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ACOUSTIC AND AERODYNAMIC PERFORMANCE OF A 1.83-METER- (6-FT-) DIAMETER 1.2-PRESSURE-RATIO FAN (QF-6)

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16. Abstract

A 1.2-pressure-ratio, 1.83-m- (6-ft-) diameter experimental fan stage with characteristics suitable for use in STOL aircraft engines was tested for acoustic and aerodynamic performance. The design incorporated 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 rows. The stage was run with four nozzles of different area. The perceived noise along a 152.4-m (500-ft) sideline was rear-quadrant dominated with a maximum design-point level of 103.9 PNdB. The acoustic 1/3-octave results were analytically separated into broadband and pure-tone components. The stage noise levels generally increased with a decrease in nozzle area, with this increase observed primarily in the broadband noise component. A stall condition was documented acoustically with a 90-percent-of-design-area nozzle.

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SUMMARY

A 1.2-pressure-ratio, 1.83-meter- (6-ft-) diameter experimental fan stage, designated QF-6, with characteristics suitable for use in short-takeoff-and-landing (STOL) aircraft engines was tested for acoustic and aerodynamic performance. The design incorporated features for low noise, including absence of inlet guide vanes, low rotor-blade-tip speed (228.6 m/sec, or 750 ft/sec), low aerodynamic blade loading, and long axial spacing between the rotor and stator blade rows (four rotor chord lengths). The stage was run with the design nozzle, with nozzles having 90 and 95 percent of the design nozzle area, and with the nozzle removed to achieve 105 percent of the design nozzle area.

The design values for pressure ratio, corrected inlet weight flow, and corrected thrust were, respectively, 1.2, 396 kilograms per second (873 lbm/sec), and 70 950 newtons (15 830 lbf). The corresponding measured values for these parameters at design speed and with the design nozzle area were, respectively, 1.18, 397 kilograms per second (875 lbm/sec), and 61 098 newtons (13 632 lbf).

The sound pressure level spectra and the sound power level spectra were typical for a subsonic relative velocity fan, with the blade-passage tone and its harmonics dominating the spectra. The sideline perceived noise levels showed QF-6 to be rear-quadrant dominated, with a maximum design-point level along a 152.4-meter (500-ft) sideline of 103.9 PNdB. In general, a decrease in nozzle area caused an increase in noise level at any fan speed. An analytical separation of the noise into broadband and pure-tone components revealed that the noise level changes due to changes in nozzle area occurred primarily in the broadband noise component.

A stall condition existed with the 10-percent-undersized (90 percent of design area) nozzle at just above 80 percent of design speed. Narrow-band sound pressure level spectra taken during this stall show a major noise contribution at about one-third of the blade-passage frequency.

INTRODUCTION

Short-takeoff-and-landing (STOL) aircraft are being considered for operation in highly populated areas. Although no firm noise specifications exist at present for STOL aircraft that are comparable to Federal Air Regulation - Part 36 (FAR-36), a much-used goal for STOL sideline noise is 95 EPNdB along a 152.4-meter (500-ft) sideline (ref. 1). This noise level is for the entire aircraft and will dictate single-engine noise levels somewhat below this value. The reduction of engine noise is therefore an important consideration that will largely dictate the engine design. An engine suitable for a quiet STOL application would have a bypass ratio of about 15 (ref. 2). Such an engine would be expected to take off at its design speed.

This report presents the acoustic and aerodynamic performance of an experimental fan suitable for a low-noise STOL engine. This 1.83-meter- (6-ft-) diameter fan, designated QF-6, incorporated features for low noise, including lack of inlet guide vanes, low rotor-blade-tip speed, low aerodynamic blade loading, and long axial spacing between the rotor and stator blade rows. Fan QF-6 included 42 rotor blades and 50 stator blades and was designed for a maximum thrust of 70 950 newtons (15 830 lbf). The design rotor-blade-tip speed was 228.6 meters per second (750 ft/sec); the design stage pressure ratio was 1.2.

Fan QF-6 was run only with hard walls; that is, there were no acoustic suppression surfaces in the flow passages. The tested configurations included (1) the design nozzle; (2) nozzles with 90 and 95 percent of the design nozzle area; and (3) the nozzle removed, which resulted in an exit area 5 percent greater than that of the design nozzle.

The acoustic results for QF-6 are presented for sound pressure levels at various azimuth angles, for sound power levels, and for perceived noise levels based on 1/3-octave data. Narrow-band sound pressure level spectra are presented for selected data. Aerodynamic results including corrected weight flow, exit velocity, corrected thrust, and stage adiabatic efficiency are also presented.

U.S. customary units were used in these tests. Conversion to the International System of Units was made for reporting purposes only.

TEST FACILITY

Fan QF-6 was tested at the NASA Quiet Fan Facility, which is shown in figure 1. The fan was located on a concrete pedestal. The 10- by 10-Foot Supersonic Wind Tunnel drive motors were used to drive the fan through a gearbox and drive shaft and could maintain the fan speed within 3 to 5 rpm of the selected test speeds. In figure 1 the microphones are shown covered with plastic bags as weather protection between the tests. Foam treatment was added to the portion of the drive motor building wall that was considered likely to cause a sound reflection problem at the microphone locations. Subsequent to treating the building wall, calibration tests showed that the test site simulates a free field within 1-decibel accuracy at frequencies above 400 hertz.

Figure 2 is a plan view of the test site. The entire test site was surfaced with asphalt. The acoustic data were taken with an array of microphones located at the fan centerline elevation 5.9 meters (19.3 ft) on a 30.5-meter- (100-ft-) radius from the fan at angular positions from the fan inlet centerline of 10° to 160° (in 10° increments). 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 0° because of the presence of the drive shaft or above 160° because of the high-velocity fan exhaust. Further details on the design of the Quiet Fan Facility are given in reference 3.

FAN DESIGN

Acoustic and Aerodynamic Considerations

Fan QF-6, a 1.2-pressure-ratio experimental fan, was designed to have characteristics of the type of fan which might be used in a turbofan engine intended for consideration in externally blown flap, under-the-wing configurations for STOL airplanes. This fan was designed to be quiet within the constraints of conservative, conventional aerodynamic design practice. Among the acoustic considerations in the design are the absence of inlet guide vanes, the low rotor-blade-tip speed, the low blade aerodynamic loading, and the long axial spacing between the rotor and stator blade rows. These features have been used before in low-noise fans (ref. 4) and are compatible with good design practice.

Inlet guide vanes were omitted from the QF-6 fan because they produce a pattern of wakes at their trailing edges which impinge on the rotor blades, causing emission of noise at the blade-passage frequency (ref. 5). This is one important noise component whose minimization is sought.

Because of the low design pressure ratio, the rotor-blade-tip speed was sufficiently low such that supersonic inlet relative Mach numbers at the rotor blade tip could be avoided without the use of inlet guide vanes. Thus, the generation of multiple pure tones was not expected.

The energy input to the air by the rotor blades is a function of both rotor-blade-tip speed and blade loading. For acoustic reasons, both of these parameters should be low. The rotor-blade-tip speed should be low for the reason just discussed. On the other hand, reference 6 indicates that low diffusion factors (and thus low loading) will aid in reducing the discrete-tone noise levels. Thus, a compromise between rotor-blade-tip speed and blade loading was made. For QF-6 it was decided to select a conservative maximum limit for the design diffusion factor and to minimize the rotor-blade-tip speed by working to that limit. The diffusion factor of 0.4 which was selected as an upper design limit is considered to be conservative compared with the more generally used upper limit of approximately 0.55.

After a number of iterations on the aerodynamic design a tip speed of 228.6 meters per second (750 ft/sec) was selected to produce the pressure ratio of 1.2. At this speed the inlet rotor-blade-tip relative Mach number for the final design is 0.88, well under the sonic regime where added noise components (multiple pure tones) normally begin to appear in the noise spectra (ref. 7).

The axial spacing between rotor and stator blade rows was made as long as reasonably possible (four rotor chords at the mean radius) in an additional effort to limit the production of noise. This long spacing provides mixing length for the rotating wake pattern in the rotor exit flow to dissipate significantly before impinging on the stator vanes. Impingement of the rotating wake pattern on the stators causes the emission of sound at blade-passage frequency. With the rotor wakes largely dissipated as a result of the long spacing and with inlet-guide-vane wakes eliminated, a reduction in blade-row-interaction noise generation at blade-passage frequency was expected (ref. 8).

In addition to the foregoing low-noise features considered in the design of QF-6, the technique proposed in reference 9 was also incorporated in the design. This technique dictates that the stator vane incidence angles be adjusted during the design process to minimize the stator acoustic response to the periodic incoming rotating gusts from the rotor blade wakes. The technique also requires a relatively long stator vane chord to aid in the minimization of the stator acoustic output. The longer stator chord, combined with conventional stator solidities, resulted in a number of stator vanes (50) just slightly greater than the number of rotor blades (42).

It has become almost conventional to base the design of low-noise fans on the "cutoff" theory of reference 10 in order to prevent forward propagation of certain spinning modes. The implementation of this technique requires the fan to have a number of stator vanes which is usually more than twice the number of rotor blades. For this fan, this requirement is in conflict with that of reference 9, and as a result the cutoff theory was not incorporated in the QF-6 design.

There is an allowance in the design for operation under conditions of possible inflow distortion. Tolerance for such distorted flow is accomplished by lowering the specific inlet flow, and in this design the specific inlet flow was set at a value (182.6 kg/(sec)(m^2), or 37.4 lbm/(sec)($ft)^2$) that was some 5 to 10 percent lower than conventional practice for higher-pressure-ratio fans.

The QF-6 fan was designed to be tested by using part of the already existing structure and exhaust-end flow ducting of the Quiet Fan Facility. As a result the fan-rotor exit flow was not divided radially (fig. 3), as would be the case in an actual turbofan engine where the inner portion of the rotor exit flow is ducted into the inlet of the core engine. This had two significant effects on the fan design. First, the absence of the flow splitter behind the rotor imposed a restriction on the aerodynamic design of both blade rows by prohibiting the use of radially discontinuous flow to relieve the otherwise possibly severe flow conditions near the hub. This potential problem would be aggravated in a fan designed for this test facility by the nontypical requirement of axial stator exit flow in this region, a requirement imposed by the centerbody support pylon shown in figure 4. This pylon is a 20-percent-thick airfoil in cross section. Any significant angularity of the flow impinging on it would cause a large flow separation, which would in turn block a portion of the already minimal flow path in this area and could thus cause the fan to operate closer to, or in, stall. With a fan of higher pressure ratio this could have presented a problem, but at the low pressure ratio of QF-6 the hub flow conditions are not severe even with the undivided flow.

The second effect of the undivided exit-flow duct was not only to increase the amount of flow in the fan exhaust, but to increase it with lower energy and more turbulent air because of the higher losses of the stator-hub flow. These effects would combine to indicate a noise production, both fore and aft, that is potentially somewhat higher than that which would be measured on an actual engine designed with a similar fan. The possible increase in noise generated by QF-6 from this source was believed to be of little consequence and thus would not affect the test results or the conclusions drawn from them.

In addition to the aeroacoustic design considerations already discussed, there were several more subtle details of the aerodynamic design that had acoustic significance or origin. These are discussed in the presentation of the details of the aerodynamic design in appendix A.

Mechanical Considerations

The tip diameter at the inlet of the QF-6 fan was set at 1.83 meters (6 ft) principally to maintain a "family" similarity among a group of fans designed for testing in this facility and also because of a dimensional limitation of the test hardware.

An inlet hub- to tip-diameter ratio of approximately 0.4 was desired as being representative of low-pressure-ratio fans. However, again because of dimensional limitations of the test hardware and after optimizing the flow path through the entire fan and its ducting, a hub- to tip-diameter ratio of 0.418 was found to be the lowest attainable.

Another fan dimension dictated by the test hardware was the stator-hub inlet diameter, which was somewhat greater than was desired. This had the effect of causing the hub flow-path wall to diverge considerably through the rotor and between the blade rows. This divergence had the beneficial effect of lowering the diffusion factors in the hub region of the rotor, although it raised them slightly near the stator hub.

With the stator-hub inlet diameter set by the test hardware and with the stator inlet volume flow set by the rotor inlet flow and the rotor energy addition, the stator-blade-tip diameter could be determined. This diameter was very slightly greater than the rotor-blade-tip diameter (by ~3.6 cm, or 1.4 in.). The resulting flow path through the stage (fig. 3) does not represent exactly the flow path which would be used in an actual engine fan of this type; but, once again, this was believed to have no adverse effect on the validity of the acoustic results for this fan.

Design Details

Selected design parameters are presented in table I. Complete details of the aerodynamic and blade designs are given in appendix A.

Aerodynamic Data

In order 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 5. Six equally spaced iron-constantan thermocouples were located on the bellmouth lip to determine the average inlet total temperature. These thermocouples extended somewhat from the surface to measure the ambient air temperature. Six static pressure taps were used for the inlet weight flow calculation, which was based on the assumptions of uniform one-dimensional flow, zero total pressure loss at the duct station, and a zero 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 identical total pressure and temperature rakes were used downstream of the stator blade row to determine the stage exit mass flow and the mass-averaged stage total pressure ratio. Iron-constantan thermocouples were used on these rakes. These rakes, one of which is shown in figure 6, were located nominally at 90° intervals but were displaced slightly in order to avoid being in a stator wake. Finally, just downstream of the nozzle exit, three equally spaced total and static pressure rakes were used for exit momentum or thrust calculations. One exit rake is presented in figure 7. This rake has three inner total pressure elements missing but sketched as they existed for testing. All rakes were removed for acoustic tests.

Performance parameters were corrected to standard-day conditions: a temperature of 15° C and atmospheric pressure of 760 mm of Hg at 0° C.

The aerodynamic data were recorded through a pressure-multiplexing valve, a pressure transducer, and a 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 separate points were taken at each test condition of speed and configuration. The arithmetic averages of the computed parameters are presented in this report.

Acoustic Data

Data acquisition system. - As indicated previously, acoustic measurements were made outdoors with microphones located on the horizontal centerline of the fan - 5.9 meters (19.3 ft) above ground level. The test site surface was asphalt. The 16 far-field microphones were located on a 30.5-meter- (100-ft-) radius (fig. 2). The microphone angular positions were measured from the fan inlet axis. In making the noise measurements, 1.3-centimeter- (1/2-in.-) diameter condenser microphones were used which had sensitivities of -60 decibels relative to 1 volt per microbar. The frequency response of the system, as a whole, was flat from 50 hertz through 20 kilohertz. Three separate samples of 100-second duration were taken for each fan speed point and averaged.

The acoustic data were both reduced on line through 1/3-octave-band filters and recorded on magnetic tape for further analysis. Prior to the set of tests for each configuration a pistonphone signal was impressed on each far-field microphone for absolute calibration.

1/3-Octave-band analysis. - The 1/3-octave-band analyzer used for on-line data reduction employed a 4-second averaging time and stepped sequentially through the angles from 10° to 160° (in 10° increments). The 4-second averaging time was selected to accommodate all angles within a 100-second sample while preserving analyzer repeatability. Options for the output of the analyzer included an oscilloscope which presented the sound pressure level (SPL) spectrum, a digital printer, and a digital incremental tape recorder.

Results of 1/3-octave-band sound pressure level 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 the continuous frequency-dependent functions derived from reference 11. The complete procedures set forth in reference 11 were not applied, as they presuppose a spectrum typical of engine jet noise. For the QF-6 results, which include significant fan noise as well as jet noise, the general shape of the measured spectrum was accounted for and the 1/3-octave-band attenuations were obtained by integrating the continuous absorption functions over each band (ref. 12).

For power calculations the sound pressure levels were presumed to be axisymmetric and were integrated over an enclosing hemisphere. Implicit in this procedure was that the ground plane was perfectly reflective in the sense that acoustic intensity was doubled in the far field. Signal interference effects at the microphones caused by ground reflections were not taken into account.

By using data referred to the source, calculations of atmospheric absorption for a standard day of 15° C and 70 percent relative humidity were made and the data so adjusted to standard-day conditions. All 1/3-octave-band sound pressure level data reported herein are adjusted to standard-day conditions.

The perceived noise levels (ref. 13) were calculated 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 caused by the fan noise. For the sideline perceived noise level determinations the data were adjusted to a 152.4-meter (500-ft) sideline, which has become standard practice for STOL noise evaluations.

