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ACOUSTIC AND AERODYNAMIC PERFORMANCE OF A 1.83-METER (6-FT) DIAMETER 1.25-PRESSURE-RATIO FAN (QF-8)

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16. Abstract

A 1.25-pressure-ratio 1.83-meter (6-ft) tip diameter experimental fan stage with characteristics suitable for engine application on STOL aircraft was tested for acoustic and aerodynamic performance. The design incorporated proven features for low noise, including absence of inlet guide vanes, low rotor blade tip speed, low aerodynamic blade loading, and long axial spacing between the rotor and stator blade rows. The fan was operated with five exhaust nozzle areas. The stage noise levels generally increased with a decrease in nozzle area. Separation of the acoustic one-third octave results into broadband and pure-tone components showed the broadband noise to be greater than the corresponding pure-tone components. The sideline perceived noise was highest in the rear quadrants. The acoustic results of QF-8 were compared with those of two similar STOL application fans in the test series. The QF-8 had somewhat higher relative noise levels than those of the other two fans. The aerodynamic results of QF-8 and the other two fans were compared with corresponding results from 50.8-cm (20-in.) diam scale models of these fans and design values. Although the results for the full-scale and scale models of the other two fans were in reasonable agreement for each design, the full-scale fan QF-8 results showed poor performance compared with corresponding model results and design expectations. Facility effects of the full-scale fan QF-8 installation were considered in analyzing this discrepancy.

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SUMMARY

A 1.25-pressure-ratio, 1.83-meter (6-ft) tip-diameter experimental fan stage suitable for engine application on a STOL aircraft was tested for acoustic and aerodynamic performance. The design incorporated features for low noise, including absence of inlet guide vanes, low rotor tip speed (258 m/sec (845 ft/sec)), low aerodynamic blade loading, and long axial spacing between the rotor and stator blade rows. At design speed the 110 percent-of-design-area nozzle enabled the QF-8 fan stage to operate closest to the design point, with a measured corrected inlet mass flow of 420 kilograms per second (927 lbm/sec), a pressure ratio of 1.230, and a corrected thrust of 80 086 newtons (18 004 lbf). Corresponding design values were 423 kilograms per second (933 lbm/sec), 1.25, and 82 939 newtons (18 647 lbf).

A 50.8-centimeter (20-in.) diameter scale model of fan QF-8 was tested for aerodynamic performance in an indoor facility. The results were compared with full-scale fan results and with design values. Although the model results were in reasonable agreement with the design, some significant differences were noted in the corresponding full-scale results. The full-scale results were adversely affected by the closeness of the support pylon to the stator exit and the circumferential increase in the diameter of the outer wall of the flow passage at the stator exit to compensate for pylon blockage.

The sound pressure and power level spectra were typical of a subsonic relative tip velocity fan. Separation of the acoustic one-third-octave results into broadband and pure tone components showed the broadband noise to be higher than the pure tone components. The sideline perceived noise for the QF-8 fan was rear quadrant dominated. At the design speed and with the 110 percent-of-design-area nozzle, the maximum sideline perceived noise along a 152.4-meter (500-ft) sideline was 108 perceived noise decibels (PNdB).

The QF-8 fan was the last of three experimental fans with characteristics suitable for a quiet STOL aircraft engine tested at the NASA quiet fan facility. The acoustic results for these three fans were compared. The QF-8 had relatively higher noise levels than those of the other two fans. The increased noise level for the QF-8 fan was believed related to the poorer aerodynamic performance of that fan compared with the other two full-scale fans.

INTRODUCTION

Noise generation as well as aerodynamic performance are important considerations for short takeoff and landing (STOL) aircraft operating near populated areas. Although no firm STOL aircraft noise specifications exist at present that are comparable to Federal Air Regulation - Part 36 (FAR-36), an often-presented goal for STOL sideline noise is 95 EPNdB along a 152.4-meter (500-ft) sideline (ref. 1). The noise of a single engine would be somewhat less than this goal for the total multiengine aircraft noise.

Cycle analysis of optimum engines for externally blown flap STOL application (ref. 2), show that the fan pressure ratio should be in the range from 1.20 to 1.35. The quiet STOL engine requirement of a large flow of relatively low exhaust velocity results in an engine bypass ratio of about 10 to 15.

This report presents the acoustic and aerodynamic results of a full-scale experimental fan with characteristics suitable for such a quiet STOL engine. This fan, designated QF-8, had a tip diameter of 1.83 meters (6 ft) and a design pressure ratio of 1.25. Major design features for low noise generation that were incorporated in QF-8 included eliminating the use of inlet guide vanes, low rotor tip speed, low aerodynamic blade loading, and long axial spacing between the rotor and stator blade rows. QF-8 had 30 rotor blades and 34 stator vanes. The blade-vane numbers were not chosen for duct-mode cutoff because of other acoustic design restraints. The design thrust of QF-8 was 82 939 newtons (18 647 lbf), and the design rotor tip speed was 258 meters per second (845 ft/sec).

Two other full-size experimental fans with characteristics suitable for a quiet STOL engine were tested at the same facility. QF-6 (ref. 3) had 42 rotor blades and 50 stator vanes and was designed for a stage pressure ratio of 1.20. QF-9 (ref. 4) also had a design stage pressure ratio of 1.20 but had only 15 rotor blades and 11 stator vanes. The low number of rotor blades on QF-9 reduced its passage tone frequency into a region of lower perceived noise weighting and facilitated a mechanism that allowed the rotor blade pitch to be adjusted for various conditions including thrust reversal. Reference 5 is a comparison of the acoustic performance of the QF-6 and QF-9 design configurations.

Of the three fans, QF-8 had the highest design values of tip speed, relative inlet Mach number, stage pressure ratio, and thrust. In general, the QF-8 fan values for solidity, number of blades, and D-factor were between the corresponding values for fans QF-6 and QF-9. The data obtained from these three fans are compared in this report.

The QF-8 fan was run without acoustic treatment in the flow passages of the simulated nacelle. A series of nozzles was tested which included the calculated design exit area and nozzles having 106, 110, 115, and 119 percent of this design exit area.

Aerodynamic results are presented in terms of corrected mass flow, exit velocity, corrected thrust, and stage adiabatic efficiency. The QF-8 fan acoustic results are presented for sound pressure level at various azimuth angles, for sound power level, and for perceived noise level based on one-third octave data. Narrow-band sound pressure level spectra are presented for selected conditions.

Scale models (50.8-cm (20-in.) rotor-tip diam) of QF-6, QF-8, and QF-9 were extensively tested for aerodynamic performance in a highly instrumented indoor facility. The aerodynamic results for the QF-8 and QF-9 models are, respectively, presented in references 6 and 7. No acoustic results are presented for the model fans since the test facility used for the model tests is not designed for such investigations. The aerodynamic results of the three full-scale fans are compared to corresponding model results and design values in this report.

FAN STAGE

Acoustic and Aerodynamic Considerations

The QF-8 experimental fan stage was designed to have characteristics suitable for a turbofan engine applicable to an externally blown flap under-the-wing configuration for a short takeoff and landing (STOL) airplane. This fan was designed to be quiet within the constraints of conservative, conventional aerodynamic design practice. Considerations for reduced acoustic noise levels include the absence of inlet guide vanes, the use of low rotor tip speed, low rotor blade aerodynamic loading, and long axial spacing between the rotor and stator blade rows. These features have been used before in low-noise fans (ref. 8) and are compatible with low-noise design practice.

Inlet guide vanes produce a pattern of trailing wakes that impinge on the rotor blades with a resultant tone contribution at the rotor blade passage frequency and associated overtones (e.g., see ref. 9). Therefore, the absence of inlet guide vanes eliminates this major noise source.

The energy input to the air by the rotor blades is a direct function of rotor tip speed and blade loading. The rotor tip speed relates to the relative Mach number on the blades. Multiple pure tones, which are associated with supersonic flow past the blade, are not expected to be generated by QF-8 because the low tip speed results in a tip relative Mach number somewhat below unity.

Local blade loading is usually expressed in terms of the diffusion factor (D-factor), which is based on the diffusion in velocity on the blade suction surface. The relation is given as

$$\text{D-factor} = 1 - \frac{V_2}{V_1} + \frac{\Delta V_\theta}{2\sigma V_1} \qquad (1)$$

where V_1 and V_2 are, respectively, the blade inlet and outlet relative velocities, ΔV_θ is the change in tangential velocity across the blade, and σ is the blade solidity. Reference 10 indicates that low diffusion factors (and thus low loading) will aid in reducing the discrete tone noise levels. The rotor-tip speed is inversely related to the average blade loading for a given work input. Therefore, a compromise was made between the rotor-tip speed and blade loading. QF-8 had a design rotor-tip speed of 258 meters per second (845 ft/sec) and a maximum rotor diffusion factor of 0.45. At the rotor hub and tip the diffusion factors were 0.32 and 0.34, respectively. These diffusion factors are well below the generally used upper limit for flow of 0.50 to 0.55. At this design rotor tip speed, the rotor-tip inlet relative Mach number is 0.921, somewhat less than that which would be expected to generate significant multiple pure tones (ref. 11).

A long axial spacing between the rotor and stator blade rows is useful in providing mixing length to help dissipate the rotor wakes before they impinge on the stator vanes. These wakes generate a noise contribution at the rotor-blade-passage frequency. However, higher aerodynamic losses may be associated with this long mixing length between the blade rows than would occur with close rotor-stator spacing. This large spacing may result in a longer, heavier engine than might be possible with a closer spacing. QF-8 had a rotor-stator axial separation of approximately 4 rotor chords at the mean radius. This large blade-row separation, together with the previously mentioned absence of inlet guide vanes, was expected to reduce blade-row interaction noise generation at blade-passage frequency (ref. 12).

Reference 13 indicates that long stator chords reduce the response to incoming rotor wakes, possibly reducing the blade-passage frequency noise. Relatively large stator chords (stator and rotor mean aerodynamic chords about equal) were used in the QF-8 fan design for this purpose. The number of stator vanes was then determined by a desire to maintain conventional solidity values.

Low-noise fans are frequently designed with consideration of the cutoff theory of reference 14 to prevent the forward propagation of certain spinning modes. This technique requires the number of stator vanes to be slightly greater than twice the number of rotor blades. QF-8 was not a cut-off fan because the small number of stator vanes (34) resulting from the relatively large chord length for the desired solidity violated this cutoff criterion.

Reference 13 also indicates an acoustic advantage in adjusting the stator-vane design incidence angles to minimize fluctuating lift. These angles were adjusted in the design in the direction of lowering blade-passage frequency noise, but they were not adjusted to the extent indicated by acoustic calculations because of the possible detriment to the aerodynamic performance of the fan. Reference 6, which describes the results of the 50.8-centimeter (20-in.) rotor-tip-diameter model of QF-8, includes a detailed description of the QF-8 fan aerodynamic design.

Design Characteristics

A summary of major design characteristics of fan QF-8 is presented in table I. Photographs of the QF-8 rotor and stator blading are presented in figure 1. Figure 1(a) shows the 30 rotor blades (looking downstream). The low hub-tip ratio (0.40) is evident in this photograph. An upstream view of the stator vanes is presented in figure 1(b). The large support pylon is clearly seen in the foreground of this view.

Figure 2 is included to show how the design rotor-tip speed and stage pressure ratio of QF-8 compare with other fans tested at the same facility. As previously mentioned, the QF-6 and QF-9 fans were also experimental STOL application fans, both with a 1.20 stage pressure ratio. The remaining fans presented in figure 2 are more suited for conventional takeoff and landing aircraft. The work coefficient values shown in figure 2 give an indication of the overall stage loading.

Flow Path

Two additional restraints were imposed on the QF-8 fan design. The flow passage was to have no inner-radius convergence through the stage as is conventional with higher pressure ratio fans. This was in consideration of the proposed blown-flap application to facilitate the rejoining of the engine fan and core flows. Also, the elimination of this convergence reduces the overall required flow passage length to achieve this joined flow, resulting in a more compact engine. This straight inner flow passage is clearly shown in the stage cross section (fig. 3). The circumferential increase in the outer radius of the flow passage downstream of the stator is shown in figure 3. This was required to compensate for the blockage caused by the facility pylon. The calculated design nozzle area of 1.912 square meters (20.58 ft^2) was similar to the flow passage area immediately downstream of the stator exit of 1.950 square meters (20.99 ft^2).

A second restraint was to design for a 0.4 rotor inlet hub-tip ratio. Advantages of a low rotor hub-tip ratio include an increased mass flow through the fan for a given tip diameter and a smaller inner flow contour radius to assist in the rejoining of the fan and engine core airflows. The QF-8 design had an inlet hub-tip ratio of 0.402.

The QF-8 fan was designed to be tested using part of the already-existing structure and exhaust-end flow ducting of the full-scale fan facility. As a result, the fan rotor discharge flow is not divided radially (fig. 3) as would be the case in an actual turbofan engine where the inner portion of the rotor flow is ducted into the core engine. Likewise, the scale model of QF-8 did not have a radially split discharge flow. The presence of a flow splitter behind the rotor would allow reduced loading of both rotor and stator near the hub.

Using figure 4 one may compare the full-scale QF-8 fan flow passage contour (fig. 4(a)) with a conventional design contour (fig. 4(c)) and with the scale model installation (fig. 4(b)). The inner-surface contour for the conventional configuration is helpful in reducing D-factors near the blade hub. The outer radius of the flow passage of the full-scale fan QF-8 was increased downstream of the stator (fig. 4(a)) to compensate for pylon blockage (fig. 5). This modification of the flow passage was not used for the 50.8-centimeter (20-in.) rotor-tip-diameter model of QF-8 as shown in figure 4(b).

The requirement of axial stator outflow for the relatively low hub-tip ratio stator used for QF-8 resulted in higher hub-region blade loadings than for a conventional stator installation. The axial requirement (at the hub) was imposed by the centerbody pylon (see fig. 5). The pylon is a 20 percent thick airfoil in cross section. Any significant angularity of the flow impinging on it would cause a large local flow separation, which would in turn block a portion of the flow path in this area, and thus cause the fan to operate closer to, or in, stall.

Design Comparisons

Three experimental fans with characteristics suitable for STOL aircraft application were tested at the quiet fan facility.

A comparison of selected design parameters for the QF-6, QF-8, and QF-9 fans is presented in table II. Design details of the QF-6 and QF-9 fans are presented in references 3 and 4. Fan QF-8 had the highest design values of tip speed, relative inlet Mach number, stage pressure ratio, and thrust. In general, the QF-8 fan values for solidity, number of blades, and D-factor were between the corresponding values for the QF-6 and QF-9 fans. The rotor-tip solidity of QF-9 was, of necessity, less than 1.0 to allow the blades to rotate to a reverse thrust position. The fan rotor-tip solidities for QF-6, QF-8, and QF-9 were 1.188, 1.000, and 0.893, respectively. The rotor D-factors were lowest for QF-6, which had a maximum rotor D-factor of 0.386. The maximum rotor D-factor for QF-8 was 0.447 and for fan QF-9, 0.530. The maximum stator D-factor for fan QF-8 was higher than the maximum D-factors of either fans QF-6 or QF-9.

TEST FACILITY

The QF-8 fan was tested at the NASA quiet fan facility, a photograph of which appears in figure 6(a). The fan was located on a concrete pedestal. Existing wind tunnel drive motors were used to drive the fan through a gear box and drive shaft and to maintain the fan speed within 0.5 percent of the selected test speeds. The microphones in figure 6(a) are shown covered with plastic bags for protection against inclement weather between the tests. Foam treatment is shown on the portion of the drive motor building wall that was considered likely to cause sound reflection at the microphone locations. With the treated building wall, calibration tests showed that the effect of the building was less than 1 decibel at frequencies above 400 hertz.

The entire test site was surfaced with asphalt. (See fig. 6(b).) The acoustic data were taken with an array of 16 microphones located at the fan centerline elevation of 5.9 meters (19.3 ft) on a 30.5-meter (100-ft) radius from the fan. The microphones are placed at 10° increments from 10° to 160° from the inlet centerline. The center of the microphone array was located 37 meters (121 ft) from the face of the wind tunnel drive motor building. Data were not taken at the inlet centerline (0°) because of the drive shaft nor above 160° because of the high-velocity fan exhaust. Further details on the design of the quiet fan facility are given in reference 15.

Aerodynamic Data

To obtain fan aerodynamic performance, measurements were made at four axial locations (fig. 3). The detailed layout of the instrumentation at each of these four measuring stations is shown in figure 7. Six equally spaced iron-constantan thermocouples were located on the bellmouth lip to determine the average inlet total temperature. These thermocouples extended about 1 centimeter (0.4 in.) from the surface to measure the ambient air temperature. Ten static taps were located on the outer wall of the inlet duct and were used for the inlet mass flow calculation using the assumptions of uniform one-dimensional flow, zero total-pressure loss at the duct station, and a zero wall boundary-layer thickness. The location of this station was established from a potential flow calculation. For the inlet mass flow calculations the ambient pressure reading was used for total pressure.

Four total-pressure and temperature rakes were used downstream of the stator blade row to determine the stage exit mass flow and mass-averaged stage total-pressure ratio. Iron-constantan thermocouples were used on these rakes. These rakes, one of which is shown in figure 8, were located nominally at 90° intervals, but displaced slightly to avoid a stator wake. Finally, just downstream of the nozzle exit, three equally spaced total-pressure rakes were used for exit momentum or thrust calculations.

All rakes were removed for acoustic tests. It should be noted that all aerodynamic instrumentation was regularly checked for malfunctions throughout the test sequence.

The aerodynamic data were recorded through a pressure multiplexing valve, pressure transducer, and data acquisition network. All temperatures were recorded by the same network, which takes one scan of aerodynamic pressures and temperatures in approximately 10 seconds. Nine consecutive scans were made at each data point, with the raw data samples arithmetically averaged and used to compute the desired flow parameters. Two points were taken at each test condition of speed and configuration. The arithmetic averages of the computed parameters are presented in this report.

Performance parameters were corrected to standard-day conditions of a temperature of 15° C and an atmospheric pressure of 101 325 pascals (760 mm Hg).

Acoustic Data

Data acquisition system. - As indicated previously, acoustic measurements were made outdoors. The 1.3-centimeter (1/2-in.) diameter condenser microphones used to make the noise measurements had sensitivities of -60 decibels relative to 1 volt per 10^{-1} pascal (1 μbar). Frequency response of the system, as a whole, was flat from 50 hertz to 20 kilohertz. Three samples of 100-second duration were taken for each fan speed point and averaged.

The acoustic data were reduced both on line through one-third-octave filters and recorded on magnetic tape for further analysis. Before the set of tests for each configuration, a pistonphone signal was impressed on each far-field microphone for absolute calibration.

One-third-octave-band analysis. - The one-third-octave-band analyzer used for on-line data reduction used a 4-second averaging time and stepped sequentially through the angles from 10° to 160°. The 4-second averaging time was selected to accommodate all angles within a 100-second sample while preserving analyzer repeatability. Three 100-second samples were taken for each data point. Options for the output of the analyzer included an oscilloscope, which presents the sound pressure level spectrum, a digital printer, and a digital incremental tape recorder.

Results of one-third-octave band sound pressure level (SPL) analysis yielded data taken under ambient conditions of the test day at the microphone locations. The data were referred back to the sound source (i.e., the effect of atmospheric absorption was removed) by computing atmospheric absorption for the test conditions over the propagation path and adjusting the data accordingly. Atmospheric absorption was computed by using continuous frequency-dependent functions derived from reference 16. The application of procedures set forth in reference 16 were not used, as they presuppose a spectrum typical of engine jet noise. For the QF-8 results, which have significant fan noise as well as jet noise, the general shape of the measured spectrum was accounted for, and the one-third-octave band attenuations were obtained by integrating the continuous absorption functions over each band (ref. 17).

For power calculations the sound pressure levels were presumed to be axisymmetric and were integrated over an enclosing hemisphere. Implicit in this procedure was a perfectly reflective ground plane in the sense that acoustic intensity was doubled in the far field. No account was made for signal interference effects at the microphones because of ground reflections.

Using data referenced to the source, calculations of atmospheric absorption for a standard day of 15° C and 70 percent relative humidity were made, and the data were so adjusted. All one-third-octave-band sound pressure level data reported herein are adjusted to standard-day conditions.

The perceived noise values were calculated (ref. 18) from the standard-day data. The perceived noise values take into consideration the frequency-dependent sensitivity of human hearing, thus giving an indication of the human annoyance of the fan noise. For the sideline perceived noise level determinations, the data were adjusted to a 152.4-meter (500-ft) sideline.

Narrow-band analysis. - Fine-resolution, constant-bandwidth analysis allows a detailed study of the sound pressure level spectra, which is not always possible with the one-third-octave analysis. Narrow-band spectra were made of selected recorded data. These spectra were not adjusted in any way and present the signals at the microphones under test-day conditions. The effective bandwidth of this analysis is inversely related to the total frequency range of the spectrum, with a 32-hertz bandwidth for a 10-kilohertz total range down to a 3.2-hertz bandwidth corresponding to a 1-kilohertz range.

RESULTS AND DISCUSSION

Aerodynamic Performance

The quiet fan facility was designed for acoustic testing of full-scale fans suitable for turbofan engines. The aerodynamic instrumentation, as described, was limited to giving an indication of the aerodynamic performance of the fan. Consequently, the aerodynamic results for QF-8 are not nearly as precise as they might be if they had been obtained from a specialized aerodynamic test facility such as that of reference 6. Table III is a summary list of selected aerodynamic data for QF-8 for the five nozzle areas that were tested.

Before going into particular measured parameters, it is useful to discuss the degree of certainty of these aerodynamic measurements. The results obtained using the nozzle having 110 percent of the theoretical design nozzle area were closest to the predicted design-point values of mass flow and pressure ratio. Therefore, the results for this nozzle area are considered to be representative of the QF-8 design configuration. The calculated design corrected inlet mass flow for QF-8 was 423 kilograms per second (933 lbm/sec). The result for the 110 percent-of-design-area nozzle at design speed was 420 kilograms per second (927 lbm/sec), which is essentially the predicted value. The design area nozzle caused the QF-8 stage to go into stall at a corrected speed just above 90 percent of the design speed. Therefore, the aerodynamic results for this nozzle are limited to 90 percent and lower fan speeds. No acoustic data were taken with this nozzle because of its poor aerodynamic performance and our desire not to operate the fan in a region of potential stall.

A conventional fan operating map for QF-8 is presented in figure 9. The stage total-pressure ratio is plotted as a function of inlet corrected mass flow to generate a series of constant speed curves. The model data of reference 6 were scaled for mass flow differences and are also presented on this map. The estimated stall line shown on the map is based on the full size fan with the design area nozzle stalling at slightly greater than 90 percent speed. The performance map of the fan shows significant differences compared with the model fan results. A discussion of the aerodynamic performance is given in appendix A.

The overall stage pressure ratio and corrected inlet mass flow shown in figure 9 are plotted as functions of corrected fan speed in figures 10(a) and (b). Figure 10(c) gives the stage adiabatic efficiency as a function of corrected fan speed. The efficiency results for the design area nozzle fall well below those for the larger nozzle areas. This is consistent with the corresponding low pressure ratio and mass flow results for this nozzle shown in figures 9 and 10(a) and (b). Also, the severe drop in efficiency for the 115 percent-of-design-area nozzle at 110 percent speed reflects the off-design nature of this point. In general, the higher efficiencies seem to relate to corresponding higher values of pressure ratio and mass flow at a particular fan speed. Efficiency measurements made at the full-scale quiet fan facility have consistently been about 10 percentage points lower than corresponding measurements made at the better-instrumented model facility. For the QF-8 fan model the measured design-point efficiency was 0.866, and that for full-scale QF-8 with the 110 percent-of-design-area nozzle was 0.734. There is a systematic difference between the measurements at the two facilities: the full-scale facility values are always below the model test values. This difference has been noted in other full-size and model fan comparisons.

The corrected nozzle exit velocity as a function of inlet mass flow is provided in figure 11 as an aid to the reader who may wish to correlate the acoustic results with the fan stage exit velocity.

Acoustic Performance

In the preceeding discussion on the QF-8 fan aerodynamic performance it was pointed out that at fan design speed the results for the 110 and 115 percent-of-design-area nozzles showed essentially the same stage pressure ratio (see fig. 10(a)). The 110-percent-of-design-area nozzle results for corrected inlet mass flow (fig. 10(b)) were closest to the design value. But the stage adiabatic efficiency for the 115 percent-of-design-area nozzle (fig. 10(c)) was about 3 percentage points higher than that measured with the 110 percent-of-design-area nozzle. The slightly higher efficiency implies better fan stage operation with the larger nozzle area. Both nozzle areas resulted in performance suitable for use as the reference for QF-8 acoustic results. The results for the 110 percent-of-design-area nozzle were chosen as the base reference for the following discussion on the acoustic performance of the QF-8 fan.

A complete listing of the acoustic results for fan QF-8 and computer plots of selected acoustic results are given in appendix B.

Sound pressure level. - One-third-octave sound pressure level (SPL) spectra, commonly used in the study of fans, are presented in figure 12 for the QF-8 fan with the 110-percent-of-design-area nozzle at 100 and 70 percent of fan design speeds. These spectra, for microphone positions at 40° and 130° from the fan inlet (figs. 12(a) and (b)), are representative of spectra in the front and rear quadrants. The fan spectra are typical, with pronounced blade-passage frequency (BPF) and first overtone (2×BPF or twice blade-passage frequency) spikes. At 70 percent fan speed the blade-passage frequency was located such that the passage tone was shared by two one-third-octave filters with both filters indicating a partial magnitude of the tone.

Narrow band (constant bandwidth) analysis allows a more detailed study of the fan noise spectra. The data of figure 12 are delineated further as narrow-band (constant 16-Hz bandwidth) spectra in figure 13. In these spectra the blade-passage tones and several overtones are clearly defined. As may be seen by comparing the front and rear quadrants at design speed (figs. 13(a) and (c)), the first and second overtones were more pronounced in the front quadrant. Similar results are shown in reference 3 for the QF-6 fan. (Neither fan was designed for cutoff.)

These results might appear from casual observation to contradict reference 19 where test results from four fans lead to the conclusion that interaction-tones between rotor and stator should be attenuated in propagating forward through the rotor blade row. This conclusion is supported by reference 20 where, when the overtones were clearly derived from rotor-stator interaction, they were stronger in the rear quadrant and attenuated in front. In view of these reference studies, it now is suggested that for the QF-8 fan (and QF-6) the overtones are derived from the inlet distortion known to exist in the test facility producing rotor-alone noises. In reference 21 it is demonstrated that even a fan with cutoff (QF-1) exhibits the same behavior as QF-8; namely, the overtones are larger in the front quadrant.

The overall sound pressure level (OASPL) at each angular position is presented in figure 14 to give an indication of the sound pressure level directivity for QF-8. This directivity shifts toward the rear quadrant with increasing nozzle area, with most of the nozzle area effect in the front quadrant.

Noise components. - As part of the one-third-octave analysis, an attempt was made to separate the tone and broadband components of the fan noise. Beginning with the actual spectrum, an assumed broadband spectrum is drawn by disregarding those data points thought to be influenced by the tone noise. In many cases, the tone spike was shared by two one-third-octave filters. The tone contribution to the SPL was found by performing a decibel subtraction of the assumed broadband spectrum level at each frequency from the SPL data as shown in figure 15. All tone contributions, fundamental and harmonic, were then added to give the total tone level. Finally, this total tone value was subtracted from the overall SPL for the spectrum to give the actual broadband sound pressure level. Had the fan operated with a rotor relative Mach number greater than 1.0, the possible existence of significant multiple pure tones in the noise spectra would have made this separation of tones much more difficult. This method of separating the tone and broadband components is an approximation and would be somewhat further enhanced by working from a fine resolution narrow-band spectrum. However, this greater resolution would also greatly increase the complexity of the calculations. Hence, the one-third-octave spectra were deemed sufficient for this study. A further discussion of the use of narrow-band spectra for analyzing noise components is given in reference 22.

Using this method of separating the tone and broadband components, the SPL spectra are plotted against angular position (fig. 16), providing directivity plots for these noise components. Figure 16 presents these component results for the theoretical design nozzle area and for nozzles having 110, 115, and 119 percent of this nozzle area. As expected both the tone and broadband SPL components generally increase in a regular manner with fan speed. The shift in maximum noise level from front to rear quadrant with increasing nozzle area (as noted for fig. 14) occurs for both the tone and broadband noise components. The 115 percent-of-design-area nozzle configuration (fig. 16(c)) includes the overspeed data at 110 percent fan design speed. For these results the rear quadrant broadband noise contribution is quite high. The reduced efficiency (see fig. 10(c)) associated with this overspeed point may imply more turbulent, hence noisier, operation of the fan than at the fan design speed.

Sound power level. - The sound power level provides a useful means of presenting the acoustic results on a nondirectional basis. The overall sound power levels (OAPWL) for QF-8 are presented as functions of rotor-tip speed in figure 17(a) and stage pressure ratio in figure 17(b). In both plots the OAPWL increases with decreasing nozzle area for any particular fan speed or pressure ratio. The 110 percent-of-design-area nozzle

OAPWL results are somewhat lower than corresponding values for the 106 percent-of-design-area nozzle at the highest tip speeds and pressure ratios run. The OAPWL results as a function of tip speed (fig. 17(a)) are almost linear for each nozzle with downward deviations from linearity at the high speeds, this deviation being most pronounced for the overspeed result for the 115 percent-of-design-area nozzle.

The sound power level results were separated into broadband and pure tone components. These results given in figure 18 show the broadband power level components to dominate the corresponding pure-tone components. The large rotor-stator axial spacing of QF-8 was expected to lower the pure tone noise component without a corresponding reduction in broadband noise. The broadband power level components are nearly linear with tip speed for each nozzle area. There is more scatter in the pure tone components. The tone power level drops for the 115 percent-of-design-area nozzle at the overspeed condition. This lower tone component result at the overspeed condition is consistent with that of the sound pressure level tone observed in figure 16(c).

Figure 19 illustrates the relation between the overall sound power level and stage adiabatic efficiency, with both of these parameters plotted as functions of the nozzle area. As the design area nozzle was tested only for some aerodynamic results, no acoustic results for the design area nozzle are presented in figure 19. This figure shows the overall sound power level to decrease as the stage adiabatic efficiency increases - both parameters responding to increasing nozzle area. The low efficiency result at design speed for the 119 percent-of-design-area nozzle was noted in the efficiency as a function of percent speed presentation of figure 10(c) and is thought to reflect the off-design point character of these data.

Reference 23 indicated that fan sound power level, normalized for thrust level, correlated with 14 $\log_{10}$ (fan total-pressure ratio - 1). Using the methods of reference 23, the sound power data of figure 19 were normalized with respect to both thrust and pressure ratio. Thrust was normalized with respect to the thrust result at design speed with the 110 percent-of-design-area nozzle (80 086 N (18 004 lbf)). These normalized values were plotted against the $-\log_{10}(1-\eta)$ in figure 20. A similar figure is presented in reference 3 in which the results were found to follow a -2 slope. The results in reference 3 had exceptionally low scatter. A similar line of -2 slope is drawn through the results in figure 20. This line may be described by the relation

$$\mathrm{PWL} = 10 \log_{10}\left(\frac{\text{thrust}}{\text{design thrust}}\right) + 14 \log_{10}(\mathrm{PR} - 1) + 20 \log (1 - \eta) + 179.5 \qquad (2)$$

The QF-8 results shown in figure 20 have considerably more scatter than that of reference 3. However, the -2 slope line drawn through these results is reasonable.

Perceived noise. - The perceived noise levels are frequency weighted for human hearing sensitivity. Therefore, these results are of major importance in selecting a fan that is suitable for operation near populated areas. In figure 21 the QF-8 perceived noise levels along a 152.4-meter (500-ft) sideline are presented for the four tested nozzle areas at the six fan speeds considered in this report. Consistent with sound pressure level and power level results, the perceived noise levels increase with decreasing nozzle area for otherwise similar conditions, and they are rear quadrant dominated. Figure 21(f) presents the 110 percent-of-design-speed sideline perceived noise results for the 115 percent-of-design-area nozzle. The rear-quadrant peak noise level is especially pronounced for these overspeed data.

This rear quadrant dominance was already observed in the broadband component of the sound pressure level (fig. 16), especially, in the overspeed results of the 115 percent-of-design-area nozzle. The marked rear quadrant increase in the broadband sound pressure level in figure 16(c) is similar to perceived noise maximum of figure 21(f). It is useful to recall that the QF-8 sound power level was clearly dominated by the broadband noise component (see fig. 18).

Figures 22 and 23 present the maximum perceived noise level along a 152.4-meter (500-ft) sideline as functions of corrected fan tip speed and stage pressure ratio, respectively. Figure 22 shows the maximum sideline perceived noise to increase reasonably linearly with increasing rotor-tip speed. Figure 23 shows abrupt increases in maximum sideline perceived noise for the overspeed results of the 115 percent-of-design-area nozzle - relatable to the high levels observed for this point in figure 21(f).

The maximum perceived noise level along the 152.4-meter (500-ft) sideline at design speed for the 110 percent-of-design-area nozzle was 108.0 PNdB. When adjusted for a 400 340-newton (90 000-lbf) thrust aircraft, this maximum perceived noise becomes 115 PNdB. This adjusted sideline perceived noise level is considerably above the maximum desired level of 95 EPNdB along a 152.4-meter (500-ft) sideline for a STOL aircraft. The effective perceived noise level is a time weighting of the PNdB results. For typical STOL aircraft flight profiles, EPNdB and PNdB values may be compared, with the PNdB results being about 1 or 2 decibels higher than corresponding EPNdB results. Also, the fan noise is but a portion of the total aircraft noise, which includes noise from the engine core and aerodynamic noise. Therefore, the QF-8 fan contribution to the total aircraft noise must be further reduced from what would be acceptable if it were the only contributing noise source. Accordingly, a substantial amount of acoustic treatment would be required on the QF-8 fan to make it acceptable for use in a quiet STOL aircraft.

The maximum fan perceived sideline noise is relatable to the stage pressure ratio in such a way as to generate a family of curves for fans of similar design (see, e.g., ref. 23). The methods of reference 23 are used to adjust the noise level to the reference 400 340-newton (90 000-lbf) thrust. The corrected perceived noise levels then consist of the measured PNdB + 10 $\log_{10}$ (400 340 N/measured thrust). Reference 23 suggests that this thrust-adjusted sideline perceived noise may be approximated within a ±2-PNdB scatterband by the curve,

$$PNL = 62.4 + 14 \log_{10} (PR - 1) + 10 \log_{10} F \tag{3}$$

where F is the thrust in pounds force. This relation is for single-stage low tip speed fans. Figure 24 shows the curve of equation (3) with a ±2-PNdB scatterband. The corrected full-scale QF-8 fan result falls about 3.7 PNdB above the curve, well above the scatterband. The QF-8 fan data were not available in formulating the relation of equation (3).

Noise Comparison with QF-6 and QF-9 Fans

The QF-8 fan was the last of three experimental research fans with characteristics suitable for quiet STOL aircraft application tested at the NASA quiet fan facility. The results for the other two fans (QF-6 and QF-9) are reported in references 3 to 5. Also, reference 23 compares the results of the QF-6 fan and a number of other STOL and CTOL fan designs, but it does not include fan QF-8 results. Both the QF-6 and QF-9 fans were designed for a stage pressure ratio of 1.20 (see table II). The QF-6 fan had 42 rotor blades, and QF-9 had 15 rotor blades. The subject of this report (QF-8) was designed for a stage pressure ratio of 1.25 and had 30 rotor blades.

The results presented in this section are for the QF-6 and QF-9 fans with their design area nozzles, which caused them to operate near design conditions of inlet mass flow and stage pressure ratio for these fans. As previously discussed, the nozzle for QF-8 having 110 percent of the design area resulted in QF-8 operating nearest to its design inlet mass flow and stage pressure ratio. However, the stage adiabatic efficiency at design speed for QF-8 with the 115 percent-of-design-area nozzle was about 3 percentage points higher than the corresponding result for the 110 percent-of-design-area nozzle. At design speed both nozzles resulted in the same stage pressure ratio, with the larger nozzle giving the higher inlet mass flow. The acoustic results for the QF-8 fan with both nozzle areas are presented for this comparison.

Sound pressure and power levels. - Figure 25 compares the front and rear quadrant sound pressure level spectra for the three fans at design speed. The microphone locations (40° and 130° from the inlet) were the front and rear quadrant locations of maximum noise level for all three fans. At both angular locations the QF-8 fan SPL results are clearly higher than those of the other two fans, with the smaller, 110 percent-of-design-area nozzle consistently showing the highest SPL results. Note that, from figure 24, the higher pressure ratio of fan QF-8 (1.25 instead of 1.20) should account for only 1.3 decibels, or about one-third of the observed increase. The relatively low rotative speed (2227 rpm) and low number of rotor blades of the QF-9 fan resulted in a low fundamental blade-passage frequency for this fan. (The corrected rotor design speeds for fans QF-6 and QF-8 were 2387 and 2706 rpm.)

The angular distribution of the OASPL (fig. 26) shows the QF-6 and QF-9 fan results to be essentially identical at each angular position and the QF-8 fan results to be essentially parallel but significantly higher. The maximum OASPL for fan QF-8 with the 110 percent-of-design-area nozzle is at 40° (in the front quadrant). Neglecting this point, the maximum OASPL for this configuration occurs at 130° (in the rear quadrant). The OASPL results for the larger fan QF-8 nozzle area configuration and the other two fans show the highest OASPL in the rear quadrant at 130°.

The corresponding sound power level spectra are presented in figure 27. The results are similar to those of figure 30 with the QF-8 fan results having the highest PWL.

Figure 28 presents the overall sound power level as a function of the measured stage pressure ratio. At similar pressure ratios the QF-9 fan results are slightly higher than those for QF-6. But the QF-8 fan values for the 110 and 115 percent-of-design-area nozzles are significantly above those for both of the other fans except for the two highest pressure ratio points for the QF-9, which were above design speed. Of the two QF-8 fan configurations presented, the more efficient configuration (the 115 percent-of-design-area nozzle; see fig. 10(c)) showed somewhat lower overall sound power levels. The overspeed results for fan QF-9 show a large increase in PWL, eventually becoming slightly higher than the fan QF-8 results at a stage pressure ratio of about 1.23. At this point the QF-9 fan is operating well beyond its design pressure ratio of 1.20, while the QF-8 fan is below its design pressure ratio. Therefore, fan QF-9 might be expected to be operating with excessive losses, making these overspeed PWL results high. Even at overspeed conditions the fan speeds were below that required to generate significant multiple pure tones.

A further refinement to the results of figure 28 would be to correct the PWL levels for thrust differences among the fans. The measured thrust for the QF-8 fan configurations shown in figure 28 is about 80 000 newtons (17 985 lbf) at fan design speed. Fans QF-6 and QF-9 indicated a thrust of about 58 000 newtons (13 039 lbf) at design conditions. The PWL correction would then be approximated by 10 $\log_{10}$ (thrust ratio), which is 1.4 decibels using the design thrust values. Therefore, the QF-8 fan results in figure 28 may be adjusted somewhat downward to account for thrust differences. None of the QF-8 fan results were thrust corrected in the figures presented in this report; however, thrust correction might be expected to lower the results by about 1 decibel.

Perceived noise. - The low number of rotor blades and the relatively low rotative speed of QF-9 give that fan a perceived noise advantage over the other two fans. Figure 29 presents a one-third-octave perceived noisiness spectrum based on a 100-decibel SPL at all frequencies. The perceived noisiness spectrum is weighted for human hearing sensitivity, reaching a maximum in the 3000 to 4000 hertz range. In figure 29 the frequency of the fundamental blade passage tone at design speed and the first overtone (2×BPF) are noted. Both tones for the QF-9 fan occur in a region of relatively low weighting. The passage tones for the QF-6 and QF-8 fans occur in a region of increased weighting, while the first overtones for these two fans occur in the region of maximum perceived noise weighting. For similar overall sound pressure levels, the QF-6 and QF-8 fans would be expected to be more annoying to the human listener than QF-9.

Figure 30, the angular distribution of perceived noise level along a 152.4-meter (500-ft) sideline, shows the results for fan QF-6 to be somewhat higher than those for fan QF-9 as might be expected by the frequency locations of the tones of these two fans. The high SPL and PWL of fan QF-8 are reflected in the high perceived noise levels shown in figure 30. All fans showed a higher perceived noise level in the rear quadrant, with this effect being less pronounced for fan QF-8 with the 110 percent-of-design-area nozzle.

Finally, figure 31 presents the maximum perceived noise along a 152.4-meter (500-ft) sideline as a function of the fan stage pressure ratio. Except at the lowest pressure ratios where the results tend to merge, the QF-6 fan was about 2 PNdB noisier than QF-9 at comparable pressure ratios. With the 110 percent-of-design-area nozzle, the QF-8 fan was about 5 PNdB noisier than fan QF-6 at these pressure ratios. Again, the results for QF-8 with the 115 percent-of-design-area nozzle were somewhat lower than corresponding results with the smaller nozzle area. If the results of the QF-8 fan with the larger nozzle area were reduced for thrust correction, they would be about 4 PNdB above the QF-6 fan results in figure 31. The overspeed results for the QF-8 fan with the 115 percent-of-design-area nozzle and for the QF-9 fan show an increase in perceived noise. These overspeed results are for off-design operation and might be expected to have excessive noise levels.

Throughout this comparison, it is apparent that QF-8 is noisier in all respects than the other two fans. The rotor-tip speed, thrust, and corrected inlet mass flow are somewhat higher for the QF-8 fan than for the other two fans, which (see table II) may have some influence on the noise generation. However, as developed in detail in appendix A, it appears that the relative increase in noise for QF-8 compared with the QF-6 and QF-9 fans may be associated with a poorer aerodynamic performance for the QF-8 fan. The poorer aerodynamic performance of QF-8 was characterized by poorer-than-design total-pressure ratios in the outer passage and by large circumferential variations in total-pressure ratios at the stator outlet.

SUMMARY OF RESULTS

A 1.25 pressure ratio, 1.83-meter (6-ft) diameter experimental fan stage, designated QF-8, with characteristics suitable for STOL externally blown flap aircraft engine application was tested for acoustic and aerodynamic performance. The design incorporated features for low noise, including absence of inlet guide vanes, relatively low rotor-blade-tip speed, low aerodynamic blade loading, and long axial spacing between the rotor and stator blade rows.

The QF-8 fan stage was run through an operating range controlled by nozzles having 100, 106, 110, 115, and 119 percent of the calculated design nozzle area. The principal results of this investigation were as follows:

1. The QF-8 fan was the last of three research fans with characteristics suitable for application to quiet STOL aircraft engines tested at the NASA quiet fan facility. The QF-8 fan acoustic results were compared with those for two other fans (QF-6 and QF-9), which had design stage pressure ratios of 1.2. Fan QF-8 had significantly higher sound pressure, sound power, and perceived noise levels than the other two fans. The relatively higher noise level for fan QF-8 was speculated to be associated with its poorer aerodynamic performance in the full-scale facility compared with the other two fans.

2. At design speed and with the 110 percent-of-design-area nozzle, the measured overall sound power level for fan QF-8 was 158.9 decibels (referenced to 10^{-13} W). Along a 152.4-meter (500-ft) sideline, the maximum perceived noise level was 108 PNdB. When adjusted to a thrust of 400 340 newtons (90 000 lbf) (for a conceptual STOL aircraft), the perceived noise level becomes 115 perceived noise decibels. This is well above a total STOL aircraft 152.4-meter (500-ft) sideline noise goal of 95 effective perceived noise decibels, implying that acoustic treatment is required on fan QF-8 to make it acceptable for quiet STOL application.

3. The one-third-octave and narrow-band (constant 16-Hz bandwidth) sound pressure level spectra of QF-8 were typical of single-stage, low speed fans. Both blade-passage tones and overtones were pronounced in these spectra. Because the rotor-tip relative inlet Mach number was somewhat below unity at design speed, no significant multiple-pure-tone generation was observed over the operating range. The sound power levels and perceived noise levels increased in a regular manner with fan speed. At any speed the noise levels were generally highest with the smallest nozzle, and decreased with increasing nozzle area. The perceived noise along a 152.4-meter (500-ft) sideline was clearly rear quadrant dominated at all speeds.

4. The one-third-octave spectra were used to separate the broadband and pure tone components of the fan noise. Both components of the sound power level showed a general shift in the maximum noise level from the front to the rear quadrant with increasing fan speed. The broadband components of the sound power level were somewhat higher than the corresponding pure tone components, thus implying that broadband noise controls the overall noise levels for fan QF-8.

5. Corrected inlet mass flow and pressure ratio results indicated that the 110 percent-of-design-area nozzle produced an operating point closest to design. With this nozzle area and at design speed, the measured corrected inlet mass flow and stage pressure ratio were 420 kilograms per second (927 lbm/sec) and 1.230. The theoretical design mass flow was 423 kilograms per second (933 lbm/sec). Although it was below the design stage pressure ratio of 1.25, the value of 1.23 was the highest observed for any nozzle area tested on QF-8 at design speed. In general, the stage adiabatic efficiency increased with increasing nozzle area. However, the efficiencies dropped considerably at highly off-design points represented by the 119 percent-of-design-area nozzle at design speed and the 115 percent-of-design-area nozzle at 110 percent speed.

6. The overall aerodynamic performance of the full-scale QF-8 fan differed significantly from the corresponding results of the 50.8-cm (20-in.) rotor-tip diameter model of QF-8 and the design values. The QF-8 fan went into stall prematurely at slightly greater than 90 percent of design speed with the design area nozzle. In general, the poor aerodynamic performance of the full-scale fan QF-8 was characterized by poorer-than-design total pressure ratio in the outer passage and by large circumferential variations in total pressure ratio at the stator outlet.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, September 5, 1975,
505-03.

