.600	
15.974	13.652	
17.350	13.764	
19.278	14.145	
[a]21.122	14.369	
21.480	14.381	
24.919	14.389	
28.364	14.389	23.421

[a]Instrumentation survey plane.

Figure 1. - Flow path for QF-1 fan model.

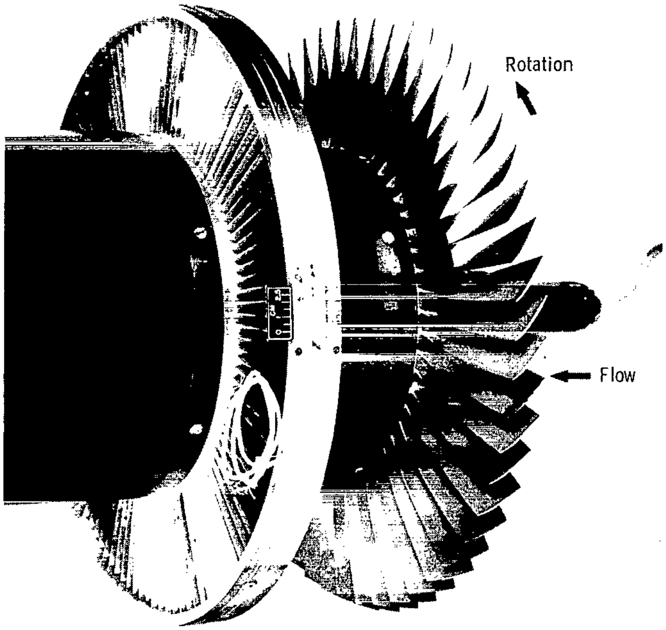
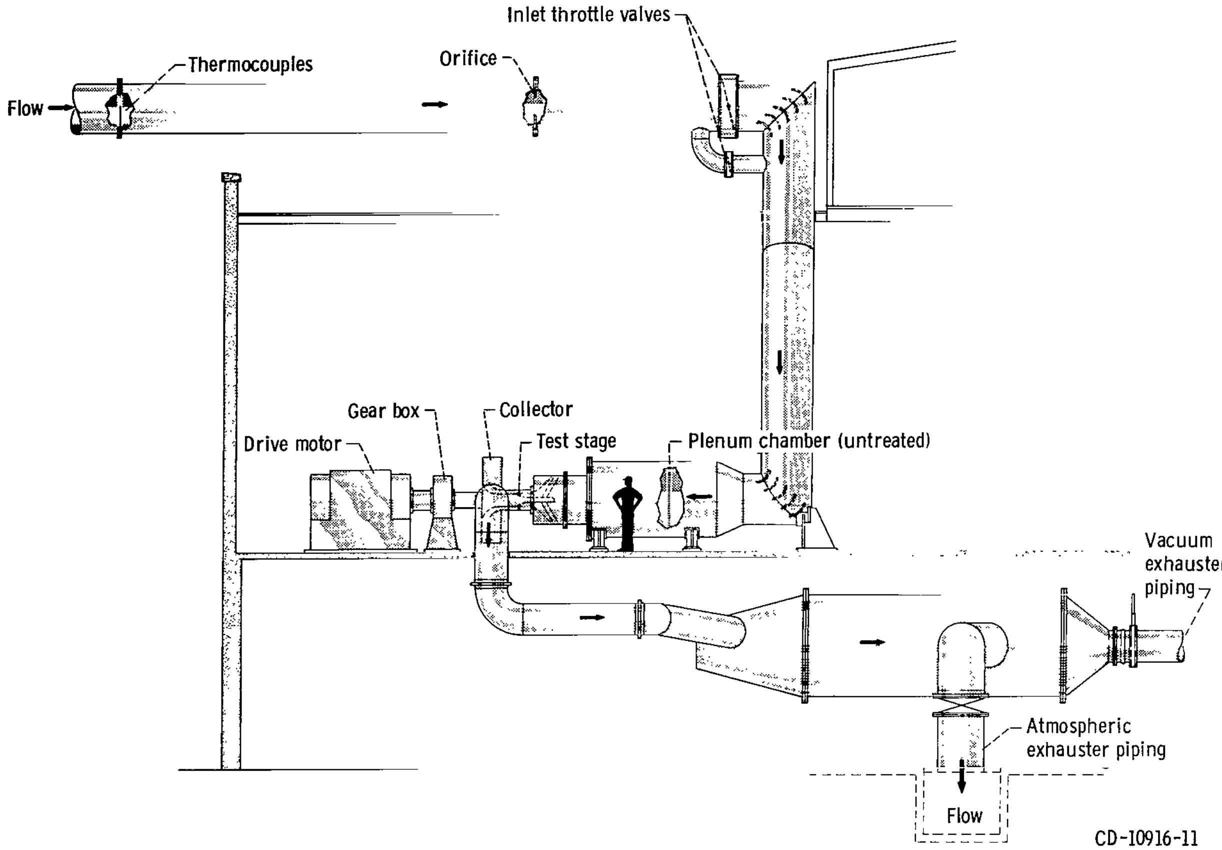
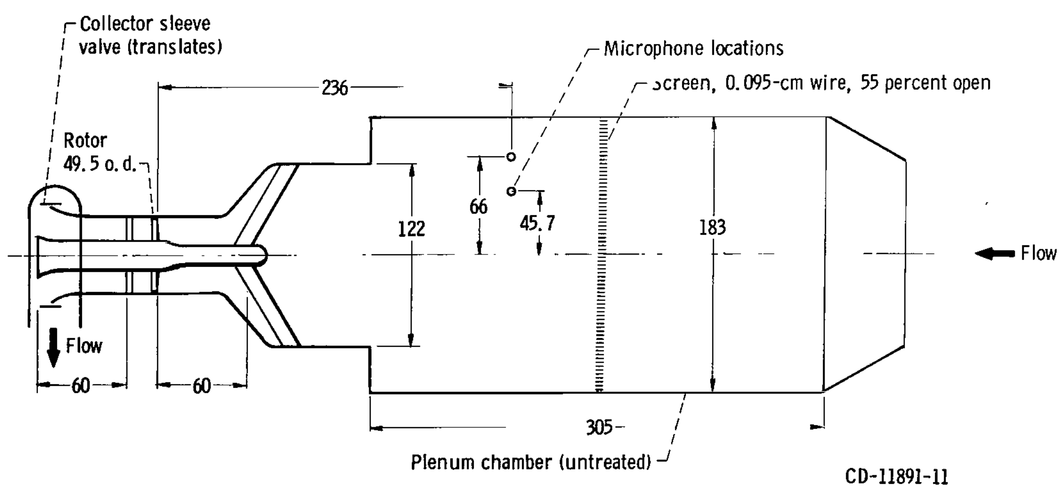


Figure 2. - Rear quarter view of stage 15-9. C-69-2510

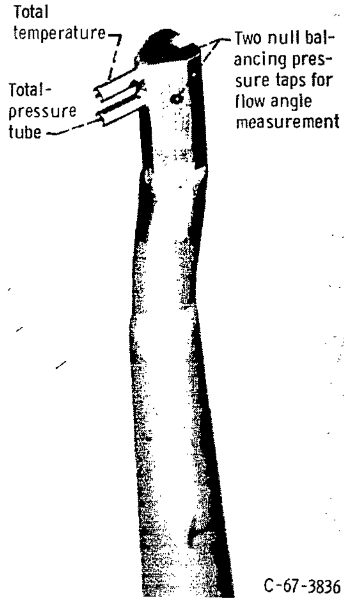


(a) Overall view.

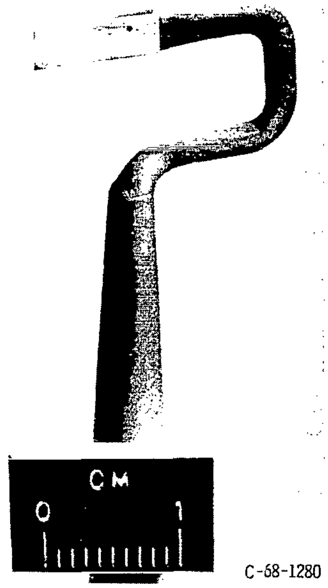


(b) Rotor and microphone locations. (All dimensions are in cm.)

Figure 3. - Compressor aerodynamic test facility with noise measuring locations.

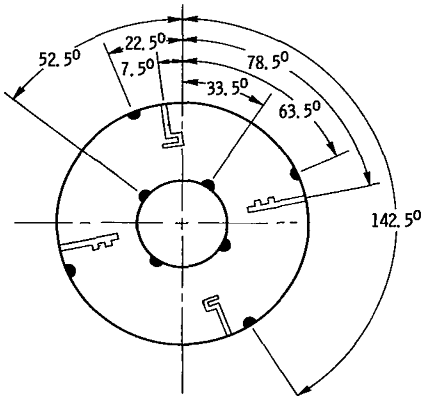


(a-1) Combination total pressure, total temperature, and flow angle probe (double barrel probe).

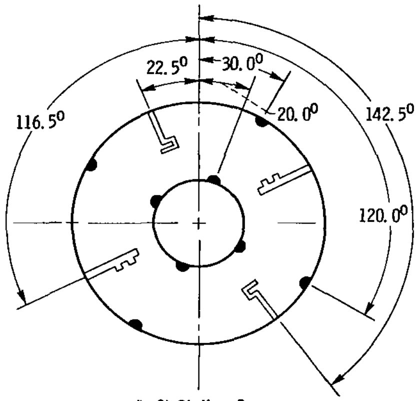


(a-2) Static pressure probe (8^{0} wedge).

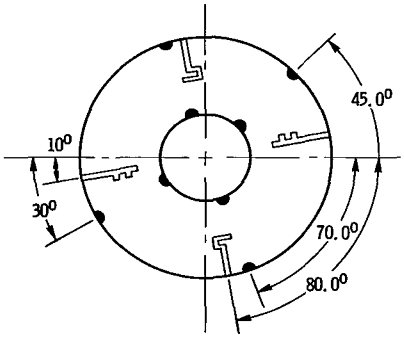
(a) Sensing probes.



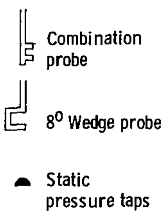
(b-1) Station 1 (see fig. 1).

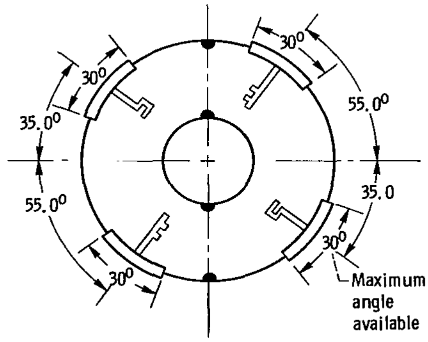


(b-2) Station 2a.



(b-3) Station 2b.





(b-4) Station 3.

(b) Circumferential location of probes at measuring stations, view facing downstream.

Figure 4. - Aerodynamic instrumentation.