Narrow-band analysis. - Fine-resolution, constant-bandwidth analysis allows a detailed study of the SPL spectra which is not always possible with the 1/3-octave analysis. By using the magnetic-tape-recorded data, narrow-band spectra were made of selected 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 related to the total frequency range of the spectrum, with a 32-hertz bandwidth corresponding to a 10-kilohertz total range and a 3.2-hertz bandwidth corresponding to a 1-kilohertz range.

AERODYNAMIC PERFORMANCE

The Quiet Fan Facility was primarily designed for acoustic testing of full-scale candidate engine fans. The facility incorporated limited aerodynamic instrumentation, as previously described, to give an indication of the aerodynamic performance of the fan. Consequently, the aerodynamic results for QF-6 are not as precise as might have been obtained from a specialized aerodynamic test facility. Table II summarizes the selected aerodynamic results for QF-6 for all four tested configurations.

Figures 8 to 17 present selected aerodynamic results for QF-6. In general, the aerodynamic results are presented as a function of the percent of corrected fan design speed to facilitate a correlation of these results with the acoustic results. Stage pressure ratio is shown in figure 8 as a function of percent of corrected fan design speed. Fan QF-6 went into a stall condition with the 10-percent-undersized nozzle at slightly above 80 percent of design speed. Hence, the higher speed data are not available for this configuration. Irrespective of nozzle area the maximum pressure ratio at design speed was about 0.02 lower than the design value.

The results of the corrected mass-flow calculations at the inlet duct station (fig. 9) were found to be in reasonably good agreement with the corresponding calculations at the stator exit station (fig. 10). The inlet corrected mass flow was essentially at the design value at design speed for the design nozzle area. The results for 105-percent-of-the-design-area nozzle (nozzle removed) were irregular at the inlet duct station, with the calculated corrected mass flow for the 105-percent-of-design-area nozzle being somewhat less than that for the design nozzle at similar fan speeds. This result is evident in figure 9 and in figure 11, which shows the pressure ratio as a function of the inlet corrected mass-flow rate. A similar fan map based on stator exit corrected mass-flow rate is given in figure 12, and the nozzle operating points fall in conventional order.

The measured adiabatic efficiencies (fig. 13) fall considerably below the theoretical design value of 0.879. However, the measured values may be low because of the limited instrumentation of the outdoor test facility. In addition to approximately a $\pm 1^{\circ}$ C measurement error of the iron-constantan thermocouples, it is likely that the efficiency measurements were adversely influenced by such facility effects as exhaust flow reingestion. With the relatively low stage pressure ratio of 1.2 the theoretical isentropic temperature ratio is only 1.053, giving a temperature rise of 15.4° C (27.7° F) above the standard-day temperature. Hence, small errors in temperature measurement may significantly affect the aerodynamic results. Although low, the efficiency points do follow a reasonably smooth curve for each fan configuration, with the efficiency decreasing with decreasing nozzle area.

An earlier fan design was tested in full scale at the Quiet Fan Facility, and as a small-scale (50.8-cm (20-in.) diam) model in a highly instrumented indoor aerodynamic test facility. In these tests the measured design-point efficiency of the small-scale model was nearly at the design value, while the measured design-point efficiency of the full-scale fan was about 10 percentage points below the design value. Otherwise, the corresponding parameters measured on the full-scale fan and on the small-scale model were in reasonable agreement - thus supporting the conclusion that the efficiencies measured at the full-scale Quiet Fan Facility are consistently below the correct values.

The corrected thrust as a function of percent of corrected fan design speed (fig. 14) shows that QF-6 developed somewhat less than the design corrected thrust of 70 950 newtons (15 830 lbf).

Figure 15, a presentation of the corrected nozzle exit velocity as a function of the inlet weight flow, is included for the reader who may wish to correlate the acoustic results as a function of the fan exit velocity.

As an insight into the typical variation of the aerodynamic results, figures 16 and 17 present the pressure data taken for one design-point (design nozzle area and speed) sample. Figure 16 presents the total pressure ratio for each element of the four rakes located at the stator exit station. The corresponding static pressure ratio as a function of angular position at the inlet duct station and at the stator exit station is shown in figure 17. The location of the downstream support pylon is noted in this figure.

ACOUSTIC PERFORMANCE

Sound Pressure Level

Figure 18 presents the 1/3-octave SPL spectra at 70 and 100 percent of design speed for two angular positions. The SPL spectra at 40^{o} and 120^{o} from the inlet are presented, respectively, in figures 18(a) and (b). These angles were selected as being representative of the front- and rear-quadrant data. The SPL spectra are typical fan spectra, with pronounced blade-passage frequency (BPF) and second-harmonic (2 BPF, twice blade-passage frequency) spikes. The QF-6 fan operated at subsonic velocities, with a design-speed rotor-blade-tip inlet relative Mach number of 0.88. Multiple pure tones were not observed in the noise spectra.

Figure 19 presents the narrow-band (constant 32-Hz bandwidth) spectra corresponding to the spectra in figure 18. Again the only pronounced features of the narrow-band spectra are the blade-passage-frequency tone and the harmonic spikes, with several harmonic spikes evident. The front-quadrant-angle (40^{o}) spectra at 70 and 100 percent of design speed, (figs. 19(a) and (b), respectively) show a slower harmonic decay rate (i.e., higher order harmonics more evident) than do the corresponding rear-quadrant-angle (120^{o}) spectra of figures 19(c) and (d).

Noise Components

As part of the 1/3-octave spectra analysis an attempt was made to separate the pure-tone and broadband components of the fan noise. The method used to separate these components is outlined in figure 20. A portion of the SPL spectrum at design speed and 40^{o} from the fan inlet is used for this discussion. Beginning with the actual spectrum an assumed broadband spectrum was drawn by disregarding those data points thought to be influenced by the pure-tone noise. In many cases the pure-tone spike was shared by two 1/3-octave filters. The pure-tone contribution to the SPL was found at each filter frequency by performing a decibel subtraction of the assumed broadband spectrum level at that frequency from the data SPL as given in figure 20. All pure-tone contributions, fundamental and harmonics, were then added to give the total pure-tone level, which in the case of figure 20 was 103.5 decibels. Finally, this total pure-tone value was subtracted from the overall SPL for the spectrum to give the actual broadband SPL level. Had the fan operated with a rotor-blade-tip relative Mach number greater than 1.0, the possible existence of multiple pure tones in the noise spectra would have made this separation of tones much more difficult. This method of separating the pure-tone and broadband noise 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 1/3-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 14.

The method presented in figure 20 was used to separate the pure-tone and broadband SPL components as a function of the angle from the fan inlet for the design nozzle configuration, as shown in figure 21. Both the pure-tone component (fig. 21(a)) and the broadband component (fig. 21(b)) increased in level with increased fan speed, except for some slight overlap considered to be caused by data fluctuations. The pure-tone component had an increase at 120° and 130°, which became more pronounced with increased fan speed. This increase was not observed in the broadband component at these angles except for the 60-percent-of-design-speed data at 130°, which is probably a data irregularity.

Figure 22 presents the broadband component of the SPL noise as a function of the angle from the fan inlet at 60, 80, and 100 percent of design for all four tested nozzle areas. At each speed the broadband noise level increased with decreasing nozzle area. However, at design speed (fig. 22(a)), the results for the 100- and 105-percent-of-design-nozzle areas are nearly identical. At lower fan speeds (figs. 22(b) and (c)) the results for these two configurations begin to assume the expected relation, with the smallest-design-nozzle-area configuration generating the greatest broadband noise.

The lower adiabatic stage efficiencies associated with decreasing nozzle area (fig. 13) may possibly be relatable to the increase in broadband noise levels with decreasing nozzle area. With a decrease in nozzle area the stage pressure ratio at a particular fan speed was seen to remain essentially constant (fig. 8). However, the corrected weight flow decreased with a decrease in nozzle area at a particular speed (figs. 9 to 12), implying an increased blade loading with the decreasing nozzle area; that is, the operating point is closer to stall. It is believed that the increased blade loading (decreased nozzle area) increases the unsteadiness and turbulence of the air, thus tending to increase the random broadband noise.

Sound Power Level

A useful method of presenting the acoustic results on a nondirectional basis is the sound power level. The overall sound power levels (OAPWL) are presented as a function of corrected rotor-blade-tip speed in figure 23 and of the fan stage pressure ratio in figure 24. Figure 23 shows the OAPWL to increase in a regular manner with speed for all configurations, with the increasing OAPWL corresponding to decreasing nozzle area at each fan speed.

The correlation with fan stage pressure ratio (fig. 24) is likewise regular, with a general increase in OAPWL with decreasing nozzle area at each pressure ratio. The results for the 90-percent-of-design-area nozzle show a slope deviation for the highest pressure ratio point attained (80 percent of design speed). This may be relatable to the approaching stall condition which occurred at just above 80 percent of design speed for this configuration. Again, the low efficiencies (fig. 13) calculated for this configuration may reflect a more unstable, hence noisier, flow condition.

The sound power level results were separated into pure-tone and broadband components in the same manner as the SPL results. Figure 25 presents this component PWL as a function of the corrected rotor-blade-tip speed. The solid symbols for the broadband noise show the usual increase in noise level with a decrease in nozzle area at each tested fan speed. The pure-tone PWL (open symbols) has, considering reasonable data scatter, no effect of nozzle area except for a decrease in PWL with the 90-percent-of-design-area nozzle. The results of this nozzle follow the slope of the pure-tone-component results of the other three configurations but fall about $1\frac{1}{2}$ decibels below the other results. This is possibly a reflection of the reduced mass flow and efficiency of this configuration, with more turbulent airflow shifting the sound energy into the broadband.

Figure 26 presents a further analysis of the relation of overall sound power level and fan efficiency as functions of nozzle area. The sound power level was normalized with respect to thrust at each speed by the subtraction of 10 $\log_{10}$ (Thrust/Design-area thrust) at each fan speed. In this figure the sound power level decreases with increasing nozzle area. Perhaps some minimum sound power level would be reached at each speed with a further increase in nozzle area. At the same time the efficiency increases with increasing nozzle area, also with the possibility that a maximum efficiency for each speed might be reached with a larger nozzle area. This comparison tends to support the contention that high efficiency is associated with low noise for a fan stage.

Reference 15 indicates that fan sound power level, normalized for thrust level, correlated with the 1.4 power of $\log_{10}$ (Fan total pressure ratio minus 1). By using the methods of reference 15 the sound power data of figure 26 were normalized with respect to both thrust and pressure ratio. Thrust was normalized with respect to the thrust value for design speed and nozzle area (60 638 kg (13 632 lbf)). The normalized sound power level values for all points in figure 26 were plotted against $-\log_{10} (1 - \eta)$ in figure 27. The data follow a slope of -2 to give a relation described by

$$\mathrm{PWL} = 10 \log_{10}\left(\frac{\text{Thrust}}{\text{Design-area thrust}}\right) + 14 \log_{10} (\mathrm{PR} - 1) + 20 \log_{10} (1 - \eta) + 174.5 \qquad (1)$$

providing a further correlation of noise in terms of efficiency for this fan. All symbols are defined in appendix B.

It should be noted, however, that since pressure ratio showed essentially no variation with nozzle area at a given speed (fig. 8), the variation in efficiency also represents an inverse variation in rotor work coefficient (function of actual work input divided by the product of efficiency and the square of the corrected tip speed). Thus, figure 27 might also reflect the effect of average blade loading.

Perceived Noise

The perceived noise levels, which are frequency weighted for human hearing sensitivity, are of major importance in selecting a fan for a quiet STOL aircraft engine. Figure 28 presents the perceived noise levels along a 152.4-meter (500-ft) sideline as a function of angular position from the inlet. Figures 28(a) to (e) present, respectively, the perceived noise results for 60, 70, 80, 90, and 100 percent of fan design speed. At 90 and 100 percent of design speed (figs. 28(d) and (e)) results are not available for the 90-percent-of-design-area nozzle because of the stall condition. At each speed the perceived noise level increased with a decrease in nozzle area. Also, as the speed increased, the perceived noise levels of the 100- and 105-percent-of-design-area nozzle configurations began to merge, with the results of the two configurations being at about the same perceived noise level at each angle at design speed. This behavior is similar to that of the broadband SPL results of figure 22. For all configurations at all speeds the perceived noise levels were rear-quadrant dominated; that is, the highest noise levels occurred in the rear quadrant.

The maximum perceived noise level along a 152.4-meter (500-ft) sideline plotted against the corrected rotor-blade-tip speed for various nozzle areas is presented in figure 29. The maximum value, like the perceived noise levels in general, increased with decreasing nozzle area. The 100- and 105-percent-of-design-area-nozzle results have about the same maximum level at 60 and 70 percent of design speed, with the 105-percent-nozzle results being somewhat lower than the design nozzle results at higher speeds.

Figure 30 presents the maximum perceived noise level along a 152.4-meter (500-ft) sideline as a function of the stage pressure ratio. This figure is very similar to the presentation of the overall sound power level in figure 26. Again, the slope deviation of the 90-percent-of-design-area-nozzle results at 80 percent of design speed may be relatable to the stall condition which occurred at just above 80 percent of design speed.

In figure 30 the maximum perceived noise along the 152.4-meter (500-ft) sideline at the fan design speed was 103.9 decibels. This results in a maximum perceived noise level of 110 decibels along a 152.4-meter (500-ft) sideline when adjusted for a 400 340-newton (90 000-lbf) thrust STOL aircraft. As this is considerably above the desirable maximum perceived noise level of 95 PNdB for an aircraft as described, acoustic treatment would be required to lower the fan noise in a STOL aircraft application. The fan noise, constituting only a part of the overall aircraft noise, would have to be reduced somewhat below 95 PNdB.

It has been noted (e.g., ref. 15) that the maximum fan perceived noise along a 304.8-meter (1000-ft) sideline is relatable to the stage pressure ratio in such a way as to generate a "family" curve for fans of similar design. For this comparison the methods of reference 12 were used to adjust the noise level to a 400 340-newton (90 000-lbf) thrust. The plotted maximum noise level consists of the measured PNdB + 10 $\log_{10}$ [400 340 N/(Measured thrust)]. Reference 15 suggests that this thrust-adjusted sideline perceived noise may be approximated within a scatterband of ±2 PNdB by the curve

$$\mathrm{PNL} = 62.4 + 14 \log_{10} (\mathrm{PR} - 1) + 10 \log_{10} F \tag{2}$$

where F is the thrust in pounds force. This relation is for single-stage, low-tip-speed fans. In figure 31 the thrust-adjusted QF-6 design-point result is seen to fall about 2 PNdB above this curve. The reader should be cautioned that the QF-6 result was used in the statistical analysis of the results from a number of fans which established this relation.

Stall Condition Spectra

Magnetic tape recordings were made of the acoustic data during the stall condition with the 90-percent-of-design-area nozzle. Continuous recordings were made as the fan speed was slowly increased from 80 percent of design until audible stall occurred. Although the actual time the fan was in stall was short, it was possible to use a short scan time to obtain narrow-band spectra of this condition. Figure 32 shows the progression of this stall condition in three narrow-band SPL spectra of 16-hertz bandwidth taken at 120° from the fan inlet. Figure 32(a) presents a normal operating spectrum at 80 percent of design speed (185 m/sec, or 607 ft/sec). As usual the blade-passage tone and its second harmonic are quite conspicuous. The spectrum may have some distortion due to the incipient stall, but this is not obvious.

Figure 32(b) is a spectrum taken at a speed above 80 percent but before a definite audible stall occurred. The blade-passage tone and its overtone remain essentially unchanged; however, a pronounced spike has now appeared at about one-third of the blade-passage frequency. It is possible that the frequency of this stall-generated spike may be relatable to a rotating stall frequency.

Finally, figure 32(c) presents the spectrum during the audible stall. The rotor-blade-tip speed is now 191 meters per second (627 ft/sec). The spike which was evident at about one-third of the blade-passage frequency in figure 32(b) is now greatly enlarged, being the dominant feature of the spectrum. The harmonics of this large spike are also evident. This condition has been termed audible stall. During this condition a low-frequency "warble" sound was clearly heard over the normal fan operating noise.