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TABLE I. - QF-8 DESIGN CHARACTERISTICS

Total pressure ratio:	
Rotor	1.270
Overall stage	1.251
Corrected inlet mass flow, kg/sec (lbm/sec)	423 (933)
Corrected specific inlet flow, $kg/sec \cdot m^2$ ($lbm/sec \cdot ft^2$)	194.4 (39.8)
Adiabatic temperature rise efficiency:	
Rotor	0.953
Stage	0.889
Corrected rotor inlet tip speed, m/sec (ft/sec)	257.6 (845)
Rotor inlet tip diameter, m (in.)	1.819 (71.6)
Corrected rotor speed, rpm	2705.6
Inlet hub-tip diameter ratio:	
Rotor	0.402
Stator	0.421
Head rise coefficient:	
Rotor	0.308
Stage	0.288
Rotor work coefficient	0.322
Input shaft power, kW (hp)	9074 (12 172)
Stage thrust, N (lbf)	82 939 (18 647)
Rotor D-factors:	
Hub	0.319
Tip	0.341
Maximum	0.447
Stator D-factors:	
Hub	0.546
Tip	0.309
Maximum	0.546
Mean radius rotor-stator spacing, rotor chords	4.0
Number of blades:	
Rotor	30
Stator	34
Blade-passage frequency, Hz	1353

TABLE II. - COMPARISON OF SELECTED DESIGN PARAMETERS OF QF-6, QF-8, AND QF-9

(a) Aerodynamic design parameters

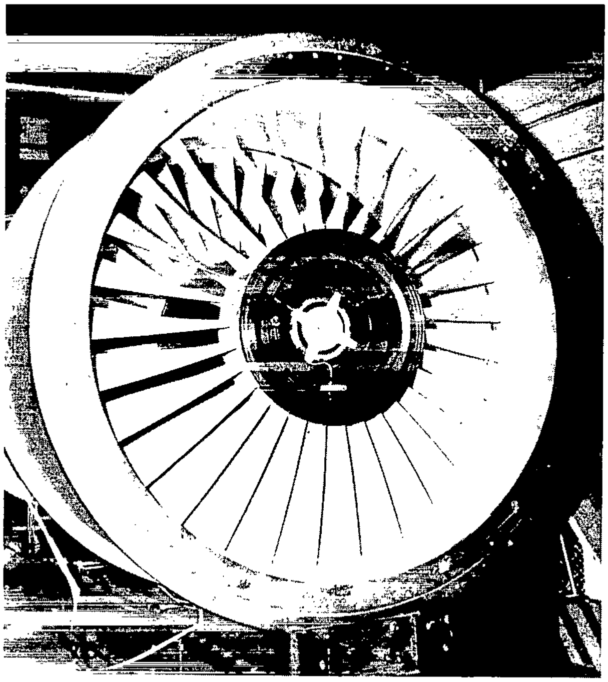
Fan	Overall total-pressure ratio	Rotor-stator separation, mean rotor chords	Corrected inlet mass flow		Corrected rotor tip speed		Corrected thrust	
			kg/sec	lbm/sec	m/sec	ft/sec	N	lbf
QF-6	1.20	4.0	396	873	229	750	70 415	15 830
QF-8	1.25	4.0	423	933	258	845	82 939	18 647
QF-9	1.20	2.0	403	889	213	700	71 705	16 120

(b) Blade design parameters

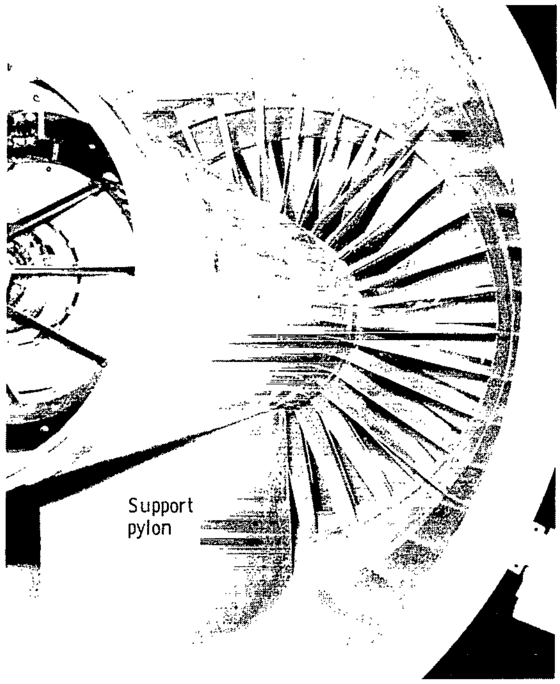
Fan	Element	Number of blades	Solidity		D-factor			Mean aspect ratio	Rotor inlet hub-tip radius ratio	Tip relative inlet Mach number	Mean aerodynamic chord	
			Hub	Tip	Hub	Maximum	Tip				cm	in.
QF-6	Rotor	42	2.827	1.188	0.151	0.386	0.357	3.08	0.416	0.878	16.31	6.42
	Stator	50	1.752	1.000	.417	.417	.301	3.46	-----	-----	11.72	4.61
QF-8	Rotor	30	2.333	1.000	.319	.447	.341	2.95	.402	.921	18.44	7.26
	Stator	34	2.591	1.150	.546	.546	.309	2.75	-----	-----	18.31	7.21
QF-9	Rotor	15	1.219	.893	.530	.530	.431	1.70	.460	.865	27.73	10.92
	Stator	11	1.406	.714	.512	.512	.363	1.23	-----	-----	38.11	15.00

TABLE III. - SELECTED AERODYNAMIC RESULTS

Nozzle area, percent of design	Percent of design speed	Corrected fan speed, rpm	Corrected tip speed		Inlet duct Mach number	Stage pressure ratio	Corrected mass flow			
			m/sec	ft/sec			Inlet		Stator discharge	
							kg/sec	lbm/sec	kg/sec	lbm/sec
100	60	1628	155	509	0.215	1.072	229	505	235	519
	70	1899	181	593	.250	1.097	264	583	273	601
	80	2168	206	677	.286	1.126	299	659	310	684
	90	2438	232	762	.321	1.157	332	731	344	759
106	70	1902	181	594	0.274	1.106	287	633	302	666
	80	2167	206	677	.314	1.138	325	716	342	754
	90	2442	233	763	.358	1.175	364	802	381	840
	100	2705	258	845	.408	1.221	406	894	422	930
110	70	1899	181	593	0.279	1.105	292	644	298	657
	80	2170	207	678	.323	1.138	333	734	340	750
	90	2441	232	763	.371	1.180	375	827	400	881
	100	2712	258	847	.426	1.230	420	927	438	965
115	70	1901	181	594	0.298	1.107	310	683	330	728
	80	2168	206	677	.344	1.141	352	777	376	828
	90	2443	233	763	.397	1.184	397	875	425	936
	100	2712	258	847	.451	1.230	440	969	465	1026
	110	2977	283	930	.477	1.245	458	1009	470	1036
119	70	1898	181	593	0.322	1.107	332	732	355	782
	80	2171	207	678	.373	1.140	376	830	401	885
	90	2440	232	762	.428	1.181	421	929	450	992
	100	2711	258	847	.475	1.215	456	1005	480	1058



(a) Showing rotor blading.



(b) Showing stator blading.

Figure 1. - Partially assembled QF-8 stage.

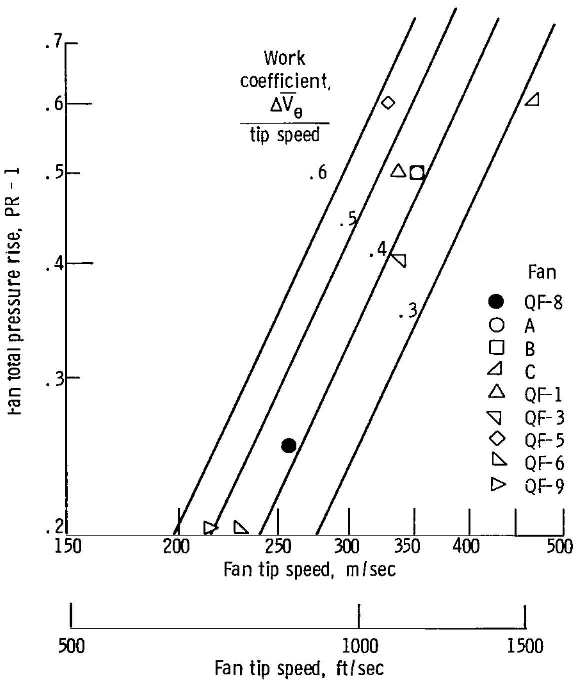


Figure 2. - Matrix of fan design parameters.

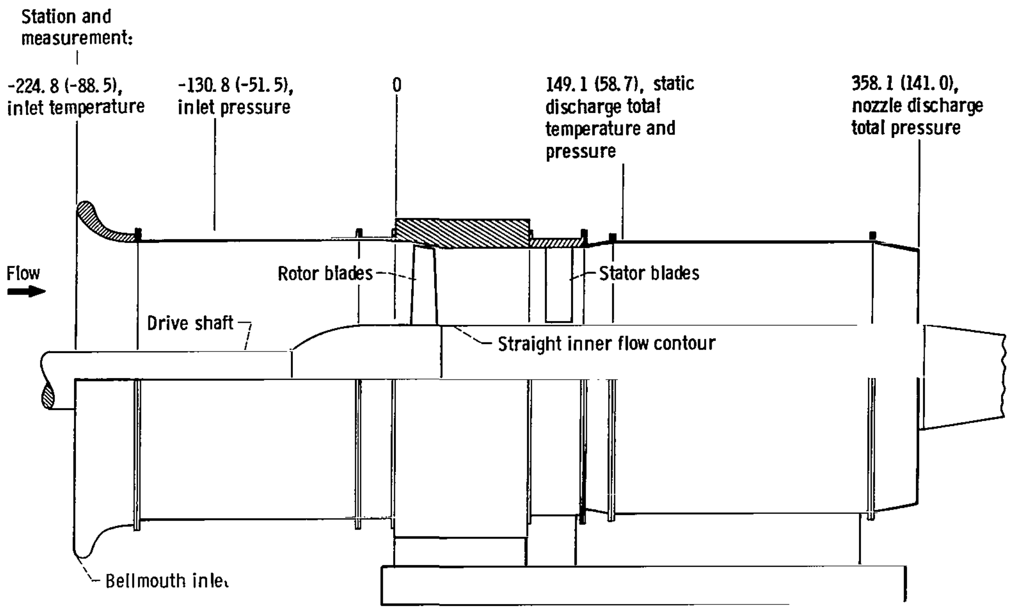


Figure 3. - QF-8 fan assembly cross section showing axial location of measurement. (Station numbers are in cm (in.).)

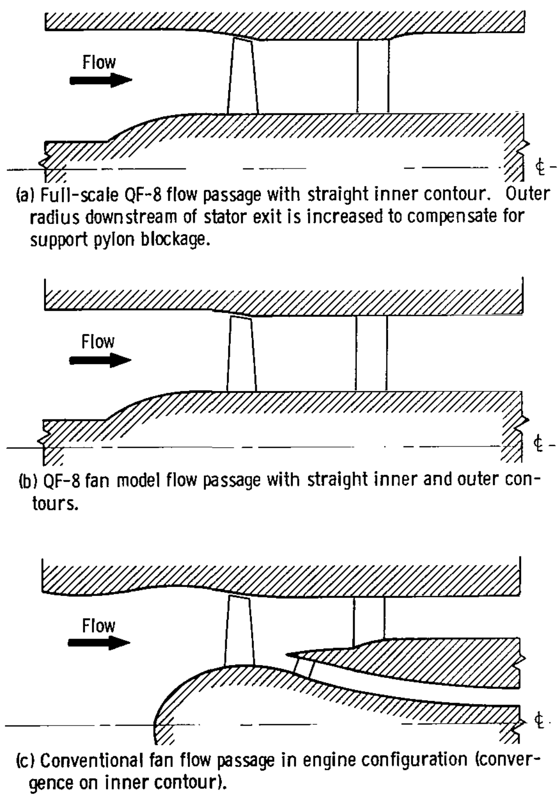


Figure 4. - Comparison of QF-8 fan and conventional flow passage contours.

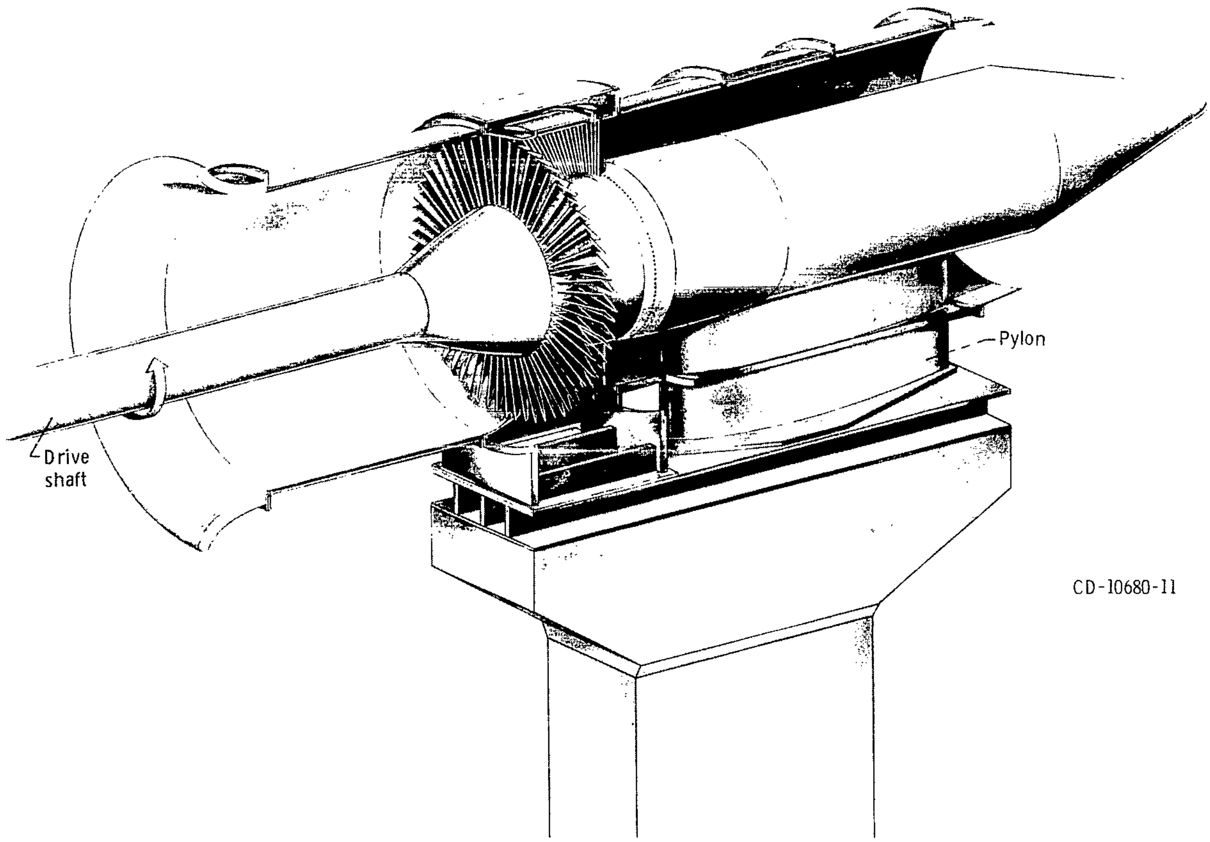
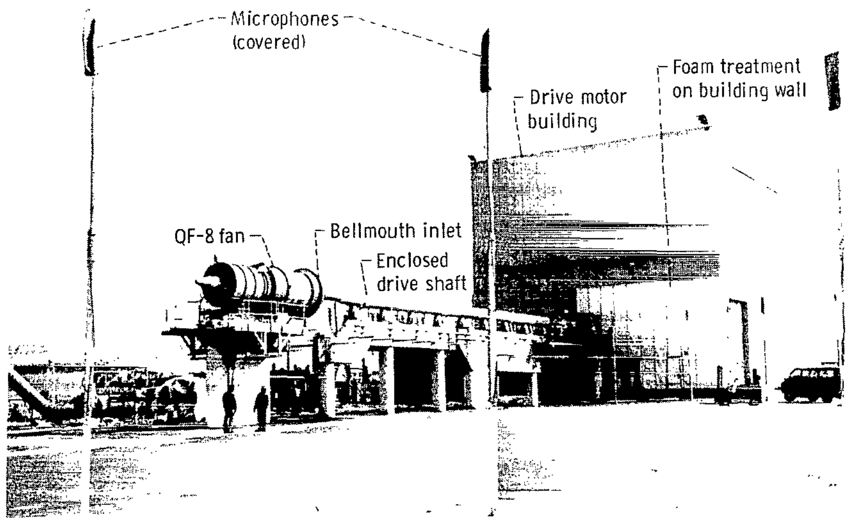
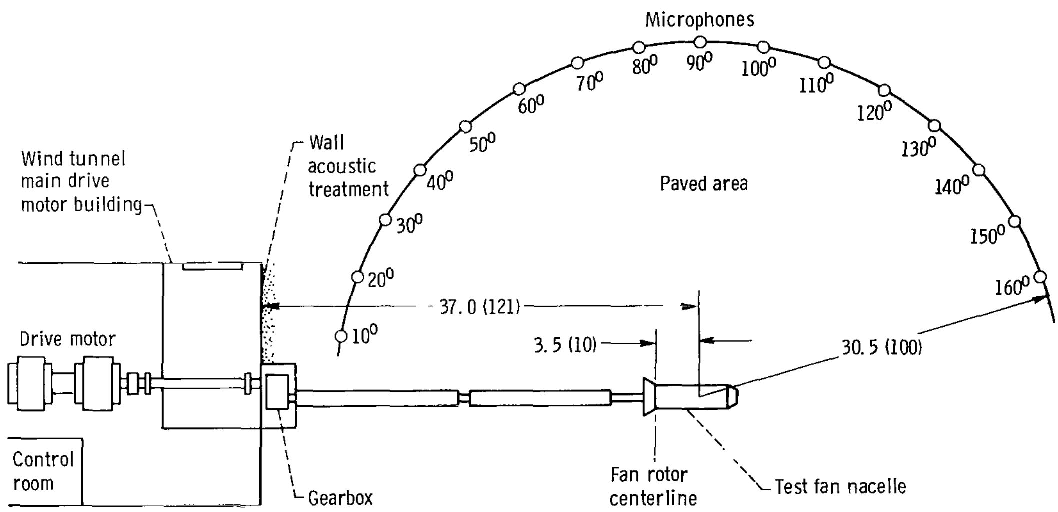


Figure 5. - Cutaway of typical fan installation.



(a) Test site showing QF-8 in place.

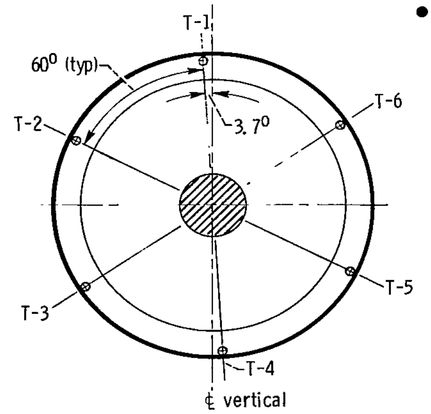


(b) Plan view. (All dimensions are in m (ft).)

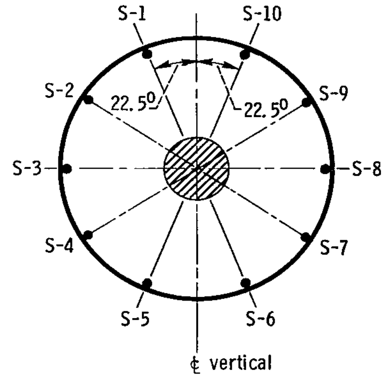
Figure 6. - Quiet fan acoustic test facility.

Instrumentation

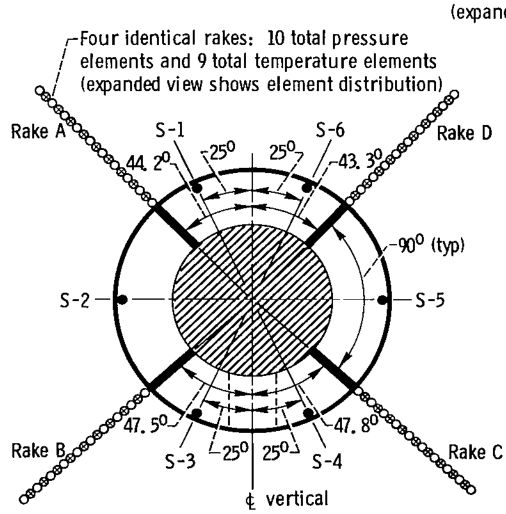
- ○ Total-pressure element
- ⊕ Total-temperature element, T
- ● Static-pressure tap, S



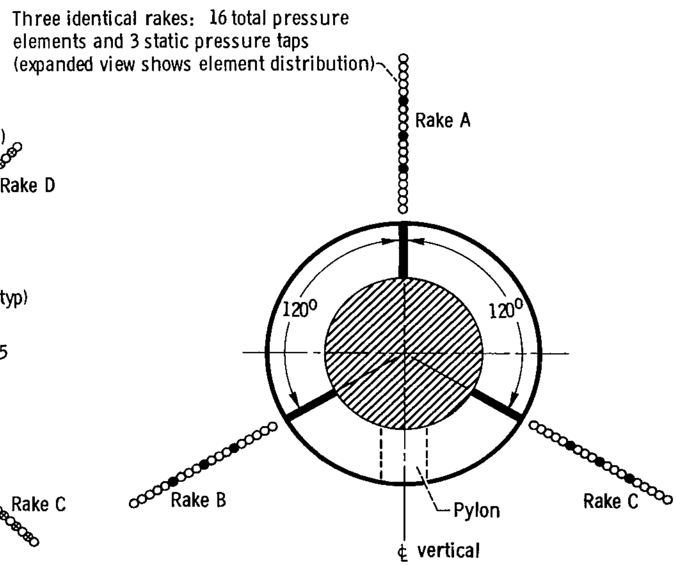
Temperature at lip of bellmouth inlet



Inlet static pressure taps



Stator discharge total pressure and temperature.



Nozzle discharge total pressure only.

Figure 7. - Detail of fan aerodynamic instrumentation. (All views looking downstream.)

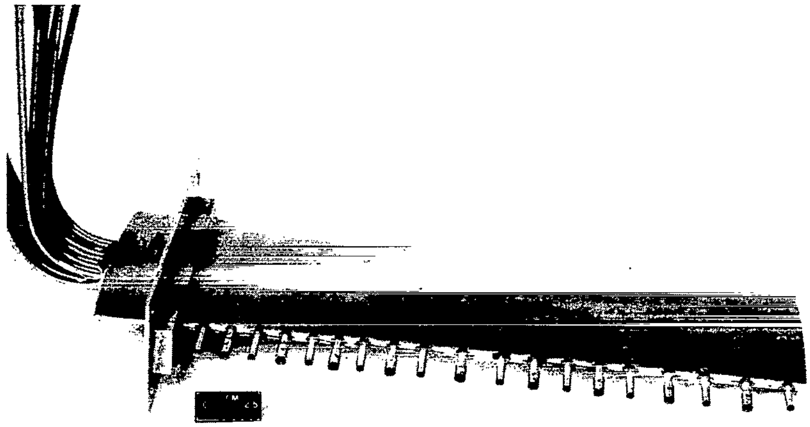


Figure 8. - Total temperature and pressure rake used at stator discharge measuring station.

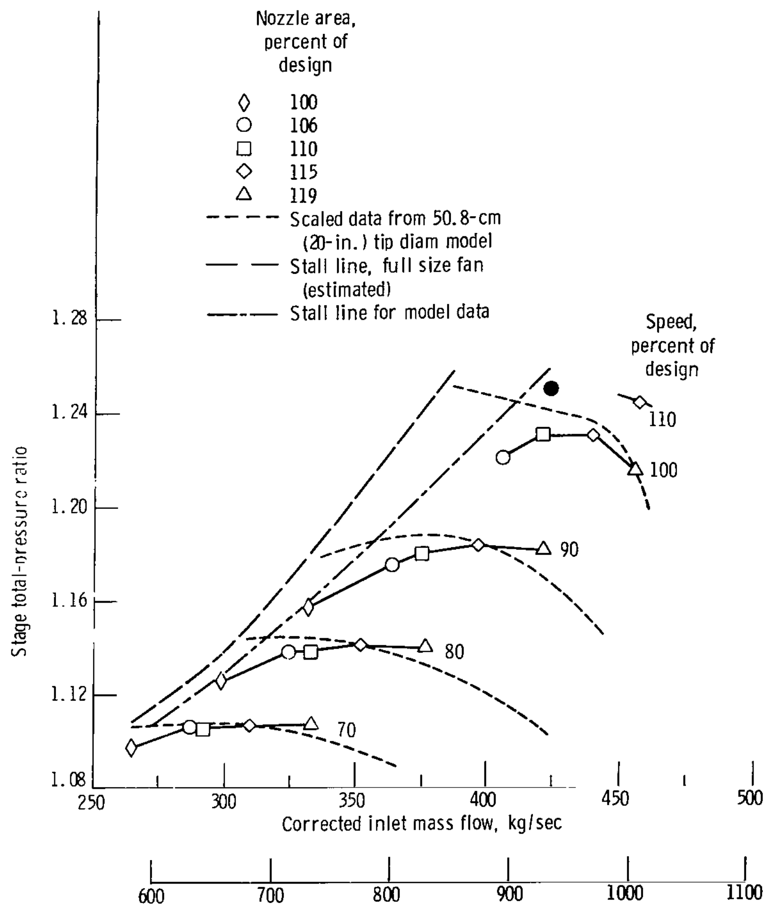


Figure 9. - QF-8 fan operating map.

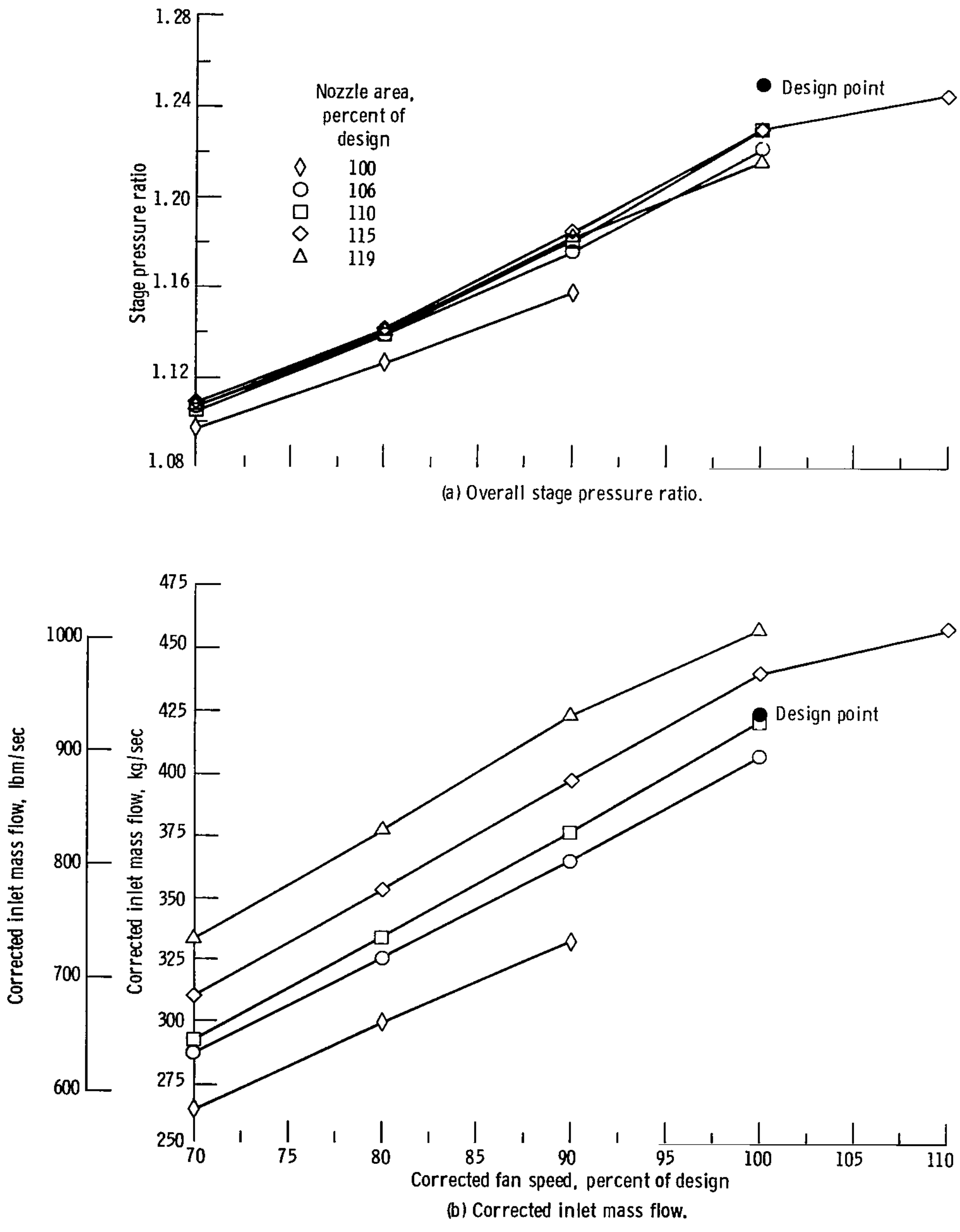
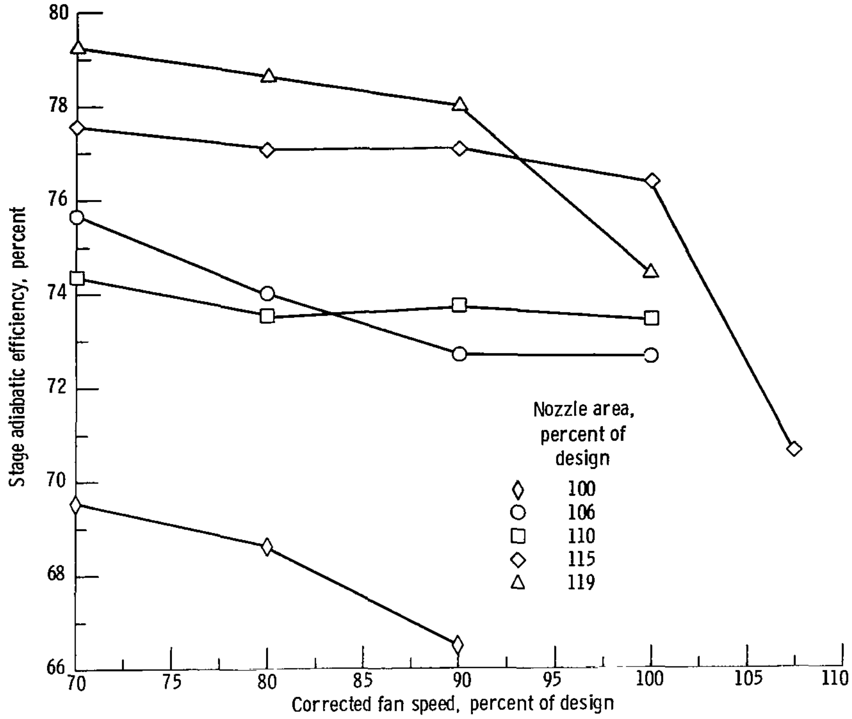


Figure 10. - QF-8 fan aerodynamic performance parameters as function of corrected fan speed.



(c) Stage adiabatic efficiency.

Figure 10. - Concluded.

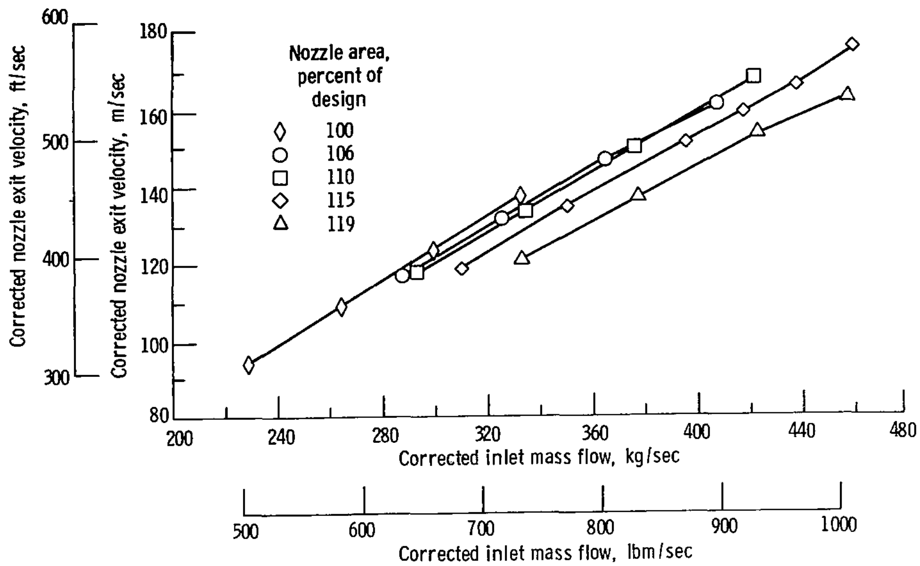


Figure 11. - QF-8 fan average corrected nozzle-exit velocity as function of corrected inlet mass flow.

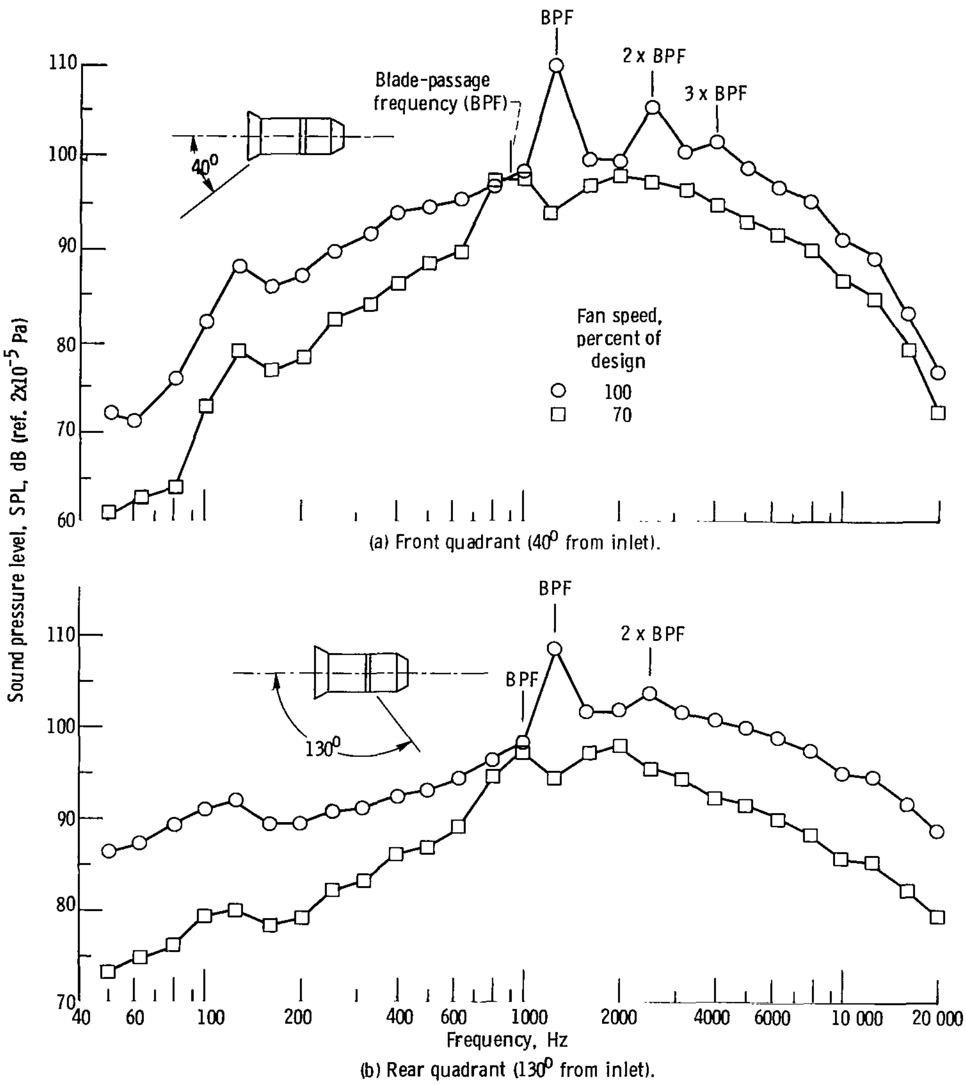


Figure 12. - QF-8 fan one-third-octave sound pressure level spectra. Nozzle area, 110 percent of design; data adjusted to standard-day conditions.

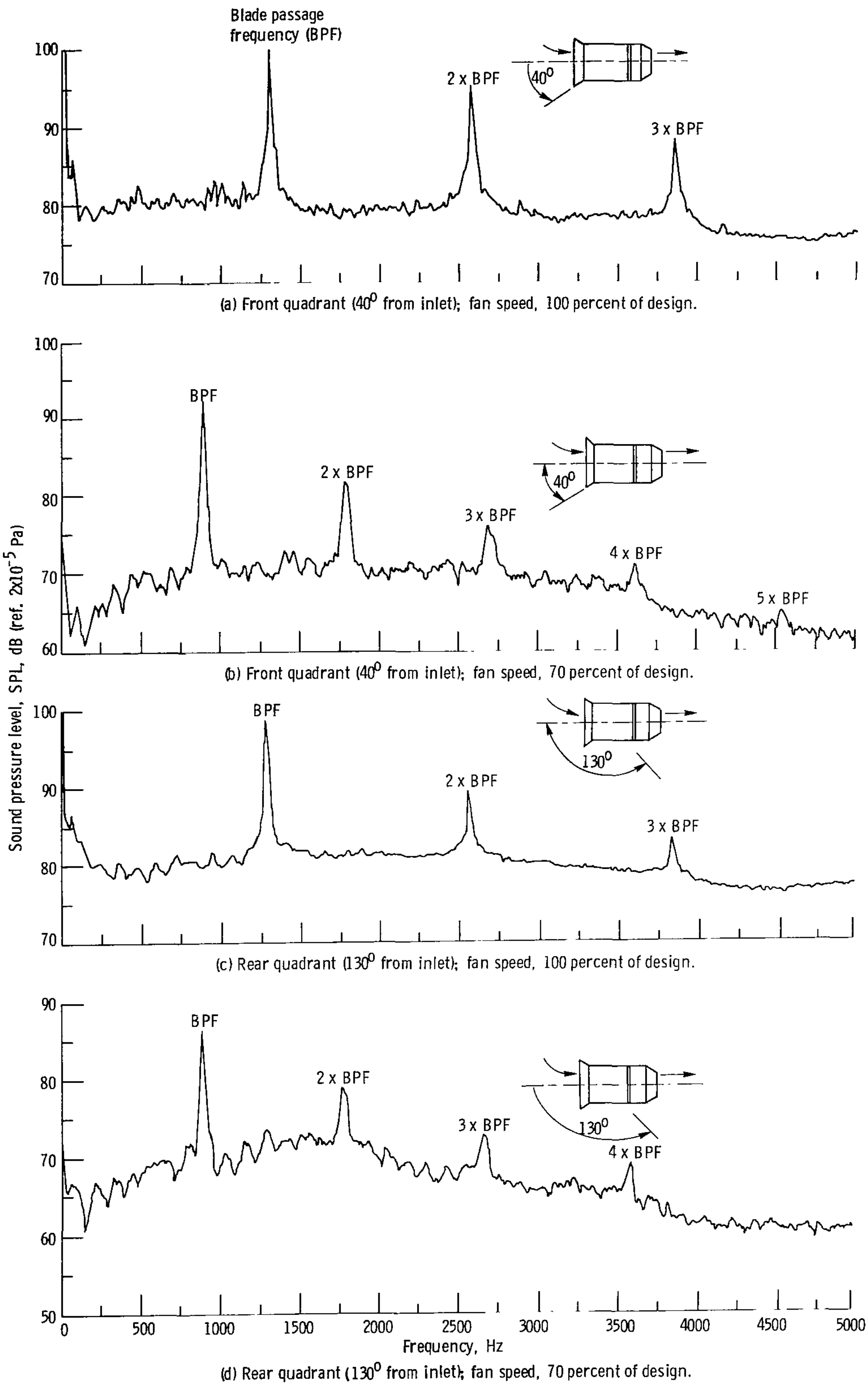


Figure 13. - QF-8 fan narrow-band (16-Hz bandwidth) spectra. Nozzle area, 110 percent of design; microphone distance from fan inlet, 30.5-meter (100-ft) radius.

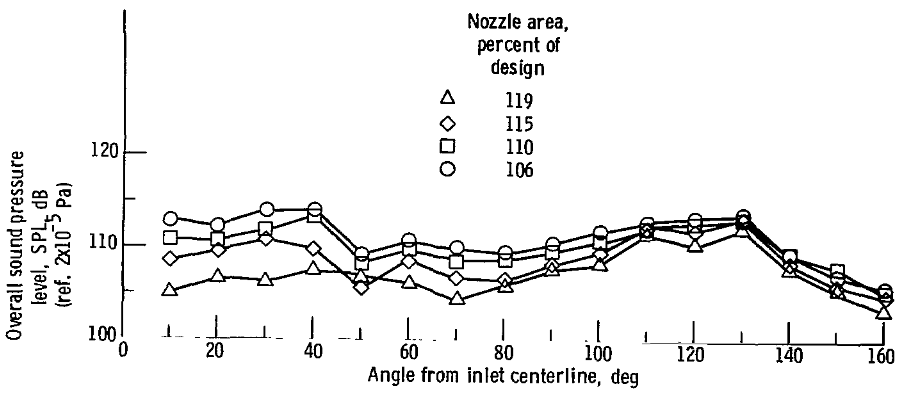


Figure 14. - QF-8 fan overall sound pressure level as function of microphone angular position; design speed.

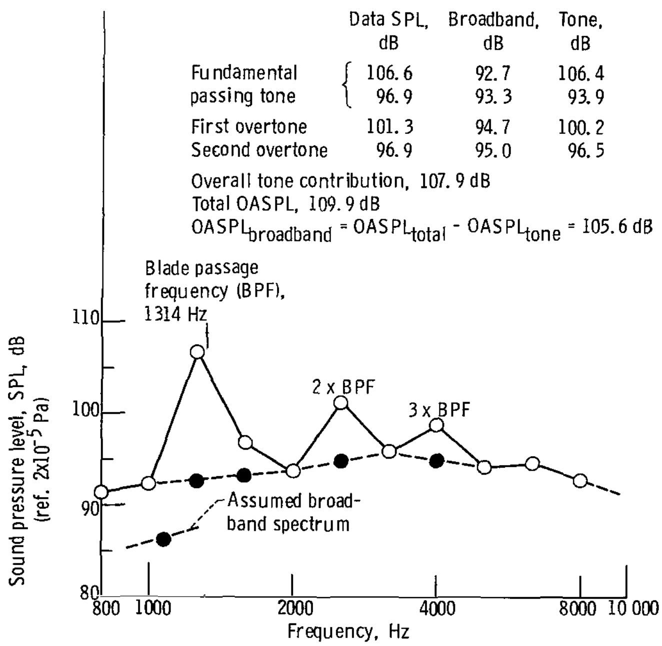


Figure 15. - Separated pure tone and broadband sound pressure and power levels in one-third-octave spectra. Nozzle area, 115 percent of design; fan speed, 100 percent of design.

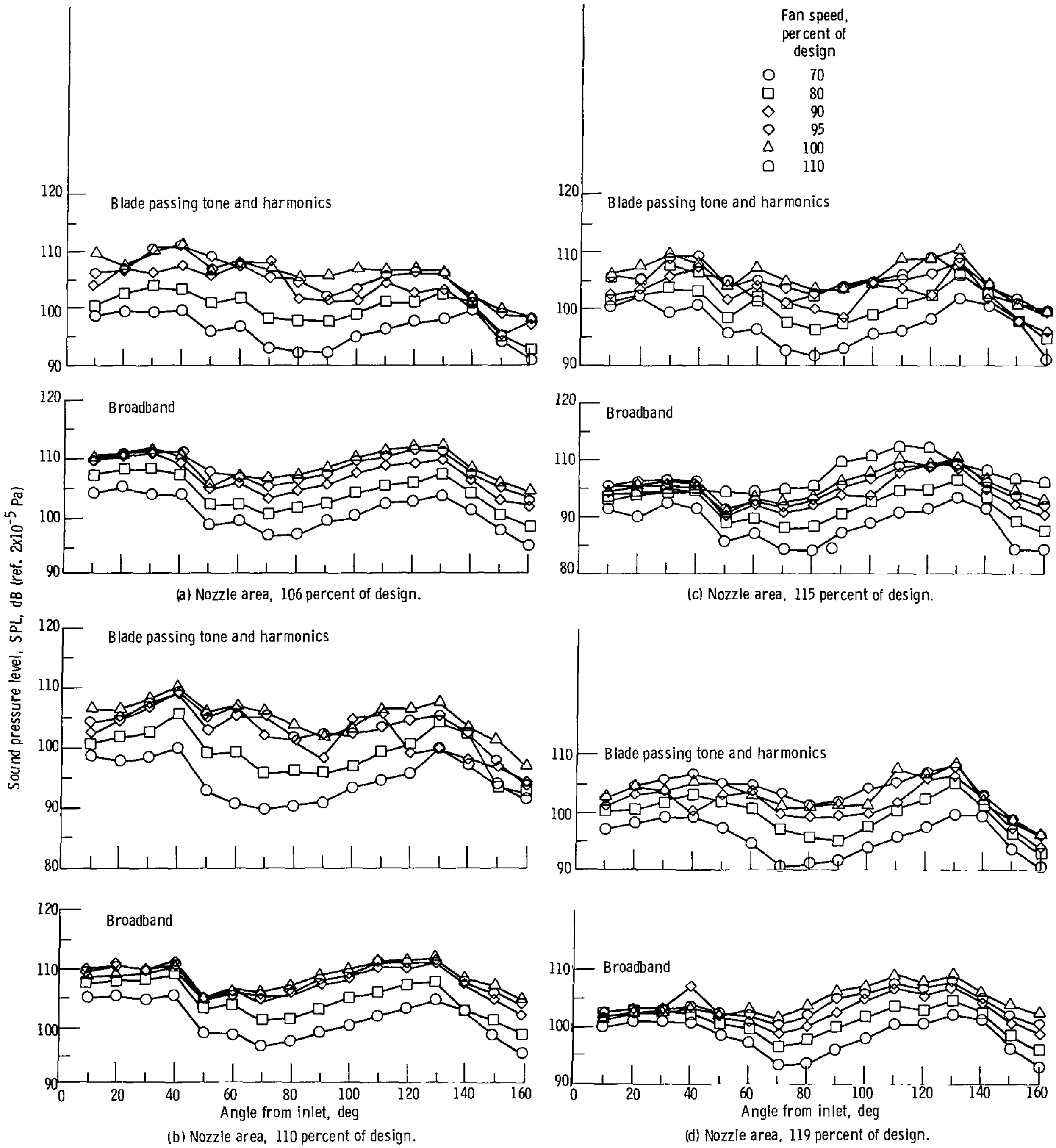
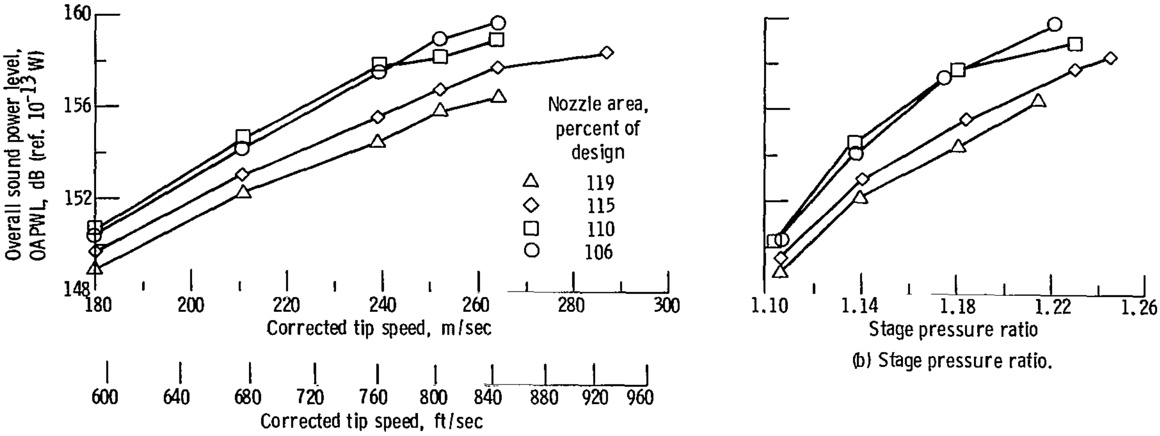


Figure 16. - QF-8 angular distribution of noise components.