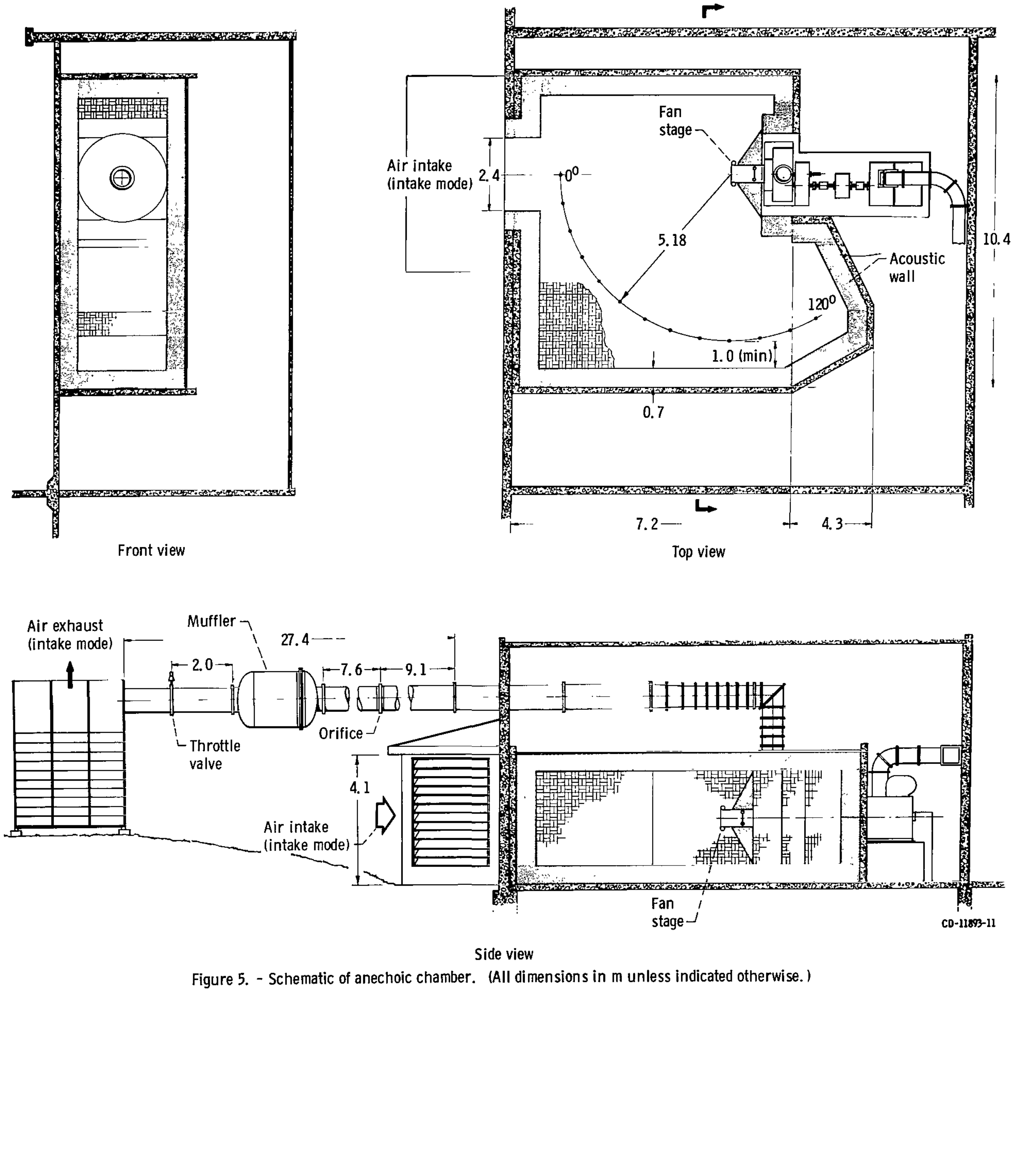


Figure 5. - Schematic of anechoic chamber. (All dimensions in m unless indicated otherwise.)

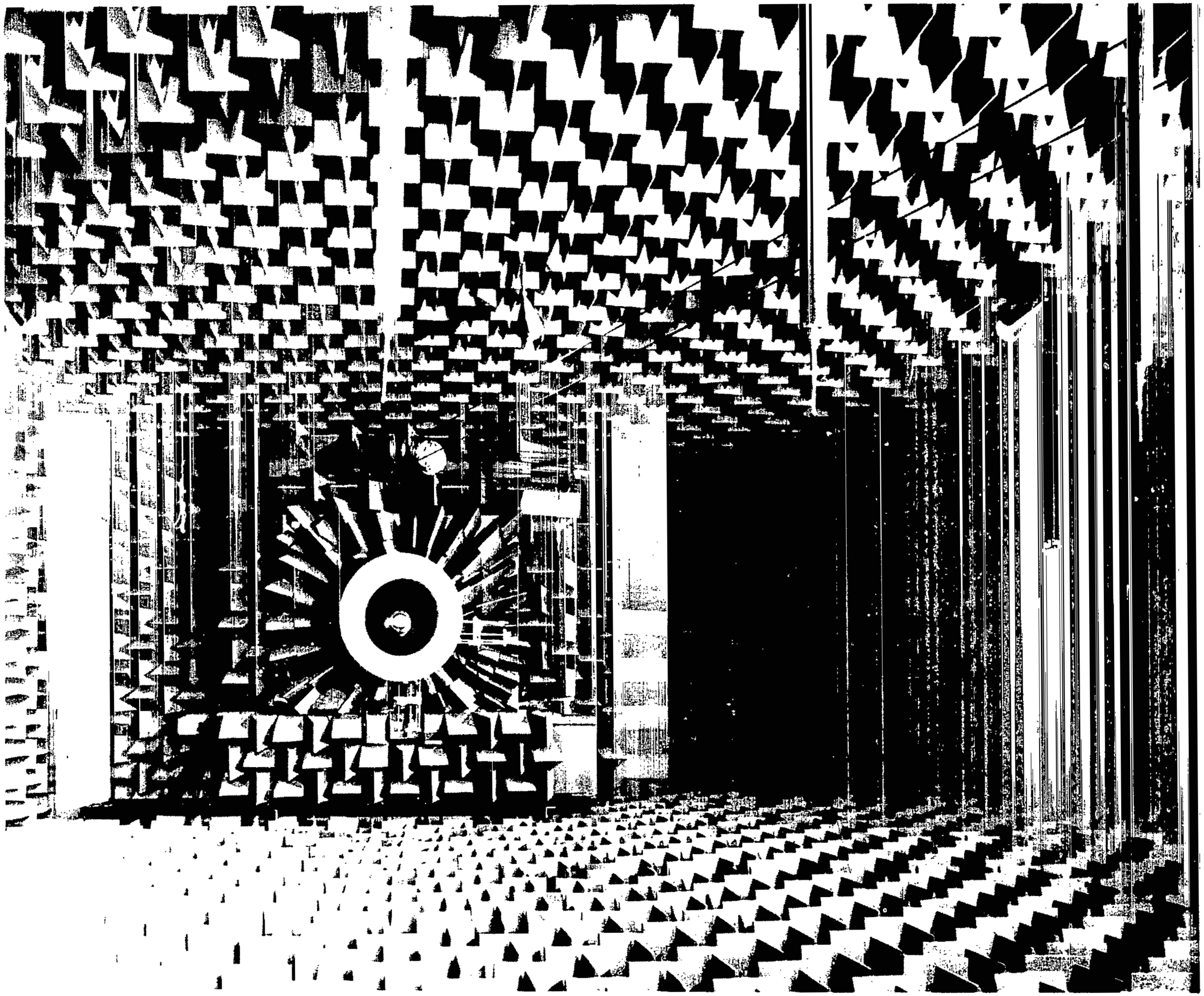


Figure 6. - Interior photograph of anechoic chamber; view looking at fan from air intake opening (intake mode), inlet screen not in place.

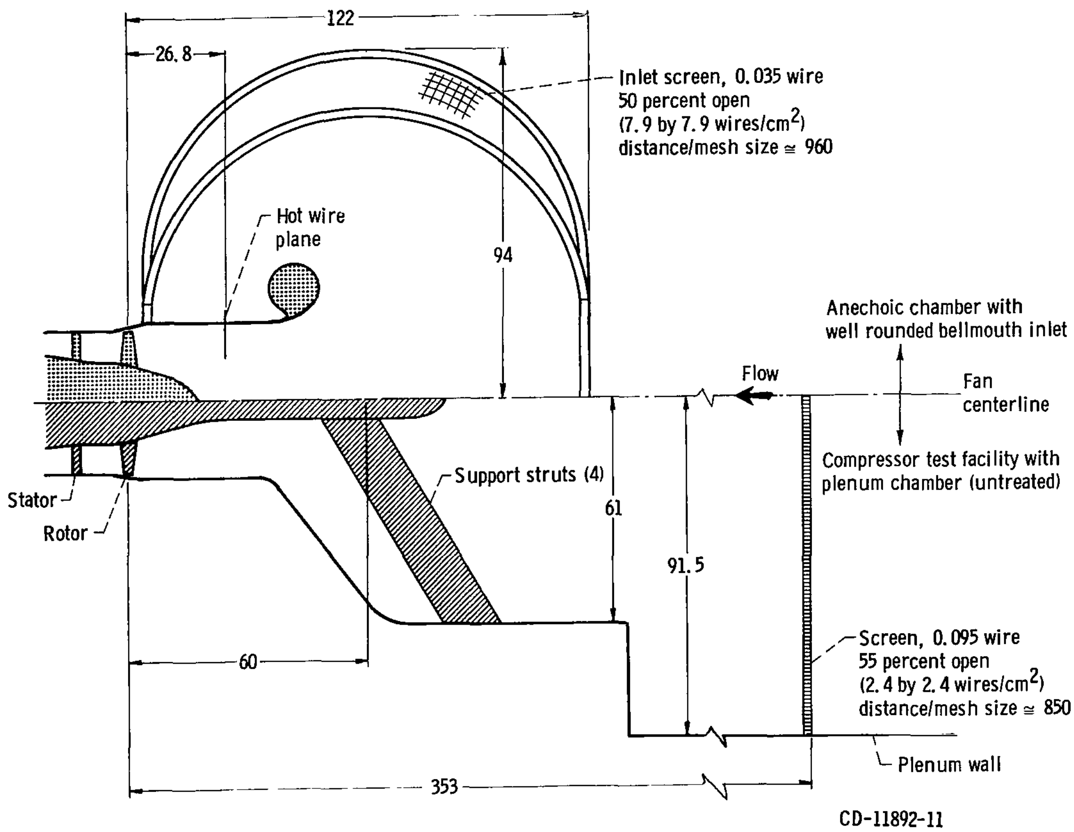
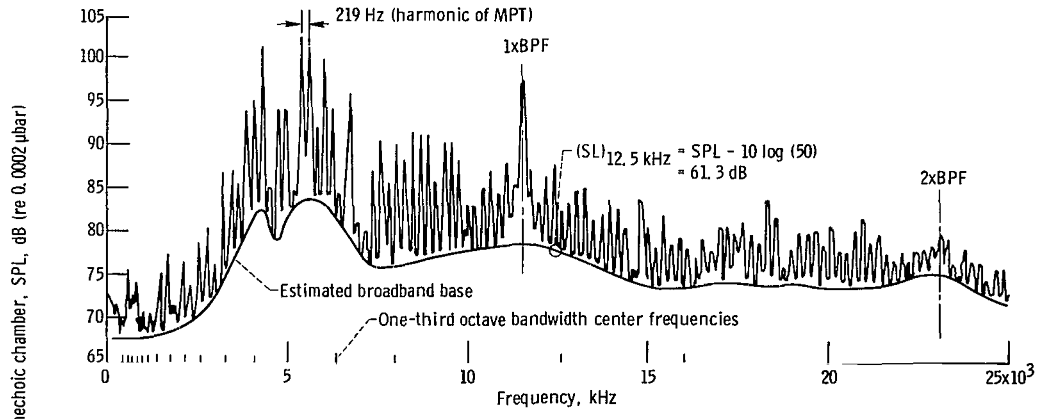
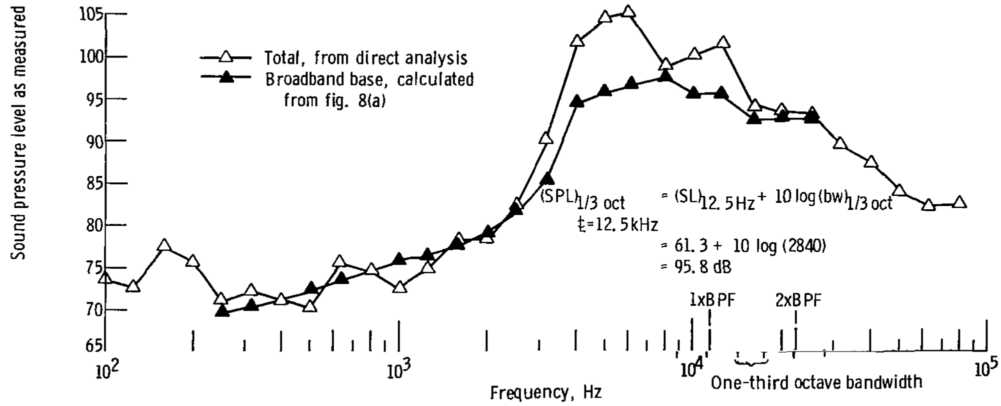


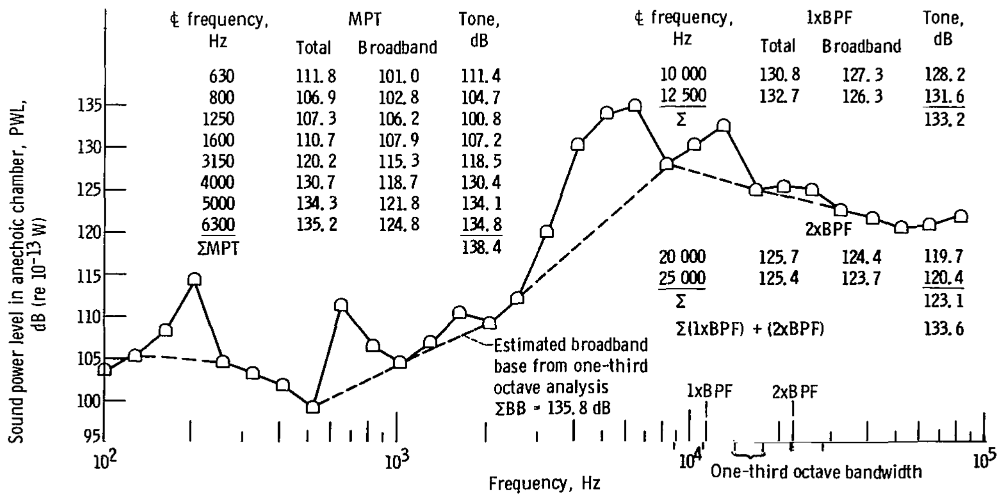
Figure 7. - Comparison of fan inlet configurations in anechoic chamber and in modified compressor test facility with plenum chamber. (All dimensions in cm.)