Detailed narrow-band SPL spectra of 3.2-hertz bandwidth were made of the major stall-related spike seen in figure 32(c). Figure 33(a) shows the spectrum at 120° from the inlet, while figure 33(b) shows this spectrum at 40° from the inlet. At 120° from the inlet the large spike of figure 32(c) is seen to be composed of a number of spikes separated by the fan shaft rotating frequency (33 Hz). At 40° from the inlet the spectrum is still composed of spikes spaced at the shaft rotating frequency, but the envelope of the spikes at this angle now has two major regions, located on either side of the center frequency of the haystack of figure 33(a).

SUMMARY OF RESULTS

A 1.2-pressure-ratio, 1.83-meter- (6-ft-) diameter experimental fan stage, designated QF-6, with characteristics suitable for use in STOL aircraft engines was tested for acoustic and aerodynamic performance. The design incorporated 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 stage was run through an operating range controlled by nozzles having 90, 95, 100, and 105 percent of the design nozzle area.

The fan achieved its design inlet corrected weight flow of 396 kilograms per second (873 lbm/sec) with the design nozzle area. However, the stage pressure ratio at this point was 1.18 rather than the design 1.2. The 90-percent-of-design-area nozzle caused a stall condition to occur just above 80 percent of design speed. As the nozzle area was increased, the stage efficiency likewise increased. It appears a maximum efficiency would be reached with a nozzle somewhat larger than 105 percent of design area.

The 1/3-octave and narrow-band (constant 32-Hz bandwidth) sound pressure level spectra for QF-6 were typical of spectra for single-stage, low-speed fans, with pronounced blade-passage tones and harmonics. The rotor inlet relative velocities were well below sonic, and no multiple pure tones were observed. The sound power levels and perceived noise levels increased in a regular, expected manner with increasing rotor speed, with the noise levels at any speed being highest with the minimum nozzle area and decreasing with increased nozzle area.

The broadband and pure-tone components of the 1/3-octave data were analytically separated. The broadband noise component was found to increase with decreasing nozzle area, while the pure-tone component levels appear to be independent of nozzle area except for the 90-percent-of-design-area-nozzle data, which had a lower pure-tone component noise.

With the design nozzle area at design speed the measured sound power level was 153.1 decibels. The corresponding maximum perceived noise along a 152.4-meter (500-ft) sideline was 103.9 PNdB. As this maximum perceived noise is still much above the goal of 95 PNdB for STOL aircraft, much work remains to be done to reach acceptable fan noise levels.

Narrow-band spectra were taken just before and during the stall condition with the 90-percent-of-design-area nozzle. During the stall condition, a localized grouping of discrete spikes, centering at a frequency of about one-third of the blade-passage frequency dominated the spectra. These spikes were spaced at the shaft rotation frequency. The center frequency of these spikes may be relatable to a rotating stall frequency.

Lewis Research Center,
National Aeronautics and Space Administration,
Cleveland, Ohio, July 29, 1974,
501-24.

APPENDIX A

DETAILED AERODYNAMIC AND BLADE DESIGN

The QF-6 fan stage velocity diagrams were determined by an iterative design program on a high-speed computer. Along with the usual program inputs such as speed, flow, and flow path coordinates, the program required a radial schedule of rotor pressure ratio and a schedule of profile loss coefficients for each blade row as a function of radial position and diffusion factor. During the first design attempt a radially constant rotor total pressure ratio was specified. However, an acoustic analysis of this design, based on the method of reference 9, indicated increased interaction noise at the rotor hub because of large air turning. Because of this indication the rotor total pressure ratio required of the inner 10 percent of the flow was graduated down somewhat (to about 96 percent of the main-stream value at the hub wall) to reduce the air turning. The overall level of the required rotor total pressure ratio was then adjusted iteratively to provide a mass-averaged stage total pressure ratio of 1.2 (including the losses through the stator blade row).

The schedules of profile loss coefficients for each blade row which were used in this design were obtained from a survey of the experimentally determined losses from a number of stages which had characteristics similar to the QF-6 stage. No data were found on fans actually designed at the low speed and pressure ratio of QF-6, but a number of sets of data were obtained from higher speed fans which, when operated off design at about the rotor-blade-tip speed of QF-6, produced a total pressure ratio of approximately 1.2 and exhibited good aerodynamic performance.

The overall aerodynamic and acoustic design characteristics of the QF-6 fan are presented on table I. The flow path evolved for this fan is presented in table III as axial coordinates of the inner and outer walls. The zero reference axial station was taken as the forward face of the heavy ring structure around the fan as shown in figure 3. The rotor blade stacking line, a radial line passing through the centers of gravity of the various rotor blade sections, was at axial station +20.55 centimeters (+8.09 in.). The stator blade stacking line was at axial station +98.63 centimeters (+38.83 in.).

The lack of inlet guide vanes caused the absolute inlet flow vector to the rotor to be axial. The fan stators were designed to return the airflow at their exit plane to the axial direction over the full-passage height. This is typical of fan bypass flow, though not of the flow from the inner portions of normal fan stators. As stated in the body of the report this requirement was imposed on the design by the downstream support pylon of the test facility.

Rotor

Forty-two rotor blades were used in the QF-6 fan; they were built of aluminum and had no part-span dampers. The rotor assembly is shown in figure 34. Blade sections were all composed of multiple circular arcs. The details of the rotor aerodynamic and blade designs are presented in tables IV and V along flow streamlines which are separated radially by equal 10-percent increments of flow. The velocity diagram terms are defined in figure 35, and the blade geometry terms are defined in figure 36. (See appendix B for definition of symbols.)

The rotor blades were designed with the relative incoming air vector tangent to the suction surface at the leading edge because the incoming tip relative Mach number of 0.88 is in the transonic regime. For the circular-arc blade sections this caused the incidence angle to be one-half of the wedge angle between the suction and pressure surfaces at the blade inlet. Maximum blade thickness varied from 5 percent of the chord at the tip to 7.5 percent at the hub, with the maximum thickness point at the mid-chord for all sections. Maximum diffusion factor on the rotor blade is 0.386 near mid-span, well under the design limit of 0.4. The minimum choking flow margin in the rotor occurred at the hub and was 4.6 percent, while the average choking flow margin over the entire blade was about 10.5 percent. These margins are quite satisfactory.

Stator

Fifty vanes were used in the stator assembly, each made of aluminum and retained by pins and epoxy resin in electron-discharge-machined slots in the inner and outer mounting rings. This retention method provided no allowance for resetting the stator vanes to adjust the aerodynamic performance if this were found to be necessary because of residual swirl in the exit duct. As was the case with the rotor blades the stator vane sections were composed of multiple circular arcs. Details of the stator aerodynamic and blade designs are presented in tables VI and VII along extensions of the same 11 flow streamlines presented for the rotor blades in tables IV and V. Common terminology is employed in all these tables. (For definitions see figs. 35 and 36 and appendix B.) Figure 37 shows the stator assembly.

The stator vanes, unlike the rotor blades, were not designed to have the incoming air vector tangent to the suction surface at the leading edge. Rather, the incidence angles were increased or decreased from tangency by the amounts shown on table VIII. This was done on the basis of the analysis of reference 9 in an effort to reduce the response of the stators to the periodic incoming gusts from the rotating rotor-blade wakes and thereby to reduce the production of noise at the blade-passage frequency. As a result of these adjustments the stator vane incidence angles were equal to one-half of the wedge angle between suction and pressure surfaces at the leading edge plus the amount of the listed adjustment. Maximum vane thickness varied from 10 percent of the chord at the tip to 6 percent of the chord at the hub, with the maximum thickness point being at mid-chord for all sections.

The diffusion factors for the stators were generally in the low 0.3 range, with a maximum of only slightly over the desired limit of 0.4 at the hub wall. The average choking flow margin in the interblade channels was about 17 percent, with the minimum value being 14.7 percent. Hence, no choking problem would be anticipated in the stators.

APPENDIX B

SYMBOLS

A	axial distance between rotor exit and stator inlet, cm (in.)
c	blade chord measured along conical stream surface, cm (in.)
D	diffusion factor, $\left(1 - \frac{V_{rel,out}}{V_{rel,in}}\right) + \left|\frac{\Delta V_T}{2\sigma V_{rel,in}}\right|$
F	thrust, N (lbf)
IX	angle by which incoming air vector deviates from being tangent to blade suction surface at leading edge (zero unless specified otherwise), rad (deg)
M	Mach number
PR	fan total pressure ratio
s	blade-to-blade spacing in tangential direction on cylindrical surface, cm (in.)
U	blade tangential (rotative) velocity, m/sec (ft/sec)
V	velocity, m/sec (ft/sec)
X	distance from leading edge to camber-line transition point along chord, cm (in.)
(XL)	location of camber-line transition point along chord, X/c
Y	distance from leading edge to maximum thickness point along chord, cm (in.)
(YL)	location of maximum thickness point along chord, Y/c
β	angle between axis and relative velocity vector, deg
$\Delta\beta$	$\beta_{in} - \beta_{out}$, rad (deg)
γ	angle between axis and blade chord, deg
η	fan stage adiabatic efficiency
θ	angle between axial and tangent to either end of a blade camber line, deg
σ	solidity, c/s at mean station radius
τ	blade thickness, cm (in.)
φ	included angle of constant turning section of blade camber line, deg
$\bar{\omega}$	total pressure loss coefficient

Subscripts:

abs	absolute component of velocity
in	inlet
LE	leading edge
max	maximum
out	outlet
R	radial
rel	component of velocity relative to rotor blade
T	tangential component of absolute velocity
TE	trailing edge
Z	axial direction
1, 2	first and second portions of camber-line curvature

APPENDIX C

COMPUTER LISTINGS AND PLOTS OF ACOUSTIC DATA

Computer listings and plots of the acoustic data for QF-6 are presented at the end of this report, in tables IX to XII and figures 38 to 45. Figure 34 presents the 1/3-octave sound power level spectra at 60, 70, 80, 90, and 100 percent of design speed for each nozzle area configuration. Figure 39 presents the overall sound power level as a function of speed. Figure 40 presents the overall sound pressure level as a function of angle on a 30.5-meter (100-ft) radius. Figure 41 presents the perceived noise on a 30.5-meter (100-ft) radius. Figures 42 to 45 present the 1/3-octave sound pressure level spectra for all run speeds and configurations tested at each angular position from 10° to 160° on a 30.5-meter (100-ft) radius.

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TABLE I. - DESIGN CHARACTERISTICS FOR QF-6 FAN

Overall stage total pressure ratio	1.2
Corrected inlet mass-flow rate, kg/sec; lbm/sec	396; 873
Corrected specific inlet flow, kg/(sec)(m^2); lbm/(sec)(ft^2)	182.6; 37.4
Stage adiabatic temperature rise efficiency	0.879
Corrected rotor-blade-tip inlet speed, m/sec; ft/sec	228.6; 750
Rotor-blade-tip inlet diameter, m; in.	1.829; 72
Corrected rotor speed, rpm	2387.2
Rotor inlet hub- to tip-diameter ratio	0.418
Stator inlet hub- to tip-diameter ratio	0.571
Rotor total pressure ratio	1.210
Rotor adiabatic temperature rise efficiency	0.920
Stage head rise coefficient	0.298
Rotor head rise coefficient	0.311
Rotor work coefficient	0.338
Input shaft power, kW; hp	7045; 9450
Stage thrust, N; lbf	70 410; 15 830
Mean radius rotor-stator spacing in rotor chords, A/c	4
Number of rotor blades	42
Number of stator blades	50
Blade-passage frequency, Hz	1671

TABLE II. - SELECTED AERODYNAMIC RESULTS

Stage description, percent of design nozzle area	Corrected fan speed, percent of design	Fan physical speed, rpm	Corrected rotor-blade-tip speed		Inlet duct Mach number	Stage pressure ratio	Inlet		Stator exit	
							Corrected mass-flow rate			
			m/sec	ft/sec			kg/sec	lbm/sec	kg/sec	lbm/sec
100	60	1432	137	451	0.230	1.066	244	538	242	534
	70	1671	160	524	.270	1.089	283	625	281	619
	80	1910	183	600	.312	1.117	323	712	320	705
	90	2149	206	674	.354	1.146	361	795	357	786
	100	2387	229	750	.397	1.182	397	875	394	868
95	60	1432	137	450	0.211	1.065	225	497	230	506
	70	1671	160	524	.255	1.088	269	593	267	589
	80	1910	183	600	.288	1.116	300	662	299	660
	90	2149	206	675	.320	1.145	331	729	331	730
	100	2387	229	750	.371	1.181	375	826	365	804
90	60	1432	137	450	0.192	1.063	205	453	208	459
	70	1671	160	525	.224	1.086	238	525	241	532
	80	1910	183	600	.255	1.110	269	593	272	600
105	60	1432	137	450	0.226	1.064	240	530	247	544
	70	1671	160	525	.266	1.088	280	617	288	635
	80	1910	183	601	.309	1.116	320	705	328	723
	90	2149	206	676	.352	1.147	359	791	367	810
	100	2387	229	750	.395	1.183	395	870	404	891

TABLE III. - QF-6 NACELLE FLOW

PASSAGE COORDINATES

Axial station[a]		Outer diameter		Inner diameter	
cm	in.	cm	in.	cm	in.
-50.80	-20.00	187.55	73.84	40.01	15.75
-40.64	-16.00	187.55	73.84	40.01	15.75
-25.40	-10.00	187.55	73.84	40.01	15.75
-10.16	-4.00	183.95	72.42	56.13	22.10
0	0	182.88	72.00	67.97	26.76
8.51	3.35	182.88	72.00	76.96	30.30
22.99	9.05	182.88	72.00	88.58	34.88
40.64	16.00	184.12	72.49	97.71	38.47
55.88	22.00	185.34	72.97	102.72	40.44
71.12	28.00	186.26	73.33	105.94	41.71
88.01	34.65	186.44	73.40	106.40	41.89
99.62	39.22	186.44	73.40	106.40	41.89
106.68	42.00	186.44	73.40	106.40	41.89

[a]Reference plane for axial positions shown in fig. 3.

TABLE IV. - QF-6 ROTOR AERODYNAMIC DESIGN CHARACTERISTICS

[Absolute tangential inlet velocity, $V_{T,in}$, 0.]

Radial station	Leading edge: Radial location of section, cm	Leading edge: in.	Trailing edge: cm	Trailing edge: in.	Axial velocity, V_Z: Inlet, m/sec	Inlet, ft/sec	Outlet, m/sec	Outlet, ft/sec	Absolute tangential outlet velocity, $V_{T,out}$, m/sec	ft/sec	Radial velocity, V_R: Inlet, m/sec	Inlet, ft/sec	Outlet, m/sec	Outlet, ft/sec	Blade tangential velocity, U: Inlet, m/sec	Inlet, ft/sec	Outlet, m/sec	Outlet, ft/sec	Inlet relative Mach number, M_{in}	Diffusion factor, D	Pressure loss coefficient, $\bar{\omega}$: Profile	Shock	Rotor total pressure ratio	Relative air turning angle, $\Delta\beta$: rad	deg
1	91.44	36.00	91.49	36.02	179.53	589.01	164.88	540.94	81.43	267.15	0.76	2.49	2.11	6.93	228.59	749.96	228.72	750.28	0.879	0.357	0.070	0	1.210	0.176	10.08
2	87.76	34.55	87.91	34.61	178.85	586.79	164.76	540.55	82.80	271.66	2.62	8.59	4.26	13.98	219.38	719.75	219.76	721.00	.856	.361	.061			.193	11.07
3	83.87	33.02	84.25	33.17	177.78	583.28	164.68	540.28	85.00	278.88	5.12	16.79	6.64	21.77	209.67	687.88	210.62	691.01	.831	.366	.054			.216	12.37
4	79.78	31.41	80.39	31.65	176.40	578.75	164.67	540.26	88.16	289.24	8.22	26.96	9.30	30.51	199.44	654.34	200.97	659.34	.805	.372	.050			.246	14.09
5	75.44	29.70	76.38	30.07	174.84	573.61	164.67	540.24	92.67	304.03	11.93	39.14	12.33	40.44	188.59	618.72	190.93	626.43	.778	.380	.050		1.211	.285	16.34
6	70.79	27.87	72.09	28.38	173.06	567.79	164.80	540.68	97.92	321.26	16.35	53.64	15.86	52.03	176.97	580.59	180.20	591.22	.749	.385	.050		1.212	.333	19.07
7	65.76	25.89	67.54	26.59	171.00	561.02	165.17	541.88	104.47	342.76	21.70	71.20	20.12	66.01	164.39	539.35	168.84	553.93	.719	.386	.051		1.213	.393	22.50
8	60.22	23.71	62.66	24.67	168.50	552.83	165.86	544.17	112.96	370.62	28.41	93.21	25.45	83.49	150.55	493.93	156.65	513.93	.687	.379	.052		1.214	.469	26.85
9	54.05	21.28	57.33	22.57	165.27	542.22	167.15	548.40	125.46	411.63	37.31	122.42	32.44	106.44	135.12	443.31	143.31	470.18	.652	.356	.055		1.219	.571	32.69
10	46.91	18.47	51.41	20.24	160.81	527.59	169.42	555.84	134.58	441.52	50.47	165.58	42.25	138.61	117.28	384.77	128.52	421.64	.615	.287	.056		1.213	.646	37.03
11	38.20	15.04	44.58	17.55	153.56	503.81	172.02	564.36	123.53	405.29	74.32	243.84	56.38	184.99	95.50	313.32	111.44	365.61	.576	.151	.070		1.159	.589	33.72

TABLE V. - QF-6 ROTOR BLADE DESIGN CHARACTERISTICS

[Maximum thickness location at all stations, (YL), 0.500.]