(a) Corrected tip speed.

(b) Stage pressure ratio.

Figure 17. - QF-8 fan overall sound power level as function of corrected tip speed and stage pressure ratio.

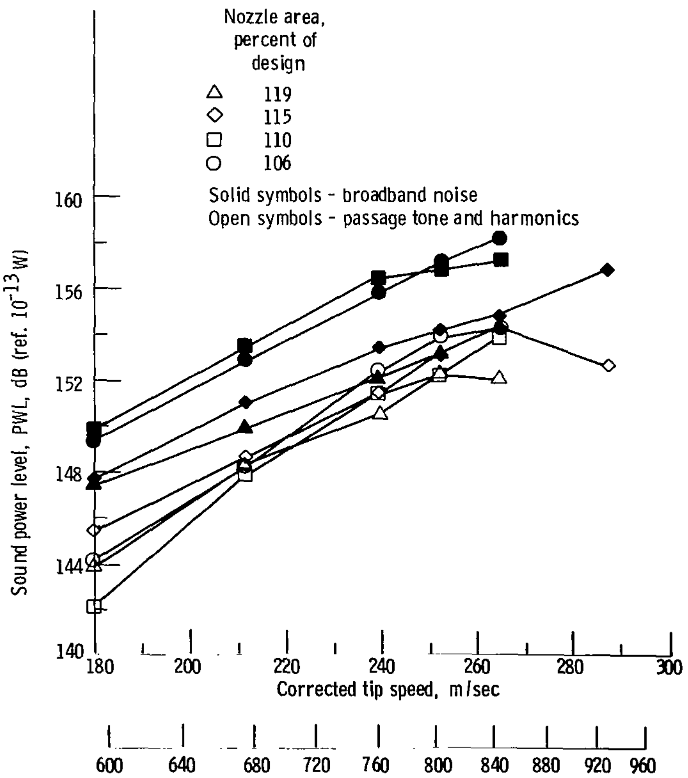


Figure 18. - Fan speed effect on sound power noise components.

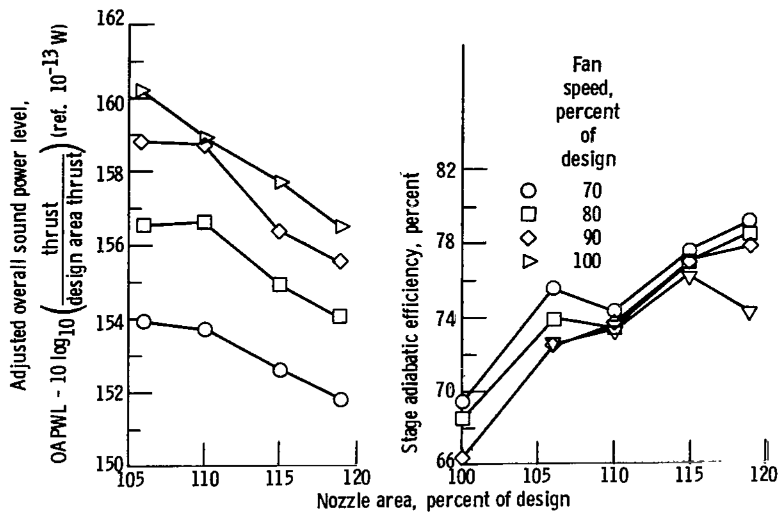


Figure 19. - Thrust adjusted overall power level and efficiency as functions of nozzle area.

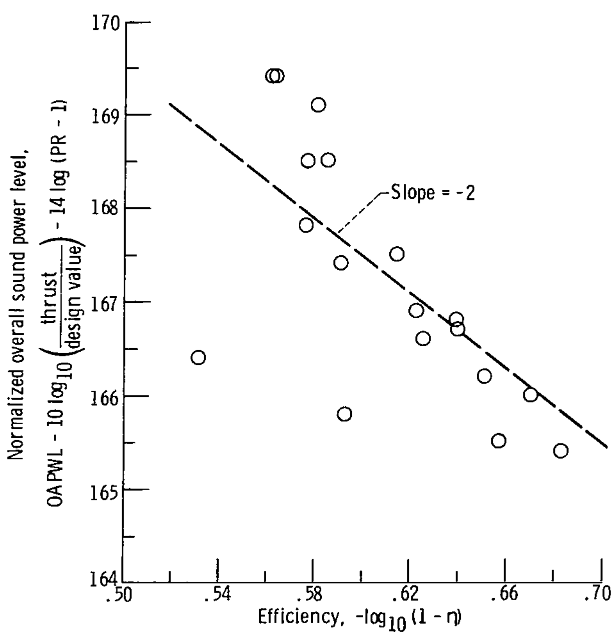
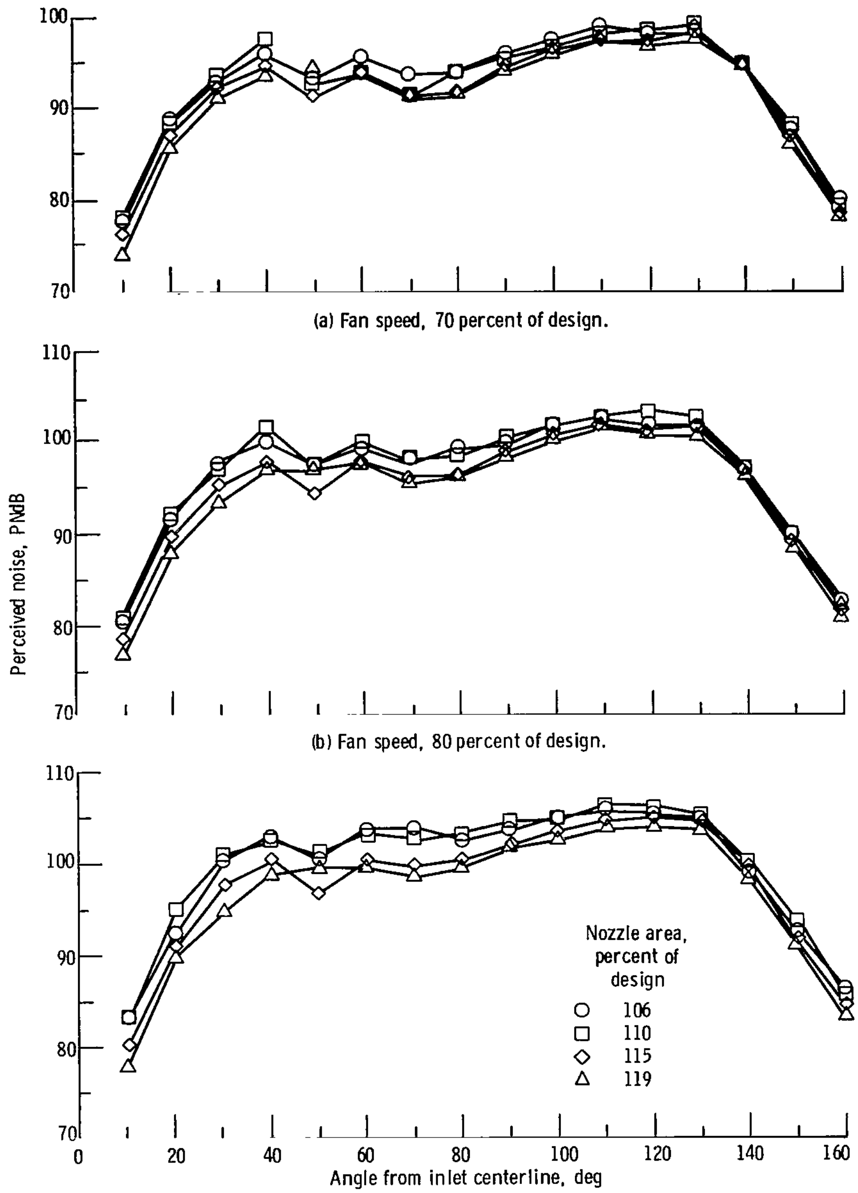


Figure 20. - Normalized overall sound power level as function of efficiency.

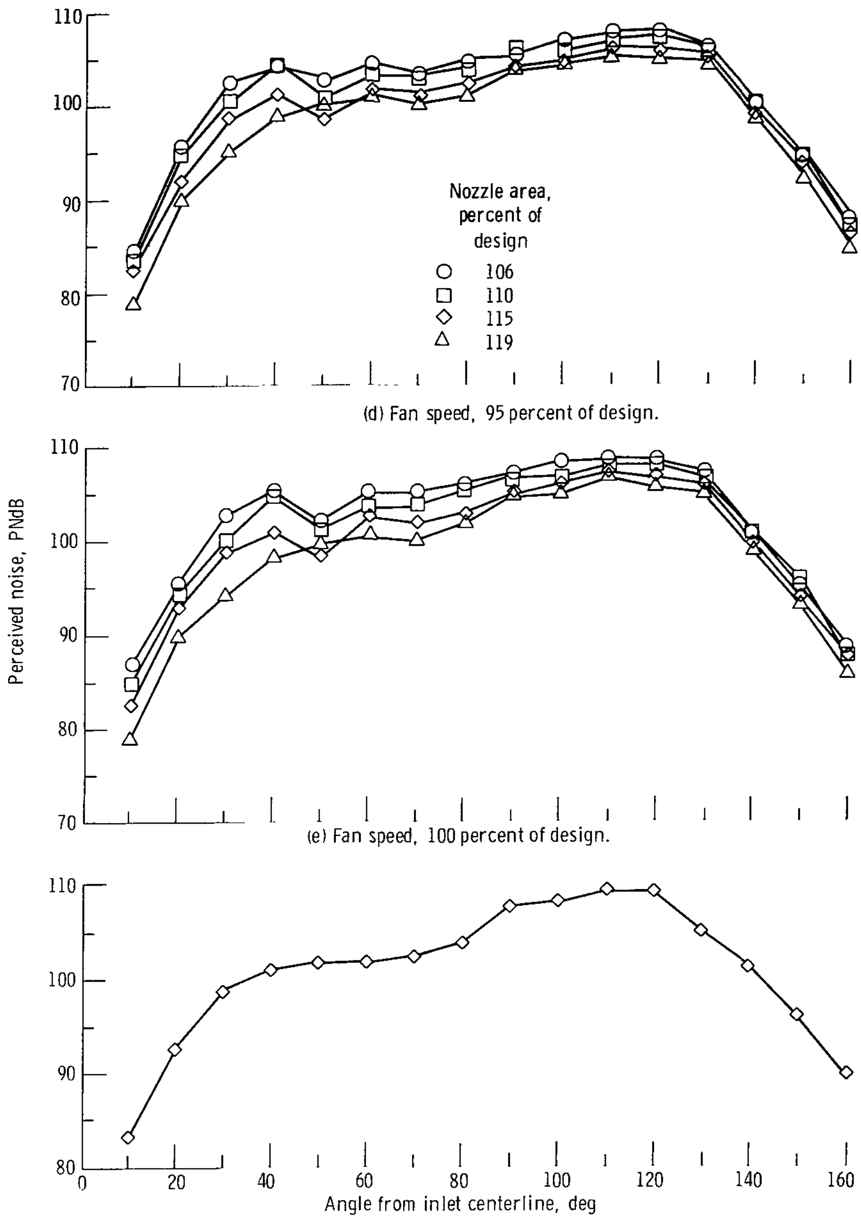


(a) Fan speed, 70 percent of design.

(b) Fan speed, 80 percent of design.

(c) Fan speed, 90 percent of design.

Figure 21. - QF-8 fan perceived noise level on 152.4-meter (500-ft) sideline as function of microphone angular position.



(d) Fan speed, 95 percent of design.

(e) Fan speed, 100 percent of design.

(f) Fan speed, 110 percent of design.

Figure 21. - Concluded.

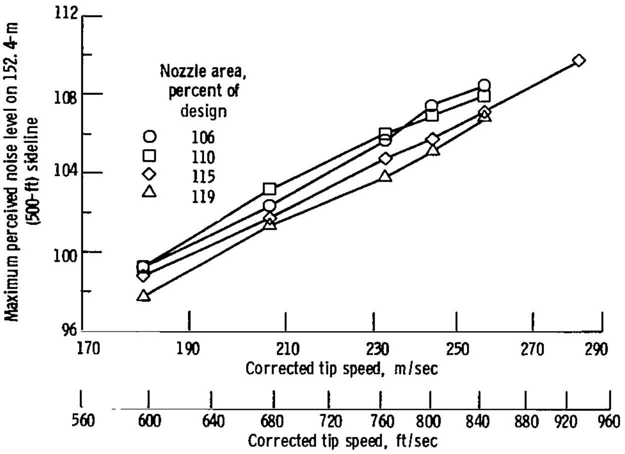


Figure 22. - Overall sound power level as function of corrected tip speed.

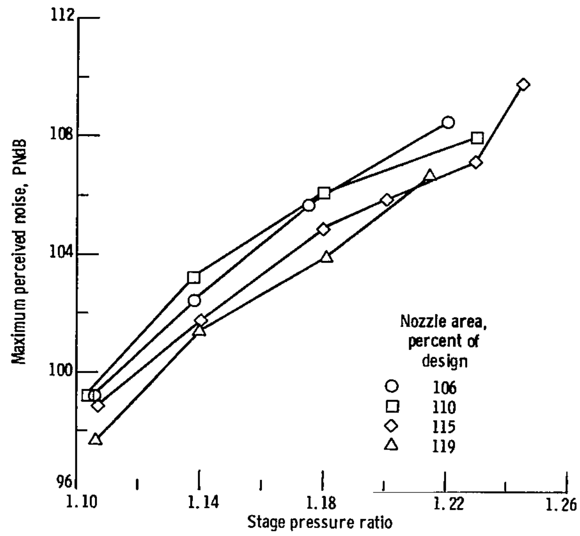


Figure 23. - QF-8 fan maximum perceived noise level along 152.4-meter (500-ft) sideline as function of stage pressure ratio.

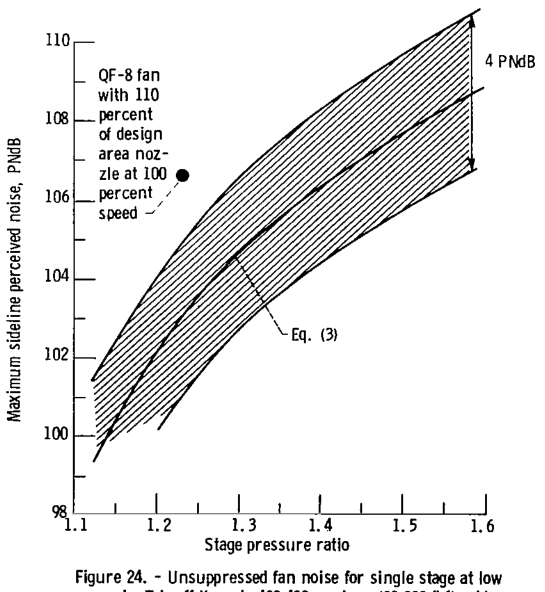


Figure 24. - Unsuppressed fan noise for single stage at low speed. Takeoff thrust, 400 400 newtons (90 000 lbf); sideline distance, 304.8 meters (1000 ft).

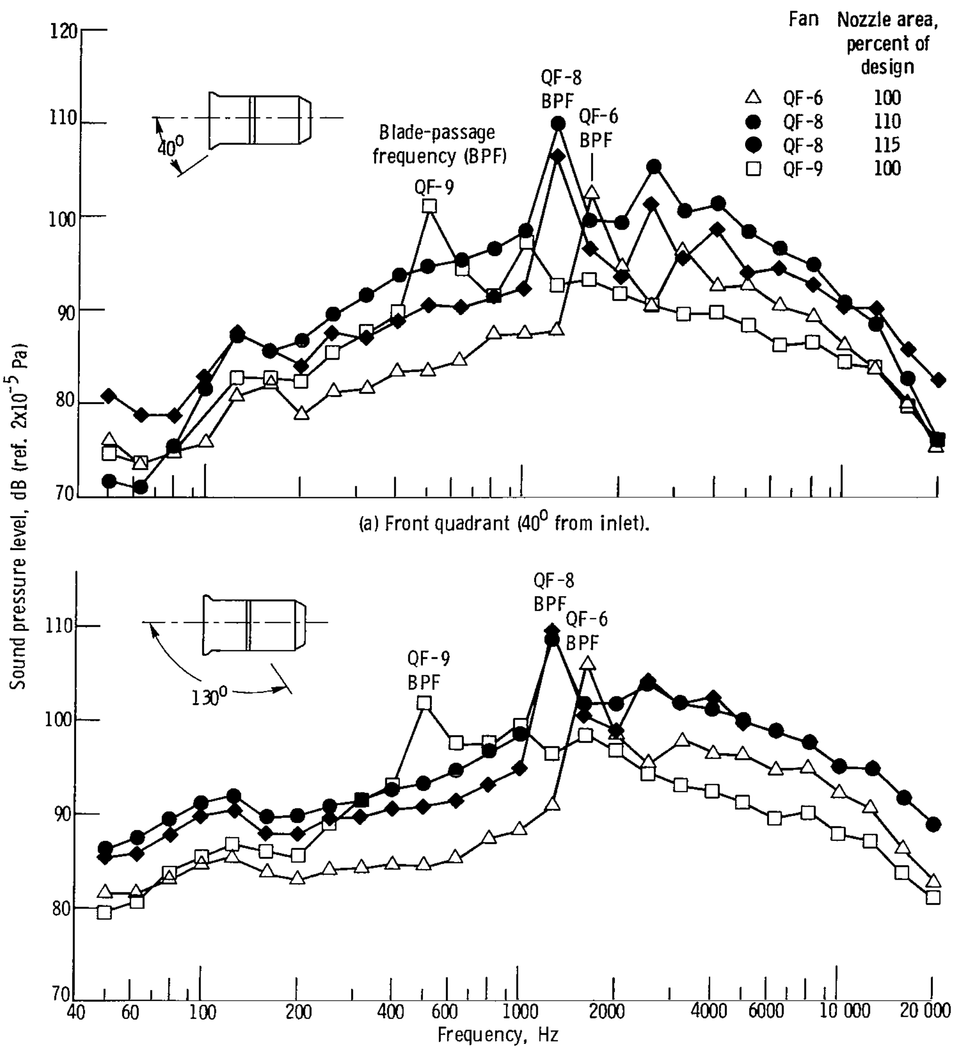


Figure 25. - One-third-octave sound pressure level spectra adjusted to standard day conditions; design fan speed.

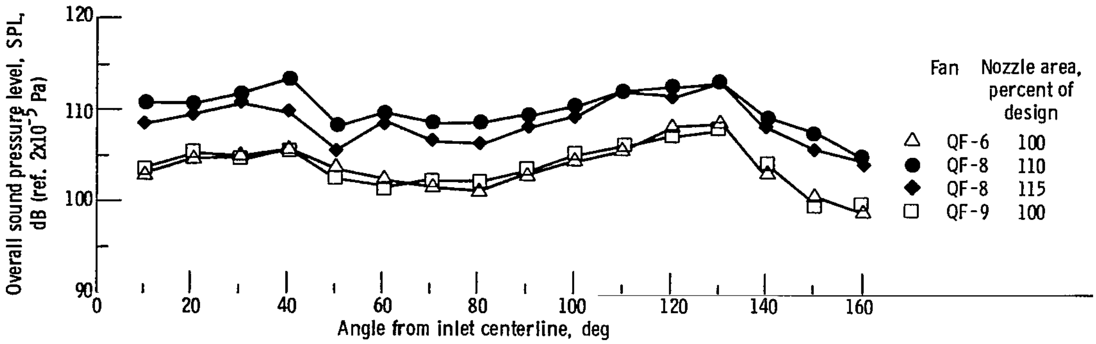


Figure 26. - Overall sound pressure level as function of microphone angular position; design speed.

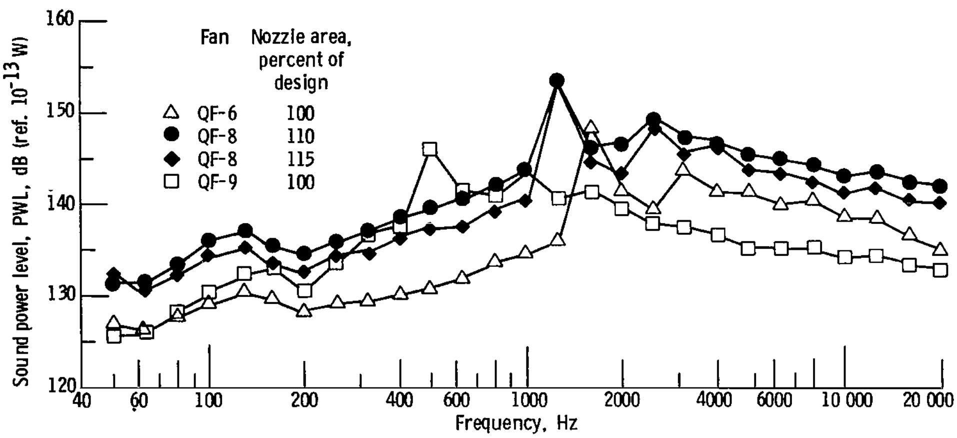


Figure 27. - Sound power level spectra at fan design speed.

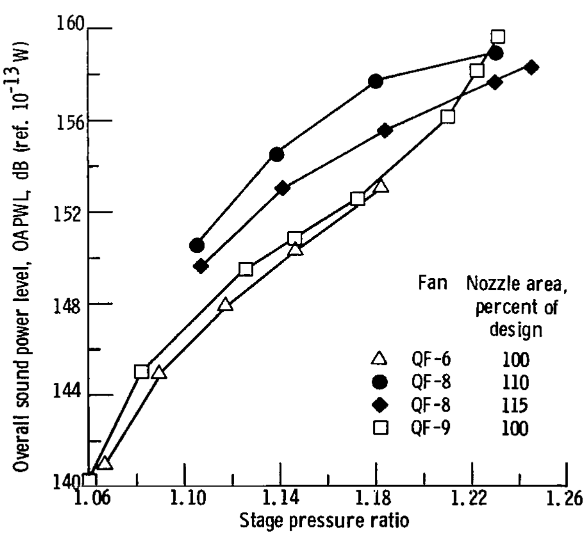


Figure 28. - Overall sound power level as function of stage pressure ratio.

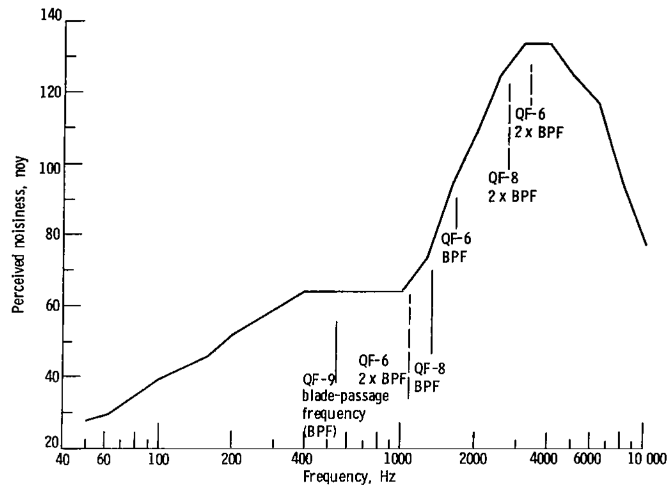


Figure 29. - One-third-octave perceived noise levels for 100-decibel (ref. 2×10^{-5} Pa) sound pressure level at each frequency.

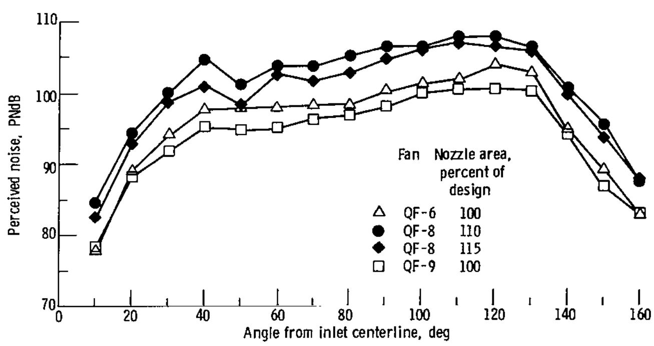


Figure 30. - Perceived noise level on 152.4-meter (500-ft) sideline at fan design speed.

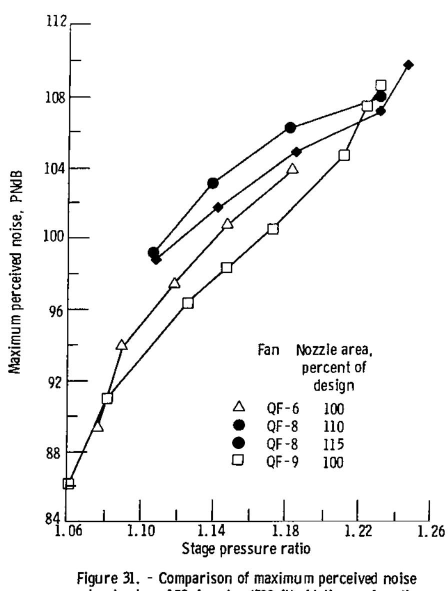


Figure 31. - Comparison of maximum perceived noise levels along 152.4-meter (500-ft) sideline as function of pressure ratio.

APPENDIX A

AERODYNAMIC COMPARISON OF QF-6, QF-8, AND QF-9 FANS

As indicated previously, the aerodynamic results for fan QF-8 were not in good agreement with the corresponding results for the 50.8-centimeter (20-in.) rotor-tip diameter QF-8 fan model, nor with the predicted design performance. The fan operating map (fig. 9) clearly shows some of the differences in corresponding aerodynamic results for the full-size and model fans. Also, the noise level of QF-8 was higher than the fan noise levels of QF-6 and QF-9 (figs. 25 to 31). These noise level differences may relate to differences in the aerodynamic performances of these fans. The aerodynamic performance of these three fans is explored in this appendix in an attempt to determine differences in the fan designs that may have contributed to these performance differences.

Fan QF-8 Results

Each fan had four total pressure rakes at the stator discharge measuring station (see fig. 7). Figure 32 presents the outer-wall circumferential static-pressure distribution and the radial total-pressure ratio distribution at the stator discharge measuring station for QF-8 operating at design speed.

The circumferential static-pressure distribution results for all tested nozzle areas show a pronounced static-pressure rise at the station adjacent to the pylon in the region of rake B. This peak static-pressure location was different for the QF-6 and QF-9 fan results, as will be discussed shortly.

Total pressure at stator exit. - The fan QF-8 stator exit total-pressure results showed large rake-to-rake differences. Also, all rakes showed a local low total pressure in the outer region of the passage. This poor tip flow probably contributed to the premature stall observed with the design area nozzle at design speed.

The fan QF-8 total-pressure-ratio stator-discharge radial distributions showed the greatest variation for the 106 percent-of-design-area nozzle (fig. 32(a)). Rakes C and D showed the lowest pressure ratios. Rake C was adjacent to the pylon. Rake B, which was adjacent to the pylon on the other side showed the highest total-pressure ratio. Increasing the nozzle area to 110 percent of design (fig. 32(b)) resulted in improved performance at the rakes C and D, with the rake D location essentially in agreement with the rake A and B locations. The pressure ratios nearest the rake C region of the pylon have noticeably improved with this nozzle area. Finally, with the 119 percent-of-design-area nozzle (fig. 32(c)) the rake D position pressure ratio sharply falls off toward the hub, a region which showed good results for nozzle areas closer to design.

In figure 32 a location about 64 percent of the span from the hub had the greatest rake-to-rake total-pressure-ratio variation. The total-pressure-ratio results for the four rakes at this 64-percent-span location are plotted as a function of percent of fan design speed on figure 33. These results are for the 110 percent-of-design-area nozzle. At all investigated speeds rake D results were considerably below those for rakes A and B, and a consistent separation was observed. These trends indicate that stator wake interference is not likely to be the cause of the reduced pressure measurement in the outer passage.

The average stator-discharge total-pressure distributions at design speed for the full-scale QF-8 fan and the 50.8-centimeter (20-in.) rotor-tip diameter model of fan QF-8 are compared with the design profile in figure 34. Except for a falloff in pressure ratio near the inner and outer wall, the model results agree well with the design. The full-scale results, however, show a marked deviation from the design. Near midspan the averaged results of the QF-8 fan are somewhat above design followed by a rapid loss of averaged total-pressure ratio toward the tip region. There is little difference between the 110 and 115 percent-of-design-area nozzle results.

Total pressure at nozzle exit. - The QF-8 fan total-pressure-ratio radial distribution at the nozzle discharge (nozzle discharge profiles are shown in fig. 35) for the 110 and 115 percent-of-design-area nozzles. As with the stator outlet, the agreement of the results of the three nozzle discharge rakes improves with the increased nozzle area. Although there are still rake-to-rake total-pressure differences at the nozzle exit, the differences are less than those observed at the stator exit, especially near the tip region where there is less dropoff in the total pressure. This shows a re-energization of the outer wall boundary layer downstream of the stator. It is not known whether the tip region total-pressure defect at the stator exit measuring station is the result of poor stator flow or flow separation from the duct outer wall downstream of the stator.

Fan QF-6 Results

The stator discharge total- and static-pressure-ratio variations are presented in figure 36. Unlike fan QF-8, which had a static pressure peak near the rake B region of the support pylon, the fan QF-6 results show a peak near the other side of the pylon for all tested nozzle areas. This may relate to differences in the turning of the exit flow from the stators of these two fans.

Pressure at stator exit. - The stator discharge total-pressure ratio profiles for the QF-6 fan also show rake-to-rake variations, with the largest differences occurring for the 95 percent-of-design-area nozzle. The scatter of figure 36(a) reflects the large departure from design operation as fan QF-6 with the 90 percent-of-design-area nozzle went into a stall at about 80 percent of design speed. The total-pressure-ratio radial profiles smooth out with the design area nozzle results (fig. 36(b)) and the 105 percent-of-design area results (fig. 36(c)). With the 105 percent-of-design-area nozzle, the results for rake A, which is well removed from the pylon, show a relatively constant level except for dropoffs at the hub and tip.

The rake-to-rake variations in stator-exit total-pressure ratio for the QF-6 fan are considerably less than those observed for fan QF-8 over the entire range of nozzle areas. For QF-8 the rake C results typically had the lowest values. The QF-6 fan results show rake C to be performing as well as or better than the other stator discharge rakes.

Average stator discharge total-pressure-ratio profiles for design nozzle area and design fan speed operation of the full-scale QF-6 fan and the 50.8-centimeter (20-in.) rotor-tip diameter QF-6 fan model are compared with the design profile in figure 37. The design profile and the fan results are in good agreement from the hub to about mid-span. Toward the tip region both full-scale and model results begin to dropoff. However, the full-scale fan QF-6 results are in much better agreement with the design values than the corresponding comparison of fan QF-8.

Total pressure at nozzle exit. - The nozzle discharge total-pressure-ratio radial distribution results for fan QF-6 at design speed are presented in figure 38 for the design area nozzle and for the 105 percent-of-design-area nozzle. The profiles show relatively small rake-to-rake variations consistent with those observed for the corresponding stator-exit cases. Also, an expected boundary-layer-related dropoff near the tip and hub regions is observed with this fan.

Fan QF-9 Results

The stator discharge static- and total-pressure-ratio distributions for the QF-9 fan are presented for the 92, 95, 100, and 105 percent-of-design-area nozzle results in figure 39. Similar to the fan QF-6 results, the QF-9 fan stator discharge static pressures show a high value near the rake C side of the pylon. The rise in static pressure across the pylon is the largest for this fan.

Total pressure at stator exit. - Like fan QF-6, the maximum pressure ratio results for QF-9 are measured by rake C, which is near the pylon. These results show the least rake-to-rake total-pressure-ratio differences of the three fans at the stator discharge measuring station.

Average stator discharge total-pressure-ratio radial profiles for the full-scale and the 50.8-centimeter (20-in.) rotor-tip diameter model of QF-9 are compared with the design profile for this fan in figure 40. The full-size and model results are in good agreement except for the data point nearest the tip, where the model result is considered to be in error and may be disregarded. The measured total-pressure profiles are similar to the design profile but fall somewhat below the design values over most of the passage height.

Total pressure at nozzle exit. - The nozzle discharge total-pressure-ratio radial distribution for QF-9 at design speed and design nozzle area is presented in figure 41. The fan QF-9 nozzle-exit rakes were not sufficiently long to measure the flow nearest the hub region. Otherwise, the nozzle-exit distributions are consistent with the stator-exit variations and the expected tip region reduction in pressure ratio.

Summary of Results

The preceding comparison of measured total-pressure distributions at the stator and nozzle exits of fans QF-6, QF-8, and QF-9 revealed a number of significant differences in the aerodynamic performance of QF-8 compared with QF-6 and QF-9. The QF-8 had substantially larger circumferential variations, a relatively large defect in total pressure in the outer portion of the flow passage at the stator-exit measuring station and a greater deviation from both design and scale-model performance. Considerable effort was made to investigate possible reasons for these differences in aerodynamic performance. The rotor and stator blades of both the full-scale and model fans were carefully checked and found to be correct in profile and setting angle in accordance with the fan design specifications. It was also determined that instrumentation malfunction or improper data sampling or transmission were unlikely causes. Flow passage and inflow differences were then explored.

Flow Path

The stator-exit flow of all full-scale fans tested at the quiet fan facility is partially blocked by a large support pylon (see fig. 4). The presence of the pylon necessitated flow contour adjustments in this region to compensate for the pylon blockage. In addition, the low-noise desirability of maximizing the rotor-stator spacing to about 4 rotor mean aerodynamic chord lengths resulted in compromising the axial spacing between the stator vanes and the pylon.

Figure 42 presents a comparison of the fan stage flow paths for fans QF-6, QF-8, and QF-9. The relatively short rotor and stator chord lengths of fan QF-6 (see table III p. 24) allowed a desirable rotor-stator axial separation and stator-pylon axial separation as shown in figure 42(a). The fan QF-8 stator-pylon separation, (fig. 42(b)) is very close. Also, the design restriction on fan QF-8 to maintain a straight inner flow path contour necessitated an abrupt circumferential increase in the outer flow path radius downstream of the stator to compensate for the pylon blockage. Although the pylon blockage is restricted to the bottom region of the flow passage, the flow passage contour correction was applied symmetrically, with a resulting flow redistribution in this region.

The flow path cross section of fan QF-9 (fig. 57(c)) is similar to that of fan QF-6 with the pylon blockage compensated for on the inner flow path. The large chord lengths of fan QF-9 again resulted in close stator-pylon axial separation. This stator-pylon separation expressed as the ratio of the separation distance divided by the mean aerodynamic stator chord length was 2.39, 0.42, and 0.22, respectively, for fans QF-6, QF-8, and QF-9.

Figure 43(a) shows the unwrapped outer flow surface for fans QF-6, QF-8, and QF-9. The locations of the stator-exit and nozzle-exit total-pressure rakes and the stator-exit outer wall static taps adjacent to the pylon are shown for each fan. Figure 43(b) presents the unwrapped inner or hub flow surfaces for the three fans. Since the pylon is of constant cross section at all radial positions, the relative blockage due to the pylon is more severe at the hub than at the tip. Also, the stator-exit and nozzle-exit total-pressure rakes are relatively closer to the pylon in the hub region than they are in the tip region.

The stator trailing edge-to-rake distance divided by the stator mean aerodynamic chord values for fans QF-6, QF-8, and QF-9, respectively, are approximately 3.0, 1.8, and 0.9. Since the actual stator trailing edge-to-rake distances are nearly the same for all three fans, the ratio values primarily reflect the stator chord lengths of the fans. In view of these large separation ratios, it is highly unlikely that stator-wake trough effects would be experienced in the total-pressure-rake measurements for any of these fans.

A second possibility is for flow separation from the pylon to affect the stator discharge rake measurements in fan QF-8. However, this possibility is precluded by the distances of the pressure rakes from the pylon near the outer wall, although some effect might be possible towards the inner wall of the flow passage. However, low total-pressure readings near the hub are not a problem for the QF-8 fan. The wall static tap locations were somewhat closer to the support pylon than the total-pressure rakes at the outer wall. These taps near the pylon would be expected to be influenced by the flow around the pylon, especially if the discharge from the stators was not axial.

Because of the proximity of the fan QF-8 stator vanes to the pylon (see fig. 43), some of the vane flow passages nearest to the pylon may have been effectively blocked with resulting adverse flow distributions on adjacent vanes. The high mass flow and low stator spacing of fan QF-8 may have further aggravated this problem. Stator vane channel blockage, which may be an especially important consideration for fan QF-8, is even more likely near the hub (fig. 43(b)).

Although fan QF-9 also had a small stator-pylon spacing, several factors in its design tend to reduce the impact of this condition. Fan QF-9 had only 11 stator vanes (compared with the 34 vanes of fan QF-8); hence, the intervane flow passages were much larger with a reduced likelihood of propagating blockage effects from the pylon. Also, the long stator chords of fan QF-9 would tend to stabilize the flow, again reducing the disturbance effects of the downstream conditions.

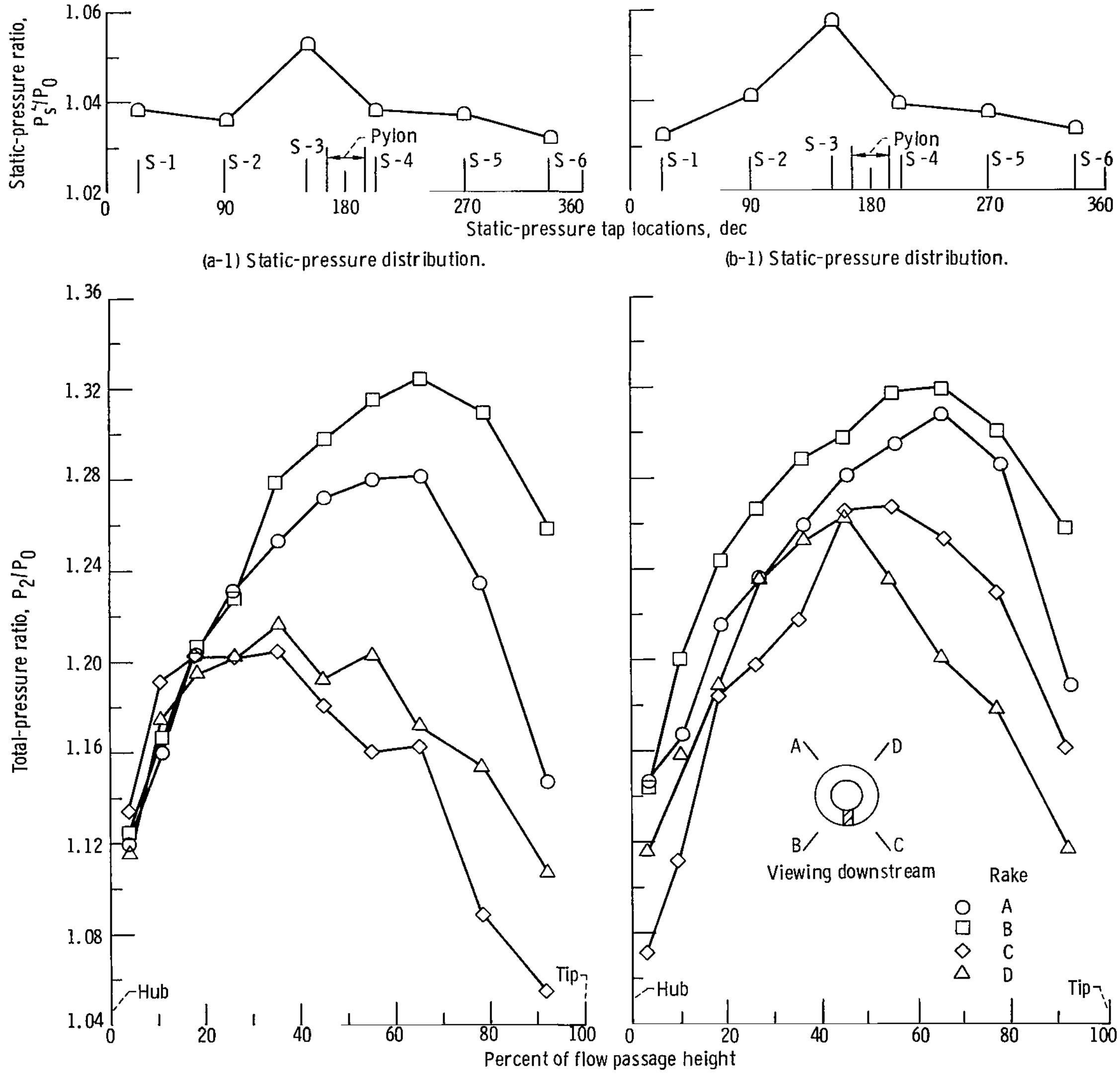
Fan QF-6 had a stator spacing between that of fans QF-8 and QF-9. In addition, the stator-pylon separation of fan QF-6 was considerably greater than that of the other two fans; so any local stator blockage problem due to the proximity of the pylon would be expected to be less than that for the QF-8 fan.

Inlet Flow

The quiet fan facility in which the QF-6, QF-8, and QF-9 fans were tested has inlet-flow distortions that can cause disturbances of the flow through the fan stage as well as increased rotor tone noise. An in-depth discussion of possible inlet distortion effects is given in reference 21. As a check of possible differences in the incoming flow to the fans, the circumferential distribution of the inlet static pressure ratios for fans QF-6, QF-8, and QF-9 is plotted in figure 44. The incoming flow for all fans appears to be reasonably uniform, with the different pressure ratios for the fans relating to differences in inlet mass flow between designs, and for different nozzle areas. It is believed, therefore, on the basis of the available instrumentation, that there is no substantial difference in inflow conditions for QF-8, compared with fans QF-6 and QF-9, that might contribute to the observed large flow nonuniformities at the outlet of the fan QF-8 stage.

Conclusions

It is strongly suspected that the higher noise level of the QF-8 fan, compared with fans QF-6 and QF-9, is associated with the large degree of circumferential flow nonuniformity and the indicated outer-wall flow separation (total-pressure defect in outer passage) downstream of the stator in the QF-8 fan. Although the reasons for the relatively poor aerodynamic performance of fan QF-8 are not known, it is suspected that the proximity of the stators to the fan pylon and the relatively sharp expansion of the outer wall contour immediately downstream of the stator may have been major contributors.



(a-1) Static-pressure distribution.

(a-2) Total pressure radial distribution.