(a) 50-Hertz constant bandwidth analysis, 60° microphone.

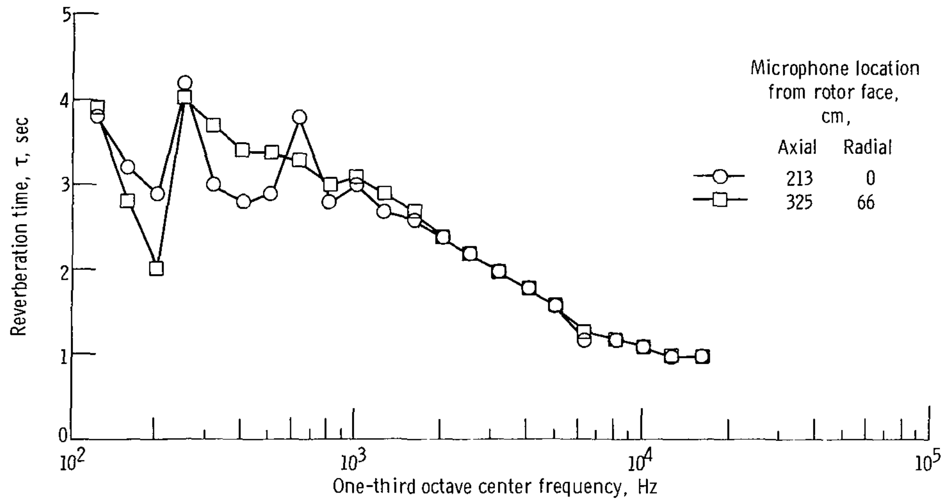


(b) One-third octave bandwidth analysis, 60° microphone.

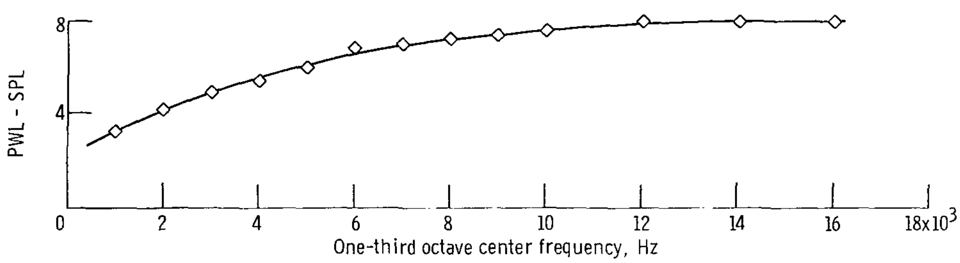


(c) One-third octave bandwidth analysis with noise components resolved.

Figure 8. - Sample sound pressure and sound power spectra from anechoic chamber. 100 Percent design speed; 99.8 percent design weight flow.



(a) Reverberation time of plenum chamber (from ref. 1).



(b) Relation of PWL to SPL in plenum chamber. PWL - SPL ≈ $10 \log v - 10 \log \tau - 19$, dB (re 10^{-13} W) (ref. 12, p. 177) where $v = 470\ ft^3$; τ = reverberation time, sec (see fig. 9(a)), ∴ PWL - SPL = $26.7 - 19 - 10 \log \tau \cong 8 - 10 \log \tau$.

Figure 9. - Determination of sound power level, PWL, from sound pressure level, SPL, measured in plenum chamber of unmodified compressor test facility.

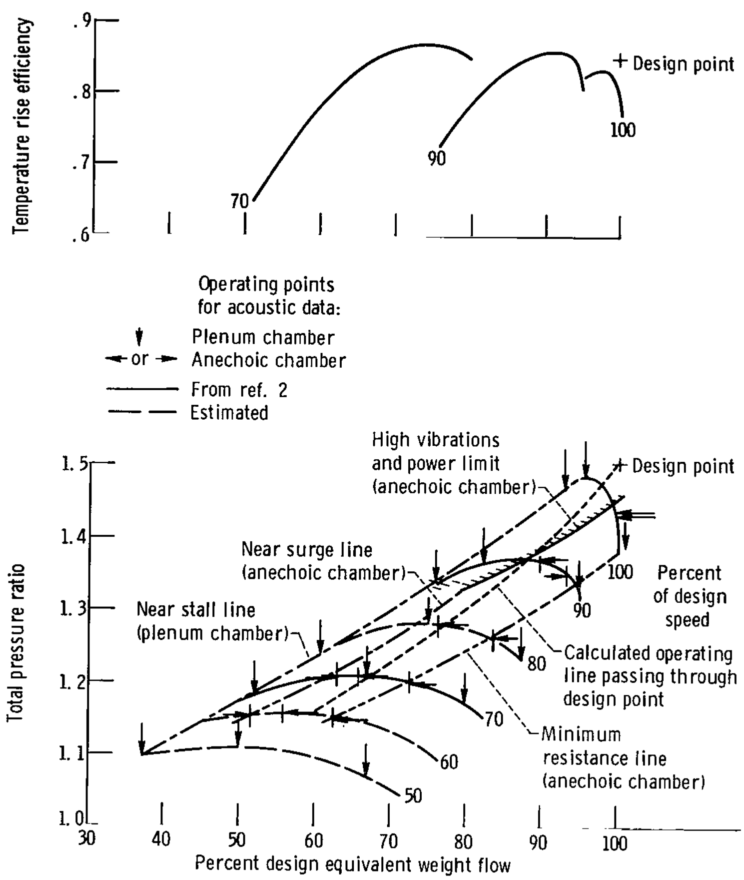


Figure 10. - Overall aerodynamic performance for stage 15-9 with operating points for acoustic data indicated.

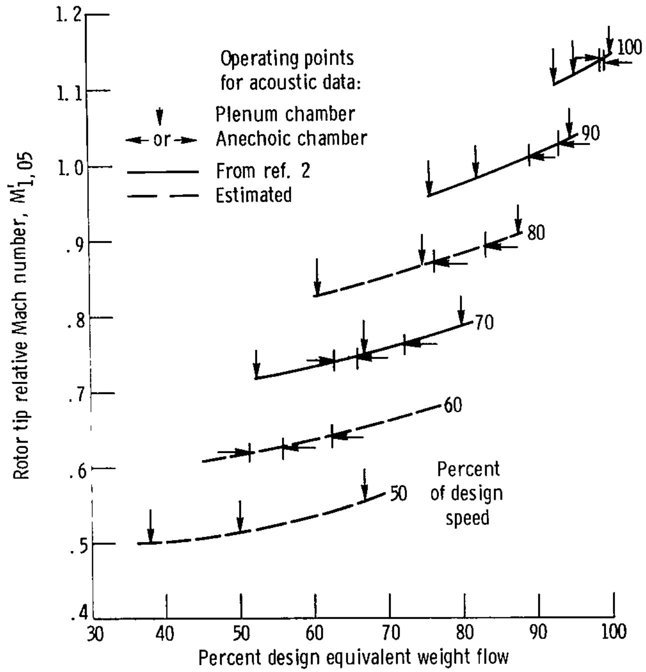


Figure 11. - Relative Mach number 5 percent span from tip of rotor 15 (from ref. 2).

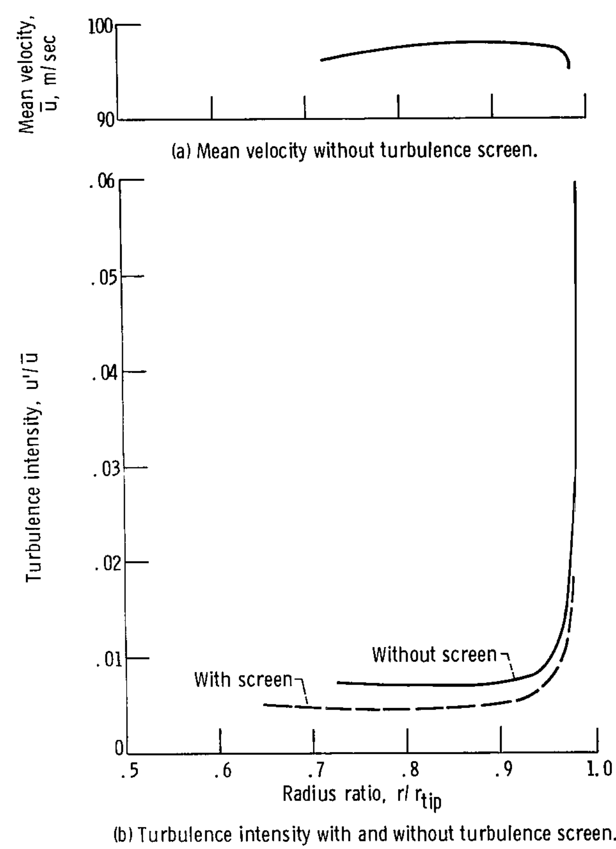


Figure 12. - Radial profiles of mean velocity and turbulence intensity 26.8 centimeters upstream of rotor in anechoic chamber installation with well rounded bellmouth. 80 Percent of design speed, 83.4 percent of design weight flow.