Radial station (as in table III)	Aerodynamic chord, c: cm	in.	Maximum blade thickness, τ_{max}: cm	in.	Thickness of rounded blade edge: Leading edge, τ_{LE}: cm	in.	Trailing edge, τ_{TE}: cm	in.	Blade solidity, σ	Camber-line curvature: Forward, φ_1: rad	deg	Rear, φ_2: rad	deg	Camber-line angle with axis: Leading edge, θ_{LE}: rad	deg	Trailing edge, θ_{TE}: rad	deg	Blade setting angle, γ: rad	deg	Camber-line transition location, (XL)
1	16.256	6.400	0.813	0.320	0.203	0.080	0.122	0.048	1.188	0.094	5.38	0.063	3.60	0.830	47.53	0.673	38.55	0.751	43.04	0.599
2	16.256	6.400	.818	.322	.203	.080	.122	.048	1.237	.099	5.70	.077	4.43	.811	46.46	.634	36.33	.722	41.39	.563
3	16.261	6.402	.833	.328	.208	.082	.124	.049	1.293	.106	6.08	.096	5.51	.790	45.27	.588	33.68	.689	39.47	.525
4	16.269	6.405	.856	.337	.213	.084	.130	.051	1.358	.114	6.56	.121	6.93	.767	43.95	.532	30.46	.649	37.19	.484
5	16.284	6.411	.892	.351	.224	.088	.135	.053	1.434	.125	7.19	.154	8.82	.741	42.46	.462	26.46	.600	34.40	.441
6	16.309	6.421	.935	.368	.234	.092	.140	.055	1.526	.136	7.78	.197	11.26	.711	40.75	.379	21.72	.543	31.11	.396
7	16.358	6.440	.988	.389	.246	.097	.147	.058	1.641	.146	3.36	.253	14.48	.677	38.77	.278	15.93	.474	27.15	.347
8	16.439	6.472	1.052	.414	.264	.104	.157	.062	1.789	.155	8.88	.329	18.84	.636	36.46	.153	8.75	.389	22.29	.296
9	16.591	6.532	1.125	.443	.282	.111	.168	.066	1.942	.163	9.36	.437	25.05	.589	33.75	-.012	-0.66	.280	16.06	.241
10	16.881	6.646	1.209	.476	.302	.119	.180	.071	2.295	.175	10.03	.515	29.48	.532	30.47	-.158	-9.03	.164	9.39	.183
11	17.501	6.890	1.300	.512	.325	.128	.196	.077	2.827	.152	8.71	.479	27.44	.457	26.18	-.174	-9.97	.107	6.12	.129

TABLE VI. - QF-6 STATOR AERODYNAMIC DESIGN CHARACTERISTICS

[Absolute tangential outlet velocity, $V_{T,out}$, 0.]

Radial station	Leading edge		Trailing edge		Inlet		Outlet		Absolute tangential inlet velocity, $V_{T,in}$		Inlet		Outlet		Inlet relative Mach number, M_{in}	Diffusion factor, D	Pressure loss coefficient, $\bar{\omega}$		Rotor total pressure ratio	Relative air turning angle, $\Delta\beta$	
	Radial location of section				Axial velocity, V_Z						Radial velocity, V_R										
	cm	in.	cm	in.	m/sec	ft/sec	m/sec	ft/sec	m/sec	ft/sec	m/sec	ft/sec	m/sec	ft/sec			Profile	Shock		rad	deg
1	93.22	36.70	93.27	36.72	181.09	594.12	178.34	585.09	79.87	262.04	-0.08	-0.25	0.01	0.04	0.583	0.301	0.021	0	1.204	0.415	23.80
2	90.02	35.44	90.04	35.45	182.09	597.42	178.23	584.74	80.87	265.33	.50	1.65	.24	.79	.587	.301	.021			.418	23.95
3	86.69	34.13	86.74	34.15	182.97	600.29	178.23	584.75	82.59	270.98	.96	3.16	.45	1.46	.592	.303	.022			.424	24.29
4	83.26	32.78	83.34	32.81	183.78	602.96	178.32	585.05	85.14	279.32	1.35	4.42	.64	2.09	.598	.307	.024			.434	24.86
5	79.68	31.37	79.76	31.40	184.56	605.50	178.49	585.60	88.82	291.40	1.70	5.58	.83	2.72	.605	.314	.025			.449	25.70
6	75.92	29.89	76.05	29.94	185.39	608.22	178.72	586.36	92.97	305.03	2.06	6.77	1.05	3.43	.614	.321	.027			.465	26.63
7	71.98	28.34	72.14	28.40	186.30	611.23	179.05	587.42	98.02	321.59	2.45	8.05	1.30	4.25	.624	.329	.030			.484	27.75
8	67.82	26.70	68.00	26.77	187.35	614.67	179.70	589.56	104.35	342.37	2.94	9.66	1.62	5.30	.636	.339	.033			.508	29.11
9	63.37	24.95	63.63	25.05	188.43	618.21	179.88	590.17	113.49	372.34	3.65	11.98	2.02	6.64	.654	.357	.040		1.206	.542	31.05
10	58.57	23.06	58.85	23.17	188.05	616.95	174.03	570.95	118.10	387.48	3.86	12.68	2.09	6.86	.661	.383	.052		1.195	.561	32.12
11	53.21	20.95	53.21	20.95	183.07	600.62	152.11	499.06	103.51	339.60	-.66	-2.16	.09	.28	.627	.417	.074		1.139	.515	29.48

TABLE VII. - QF-6 STATOR BLADE DESIGN CHARACTERISTICS

[Maximum thickness location at all stations, (YL), 0.500.]

Radial station (as in table III)	Aerodynamic chord, c		Maximum blade thickness, τ_{max}		Thickness of rounded blade edge				Blade solidity, σ	Camber-line curvature				Camber-line angle with axis				Blade setting angle, γ		Camber-line transition location, (XL)
					Leading edge, τ_{LE}		Trailing edge, τ_{TE}			Forward, φ_1		Rear, φ_2		Leading edge, θ_{LE}		Trailing edge, θ_{TE}				
	cm	in.	cm	in.	cm	in.	cm	in.		rad	deg	rad	deg	rad	deg	rad	deg	rad	deg	
1	11.717	4.613	1.161	0.457	0.290	0.114	0.175	0.069	1.000	0.145	8.31	0.131	7.52	0.225	12.91	-0.051	-2.92	0.036	2.07	0.154
2			1.115	.439	.279	.110	.165	.065	1.036	.146	8.34	.139	7.99	.233	13.33	-.052	-3.00	.040	2.27	.156
3			1.067	.420	.267	.105	.160	.063	1.075	.146	8.35	.150	8.60	.241	13.83	-.055	-3.13	.044	2.52	.158
4			1.021	.402	.257	.101	.152	.060	1.119	.154	8.83	.167	9.59	.261	14.98	-.060	-3.44	.050	2.89	.165
5			.975	.384	.244	.096	.147	.058	1.170	.175	10.01	.193	11.06	.298	17.07	-.070	-4.00	.060	3.44	.180
6			.930	.366	.231	.091	.140	.055	1.227	.196	11.24	.218	12.50	.336	19.23	-.079	-4.52	.070	4.03	.192
7			.881	.347	.221	.087	.132	.052	1.294	.201	11.54	.262	15.02	.376	21.52	-.088	-5.05	.092	5.27	.209
8			.836	.329	.208	.082	.124	.049	1.373	.206	11.79	.313	17.92	.421	24.11	-.098	-5.59	.118	6.76	.226
9	11.720	4.614	.790	.311	.198	.078	.119	.047	1.469	.210	12.06	.373	21.35	.475	27.21	-.108	-6.20	.150	8.59	.243
10	11.720	4.614	.742	.292	.185	.073	.112	.044	1.589	.201	11.49	.429	24.57	.515	29.52	-.113	-6.50	.180	10.34	.250
11	11.717	4.613	.696	.274	.175	.069	.104	.041	1.752	.153	8.78	.442	25.33	.493	28.27	-.102	-5.83	.188	10.77	.228

TABLE VIII. - STATOR INCIDENCE

ANGLE ADJUSTMENTS

Radial station	Incidence adjustment angle, IX	
	rad	deg
1	0.087	5.0
2	.087	5.0
3	.087	5.0
4	.079	4.5
5	.058	3.3
6	.038	2.2
7	.019	1.1
8	0	0
9	-.018	-1.0
10	-.035	-2.0
11	-.052	-3.0

TABLE IX. - NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR 105 PERCENT OF DESIGN NOZZLE AREA

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL re 0.00002 N/m^2; PWL re 0.1 pW.]

(a) Corrected fan speed, 60 percent of design; fan physical speed, 1447 rpm; fundamental blade-passage frequency, 1012 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	73.3	66.7	68.8	68.0	69.5	67.7	70.2	65.3	68.3	66.3	66.3	67.8	67.8	69.7	68.3	70.1	68.3	115.7
63	65.1	65.4	65.4	64.3	66.1	63.9	64.9	64.3	64.6	64.4	64.6	65.0	66.4	67.1	67.9	68.1	65.4	112.8
80	67.5	67.5	67.0	65.7	65.0	65.3	66.0	64.2	64.7	65.5	66.2	66.6	67.8	68.5	68.8	70.2	66.5	113.9
100	68.0	66.0	66.0	65.1	64.1	64.1	63.3	63.6	64.6	65.1	65.3	66.5	67.6	68.1	68.5	68.7	65.8	113.2
125	69.4	71.3	70.1	68.8	68.6	69.3	68.3	66.9	69.1	68.9	70.3	69.0	70.4	69.8	69.3	67.8	69.2	116.6
160	70.0	71.0	70.5	69.1	67.5	67.0	66.8	66.3	67.0	67.1	67.8	69.2	67.5	67.6	67.5	67.2	67.9	115.3
200	70.5	69.7	68.8	65.8	66.0	64.8	65.3	65.3	65.2	64.8	65.3	66.4	66.5	66.2	66.5	66.4	66.2	113.6
250	70.3	71.0	69.0	67.5	66.2	65.8	64.7	65.2	66.2	67.3	68.0	69.2	70.0	69.5	67.5	66.0	67.7	115.1
315	72.6	72.2	70.6	68.6	68.9	67.4	67.1	67.1	67.7	68.1	69.2	70.3	70.7	70.1	68.2	66.6	69.0	116.4
400	73.3	73.1	73.3	70.1	68.4	67.9	67.3	67.1	68.8	70.6	71.8	72.9	72.6	71.4	68.3	66.0	70.6	118.0
500	74.5	75.5	75.0	73.1	71.6	70.0	68.5	69.0	69.6	71.8	73.5	74.7	73.8	72.6	69.6	66.5	72.3	119.7
630	75.5	76.6	75.6	74.6	73.0	70.8	68.8	69.3	71.0	72.8	75.1	76.4	76.0	74.8	71.3	67.9	73.7	121.1
800	77.0	78.7	78.5	76.9	75.7	73.4	71.5	71.4	73.4	75.5	78.0	79.0	78.7	77.5	73.9	70.8	76.3	123.7
1000	88.5	89.5	87.4	87.7	88.4	85.9	84.0	80.5	83.4	85.4	90.0	90.3	90.7	90.5	86.4	83.6	87.8	135.2
1250	81.0	82.3	81.0	79.5	78.0	75.3	73.2	73.2	75.2	77.7	80.0	81.4	81.2	81.0	76.8	74.0	78.9	126.3
1600	81.3	83.2	82.3	80.5	78.5	75.3	72.8	73.8	77.0	79.5	81.7	82.4	82.8	82.3	77.5	74.6	80.1	127.5
2000	85.5	88.2	86.4	85.0	83.7	80.2	76.9	77.7	80.0	83.4	86.2	85.8	87.2	87.5	83.5	78.3	84.6	132.0
2500	83.6	84.6	83.0	81.3	79.8	76.5	74.0	73.8	77.1	80.0	82.5	83.4	84.3	84.6	80.6	74.4	81.5	128.9
3150	83.9	84.8	84.4	83.3	81.1	78.3	75.1	73.8	77.8	80.3	82.4	83.9	85.6	85.8	82.1	75.0	82.6	130.0
4000	83.8	84.6	83.7	82.7	80.7	77.4	73.4	72.6	76.7	79.9	82.1	82.4	83.7	83.6	79.8	74.0	81.7	129.1
5000	81.6	81.9	80.6	80.1	78.4	74.9	70.6	69.7	74.6	77.4	79.9	81.3	81.2	81.1	80.2	72.2	79.8	127.2
6300	79.4	80.7	80.0	78.5	76.7	74.4	70.4	67.6	73.5	76.0	77.7	79.1	80.0	80.0	78.4	70.1	78.8	126.2
8000	79.5	80.7	79.2	78.0	75.5	73.9	68.5	66.0	72.7	74.7	77.2	77.0	78.9	79.2	75.2	69.5	78.4	125.8
10000	76.9	77.5	76.5	75.2	72.7	71.4	65.2	63.0	69.0	71.7	74.4	74.0	75.4	75.0	72.5	65.7	76.3	123.7
12500	75.3	76.2	74.7	73.2	71.2	68.9	63.5	60.7	66.4	69.3	72.5	72.7	73.6	72.8	70.0	63.8	75.8	123.2
16000	71.5	72.8	71.3	69.7	68.0	64.6	59.9	55.9	62.8	65.6	68.1	69.7	68.4	69.3	67.2	60.0	74.0	121.4
20000	67.4	68.0	66.9	65.4	62.4	60.0	54.1	51.4	56.6	60.7	63.1	64.2	64.7	64.5	61.6	55.5	71.9	119.3
OVERALL	94.3	95.5	94.2	93.2	92.3	89.7	87.2	85.7	88.7	91.1	94.2	94.7	95.4	95.3	91.7	87.5	93.1	140.5
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	66.6	78.7	82.4	84.1	84.8	83.3	81.4	81.7	84.7	87.3	89.3	88.7	88.3	86.2	79.5	69.9		

(b) Corrected fan speed, 70 percent of design; fan physical speed, 1689 rpm; fundamental blade-passage frequency, 1182 hertz

FRECLENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	75.6	69.2	68.7	68.7	68.7	67.7	69.2	67.7	68.9	69.1	69.4	71.3	69.6	71.4	71.6	73.1	69.8	117.2
63	75.7	69.0	68.0	66.4	68.4	66.4	68.2	66.2	67.2	66.9	68.7	70.3	69.7	72.0	72.5	72.8	69.2	116.6
80	69.0	68.0	68.2	66.5	68.2	67.0	66.4	66.0	66.7	68.2	69.0	70.3	71.0	72.0	73.0	74.1	69.2	116.6
100	69.6	69.1	69.0	67.8	67.3	67.1	66.3	65.6	66.8	68.5	69.6	71.1	72.1	73.3	73.3	73.7	69.7	117.1
125	72.7	73.0	73.2	72.4	72.0	71.0	70.7	69.2	71.5	72.2	72.7	73.0	73.9	73.9	73.4	73.1	72.3	119.7
160	73.1	73.1	73.6	71.9	71.6	70.4	70.1	69.6	70.7	71.1	71.2	72.3	71.9	72.6	72.2	71.1	71.5	118.9
200	73.2	73.0	71.7	69.9	68.7	68.2	68.0	67.7	68.7	68.4	68.7	70.1	70.5	71.5	70.9	70.4	69.7	117.1
250	74.4	75.2	73.4	71.2	71.1	69.1	67.7	68.1	70.1	70.9	71.7	73.0	73.2	73.6	71.6	69.9	71.5	118.9
315	75.3	75.4	74.1	72.4	72.1	70.6	70.1	69.9	71.6	72.4	72.6	73.7	73.6	73.1	71.9	70.8	72.4	119.8
400	75.8	76.3	75.5	74.3	72.7	71.5	70.8	70.8	71.7	73.7	74.7	75.6	75.5	74.2	71.8	69.7	73.7	121.1
500	77.3	78.3	77.4	75.8	75.4	73.4	71.9	72.3	73.3	75.1	76.4	77.5	76.1	75.6	72.4	70.2	75.3	122.7
630	78.5	80.2	78.8	77.2	76.5	74.5	73.3	73.5	74.8	77.2	78.8	80.1	78.0	77.5	74.0	71.6	77.1	124.5
800	79.4	80.9	80.7	78.9	77.2	74.9	74.0	74.1	76.9	79.1	80.7	81.1	80.6	79.4	74.7	72.6	78.6	126.0
1000	84.5	85.0	84.9	83.2	82.0	79.7	77.7	79.9	80.9	82.7	84.4	87.3	86.9	83.7	79.7	77.2	83.5	130.9
1250	93.2	92.7	93.4	91.5	90.4	88.4	85.5	88.5	88.5	88.7	91.0	96.6	96.7	91.9	88.2	85.1	92.0	139.4
1600	84.3	85.9	85.4	82.9	81.3	78.3	76.1	77.4	80.9	82.9	84.4	85.5	85.6	84.4	79.8	77.2	83.0	130.4
2000	86.8	88.1	86.9	85.3	83.8	80.9	78.4	78.8	82.6	84.9	86.6	87.7	87.9	87.4	82.3	78.5	85.3	132.7
2500	89.2	91.1	89.6	88.9	86.9	84.4	81.7	80.6	84.6	86.1	88.2	91.3	90.7	90.7	85.9	80.3	88.2	135.6
3150	85.9	87.3	87.1	85.8	84.1	81.8	78.6	78.3	82.3	84.8	86.1	87.5	88.4	87.8	81.8	77.0	85.6	133.0
4000	86.6	87.8	87.4	86.1	84.9	82.1	78.4	77.9	82.1	84.6	86.1	86.9	87.9	87.1	81.3	77.0	85.7	133.1
5000	84.8	85.3	84.3	84.4	83.4	80.0	76.0	75.3	80.1	82.8	84.3	85.9	86.3	84.9	81.8	75.4	84.2	131.6
6300	83.1	84.8	84.3	83.0	81.7	79.5	76.0	73.3	79.1	81.5	83.0	83.5	84.5	83.5	80.9	73.7	83.3	130.7
8000	83.3	84.6	83.4	82.4	80.2	78.8	74.2	72.6	78.8	80.7	82.3	82.4	83.7	82.7	77.6	73.4	83.1	130.5
10000	80.7	81.6	80.9	79.7	77.4	76.1	71.1	69.6	75.4	77.2	79.2	79.6	80.4	79.4	75.4	69.9	81.1	128.5
12500	79.6	80.0	78.9	77.4	76.2	73.8	68.7	67.3	72.8	75.4	77.7	77.6	78.4	77.4	73.9	68.2	80.6	128.0
16000	75.7	76.4	75.0	74.1	72.8	69.7	65.5	62.8	69.2	71.7	73.2	75.0	73.7	73.0	71.1	64.5	78.7	126.1
20000	71.4	71.7	70.7	70.1	66.9	64.6	59.8	58.0	63.1	67.7	68.2	69.7	69.9	69.2	66.0	60.0	76.8	124.2
OVERALL	98.0	98.7	98.3	96.9	95.5	93.2	90.4	91.5	93.6	95.2	96.9	100.0	100.1	97.9	93.7	90.1	97.1	144.4
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	70.8	82.0	86.3	88.3	88.9	87.9	86.3	86.8	90.0	91.6	92.8	94.2	92.6	89.8	82.3	72.9		

TABLE IX. - Continued. NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR 105 PERCENT OF DESIGN NOZZLE AREA

[Data adjusted to standard day of 15^{o} C and 70 percent relative humidity; SPL re 0.00002 N/m^{2}; PWL re 0.1 pW.]

(c) Corrected fan speed, 80 percent of design; fan physical speed, 1930 rpm; fundamental blade-passage frequency, 1351 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	72.7	69.5	69.8	70.3	70.3	70.5	71.2	70.8	72.0	71.7	71.8	73.4	74.2	76.8	77.0	78.7	73.0	120.4
63	77.7	73.8	71.2	68.8	71.2	70.0	70.2	69.8	71.5	71.0	75.2	72.9	75.8	76.5	77.0	78.9	73.5	120.9
80	70.3	69.8	70.0	68.1	68.5	67.3	67.6	67.5	69.1	69.8	71.5	73.7	76.1	77.5	77.8	79.5	72.8	120.2
100	72.3	70.8	72.7	71.3	69.7	69.2	69.5	69.8	71.8	73.0	74.0	75.9	77.0	79.2	79.0	79.4	74.4	121.8
125	75.4	75.8	76.3	75.6	74.3	73.6	74.4	73.4	74.6	76.8	76.4	77.0	77.9	79.6	78.9	78.2	76.3	123.7
160	76.5	76.8	76.5	75.5	74.8	74.7	74.2	73.3	74.8	74.7	75.8	76.3	77.0	78.5	76.8	76.2	75.7	123.1
200	76.7	75.8	74.0	73.0	72.3	72.0	71.2	71.5	72.0	72.5	72.5	74.1	76.5	77.5	76.2	75.7	73.9	121.3
250	78.0	78.0	76.2	74.2	73.2	72.8	71.0	71.5	73.5	74.5	75.2	75.8	78.0	77.2	76.3	74.6	75.0	122.4
315	79.0	78.0	76.5	75.4	75.0	73.9	74.2	73.9	75.2	75.5	76.0	76.9	77.9	77.7	76.0	75.1	75.9	123.3
400	79.6	78.9	78.6	76.4	75.4	73.9	73.8	73.9	75.1	76.4	77.3	78.3	78.3	77.6	75.9	74.1	76.6	124.0
500	80.5	80.3	79.8	78.3	77.6	75.5	75.3	75.0	76.5	77.8	79.1	80.0	78.8	78.1	75.6	73.8	77.9	125.3
630	81.0	82.1	80.8	80.0	79.1	76.8	76.5	76.6	78.0	80.3	81.5	82.5	81.0	79.5	76.0	74.3	79.7	127.1
800	82.0	83.0	83.3	81.6	80.1	78.0	77.3	77.5	80.1	82.3	83.3	83.6	82.5	80.8	77.3	75.3	81.2	128.6
1000	83.6	83.9	83.6	82.1	80.6	78.9	78.1	78.9	81.6	83.4	84.6	85.2	84.4	81.9	78.6	76.6	82.5	129.9
1250	93.0	94.8	92.6	94.0	92.1	90.5	86.1	87.8	89.6	92.0	94.0	95.6	99.0	93.1	88.1	88.9	93.3	140.7
1600	88.2	89.5	89.0	88.5	86.9	84.7	81.5	82.7	85.9	87.7	89.4	90.5	92.4	88.4	83.9	83.3	88.1	135.5
2000	89.2	89.5	88.5	86.8	85.7	83.3	81.2	81.7	85.5	87.5	88.8	89.4	89.7	87.0	82.5	80.6	87.1	134.5
2500	90.5	91.3	91.8	92.1	90.6	88.6	86.0	84.0	87.5	91.0	91.5	93.1	94.0	91.8	86.5	82.0	90.9	138.3
3150	88.6	89.7	89.7	89.2	87.4	85.2	83.1	82.6	86.2	88.4	89.6	90.8	91.4	89.2	83.7	80.3	88.7	136.1
4000	89.4	90.6	91.1	90.6	89.4	87.2	83.7	83.4	86.9	89.1	90.1	90.5	91.4	88.7	83.4	80.5	89.5	136.9
5000	87.6	87.8	87.4	88.6	86.9	84.1	80.6	80.3	84.6	86.6	87.8	89.6	89.1	86.9	83.6	78.4	87.6	135.0
6300	86.1	87.4	87.6	87.1	84.9	84.1	80.7	78.6	83.9	85.7	86.7	87.8	87.6	86.4	82.6	77.2	87.0	134.4
8000	86.3	87.3	86.6	86.8	84.1	83.8	79.5	77.6	83.6	84.8	86.3	86.3	87.6	85.8	80.5	77.1	87.0	134.4
10000	84.1	84.8	84.4	84.1	81.4	81.6	76.8	75.1	80.9	81.9	83.6	83.6	84.6	82.3	78.6	73.7	85.3	132.7
12500	82.3	82.8	81.8	81.8	79.9	79.4	73.9	72.7	78.2	79.6	82.1	82.0	82.4	80.3	77.0	72.1	84.6	132.0
16000	78.6	79.5	78.3	77.8	76.6	74.9	70.4	68.4	74.2	76.0	78.1	79.5	77.6	76.3	74.7	68.4	82.8	130.2
20000	73.9	74.9	73.9	74.1	71.1	69.9	64.1	63.9	68.6	71.9	73.1	74.2	73.9	72.8	69.6	64.0	80.9	128.3
OVERALL	99.7	100.7	100.1	100.1	98.4	96.7	93.6	93.5	96.7	98.9	100.2	101.4	102.9	99.6	95.3	93.8	99.8	147.2
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	72.0	83.3	88.5	91.6	92.2	91.8	90.3	89.9	93.3	95.7	96.1	96.4	95.8	91.5	83.8	76.6		

(d) Corrected fan speed, 90 percent of design; fan physical speed, 2171 rpm; fundamental blade-passage frequency, 1519 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	75.0	71.7	72.3	73.3	73.3	73.5	74.3	74.7	74.2	75.2	75.3	76.9	77.8	79.0	80.8	82.7	76.3	123.7
63	71.7	72.0	72.2	71.3	72.2	72.5	72.8	72.7	72.7	72.7	74.7	76.1	77.8	79.3	80.8	82.4	75.6	123.0
80	75.5	73.7	72.3	72.3	71.7	71.8	72.5	72.0	72.0	73.7	75.5	77.4	79.0	81.2	82.5	83.7	76.7	124.1
100	75.0	74.8	75.0	73.0	76.6	78.3	75.5	73.8	75.1	77.0	78.8	80.5	80.8	82.6	83.3	83.3	78.7	126.1
125	78.3	79.0	79.0	77.3	77.3	77.5	76.3	76.1	77.0	78.1	79.6	81.1	81.3	82.3	83.0	82.0	79.3	126.7
160	80.3	79.8	79.3	77.5	77.7	77.8	77.0	78.0	77.8	78.3	79.3	80.4	80.2	80.5	81.0	80.7	79.0	126.4
200	79.5	78.3	76.3	75.6	75.5	75.3	75.3	75.1	75.6	76.1	76.6	77.7	79.5	79.6	80.6	79.5	77.2	124.6
250	81.2	81.6	79.2	78.1	75.9	75.2	75.2	75.1	75.9	77.6	78.4	80.1	80.7	80.4	79.9	78.9	78.3	125.7
315	81.2	80.5	79.3	78.2	77.2	76.3	77.0	77.7	78.0	79.0	79.5	80.6	80.8	80.3	80.2	78.6	79.0	126.4
400	82.7	82.2	81.6	79.7	78.2	77.6	77.2	77.2	78.1	79.7	80.7	82.0	81.6	80.6	79.4	77.5	79.9	127.3
500	82.5	82.7	81.8	80.7	79.8	78.7	77.8	78.8	79.8	80.8	82.2	82.8	81.5	81.0	78.8	77.2	80.7	128.1
630	83.0	84.3	83.0	82.0	81.5	79.8	78.8	80.2	81.0	82.8	84.5	84.9	83.2	81.8	79.5	77.6	82.3	129.7
800	85.0	85.5	85.8	83.8	82.8	81.0	80.6	81.1	83.0	85.0	86.5	86.6	85.3	83.8	80.5	78.9	84.1	131.5
1000	84.7	85.9	85.4	84.0	82.5	81.0	80.9	82.2	84.0	85.9	86.8	86.9	86.3	84.2	81.2	79.4	84.6	132.0
1250	87.2	88.0	87.8	87.3	85.7	84.3	83.5	84.0	86.3	89.2	90.5	90.6	89.2	87.0	82.7	82.6	87.7	135.1
1600	96.5	96.9	97.2	97.7	96.0	95.4	94.0	91.9	94.2	97.5	99.9	100.3	98.4	97.2	90.9	91.8	97.1	144.5
2000	90.0	90.6	89.1	88.3	87.3	85.5	83.6	84.6	87.8	90.3	91.0	91.7	91.8	88.1	84.3	82.7	89.1	136.5
2500	90.1	90.5	90.0	89.5	88.2	86.0	84.2	85.5	88.5	90.6	92.0	93.1	93.2	89.3	84.8	82.4	90.1	137.5
3150	92.5	94.3	95.5	94.5	93.1	91.8	89.0	88.3	91.0	94.0	94.5	95.6	96.6	93.8	89.0	85.7	93.9	141.3
4000	90.4	91.2	91.7	91.7	90.1	88.2	85.7	86.6	89.7	91.6	92.6	93.2	93.1	89.4	84.4	82.8	91.3	138.7
5000	89.6	90.3	89.8	91.4	89.4	87.8	84.8	84.8	88.3	90.3	91.4	93.2	92.4	90.1	85.6	81.7	90.9	138.3
6300	87.9	89.2	89.7	88.9	87.5	86.9	84.6	83.4	87.4	89.1	90.4	91.1	90.9	88.9	84.7	80.2	90.0	137.4
8000	88.0	89.2	88.7	88.9	86.4	87.0	82.7	82.4	87.7	88.9	90.2	89.8	91.0	88.5	83.2	80.0	90.2	137.6
10000	85.4	86.2	85.9	85.9	83.6	83.9	79.6	80.1	84.6	85.9	87.6	87.7	88.2	84.7	81.2	77.2	88.4	135.8
12500	83.3	84.1	83.8	83.3	81.6	81.7	77.1	77.3	81.9	83.6	86.1	85.3	86.0	82.9	79.6	75.3	87.6	135.0
16000	79.4	80.6	80.0	79.6	78.2	77.1	73.8	73.3	78.5	80.2	82.0	83.1	81.1	79.6	77.4	71.8	85.9	133.3
20000	75.1	75.7	75.4	75.4	72.3	71.8	67.9	68.3	72.6	75.9	77.0	78.1	77.6	75.7	72.5	67.4	83.9	131.3
OVERALL	101.6	102.4	102.5	102.3	100.8	99.8	97.8	97.2	100.0	102.5	104.0	104.6	104.1	101.9	97.8	96.7	102.6	150.0
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	75.6	86.1	91.2	93.9	94.7	95.0	94.3	94.0	96.8	99.1	100.2	99.9	98.2	93.8	86.3	80.9		

TABLE IX. - Concluded. NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR 105 PERCENT OF DESIGN NOZZLE AREA

[Data adjusted to standard day of 15^{0} C and 70 percent relative humidity; SPL re 0.00002 N/m^{2}; PWL re 0.1 pW.]