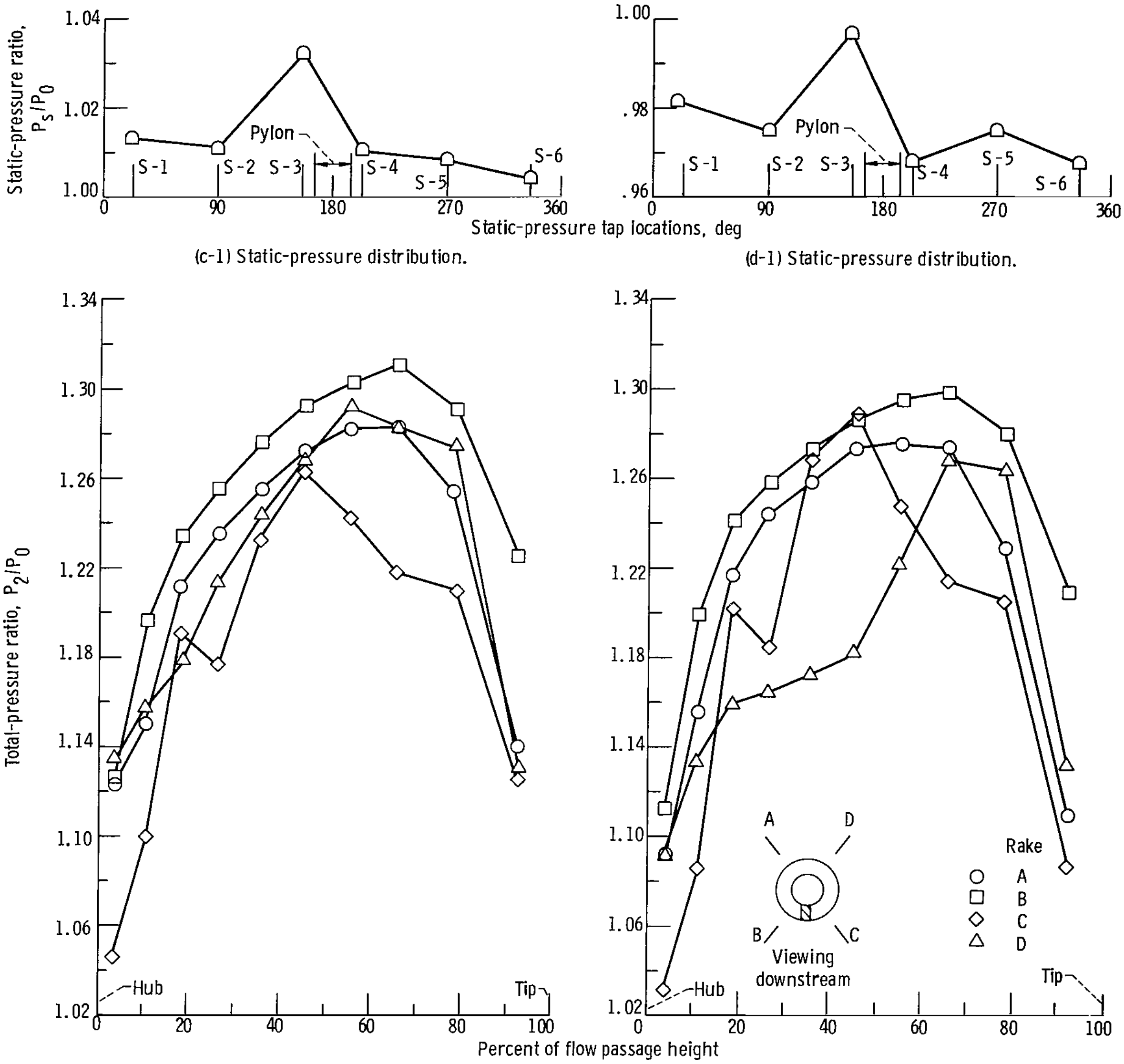
(a) 106 Percent-of-design-area nozzle.

(b-1) Static-pressure distribution.

(b-2) Total-pressure radial distribution

(b) 110 Percent-of-design-area nozzle.

Figure 32. - QF-8 fan pressure distributions at stator-exit measuring station; design speed. (See fig. 7.)



(c-1) Static-pressure distribution.

(d-1) Static-pressure distribution.

(c-2) Total-pressure radial distribution

(c) 115 Percent-of-design-area nozzle.

(d-2) Total-pressure radial distribution.

(d) 119 Percent-of-design-area nozzle.

Figure 32. - Concluded.

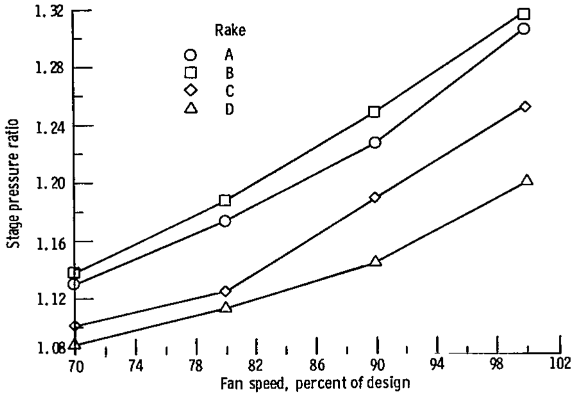


Figure 33. - QF-8 fan stator-exit total-pressure ratio as function of fan speed for 64 percent span location; nozzle area, 110 percent of design.

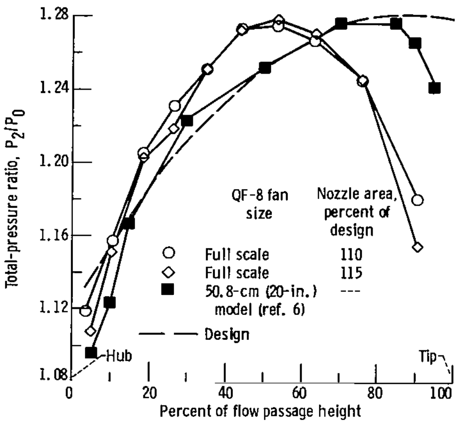
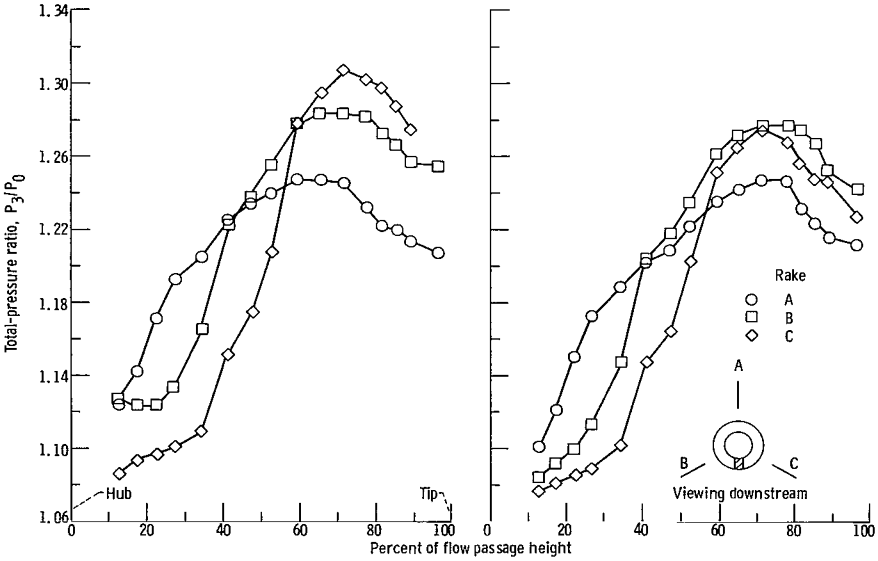
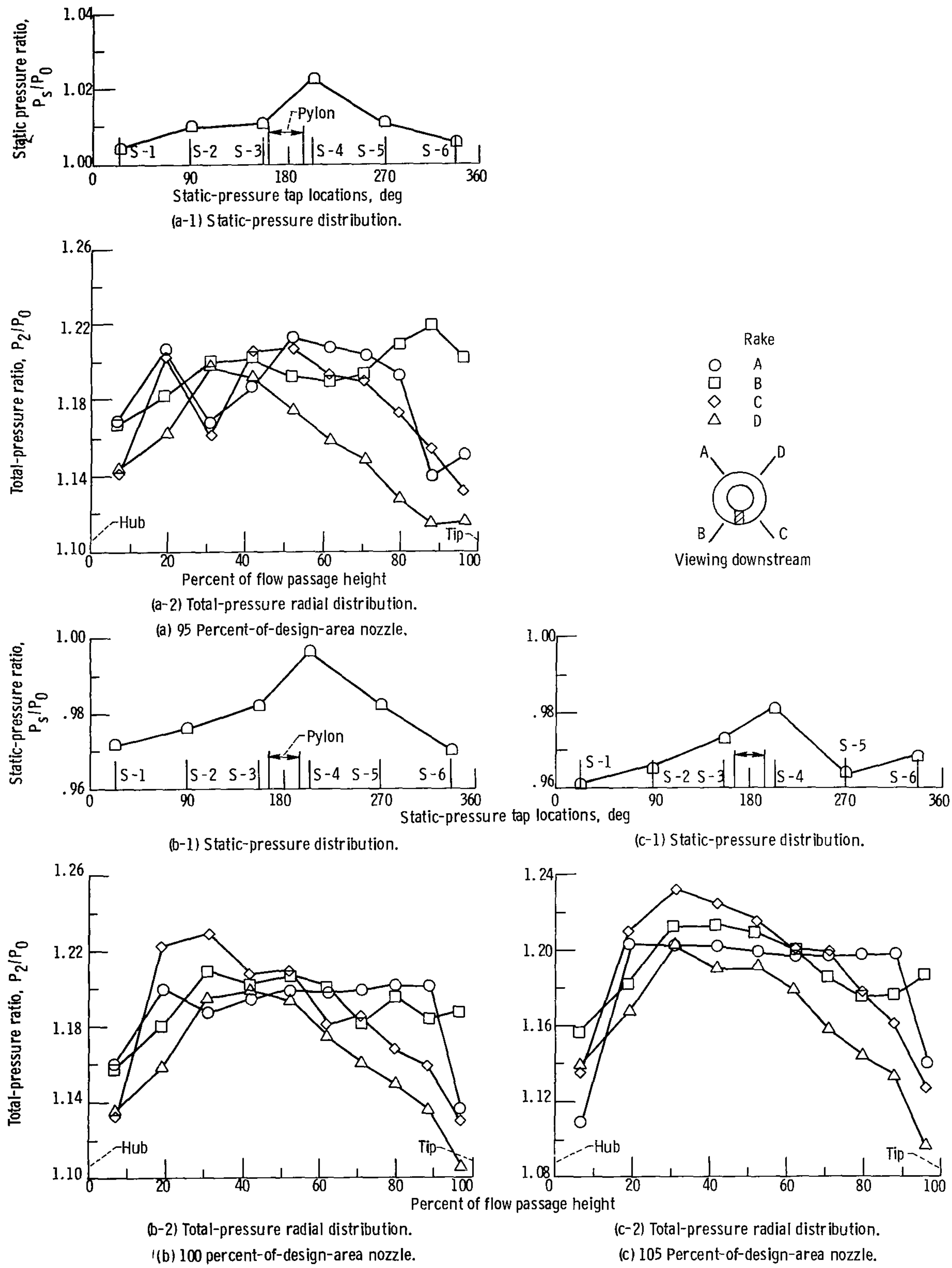


Figure 34. - QF-8 fan average total-pressure radial distribution at stator-exit measuring station; design speed.



(a) 110 Percent-of-design-area nozzle. (b) 115 Percent-of-design-area nozzle.

Figure 35. - QF-8 fan total-pressure radial distribution at nozzle-exit measuring station, design speed.



(a-1) Static-pressure distribution.

(a-2) Total-pressure radial distribution.

(a) 95 Percent-of-design-area nozzle.

(b-1) Static-pressure distribution.

(c-1) Static-pressure distribution.

(b-2) Total-pressure radial distribution.

(c-2) Total-pressure radial distribution.

(b) 100 percent-of-design-area nozzle.

(c) 105 Percent-of-design-area nozzle.

Figure 36. - QF-6 fan pressure distributions at stator-exit measuring station; design speed. (See fig. 7.)

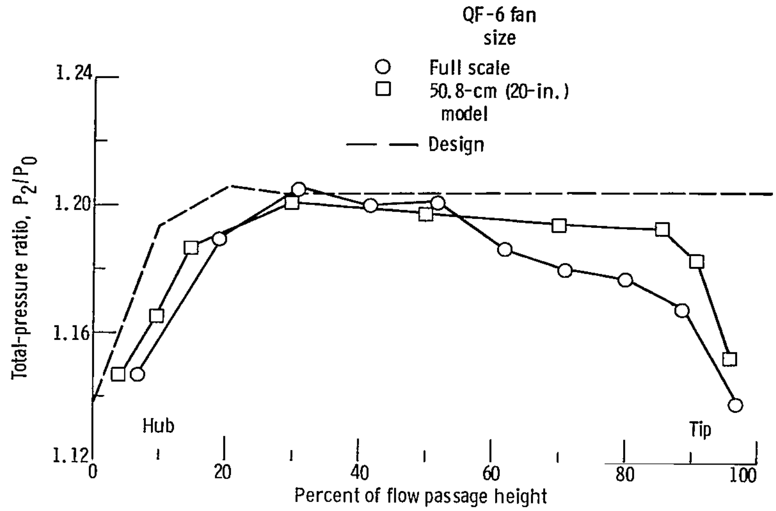
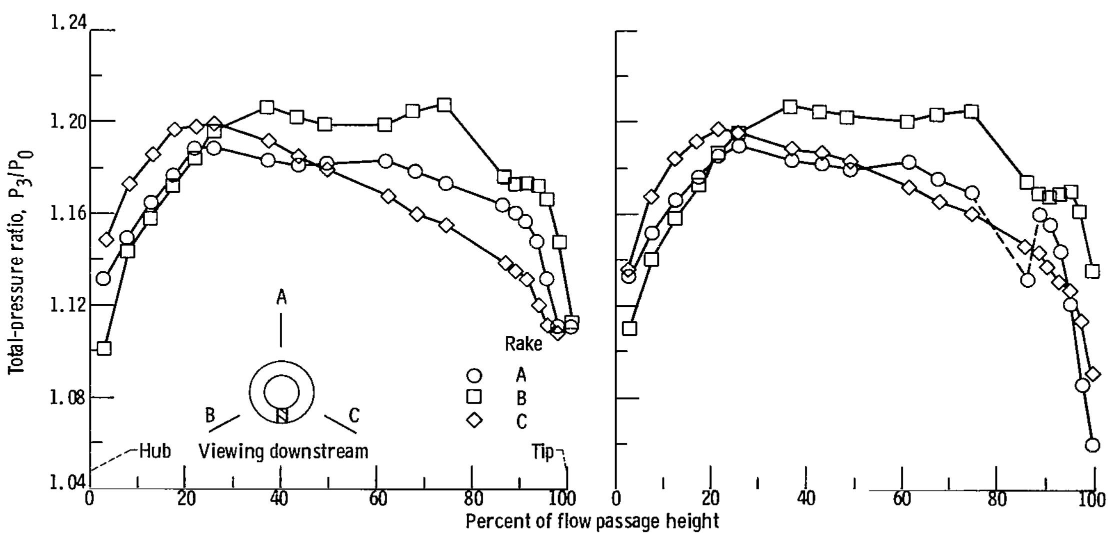
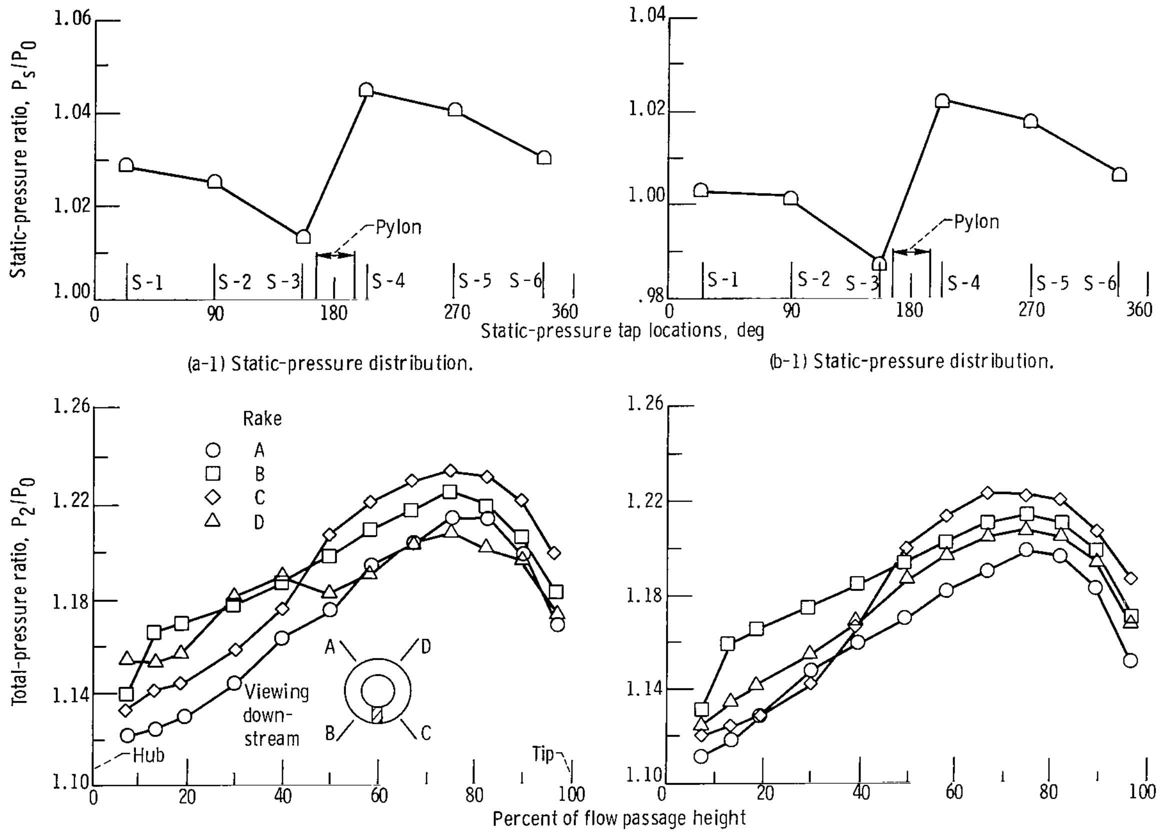


Figure 37. - QF-6 fan average total-pressure radial distribution at stator-exit measuring station. Design speed; nozzle area, 100 percent of design.



(a) 100 Percent-of-design-area nozzle. (b) 105 Percent-of-design-area nozzle.

Figure 38. - QF-6 fan total-pressure radial distribution at nozzle-exit measuring station; design speed.



(a-1) Static-pressure distribution.

(b-1) Static-pressure distribution.

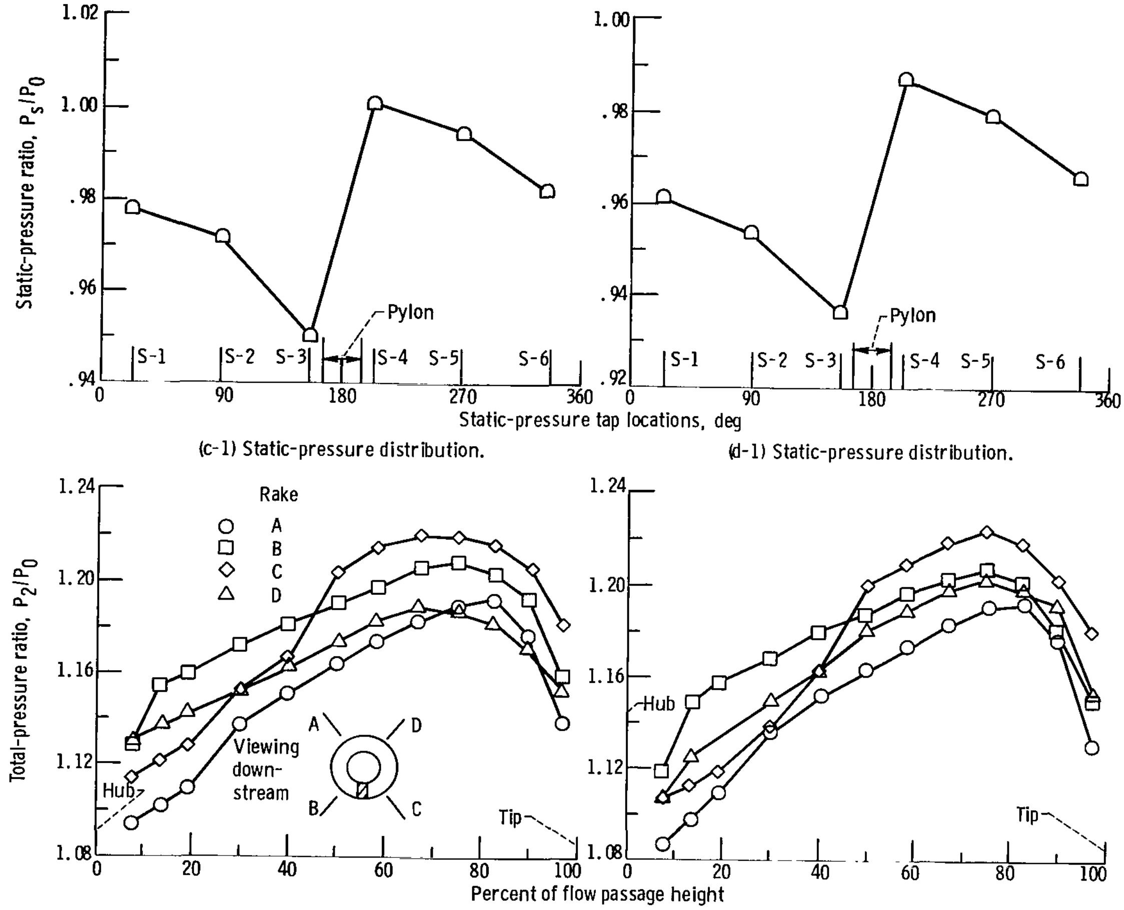
(a-2) Total-pressure distribution.

(a) 92 Percent-of-design-area nozzle.

(b-2) Total-pressure radial distribution.

(b) 95 Percent-of-design-area nozzle.

Figure 39. - QF-9 fan pressure distributions at stator-exit measuring station; design speed. (See fig. 7.)



(c-1) Static-pressure distribution.

(d-1) Static-pressure distribution.

(c-2) Total-pressure radial distribution.

(d-2) Total-pressure radial distribution.

(c) Design area nozzle.

(d) 105 Percent-of-design-area nozzle.

Figure 39. - Concluded.

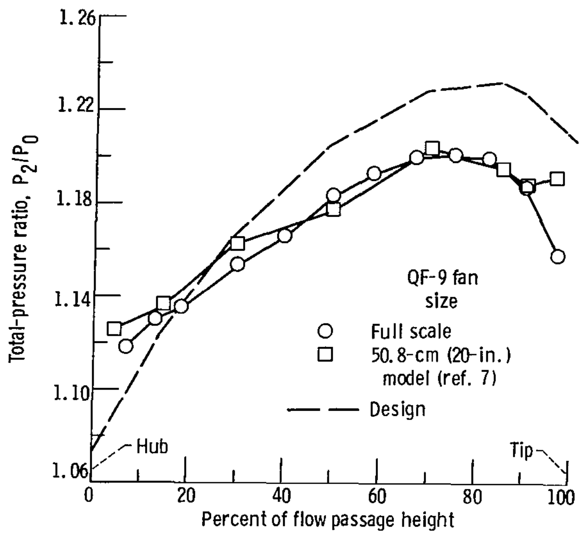


Figure 40. - QF-9 fan average total-pressure radial distribution at stator-exit measuring station. Design speed; design area nozzle.

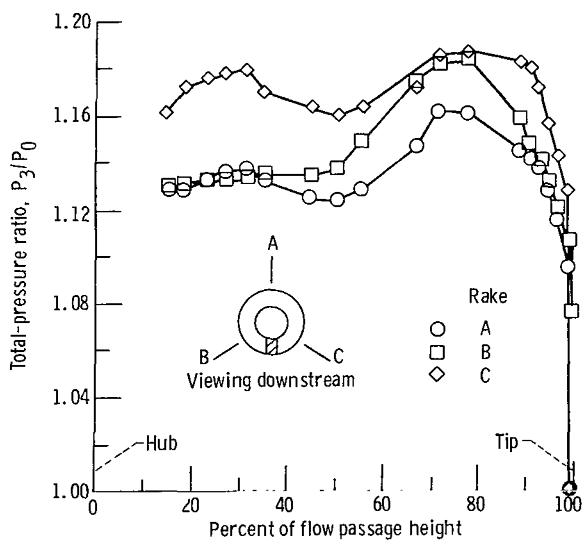
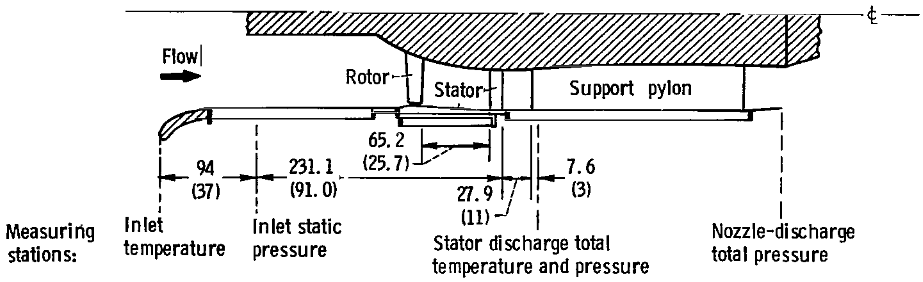
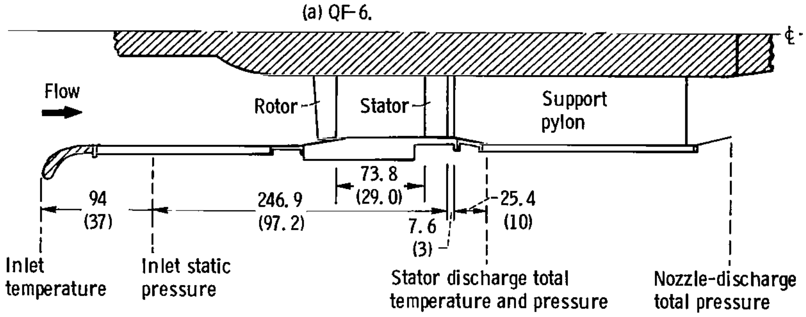


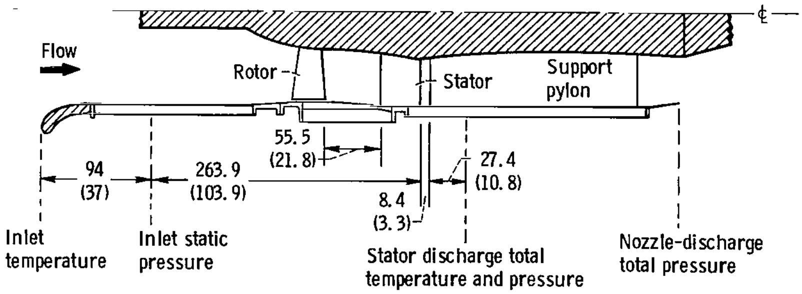
Figure 41. - QF-9 fan total-pressure radial distribution at nozzle-exit measuring station. Design speed; takeoff nozzle area.



(a) QF-6.



(b) QF-8.



(c) QF-9.

Figure 42. - Comparison of cross sections of QF-6, QF-8, and QF-9 fan flow paths. (All dimensions are in cm (in.).)

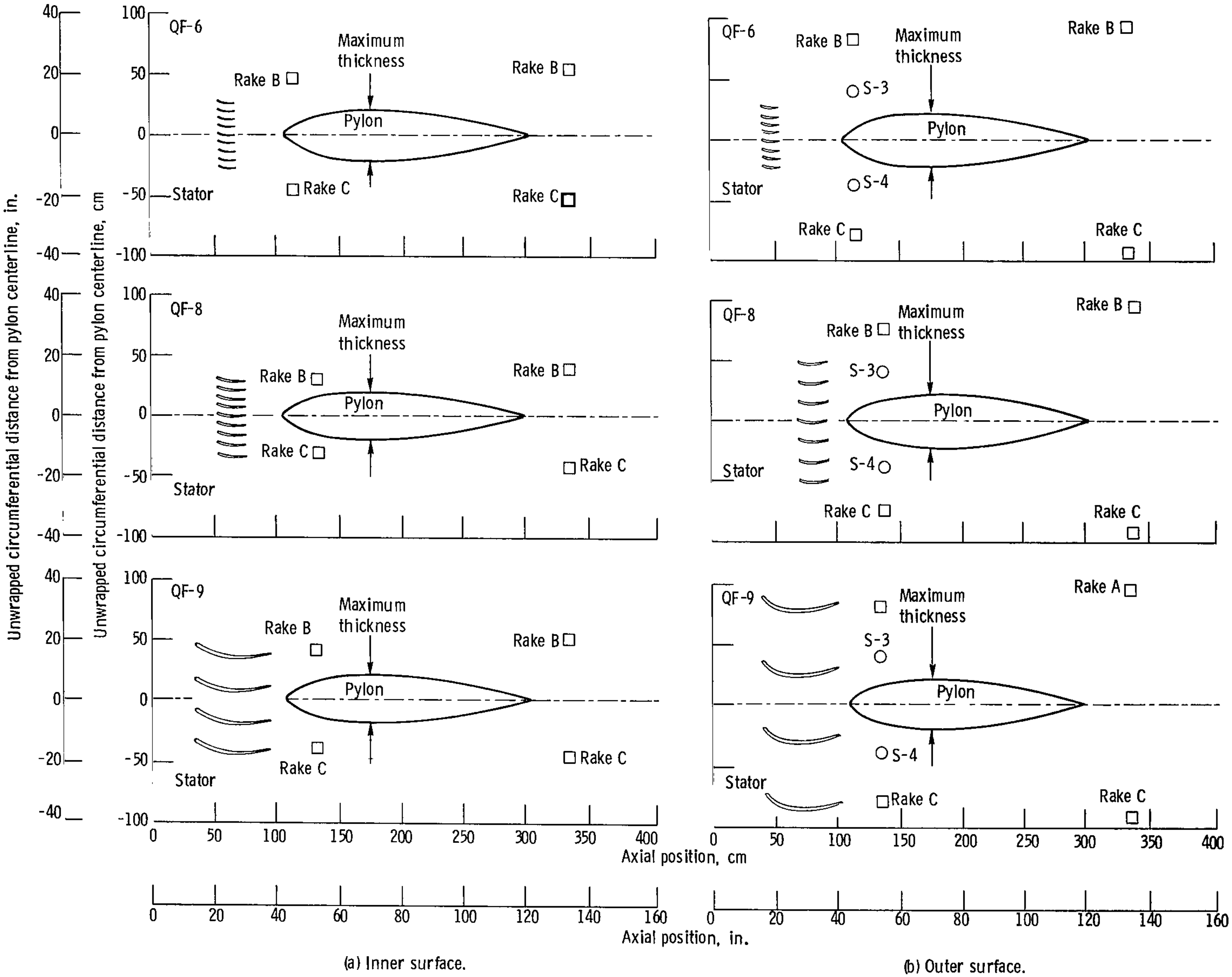


Figure 43. - Location of pylon, fan instrumentation, and stator vanes on unwrapped flow surface (view, toward hub).

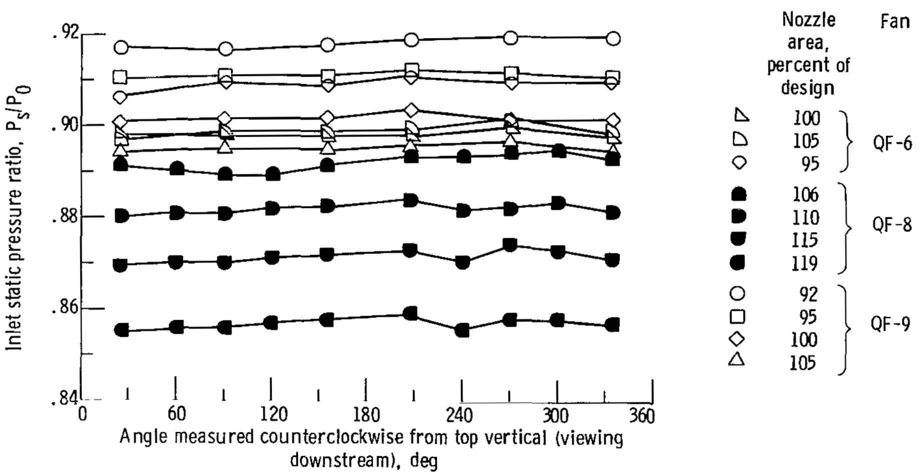


Figure 44. - Inlet static-pressure distribution; design speed.

APPENDIX B

QF-8 ACOUSTIC DATA

This appendix contains data tables and plots of the QF-8 acoustic data. Tables IV to VII show the data. Figure 45 presents the one-third-octave sound power level spectra at 70, 80, 90, 95, and 100 percent design speed for each nozzle area configuration. Figure 46 presents the overall sound power as a function of speed. Figure 47 presents the overall sound pressure level as a function of angle on a 30.5-meter (100-ft) radius. Figure 48 presents the perceived noise on a 30.5-meter (100-ft) radius. Figures 49 to 52 present the one-third-octave sound pressure level spectra for all run speeds and configurations tested at each angle from 10^{o} to 160^{o} on a 30.5-meter (100-ft) radius.

TABLE IV. - ACOUSTIC DATA FOR STOL QF-8 FAN WITH 106 PERCENT-OF-DESIGN-AREA NOZZLE

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(a) 70 Percent speed; fan physical speed, 1845 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	73.2	72.2	74.7	72.8	69.0	71.3	72.0	70.7	72.5	72.5	72.7	71.4	76.3	73.7	76.5	79.6	73.4	120.8
63	74.9	72.4	74.2	73.0	68.2	69.7	70.9	71.2	71.7	73.5	72.3	71.8	76.5	74.7	77.4	78.9	73.4	120.8
80	73.6	73.4	74.4	71.6	67.6	69.6	70.1	71.7	71.6	72.4	73.7	74.0	77.9	76.4	78.1	79.4	74.0	121.4
100	75.2	78.3	78.7	77.0	72.3	75.3	74.5	75.0	76.3	76.8	76.5	78.1	79.8	78.5	79.5	79.4	77.2	124.6
125	81.5	82.8	80.7	81.5	75.8	77.7	78.5	77.2	77.5	78.7	78.5	78.4	79.8	79.2	80.2	78.7	79.0	126.4
160	81.7	81.3	79.5	78.3	74.0	75.0	76.0	75.3	76.5	76.5	77.0	77.3	78.5	77.2	77.2	77.2	77.2	124.6
200	82.4	82.6	79.4	77.6	72.7	73.9	74.4	74.4	74.1	75.9	76.9	77.7	79.4	78.1	78.1	76.6	77.1	124.5
250	84.2	84.6	81.6	81.9	77.5	79.4	77.6	76.9	77.7	79.6	80.1	81.8	82.9	81.1	78.9	77.8	80.3	127.7
315	86.8	86.0	83.2	82.5	77.3	79.3	78.0	77.8	79.2	81.2	82.0	82.9	83.0	81.7	79.8	77.2	81.3	128.7
400	88.3	87.5	86.3	84.6	79.6	81.0	80.3	80.8	81.5	83.6	85.0	85.9	85.3	83.1	80.5	77.9	83.7	131.1
500	88.1	88.5	87.3	86.3	81.5	82.3	82.0	81.8	83.0	85.1	86.5	86.6	86.3	85.0	81.5	79.7	84.9	132.3
630	88.2	89.5	87.7	87.3	82.3	83.0	82.7	83.3	85.0	87.2	88.2	88.1	88.0	86.8	82.5	81.4	86.3	133.7
800	93.2	93.7	93.1	93.2	89.1	89.7	87.7	87.6	89.1	90.6	91.9	92.8	93.1	93.1	88.4	86.0	91.2	138.6
1000	97.3	98.0	98.0	97.8	94.3	95.2	91.8	91.5	91.7	93.3	95.7	97.1	97.0	96.7	92.2	89.6	95.3	142.7
1250	92.7	93.7	91.8	91.3	86.2	86.6	85.5	86.5	88.6	90.3	92.5	93.6	93.3	91.2	87.2	84.6	90.7	138.1
1600	94.5	95.0	93.7	93.5	89.2	89.7	87.5	87.4	89.7	91.4	93.5	94.1	95.0	93.5	89.2	86.1	92.2	139.6
2000	96.1	97.6	96.8	96.3	92.1	92.8	89.8	89.3	91.6	92.8	94.6	95.7	97.1	96.1	91.1	88.0	94.4	141.8
2500	94.3	96.1	95.3	94.8	89.8	90.5	88.0	87.5	89.8	90.6	92.3	93.9	94.6	92.0	87.8	85.1	92.4	139.8
3150	94.3	95.6	94.5	94.8	90.1	91.1	87.3	87.5	89.0	91.1	93.5	93.3	94.1	92.1	87.8	84.2	92.5	139.9
4000	92.8	93.8	92.6	94.8	88.4	89.4	85.3	84.9	86.1	89.3	91.8	91.1	92.8	91.6	86.6	83.2	91.2	138.6
5000	90.5	92.5	91.0	92.0	85.8	87.3	83.9	82.2	84.7	85.7	88.7	88.0	90.7	87.7	83.8	80.2	89.0	136.4
6300	89.1	91.3	89.6	91.0	84.0	85.8	81.9	79.7	82.4	84.2	87.5	85.2	89.0	87.1	82.8	79.5	88.0	135.4
8000	88.4	90.6	88.4	89.2	82.7	84.5	80.9	78.5	80.9	82.5	85.2	82.7	87.9	84.7	80.7	77.4	87.1	134.5
10000	86.4	88.9	86.2	87.6	80.2	82.0	78.7	75.9	78.2	79.5	83.2	78.8	85.7	82.0	78.7	75.0	85.9	133.3
12500	86.0	88.8	85.1	86.8	79.3	81.3	78.0	74.8	77.6	79.1	82.1	76.8	85.5	82.1	78.3	74.6	86.7	134.1
16000	83.3	85.1	81.8	83.3	75.8	78.3	74.4	71.4	74.6	75.9	78.9	71.1	83.3	78.8	75.5	71.5	85.4	132.8
20000	80.8	82.6	78.4	79.9	72.6	74.9	71.3	68.5	71.3	72.6	75.4	66.0	80.3	75.8	72.5	68.8	85.0	132.4
OVERALL	104.9	106.0	104.9	105.0	100.3	101.2	98.4	98.1	99.7	101.3	103.4	104.0	104.9	103.5	99.3	96.7	103.0	150.4
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	82.5	93.1	96.7	99.6	96.7	99.1	97.1	97.3	99.2	100.8	102.4	101.7	101.6	98.3	91.2	83.8		
152.4 M	78.0	89.2	93.2	96.1	93.4	95.8	94.0	94.1	96.1	97.6	99.2	98.6	98.4	95.0	87.7	80.1		
304.8 M	65.6	78.7	83.7	87.0	84.8	87.4	85.8	86.0	88.1	89.4	90.7	90.4	89.9	86.2	78.4	69.8		

TABLE IV. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(b) 80 Percent speed; fan physical speed, 2109 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	75.1	73.1	72.8	73.1	69.6	72.3	73.4	72.9	74.6	75.6	74.4	74.2	76.4	77.4	78.8	82.1	75.2	122.6
63	75.7	73.7	72.8	72.8	70.2	72.7	73.0	71.7	73.7	74.0	74.5	74.8	78.2	79.2	80.3	82.2	75.6	123.0
80	76.6	76.1	73.6	71.9	68.9	71.6	71.9	71.9	73.8	75.1	75.8	77.0	79.6	81.3	81.9	82.8	76.7	124.1
100	81.9	81.8	80.8	80.9	75.4	75.8	78.1	77.8	78.6	79.1	80.3	80.5	82.4	83.1	83.9	83.3	80.5	127.9
125	83.7	86.0	85.7	83.5	78.7	81.9	80.0	79.9	80.2	81.4	81.7	81.8	82.5	83.4	83.5	81.1	82.1	129.5
160	84.2	84.7	83.5	82.0	76.5	78.5	77.9	78.2	78.7	79.7	79.7	80.5	80.7	80.2	80.7	79.9	80.2	127.6
200	87.0	86.5	84.0	81.5	76.8	78.8	78.1	76.6	77.0	78.3	79.3	80.1	82.1	81.8	81.3	78.9	80.5	127.9
250	87.6	87.6	86.3	86.1	81.0	83.3	81.1	80.1	80.6	82.5	82.8	84.6	85.8	84.5	82.1	79.7	83.6	131.0
315	89.4	89.2	87.2	86.0	81.0	82.4	80.2	80.7	82.0	84.0	84.7	85.8	85.9	84.9	81.7	80.1	84.3	131.7
400	91.1	90.4	90.3	87.4	82.9	84.3	82.1	83.3	84.8	86.9	87.8	88.5	88.4	86.4	82.6	81.0	86.7	134.1
500	91.3	91.7	91.2	89.3	83.8	84.8	83.5	84.8	86.2	88.3	88.8	89.6	90.0	87.3	83.7	81.6	87.9	135.3
630	90.6	92.0	92.3	90.5	86.5	86.6	85.1	87.0	88.5	90.5	91.0	91.4	92.0	89.3	85.5	83.7	89.6	137.0
800	93.4	93.4	93.7	91.9	86.9	87.9	87.2	88.7	90.5	92.4	93.0	94.0	94.4	92.2	88.2	86.3	91.6	139.0
1000	99.8	101.8	102.6	102.3	100.0	101.0	97.3	97.1	97.5	98.5	100.5	101.2	102.1	99.3	94.8	92.9	100.0	147.4
1250	96.3	97.0	97.3	96.3	91.8	92.3	90.6	92.0	93.0	94.3	96.1	97.1	97.8	94.6	90.8	88.0	94.9	142.3
1600	96.8	96.6	97.6	96.1	91.4	91.6	89.6	91.3	92.9	94.6	96.6	97.0	97.9	94.3	90.8	88.0	94.9	142.3
2000	98.5	100.0	101.4	100.5	95.4	95.7	93.2	94.5	94.7	96.4	97.9	98.8	100.2	97.5	92.7	89.8	97.7	145.1
2500	97.1	98.6	99.8	97.8	93.1	92.6	90.9	92.6	93.1	94.8	95.3	96.9	97.6	94.4	90.1	87.7	95.6	143.0
3150	98.1	99.1	100.1	99.1	94.9	95.1	92.1	93.4	93.1	95.8	96.6	97.0	98.3	95.8	90.9	88.2	96.7	144.1
4000	96.1	97.1	97.6	98.4	92.2	92.1	89.4	90.2	90.6	93.9	95.1	94.7	96.4	93.9	88.7	86.4	94.9	142.3
5000	94.2	96.2	96.8	96.0	90.5	90.2	87.3	88.3	89.2	90.8	92.8	92.0	94.5	90.8	87.2	83.5	93.2	140.6
6300	93.5	94.6	95.3	95.1	89.1	89.0	86.3	86.4	87.1	89.1	91.6	89.4	93.3	90.3	85.8	82.9	92.3	139.7
8000	92.4	93.9	94.0	93.2	87.2	87.7	85.0	84.7	85.7	87.2	89.5	86.7	91.9	88.2	84.2	80.9	91.3	138.7
10000	90.1	91.9	92.1	91.8	84.2	85.4	82.9	82.1	82.7	84.4	87.4	82.8	88.9	85.6	81.7	78.7	90.0	137.4
12500	89.3	92.0	90.8	91.1	83.6	84.5	82.0	80.5	82.6	84.0	86.3	80.5	88.6	85.1	81.5	78.0	90.7	138.1
16000	86.3	88.3	87.1	87.3	79.8	81.1	78.8	77.3	78.9	80.3	83.4	75.0	85.4	82.3	78.6	75.0	89.1	136.5
20000	84.0	85.7	83.4	83.9	75.9	77.7	75.4	74.0	76.1	77.4	80.2	69.8	82.2	79.0	75.6	72.2	88.6	136.0
OVERALL	107.7	108.9	109.6	108.8	104.5	105.0	102.2	103.0	103.6	105.4	106.8	107.3	108.6	105.7	101.6	99.4	106.7	154.1
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	85.2	95.8	101.3	103.4	103.8	102.6	100.9	102.5	103.0	105.0	105.6	105.0	105.0	100.5	93.4	86.2		
152.4 M	80.6	91.9	97.7	99.9	97.4	99.3	97.7	99.3	99.8	101.8	102.4	101.8	101.8	97.1	89.9	82.5		
304.8 M	68.3	81.4	88.2	90.6	88.3	90.5	89.2	90.8	91.6	93.3	93.9	93.6	93.2	88.2	80.5	72.1		

TABLE IV. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(c) 90 Percent speed; fan physical speed, 2373 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																		
50	77.3	74.3	75.3	76.1	71.3	75.1	74.5	76.9	76.3	76.3	78.1	76.4	79.1	80.9	82.9	83.6	77.8	125.2
63	75.8	75.3	74.7	74.3	70.7	73.3	74.0	74.3	74.8	76.2	76.8	76.9	80.7	82.2	84.5	85.4	78.2	125.6
80	79.5	79.3	77.3	75.1	70.3	75.0	74.8	74.0	75.5	77.3	79.1	79.7	82.6	84.5	86.0	86.7	79.9	127.3
100	84.8	83.3	82.8	81.5	77.3	80.3	78.4	79.6	80.8	81.3	82.9	83.2	85.3	86.6	87.8	86.8	83.0	130.4
125	87.2	89.8	89.2	86.3	82.2	84.5	82.2	83.2	82.5	83.8	85.0	84.8	85.7	86.8	86.5	84.6	85.2	132.6
160	87.5	87.5	86.5	84.7	79.9	82.5	80.5	82.2	81.4	83.2	83.2	84.0	83.4	83.5	84.0	82.9	83.4	130.8
200	89.3	88.8	86.3	83.5	78.3	80.0	78.8	79.5	79.6	80.8	82.0	83.0	84.6	84.8	84.3	82.2	82.9	130.3
250	91.2	91.5	85.4	87.4	83.0	84.4	82.7	82.7	83.7	85.4	86.0	87.6	87.9	86.7	84.5	83.1	86.2	133.6
315	92.0	91.7	90.6	89.0	84.2	86.3	84.8	84.3	85.5	86.8	87.7	88.1	89.0	87.7	85.5	83.1	87.4	134.8
400	94.1	93.2	92.7	89.6	85.9	87.6	86.2	86.7	87.7	89.6	91.2	91.5	90.9	89.2	85.7	84.4	89.6	137.0
500	94.5	95.1	94.1	91.9	87.1	88.1	88.1	87.9	89.4	91.1	92.6	92.7	92.6	89.7	86.6	84.8	91.0	138.4
630	94.5	94.8	95.8	94.0	89.5	90.5	89.3	89.7	91.7	93.2	93.5	93.9	94.5	91.0	88.2	86.5	92.5	139.9
800	95.4	95.8	95.9	94.4	90.1	91.9	91.4	92.3	93.4	94.9	96.1	97.0	97.6	93.8	90.6	89.2	94.5	141.9
1000	97.3	98.7	96.5	98.0	95.2	97.2	97.0	94.5	95.7	96.5	98.2	98.9	99.0	95.5	92.0	91.6	97.2	144.6
1250	104.1	106.8	105.6	106.8	105.1	107.1	107.6	101.8	101.6	101.8	104.5	103.6	104.1	101.3	96.6	97.9	104.7	152.1
1600	97.8	98.3	96.6	97.4	93.6	94.4	93.3	93.9	95.8	97.1	99.3	99.7	100.4	95.9	92.8	91.3	97.2	144.6
2000	98.5	100.2	101.5	99.4	95.0	95.7	94.2	94.5	96.2	98.2	99.7	100.5	100.9	96.7	92.4	91.1	98.3	145.7
2500	101.1	103.1	104.1	102.8	98.8	99.6	97.1	97.4	98.1	99.2	100.1	101.5	102.1	97.7	93.9	92.3	100.4	147.8
3150	99.8	101.3	101.4	100.4	96.1	97.1	94.6	95.6	96.3	98.8	99.8	100.1	100.6	96.3	92.3	90.2	98.9	146.3
4000	99.0	100.0	99.6	101.0	95.5	96.6	93.3	93.8	94.3	97.6	98.9	98.1	98.9	95.8	91.3	89.1	98.0	145.4
5000	96.8	98.6	99.0	98.5	93.1	94.1	91.8	91.5	92.8	94.1	96.5	95.8	97.5	93.0	89.5	86.8	96.2	143.6
6300	99.5	97.2	97.4	97.9	91.5	93.1	90.4	89.3	91.1	93.4	95.4	93.3	96.6	92.9	88.7	86.3	95.5	142.9
8000	94.7	96.6	96.9	95.5	89.5	91.7	89.1	88.1	90.1	91.9	93.6	91.1	95.6	90.7	87.2	84.6	94.7	142.1
10000	97.7	94.9	94.3	94.2	87.0	89.5	87.2	85.3	87.2	88.5	91.5	87.4	92.7	88.7	85.0	82.1	93.3	140.7
12500	91.6	94.6	93.5	93.3	86.1	88.6	86.0	84.5	87.3	88.3	90.8	85.3	92.0	88.5	85.0	82.1	94.0	141.4
16000	88.8	90.9	89.9	90.1	82.6	85.4	82.9	81.1	83.9	84.9	87.4	79.5	89.3	85.3	82.3	79.0	92.6	140.0
20000	86.5	88.4	86.7	86.4	78.7	82.0	79.7	77.7	80.9	81.7	84.0	73.9	85.7	82.2	79.4	76.4	92.0	139.4
OVERALL	110.3	112.0	111.5	111.6	108.2	109.8	109.4	106.4	107.1	108.5	110.2	110.2	111.0	107.4	103.8	103.0	110.0	157.4
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	87.7	99.1	104.3	106.2	104.0	106.7	106.8	105.7	106.7	108.1	108.9	108.5	107.9	102.2	95.8	89.7		
152.4 M	83.4	95.1	100.6	102.8	100.7	103.6	103.8	102.5	103.6	104.9	105.7	105.3	104.7	98.9	92.3	86.1		
304.8 M	71.6	84.5	90.7	93.4	92.4	95.6	96.0	94.3	95.3	96.6	97.2	96.8	95.8	89.7	82.5	76.5		