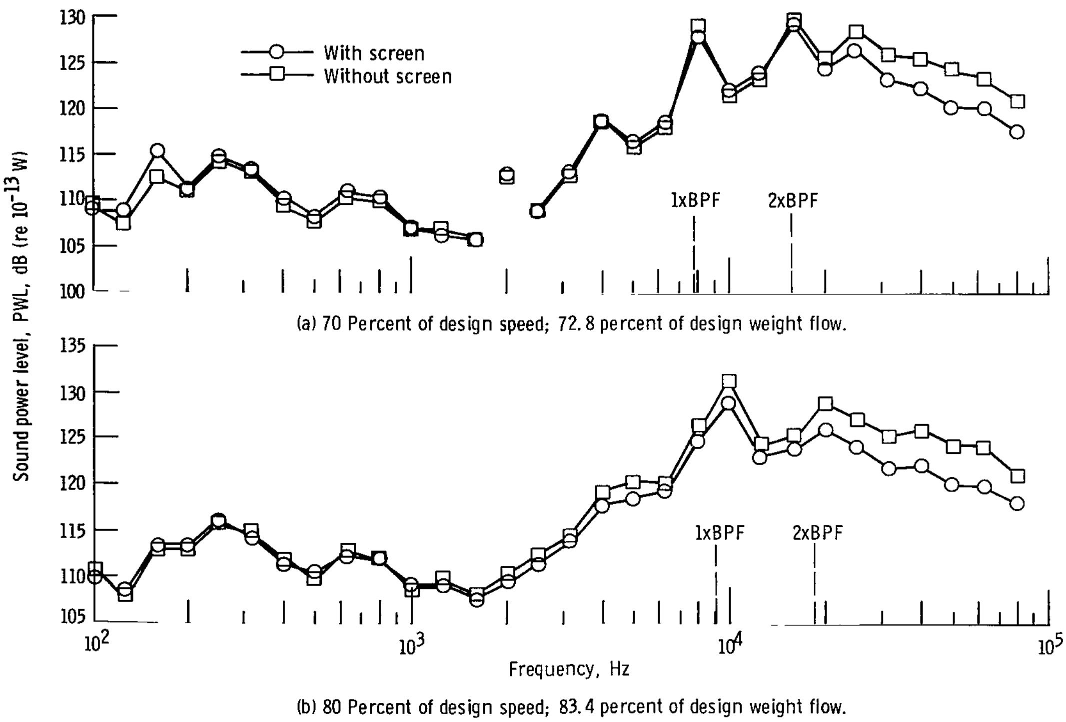
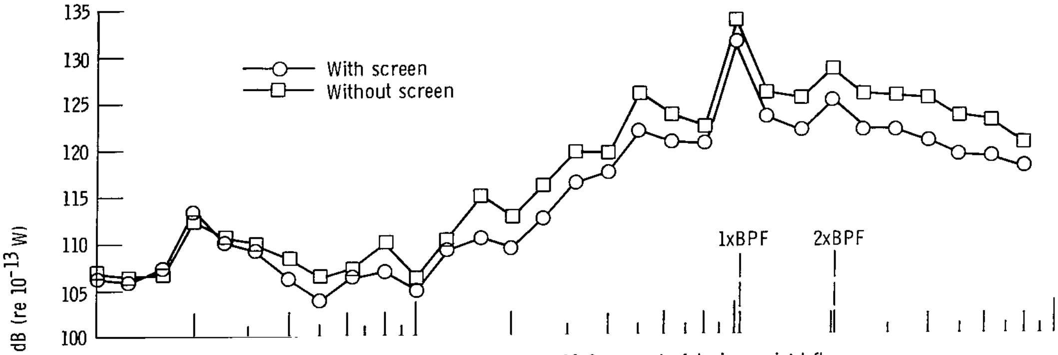
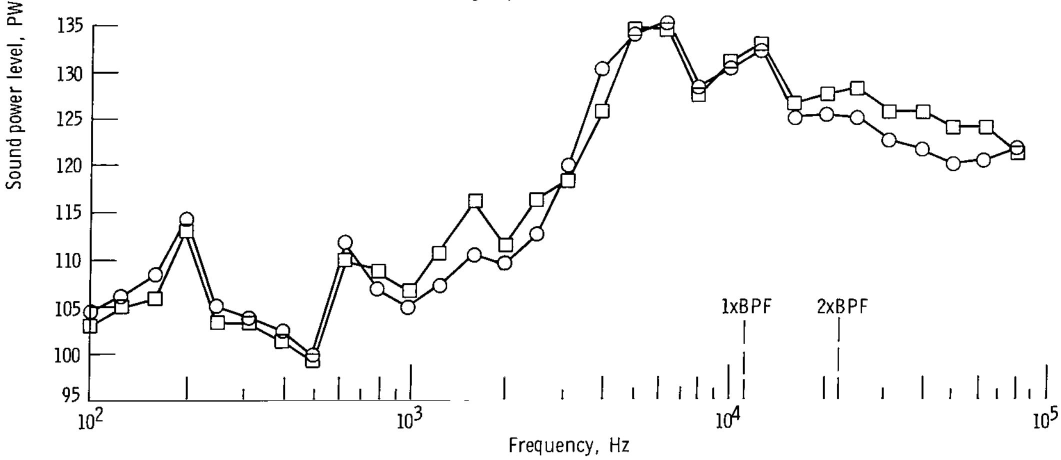


Figure 13. - Effect of inlet turbulence screen on inlet sound power spectrum in anechoic chamber.



(c) 90 Percent of design speed; 93.8 percent of design weight flow.



(d) 100 Percent of design speed; 99.8 percent of design weight flow.

Figure 13. - Concluded.

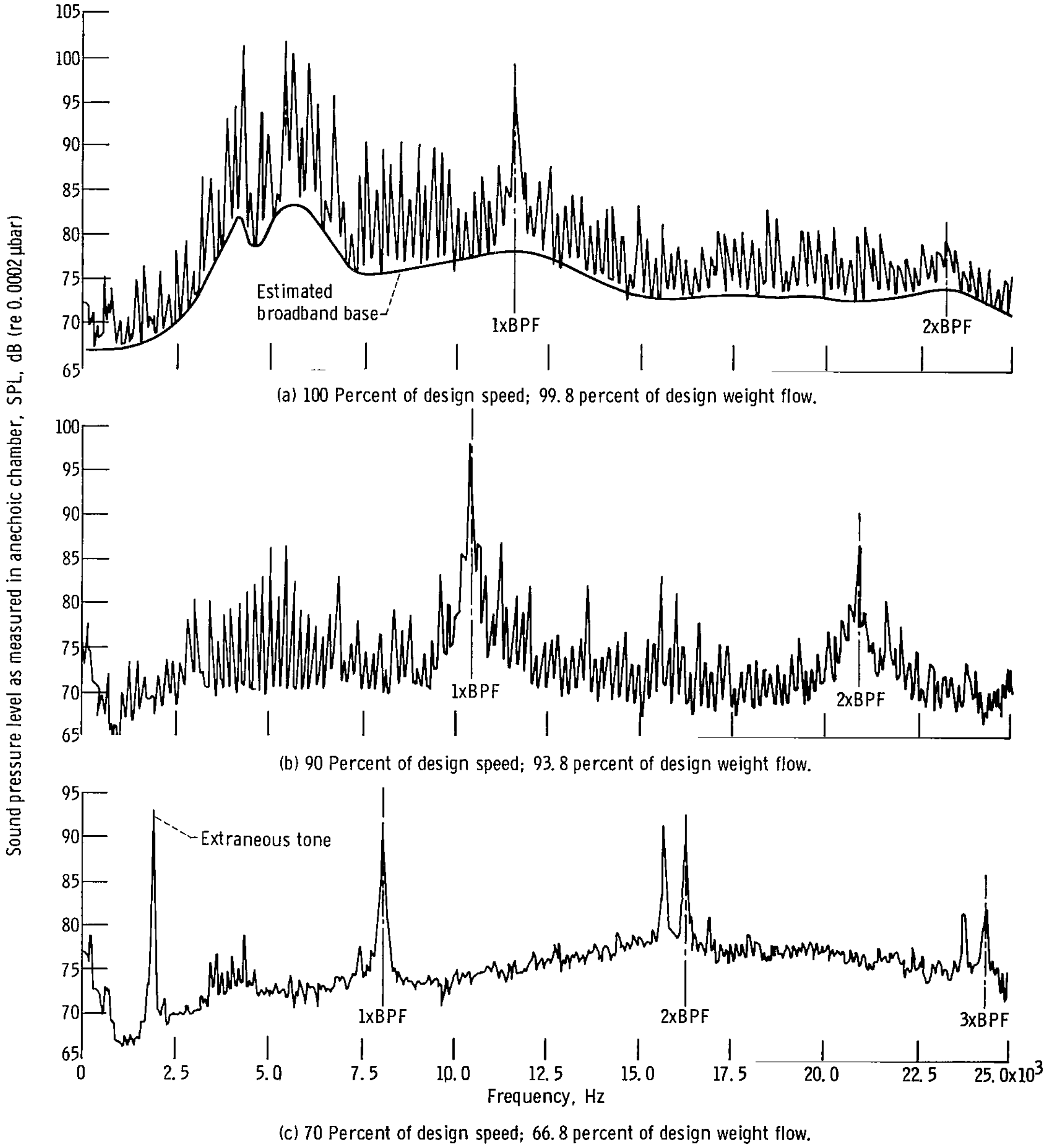


Figure 14. - Inlet sound pressure level spectra in anechoic chamber; 60° microphone. Typical 50-hertz constant bandwidth analysis.

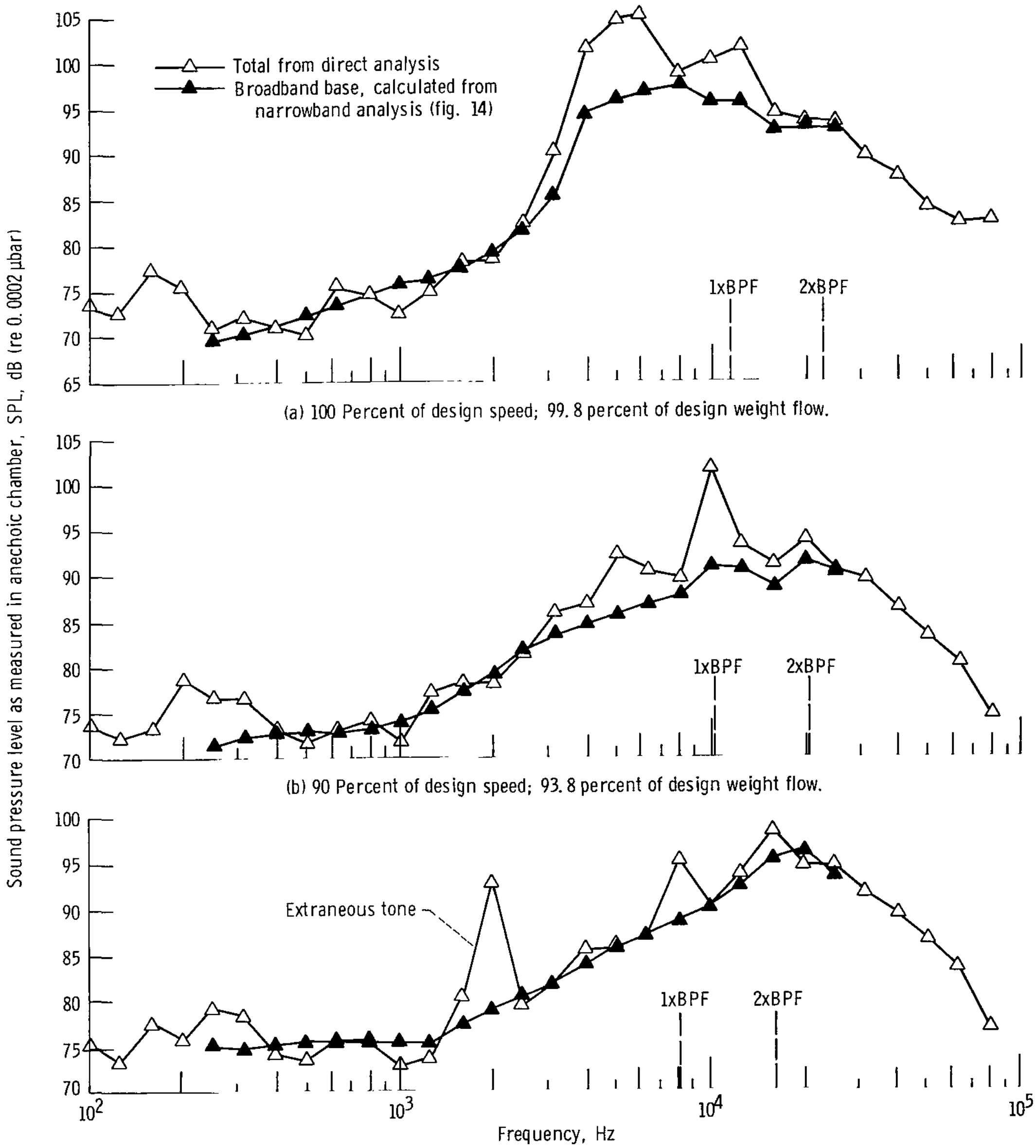


Figure 15. - Inlet sound pressure level spectra in anechoic chamber; 60° microphone. Comparison of direct one-third octave band analysis of total noise with values of broadband component calculated from 50-hertz constant bandwidth analysis.