(e) Corrected fan speed, 100 percent of design; fan physical speed, 2412 rpm; fundamental blade-passage frequency, 1688 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	77.9	74.9	75.9	75.0	75.4	76.0	77.0	76.9	77.2	78.5	79.5	80.1	81.9	83.0	84.9	86.1	79.7	127.1
63	73.1	76.0	74.3	73.6	75.1	74.6	75.0	74.6	75.6	76.5	78.1	80.2	80.6	83.0	84.3	86.0	78.9	126.3
80	78.0	78.6	77.5	77.0	79.8	77.6	78.0	76.8	77.3	78.3	79.8	80.9	83.5	85.1	87.1	88.4	81.3	128.7
100	77.3	76.0	75.7	74.7	75.2	75.0	75.3	76.3	78.2	79.5	81.3	82.8	84.8	86.0	87.7	87.9	81.6	129.0
125	82.7	83.2	82.5	80.4	80.5	79.5	79.2	80.5	82.4	82.2	83.5	84.3	85.5	86.5	87.5	86.8	83.3	130.7
160	82.2	83.4	83.2	82.1	81.6	80.7	80.4	80.4	81.9	82.6	82.9	84.1	83.7	84.2	85.6	84.3	82.7	130.1
200	82.7	82.5	80.5	78.5	78.5	78.4	78.5	78.5	78.9	79.5	80.4	81.8	82.9	83.9	84.9	83.6	80.9	128.3
250	84.4	85.4	83.2	79.7	79.9	77.7	77.5	77.9	80.0	80.5	81.7	83.6	84.2	84.7	84.2	82.7	81.8	129.2
315	83.0	83.7	81.7	79.7	80.5	78.9	79.2	79.5	81.2	81.9	82.5	83.8	83.9	83.5	84.0	82.4	81.9	129.3
400	85.1	85.1	84.8	81.8	81.5	80.0	80.3	80.3	81.6	82.5	83.1	83.9	84.3	83.8	83.1	81.0	82.7	130.1
500	85.2	85.3	84.7	82.5	82.7	81.5	81.7	81.8	83.2	84.5	84.7	85.1	84.5	83.8	82.2	80.7	83.6	131.0
630	84.9	86.0	84.9	82.5	83.0	82.2	82.2	82.9	84.2	86.0	86.5	86.5	85.2	83.9	82.2	80.4	84.5	131.9
800	87.2	88.9	87.7	86.6	86.1	84.7	84.6	84.7	86.6	87.9	88.9	88.2	86.6	85.4	83.2	81.1	86.7	134.1
1000	87.1	88.6	87.6	85.9	84.9	83.6	84.4	85.4	87.6	88.6	88.9	88.6	87.7	85.9	83.4	81.1	86.9	134.3
1250	87.0	88.5	88.2	87.0	85.9	84.4	84.7	86.2	88.9	89.7	91.2	90.5	89.4	86.7	84.0	82.3	88.3	135.7
1600	99.2	102.7	101.6	102.7	101.2	96.7	96.6	96.7	98.4	101.7	102.6	100.7	101.9	98.2	93.9	96.1	100.4	147.8
2000	92.7	94.6	94.2	93.9	92.9	89.6	89.1	89.9	92.6	94.6	95.4	94.8	96.1	92.2	88.9	88.5	93.5	140.9
2500	90.1	91.1	90.2	89.2	88.7	87.1	87.2	88.2	91.2	92.7	93.7	94.5	93.9	89.7	86.6	83.3	91.5	138.9
3150	94.3	96.9	97.3	96.6	94.8	94.8	92.4	91.6	94.4	96.4	96.9	98.5	98.1	94.1	89.4	87.7	96.2	143.6
4000	91.2	93.1	92.6	91.9	90.7	89.9	88.7	89.6	93.2	94.2	95.1	95.5	95.6	91.4	87.1	85.1	93.5	140.9
5000	91.0	92.5	92.1	92.3	91.3	89.1	87.8	88.5	91.8	92.8	94.8	96.4	95.6	92.1	88.3	84.1	93.6	141.0
6300	88.6	90.6	90.5	89.1	88.0	87.6	87.1	86.5	91.2	92.1	93.1	93.9	93.7	90.7	86.7	82.5	92.3	139.7
8000	87.9	90.1	89.1	88.4	86.9	87.1	85.7	85.4	91.6	91.8	93.4	92.6	94.1	90.8	85.8	82.7	92.6	140.0
10000	84.6	86.5	86.3	85.3	83.8	84.5	82.1	82.8	88.5	89.1	91.0	90.5	91.3	87.8	84.0	79.8	90.9	138.3
12500	82.6	84.5	83.9	82.6	82.3	82.2	79.6	80.6	85.9	87.2	89.7	88.8	89.4	86.0	82.7	78.3	90.4	137.8
16000	77.9	80.3	79.3	78.3	77.9	77.3	75.8	76.6	82.3	83.9	85.4	86.2	84.4	82.7	80.4	74.8	88.5	135.9
20000	73.1	74.9	74.6	73.4	71.3	72.0	70.4	72.1	76.9	79.6	80.6	81.3	81.0	78.8	75.6	70.6	86.6	134.0
OVERALL	103.4	105.9	105.2	105.3	104.0	101.5	100.8	101.0	103.8	105.7	106.7	106.5	106.8	103.6	100.7	100.4	105.3	152.7
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	78.0	90.3	94.3	97.3	98.2	97.4	97.2	97.9	100.4	102.5	102.9	101.9	100.5	95.4	89.2	84.6		

TABLE X. - NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR DESIGN NOZZLE AREA

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL re 0.00002 N/m^2; PWL re 0.1 pW.]

(a) Corrected fan speed, 60 percent of design; fan physical speed, 1443 rpm; fundamental blade-passage frequency, 1010 hertz

FRECLENCY	ANGLE, DEG																AVERAGE SPL	POWER LEVEL (PWL)
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160		
	1/3-OCTAVE BAND SCUNO PRESSURE LEVEL (SPL) ON 30.5-METER RADIUS																	
50	73.8	69.4	68.9	69.3	70.4	70.4	70.4	67.3	69.6	68.9	70.3	67.7	68.9	70.6	69.8	69.1	69.6	117.0
63	67.1	67.5	66.0	65.1	66.5	67.6	66.3	65.6	65.6	64.5	65.6	66.4	66.1	68.0	68.0	68.2	66.4	113.8
80	70.5	71.0	68.8	66.3	65.8	66.8	66.5	65.8	65.8	65.7	66.2	68.1	67.9	69.2	69.8	70.2	67.5	114.9
100	70.4	68.4	67.3	67.1	65.6	66.6	66.3	65.9	65.9	65.9	67.1	67.9	67.6	69.3	69.6	69.7	67.3	114.7
125	71.8	73.6	72.1	71.4	69.9	70.6	68.6	68.1	68.4	69.6	70.6	69.9	70.9	70.9	69.4	69.2	70.2	117.6
160	73.0	73.8	71.8	70.5	68.5	69.2	68.3	67.8	68.0	68.8	69.7	70.8	69.2	69.7	68.7	68.1	69.6	117.0
200	72.1	72.3	69.8	68.1	67.1	66.3	65.8	66.0	65.8	65.5	66.1	67.4	67.4	68.3	67.5	67.2	67.4	114.8
250	73.0	75.0	72.6	71.1	67.6	67.6	66.0	66.3	67.6	68.3	69.8	71.9	71.9	71.1	69.0	67.2	69.9	117.3
315	74.9	75.0	72.2	70.7	68.9	68.9	67.5	68.4	68.2	69.7	70.7	71.8	72.0	70.9	69.7	67.6	70.4	117.8
400	75.0	76.4	74.9	72.9	70.5	69.5	68.0	67.9	69.0	71.4	73.0	74.6	75.0	73.0	70.4	66.9	72.3	119.7
500	76.4	78.3	77.1	75.4	73.1	71.3	69.9	69.9	70.3	72.9	74.4	75.5	76.1	74.6	71.6	68.0	73.9	121.3
630	76.6	79.4	77.8	76.6	74.6	72.1	70.6	70.8	72.1	73.9	75.6	77.0	77.9	76.4	73.6	69.8	75.2	122.6
800	78.9	80.8	80.1	78.8	76.4	74.4	72.4	73.1	74.9	76.6	77.8	79.5	81.4	78.9	74.6	71.8	77.6	125.0
1000	89.3	91.0	89.5	88.7	87.0	84.2	83.7	82.0	85.5	87.2	88.2	90.4	91.4	87.8	83.0	85.9	87.8	135.2
1250	82.6	84.5	83.0	81.3	79.3	77.0	75.0	74.8	77.3	78.6	80.3	82.2	83.4	81.6	77.5	74.9	80.3	127.7
1600	83.0	84.7	84.0	82.0	80.0	77.2	74.7	75.5	78.3	80.2	82.2	83.1	84.7	83.3	78.2	73.9	81.3	128.7
2000	86.5	88.3	87.1	85.8	84.5	81.3	77.8	77.3	80.8	83.1	85.3	86.1	87.9	87.1	82.8	78.4	84.8	132.2
2500	85.0	85.8	83.8	82.7	80.7	77.7	74.7	74.8	78.0	80.0	83.0	83.9	85.7	85.0	80.7	75.6	82.3	129.7
3150	84.9	85.9	85.1	83.9	82.1	79.2	75.4	74.7	78.6	80.4	82.6	84.5	86.3	86.1	82.2	76.3	83.2	130.6
4000	84.2	85.0	84.4	83.5	81.9	78.7	74.2	74.2	77.7	79.7	82.5	83.0	84.8	84.4	80.4	74.8	82.4	129.8
5000	82.1	82.4	81.3	81.3	78.9	75.9	71.6	71.2	74.9	77.4	80.8	81.5	82.4	81.4	79.8	73.2	80.4	127.8
6300	80.3	81.7	80.8	79.3	77.7	75.5	70.3	69.1	74.0	75.2	78.4	79.2	80.2	80.2	77.3	71.1	79.2	126.6
8000	80.4	81.1	80.1	79.6	76.6	75.1	69.1	67.5	72.9	74.6	77.4	78.0	80.1	79.7	76.4	70.3	79.2	126.6
10000	77.9	78.8	77.8	76.4	73.8	72.1	66.3	64.4	69.4	70.9	74.3	74.6	76.6	75.8	73.1	66.9	77.1	124.5
12500	76.6	77.1	75.6	75.1	72.3	70.1	64.4	61.8	66.5	69.1	72.6	73.8	74.8	73.9	71.1	64.8	76.8	124.2
16000	73.3	74.1	72.3	71.6	68.4	66.2	59.7	57.4	62.9	64.9	68.0	70.1	70.3	70.3	67.0	61.2	74.9	122.3
20000	69.5	69.8	68.5	67.5	64.2	61.2	55.5	53.2	57.4	61.2	63.0	64.5	66.4	66.3	62.7	57.2	73.3	120.7
CVERALL	95.4	96.7	95.5	94.4	92.5	89.9	87.6	86.9	90.0	91.8	93.7	95.1	96.5	95.0	91.1	88.9	93.7	141.1
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	67.9	79.7	83.4	85.3	85.7	84.4	82.2	82.4	85.6	87.4	89.1	89.3	89.3	86.4	79.4	71.2		

TABLE X. - Continued. NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR DESIGN NOZZLE AREA

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL re 0.00002 N/m^2; PWL re 0.1 pW.]

(b) Corrected fan speed, 70 percent of design; fan physical speed, 1685 rpm; fundamental blade passage frequency, 1179 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	76.0	68.0	66.3	68.5	68.3	68.3	68.5	67.3	68.5	69.6	69.1	71.1	70.1	72.1	73.3	74.5	70.0	117.4
63	75.7	66.7	65.4	67.2	66.7	68.4	67.4	65.7	66.7	66.9	68.1	70.5	69.6	72.2	73.2	73.8	69.2	116.6
80	66.0	68.8	67.3	66.0	65.5	67.0	65.3	65.1	66.1	67.0	67.6	70.4	71.1	73.1	74.3	74.0	69.1	116.5
100	71.0	68.8	68.6	67.6	66.0	67.3	66.3	66.3	68.0	69.1	69.6	72.1	73.0	73.6	74.3	74.4	70.2	117.6
125	73.4	74.1	72.8	71.8	72.1	71.4	69.8	69.3	71.3	72.4	73.4	73.7	73.4	74.3	74.3	73.8	72.5	119.9
160	74.3	74.6	73.8	72.3	71.3	70.9	71.1	70.8	71.4	71.8	72.4	73.7	72.9	73.3	72.9	72.0	72.3	119.7
200	73.8	73.8	71.6	69.1	68.1	67.6	67.9	68.3	68.3	68.1	68.9	70.5	71.1	71.9	72.1	71.0	69.9	117.3
250	75.6	75.8	73.8	71.3	70.3	68.4	67.4	67.9	70.1	71.4	72.3	73.9	73.9	74.1	72.3	70.8	71.9	119.3
315	76.8	75.8	73.5	72.5	71.0	70.0	70.2	70.2	71.8	72.7	73.2	74.1	73.8	73.7	72.5	70.9	72.6	120.0
400	77.7	77.0	77.0	74.5	72.7	71.0	70.9	70.9	72.5	74.2	74.7	76.3	76.2	75.5	72.2	70.4	74.3	121.7
500	78.9	79.4	79.1	77.1	75.6	73.6	72.7	72.6	74.1	76.1	76.7	77.8	77.7	76.2	73.1	71.0	76.1	123.5
630	79.7	81.2	80.1	78.6	76.6	73.7	73.4	73.7	75.9	78.1	79.1	79.8	79.7	78.7	75.2	72.3	77.8	125.2
800	80.6	82.1	82.1	80.1	78.0	75.5	74.6	75.6	77.3	79.3	80.5	81.7	82.3	80.3	75.8	73.0	79.4	126.8
1000	85.4	86.7	85.2	84.4	81.9	80.4	78.7	79.9	81.1	82.7	84.9	87.2	87.1	84.7	79.4	77.6	83.9	131.3
1250	93.5	94.3	92.1	92.0	89.6	88.3	86.1	88.1	88.5	89.0	92.5	96.1	95.8	93.0	87.6	85.7	91.9	139.3
1600	85.2	87.3	87.0	84.8	82.3	80.2	78.2	78.8	81.5	83.3	85.3	86.3	87.2	85.2	79.8	76.1	84.1	131.5
2000	87.8	89.4	88.8	86.4	84.9	82.3	79.4	79.6	83.1	84.9	87.1	88.2	89.4	87.9	82.3	78.5	86.2	133.6
2500	89.4	90.9	90.1	88.8	87.6	85.1	81.8	81.4	84.1	86.1	88.9	90.4	91.8	90.9	85.8	80.5	88.4	135.8
3150	87.1	88.6	88.3	87.1	84.8	82.6	79.4	79.3	82.4	84.4	86.6	88.0	89.3	88.3	82.8	78.3	86.3	133.7
4000	87.0	88.3	88.3	87.7	85.3	83.2	78.8	78.8	82.3	84.3	86.5	87.1	88.8	87.5	82.3	78.1	86.3	133.7
5000	85.4	86.1	85.6	85.9	83.4	81.1	77.2	76.6	80.2	82.6	85.1	86.3	86.7	85.7	81.4	76.5	84.8	132.2
6300	84.1	85.6	85.7	84.2	82.1	80.2	75.6	74.6	79.6	80.9	83.4	83.9	85.1	84.4	80.4	74.8	83.9	131.3
8000	84.2	85.2	84.6	84.1	81.2	79.7	74.7	73.4	78.4	80.1	82.2	83.0	84.6	83.7	79.4	74.4	83.8	131.2
10000	81.9	82.8	82.3	81.4	78.4	77.3	72.4	70.6	75.2	76.8	79.3	79.9	81.4	79.9	76.8	70.9	81.9	129.3
12500	80.3	81.1	80.6	79.4	77.1	75.1	70.2	68.2	72.2	74.9	78.1	78.8	79.6	78.3	75.1	69.1	81.6	129.0
16000	77.1	78.1	76.9	76.0	73.0	71.0	65.2	63.9	68.9	71.1	73.7	75.6	75.4	74.3	71.1	65.0	79.7	127.1
20000	73.0	73.3	72.8	72.7	68.5	66.0	61.0	59.1	63.2	66.8	68.7	69.8	71.3	70.5	67.3	61.1	78.0	125.4
OVERALL	98.6	99.7	98.7	97.8	95.6	93.8	91.0	91.7	93.7	95.2	97.7	99.8	100.3	98.6	93.8	90.6	97.5	144.9
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	71.4	82.5	87.0	88.9	89.3	88.6	86.7	87.1	89.9	91.6	93.4	93.9	93.5	90.3	82.4	73.4		