TABLE IV. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(d) 95 Percent speed; fan physical speed, 2505 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	79.3	86.3	78.7	78.8	74.2	78.5	78.0	78.5	79.3	80.0	80.0	79.3	81.8	83.3	85.5	87.1	81.0	128.4
63	77.5	85.2	77.2	77.2	73.7	76.8	76.3	76.8	76.7	76.0	79.7	80.6	82.8	84.5	87.0	88.6	81.1	128.5
80	81.8	86.3	81.3	79.5	73.3	76.5	76.8	76.6	78.5	80.5	82.1	82.6	85.5	87.0	88.6	89.5	82.9	130.3
100	86.5	87.8	84.5	84.0	80.0	82.7	81.0	82.3	83.3	84.2	85.3	86.3	87.7	89.0	90.3	89.6	85.6	133.0
125	89.5	90.8	90.3	87.3	84.0	86.8	83.8	85.3	84.3	86.2	87.0	86.7	88.6	88.7	89.5	87.7	87.1	134.5
160	88.7	89.5	87.7	86.0	81.0	84.2	83.0	83.7	83.0	84.3	85.2	86.1	85.5	86.2	86.5	85.9	85.2	132.6
200	91.0	90.7	88.3	86.2	79.8	82.2	81.3	81.3	82.2	82.8	84.5	85.6	86.7	86.3	86.8	85.6	85.1	132.5
250	92.5	92.2	91.0	88.2	84.6	86.7	84.5	84.7	85.7	86.8	88.7	90.1	89.3	87.8	86.7	85.6	87.9	135.3
315	93.9	93.0	91.4	90.5	85.2	86.7	85.9	85.7	86.7	87.7	88.9	89.8	90.2	88.7	87.0	84.9	88.6	136.0
400	94.8	93.8	93.5	91.2	86.3	89.3	88.0	88.3	89.5	91.0	92.0	92.9	92.0	90.6	87.8	86.5	90.9	138.3
500	95.2	94.9	94.5	93.5	88.0	90.0	89.0	89.9	91.0	92.9	94.0	94.8	94.0	91.7	88.7	87.1	92.4	139.8
630	94.9	95.1	96.4	94.6	89.6	90.9	90.1	91.6	93.4	95.1	95.2	96.3	96.2	92.4	89.1	88.1	93.9	141.3
800	96.1	96.3	97.1	96.3	90.8	93.0	92.5	94.3	95.3	97.0	97.8	99.4	99.3	95.1	92.1	90.7	96.2	143.6
1000	97.4	97.6	98.8	98.6	94.4	94.9	94.3	95.6	96.1	97.6	99.1	100.8	100.1	95.8	93.4	91.5	97.6	145.0
1250	105.5	106.0	105.3	110.3	108.2	106.3	104.8	103.8	102.5	104.0	105.2	106.6	106.5	102.3	99.3	97.6	106.1	153.5
1600	98.9	99.2	100.0	99.3	95.3	95.8	94.8	96.0	97.5	99.4	101.7	102.5	101.7	96.9	94.7	92.8	99.1	146.5
2000	99.6	100.4	101.6	100.1	95.4	96.6	94.9	96.3	97.9	99.7	101.4	102.7	101.6	97.1	94.1	92.5	99.5	146.9
2500	102.4	103.4	106.6	104.3	101.1	101.3	98.9	99.8	99.8	100.8	101.9	103.9	103.4	98.8	96.1	94.4	102.2	149.6
3150	100.7	101.4	102.0	101.5	96.7	97.7	95.8	97.0	98.0	100.4	101.7	102.1	101.7	97.2	94.5	92.1	100.2	147.6
4000	100.0	101.5	101.8	103.2	97.7	98.7	95.5	96.3	96.5	100.0	101.0	101.3	101.5	97.8	94.2	91.6	100.3	147.7
5000	97.3	100.2	100.2	99.6	94.0	95.3	92.8	93.5	94.8	96.3	98.1	98.3	99.1	94.1	92.0	88.5	97.8	145.2
6300	96.5	99.7	98.5	99.0	92.6	94.0	91.5	91.8	93.3	95.8	97.7	96.3	98.2	94.7	91.5	88.5	97.3	144.7
8000	95.3	99.3	97.5	97.0	90.8	92.8	90.2	90.1	92.1	94.1	96.0	94.0	97.3	93.1	89.8	86.7	96.5	143.9
10000	92.9	97.8	94.9	95.2	87.5	89.6	88.1	87.6	89.4	91.4	93.1	89.8	94.4	90.4	87.9	83.9	94.9	142.3
12500	92.2	97.7	93.9	94.4	87.2	88.9	87.1	86.6	89.1	90.6	92.4	87.9	93.7	89.7	87.4	83.9	95.6	143.0
16000	89.0	94.7	90.0	90.9	83.2	85.2	83.9	83.4	85.9	87.2	89.0	82.1	90.5	87.0	84.2	80.6	94.1	141.5
20000	86.5	92.8	86.8	87.1	79.6	82.2	80.5	80.2	82.3	84.0	85.5	76.4	87.3	84.0	81.0	77.1	93.7	141.1
OVERALL	111.4	112.6	113.9	113.8	110.5	109.9	108.2	108.4	108.6	110.4	111.8	112.7	112.6	108.6	106.1	104.3	111.5	158.9
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	88.9	99.7	106.1	107.8	105.9	107.7	106.5	107.8	108.4	109.9	110.8	110.9	109.4	103.5	98.1	91.6		
152.4 M	84.6	95.7	102.5	104.3	102.8	104.5	103.4	104.7	105.3	106.7	107.5	107.7	106.1	100.1	94.5	87.7		
304.8 M	72.8	85.0	92.6	95.7	94.6	95.9	95.1	96.4	97.0	98.3	99.0	99.3	97.3	90.9	84.7	77.5		

TABLE IV. - Concluded.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(e) 100 Percent speed; fan physical speed, 2636 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
							1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS											
50	84.0	83.1	80.6	79.3	75.6	81.5	80.3	85.6	85.1	84.0	82.5	81.6	83.8	85.8	87.6	89.2	83.8	131.2
63	78.7	83.9	78.5	78.0	74.2	77.5	77.4	78.5	79.0	79.0	80.7	81.1	84.9	86.7	89.4	90.6	82.7	130.1
80	81.8	85.7	81.5	78.3	74.5	77.3	77.8	78.5	79.7	81.0	83.0	83.4	86.3	89.8	91.2	91.7	84.5	131.9
100	87.2	87.7	86.2	84.7	81.7	83.4	81.7	83.6	84.6	85.4	86.4	87.1	89.4	90.4	92.7	91.6	87.0	134.4
125	90.5	94.5	92.9	89.7	86.0	88.2	85.4	88.4	85.9	86.5	88.7	88.8	90.7	90.7	90.7	89.6	89.3	136.7
160	89.8	90.5	90.0	87.0	83.2	85.5	83.8	85.7	85.2	86.3	86.7	87.4	87.2	87.8	88.2	87.2	86.8	134.2
200	91.5	91.0	89.9	86.7	82.0	83.7	82.7	83.5	83.9	84.0	86.0	86.8	88.5	88.9	88.4	87.2	86.5	133.9
250	93.6	93.1	92.2	89.7	85.7	87.4	85.7	85.9	86.7	88.7	89.9	91.3	90.9	89.6	88.4	87.6	89.2	136.6
315	94.3	93.3	92.5	91.5	86.3	88.5	87.7	86.8	87.8	89.2	90.2	91.3	91.8	90.8	88.5	86.7	89.9	137.3
400	95.9	94.4	95.5	92.8	88.3	89.3	85.4	88.8	89.9	92.1	93.1	93.9	93.9	91.6	89.3	88.2	92.0	139.4
500	96.7	95.7	96.7	94.4	90.0	91.4	91.4	91.2	92.2	94.4	95.2	95.0	94.9	92.7	90.0	88.8	93.6	141.0
630	97.0	95.8	97.2	96.0	90.5	92.3	92.2	92.0	94.2	96.2	96.0	96.8	96.8	92.8	90.8	89.4	94.8	142.2
800	97.5	96.8	98.0	97.0	92.0	93.8	94.1	95.3	96.6	98.0	98.3	99.4	99.1	95.6	92.6	91.9	96.8	144.2
1000	98.0	97.4	99.0	98.0	94.0	95.1	95.3	97.1	97.6	99.4	99.4	101.0	100.6	96.1	94.3	92.7	98.2	145.6
1250	108.8	106.8	109.3	109.6	106.0	107.5	106.5	104.7	104.7	105.0	106.2	107.3	107.3	102.5	100.8	98.6	106.6	154.0
1600	101.0	100.2	101.8	101.2	97.3	98.7	98.0	98.3	99.7	101.2	102.3	103.4	102.7	98.2	95.7	94.6	100.6	148.0
2000	99.6	99.6	101.6	99.9	95.4	96.9	96.4	97.4	99.2	100.9	102.2	103.5	102.4	97.7	94.9	93.3	100.2	147.6
2500	103.3	103.0	106.2	105.8	100.3	101.8	101.0	100.7	101.7	102.8	103.3	104.6	104.7	99.0	96.0	94.7	103.1	150.5
3150	101.1	100.6	102.7	101.4	96.7	97.9	97.4	98.8	99.9	102.3	102.8	103.1	102.9	98.3	94.9	93.0	101.2	148.6
4000	100.9	100.4	101.4	103.9	96.6	98.6	96.3	97.1	96.3	101.4	102.1	101.9	102.1	98.3	93.9	92.7	100.9	148.3
5000	98.0	98.8	99.6	99.6	93.6	95.8	94.5	94.8	96.8	98.0	99.8	98.8	100.5	95.5	92.3	89.8	98.6	146.0
6300	97.0	98.5	98.8	99.1	91.9	94.3	92.8	93.4	95.3	97.5	99.6	97.6	99.8	95.6	91.6	89.7	98.3	145.7
8000	95.7	97.5	97.0	97.0	90.4	93.2	91.5	91.5	94.0	96.0	97.7	94.9	98.7	93.9	90.0	88.1	97.3	144.7
10000	93.2	95.8	94.6	95.3	87.4	90.2	85.2	86.9	91.4	92.9	95.6	91.0	96.1	91.8	88.4	85.9	95.8	143.2
12500	92.0	95.8	93.3	94.1	86.5	89.0	86.0	87.8	91.3	92.5	94.3	88.7	95.3	91.2	87.8	85.5	96.3	143.7
16000	88.8	93.3	89.4	90.3	82.8	85.5	85.0	84.6	88.0	88.6	91.0	83.3	92.3	88.0	84.5	82.2	94.8	142.2
20000	86.4	91.0	85.8	86.3	78.8	82.1	81.8	81.3	84.4	85.3	87.4	77.3	68.9	85.3	81.8	79.4	94.2	141.6
OVERALL	113.0	112.4	114.0	114.0	109.2	110.8	105.9	109.5	110.5	111.9	112.9	113.4	113.6	109.3	107.0	105.6	112.3	159.7
DISTANCE							SIDELINE PERCEIVED NOISE LEVELS											
114.3 M	91.0	99.5	106.3	108.7	105.4	108.4	106.4	109.0	110.2	111.6	111.9	111.7	110.6	104.2	98.6	92.5		
152.4 M	86.7	95.5	102.7	105.3	102.1	105.2	105.2	105.9	107.1	108.4	108.7	108.5	107.3	100.8	95.1	88.6		
304.8 M	74.9	85.4	92.8	96.0	93.6	96.8	96.9	97.6	98.8	100.1	100.2	100.0	98.4	91.6	85.9	78.8		

TABLE V. - ACOUSTIC DATA FOR STOL QF-8 FAN WITH 110 PERCENT-OF-DESIGN-AREA NOZZLE

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(a) 70 Percent speed; fan physical speed, 1803 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	74.4	70.9	70.0	60.9	66.5	69.2	70.7	71.7	71.5	72.2	71.4	70.6	73.5	73.7	75.7	76.6	71.8	119.2
63	79.7	73.2	69.9	62.5	68.5	70.9	70.5	72.0	69.5	71.7	71.5	71.5	75.0	75.2	76.7	77.6	72.7	120.1
80	72.7	72.9	70.7	63.7	65.4	67.4	66.7	68.7	69.6	70.4	71.9	73.5	76.1	76.7	78.6	79.0	72.8	120.2
100	75.7	79.9	78.4	72.4	71.2	75.6	73.9	73.7	75.2	75.7	76.2	77.2	79.4	79.4	80.4	80.0	76.9	124.3
125	82.4	83.7	81.9	78.4	75.7	78.4	77.4	76.9	77.7	77.4	76.4	79.0	80.0	80.4	80.5	79.1	79.0	126.4
160	81.7	81.4	78.9	76.2	73.2	74.9	75.1	75.2	76.2	75.9	76.4	76.1	78.4	77.4	78.4	77.6	77.0	124.4
200	83.1	83.6	80.1	77.8	72.8	73.3	73.1	73.6	74.1	74.3	75.8	76.9	79.1	78.6	78.1	76.8	77.0	124.4
250	84.2	84.4	81.9	82.1	76.4	78.2	76.9	76.9	78.2	79.2	79.7	81.7	82.2	81.4	79.7	77.0	80.1	127.5
315	87.7	86.7	84.2	83.9	77.2	78.9	78.6	78.6	79.4	80.4	81.7	82.8	83.4	82.7	80.4	78.1	81.7	129.1
400	88.5	87.3	86.5	86.0	79.8	80.8	79.8	80.8	81.8	83.2	85.2	86.6	86.2	84.3	81.3	78.7	84.1	131.5
500	88.3	88.4	87.3	88.3	81.8	81.9	81.1	81.8	83.3	84.9	86.4	87.2	86.9	86.1	82.4	79.7	85.3	132.7
630	89.1	89.9	88.8	85.4	82.9	83.3	82.6	83.8	84.8	86.9	88.3	88.7	89.1	88.1	82.8	80.5	86.9	134.3
800	96.5	95.3	95.2	97.2	89.2	88.0	87.2	88.0	89.5	91.2	91.5	93.1	94.7	93.5	89.0	86.7	92.3	139.7
1000	96.8	96.3	95.6	97.4	89.6	89.3	86.6	89.6	89.6	91.8	92.6	94.5	97.3	94.8	90.6	88.5	93.4	140.8
1250	93.1	93.8	93.1	93.8	85.6	85.6	84.6	86.6	88.8	90.3	91.9	93.2	94.8	91.9	87.8	85.3	91.1	138.5
1600	95.3	95.2	95.3	96.7	90.0	88.5	86.5	87.7	89.8	91.5	93.2	95.1	97.0	94.0	90.0	86.4	93.1	140.5
2000	96.1	96.9	96.9	97.7	91.6	89.7	87.4	88.7	90.1	91.2	93.6	96.0	97.9	95.7	91.2	86.6	94.2	141.6
2500	95.3	95.6	96.0	97.0	90.1	89.1	86.6	88.0	89.5	89.8	91.8	94.2	95.5	93.3	88.3	83.7	92.8	140.2
3150	94.8	94.6	94.6	96.3	89.3	89.1	86.3	87.1	86.4	89.4	92.1	93.1	94.6	92.8	88.4	84.0	92.3	139.7
4000	93.2	93.0	92.7	94.3	87.5	87.2	84.0	84.6	85.8	88.7	89.6	90.1	92.5	91.3	87.0	82.9	90.5	137.9
5000	91.9	92.0	91.5	92.7	86.4	86.4	82.4	83.0	85.4	87.2	88.2	88.5	91.7	89.0	85.9	81.2	89.5	136.9
6300	91.8	91.6	91.1	91.4	85.2	85.4	81.6	81.6	83.6	85.2	87.4	86.5	90.2	87.9	84.1	81.1	88.8	136.2
8000	90.8	91.3	89.8	89.7	83.8	85.4	81.1	81.1	82.6	84.1	85.9	83.9	86.3	85.9	83.1	78.9	88.1	135.5
10000	89.1	89.3	88.1	86.3	82.0	83.5	79.5	78.5	80.1	81.3	84.1	80.0	85.8	83.5	81.0	77.3	86.8	134.2
12500	86.9	89.0	87.0	84.4	81.9	82.7	78.5	77.7	79.5	80.7	82.9	78.1	85.5	82.7	80.5	77.1	87.4	134.8
16000	85.2	85.4	82.9	78.8	78.4	79.5	75.2	74.4	76.0	79.6	80.2	72.8	82.4	79.7	77.4	74.6	85.9	133.3
20000	81.5	82.0	79.0	71.9	74.2	75.5	71.5	70.7	72.7	77.0	76.7	67.5	79.4	76.7	74.9	72.2	85.1	132.5
OVERALL	105.7	105.7	105.3	106.3	99.6	99.1	97.0	97.9	99.3	100.6	102.4	103.8	105.7	103.6	99.6	96.5	103.1	150.5
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	83.0	92.7	97.2	101.0	96.3	97.4	95.9	97.3	96.9	99.9	101.4	101.8	102.4	98.4	91.6	83.2		
152.4 M	78.4	88.9	93.6	97.6	93.0	94.1	92.7	94.2	95.8	96.7	98.2	98.7	99.2	95.1	88.1	79.5		
304.8 M	66.3	78.4	84.0	86.4	84.4	85.2	84.2	85.9	87.6	88.5	89.8	90.5	90.7	86.3	78.7	69.1		

TABLE V. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(b) 80 Percent speed; fan physical speed, 2060 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	76.0	72.2	73.3	64.5	70.0	72.7	73.5	74.3	75.0	75.5	75.3	75.1	77.0	78.5	81.2	81.2	75.7	123.1
63	80.1	75.1	72.3	65.6	70.5	75.0	74.1	74.3	76.0	75.8	73.6	75.4	78.6	79.1	82.5	82.5	76.6	124.0
80	78.0	76.8	74.8	66.8	69.2	71.8	71.3	73.0	73.8	75.7	76.2	77.4	80.7	81.3	83.8	84.2	77.5	124.9
100	82.9	81.9	81.3	76.3	75.6	79.8	76.9	78.1	78.6	80.1	80.4	81.5	83.3	83.8	85.3	84.5	80.9	123.3
125	84.9	86.4	86.4	82.6	79.4	82.3	80.1	80.8	80.6	81.8	82.6	83.2	83.6	84.1	84.8	83.0	82.8	130.2
160	84.6	84.3	83.0	80.6	77.0	79.5	79.0	79.3	79.3	80.6	80.5	82.2	81.6	81.3	81.8	81.2	80.8	128.2
200	86.4	87.0	84.6	81.7	77.5	78.0	77.4	77.4	77.4	78.4	79.4	80.8	82.2	81.7	82.0	80.7	80.7	128.1
250	87.5	87.6	87.1	88.3	83.6	84.6	83.0	80.5	81.5	82.3	83.6	86.6	86.0	84.6	82.1	80.5	84.6	132.0
315	90.2	89.7	87.3	87.8	81.7	83.3	81.8	81.5	82.3	83.8	85.3	86.9	87.0	85.3	83.0	80.6	85.1	132.5
400	91.6	90.3	90.4	89.1	83.8	84.6	83.6	83.6	85.1	86.6	88.8	91.0	89.4	87.3	83.9	82.1	87.6	135.0
500	91.1	91.3	91.8	92.1	85.8	86.8	84.8	85.3	86.1	88.5	90.0	91.2	91.0	87.6	84.0	82.2	88.9	136.3
630	91.2	92.7	93.2	93.5	86.0	88.3	86.7	87.0	88.3	90.8	92.2	93.1	93.2	89.3	85.0	83.1	90.7	138.1
800	93.1	94.3	93.9	95.0	88.5	90.1	86.9	89.3	90.9	93.3	93.8	95.4	95.3	91.8	86.9	85.5	92.6	140.0
1000	100.1	100.7	101.7	104.9	96.2	98.6	95.2	95.4	96.1	97.4	98.6	100.3	104.2	98.4	93.4	92.0	99.7	147.1
1250	95.9	96.9	96.4	97.6	91.1	91.6	89.9	91.2	93.2	94.4	96.1	97.7	98.4	93.9	90.4	88.5	95.0	142.4
1600	96.2	96.7	97.1	98.7	92.6	92.6	89.7	91.2	93.6	95.6	96.9	98.7	99.2	94.7	91.1	88.5	95.8	143.2
2000	98.7	100.5	100.8	102.2	95.8	95.8	93.0	93.7	95.0	96.5	97.7	100.6	101.0	97.5	92.5	88.7	98.2	145.6
2500	97.1	98.5	98.8	100.1	93.8	93.8	91.0	91.8	93.6	94.5	95.5	97.9	97.8	94.3	90.0	86.2	96.0	143.4
3150	98.3	98.6	98.6	101.1	94.3	95.3	92.1	92.1	93.6	94.9	96.6	97.9	98.3	95.8	91.1	87.4	96.8	144.2
4000	96.2	96.4	96.6	98.4	91.7	92.9	89.2	89.1	91.1	93.6	94.2	95.2	95.7	93.2	88.6	86.0	94.6	142.0
5000	95.1	95.8	95.4	96.8	91.1	92.1	87.8	87.8	89.8	92.3	92.4	92.9	95.1	91.8	87.9	83.7	93.6	141.0
6300	94.7	94.8	94.7	95.1	90.0	91.0	87.2	86.7	89.0	90.1	92.2	91.1	93.6	90.8	86.3	84.0	92.9	140.3
8000	93.7	94.9	93.7	94.1	88.7	90.7	86.4	85.7	87.6	89.6	91.2	88.9	92.2	89.1	85.7	82.4	92.5	139.9
10000	91.9	92.7	91.9	90.7	87.0	88.5	84.2	83.5	85.4	87.0	89.0	85.3	89.7	86.7	83.2	80.5	91.1	138.5
12500	91.6	92.8	90.4	88.7	86.4	87.9	83.4	82.6	84.8	86.3	87.9	83.0	88.9	86.1	83.1	80.6	91.6	139.0
16000	88.6	88.9	86.7	82.8	82.9	84.4	80.4	79.4	81.6	84.8	85.1	77.7	86.3	82.9	79.9	78.0	90.2	137.6
20000	84.6	85.9	82.7	76.3	78.9	80.4	76.6	75.2	78.3	82.7	81.9	72.2	83.1	79.8	77.4	75.6	89.5	136.9
OVERALL	108.0	106.8	108.9	110.5	104.3	104.9	101.9	102.3	103.8	105.4	106.7	108.2	109.5	105.6	101.6	99.3	107.1	154.5
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	85.4	95.9	100.7	105.1	100.8	103.1	101.1	101.7	103.4	104.8	105.7	106.3	105.7	100.5	93.4	85.8		
152.4 M	80.8	92.1	97.2	101.6	97.4	99.8	97.6	98.6	100.3	101.6	102.4	103.2	102.5	97.1	89.9	82.1		
304.8 M	68.5	81.5	87.7	92.5	88.7	90.9	89.2	90.3	91.9	93.3	93.9	95.0	94.0	88.2	80.6	71.8		

TABLE V. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(c) 90 Percent speed; fan physical speed, 2318 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	78.4	74.7	75.7	68.1	73.4	76.7	77.9	77.6	78.9	79.1	78.9	78.7	81.1	81.6	84.7	85.8	79.4	126.8
63	77.7	76.9	75.6	68.7	72.7	74.9	76.4	76.4	77.2	78.1	78.1	79.2	82.9	84.1	86.7	87.1	80.1	127.5
80	81.1	83.9	80.1	71.9	72.6	77.1	79.6	78.1	77.9	79.6	81.4	81.8	85.3	86.6	89.3	88.5	82.5	129.9
100	85.9	84.7	84.4	79.1	78.9	81.6	80.6	81.6	82.4	85.2	84.4	85.3	86.7	88.1	89.6	89.4	84.6	132.0
125	88.2	89.9	89.5	84.7	85.0	85.4	83.4	84.5	83.5	85.5	86.0	86.1	87.5	87.9	88.4	87.1	86.2	133.6
160	87.8	87.5	86.6	84.0	80.5	83.1	82.5	83.5	82.6	84.5	84.1	85.6	85.5	85.5	86.3	84.9	84.5	131.9
200	85.9	85.8	86.9	84.3	78.9	81.1	80.4	81.1	81.1	82.4	82.9	84.2	85.6	85.9	86.6	84.7	84.1	131.5
250	91.0	90.8	89.6	89.1	84.3	85.6	84.8	84.0	84.6	86.0	87.3	86.2	89.1	88.1	86.1	85.0	87.1	134.5
315	93.5	93.0	91.3	92.3	86.1	88.5	86.3	85.5	86.0	86.6	87.6	88.7	90.0	89.0	87.1	84.9	88.6	136.0
400	94.6	93.8	93.1	92.9	86.4	88.1	87.3	87.3	87.9	89.6	91.1	92.4	91.9	90.3	87.9	85.7	90.4	137.8
500	94.3	94.8	94.4	94.8	87.4	88.9	87.9	87.9	90.1	91.4	93.4	94.0	93.9	91.4	87.9	85.5	91.9	139.3
630	93.9	95.0	95.9	96.4	89.5	90.5	89.9	89.7	91.7	93.7	94.5	95.0	95.4	91.7	88.7	86.3	93.2	140.6
800	96.1	96.8	96.4	98.4	90.6	92.4	92.4	92.6	94.8	95.9	96.6	97.9	97.6	93.9	90.6	87.8	95.4	142.8
1000	98.6	99.6	99.6	102.6	97.6	99.1	95.9	96.1	96.3	97.8	98.9	100.2	100.6	96.9	93.6	90.7	98.7	146.1
1250	103.2	104.0	104.5	108.7	104.2	106.0	101.5	100.9	99.5	102.0	102.9	104.5	106.2	103.0	97.9	95.6	104.0	151.4
1600	98.4	98.7	98.7	100.5	93.7	94.2	93.5	94.7	96.9	98.4	100.2	101.2	101.7	96.4	93.9	91.3	98.3	145.7
2000	99.3	100.8	101.4	102.6	96.1	96.3	94.9	95.9	97.8	98.4	100.3	101.9	101.4	97.1	93.9	90.3	99.3	146.7
2500	101.0	103.0	104.4	105.5	99.2	99.7	97.7	97.9	98.9	98.2	100.2	102.1	102.2	98.9	94.5	90.3	101.0	148.4
3150	100.0	100.7	100.9	103.4	96.0	97.2	95.7	96.2	97.4	97.7	100.4	100.3	100.5	97.5	93.7	89.8	99.4	146.8
4000	98.3	98.9	98.1	100.9	93.6	95.1	93.3	93.8	95.1	96.9	98.1	98.1	98.4	95.8	92.3	88.9	97.5	144.9
5000	97.1	96.2	97.7	99.5	93.4	94.7	92.0	92.5	94.4	96.0	96.9	96.0	98.1	94.7	91.4	87.2	96.8	144.2
6300	96.7	97.2	96.9	96.3	91.9	93.1	91.6	90.9	93.4	94.2	96.4	94.6	97.1	93.9	90.4	87.5	96.2	143.6
8000	95.8	97.1	95.5	96.1	90.8	92.6	90.4	90.3	92.4	93.3	95.3	92.3	95.6	92.6	89.9	85.8	95.6	143.0
10000	94.7	95.0	94.0	92.8	88.7	90.5	88.2	88.2	90.3	91.3	93.3	88.5	93.0	90.3	87.7	84.3	94.3	141.7
12500	93.7	94.9	92.6	90.8	88.3	90.3	87.9	87.1	89.9	90.6	92.3	86.2	92.6	89.9	86.9	84.6	94.9	142.3
16000	90.4	91.2	88.9	84.8	84.6	86.6	84.6	83.7	86.4	89.4	89.4	81.2	89.6	87.2	84.1	82.0	93.6	141.0
20000	86.6	88.1	84.7	76.0	80.6	82.7	80.6	79.9	82.9	86.9	85.9	75.8	86.7	83.9	81.4	79.3	92.9	140.3
OVERALL	110.5	111.4	111.5	113.7	108.1	109.5	106.7	106.7	107.6	108.8	110.3	111.1	111.9	108.6	105.2	102.6	110.4	157.7
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	87.9	99.0	104.3	108.5	104.3	106.6	105.6	106.3	107.6	107.9	109.4	109.2	108.4	103.4	97.0	89.0		
152.4 M	83.3	95.0	100.7	105.1	101.0	103.4	102.5	103.2	104.5	104.8	106.2	106.1	105.2	100.0	93.4	85.3		
304.8 M	71.4	83.9	90.8	95.9	92.2	95.3	94.0	94.9	96.2	96.4	97.5	97.6	96.4	90.8	83.7	75.7		

TABLE V. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(d) 95 Percent speed; fan physical speed, 2446 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	80.9	77.6	79.1	69.9	76.9	78.8	79.8	80.1	81.3	81.8	82.1	81.7	84.4	85.6	87.8	89.6	82.5	129.9
63	79.2	79.2	78.5	70.0	74.0	77.0	77.5	78.4	79.9	80.4	80.9	81.5	85.0	86.7	88.7	90.4	82.5	129.9
80	88.6	85.7	83.1	76.4	75.6	79.2	79.4	80.1	81.1	83.2	83.7	84.5	87.4	89.1	91.6	92.8	85.2	132.6
100	87.9	86.0	85.4	80.5	80.4	82.9	82.5	84.2	84.5	86.0	86.5	87.6	89.4	90.7	93.0	92.3	87.1	134.5
125	90.4	92.2	91.7	88.9	85.1	86.6	85.4	87.1	88.1	87.7	88.1	88.8	90.2	90.6	91.7	89.6	88.6	136.0
160	88.1	88.9	87.7	84.4	82.7	85.1	84.7	86.1	85.6	86.2	86.2	87.7	87.2	87.9	89.1	87.8	86.5	133.9
200	90.9	91.4	87.6	85.2	80.9	82.7	82.2	82.6	83.7	84.1	84.6	85.8	87.6	87.9	89.1	87.3	85.8	133.2
250	91.3	92.1	89.5	85.3	84.1	85.3	84.6	84.8	85.6	86.8	87.6	88.9	89.8	89.1	89.5	86.9	87.8	135.2
315	93.3	93.6	92.0	92.1	86.1	86.6	86.0	86.3	87.5	88.0	88.3	89.7	89.8	89.8	88.3	86.7	89.0	136.4
400	94.7	94.2	93.6	93.1	86.2	88.4	87.9	88.1	89.4	90.1	91.2	92.2	91.6	90.9	89.2	87.5	90.8	138.2
500	94.2	94.7	93.7	94.4	86.2	88.9	89.1	89.2	90.9	91.9	92.4	93.3	92.6	91.4	89.2	87.3	91.7	139.1
630	93.8	94.3	95.0	95.3	89.3	89.6	89.6	90.1	92.5	93.8	94.0	95.1	95.3	92.0	89.5	87.7	93.0	140.4
800	95.1	96.2	96.1	97.1	90.9	91.7	91.9	93.2	94.9	95.9	96.4	97.8	97.2	93.6	90.4	88.6	95.1	142.5
1000	97.2	98.1	97.9	99.2	92.9	94.4	94.6	94.7	96.2	96.9	96.2	99.7	99.1	95.1	92.6	90.3	97.0	144.4
1250	103.8	105.3	106.8	109.0	102.3	105.2	105.3	101.8	102.5	103.0	104.2	106.0	106.2	102.8	98.7	95.2	104.8	152.2
1600	98.0	98.5	98.5	99.7	93.2	94.2	93.5	94.9	97.7	98.4	100.4	102.2	101.4	96.0	94.7	92.3	98.4	145.8
2000	98.7	99.7	99.7	100.7	94.9	95.1	94.4	95.9	98.0	98.5	100.2	102.8	102.0	97.0	94.2	91.1	99.1	146.5
2500	101.0	102.4	103.9	104.9	99.2	100.0	97.4	98.2	100.4	99.2	101.2	103.1	103.0	99.0	95.4	91.8	101.3	148.7
3150	99.6	99.8	99.8	101.1	95.0	95.6	95.0	96.1	98.0	96.0	100.8	101.6	101.0	97.3	94.5	90.7	99.2	146.6
4000	98.4	99.0	99.0	101.2	94.7	95.0	94.2	94.5	96.9	98.5	99.4	99.5	99.9	96.5	93.2	90.2	98.5	145.9
5000	96.7	98.0	98.2	98.8	93.7	94.5	92.0	93.3	95.7	97.2	97.8	97.5	99.2	95.2	92.5	88.5	97.4	144.8
6300	98.6	96.9	96.8	97.4	92.0	93.1	91.4	91.8	95.1	95.4	97.6	96.0	97.9	94.6	91.6	88.9	96.8	144.2
8000	95.5	96.5	95.8	96.0	90.6	92.6	90.5	91.6	94.1	95.0	96.3	94.0	97.0	93.8	91.1	87.6	96.4	143.8
10000	93.8	94.6	93.8	92.3	88.6	90.6	88.8	85.3	91.9	92.6	94.4	90.1	94.3	91.1	89.1	85.9	95.0	142.4
12500	93.0	94.2	92.2	90.1	87.7	89.9	87.9	88.5	91.4	92.2	93.4	88.1	93.7	90.5	88.5	85.5	95.5	142.9
16000	89.6	90.2	88.2	84.3	84.2	86.2	84.4	85.2	87.7	91.1	90.8	82.8	91.1	87.8	85.8	83.5	94.4	141.8
20000	85.7	87.1	84.6	77.4	80.2	82.7	81.1	81.2	84.2	88.6	87.2	77.2	87.6	84.7	82.9	81.0	93.7	141.1
OVERALL	110.4	111.3	111.8	113.1	107.0	106.7	106.1	107.2	108.9	109.5	111.0	112.1	112.2	108.7	106.3	104.0	110.7	158.1
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	87.9	98.7	104.1	107.6	104.1	106.4	106.1	106.8	109.0	108.8	110.0	110.3	109.1	103.6	98.1	90.4		
152.4 M	83.5	94.7	100.5	104.4	100.8	103.2	103.0	103.7	105.8	105.6	106.7	107.1	105.8	100.2	94.5	86.6		
304.8 M	71.7	84.3	90.6	95.2	92.0	94.6	95.2	95.4	97.5	97.3	96.2	98.6	96.9	91.0	84.8	76.6		

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(e) 100 Percent speed; fan physical speed, 2574 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	81.9	79.7	80.9	71.6	78.4	81.6	81.1	82.1	83.2	83.4	83.7	83.3	86.1	87.1	89.4	90.6	84.1	131.5
63	80.0	80.8	79.3	71.0	77.0	79.5	79.3	78.8	80.3	82.0	82.8	83.6	87.2	88.5	91.2	91.6	84.3	131.7
80	88.3	85.3	83.5	75.3	77.0	80.0	79.5	81.0	82.8	83.2	84.8	86.6	89.3	89.8	93.5	93.4	86.4	133.8
100	88.0	86.9	86.5	81.7	81.4	84.2	84.2	85.0	86.2	87.4	88.0	89.3	91.0	92.5	94.7	94.4	88.7	136.1
125	91.2	93.2	91.4	87.4	86.5	87.9	87.0	86.9	87.9	89.0	89.5	90.6	91.9	91.5	93.4	91.6	89.8	137.2
160	89.3	90.6	89.6	85.6	84.8	85.6	86.3	85.6	86.9	86.6	87.8	89.0	89.4	89.8	91.1	89.3	87.9	135.3
200	91.2	92.1	89.4	86.9	82.9	83.9	83.2	83.7	84.7	85.2	86.4	87.6	89.6	89.6	91.1	89.1	87.3	134.7
250	91.8	92.1	90.1	89.5	85.5	85.8	85.3	86.3	88.8	87.5	88.1	90.4	90.8	90.1	90.3	88.3	88.6	136.0
315	93.1	93.6	91.5	91.6	88.0	87.3	86.8	87.1	88.0	89.0	89.6	91.2	91.1	90.8	90.6	87.9	89.7	137.1
400	94.5	94.0	93.0	93.7	87.5	88.7	88.2	89.0	90.0	90.8	92.0	93.1	92.5	91.8	90.3	88.0	91.3	138.7
500	94.4	93.7	93.9	94.7	88.9	90.6	90.2	90.7	91.7	93.1	93.4	94.0	93.1	92.0	90.0	87.9	92.4	139.8
630	93.8	94.2	94.7	95.2	89.8	90.7	90.5	91.3	93.0	94.2	94.7	95.1	94.5	91.7	90.2	88.1	93.2	140.6
800	95.0	95.3	95.8	96.8	90.3	91.7	92.0	93.8	95.2	96.3	96.5	97.4	96.5	92.8	90.8	88.9	95.0	142.4
1000	95.5	95.8	96.7	96.5	92.5	93.4	94.0	95.5	96.8	97.2	97.8	99.4	98.2	94.3	92.0	89.7	96.6	144.0
1250	106.6	106.0	106.3	110.0	105.8	107.0	105.8	104.0	102.3	104.0	106.2	107.3	108.5	103.8	101.8	97.6	106.3	153.7
1600	97.7	97.5	96.2	95.7	94.2	95.2	95.0	96.0	98.3	98.8	101.2	102.1	101.7	97.2	95.3	92.4	98.8	146.2
2000	97.1	97.9	98.6	99.4	93.8	94.1	94.4	96.8	98.6	99.4	101.3	102.7	101.8	97.4	94.8	91.2	99.1	146.5
2500	101.1	102.3	103.1	105.6	99.6	99.9	99.1	100.1	101.1	100.1	102.6	104.1	103.6	99.3	96.4	92.4	102.0	149.4
3150	98.2	98.7	98.7	100.5	93.8	95.0	95.0	97.5	99.5	99.5	101.8	102.6	101.8	97.8	95.5	91.3	99.8	147.2
4000	98.0	98.5	98.4	101.4	95.2	96.0	94.8	96.0	98.2	100.0	100.7	101.0	100.9	97.4	94.5	91.3	99.4	146.8
5000	95.8	96.8	97.1	96.6	93.0	94.5	92.5	95.0	97.0	98.6	99.3	98.8	100.0	96.1	93.5	89.2	98.1	145.5
6300	95.3	95.8	95.8	96.7	91.8	93.1	91.9	93.3	96.6	96.9	99.1	97.5	98.9	95.9	92.8	89.9	97.6	145.0
8000	94.2	94.9	94.4	95.0	90.2	92.1	91.1	92.9	95.6	96.4	98.1	94.9	97.5	94.4	92.2	88.9	97.0	144.4
10000	92.5	93.0	92.3	91.0	87.6	90.1	89.5	90.6	93.1	94.3	96.1	91.5	95.1	92.1	90.5	86.8	95.7	143.1
12500	91.5	92.4	90.7	88.8	86.7	89.4	88.5	90.2	92.7	94.0	95.2	88.8	94.7	91.9	89.7	86.7	96.3	143.7
16000	87.7	88.4	86.5	82.6	83.1	86.1	85.4	86.7	89.2	92.6	92.1	83.8	91.9	88.9	86.7	84.6	95.2	142.6
20000	83.7	85.0	82.2	76.2	79.0	82.0	81.7	82.5	80.4	90.0	88.9	78.6	88.9	85.7	83.9	82.1	94.7	142.1
OVERALL	110.9	110.9	111.9	113.5	108.5	109.6	108.7	108.8	109.7	110.6	112.3	112.8	113.2	109.5	107.9	105.2	111.5	158.9
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	88.9	98.3	103.5	108.1	104.5	106.7	106.8	108.4	109.8	109.8	111.1	111.2	109.7	104.2	99.2	91.3		
152.4 M	84.7	94.4	100.0	104.7	101.2	103.6	103.7	105.2	106.7	106.6	107.9	108.0	106.5	100.8	95.7	87.5		
304.8 M	73.1	84.3	90.9	95.5	92.9	95.6	95.8	96.9	98.3	98.2	99.5	99.5	97.6	91.6	86.7	78.0		

TABLE VI. - ACOUSTIC DATA FOR STOL QF-8 FAN WITH 115 PERCENT-OF-DESIGN-AREA NOZZLE

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(a) 70 Percent speed; fan physical speed, 1844 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) CN 30.5 METER RADILS																	
50	71.6	69.1	69.1	70.1	66.9	68.4	69.6	70.1	70.7	71.4	71.9	69.0	73.1	73.7	75.2	76.1	71.3	118.7
63	75.1	71.3	68.8	68.4	66.1	69.8	69.6	68.8	68.9	69.4	71.6	70.0	73.8	75.1	75.6	77.0	71.5	118.9
80	70.1	69.9	68.4	67.1	64.4	65.7	66.6	67.1	68.4	69.7	71.6	71.3	74.9	75.6	76.9	77.6	71.5	118.9
100	75.9	74.7	75.5	73.4	69.9	73.2	72.4	72.7	74.2	74.0	75.4	76.0	77.0	76.2	78.0	78.6	75.1	122.5
125	77.9	79.4	79.4	78.4	73.7	76.4	75.5	74.2	76.0	76.5	77.5	77.1	77.7	78.0	78.4	77.4	77.0	124.4
160	76.7	78.4	77.0	76.5	70.9	74.0	72.9	73.5	74.5	74.9	75.9	76.3	76.5	76.4	76.2	75.8	75.4	122.8
200	79.6	79.6	76.6	74.3	70.4	71.9	71.6	71.9	72.8	73.6	74.1	74.8	76.1	76.1	75.9	75.0	74.5	121.9
250	80.6	81.6	79.0	78.3	74.1	75.6	74.0	74.3	75.6	76.6	76.8	78.4	78.6	78.8	76.5	75.0	77.1	124.5
315	84.1	83.2	79.9	79.1	74.4	76.2	75.1	75.2	76.4	77.4	79.1	79.0	79.4	78.7	76.6	75.1	78.1	125.5
400	84.8	83.5	83.3	81.0	76.5	78.3	77.1	77.8	79.5	81.0	82.3	82.7	82.0	81.0	77.6	75.5	80.7	128.1
500	83.4	84.4	83.4	82.4	77.7	78.7	77.9	77.9	80.1	81.6	82.7	82.8	82.7	81.4	78.1	76.1	81.2	128.6
630	84.4	85.8	84.9	83.6	78.6	79.8	78.9	79.8	81.6	83.6	84.9	84.7	85.1	83.4	79.3	77.0	82.9	130.3
800	93.7	92.5	92.0	92.7	87.5	88.7	85.8	85.0	87.5	89.8	89.8	92.6	94.7	92.8	88.5	85.0	90.6	138.0
1000	99.0	97.0	96.9	98.4	93.7	94.4	91.2	90.0	91.9	94.2	93.4	96.6	100.2	97.9	93.7	90.1	95.6	143.0
1250	89.8	90.3	89.5	88.0	82.7	83.3	81.5	82.5	85.7	87.5	89.3	90.4	91.3	89.0	84.7	82.2	87.8	135.2
1600	92.4	92.5	92.7	91.5	86.4	87.5	84.4	85.0	88.4	89.7	91.7	92.6	94.7	93.0	87.2	84.4	90.7	138.1
2000	95.2	96.4	96.6	95.6	90.6	91.9	87.7	88.4	90.4	92.1	93.7	95.0	98.2	96.4	90.6	87.0	94.0	141.4
2500	92.7	93.6	94.4	92.7	86.9	88.4	85.6	85.4	87.9	90.1	91.6	93.2	95.1	93.1	87.1	83.5	91.4	138.8
3150	92.4	93.3	94.1	92.8	87.0	88.6	85.1	84.8	87.6	90.3	91.8	92.9	94.6	93.3	87.6	83.7	91.5	138.9
4000	91.0	92.2	93.0	93.4	86.4	87.5	83.4	82.7	86.7	89.0	91.4	90.8	93.2	93.2	87.5	83.3	90.8	138.2
5000	88.7	91.1	91.2	90.6	84.9	85.2	81.7	80.4	83.5	85.2	88.4	87.4	91.1	86.7	84.7	80.2	88.4	135.8
6300	87.8	88.9	88.3	90.5	83.5	83.5	80.0	77.9	82.1	83.6	86.6	84.8	89.4	87.3	82.7	78.6	87.2	134.6
8000	86.7	87.8	88.2	89.2	82.2	82.7	79.2	76.7	79.2	81.5	84.0	82.5	87.8	84.8	79.8	76.6	86.3	133.7
10000	85.2	86.9	85.9	87.2	80.5	80.4	77.2	74.4	77.9	79.2	83.0	79.2	85.0	82.7	78.5	74.8	85.3	132.7
12500	84.5	86.5	84.3	87.0	80.4	79.5	76.3	73.2	76.5	78.5	81.8	76.7	84.3	81.5	77.5	74.0	85.9	133.3
16000	82.1	82.8	80.4	83.1	78.3	76.6	72.9	69.6	72.9	75.3	78.7	71.1	80.8	77.9	74.1	70.7	84.3	131.7
20000	80.2	80.5	77.1	80.7	76.0	73.9	70.3	67.4	69.8	72.6	75.1	66.0	78.3	75.3	71.4	68.3	84.4	131.8
OVERALL	104.0	104.1	104.1	104.1	98.7	99.6	96.4	96.0	98.5	100.5	101.8	103.0	105.7	103.9	99.0	95.8	102.2	149.6
CISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	81.0	91.2	95.9	98.1	94.7	97.3	94.8	95.3	97.8	99.7	100.8	100.7	102.0	98.4	90.5	82.6		
152.4 M	76.6	87.3	92.4	94.7	91.5	94.1	91.6	92.2	94.8	96.5	97.5	97.5	98.8	95.1	87.0	78.8		
304.8 M	65.1	76.7	82.8	85.6	82.8	85.7	83.4	84.2	86.7	88.3	89.3	89.2	90.2	86.2	77.5	68.3		