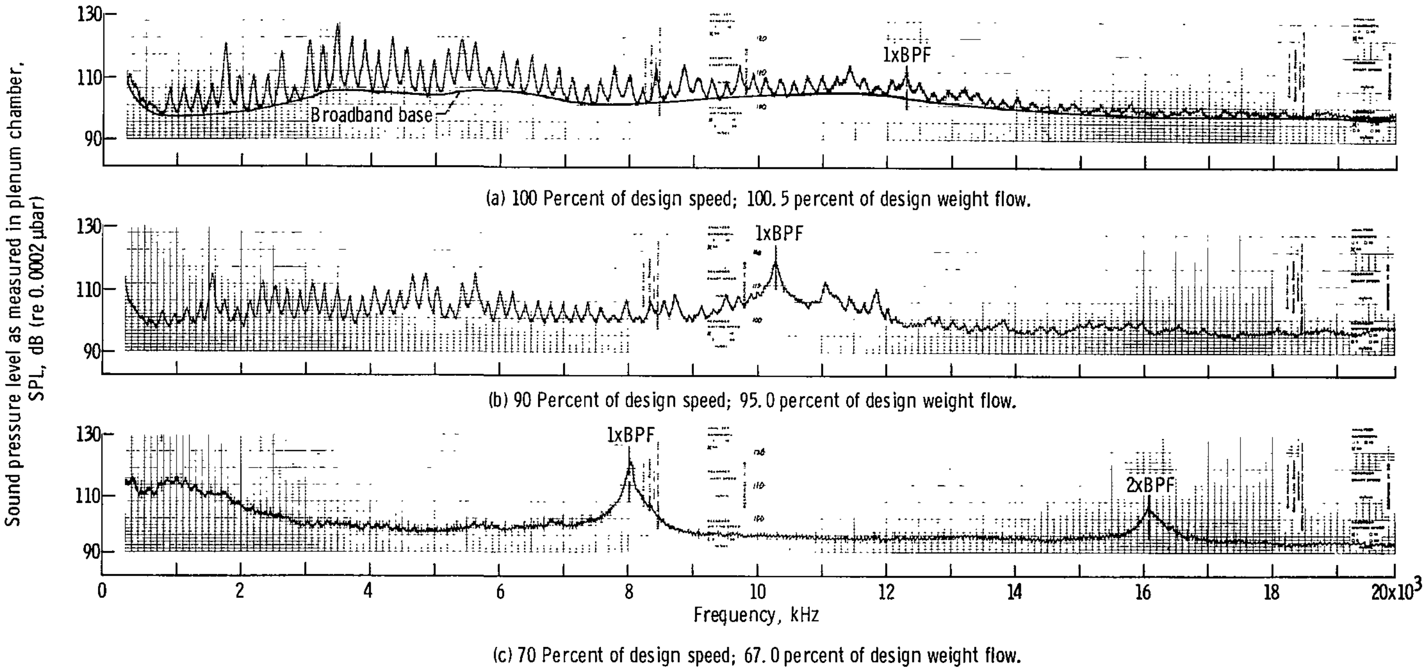
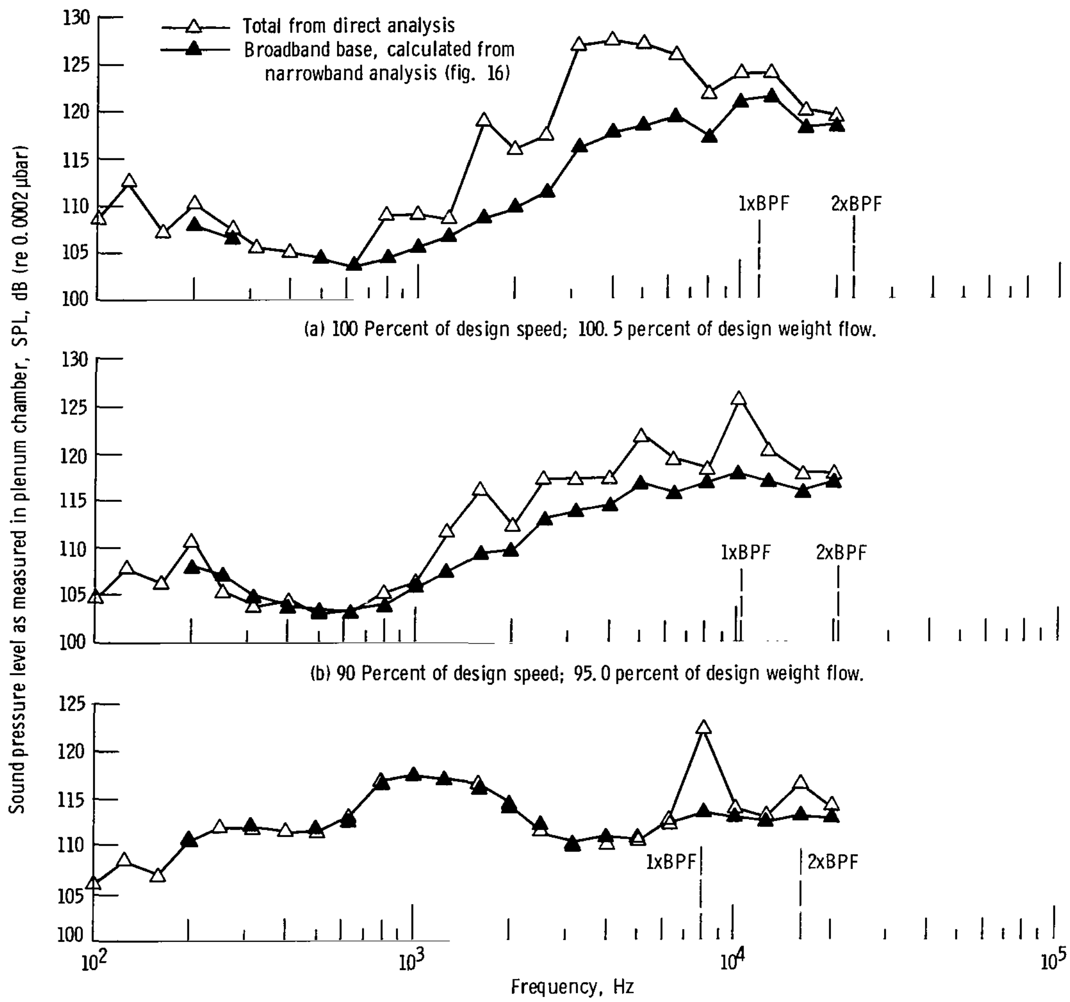
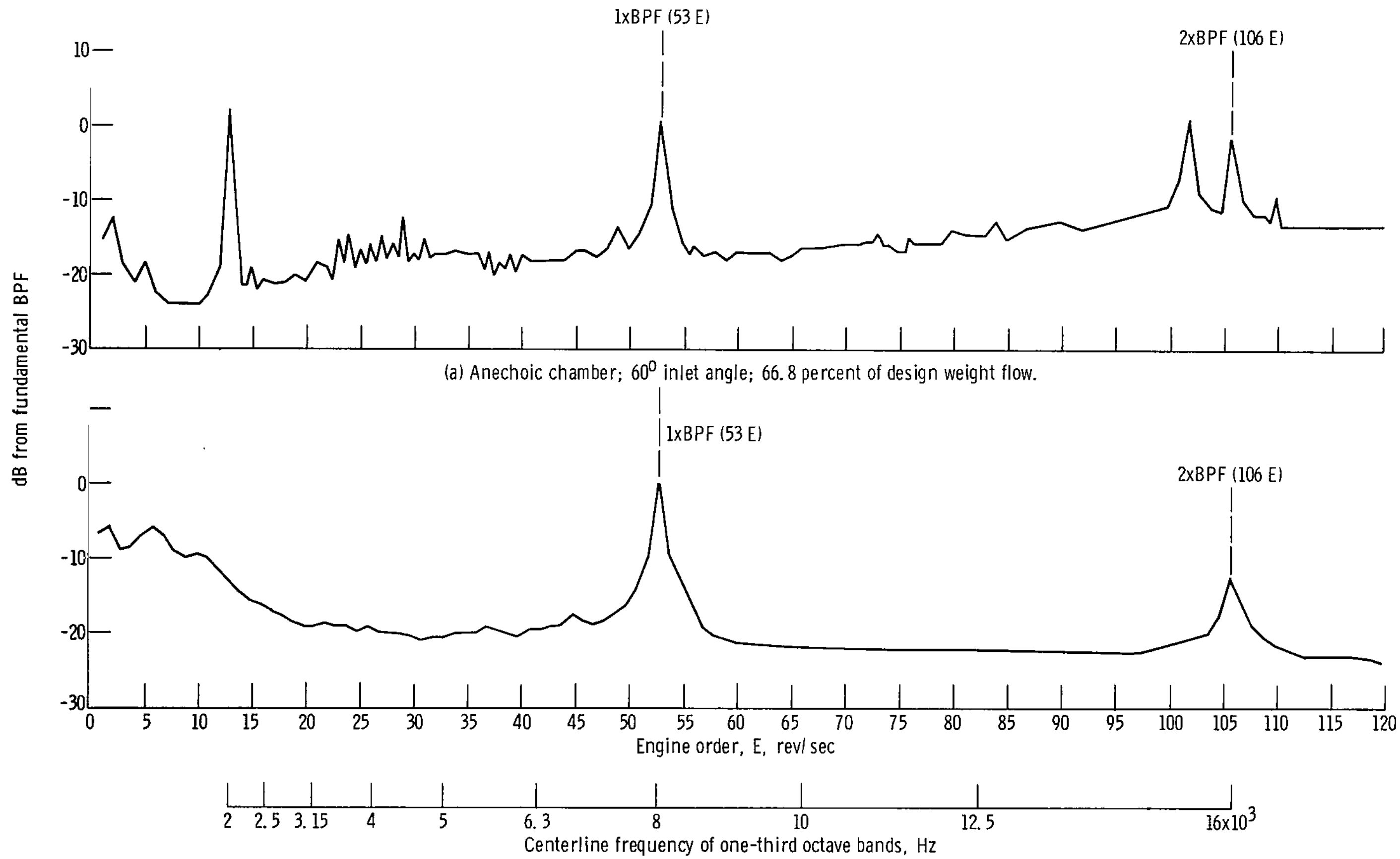


Figure 16. - Inlet sound pressure level spectra in unmodified compressor test facility. Typical 50-hertz constant bandwidth analysis.



(c) 70 Percent design speed; 67.0 percent of design weight flow.

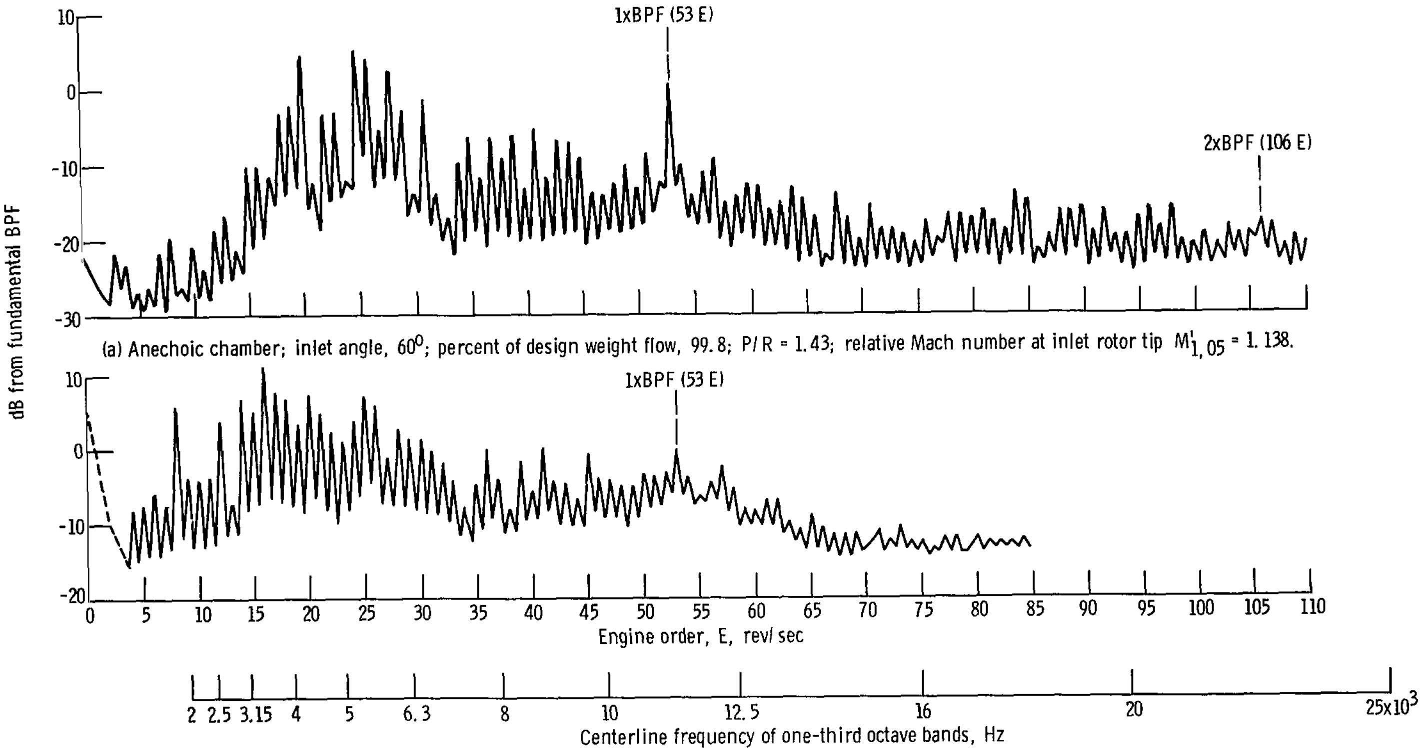
Figure 17. - Inlet sound pressure level spectra in unmodified compressor test facility. Comparison of direct one-third octave band analysis of total noise with values of broadband component calculated from 50-hertz constant bandwidth analysis.