(c) Corrected fan speed, 80 percent of design; fan physical speed, 1926 rpm; fundamental blade-passage frequency, 1348 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	71.4	68.7	69.7	69.4	70.0	69.2	70.5	71.2	71.4	71.0	72.5	74.3	74.0	75.9	76.9	77.9	72.7	120.1
63	77.7	74.7	69.2	68.4	69.4	69.5	70.4	71.5	71.4	71.5	74.4	73.4	74.7	75.9	76.9	78.4	73.2	120.6
80	69.5	69.6	69.5	68.1	68.1	67.8	67.8	68.3	68.8	70.0	71.5	73.9	75.0	76.6	78.1	79.5	72.6	120.0
100	72.8	71.3	70.7	70.0	69.3	69.5	69.5	69.8	71.2	72.7	74.2	75.9	77.0	78.7	78.7	79.6	74.2	121.6
125	77.0	77.1	76.3	75.1	74.5	73.5	73.5	73.1	74.5	76.0	76.1	77.2	77.1	78.6	78.5	78.4	76.0	123.4
160	77.7	78.1	76.2	75.7	75.6	73.4	73.7	73.7	74.7	75.1	76.2	76.8	76.7	76.7	76.7	76.9	75.7	123.1
200	76.5	76.2	73.5	72.4	71.9	71.2	71.2	71.7	71.7	72.0	72.7	74.1	74.9	76.0	76.7	76.2	73.5	120.9
250	79.0	79.2	76.2	74.0	73.7	72.0	70.7	71.5	73.0	74.0	75.7	76.9	77.5	76.9	76.2	74.9	75.1	122.5
315	79.1	78.6	76.2	76.1	74.9	72.7	72.7	73.9	74.9	76.1	76.7	77.7	77.4	76.4	76.6	75.3	75.9	123.3
400	80.0	79.6	79.3	77.6	75.6	74.3	74.1	74.5	75.1	76.8	78.1	79.2	79.3	77.8	75.8	74.2	77.2	124.6
500	81.1	81.4	80.3	79.3	78.1	75.6	76.3	76.3	76.9	78.4	79.9	80.9	80.4	78.4	76.3	74.5	78.7	126.1
630	81.8	83.2	81.7	80.8	79.5	76.8	76.5	77.3	79.2	80.5	82.3	83.1	82.3	80.5	78.3	75.6	80.5	127.9
800	83.0	84.5	84.2	82.4	80.2	78.0	77.9	79.4	80.9	82.2	83.4	84.4	84.5	81.9	78.5	76.1	82.0	129.4
1000	84.4	85.6	84.3	83.3	81.4	79.6	79.1	80.4	82.1	83.8	84.6	86.5	85.9	82.9	78.9	77.6	83.4	130.8
1250	93.5	94.0	94.2	95.5	93.5	89.7	88.5	87.3	91.8	92.0	94.3	99.8	98.7	93.5	91.3	87.2	94.5	141.9
1600	89.0	90.2	90.2	89.8	87.5	84.8	83.3	83.2	86.7	87.7	89.3	93.1	92.8	89.0	85.2	81.6	89.0	136.4
2000	89.5	90.7	89.5	88.5	86.5	84.8	82.2	83.2	85.8	88.2	89.2	90.4	91.8	88.2	83.5	80.6	88.2	135.6
2500	90.9	92.0	91.9	91.9	90.7	87.7	85.0	85.2	87.0	89.5	91.0	94.1	95.0	92.2	87.2	83.1	91.1	138.5
3150	89.1	90.6	90.4	90.3	88.3	86.6	83.6	83.9	86.6	88.1	89.9	91.4	92.6	89.8	84.8	81.3	89.4	136.8
4000	89.9	91.6	91.1	91.9	89.9	87.7	84.1	84.2	86.7	88.6	90.2	91.0	92.2	89.2	84.7	81.0	90.0	137.4
5000	88.1	88.9	87.9	89.6	87.1	84.9	81.4	81.6	84.3	86.6	88.3	90.1	90.3	87.6	83.6	79.2	88.2	135.6
6300	86.8	88.5	87.8	88.0	86.0	85.0	80.8	79.8	83.5	85.1	86.8	87.7	88.8	86.8	82.1	77.9	87.4	134.8
8000	87.1	88.4	87.6	87.9	85.3	84.8	80.3	79.1	83.4	84.6	86.4	87.2	88.4	86.4	81.8	77.5	87.7	135.1
10000	85.0	85.9	85.2	85.3	82.7	82.4	77.8	76.3	80.2	81.7	83.9	84.3	85.7	83.2	79.4	74.8	86.0	133.4
12500	83.0	84.7	83.0	83.1	81.0	80.5	75.4	73.7	77.6	79.8	82.5	83.2	83.8	81.2	78.0	73.2	85.6	133.0
16000	79.9	81.2	79.5	79.7	77.1	76.3	69.9	69.4	73.9	75.8	78.4	79.9	79.4	78.0	74.3	69.4	83.7	131.1
20000	76.1	76.7	75.7	76.4	72.5	71.4	65.9	64.7	68.8	71.9	73.7	74.4	75.4	74.1	70.4	65.2	82.1	129.5
OVERALL	100.2	101.3	100.8	101.2	99.2	96.8	94.4	94.2	97.3	98.6	100.4	103.4	103.5	100.0	96.6	93.5	100.5	147.9
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	72.5	84.1	88.9	92.0	92.6	91.6	90.2	90.9	93.3	95.0	96.0	97.5	96.7	91.9	84.7	76.3		

TABLE X. - Concluded. NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR DESIGN NOZZLE AREA

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL re 0.00002 N/m^2; PWL re 0.1 pW.]

(d) Corrected fan speed, 90 percent of design; fan physical speed, 2167 rpm; fundamental blade-passage frequency, 1516 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	73.9	70.9	72.4	72.1	72.8	72.8	73.6	74.4	74.4	74.4	75.4	78.0	76.8	78.6	81.3	81.5	76.0	123.4
63	72.4	72.8	72.1	71.6	71.9	72.3	71.9	72.6	72.6	74.1	74.3	76.9	77.9	78.8	80.9	82.7	75.7	123.1
80	76.8	74.6	71.8	70.8	71.1	71.6	70.6	72.5	73.0	74.0	75.6	77.6	79.5	81.6	82.8	84.4	77.0	124.4
100	75.0	74.3	73.7	73.3	72.5	73.2	72.3	72.8	75.0	76.2	77.5	79.9	81.0	82.3	83.7	84.0	78.1	125.5
125	78.8	80.5	79.6	78.5	77.3	77.3	76.1	76.0	76.8	78.6	79.1	81.2	82.1	82.3	83.3	82.7	79.6	127.0
160	80.6	80.9	79.6	79.3	77.8	77.1	77.1	76.8	78.1	78.1	79.3	80.4	80.1	80.6	81.1	81.3	79.1	126.5
200	79.8	80.0	77.0	75.2	74.7	74.5	74.3	74.8	75.3	75.8	76.7	78.1	79.0	80.0	80.8	80.2	77.2	124.6
250	81.9	83.1	80.1	77.3	76.3	75.6	74.1	74.3	75.8	77.4	79.1	80.2	80.6	80.1	80.6	79.0	78.5	125.9
315	81.7	82.2	79.8	77.8	78.3	76.5	76.7	77.7	78.5	78.5	79.5	80.8	80.3	80.2	80.2	78.7	79.1	126.5
400	82.2	82.7	82.1	79.6	77.7	76.6	76.7	77.1	78.1	79.7	80.6	81.7	81.6	80.6	79.6	77.8	79.8	127.2
500	83.1	83.8	83.0	80.6	79.1	78.3	78.1	79.5	80.1	81.5	82.1	82.9	82.1	80.6	79.3	77.5	81.0	128.4
630	83.6	85.1	83.6	82.6	81.3	79.6	79.6	80.6	82.0	83.1	84.0	84.9	83.6	82.6	80.5	78.0	82.6	130.0
800	85.5	87.0	86.7	84.8	82.7	81.2	81.2	82.5	84.0	85.2	85.8	86.9	85.8	83.5	80.2	78.7	84.5	131.9
1000	85.8	87.5	86.5	85.0	83.3	81.7	82.5	83.3	84.6	86.4	86.9	88.1	86.7	83.3	80.6	79.5	85.3	132.7
1250	87.4	88.9	88.7	87.7	85.9	85.1	84.4	85.1	86.9	89.1	90.2	91.5	89.9	86.1	83.2	81.5	88.1	135.5
1600	95.2	97.0	97.3	97.2	95.5	94.7	93.2	92.2	95.0	96.8	98.5	101.6	99.3	95.0	91.0	90.2	97.0	144.4
2000	91.3	91.7	90.3	89.5	88.2	86.5	85.2	86.0	88.7	90.5	91.7	92.9	93.0	88.2	84.5	82.6	90.0	137.4
2500	90.9	91.6	90.8	90.5	89.1	87.3	86.0	86.8	89.1	91.3	92.3	93.9	93.6	89.5	84.8	82.8	90.8	138.2
3150	92.6	95.4	95.7	95.1	94.2	92.1	89.7	89.4	91.7	93.2	94.1	96.3	96.7	93.2	88.6	85.5	94.2	141.6
4000	91.0	92.3	92.6	92.3	90.5	89.1	86.5	87.3	90.1	92.1	92.8	93.7	93.8	90.0	86.0	82.7	91.9	139.3
5000	90.1	91.3	90.8	91.8	89.6	88.3	85.6	85.6	88.4	90.8	91.6	93.9	93.3	90.3	85.8	82.4	91.4	138.8
6300	88.7	90.5	90.5	89.5	87.9	87.0	84.0	83.7	87.5	89.2	90.2	91.1	92.0	90.2	84.4	81.1	90.4	137.8
8000	88.7	90.1	89.5	89.8	87.8	87.3	83.5	83.0	87.1	88.8	90.2	90.8	92.0	89.8	84.3	80.6	90.8	138.2
10000	86.3	87.4	87.1	86.9	84.9	84.8	80.9	80.1	84.4	85.6	87.6	87.8	88.8	85.9	82.4	77.7	88.9	136.3
12500	84.4	85.9	84.7	84.4	83.2	82.6	78.4	77.9	81.5	84.0	86.5	87.1	87.0	84.4	80.7	76.1	88.6	136.0
16000	80.6	82.6	81.2	81.3	79.0	78.3	73.3	73.8	78.1	80.1	82.2	83.8	82.9	80.9	77.3	72.5	86.7	134.1
20000	76.7	77.7	77.3	77.5	74.0	72.9	69.0	69.0	72.7	76.3	78.2	78.5	79.4	77.2	73.5	68.7	85.1	132.5
OVERALL	101.7	103.3	103.0	102.7	101.1	99.9	98.0	97.9	100.5	102.3	103.5	105.5	104.8	101.5	98.0	96.4	102.9	150.3
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	75.2	86.7	91.6	94.3	95.3	95.2	94.3	94.9	97.3	98.8	99.5	100.8	98.6	93.2	86.4	80.2		

(e) Corrected fan speed, 100 percent of design; fan physical speed, 2408 rpm; fundamental blade-passage frequency, 1685 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	76.6	75.0	75.1	76.0	75.3	75.8	76.6	77.0	76.6	78.1	78.1	80.5	81.3	82.8	85.1	86.7	79.6	127.0
63	72.3	75.1	73.9	73.6	74.8	74.6	74.9	75.1	75.3	76.3	77.1	79.7	81.3	83.8	84.9	85.7	79.0	126.4
80	79.3	77.6	75.1	74.9	74.8	74.1	74.6	73.3	75.3	76.8	78.8	81.7	82.9	84.9	87.3	87.8	80.5	127.9
100	77.3	76.3	75.3	75.6	74.8	75.3	75.1	75.6	77.6	79.5	81.1	84.4	84.5	86.6	87.5	88.2	81.8	129.2
125	82.1	83.1	81.9	80.6	79.6	79.8	78.9	79.3	80.3	81.6	83.1	84.9	85.1	85.8	87.4	86.7	82.9	130.3
160	81.8	82.8	82.6	82.0	80.0	80.5	79.5	80.5	80.8	81.6	82.6	84.4	83.3	84.1	85.0	84.7	82.3	129.7
200	82.2	83.2	79.7	78.8	77.7	77.6	78.0	77.5	78.3	78.6	80.2	81.7	82.8	84.0	84.8	84.4	80.7	128.1
250	84.6	85.6	83.3	81.1	79.0	77.8	76.6	77.5	79.1	80.3	82.1	83.7	83.8	84.0	84.1	83.0	81.7	129.1
315	83.2	83.8	82.0	81.3	79.7	78.2	78.8	80.0	80.8	81.8	82.5	84.2	84.0	84.2	83.8	82.2	82.0	129.4
400	84.5	85.0	85.0	83.2	80.5	79.5	79.9	80.2	81.2	82.9	83.0	84.1	84.4	83.7	82.9	81.1	82.7	130.1
500	84.4	85.4	84.4	83.5	82.2	80.9	80.7	81.9	83.2	84.2	84.2	84.8	84.2	83.7	82.5	80.6	83.4	130.8
630	84.5	85.9	84.9	84.6	82.9	81.4	81.9	82.9	84.5	86.2	86.2	86.5	85.0	84.5	83.2	80.8	84.6	132.0
800	86.5	88.3	87.8	87.3	85.3	83.6	83.6	85.0	86.3	87.6	87.8	88.9	87.1	85.5	82.5	81.2	86.5	133.9
1000	86.8	88.3	87.5	87.2	85.2	84.5	85.2	86.3	87.3	88.5	89.0	89.4	88.0	85.3	83.0	81.6	87.2	134.6
1250	87.3	89.0	88.6	87.8	86.3	85.3	86.0	86.3	88.9	90.1	90.3	91.2	90.6	86.1	83.8	82.3	88.6	136.0
1600	96.8	100.3	101.2	102.5	100.5	98.7	98.2	97.2	98.0	98.8	100.2	105.1	105.8	97.3	93.7	92.6	101.0	148.4
2000	92.6	93.9	93.7	94.6	92.6	91.2	90.2	90.3	91.8	93.8	94.6	97.2	98.1	92.3	88.9	86.6	94.0	141.4
2500	90.1	91.3	90.8	90.4	88.8	87.8	87.8	88.8	90.9	92.8	93.8	95.2	95.1	89.4	86.1	83.8	91.9	139.3
3150	93.0	96.8	97.2	96.7	96.0	94.2	93.2	92.2	94.2	95.7	97.2	98.8	97.8	93.2	89.8	87.6	96.2	143.6
4000	91.2	93.0	92.8	92.5	91.5	90.3	89.7	90.2	93.0	94.5	95.3	96.3	96.2	91.2	88.3	85.2	93.9	141.3
5000	90.4	92.1	91.3	92.9	90.8	90.1	88.6	88.8	91.4	93.4	94.9	96.7	96.1	91.8	88.1	84.7	93.8	141.2
6300	87.9	90.6	90.2	90.3	88.2	88.6	86.3	86.7	90.9	92.2	93.2	94.2	94.6	91.4	86.7	83.3	92.6	140.0
8000	87.7	89.7	89.1	89.4	87.4	88.1	85.1	86.2	90.7	92.1	93.2	94.0	94.9	91.1	87.1	83.5	93.0	140.4
10000	85.2	86.7	86.2	86.2	84.4	85.4	82.6	83.4	87.7	89.2	90.9	90.9	92.1	88.1	85.1	80.6	91.2	138.6
12500	82.7	84.5	83.5	83.9	82.9	83.1	80.1	81.0	85.2	87.9	90.0	90.2	90.5	86.4	83.7	79.2	91.1	138.5
16000	75.0	81.0	80.1	80.0	78.1	78.5	74.8	77.1	81.7	83.7	86.1	87.3	86.1	83.7	79.7	75.6	89.2	136.6
20000	74.1	75.5	75.4	75.6	72.9	73.0	71.3	72.8	76.7	80.5	81.8	82.0	82.5	80.0	76.7	71.6	87.6	135.0
OVERALL	103.0	104.8	105.0	105.6	103.8	102.5	101.7	101.5	103.3	104.7	105.9	108.5	108.8	103.3	100.8	99.4	105.7	153.1
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	77.6	89.0	94.0	97.6	97.8	97.8	98.1	98.3	100.0	101.3	101.9	103.9	102.8	94.9	89.1	82.9		

TABLE XI. - NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR 95 PERCENT OF DESIGN NOZZLE AREA

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL re 0.00002 N/m^2; PWL re 0.1 pW.]