TABLE VI. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(b) 80 Percent speed; fan physical speed, 2107 rpm

FREQUENCY	ANGLE, DEG																SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160		
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	74.3	71.3	73.0	73.3	69.8	71.8	73.5	73.5	74.7	75.3	74.8	74.4	76.3	78.3	79.3	80.7	75.2	122.6
63	73.8	73.7	72.5	72.8	70.3	72.5	73.8	72.8	73.5	74.5	74.3	74.9	78.3	79.2	81.0	82.2	75.8	123.2
80	74.6	74.1	72.9	71.1	69.3	71.3	71.9	72.4	73.3	74.8	75.9	76.3	79.8	80.4	82.1	82.5	76.4	123.8
100	79.6	78.5	78.1	77.8	75.6	76.0	75.6	76.8	77.8	79.1	80.0	80.0	82.0	83.5	83.6	83.3	79.6	127.0
125	81.8	83.3	83.4	82.4	76.6	79.4	77.3	78.6	79.4	80.1	81.8	81.0	81.8	82.9	83.1	81.6	80.9	128.3
160	82.1	81.5	80.8	80.1	74.5	77.1	76.3	78.1	77.8	78.8	79.5	80.1	80.0	80.5	80.6	79.7	79.1	126.5
200	83.1	83.1	80.3	78.6	74.8	75.6	75.8	76.6	75.8	77.4	78.1	78.9	80.8	80.4	80.8	79.8	78.6	126.0
250	85.0	84.8	83.5	84.0	80.0	82.0	78.1	77.8	79.0	80.1	81.5	82.2	83.6	82.0	80.6	79.5	81.5	128.9
315	86.8	86.0	84.5	84.1	78.8	80.0	78.6	78.8	79.8	80.8	82.1	82.7	83.1	82.6	80.8	79.0	81.8	129.2
400	88.1	86.7	86.2	84.9	79.2	80.9	80.6	81.4	82.4	84.2	85.2	86.3	85.1	83.7	81.1	79.4	83.9	131.3
500	86.9	87.4	86.2	85.6	80.4	80.9	80.2	81.4	82.9	84.7	86.2	86.2	85.4	83.9	80.7	79.3	84.2	131.6
630	86.6	87.6	87.6	86.6	82.1	82.8	82.0	83.0	84.1	87.0	87.6	87.2	87.3	85.5	81.8	80.0	85.6	133.0
800	89.2	89.7	89.2	88.0	82.8	83.8	83.8	84.5	86.8	89.0	90.7	90.6	90.2	88.3	84.2	82.7	88.0	135.4
1000	100.1	100.8	101.3	101.3	96.8	100.4	95.8	95.1	96.3	97.8	99.8	100.9	105.1	101.3	96.9	94.2	99.9	147.3
1250	93.4	93.6	93.9	93.3	88.4	90.6	87.8	87.8	90.1	91.6	93.8	94.5	96.3	93.1	89.1	87.0	92.4	139.8
1600	93.4	92.9	93.0	92.2	87.2	88.4	86.5	87.4	90.5	92.0	94.4	94.8	96.0	91.9	87.2	86.3	92.1	139.5
2000	97.3	98.7	99.7	98.7	93.3	95.2	92.7	92.0	93.5	95.5	97.3	99.1	101.0	97.3	92.2	89.2	97.0	144.4
2500	94.2	94.5	95.9	94.9	89.0	90.9	88.7	89.2	91.4	93.7	95.2	96.5	97.7	93.7	88.9	86.5	94.0	141.4
3150	95.8	96.5	97.7	97.3	91.7	93.8	91.2	90.5	92.7	95.0	96.5	97.3	99.0	96.0	90.5	87.9	95.8	143.2
4000	93.8	94.4	95.3	95.6	88.8	90.6	87.9	87.4	91.3	92.6	94.8	94.2	96.3	94.4	89.3	86.1	93.7	141.1
5000	91.8	93.6	93.6	93.3	88.0	89.0	86.5	86.0	88.6	90.1	93.1	92.1	94.8	91.3	87.6	84.1	92.1	139.5
6300	91.2	91.7	91.5	93.7	87.0	87.5	85.4	83.3	86.8	89.0	91.5	89.5	93.5	90.3	85.6	82.3	91.2	138.6
8000	89.9	90.7	91.4	92.5	86.0	86.7	84.2	82.0	84.0	86.8	89.2	86.9	92.2	88.0	83.2	80.4	90.3	137.7
10000	88.6	89.8	88.7	90.6	84.4	84.8	82.4	79.8	82.8	84.4	88.3	83.6	89.2	86.1	81.4	78.9	89.3	136.7
12500	88.1	89.3	87.4	90.4	84.3	83.4	81.4	79.1	82.1	84.3	87.1	81.6	88.9	85.1	81.1	78.3	90.0	137.4
16000	85.1	85.8	83.4	86.6	81.9	79.9	77.9	75.8	77.9	80.4	83.9	76.0	85.6	82.1	77.4	75.2	88.4	135.8
20000	83.4	83.4	80.3	84.0	79.2	77.4	75.2	73.2	75.2	78.1	80.5	70.9	82.3	79.2	74.9	72.5	88.3	135.7
OVERALL	105.8	106.5	107.0	106.9	101.6	103.9	100.7	100.3	102.2	104.0	106.0	106.6	109.2	105.8	101.5	99.1	105.6	153.0
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	83.2	93.5	98.7	101.2	97.8	101.0	99.5	99.6	101.9	103.8	105.0	104.6	105.0	100.1	92.6	85.5		
152.4 M	78.5	89.6	95.2	97.7	94.4	97.7	96.3	96.4	98.7	100.6	101.8	101.3	101.8	96.6	89.1	81.8		
304.8 M	66.7	79.0	85.6	88.6	85.6	89.1	87.8	88.1	90.1	92.0	93.1	93.0	93.2	87.6	79.7	72.0		

TABLE VI. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(c) 90 Percent speed; fan physical speed, 2370 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	77.8	74.1	76.3	75.9	74.1	76.3	76.8	76.9	78.4	78.1	79.3	78.2	80.6	82.6	84.6	86.3	79.4	126.8
63	75.1	76.6	75.4	75.9	72.9	75.1	75.1	75.4	76.1	77.1	79.1	78.7	82.1	83.9	85.8	86.5	79.6	127.0
80	78.4	77.4	75.1	74.6	72.1	74.6	75.1	75.1	76.6	78.4	79.6	80.7	83.9	85.9	87.4	88.3	81.0	128.4
100	81.3	79.9	80.1	79.9	75.9	78.6	77.4	79.4	80.3	82.1	83.8	84.5	85.8	87.4	88.8	88.6	83.3	130.7
125	84.7	86.4	86.0	84.2	80.5	82.0	80.7	82.0	82.2	84.2	84.9	85.3	86.5	86.9	87.5	86.8	84.5	131.9
160	84.3	84.3	84.3	82.3	78.3	79.9	80.4	81.3	82.3	82.4	83.1	84.0	83.9	84.6	85.3	84.5	82.8	130.2
200	85.6	85.6	82.9	80.3	76.6	78.9	79.1	79.3	80.1	80.8	81.6	82.7	83.9	84.9	85.3	84.2	82.0	129.4
250	87.6	87.3	86.0	84.8	80.5	81.0	80.8	81.0	82.0	83.3	84.5	85.1	86.3	85.8	85.0	83.7	84.0	131.4
315	89.1	88.0	88.8	88.3	83.5	86.0	83.5	82.6	83.3	84.1	84.8	85.4	86.1	86.1	84.5	82.8	85.4	132.8
400	89.4	88.9	90.1	88.1	84.7	86.7	84.6	85.2	85.4	86.4	87.6	88.0	87.7	86.7	84.7	82.8	86.9	134.3
500	88.9	89.2	88.9	87.7	83.0	85.0	83.7	84.7	85.9	87.7	89.2	89.1	87.7	86.2	84.4	82.4	87.0	134.4
630	88.8	88.6	89.8	88.8	83.4	85.3	84.6	85.3	86.9	88.8	90.1	89.5	88.8	87.1	84.3	82.7	87.7	135.1
800	91.1	90.8	90.6	90.0	85.0	87.0	86.8	87.3	89.1	91.5	92.5	91.9	91.3	88.5	85.8	84.2	89.8	137.2
1000	94.3	94.1	95.6	95.6	90.8	93.1	90.6	91.0	91.9	93.9	95.6	97.2	98.8	93.0	90.0	87.8	94.5	141.9
1250	101.9	101.9	104.4	105.7	100.5	103.0	99.7	99.2	98.2	100.9	103.4	105.8	108.2	101.5	97.7	95.8	103.2	150.6
1600	93.2	93.0	93.7	92.8	87.5	89.5	88.3	89.8	92.5	94.3	95.8	96.8	97.3	91.8	89.0	87.2	93.5	140.9
2000	94.5	95.0	96.5	95.7	89.8	91.8	90.5	91.8	94.0	95.7	97.7	99.3	99.7	93.7	90.0	87.9	95.7	143.1
2500	98.3	99.7	101.7	101.0	95.0	97.0	96.0	95.7	96.5	98.0	99.0	101.9	103.0	96.8	93.3	90.3	99.2	146.6
3150	95.7	96.0	97.5	96.7	90.7	93.2	91.5	93.1	95.2	97.4	99.1	99.8	100.4	95.6	91.9	88.8	97.1	144.5
4000	95.1	95.8	96.9	97.6	90.6	93.1	90.2	91.9	94.6	96.2	98.1	97.5	99.2	95.6	91.8	88.5	96.4	143.8
5000	92.6	94.8	95.4	95.1	89.1	91.4	89.1	89.7	92.4	93.6	96.9	95.6	97.8	93.1	90.3	86.6	94.9	142.3
6300	92.2	92.8	92.6	95.5	88.7	89.5	87.8	87.8	91.6	92.8	95.9	93.8	96.8	92.8	89.1	85.2	94.3	141.7
8000	90.7	91.7	92.5	94.0	87.0	88.7	85.2	86.5	88.5	91.4	93.4	91.0	95.7	90.7	86.3	83.8	93.2	140.6
10000	88.9	90.3	89.4	91.8	85.3	86.4	84.4	84.1	87.3	88.8	91.9	87.1	92.7	88.8	84.6	81.0	91.9	139.3
12500	88.2	89.7	88.5	91.5	84.7	85.4	83.7	82.9	86.5	88.5	90.9	85.6	92.2	88.0	84.0	80.7	92.6	140.0
16000	84.8	85.9	84.0	87.6	81.9	81.6	80.4	79.4	82.7	85.1	87.8	79.8	89.1	85.1	80.9	78.5	91.0	138.4
20000	83.0	83.0	80.0	85.0	79.6	78.7	77.4	77.5	79.7	82.2	84.7	74.8	86.2	82.0	78.0	75.7	90.8	138.2
OVERALL	107.0	107.4	108.9	109.4	103.8	106.1	103.7	103.9	105.0	106.9	108.9	110.1	111.9	106.5	103.4	101.5	108.2	155.5
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	84.5	95.0	101.2	103.8	100.0	103.4	102.8	103.6	105.0	106.6	107.8	108.1	108.0	101.1	95.1	87.9		
152.4 M	80.2	91.0	97.6	100.3	96.7	100.2	99.7	100.4	101.9	103.4	104.6	104.9	104.7	97.7	91.5	84.3		
304.8 M	68.4	80.1	87.6	91.1	88.0	91.9	91.3	92.1	93.5	95.0	95.8	96.4	95.9	88.5	82.1	74.7		

TABLE VI. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(d) 95 Percent speed; fan physical speed, 2502 rpm

FREQUENCY	ANGLE, DEG																SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160		
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	79.9	76.1	78.1	77.7	75.2	78.1	79.2	79.9	80.6	80.7	80.7	79.8	82.9	84.2	86.7	88.0	81.4	128.8
63	76.9	78.2	76.9	77.4	74.4	77.0	77.4	77.9	78.7	78.9	80.2	80.8	84.2	86.7	87.4	88.9	81.7	129.1
80	81.7	81.7	80.4	79.1	74.6	76.1	76.6	77.2	79.2	80.2	82.4	83.5	85.9	87.9	89.7	89.6	83.2	130.6
100	82.9	81.8	82.1	81.4	78.1	80.3	80.1	80.9	82.6	83.8	85.4	85.5	88.4	89.1	91.3	91.0	85.3	132.7
125	86.6	88.4	86.8	85.4	83.3	84.[illegible]	84.3	84.1	84.4	86.4	86.3	86.7	87.9	88.9	90.8	88.5	86.5	133.9
160	87.0	86.5	85.3	84.1	81.3	83.0	83.3	83.0	84.5	84.0	85.8	85.7	86.1	87.0	87.1	86.2	84.9	132.3
200	87.6	86.9	84.4	82.6	79.4	80.8	81.4	81.3	82.3	82.6	83.8	84.7	85.9	86.9	87.6	86.1	84.0	131.4
250	88.4	88.2	86.6	85.4	82.1	82.4	81.9	83.7	84.1	84.7	85.7	87.0	87.7	87.4	87.4	85.5	85.5	132.9
315	89.9	88.9	89.2	87.7	84.2	85.1	83.9	84.4	85.2	85.9	87.1	87.0	87.6	87.9	86.9	84.8	86.5	133.9
400	91.2	90.9	90.6	90.2	89.9	89.2	86.6	88.1	87.2	88.2	89.4	89.5	89.6	88.7	87.4	85.1	89.0	136.4
500	91.2	90.8	90.7	90.8	88.8	89.2	87.0	88.0	88.5	90.0	90.8	90.4	89.2	88.3	85.8	85.1	89.4	136.8
630	90.4	90.3	91.1	89.6	85.4	86.8	85.6	87.1	88.4	90.3	91.4	90.5	89.9	88.6	86.3	84.6	89.1	136.5
800	91.9	91.4	92.3	90.9	86.4	87.9	87.8	89.1	90.9	92.9	93.4	92.9	91.9	90.1	87.4	85.8	91.0	138.4
1000	93.6	93.3	94.6	94.3	89.3	90.6	90.0	91.0	92.8	94.1	94.8	95.6	95.6	91.8	89.5	87.9	93.3	140.7
1250	105.0	104.4	108.0	108.2	103.2	104.0	102.7	102.0	102.9	103.9	104.4	106.5	107.4	103.2	101.4	98.4	104.9	152.3
1600	94.5	94.0	95.4	94.7	89.7	91.2	90.5	92.0	94.0	95.4	97.2	97.6	97.9	93.9	90.7	88.9	94.8	142.2
2000	94.9	94.8	95.4	94.6	89.3	91.3	90.8	92.4	94.9	96.2	97.7	99.2	98.9	93.7	90.6	88.7	95.6	143.0
2500	100.3	100.7	102.5	101.7	96.2	98.7	97.2	97.3	98.7	99.3	101.0	102.3	103.7	98.0	94.3	92.4	100.3	147.7
3150	95.6	95.2	96.9	96.1	90.6	92.7	91.6	93.7	96.2	97.7	99.6	100.2	100.9	96.1	92.6	89.8	97.4	144.8
4000	96.6	96.7	98.6	99.2	93.1	95.4	92.9	93.7	96.7	98.2	99.9	99.4	101.4	97.1	93.2	90.5	98.3	145.7
5000	93.1	94.8	95.7	95.1	90.8	91.9	90.4	91.1	93.8	94.9	98.1	96.7	98.9	94.1	91.6	87.6	95.9	143.3
6300	92.3	92.6	92.7	95.0	89.4	89.9	88.6	89.1	92.9	94.1	97.6	94.7	97.8	93.6	90.1	87.0	95.2	142.6
8000	90.9	91.3	92.1	93.6	87.6	88.9	87.6	87.9	89.8	92.9	94.4	92.5	96.4	91.9	88.1	85.2	94.0	141.4
10000	88.5	89.7	89.3	90.8	85.7	86.5	85.5	85.2	89.0	90.0	93.5	88.6	93.8	90.0	86.2	83.1	92.8	140.2
12500	87.7	88.8	88.0	90.3	85.2	85.5	84.8	84.3	88.2	90.4	92.7	86.9	93.7	89.3	85.7	82.7	93.6	14[illegible].0
16000	84.5	85.0	83.2	86.3	82.4	81.8	81.2	81.4	84.5	86.8	89.5	81.5	90.7	86.5	82.5	80.1	92.1	139.5
20000	81.8	81.7	79.1	82.8	79.7	78.7	78.8	78.9	81.7	83.8	86.2	76.4	87.7	83.8	79.5	77.3	91.7	139.1
OVERALL	108.7	108.6	110.8	110.8	105.8	107.0	105.7	105.8	107.4	108.6	110.1	110.7	111.9	107.8	105.6	103.4	109.4	156.7
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	86.6	95.9	102.1	104.5	101.5	104.6	104.2	105.2	107.1	107.9	109.1	108.8	108.7	102.3	96.9	90.0		
152.4 M	82.4	91.9	98.5	101.2	98.4	101.5	101.1	102.1	103.9	104.8	105.9	105.6	105.3	98.9	93.5	86.4		
304.8 M	70.6	81.8	89.5	92.7	90.2	92.9	92.7	93.8	95.6	96.4	97.3	97.0	96.4	89.9	84.6	76.8		

TABLE VI. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(e) 100 Percent speed; fan physical speed, 2634 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	82.8	77.9	80.3	80.8	77.8	84.3	82.6	86.6	85.8	84.8	83.9	83.2	85.3	87.3	89.1	90.5	85.0	132.4
63	78.6	79.1	79.3	78.8	76.5	78.3	78.8	79.1	79.6	80.8	82.1	81.9	85.8	88.0	89.6	90.5	83.3	130.7
80	82.5	81.3	79.1	78.6	76.0	79.5	77.6	78.1	80.1	82.3	84.1	84.9	87.6	90.1	91.6	92.2	85.0	132.4
100	84.6	83.5	83.3	83.0	79.3	81.5	81.8	83.0	83.8	85.8	87.0	87.4	89.5	91.1	92.8	92.5	86.9	134.3
125	87.4	88.9	87.4	87.9	83.6	85.4	84.9	85.4	86.3	87.6	87.6	88.5	90.1	90.3	92.3	89.8	87.9	135.3
160	86.9	87.4	85.9	85.4	81.4	84.4	84.2	84.5	85.5	85.5	86.4	87.3	87.7	88.7	89.2	88.2	86.2	133.6
200	87.8	87.8	85.5	84.0	80.0	82.8	82.5	82.8	83.5	84.5	85.5	86.1	87.7	88.7	89.3	87.7	85.5	132.9
250	89.3	89.8	88.1	87.6	82.6	85.4	83.9	83.6	85.3	86.4	87.1	88.4	89.1	89.3	88.8	87.2	87.0	134.4
315	89.0	88.9	88.0	87.0	83.0	85.5	85.2	85.2	86.4	87.2	88.0	88.8	89.5	88.9	88.4	86.6	87.3	134.7
400	90.8	90.6	89.9	88.9	84.6	86.8	87.4	87.8	88.1	88.9	90.4	90.7	90.3	89.8	88.6	86.3	89.0	136.4
500	91.1	90.6	90.5	90.5	86.6	88.5	88.0	88.1	89.6	91.1	92.1	91.7	90.5	89.3	88.0	86.4	90.0	137.4
630	90.7	90.2	90.2	90.3	86.3	88.8	87.7	88.7	90.0	91.7	92.5	91.9	91.2	89.7	87.8	86.2	90.2	137.6
800	92.0	92.3	91.6	91.3	87.1	89.3	89.5	90.1	92.6	94.0	94.5	94.1	93.0	90.8	88.3	87.5	92.0	139.4
1000	92.8	92.8	93.3	92.3	88.1	91.5	90.0	91.1	93.3	94.5	95.5	95.9	94.8	91.5	89.3	88.2	93.2	140.6
1250	105.3	106.6	108.4	106.6	103.1	106.3	103.9	102.4	102.8	104.3	108.4	108.0	109.8	103.3	99.9	99.2	106.1	153.5
1600	95.7	97.1	98.2	96.9	92.7	95.7	94.1	94.2	96.1	97.2	99.7	100.0	100.4	95.9	92.6	91.6	97.3	144.7
2000	93.3	94.2	94.7	93.7	88.7	91.7	91.2	93.0	95.8	97.0	98.8	99.3	98.8	94.0	90.8	89.1	95.9	143.3
2500	99.8	100.6	102.5	101.3	96.1	99.6	97.6	98.0	99.5	100.8	102.0	103.4	104.0	98.2	95.0	93.2	100.9	148.3
3150	94.6	95.3	96.6	95.9	90.4	93.9	92.6	94.6	97.5	98.6	100.5	101.2	101.6	97.0	94.0	91.4	98.2	145.6
4000	95.6	96.8	98.0	98.8	92.3	95.3	93.0	94.1	97.6	99.0	101.1	100.6	102.1	97.8	94.1	91.6	98.9	146.3
5000	92.4	94.5	94.7	94.2	90.0	91.8	90.9	91.7	94.9	95.7	99.2	97.5	99.4	94.7	92.2	88.4	96.4	143.8
6300	91.2	92.3	91.8	94.6	88.5	90.0	89.4	89.9	94.0	95.4	98.7	95.8	98.7	94.6	91.1	88.3	96.0	143.4
8000	89.4	90.7	91.2	92.9	86.6	89.1	88.2	89.1	91.6	94.1	96.2	93.2	97.7	92.9	88.9	86.8	94.9	142.3
10000	87.6	89.3	88.2	90.4	84.9	86.4	86.3	86.8	90.1	91.6	94.9	89.6	94.9	90.9	87.4	84.5	93.7	141.1
12500	86.6	88.4	86.4	90.1	84.3	85.6	85.8	86.3	89.8	91.3	93.8	87.8	94.6	90.3	86.9	84.3	94.4	141.8
16000	83.2	84.1	81.8	85.9	81.4	81.7	82.6	82.7	86.1	88.4	90.9	82.8	91.4	87.4	83.9	81.3	93.0	140.4
20000	80.8	81.5	78.0	82.3	78.4	78.9	79.7	80.4	83.2	85.5	87.5	77.6	88.7	84.9	80.9	78.8	92.7	140.1
OVERALL	108.6	109.6	110.9	109.9	105.6	108.7	106.8	106.5	108.2	109.5	112.3	111.9	113.3	108.4	106.0	104.7	110.3	157.7
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	86.6	96.4	102.0	104.2	101.3	105.7	105.0	106.0	108.0	109.2	110.4	109.9	109.4	103.0	97.5	91.2		
152.4 M	82.5	92.8	98.6	100.8	98.2	102.5	101.8	102.9	104.9	106.0	107.2	106.7	106.1	99.6	93.9	87.6		
304.8 M	70.7	83.1	89.7	91.9	90.0	94.6	93.8	94.6	96.6	97.6	99.0	98.2	97.5	90.5	84.7	78.0		

TABLE VI. - Concluded.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(f) 110 Percent speed; fan physical speed, 2967 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
								1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS										
50	66.9	79.9	88.2	84.9	83.7	82.7	83.2	84.7	85.7	84.5	85.9	86.3	85.7	89.7	91.7	92.9	86.6	134.0
63	78.9	81.3	79.9	80.8	80.3	80.8	80.9	80.9	82.3	83.1	84.3	86.7	85.8	89.9	91.6	93.8	85.6	133.0
80	80.9	82.2	79.9	79.2	78.9	79.9	79.9	80.7	82.4	83.7	86.6	88.5	88.7	92.1	94.6	95.8	87.5	134.9
100	86.4	85.7	85.4	84.2	83.1	84.9	85.9	84.7	87.9	89.4	90.7	91.7	90.9	94.6	96.1	97.1	90.3	137.7
125	87.9	89.4	88.3	88.1	86.4	86.8	86.9	86.3	88.9	88.9	90.6	91.9	90.6	93.3	94.6	93.7	90.0	137.4
160	89.1	89.1	87.9	87.6	86.1	86.3	86.1	86.9	87.8	88.1	89.4	90.7	88.8	91.4	92.6	90.8	88.8	136.2
200	88.9	88.9	87.2	85.7	84.7	84.7	85.2	84.5	85.9	86.9	88.4	89.5	89.0	91.7	92.5	90.4	88.0	135.4
250	90.5	90.8	88.8	88.8	87.3	86.5	85.6	85.6	87.8	88.8	90.5	91.7	89.6	92.1	92.1	90.2	89.3	136.7
315	91.3	90.8	90.8	90.8	90.6	90.4	88.4	87.9	89.1	89.4	90.8	92.0	90.6	92.3	91.8	89.5	90.4	137.8
400	90.6	90.9	91.4	91.4	90.4	89.1	88.6	88.6	90.2	90.6	92.2	93.6	91.6	91.9	90.9	89.3	91.0	138.4
500	90.3	91.3	91.5	92.2	92.7	92.0	91.5	90.3	93.2	93.0	94.8	95.3	92.3	92.8	91.5	90.0	92.8	140.2
630	90.2	91.7	92.2	94.9	94.4	93.4	92.7	91.1	94.6	94.7	96.6	96.7	93.1	92.6	91.1	89.8	94.1	141.5
800	91.1	91.9	92.9	93.9	93.7	91.2	92.7	93.1	96.6	97.6	98.4	98.2	94.1	94.2	91.9	90.8	95.3	142.7
1000	91.2	91.9	92.4	93.8	93.5	91.8	94.2	94.2	97.5	98.5	99.3	99.8	95.2	94.2	92.8	92.0	96.2	143.6
1250	95.9	95.6	97.1	97.1	95.9	94.6	94.9	96.2	99.1	100.4	101.6	102.0	98.1	95.9	94.3	93.6	98.5	145.9
1600	105.1	104.6	107.1	105.3	103.8	101.8	100.8	101.6	104.8	105.6	106.6	108.5	104.8	102.3	100.4	99.7	104.9	152.3
2000	92.6	93.2	93.4	94.1	93.7	93.2	94.2	95.1	99.6	100.2	101.7	100.8	98.1	96.1	93.4	92.0	98.0	145.4
2500	92.7	93.7	94.4	95.1	94.4	93.9	95.2	95.9	100.4	100.6	102.7	102.7	99.4	97.4	93.9	92.5	99.1	146.5
3150	97.7	97.7	99.0	99.9	99.0	96.9	97.2	98.2	102.4	103.0	104.9	106.1	103.9	100.9	97.0	94.4	102.3	149.7
4000	92.5	92.5	93.0	95.2	92.7	92.2	93.0	95.0	99.5	100.9	102.7	103.0	99.9	98.2	95.2	92.6	99.4	146.8
5000	90.3	90.8	91.0	92.5	92.0	91.3	92.3	94.0	98.0	98.5	100.7	100.8	97.8	95.5	92.6	89.7	97.7	145.1
6300	89.4	88.9	90.0	91.0	90.4	90.1	90.6	93.3	97.9	96.6	100.4	101.1	98.3	96.6	92.4	89.5	97.9	145.3
8000	87.1	86.9	87.4	88.6	88.3	88.6	89.5	92.1	95.4	96.6	98.8	99.1	95.4	93.8	90.5	87.6	96.7	144.1
10000	83.4	83.4	83.7	85.5	85.4	85.9	86.5	89.6	92.2	92.9	96.6	96.9	93.2	91.7	88.2	85.1	95.1	142.5
12500	80.7	80.3	80.0	82.0	82.8	83.2	84.4	87.8	90.0	91.0	94.4	94.2	91.2	88.8	86.0	83.4	94.1	141.5
16000	73.8	74.9	73.7	76.4	77.2	78.6	79.9	83.7	85.7	84.5	89.4	89.3	86.2	83.9	80.7	78.0	91.0	138.4
20000	68.3	68.9	67.6	69.9	71.6	72.4	74.6	78.5	79.4	78.9	83.6	83.4	81.1	78.3	75.5	72.9	88.0	135.4
OVERALL	107.9	107.8	109.4	108.9	107.8	106.4	106.5	107.3	110.9	111.6	113.3	114.1	111.0	109.4	107.7	106.8	110.9	158.3
DISTANCE								SIDELINE PERCEIVED NOISE LEVELS										
114.3 M	87.6	96.4	102.3	104.5	105.2	105.1	106.0	107.4	111.3	111.8	113.1	113.0	109.0	105.2	99.8	94.1		
152.4 M	83.3	92.8	99.0	101.3	102.1	102.0	102.8	104.2	108.1	108.6	109.8	109.7	105.6	101.7	96.4	90.5		
304.8 M	71.1	83.0	90.1	92.8	93.9	94.0	94.8	96.0	99.6	100.1	101.1	101.1	96.4	92.5	87.4	80.9		

TABLE VII. - ACOUSTIC DATA FOR STOL QF-8 FAN WITH 119 PERCENT-OF-DESIGN-AREA NOZZLE

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(a) 70 Percent speed; fan physical speed, 1832 rpm

FREQUENCY	ANGLE, DEG																SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160		
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	71.1	67.3	68.3	57.5	68.5	70.1	69.5	70.1	70.5	70.6	71.5	70.2	73.1	74.0	76.0	76.5	71.3	118.7
63	80.2	71.2	67.5	59.8	69.5	71.3	70.8	70.7	68.8	70.0	72.2	70.9	73.8	74.8	76.5	77.7	72.3	119.7
80	68.7	68.3	67.0	60.0	65.3	66.3	66.2	66.3	67.7	69.2	71.5	71.9	74.8	76.3	77.7	77.9	71.6	119.0
100	74.3	73.4	73.3	67.4	71.3	71.9	70.4	71.3	72.9	73.8	74.9	75.7	77.4	78.3	79.4	79.7	74.8	122.2
125	76.1	77.8	77.8	73.8	74.8	75.6	73.8	74.6	74.6	75.6	76.9	76.9	77.4	77.8	78.6	77.8	76.2	123.6
160	75.8	75.7	75.2	72.8	72.7	74.0	72.7	74.0	73.7	75.2	75.3	76.1	75.8	76.0	76.5	75.9	74.8	122.2
200	76.8	77.6	74.6	72.1	71.3	71.6	71.3	71.9	72.1	72.6	73.3	74.0	75.3	75.8	75.4	74.8	73.6	121.0
250	78.0	79.5	77.3	76.3	75.5	75.0	72.8	73.8	74.5	75.3	76.3	77.2	78.3	77.5	76.1	75.2	76.1	123.5
315	81.5	81.5	78.2	78.2	76.2	75.7	74.2	74.8	75.3	76.2	77.8	78.2	78.5	77.5	76.5	74.9	77.1	124.5
400	82.3	82.4	81.6	80.1	77.3	77.3	75.9	76.8	77.8	79.3	80.9	81.0	80.6	78.9	76.4	75.1	79.3	126.7
500	81.3	82.8	81.5	81.3	78.8	77.8	75.8	77.1	78.1	79.6	81.1	81.2	81.5	79.3	76.5	74.8	79.7	127.1
630	82.3	84.5	83.5	82.8	80.7	79.2	77.7	78.3	79.7	81.7	83.3	83.1	83.2	81.5	77.7	75.6	81.5	128.9
800	91.2	92.6	92.1	92.6	90.7	88.4	84.9	85.7	85.4	88.2	90.1	91.7	92.9	91.9	87.1	83.4	90.0	137.4
1000	95.0	96.0	96.6	97.0	95.1	92.3	88.3	89.3	89.0	91.6	93.0	95.2	97.5	96.1	91.5	88.7	94.0	141.4
1250	87.1	88.3	88.1	87.1	84.3	82.8	80.1	81.1	83.6	85.5	88.1	88.6	89.3	88.1	82.8	80.0	86.3	133.7
1600	90.3	91.3	92.0	91.7	90.0	87.7	84.0	84.3	86.7	88.0	91.7	92.0	93.8	92.4	86.3	82.9	90.2	137.6
2000	93.4	94.7	95.7	95.6	94.4	91.7	87.5	87.4	90.4	91.4	94.4	95.3	96.7	96.5	90.4	86.8	93.8	141.2
2500	90.9	92.1	92.6	93.4	90.8	88.8	84.6	85.6	88.1	89.8	91.9	93.4	93.6	92.8	86.9	83.4	91.2	138.6
3150	90.7	91.2	92.4	92.1	89.7	88.1	84.6	84.7	87.6	90.4	92.2	92.7	93.4	93.4	87.1	83.2	91.1	138.5
4000	89.9	90.1	92.2	90.6	88.1	86.2	83.4	82.7	85.6	89.1	90.4	90.4	92.7	93.4	86.2	82.7	90.1	137.5
5000	88.0	88.7	89.2	89.0	87.7	85.7	80.5	81.4	84.4	85.9	88.4	88.0	91.7	89.5	84.5	79.9	88.4	135.8
6300	87.4	87.3	87.0	86.9	85.5	83.8	79.1	79.4	82.2	84.0	87.4	85.7	89.5	88.2	82.4	78.6	87.0	134.4
8000	85.9	87.0	85.0	84.7	84.2	83.2	77.7	78.0	81.0	82.5	85.9	82.4	88.0	85.5	81.0	76.9	86.0	133.4
10000	84.5	85.0	83.3	81.5	82.3	81.6	74.6	76.1	78.5	80.0	83.3	79.2	85.0	82.6	78.1	74.2	84.5	131.9
12500	83.9	84.4	81.0	79.3	81.2	80.4	74.1	74.4	77.2	78.6	82.1	76.1	84.1	81.2	77.2	73.2	84.6	132.0
16000	81.2	80.8	76.9	73.4	77.8	76.8	69.9	70.8	73.3	74.8	78.8	70.9	80.7	77.0	73.3	69.9	82.8	130.2
20000	77.8	78.0	72.5	68.4	75.2	74.3	66.0	67.8	70.3	72.2	76.0	65.5	77.8	74.0	70.2	67.1	82.5	129.9
OVERALL	101.7	102.6	103.0	103.0	101.2	99.0	95.2	95.7	97.5	99.5	101.8	102.5	104.2	103.4	98.1	95.0	101.5	148.9
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	79.0	89.6	94.8	97.3	97.8	97.0	94.1	94.8	97.4	99.3	100.8	100.5	100.7	98.2	90.0	82.1		
152.4 M	74.3	85.7	91.3	94.0	94.5	93.8	91.0	91.8	94.3	96.1	97.7	97.4	97.5	94.9	86.5	78.4		
304.8 M	61.9	75.1	81.7	85.1	85.9	85.4	82.7	83.6	86.2	87.5	89.4	89.1	88.8	85.9	77.0	67.8		

TABLE VII. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(b) 80 Percent speed; fan physical speed, 2092 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																		
50	72.8	69.9	72.1	61.8	71.6	73.3	72.9	73.8	73.9	73.9	75.1	74.5	76.9	77.9	80.6	81.3	75.2	122.6
63	76.8	74.2	71.2	63.7	72.5	74.0	73.5	73.5	74.3	74.0	75.2	74.7	78.2	79.7	80.5	81.7	75.8	123.2
80	75.0	73.7	69.9	63.2	70.0	71.7	70.7	71.4	72.7	74.4	75.7	76.6	79.9	80.9	82.4	82.2	76.3	123.7
100	77.6	78.1	77.1	73.3	75.6	77.6	76.5	77.3	76.6	78.6	79.8	79.9	82.5	83.0	84.3	84.2	79.6	127.0
125	79.5	81.5	81.1	75.6	78.3	78.1	76.8	78.3	78.1	79.6	80.5	81.1	82.5	82.3	82.5	81.8	80.0	127.4
160	78.3	79.8	79.3	75.3	76.6	77.5	76.3	77.1	77.8	78.5	79.3	80.4	80.0	80.6	81.1	79.8	78.7	126.1
200	80.1	81.6	79.1	76.5	75.6	76.8	75.1	75.5	76.1	76.8	77.8	78.2	79.8	79.8	80.3	79.5	77.9	125.3
250	82.2	82.7	82.3	82.3	81.8	83.8	79.0	79.3	79.5	80.0	80.2	81.4	83.0	81.8	81.2	79.2	81.3	128.7
315	84.4	84.7	82.4	81.5	79.4	80.2	78.5	78.4	79.5	80.0	81.2	81.8	82.2	81.4	80.0	78.8	80.8	128.2
400	84.8	85.3	85.1	83.1	80.8	80.4	79.1	80.1	81.6	82.4	84.1	84.4	83.9	82.4	80.3	78.8	82.6	130.0
500	83.9	85.1	83.9	84.1	80.9	81.1	79.3	80.1	81.6	83.1	84.6	84.4	83.9	82.1	79.6	78.2	82.7	130.1
630	84.2	85.9	85.2	86.0	83.2	83.0	81.2	81.2	83.2	84.4	86.4	85.5	85.0	83.0	80.2	78.4	84.1	131.5
800	88.1	88.1	87.1	87.6	85.1	84.6	82.9	83.4	85.4	87.4	89.9	88.6	88.1	86.1	82.4	80.3	86.7	134.1
1000	99.3	99.0	100.1	101.5	100.3	99.1	95.3	94.5	94.1	96.3	99.1	100.6	104.0	99.6	95.5	92.2	99.2	146.6
1250	90.8	91.4	92.1	92.2	90.1	88.9	86.1	86.3	87.9	90.3	91.9	92.5	94.1	91.1	87.1	84.3	90.7	138.1
1600	90.3	91.2	91.3	91.3	89.0	88.0	85.2	86.0	89.0	90.5	92.5	92.9	93.0	90.3	85.8	83.6	90.4	137.8
2000	94.9	96.7	97.5	99.0	96.7	95.7	91.7	91.5	92.5	94.5	97.2	99.0	99.5	96.7	91.0	88.1	96.5	143.9
2500	91.8	92.9	93.3	93.6	91.9	90.6	87.3	88.9	91.3	93.1	94.3	95.7	95.4	93.1	88.3	84.9	93.0	140.4
3150	93.6	94.8	95.8	96.1	94.5	93.3	90.5	90.5	92.6	94.8	96.6	97.3	98.0	96.1	89.8	86.6	95.4	142.8
4000	91.9	92.3	94.1	92.9	91.1	89.7	87.2	87.6	90.1	92.9	94.4	93.2	95.4	93.9	87.8	85.1	92.9	140.3
5000	90.5	91.9	91.4	91.4	90.5	89.2	84.9	86.9	88.9	90.4	92.7	91.9	95.4	92.0	86.9	83.2	91.9	139.3
6300	90.3	89.8	89.8	89.7	88.8	87.8	83.6	85.0	87.4	88.8	92.1	89.8	93.3	90.7	85.1	81.9	90.8	138.2
8000	88.6	89.6	88.1	87.2	87.2	87.1	82.4	83.9	86.2	87.1	90.4	86.6	91.7	88.7	84.2	80.5	89.8	137.2
10000	87.3	87.5	86.2	84.1	85.2	85.2	79.5	81.2	83.5	84.3	88.2	83.4	88.8	86.2	81.7	77.8	88.3	135.7
12500	86.5	87.3	84.0	81.7	84.1	84.0	78.6	79.8	83.0	83.6	87.3	80.3	87.6	84.4	80.4	76.9	88.5	135.9
16000	83.3	83.3	79.2	75.7	80.8	80.8	74.5	76.3	79.1	80.3	84.0	75.0	84.8	81.0	76.8	73.3	86.9	134.3
20000	80.3	80.8	75.1	70.9	77.8	77.5	71.0	73.3	75.6	77.0	80.5	70.1	81.6	77.6	73.8	70.8	86.3	133.7
OVERALL	104.1	104.7	105.2	105.8	104.3	103.3	99.8	99.9	101.3	103.2	105.5	106.0	108.0	104.9	100.5	97.8	104.8	152.2
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	80.8	91.6	96.7	100.2	100.3	100.8	98.6	99.5	101.5	103.3	104.7	104.1	103.9	99.7	91.7	84.3		
152.4 M	76.6	87.7	93.2	96.9	97.1	97.6	95.4	96.3	98.3	100.1	101.4	100.9	100.5	96.2	88.1	80.6		
304.8 M	65.0	77.1	83.6	87.9	88.4	89.2	86.9	87.7	89.6	91.4	92.6	92.5	91.8	86.8	78.6	70.4		

TABLE VII. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(c) 90 Percent speed; fan physical speed, 2353 rpm

FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	75.4	73.3	75.1	65.1	75.8	76.8	75.9	77.1	76.8	78.8	78.8	77.7	81.8	82.3	84.6	86.0	79.2	126.6
63	74.0	75.0	73.8	66.3	74.0	76.3	75.0	75.3	75.8	77.3	78.6	78.2	82.0	84.1	85.6	86.3	79.4	126.8
80	76.5	76.0	72.8	67.0	76.5	76.3	74.5	74.3	76.0	78.1	80.1	80.9	84.3	85.6	86.5	87.5	80.7	128.1
100	79.7	79.0	78.7	74.2	77.9	78.5	77.5	78.5	79.7	81.7	83.4	83.8	86.5	87.4	88.4	89.2	83.1	130.5
125	83.7	84.8	84.0	80.0	83.3	82.7	81.3	81.2	82.0	83.5	84.3	84.6	86.0	86.7	86.7	85.7	83.9	131.3
160	82.3	82.8	81.7	78.5	80.8	81.0	80.3	80.0	81.7	82.3	83.5	83.9	84.7	85.3	85.2	83.9	82.6	130.0
200	82.3	84.5	81.2	78.8	78.8	79.7	78.7	79.0	79.3	80.5	81.7	82.1	84.0	84.5	84.5	83.4	81.5	128.9
250	83.9	85.0	83.9	82.2	81.2	81.4	79.0	80.0	80.7	82.5	83.7	84.6	85.4	85.5	84.9	82.9	83.0	130.4
315	86.0	87.2	84.7	85.4	86.2	85.2	81.9	81.4	82.4	83.2	84.5	85.0	86.0	85.5	84.7	82.4	84.5	131.9
400	87.0	88.5	86.5	87.3	86.6	85.0	83.1	83.0	84.6	85.3	86.8	86.9	86.5	85.6	84.5	82.4	85.8	133.2
500	87.8	88.8	86.2	88.0	86.0	85.2	83.5	83.7	85.3	87.0	88.2	87.4	86.5	85.7	83.8	82.1	86.3	133.7
630	87.0	88.8	86.5	88.1	86.0	85.3	83.5	84.1	85.8	87.8	89.0	87.6	86.6	86.0	83.3	81.0	86.6	134.0
800	88.8	90.6	88.4	89.4	87.1	87.3	85.6	86.6	88.4	90.8	91.4	90.2	88.9	87.8	84.4	82.7	88.8	136.2
1000	93.2	94.9	94.4	96.2	93.6	94.2	90.7	90.6	91.4	93.6	95.1	96.8	98.1	93.9	88.7	86.1	94.4	141.8
1250	99.8	101.8	102.3	104.8	101.3	102.5	98.3	97.6	97.6	99.8	101.6	104.7	105.5	101.8	96.3	92.9	101.9	149.3
1600	90.1	91.4	90.4	91.1	89.7	88.6	86.7	88.1	91.2	93.2	94.6	94.0	94.2	91.1	86.9	84.8	91.7	139.1
2000	91.8	93.9	93.6	94.3	93.1	91.5	89.1	90.6	93.4	94.8	96.8	97.1	96.8	93.4	88.6	86.5	94.3	141.7
2500	96.2	98.2	98.6	99.9	98.6	96.9	94.4	94.9	96.6	96.9	99.1	100.8	100.9	96.9	92.7	89.6	98.3	145.7
3150	93.1	94.6	95.0	95.7	93.4	92.7	90.4	91.8	94.1	96.3	98.1	98.4	98.8	96.0	90.8	87.4	96.0	143.4
4000	92.1	93.6	94.4	93.9	91.6	90.9	89.6	90.3	92.3	95.3	96.9	96.4	97.4	95.4	89.9	87.6	94.9	142.3
5000	90.8	92.4	92.1	92.1	91.8	90.4	86.8	89.3	92.6	93.6	95.8	94.9	97.3	93.4	89.6	85.4	94.1	141.5
6300	89.9	90.2	89.8	90.2	89.3	88.4	85.4	87.7	91.1	92.2	95.1	92.5	96.0	92.9	87.6	84.6	93.1	140.5
8000	88.2	89.6	87.6	87.2	87.7	87.6	83.9	86.4	89.9	90.9	93.7	89.8	94.2	90.7	87.1	83.3	92.1	139.5
10000	86.3	87.1	85.6	83.9	84.8	85.4	80.9	84.1	87.1	88.3	91.4	86.3	91.6	88.3	84.1	80.9	90.5	137.9
12500	85.2	86.2	83.1	81.3	83.6	83.9	80.3	82.9	86.4	87.8	90.3	83.6	90.8	87.4	83.4	79.7	90.8	138.2
16000	81.5	81.8	78.2	74.7	79.6	80.1	76.4	79.3	83.3	84.1	87.3	78.8	88.0	83.8	79.8	76.8	89.3	136.7
20000	78.4	79.0	73.5	70.2	76.7	77.0	72.8	76.5	79.9	81.0	83.9	73.6	84.3	80.5	76.5	74.3	88.6	136.0
OVERALL	104.7	106.4	106.4	107.9	105.6	105.6	102.3	102.7	104.4	106.1	108.0	108.8	109.8	106.6	102.4	100.2	107.0	154.4
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	82.2	93.7	98.3	102.1	102.8	103.1	101.4	102.6	104.7	105.6	107.1	106.9	106.2	101.1	94.3	86.9		
152.4 M	78.0	89.7	94.7	98.7	99.5	99.9	98.3	99.5	101.6	102.5	103.9	103.7	102.9	97.7	90.7	83.0		
304.8 M	66.1	79.5	84.9	89.8	90.7	91.4	89.9	91.1	93.2	94.1	95.3	95.1	93.9	88.5	80.9	72.8		