(a) Anechoic chamber; 60° inlet angle; 66.8 percent of design weight flow.

(b) Untreated plenum chamber; 67.0 percent of design weight flow.

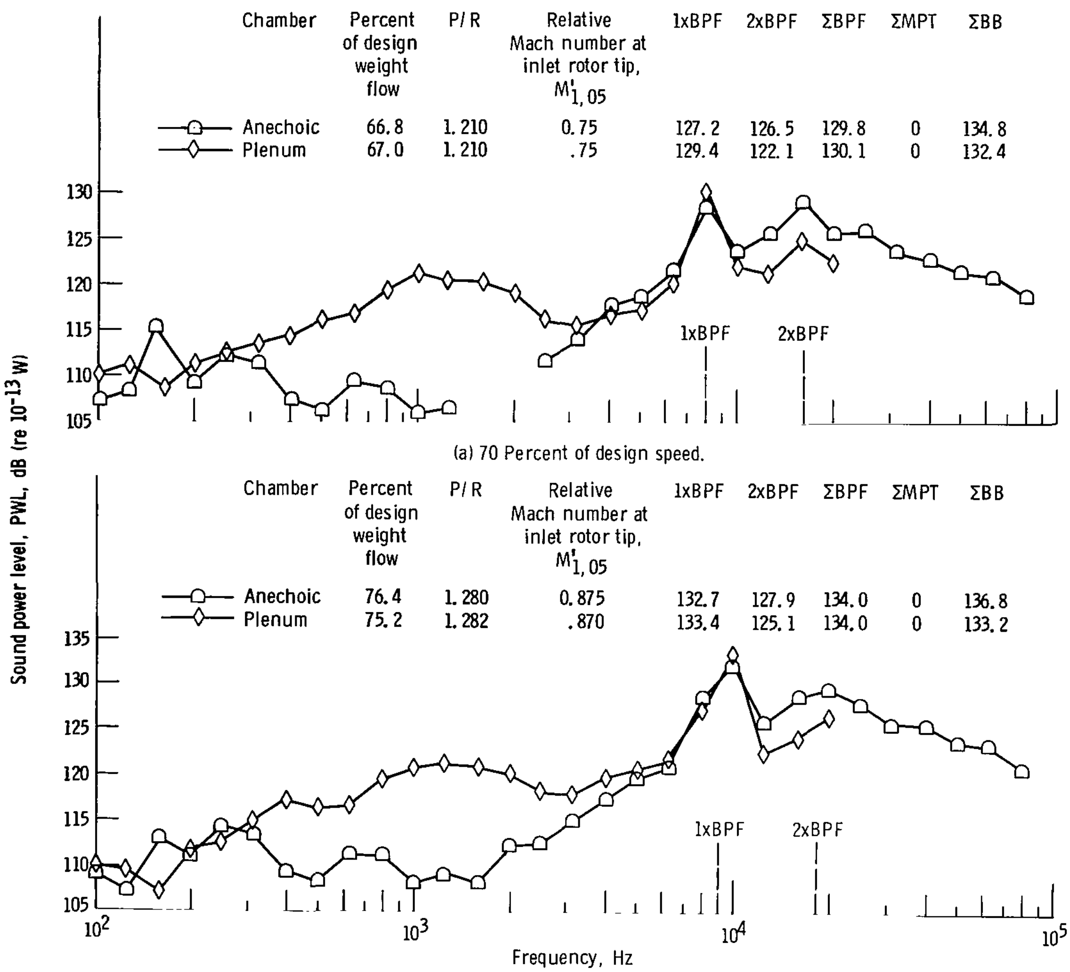
Figure 18. - Typical continuous 50-hertz constant bandwidth spectra (simulated) in anechoic chamber at 60° inlet angle and in inlet plenum chamber of unmodified compressor test facility. 70 Percent of design speed; P/R = 1.21; relative Mach number at inlet rotor tip, $M'_{1,05}$ = 0.75.



(a) Anechoic chamber; inlet angle, 60°; percent of design weight flow, 99.8; P/R = 1.43; relative Mach number at inlet rotor tip $M'_{1,05}$ = 1.138.

(b) Untreated plenum chamber; percent of design weight flow, 100.5; P_3/P_1 = 1.385; relative Mach number at inlet rotor tip $M'_{1,05}$ = 1.145.

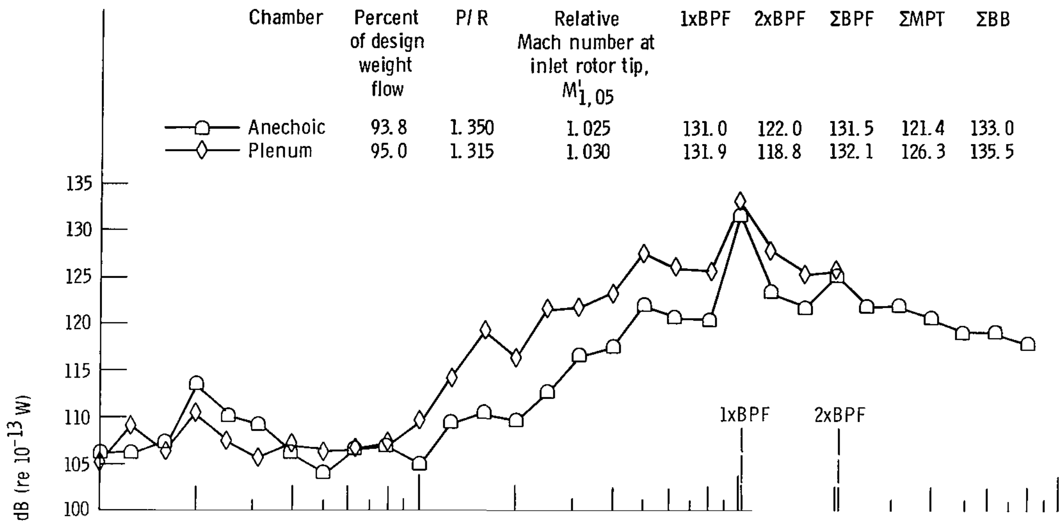
Figure 19. - Typical continuous 50-hertz constant bandwidth spectra (simulated) in anechoic chamber at 60° inlet angle and in inlet plenum chamber of unmodified compressor test facility. 100 Percent of design speed.



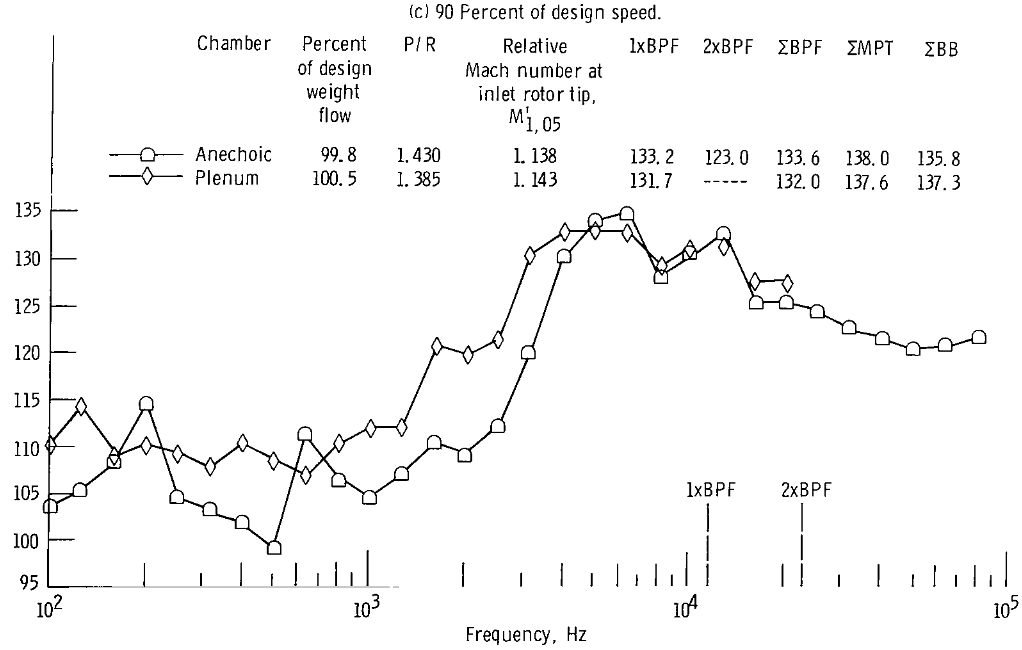
(a) 70 Percent of design speed.

(b) 80 Percent of design speed.

Figure 20. - Inlet sound power spectra as measured in anechoic chamber and in unmodified compressor test facility at comparable conditions.



(c) 90 Percent of design speed.



(d) 100 Percent of design speed.

Figure 20. - Concluded.

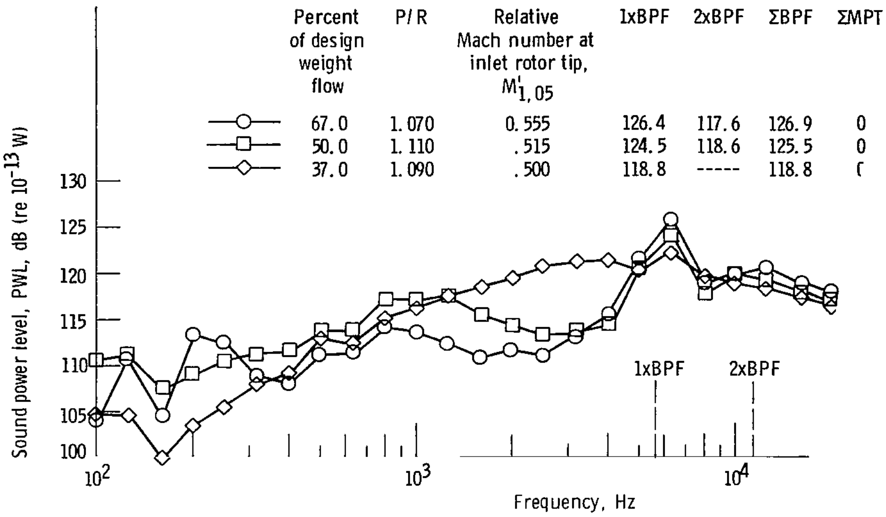


Figure 21. - Inlet sound power spectrum as measured in unmodified compressor design speed.