TABLE VII. - Continued.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(d) 95 Percent speed; fan physical speed, 2404 rpm

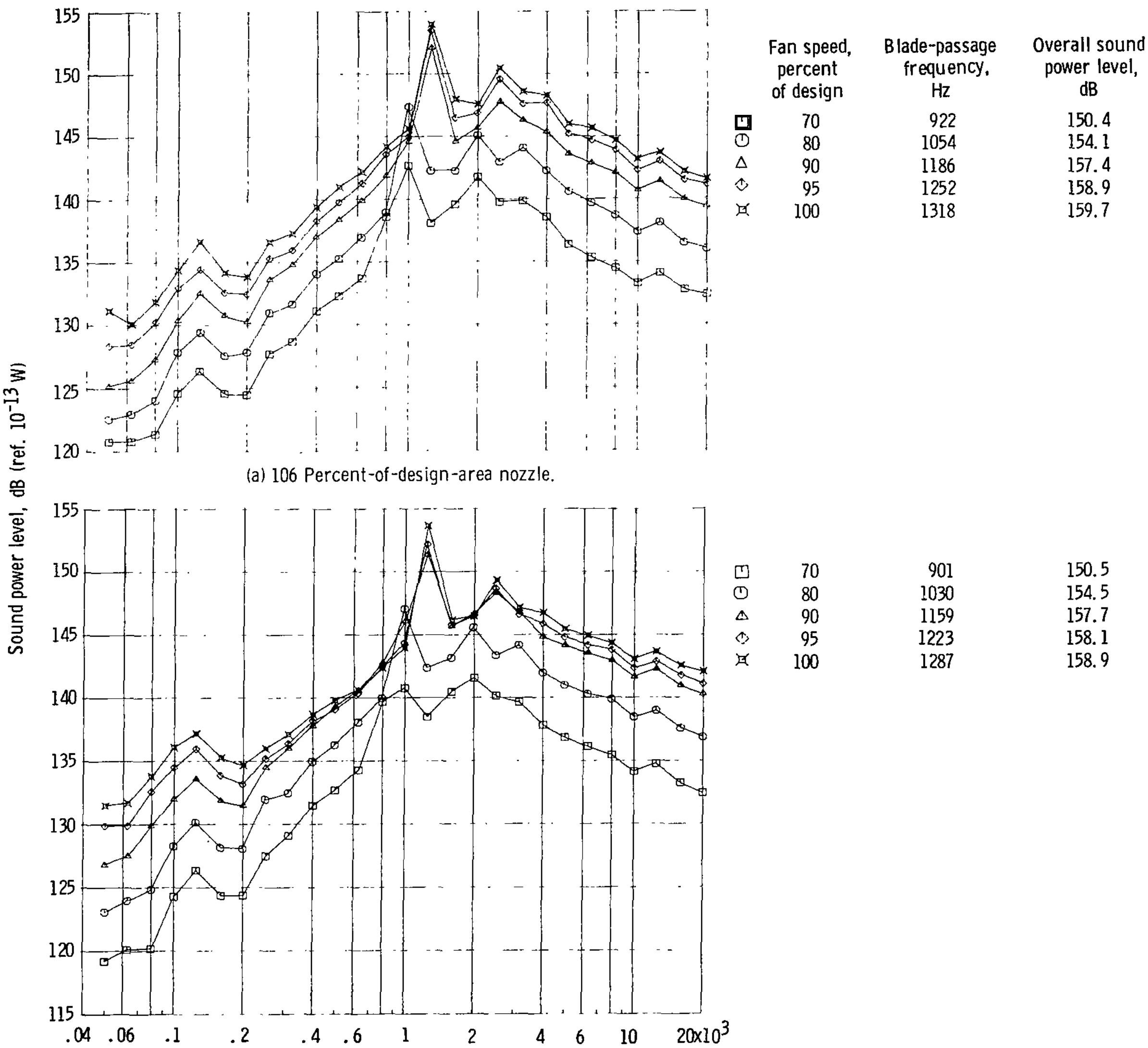
FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	78.2	74.7	76.9	67.7	77.5	79.2	78.4	79.2	80.4	80.4	81.0	79.1	83.5	84.7	86.9	88.3	81.4	128.8
63	75.7	76.9	75.7	67.5	76.2	76.9	76.4	76.7	77.7	79.7	80.4	80.6	84.9	86.2	87.7	88.4	81.5	128.9
80	80.8	78.2	76.7	69.0	75.0	76.5	76.0	76.2	78.3	80.5	82.3	82.8	86.3	87.8	88.2	89.2	82.6	130.0
100	81.2	81.2	80.0	75.7	79.5	80.3	79.0	80.2	82.0	83.7	85.7	85.6	88.0	90.2	90.7	91.2	85.2	132.6
125	85.7	85.8	85.8	81.3	84.2	86.2	84.3	82.5	85.2	85.3	86.3	86.6	87.5	88.5	89.3	88.4	86.0	133.4
160	86.7	87.0	82.8	80.5	84.0	83.5	82.7	82.5	83.5	84.5	85.3	85.6	86.5	87.3	87.2	86.6	84.8	132.2
200	84.4	85.0	82.2	80.9	80.9	81.0	80.2	80.4	82.0	82.4	84.0	84.3	85.9	86.9	87.2	85.4	83.5	130.9
250	84.4	85.2	83.0	84.2	83.4	83.9	81.4	81.5	83.5	84.9	85.7	86.1	87.7	87.2	87.2	85.4	84.9	132.3
315	85.6	86.1	84.2	85.1	83.9	83.9	82.6	83.2	84.6	85.2	86.7	86.7	87.1	87.2	86.1	84.5	85.3	132.7
400	87.5	87.3	85.7	87.0	86.0	85.5	84.5	84.8	86.2	86.8	88.5	88.3	88.2	87.5	86.2	84.2	86.8	134.2
500	87.7	87.7	87.2	89.4	87.9	87.6	85.7	86.4	87.7	88.6	89.7	88.8	87.9	87.2	85.4	83.6	87.9	135.3
630	87.1	87.2	88.1	89.1	87.9	87.9	86.6	86.4	87.7	88.9	90.4	89.0	88.2	87.1	85.1	83.3	88.1	135.5
800	89.1	89.1	88.4	89.7	87.9	87.9	87.6	88.4	90.4	91.6	93.1	91.0	90.6	88.7	86.1	84.3	89.9	137.3
1000	90.8	91.6	92.0	93.1	91.3	91.5	90.8	90.8	92.3	93.8	94.6	94.6	94.5	90.9	87.6	85.7	92.7	140.1
1250	101.5	103.9	104.9	106.2	104.2	104.0	102.9	100.9	101.4	103.9	104.7	106.5	107.7	102.2	98.4	95.4	104.3	151.7
1600	90.0	91.3	91.8	92.7	91.2	91.0	89.5	90.5	93.4	94.5	95.8	95.8	95.8	92.0	89.0	86.6	93.3	140.7
2000	89.9	91.3	91.6	92.6	91.4	90.9	89.8	91.3	94.4	95.3	97.1	96.7	96.4	92.8	89.1	86.8	94.1	141.5
2500	96.3	97.5	98.2	99.5	99.0	97.7	95.3	96.2	98.7	98.5	100.3	101.8	102.2	97.7	93.3	90.8	99.2	146.6
3150	91.4	91.7	92.9	93.8	91.9	91.8	90.5	92.7	95.7	97.0	98.5	98.7	99.0	95.9	91.2	88.8	96.1	143.5
4000	92.5	93.2	95.2	95.0	93.0	93.0	91.5	92.2	95.4	97.7	98.7	98.7	99.7	96.9	91.4	89.3	96.8	144.2
5000	89.8	90.9	91.2	92.2	91.8	91.1	87.9	91.1	94.3	95.1	97.3	96.2	98.6	94.4	90.3	86.4	95.2	142.6
6300	89.0	88.7	88.7	89.5	89.2	89.1	87.0	89.1	92.8	93.6	96.1	94.4	97.0	93.6	88.6	85.7	94.1	141.5
8000	87.1	87.9	86.6	86.9	87.6	88.1	85.2	88.3	92.1	92.6	95.1	91.1	95.9	92.1	88.3	84.8	93.4	140.8
10000	84.9	85.1	84.1	83.1	84.8	85.1	82.3	86.1	89.4	90.0	92.8	88.0	92.8	89.6	85.8	82.4	91.7	139.1
12500	83.5	84.3	81.6	80.6	83.3	84.2	81.5	84.8	88.8	89.5	91.9	85.5	92.4	88.7	84.8	81.2	92.2	139.6
16000	79.7	80.0	76.4	74.3	79.5	80.5	78.0	81.7	85.2	86.0	88.9	80.1	89.2	85.5	81.4	78.2	90.7	138.1
20000	76.5	77.0	71.9	69.4	76.5	77.5	75.0	78.5	82.1	83.0	85.4	75.4	86.3	82.1	78.8	75.7	90.2	137.6
OVERALL	105.1	106.6	107.3	108.4	106.9	106.6	105.2	104.8	106.8	108.2	109.6	110.1	111.2	107.2	103.9	102.0	108.4	155.8
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	83.0	93.4	98.3	102.0	103.2	103.9	103.0	104.2	106.8	107.2	108.4	108.0	107.4	101.9	95.4	88.4		
152.4 M	78.8	89.8	95.0	98.8	99.9	100.7	100.0	101.0	103.7	104.1	105.2	104.8	104.1	98.5	91.8	84.5		
304.8 M	67.1	80.1	86.1	90.4	91.2	92.6	92.2	92.7	95.3	95.7	96.7	96.2	95.3	89.2	82.6	74.9		

TABLE VII. - Concluded.

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL referenced to 2×10^{-5} Pa; PWL referenced to 0.1 pW.]

(e) 100 Percent speed; fan physical speed, 2615 rpm

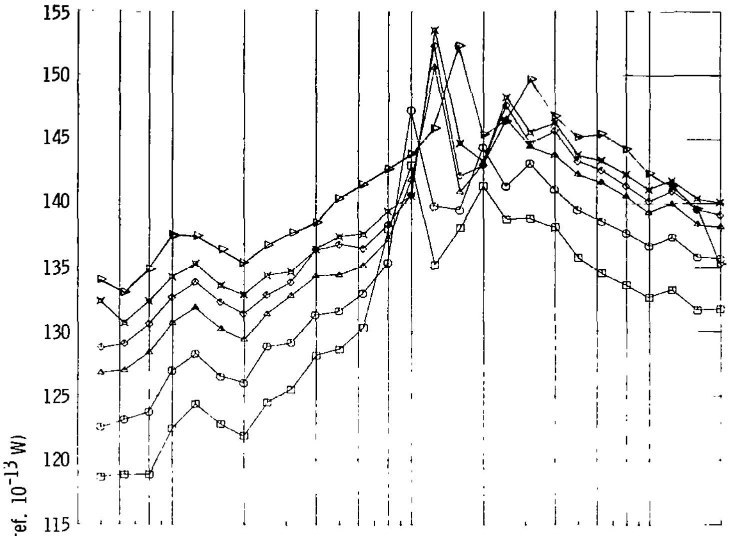
FREQUENCY	ANGLE, DEG 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	SIMPLE SOURCE SPL	POWER LEVEL (PWL)
	1/3-OCTAVE BAND SOUND PRESSURE LEVELS (SPL) ON 30.5 METER RADIUS																	
50	80.2	76.5	79.3	68.5	79.2	83.2	82.0	84.8	84.7	84.5	83.3	82.9	85.7	87.8	88.7	90.9	84.5	131.9
63	76.6	77.6	77.0	69.0	77.5	78.1	78.1	78.5	79.0	80.5	81.5	81.9	86.5	87.8	89.6	91.0	83.2	130.6
80	78.8	77.4	75.4	69.9	75.3	76.6	76.4	77.3	79.6	81.6	83.9	84.3	87.9	89.6	91.1	92.1	84.5	131.9
100	82.3	81.6	81.4	76.9	80.3	81.6	80.6	82.6	83.3	84.8	86.9	87.0	90.3	91.9	93.1	93.2	87.0	134.4
125	85.1	86.3	85.9	83.3	85.6	85.1	84.6	85.4	85.3	85.8	86.9	87.9	89.9	90.9	91.4	90.5	87.3	134.7
160	83.6	84.0	84.0	81.1	83.3	84.5	83.6	84.3	85.0	85.3	86.1	87.1	88.0	89.0	89.6	88.4	85.9	133.3
200	83.6	86.1	84.0	81.8	81.8	82.5	82.8	82.5	83.3	83.3	85.6	86.7	87.6	88.8	89.1	87.7	85.2	132.6
250	84.8	85.9	83.9	83.9	83.4	83.6	83.1	83.8	84.8	85.6	87.3	88.2	89.1	89.3	89.4	87.7	86.3	133.7
315	86.0	87.0	84.8	84.5	84.2	85.5	84.2	84.3	85.7	86.3	87.7	88.6	89.0	89.3	88.8	86.4	86.7	134.1
400	87.1	87.9	85.6	85.7	84.9	86.1	85.6	86.1	87.4	88.1	89.2	89.3	89.6	89.6	88.2	85.9	87.7	135.1
500	86.7	87.9	86.9	88.4	86.9	87.7	86.4	87.6	89.4	89.7	90.7	90.0	89.1	88.7	87.9	85.6	88.7	136.1
630	86.8	88.1	87.6	89.4	88.1	89.8	87.8	87.8	89.4	90.6	91.6	90.5	89.8	89.1	87.1	84.8	89.4	136.8
800	88.2	89.7	88.7	90.2	88.7	89.3	88.8	90.2	91.7	93.3	94.0	92.6	92.2	90.3	88.0	86.4	91.2	138.6
1000	89.4	90.6	90.2	91.7	90.6	90.4	89.7	91.7	93.2	93.9	95.4	94.5	94.9	90.9	88.4	86.9	92.7	140.1
1250	102.1	104.0	103.0	104.8	104.5	102.8	100.8	101.0	101.1	100.8	107.5	106.2	108.3	102.0	98.8	95.9	104.2	151.6
1600	91.6	93.0	93.0	94.3	93.5	93.1	91.8	93.0	95.0	95.6	98.8	97.4	99.1	94.5	91.6	88.9	95.5	142.9
2000	89.6	91.2	91.4	92.6	91.1	91.4	90.7	92.9	96.1	96.6	98.2	97.2	97.2	93.4	90.1	88.0	95.0	142.4
2500	94.9	96.9	97.4	98.4	97.5	97.0	94.7	96.4	99.2	99.2	101.7	102.3	102.6	97.4	93.6	91.1	99.4	146.8
3150	90.6	91.6	93.1	94.1	92.3	92.6	91.8	94.1	97.0	98.1	100.0	99.6	100.3	97.0	92.6	89.4	97.2	144.6
4000	91.5	92.4	94.5	94.4	92.5	92.5	91.5	92.9	96.9	98.4	99.5	98.7	100.5	96.2	92.0	89.7	97.2	144.6
5000	89.3	90.4	90.7	91.7	91.1	91.3	88.9	92.4	95.9	96.1	98.4	97.1	99.3	94.8	91.3	87.6	96.0	143.4
6300	88.4	88.6	88.7	89.5	89.0	89.2	88.1	90.9	94.1	95.1	97.9	95.2	97.7	94.6	89.9	86.9	95.2	142.6
8000	86.3	87.8	86.2	86.7	87.3	88.6	85.6	89.8	93.8	94.1	96.9	92.8	96.9	92.9	89.4	86.3	94.7	142.1
10000	84.6	85.1	83.6	83.1	85.0	86.3	84.0	87.8	91.5	91.6	94.8	89.5	94.5	90.6	87.5	83.7	93.3	140.7
12500	83.1	83.9	80.8	80.3	83.2	85.3	83.3	86.6	90.9	91.1	93.8	87.1	93.9	89.9	86.6	83.3	93.8	141.2
16000	79.7	79.5	75.9	74.4	79.3	81.7	79.8	83.3	87.3	87.7	90.5	81.9	91.0	86.7	83.2	80.0	92.3	139.7
20000	75.8	76.3	71.1	69.5	76.0	78.9	76.5	80.3	83.8	84.5	87.3	76.7	88.2	84.0	80.7	77.9	91.9	139.3
OVERALL	105.0	106.6	106.2	107.5	106.9	106.1	104.4	105.7	107.7	108.2	111.5	110.4	112.1	107.7	105.2	103.4	109.0	156.4
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
114.3 M	83.1	93.4	97.6	101.3	102.6	103.7	102.9	105.1	107.7	108.0	109.9	108.7	108.2	102.4	96.5	89.5		
152.4 M	78.9	89.8	94.0	98.0	99.5	100.5	99.8	101.9	104.6	104.8	106.7	105.5	104.9	98.9	92.9	85.6		
304.8 M	67.1	80.2	85.1	89.6	91.3	92.2	91.6	93.6	96.2	96.4	98.3	96.9	96.3	89.7	83.8	76.1		



(a) 106 Percent-of-design-area nozzle.

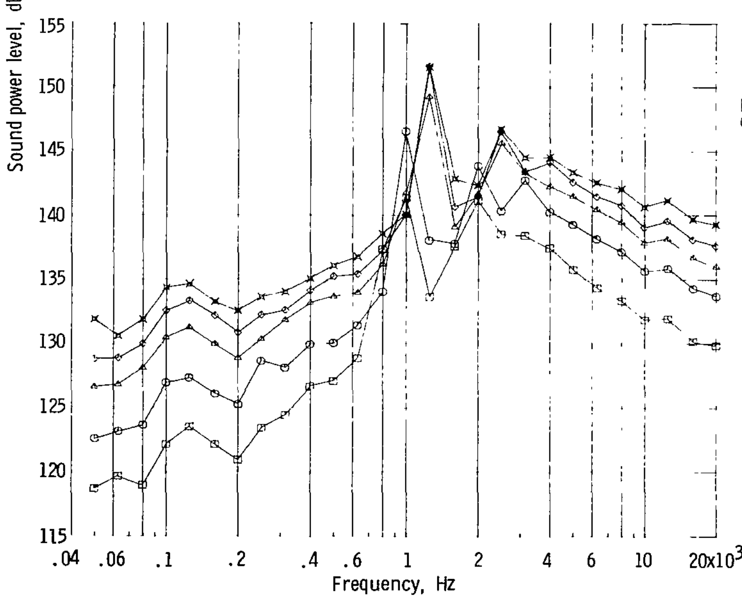
(b) 110 Percent-of-design-area nozzle.

Figure 45. - OF-8 fan power spectrum.



Fan speed, percent of design	Blade-passage frequency, Hz	Overall sound power level, dB
70	922	149.6
80	1053	153.0
90	1185	155.5
95	1251	156.7
100	1317	157.7
110	1484	158.3

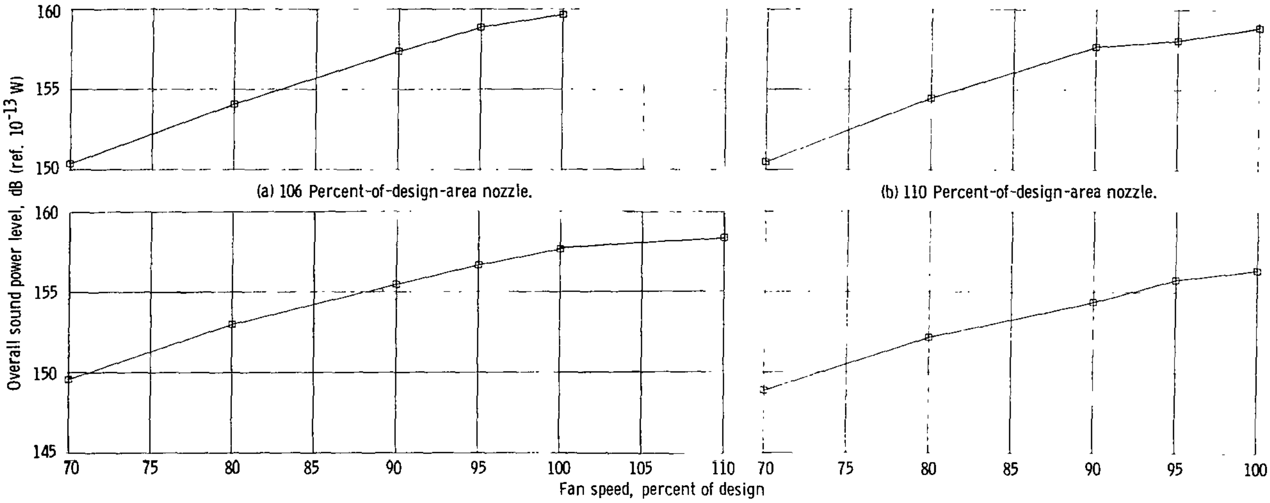
(c) 115 Percent-of-design-area nozzle.



Fan speed, percent of design	Blade-passage frequency, Hz	Overall sound power level, dB
70	916	148.9
80	1046	152.2
90	1176	154.4
95	1242	155.8
100	1307	156.4

(d) 119 Percent-of-design-area nozzle.

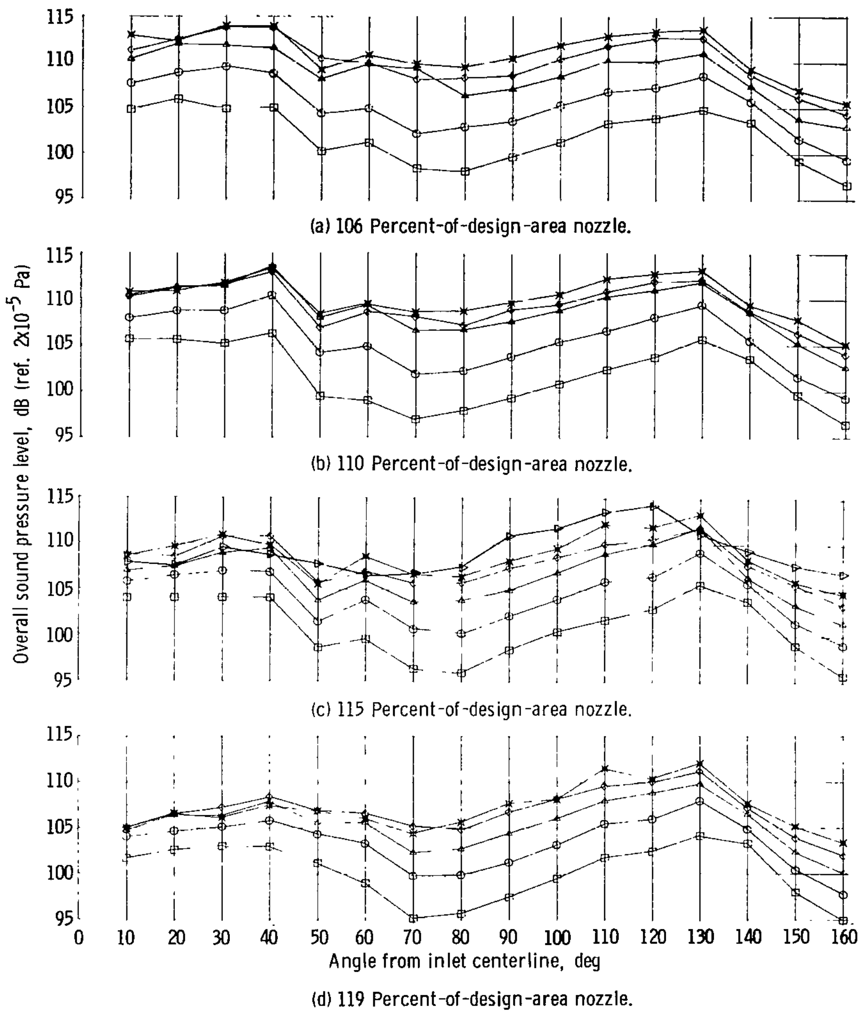
Figure 45. - Concluded.



(c) 115 Percent-of-design-area nozzle.

(d) 119 Percent-of-design-area nozzle.

Figure 46. - QF-8 fan overall sound power level as function of speed.



	Fan speed, percent of design	Blade-passage frequency, Hz
□	70	922
○	80	1054
△	90	1186
◇	95	1252
⌘	100	1318

□	70	901
○	80	1030
△	90	1159
◇	95	1223
⌘	100	1287

□	70	922
○	80	1053
△	90	1185
◇	95	1251
⌘	100	1317
▷	110	1484

□	70	916
○	80	1046
△	90	1176
◇	95	1242
⌘	100	1307

Figure 47. - QF-8 fan overall sound pressure level as function of microphone angular position on 30.5-meter (100-ft) radius.

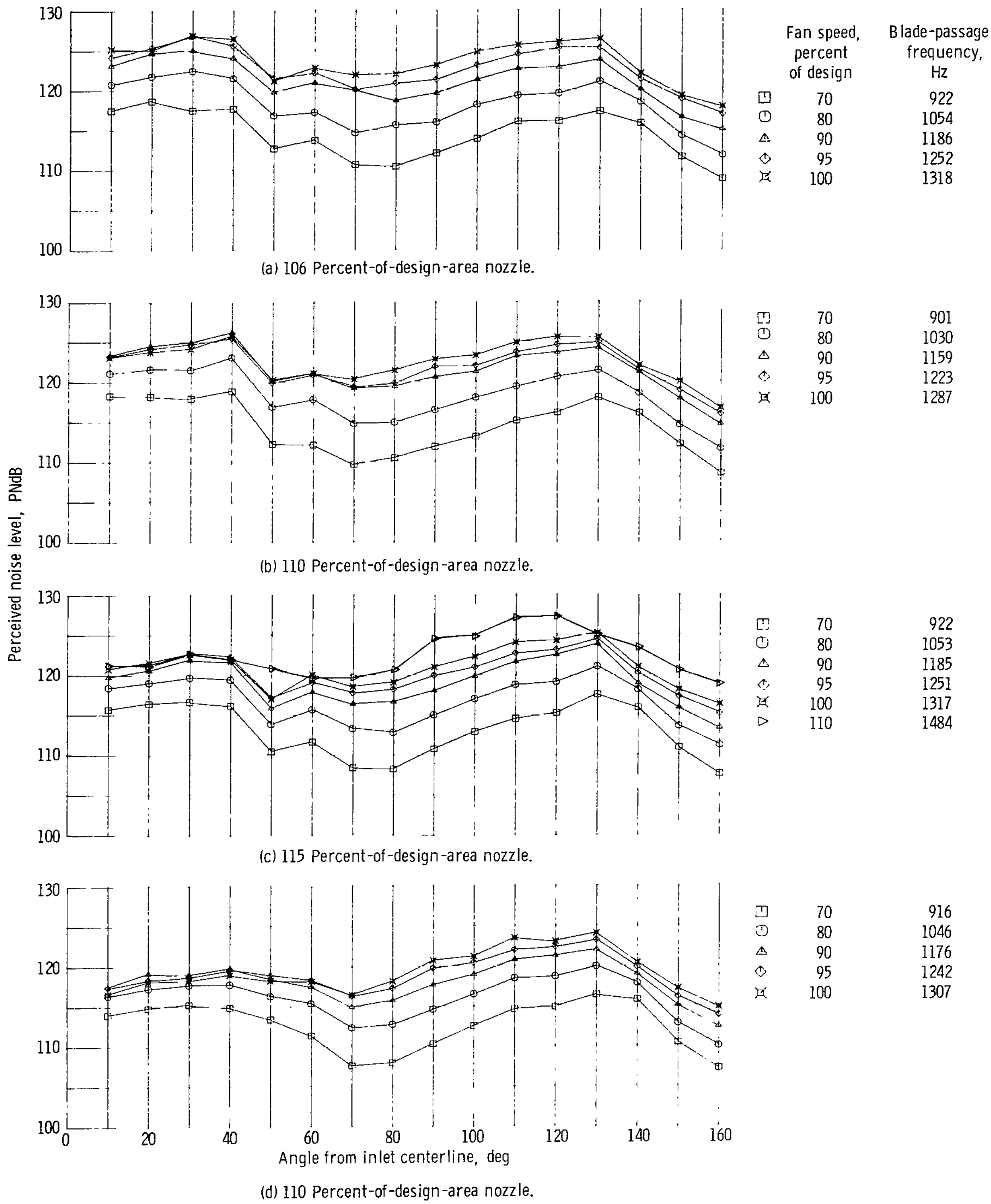
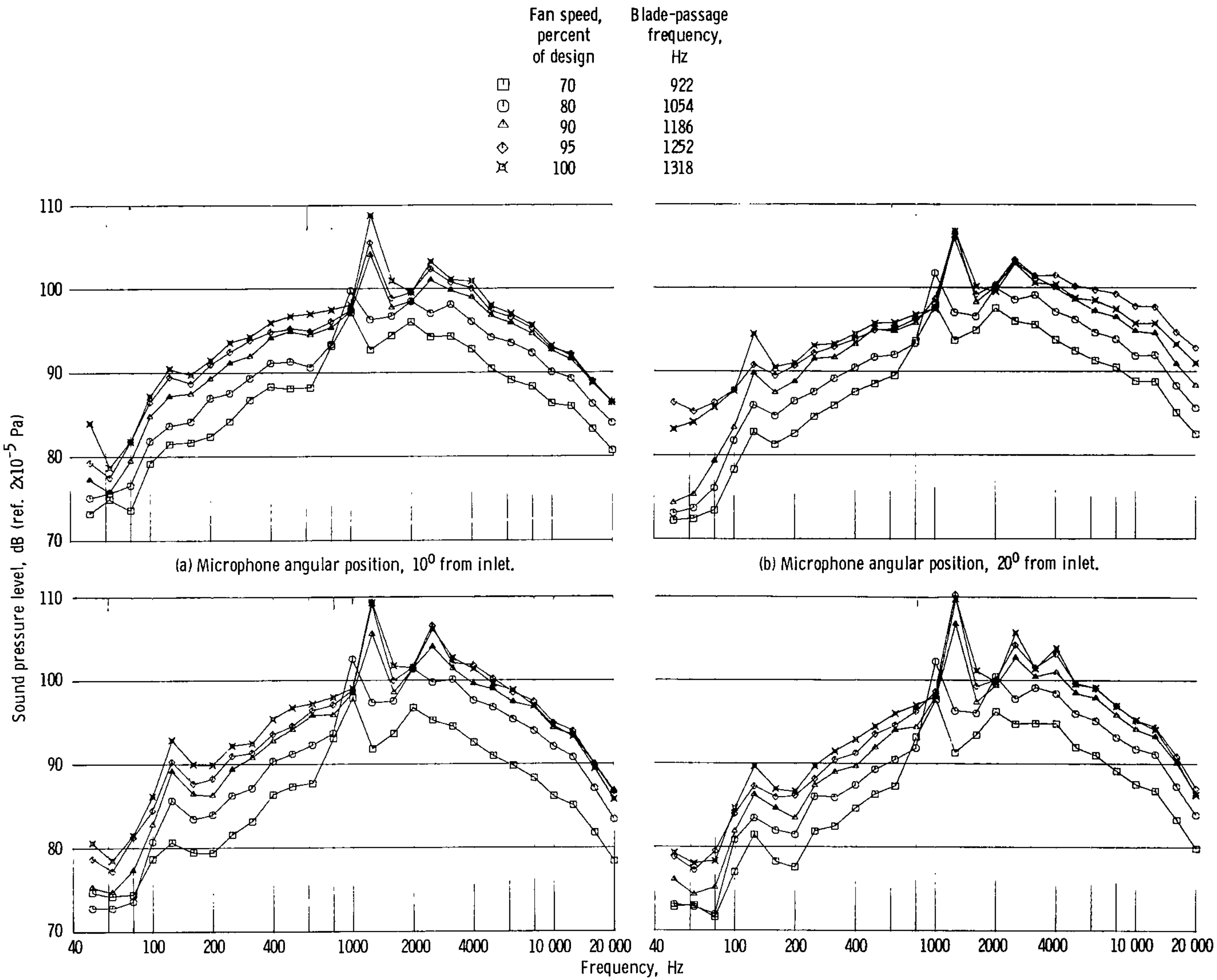


Figure 48. - QF-8 fan perceived noise as function of microphone angular position on 30.5-meter (100-ft) radius.



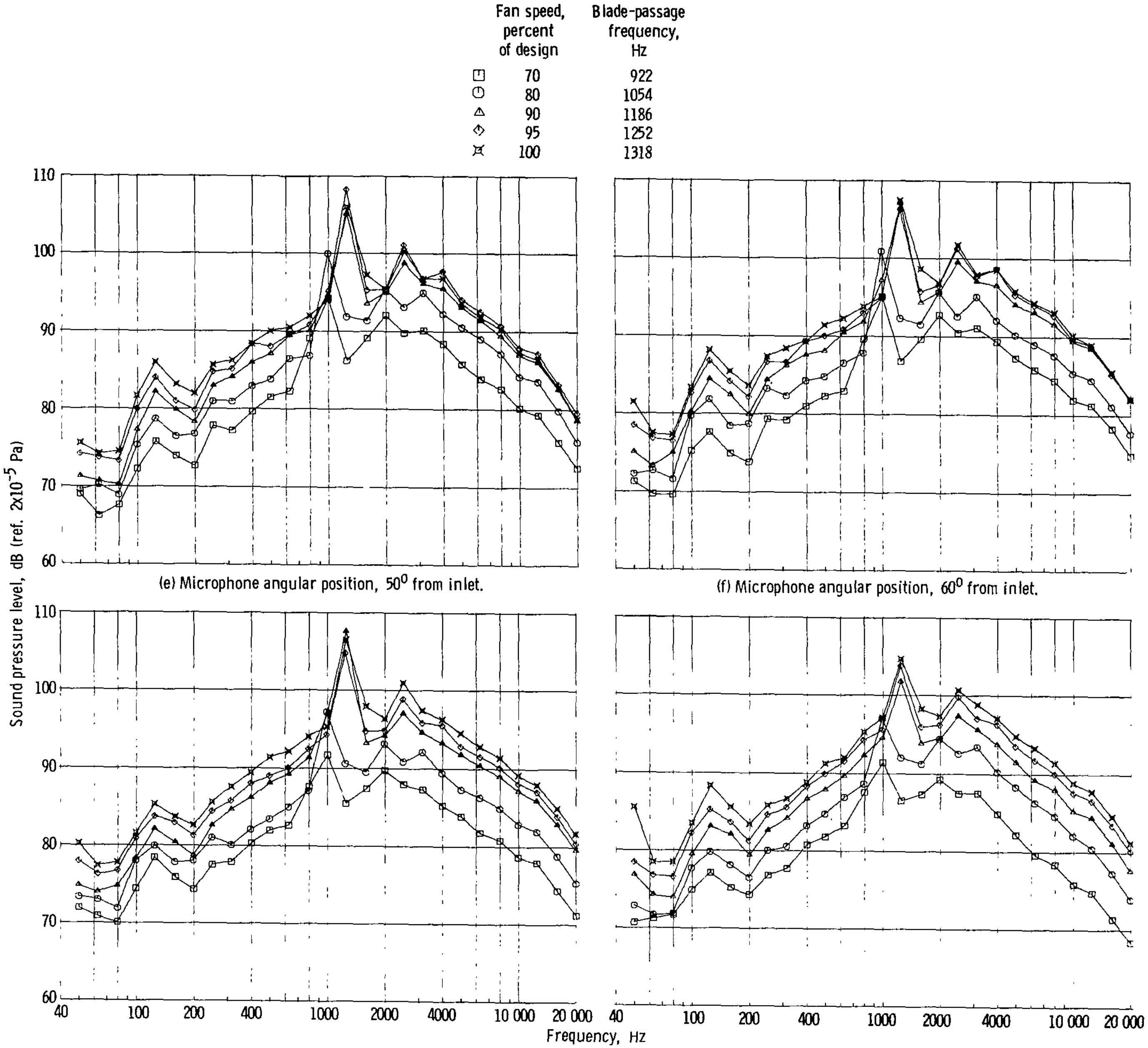
(a) Microphone angular position, 10° from inlet.

(b) Microphone angular position, 20° from inlet.

(c) Microphone angular position, 30° from inlet.

(d) Microphone angular position, 40° from inlet.

Figure 49. - QF-8 fan one-third-octave-band spectra on 30.5-meter (100-ft) sideline with 106 percent-of-design-area nozzle.



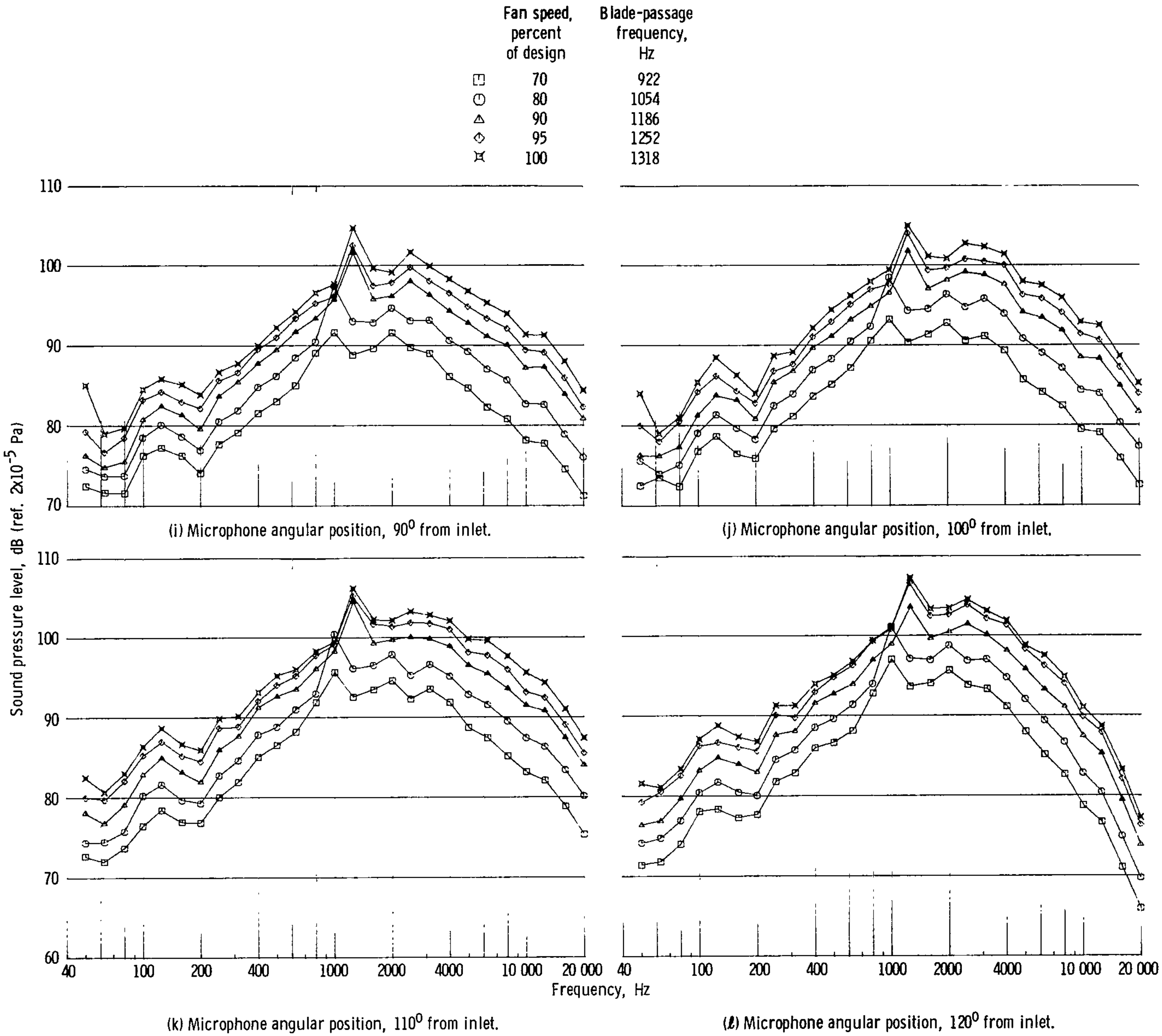
(e) Microphone angular position, 50° from inlet.

(f) Microphone angular position, 60° from inlet.

(g) Microphone angular position, 70° from inlet.

(h) Microphone angular position, 80° from inlet.

Figure 49. - Continued.



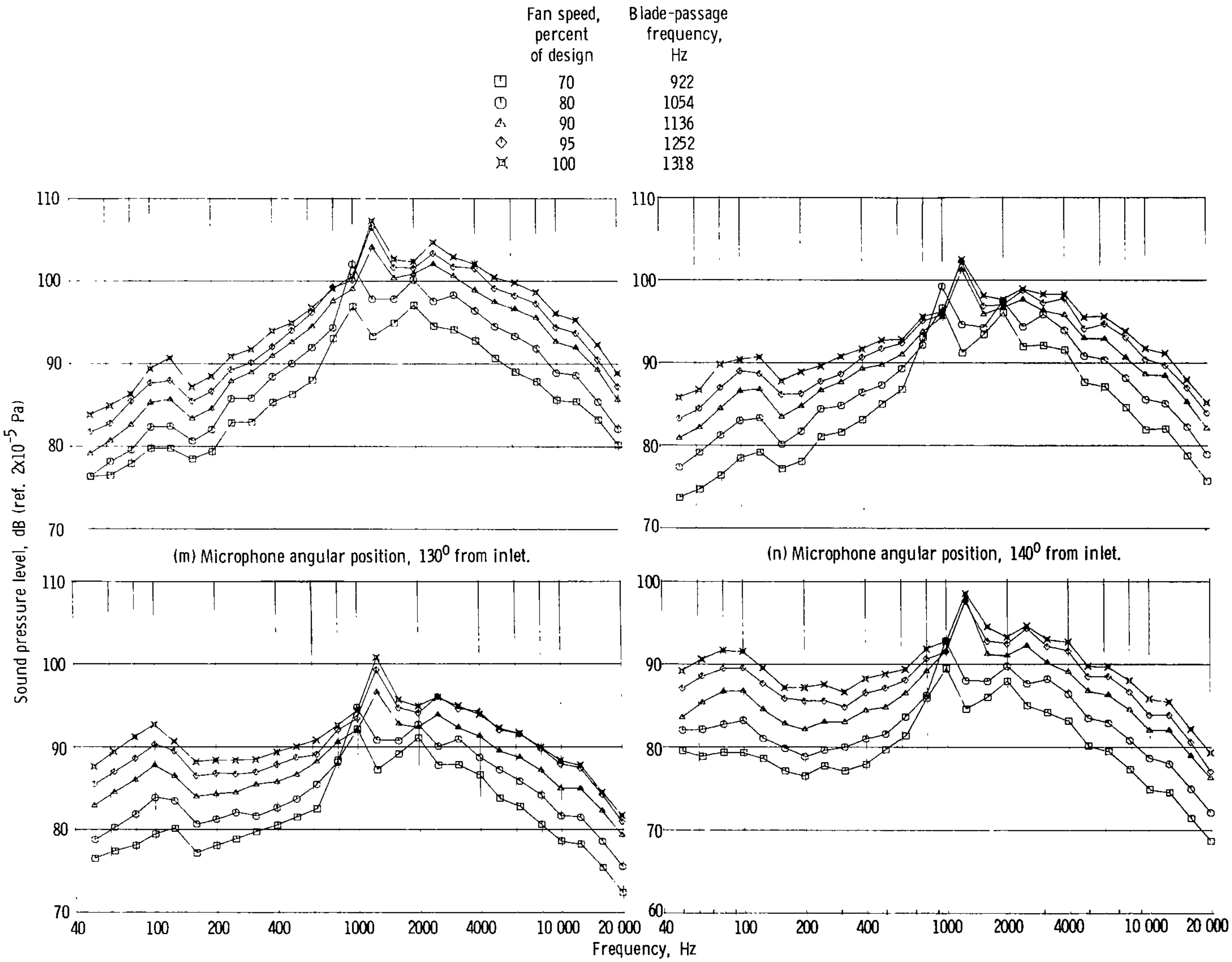
(i) Microphone angular position, 90° from inlet.

(j) Microphone angular position, 100° from inlet.

(k) Microphone angular position, 110° from inlet.

(ℓ) Microphone angular position, 120° from inlet.

Figure 49. - Continued.



(o) Microphone angular position, 150° from inlet.

(p) Microphone angular position, 160° from inlet.

Figure 49. - Concluded.

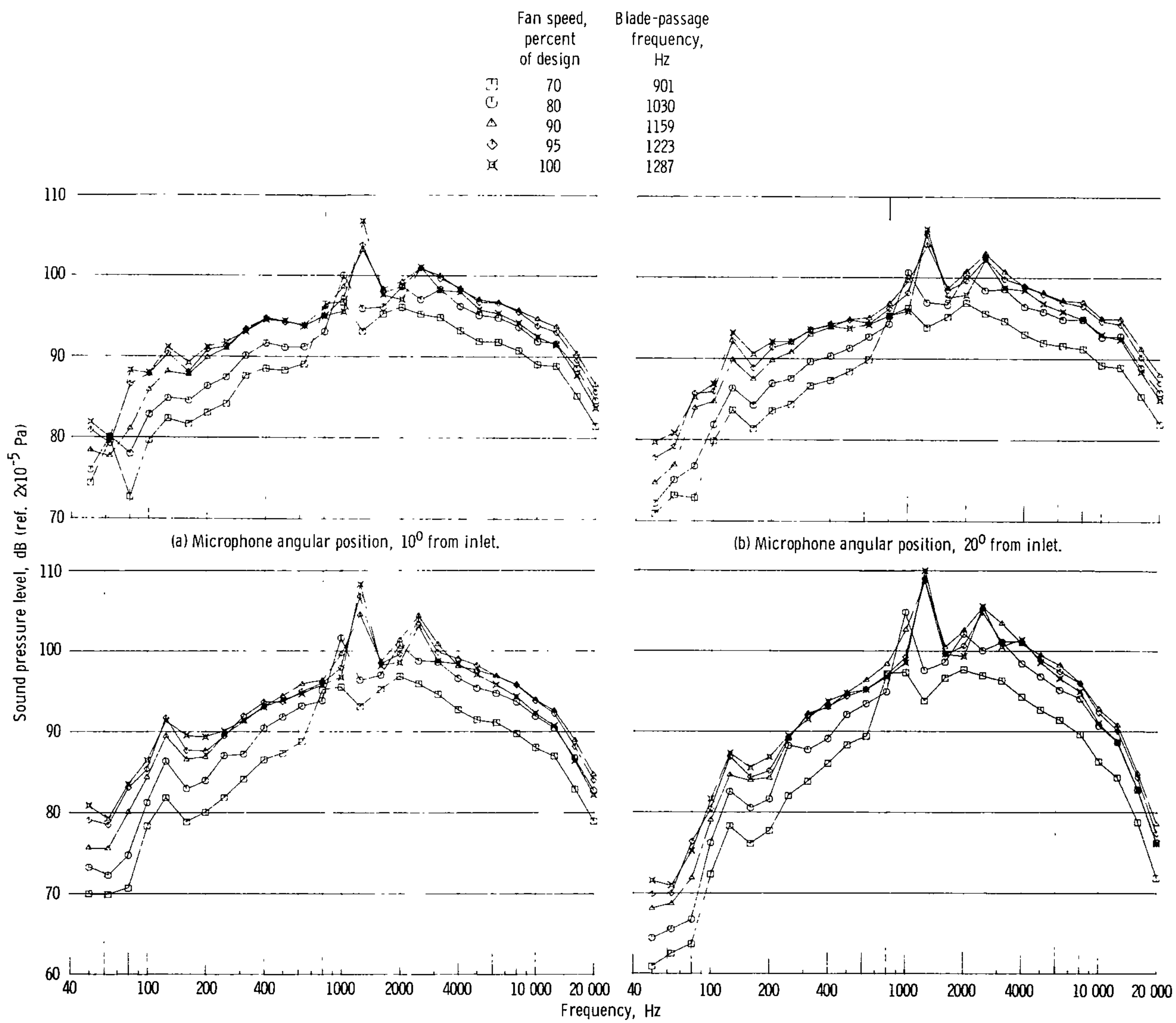


Figure 50. - QF-8 fan one-third-octave-band spectra on 30.5-meter (100-ft) radius sideline with 110 percent-of-design-area nozzle.

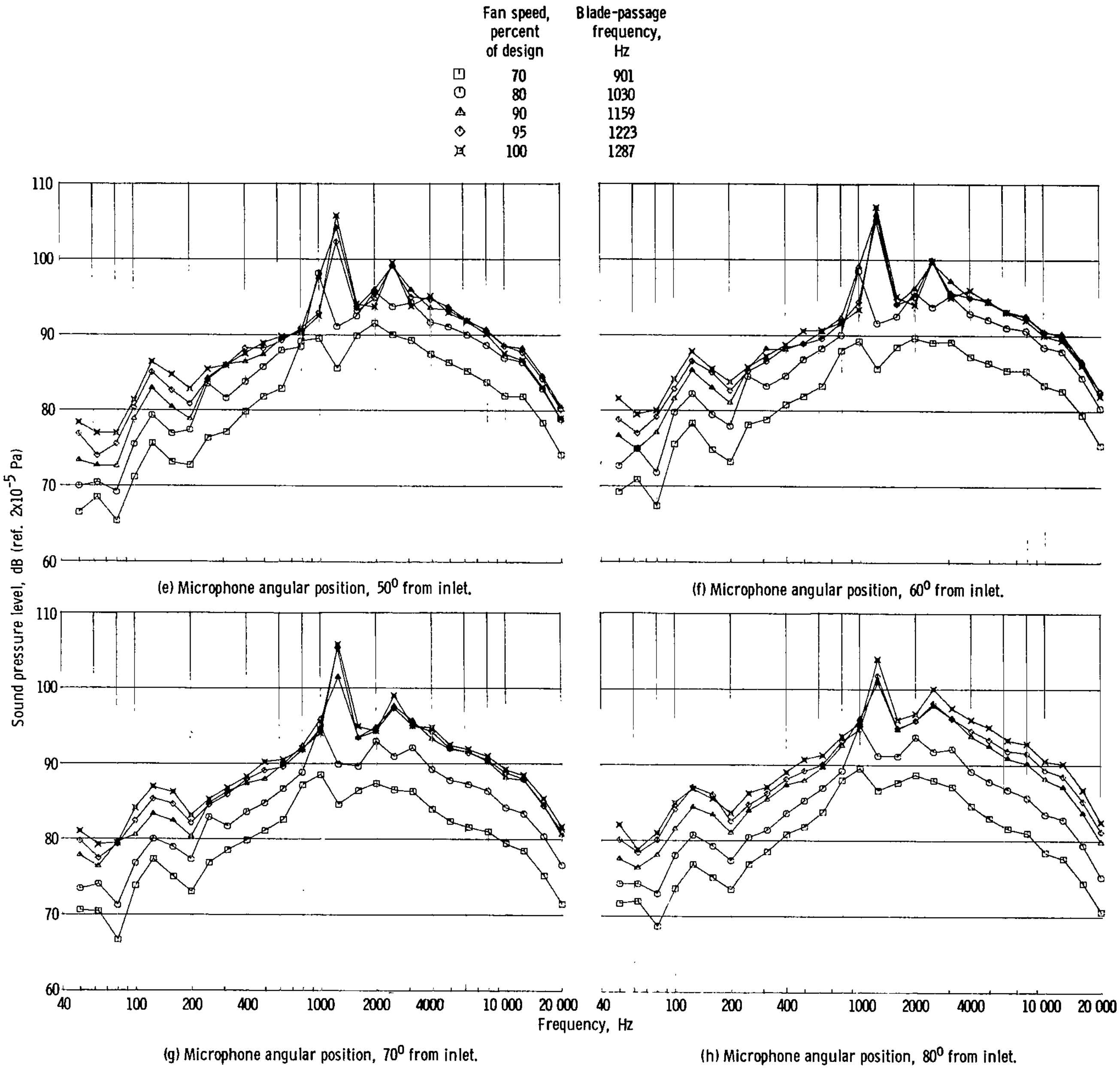
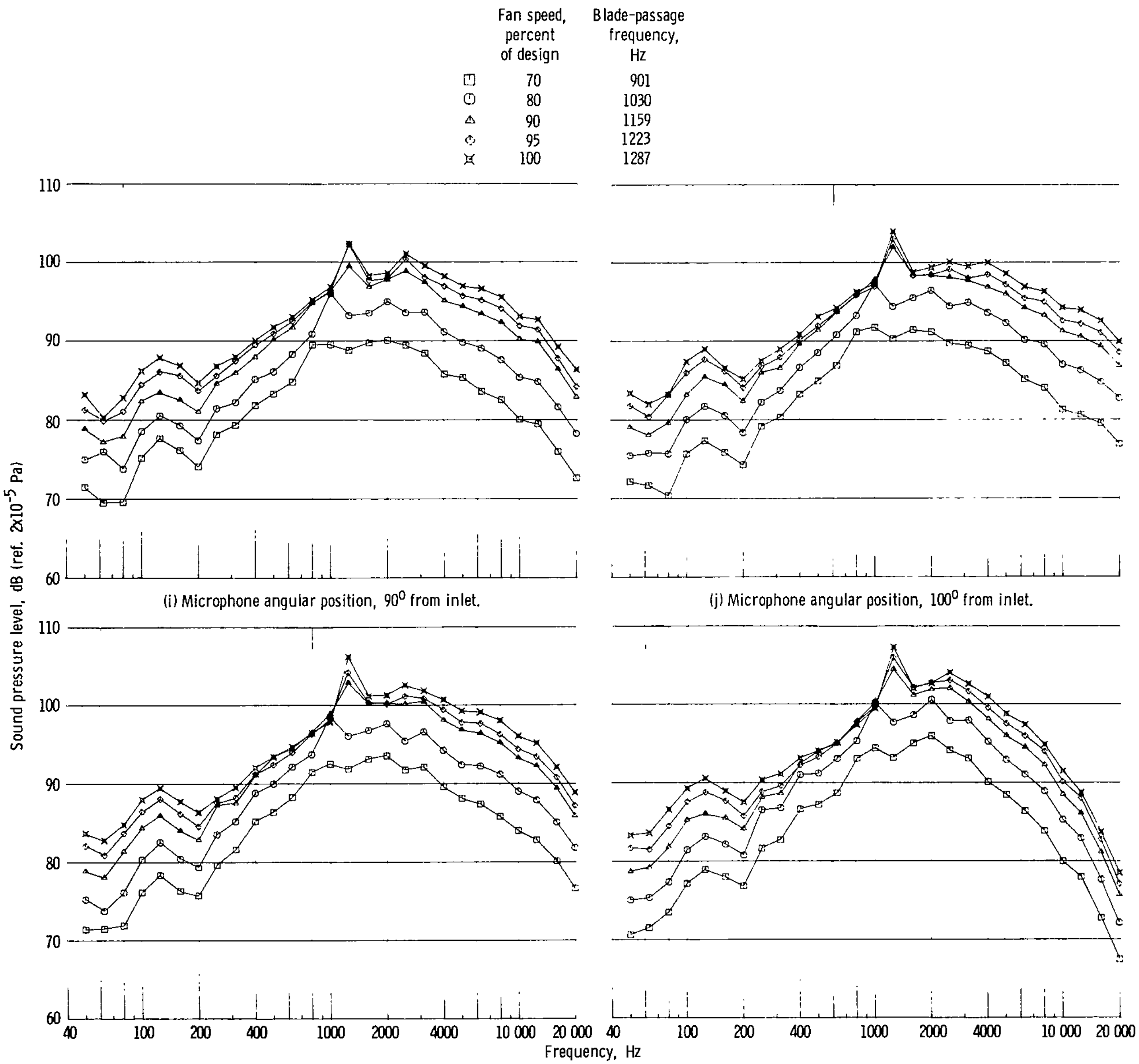


Figure 50. - Continued.



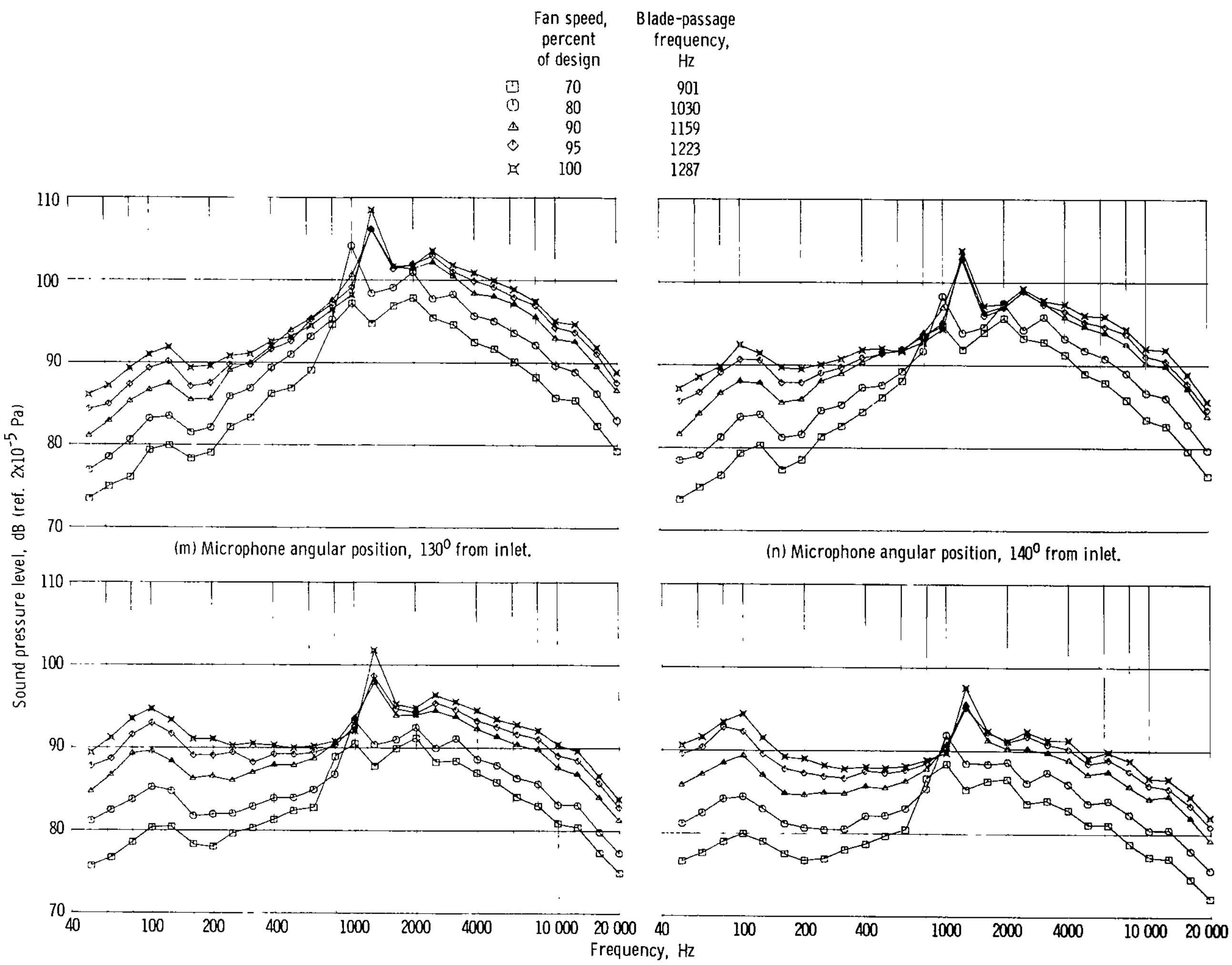
(i) Microphone angular position, 90° from inlet.

(j) Microphone angular position, 100° from inlet.

(k) Microphone angular position, 110° from inlet.

(ℓ) Microphone angular position, 120° from inlet.

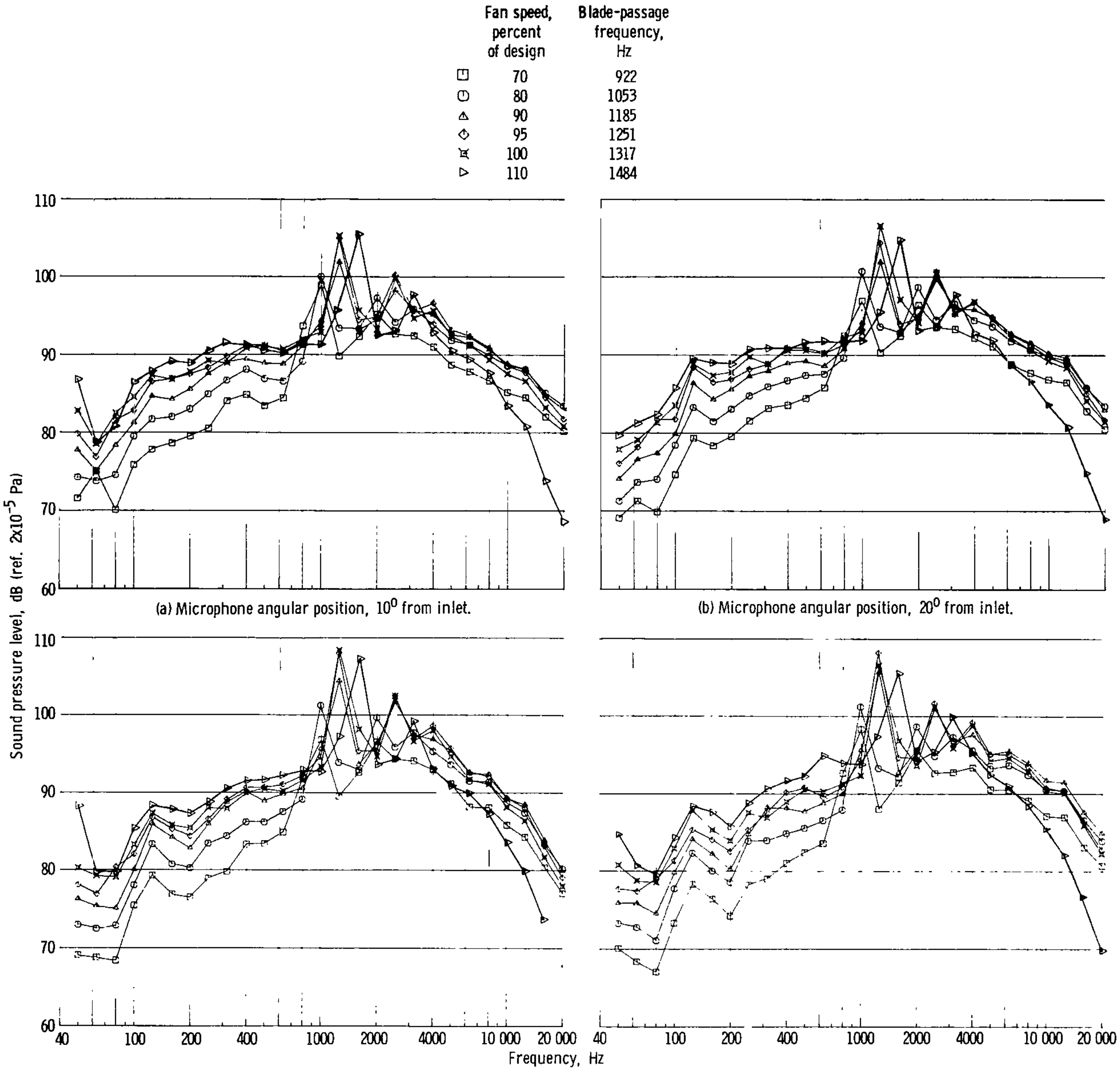
Figure 50. - Continued.



(o) Microphone angular position, 150° from inlet.

(p) Microphone angular position, 160° from inlet.

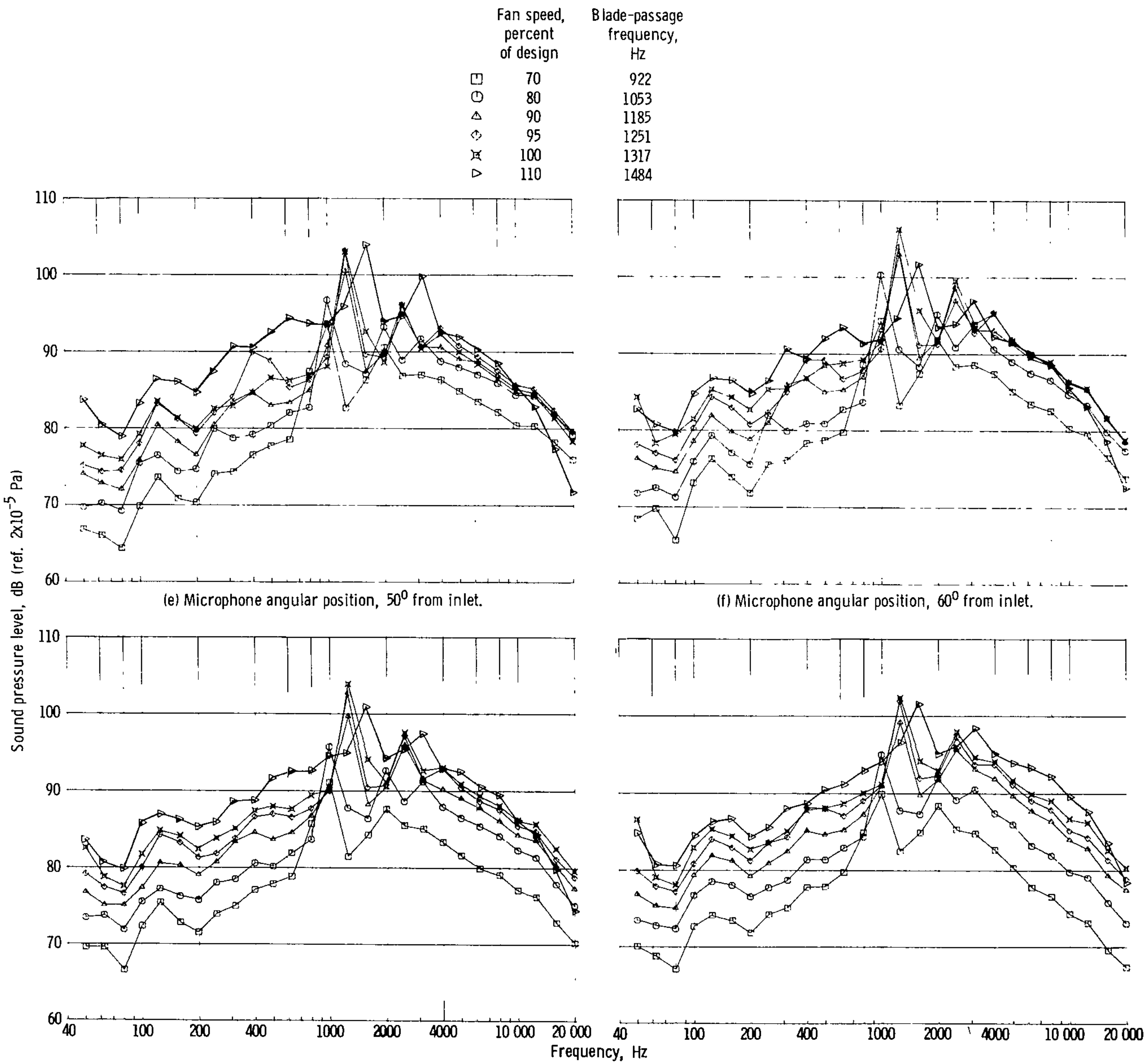
Figure 50. - Concluded.



(c) Microphone angular position, 30° from inlet.

(d) Microphone angular position, 40° from inlet.

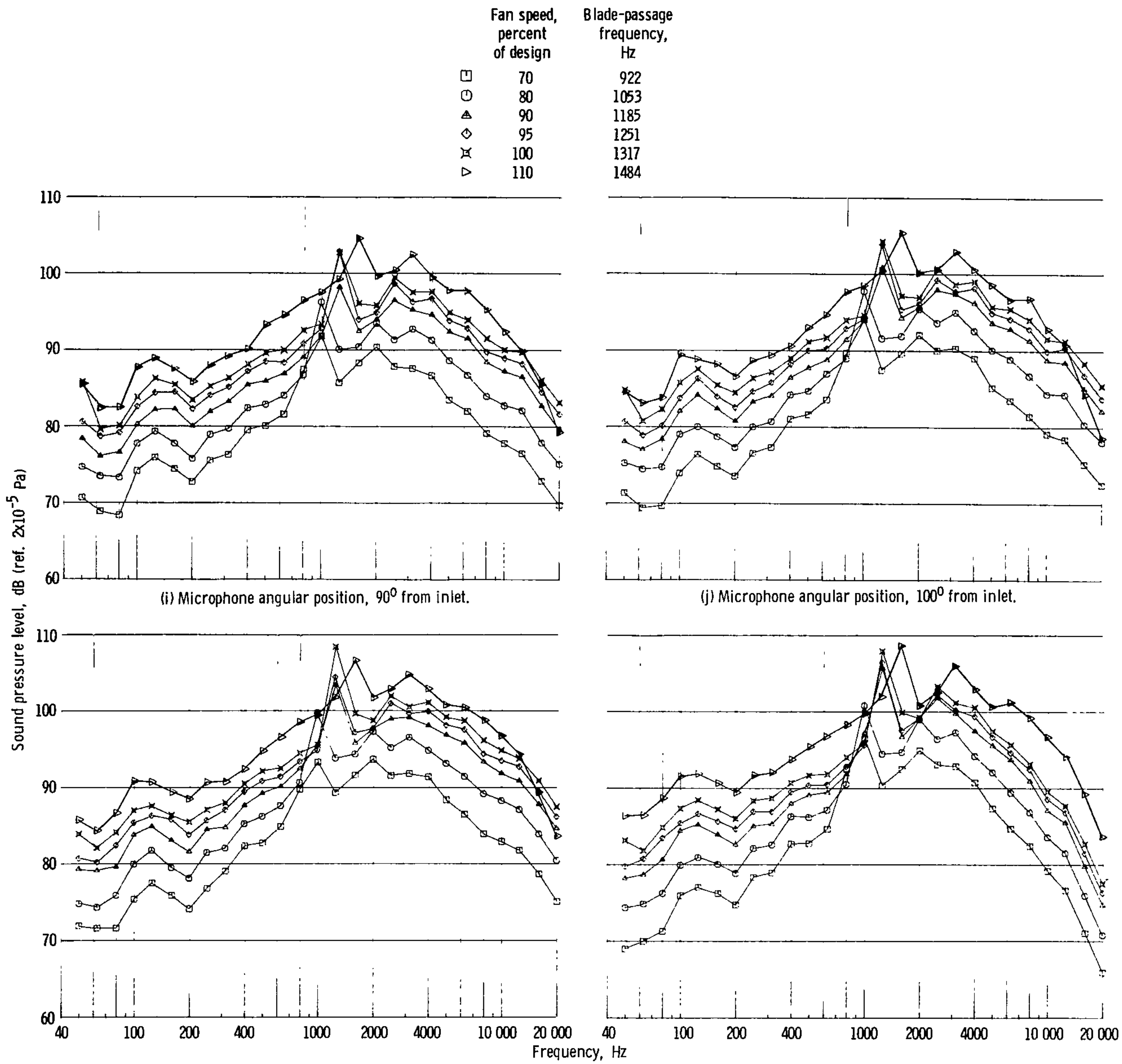
Figure 51. - QF-8 fan one-third-octave-band spectra on 30.5-meter (100-ft) sideline with 115 percent-of-design-area nozzle.



(g) Microphone angular position, 70° from inlet.

(h) Microphone angular position, 80° from inlet.

Figure 51. - Continued.



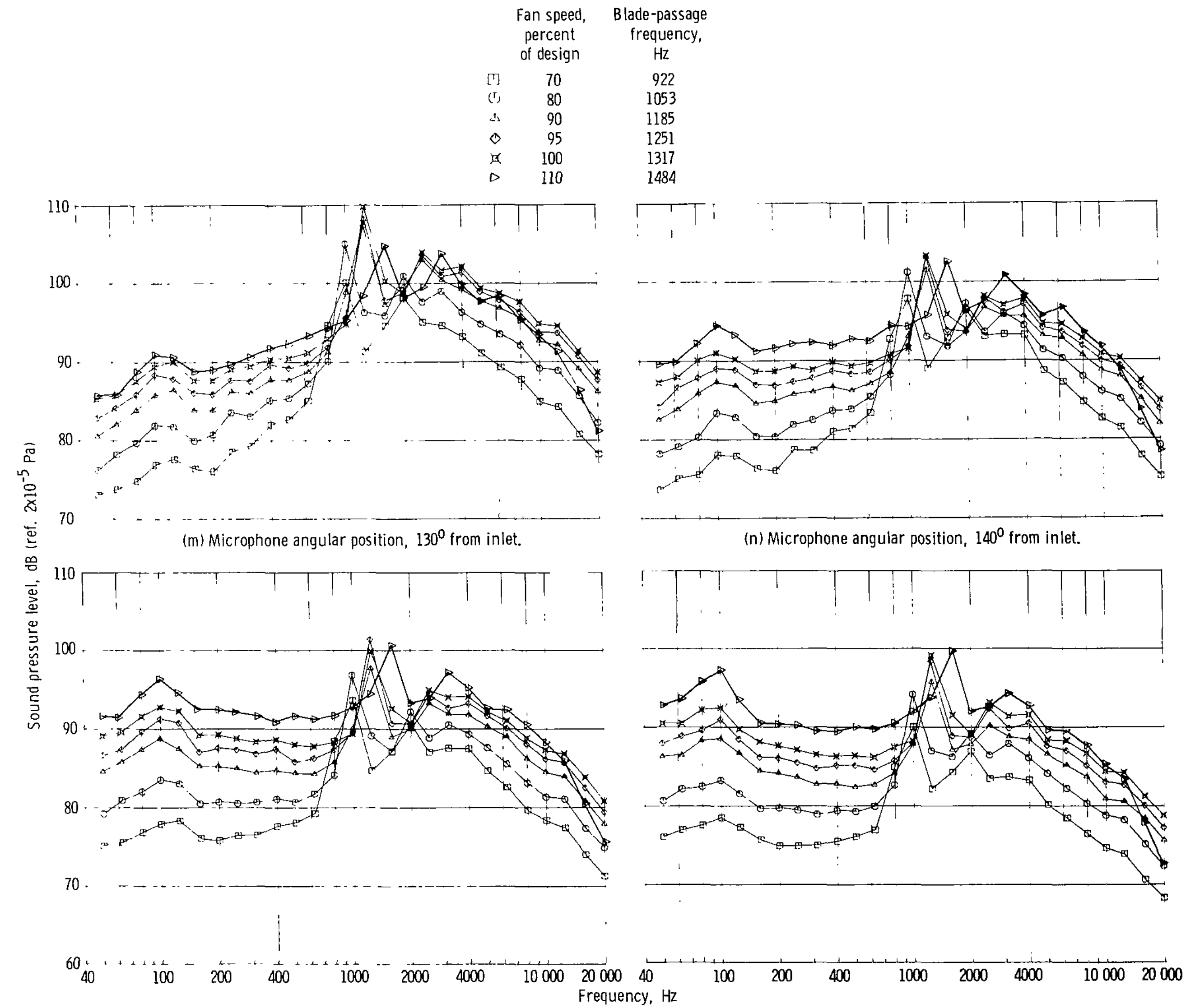
(i) Microphone angular position, 90° from inlet.

(j) Microphone angular position, 100° from inlet.

(k) Microphone angular position, 110° from inlet.

(ℓ) Microphone angular position, 120° from inlet.

Figure 51. - Continued.



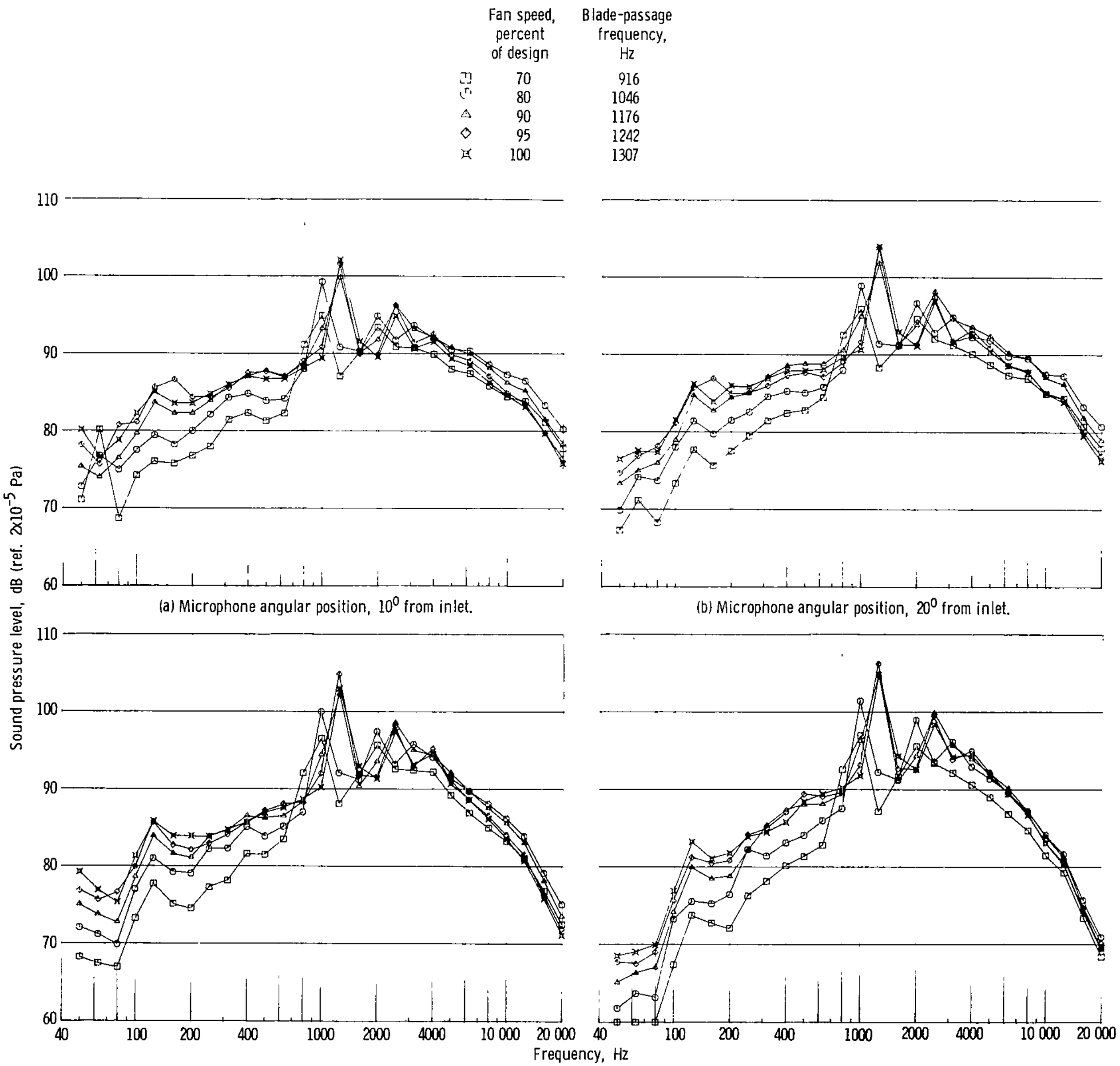
(m) Microphone angular position, 130° from inlet.

(n) Microphone angular position, 140° from inlet.

(o) Microphone angular position, 150° from inlet.

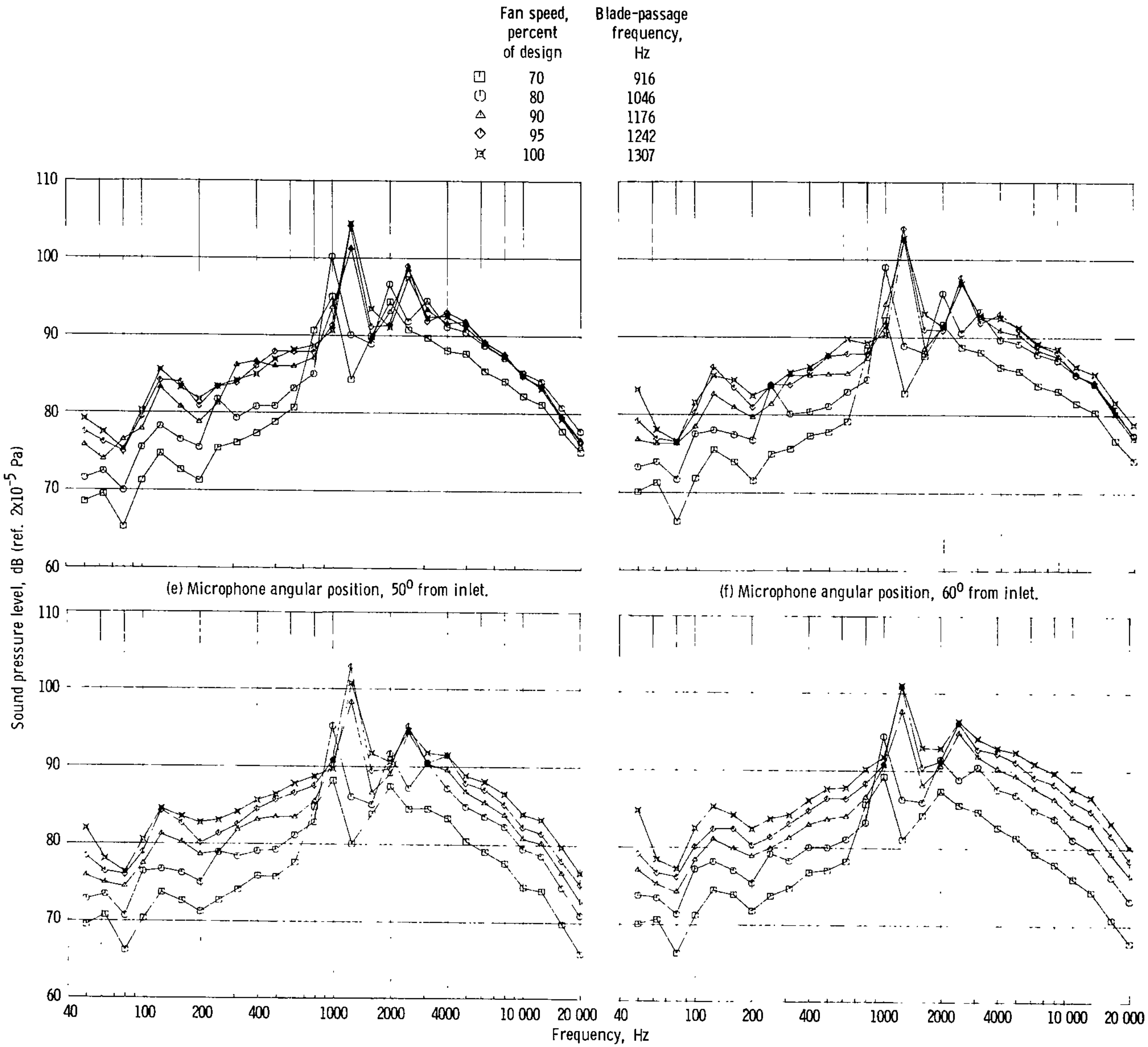
(p) Microphone angular position, 160° from inlet.

Figure 51. - Concluded.



(c) Microphone angular position, 30° from inlet. (d) Microphone angular position, 40° from inlet.

Figure 52. - QF-8 fan one-third-octave-band spectra on 30.5-meter (100-ft) sideline with 119 percent-of-design-area nozzle.



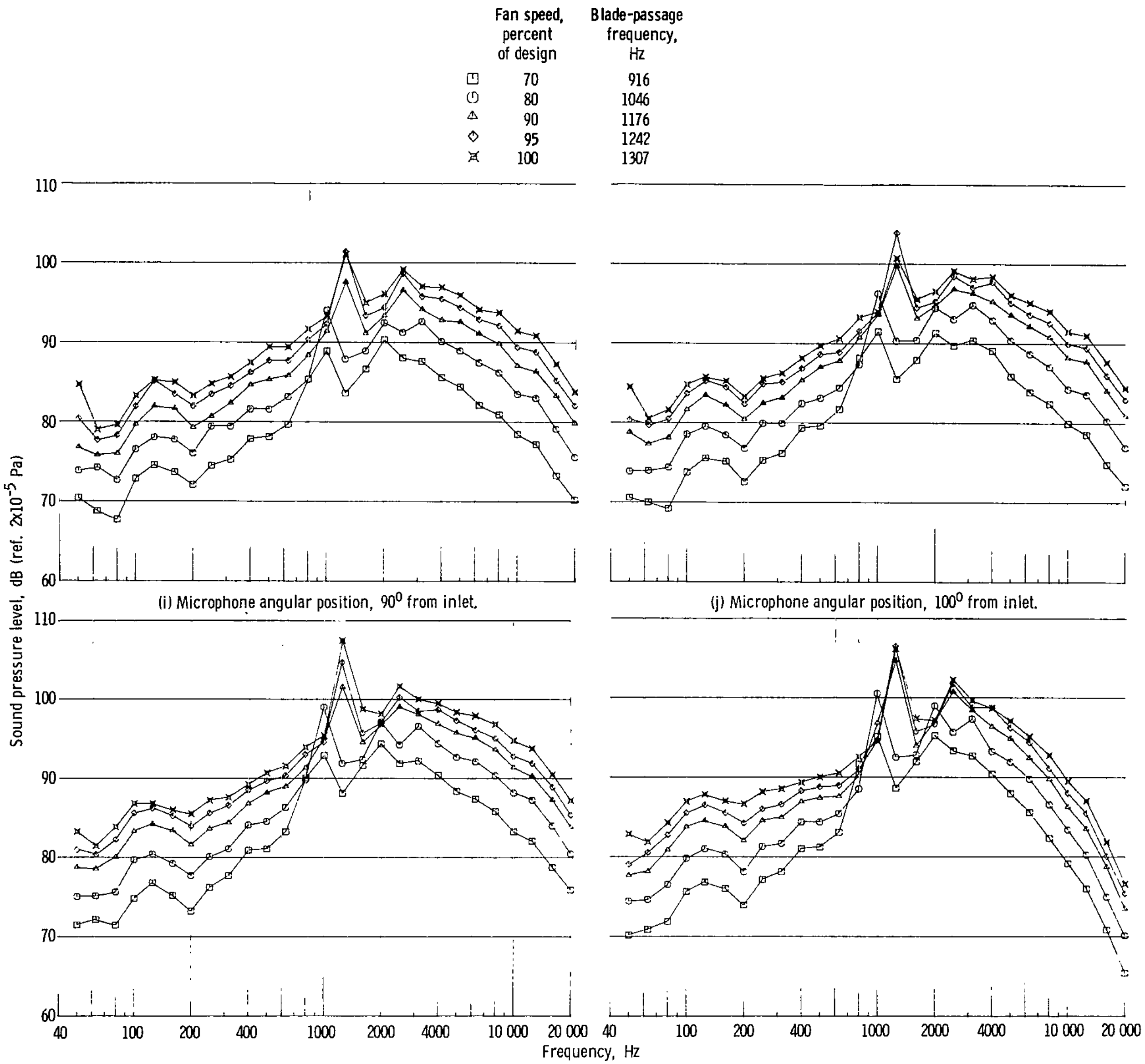
(e) Microphone angular position, 50° from inlet.

(f) Microphone angular position, 60° from inlet.

(g) Microphone angular position, 70° from inlet.

(h) Microphone angular position, 80° from inlet.

Figure 52. - Continued.



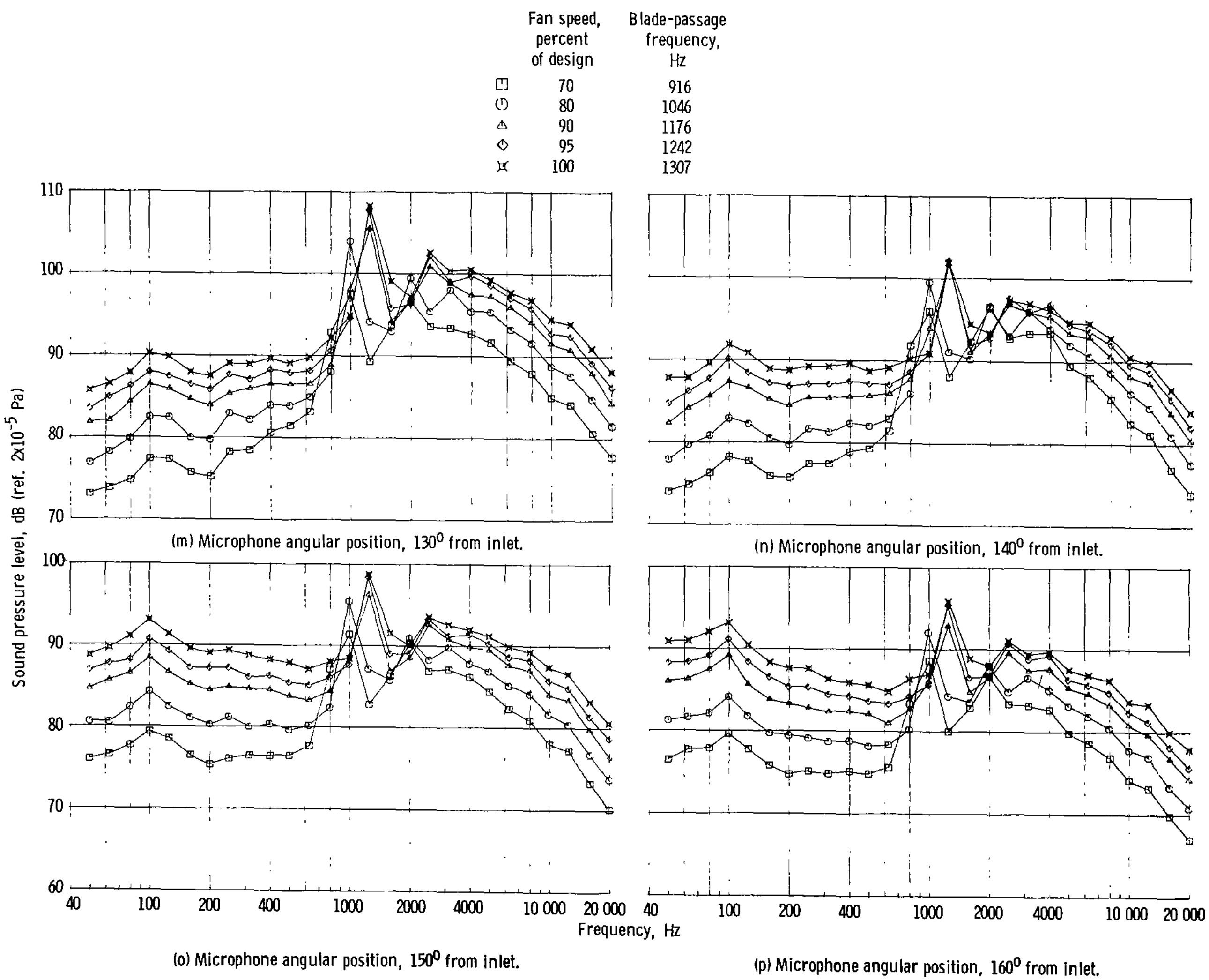
(i) Microphone angular position, 90° from inlet.

(j) Microphone angular position, 100° from inlet.

(k) Microphone angular position, 110° from inlet.

(ℓ) Microphone angular position, 120° from inlet.

Figure 52. - Continued.



(m) Microphone angular position, 130° from inlet.

(n) Microphone angular position, 140° from inlet.

(o) Microphone angular position, 150° from inlet.

(p) Microphone angular position, 160° from inlet.

Figure 52. - Concluded.

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