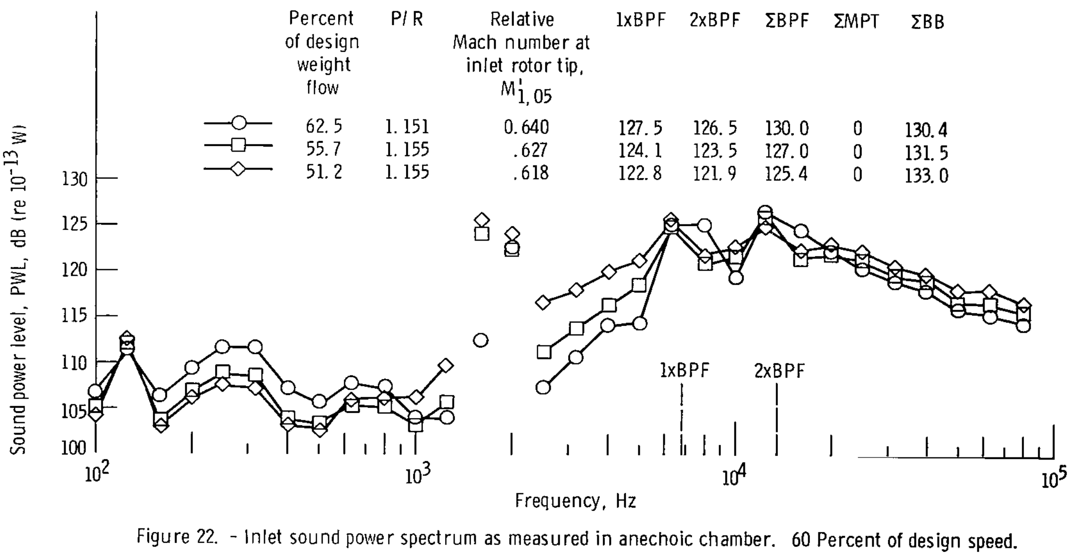
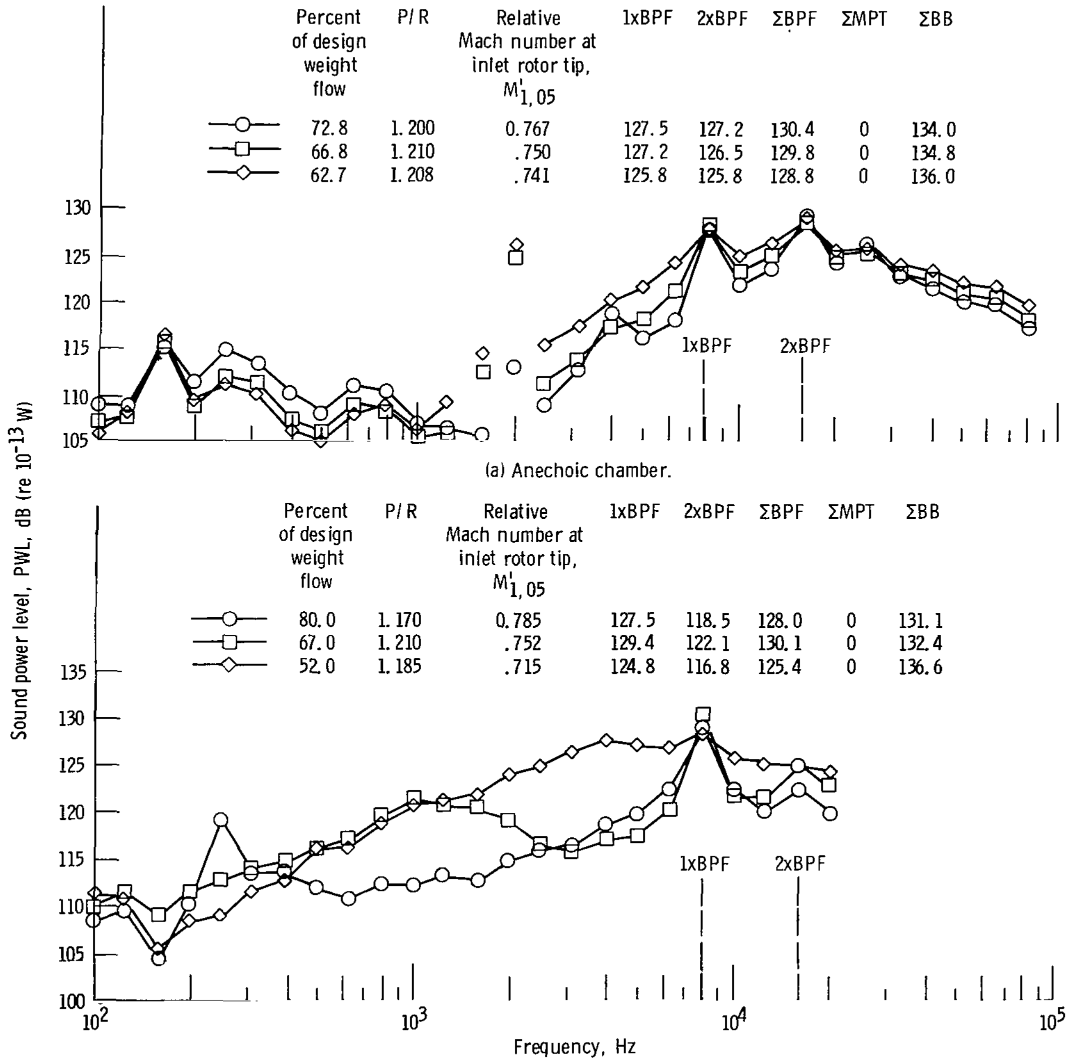
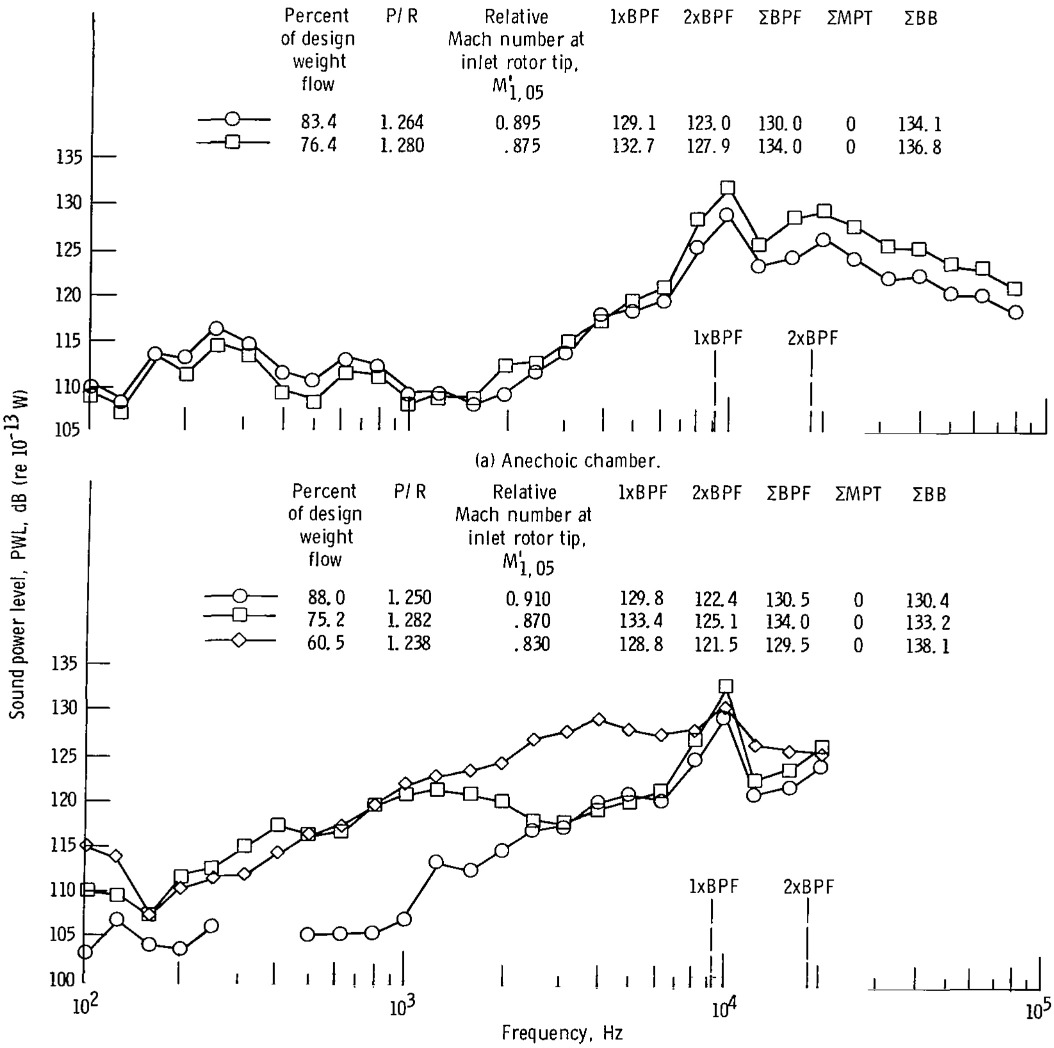


Figure 22. - Inlet sound power spectrum as measured in anechoic chamber. 60 Percent of design speed.



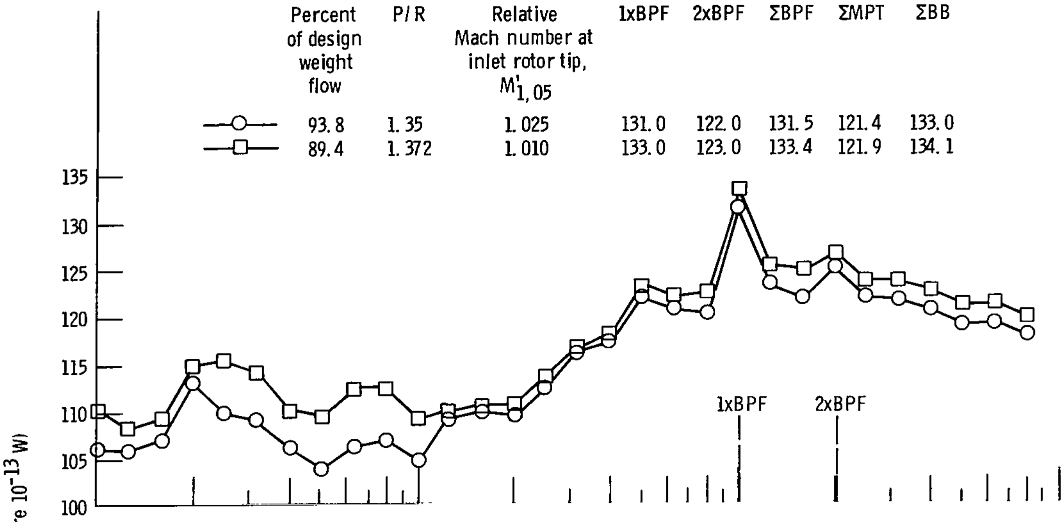
(b) Plenum chamber.

Figure 23. - Inlet sound power spectrum as measured in anechoic chamber and in unmodified compressor test facility. 70 Percent of design speed.

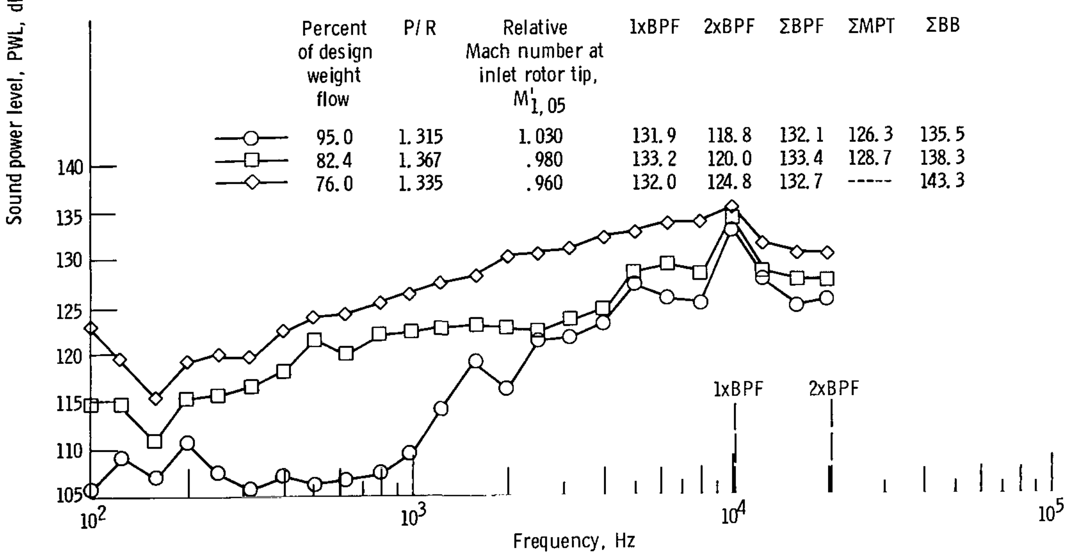


(b) Plenum chamber.

Figure 24. - Inlet sound power spectrum as measured in anechoic chamber and in unmodified compressor test facility. 80 Percent of design speed.

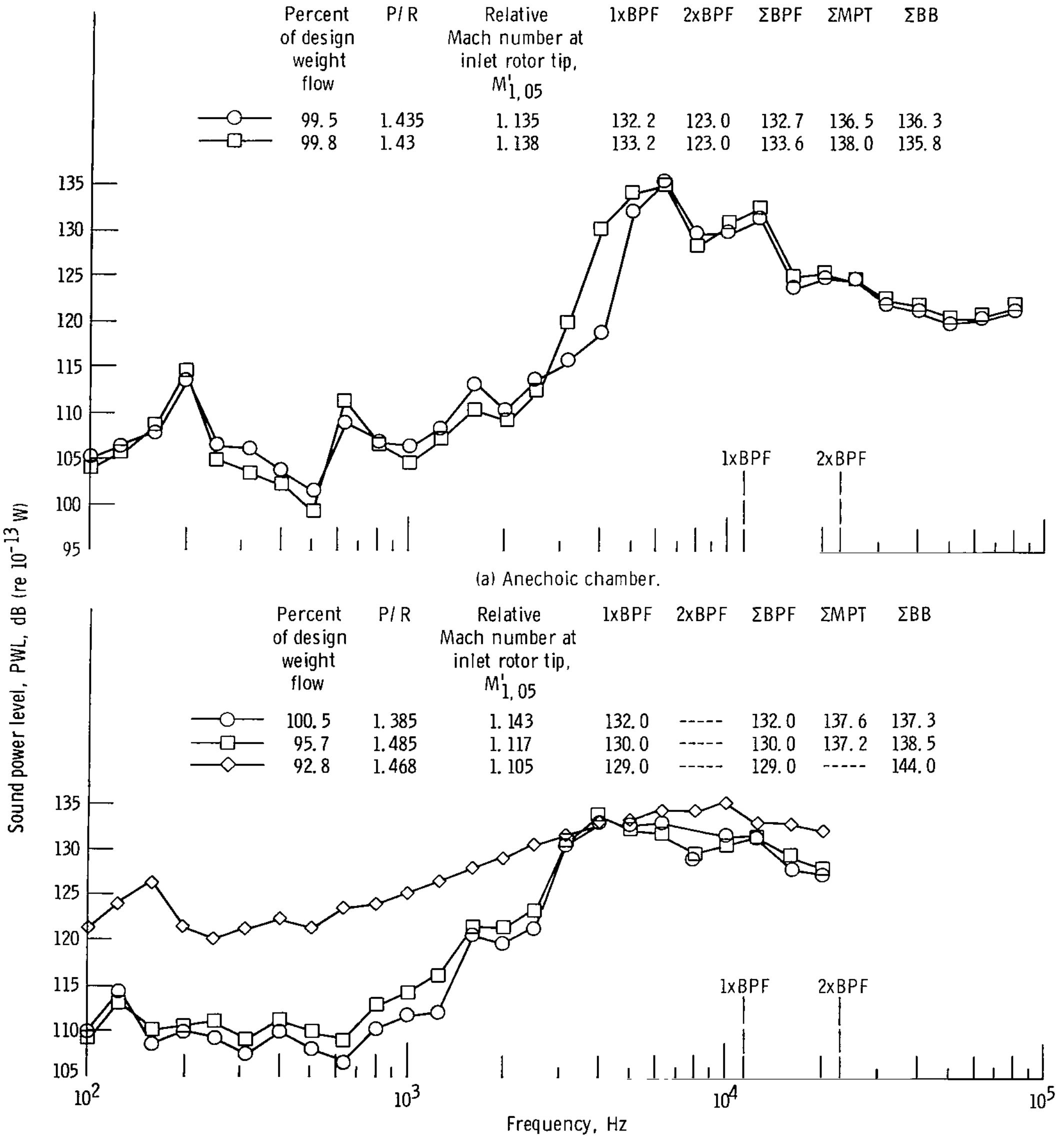


(a) Anechoic chamber.



(b) Plenum chamber.

Figure 25. - Inlet sound power spectrum as measured in anechoic chamber and in unmodified compressor test facility. 90 Percent of design speed.



(b) Plenum chamber.

Figure 26. - Inlet sound power spectrum as measured in anechoic chamber and in unmodified compressor test facility. 100 Percent of design speed.

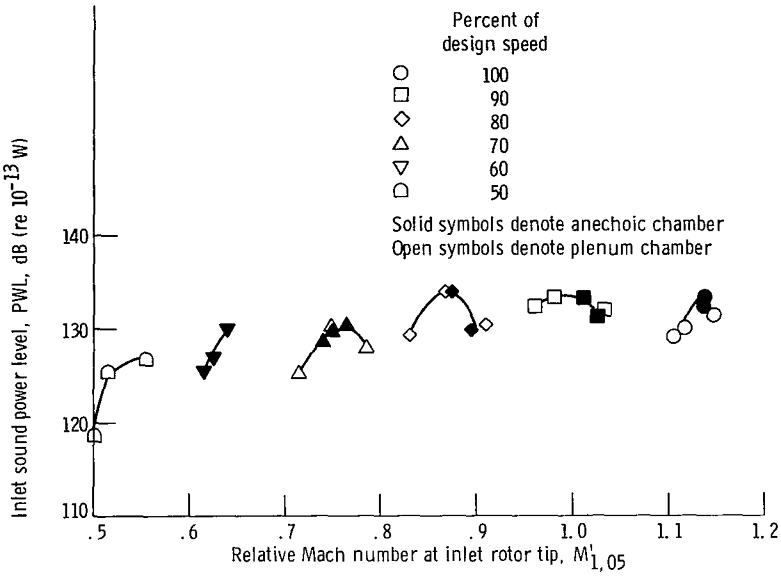


Figure 27. - Blade passing frequency noise (1xBPF + 2xBPF) as measured in unmodified compressor test facility and in anechoic chamber. One-third octave analysis.

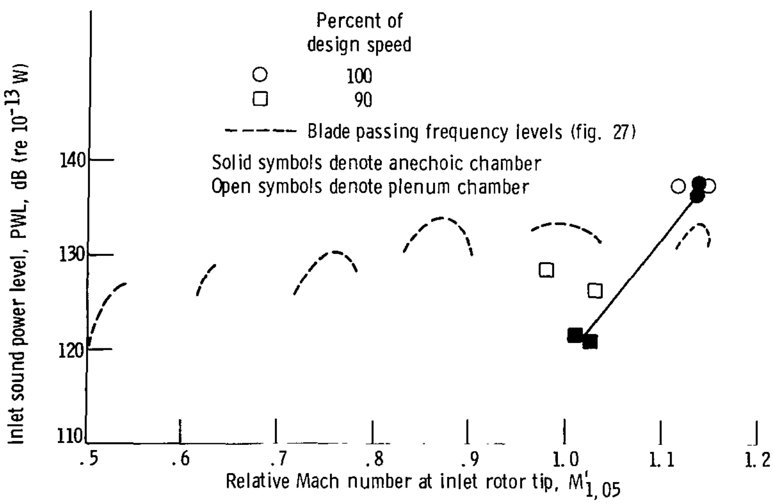


Figure 28. - Multiple pure tone noise (BPF's excluded) as measured in unmodified compressor test facility and in anechoic chamber. One-third octave analysis.

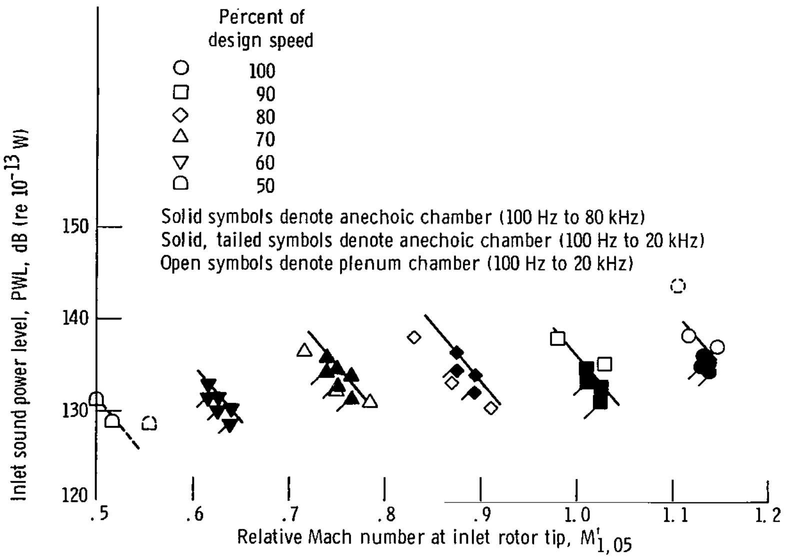
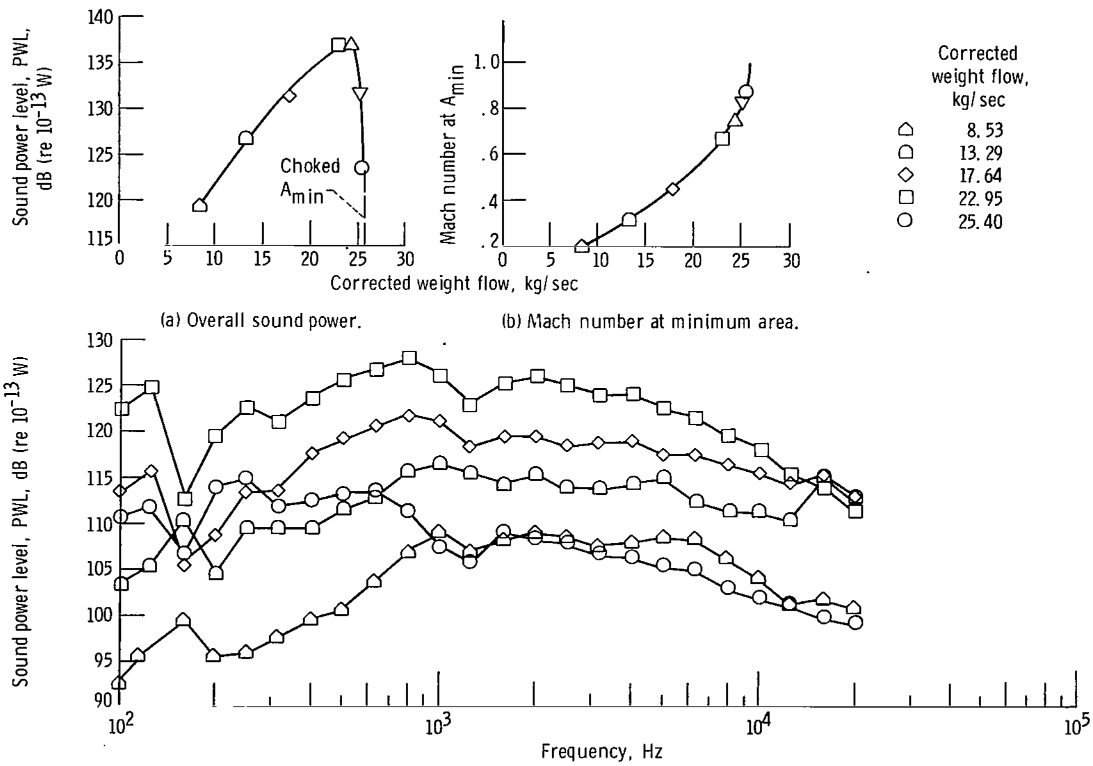


Figure 29. - Broadband noise as measured in unmodified compressor test facility and in anechoic chamber. One-third octave analysis.



(c) One-third octave sound power spectra for range of flows.

Figure 30. - Effects of corrected weight flow induced without rotor or stator in unmodified compressor test facility with collector sleeve valve.

"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

NASA SCIENTIFIC AND TECHNICAL PUBLICATIONS

TECHNICAL REPORTS: Scientific and technical information considered important, complete, and a lasting contribution to existing knowledge.

TECHNICAL NOTES: Information less broad in scope but nevertheless of importance as a contribution to existing knowledge.

TECHNICAL MEMORANDUMS: Information receiving limited distribution because of preliminary data, security classification, or other reasons. Also includes conference proceedings with either limited or unlimited distribution.

CONTRACTOR REPORTS: Scientific and technical information generated under a NASA contract or grant and considered an important contribution to existing knowledge.

TECHNICAL TRANSLATIONS: Information published in a foreign language considered to merit NASA distribution in English.

SPECIAL PUBLICATIONS: Information derived from or of value to NASA activities. Publications include final reports of major projects, monographs, data compilations, handbooks, sourcebooks, and special bibliographies.

TECHNOLOGY UTILIZATION PUBLICATIONS: Information on technology used by NASA that may be of particular interest in commercial and other non-aerospace applications. Publications include Tech Briefs, Technology Utilization Reports and Technology Surveys.

Details on the availability of these publications may be obtained from:

SCIENTIFIC AND TECHNICAL INFORMATION OFFICE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington, D.C. 20546