(a) Corrected fan speed, 60 percent of design; fan physical speed, 1446 rpm; fundamental blade-passage frequency, 1012 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	75.4	70.2	68.7	68.0	70.4	69.9	69.7	66.5	71.2	68.5	70.7	68.6	69.4	72.0	71.2	73.2	70.1	117.5
63	64.4	68.0	63.5	63.9	66.9	65.0	63.9	64.9	65.5	65.0	64.7	65.5	65.9	69.4	68.5	70.8	66.1	113.5
80	67.0	69.5	67.0	65.5	66.8	65.2	65.2	65.2	66.5	65.8	65.8	66.9	67.7	70.3	69.7	71.9	67.2	114.6
100	69.7	69.4	67.7	67.9	66.7	65.7	64.7	65.6	67.1	66.2	67.7	67.8	69.6	71.4	69.9	70.8	67.9	115.3
125	73.2	73.8	73.0	71.3	71.3	70.0	67.7	69.0	69.2	70.7	71.5	70.8	72.3	73.0	70.5	70.7	71.0	118.4
160	72.4	74.1	73.1	71.7	70.6	69.1	68.6	69.1	70.6	70.1	71.4	72.0	71.1	71.9	70.4	69.9	70.9	118.3
200	73.4	73.9	71.1	69.1	68.1	65.6	66.4	66.9	67.6	67.1	67.4	68.2	69.8	70.4	69.3	68.5	68.7	116.1
250	75.1	76.8	73.8	72.8	69.9	68.8	67.6	67.8	69.4	70.6	71.9	73.2	74.9	74.1	71.4	68.8	71.9	119.3
315	76.8	76.8	74.3	73.4	72.6	70.3	69.9	70.3	71.3	72.3	72.8	74.0	74.8	74.3	70.8	69.7	72.8	120.2
400	77.7	78.0	77.4	75.4	74.2	72.0	70.0	70.9	72.4	73.9	75.0	76.3	77.0	76.7	72.5	69.4	74.7	122.1
500	79.2	80.5	79.2	78.2	76.7	73.3	72.8	72.7	73.8	75.5	76.2	77.6	78.5	77.5	73.8	71.0	76.4	123.8
630	80.4	82.2	80.7	79.0	77.4	74.4	73.0	73.9	75.7	77.0	78.0	79.3	80.2	79.2	76.7	72.8	77.9	125.3
800	81.7	83.2	82.5	80.9	79.2	76.4	74.8	76.3	78.3	79.0	80.2	81.3	83.0	82.3	77.7	74.4	80.0	127.4
1000	89.3	91.8	91.1	89.6	87.9	86.1	83.1	82.4	84.6	86.3	89.1	91.5	91.4	89.3	85.1	83.5	88.4	135.8
1250	84.7	86.2	84.7	82.8	81.0	78.5	76.8	77.5	79.7	81.2	82.5	83.8	85.0	83.8	80.0	76.4	82.2	129.6
1600	84.9	86.8	85.6	83.6	81.9	79.3	77.1	77.6	80.9	82.6	83.6	84.4	86.4	84.8	80.4	75.5	83.1	130.5
2000	87.5	89.4	88.0	86.7	85.5	82.5	78.9	78.9	82.2	84.2	86.0	86.5	88.9	87.7	84.0	79.4	85.7	133.1
2500	86.6	86.9	85.3	83.8	82.3	79.6	76.3	76.3	79.8	81.3	83.8	84.9	87.3	86.3	82.1	76.8	83.6	131.0
3150	85.6	86.8	86.0	84.1	82.8	79.8	76.3	75.8	79.3	80.8	82.5	84.1	86.8	86.5	82.5	77.2	83.6	131.0
4000	84.7	85.7	85.4	84.1	82.4	79.4	75.2	74.7	78.9	80.2	82.4	83.0	85.0	84.4	80.2	75.1	82.8	130.2
5000	83.1	83.3	81.8	81.8	79.8	76.6	72.3	72.0	75.8	77.6	80.6	81.6	82.8	81.6	79.8	73.6	80.8	128.2
6300	81.2	82.7	82.0	80.3	78.5	76.5	71.7	70.1	74.7	76.0	78.2	79.0	81.0	80.2	77.7	71.6	79.8	127.2
8000	81.5	82.3	80.8	80.0	77.3	76.3	70.6	69.0	74.0	74.8	77.5	77.8	80.5	80.0	75.6	70.7	79.7	127.1
10000	75.5	80.4	78.7	77.7	74.9	73.7	67.8	65.5	70.7	71.2	74.0	74.8	77.0	76.2	73.0	67.7	77.9	125.3
12500	78.1	78.8	77.1	76.0	73.8	71.3	65.6	63.3	67.7	69.1	72.8	73.7	74.8	74.1	71.6	65.8	77.6	125.0
16000	75.1	76.1	73.9	72.9	71.1	67.5	62.0	59.2	64.6	65.6	68.3	70.4	70.8	71.2	68.9	62.3	76.2	123.6
20000	71.4	71.7	69.9	69.2	65.1	62.5	56.8	54.4	59.1	61.2	63.3	64.4	66.7	67.2	63.8	58.2	74.4	121.8
OVERALL	96.4	97.9	96.8	95.4	93.7	91.3	88.3	88.2	91.0	92.5	94.5	95.9	97.2	96.1	92.3	88.8	94.6	142.0
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	69.2	81.0	84.6	86.3	87.0	85.6	83.4	83.9	87.1	88.6	89.9	89.8	90.4	87.4	80.6	71.6		

(b) Corrected fan speed, 70 percent of design; fan physical speed, 1687 rpm; fundamental blade-passage frequency, 1180 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	77.6	70.6	70.6	70.5	72.3	69.3	77.3	69.0	70.3	71.3	71.0	72.3	73.8	73.6	73.9	74.4	72.7	120.1
63	77.2	69.6	69.9	68.5	70.9	68.1	76.0	67.4	68.9	69.1	69.0	70.9	72.7	73.0	73.0	74.0	71.5	118.9
80	69.3	69.8	69.8	68.3	70.9	67.6	73.7	67.3	68.6	69.1	70.1	69.9	74.6	73.8	74.7	75.1	71.3	118.7
100	72.1	71.1	71.4	70.6	71.1	69.8	74.4	68.7	69.9	70.7	71.7	72.1	74.8	74.4	75.2	75.1	72.3	119.7
125	76.2	76.3	75.7	74.4	75.1	73.1	76.6	71.2	71.6	73.8	74.2	74.7	76.4	75.3	75.1	74.3	74.6	122.0
160	76.1	76.9	76.4	75.4	74.6	73.4	76.4	72.6	73.4	73.5	74.5	75.0	75.1	74.2	73.6	73.4	74.6	122.0
200	76.0	76.5	73.5	72.1	71.1	70.0	73.1	69.9	70.1	70.4	71.0	71.7	73.5	72.6	73.1	72.3	72.1	119.5
250	76.1	79.5	76.5	75.1	74.0	72.1	73.0	71.0	72.5	73.3	74.8	76.6	76.6	75.6	74.2	72.2	74.7	122.1
315	80.0	79.5	77.0	76.1	75.1	74.1	75.1	73.1	74.2	75.2	75.6	76.5	77.1	75.5	74.3	72.8	75.6	123.0
400	80.4	80.4	80.0	78.0	76.6	75.1	75.0	73.7	75.1	77.5	78.0	78.7	79.4	78.1	75.2	72.7	77.4	124.8
500	81.8	82.7	81.9	81.2	79.8	77.4	76.7	75.7	76.7	78.8	79.8	80.4	80.8	79.2	76.1	73.9	79.3	126.7
630	82.5	84.8	83.2	81.7	80.7	78.4	77.0	77.0	78.9	80.5	81.3	82.3	82.8	81.3	78.4	75.4	80.8	128.2
800	83.6	85.4	84.8	83.5	81.2	79.7	78.2	79.3	80.8	82.7	83.2	84.2	85.3	84.1	79.8	77.1	82.6	130.0
1000	87.0	88.5	87.0	86.4	84.1	82.7	81.0	82.1	83.9	85.7	86.6	87.9	88.2	86.5	82.2	80.1	85.7	133.1
1250	92.7	94.2	92.9	92.9	89.7	89.3	86.0	87.7	88.9	90.2	93.2	94.6	94.3	92.8	89.2	85.9	91.7	139.1
1600	86.1	89.9	89.1	87.1	85.2	83.4	81.1	82.1	84.5	86.2	87.2	88.0	89.6	87.1	82.9	79.6	86.5	133.9
2000	89.7	91.3	90.1	88.9	87.6	85.2	81.9	82.3	85.7	87.6	89.4	89.8	90.9	89.2	85.1	81.3	88.2	135.6
2500	90.6	91.8	90.8	90.3	89.3	86.2	82.3	82.6	85.3	87.7	89.7	90.5	92.2	90.8	87.1	82.2	89.2	136.6
3150	86.6	90.3	90.1	88.6	86.5	84.6	81.0	80.9	84.0	85.6	86.9	88.2	89.8	88.4	83.6	80.2	87.3	134.7
4000	86.4	89.6	89.7	88.5	87.0	84.9	80.2	80.4	83.5	85.0	86.6	87.1	89.0	87.2	83.0	78.9	87.0	134.4
5000	86.7	87.2	86.6	86.4	85.1	82.7	77.8	77.7	80.8	82.9	85.2	86.6	86.8	85.3	83.3	77.4	85.4	132.8
6300	85.4	86.6	86.5	85.0	83.1	82.2	76.5	75.6	80.1	81.4	83.1	83.7	85.2	83.9	81.7	75.8	84.4	131.8
8000	85.7	86.9	85.9	85.0	82.6	82.4	76.1	74.5	79.4	80.5	82.6	82.8	84.9	83.7	79.5	74.9	84.6	132.0
10000	83.6	84.5	83.5	82.5	80.5	80.0	73.6	71.6	76.0	77.2	79.5	79.9	82.0	80.3	77.5	72.2	82.9	130.3
12500	82.4	83.0	82.1	80.6	79.1	78.1	71.2	69.1	73.5	75.0	78.0	78.6	79.8	78.5	76.1	70.4	82.6	130.0
16000	79.1	80.2	78.7	77.5	76.1	74.2	67.3	64.8	69.9	71.6	73.7	75.1	75.6	75.1	73.1	66.4	81.0	128.4
20000	75.2	75.6	74.6	73.6	70.4	69.2	62.3	60.1	64.3	67.2	68.7	70.0	71.9	71.4	68.2	62.8	79.2	126.6
OVERALL	95.7	101.0	100.1	99.2	97.4	95.7	92.8	92.9	95.2	96.8	98.7	99.7	100.6	99.0	95.5	92.0	98.4	145.8
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	72.2	84.0	88.3	90.6	91.4	90.5	88.4	88.8	91.5	93.3	94.5	94.4	94.3	90.7	84.1	75.1		

TABLE XI. - Continued. NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR 95 PERCENT OF DESIGN NOZZLE AREA

[Data adjusted to standard day of 15^{0} C and 70 percent relative humidity; SPL re 0.00002 N/m^2; PWL re 0.1 pW.]

(c) Corrected fan speed, 80 percent of design; fan physical speed, 1928 rpm; fundamental blade-passage frequency, 1349 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	74.7	71.9	71.5	72.0	72.2	71.5	70.9	71.9	73.2	72.7	72.4	74.1	77.9	76.0	77.5	79.6	74.1	121.5
63	78.0	74.7	69.9	70.4	72.5	71.2	71.0	72.5	71.5	70.9	75.0	72.6	78.0	76.2	77.4	78.9	74.1	121.5
80	71.9	71.4	69.7	69.4	70.5	69.9	68.4	69.4	70.2	70.0	71.9	73.8	78.2	77.5	79.2	80.2	73.8	121.2
100	75.2	74.5	73.3	72.7	71.8	71.3	70.3	71.5	72.0	73.5	74.0	75.6	78.8	78.2	79.8	80.4	75.1	122.5
125	78.5	79.2	77.9	77.2	75.9	75.2	74.9	74.4	75.2	76.2	77.0	78.1	79.5	78.9	79.0	79.9	77.2	124.6
160	79.2	80.1	79.2	78.4	76.2	74.9	74.9	75.2	76.2	75.9	77.1	77.2	78.6	77.9	77.9	77.8	77.1	124.5
200	79.1	79.1	76.2	74.4	73.4	72.6	72.2	72.6	73.1	72.6	73.9	75.0	76.6	76.4	77.4	76.8	74.8	122.2
250	81.5	82.2	79.5	77.2	75.7	74.2	73.4	73.9	75.0	76.2	76.9	78.5	78.7	78.2	77.2	76.4	77.1	124.5
315	82.1	82.3	80.1	78.9	77.6	75.8	75.6	76.1	77.3	78.3	78.8	79.7	79.1	78.6	77.6	77.0	78.3	125.7
400	83.1	83.3	82.6	80.3	78.8	77.5	76.5	77.6	78.6	80.0	80.5	82.1	81.6	81.0	77.8	76.4	80.1	127.5
500	84.1	85.0	84.0	82.8	82.0	79.8	78.3	79.8	80.5	81.5	82.0	83.2	82.6	81.5	78.6	77.2	81.7	129.1
630	85.4	87.4	85.7	84.1	83.1	80.2	79.7	80.6	82.1	83.4	84.2	85.0	84.7	83.9	80.4	78.4	83.4	130.8
800	86.5	88.2	87.7	85.9	83.9	81.7	81.4	82.4	83.9	84.9	86.2	87.0	86.9	85.9	81.5	79.8	85.1	132.5
1000	87.7	89.4	88.2	86.5	85.2	82.9	83.2	83.9	85.7	87.4	88.0	89.3	88.7	87.2	82.5	81.6	86.8	134.2
1250	94.9	96.2	95.4	95.2	94.9	91.7	89.5	91.0	91.4	92.4	93.7	98.3	99.5	93.7	90.7	86.6	94.7	142.1
1600	91.9	93.9	92.9	91.6	90.4	87.7	85.9	86.9	88.4	90.1	90.9	93.2	94.1	91.1	86.6	83.8	90.8	138.2
2000	92.7	93.7	92.4	91.2	90.2	87.2	85.7	86.0	88.5	90.5	91.7	92.6	93.2	90.9	86.7	83.8	90.7	138.1
2500	93.0	94.2	93.7	93.7	93.2	89.7	87.2	87.0	89.0	91.2	92.5	94.5	95.0	93.2	89.0	84.8	92.4	139.8
3150	91.8	93.2	93.3	92.2	90.8	88.2	85.8	85.7	87.8	89.5	90.7	91.9	92.8	91.0	86.3	83.1	90.8	138.2
4000	92.0	93.4	93.5	92.7	91.4	88.5	85.9	85.2	87.9	89.2	90.5	91.3	92.2	89.9	85.7	82.5	90.9	138.3
5000	90.2	91.0	89.8	90.7	89.5	86.2	83.5	82.7	85.0	87.2	88.7	90.4	90.5	88.3	85.8	80.7	89.2	136.6
6300	89.1	90.8	89.9	89.3	87.6	85.9	82.6	80.6	83.9	85.6	86.9	87.8	88.8	86.9	84.2	79.4	88.3	135.7
8000	85.5	90.6	89.5	89.5	87.0	86.3	82.0	79.8	84.0	84.8	86.6	87.3	88.8	87.1	82.5	79.1	88.7	136.1
10000	87.8	88.3	87.4	86.9	84.8	83.7	79.4	77.6	80.9	82.2	83.9	84.4	85.7	83.7	80.4	76.2	87.1	134.5
12500	86.3	86.8	85.5	85.2	83.3	81.5	77.5	74.9	78.3	80.0	82.7	83.2	83.8	82.3	79.7	74.5	86.8	134.2
16000	83.0	84.0	82.0	81.9	80.2	77.8	73.8	70.8	74.9	76.5	78.3	80.1	79.8	78.7	76.9	71.1	85.2	132.6
20000	78.7	79.4	78.1	78.1	74.5	72.8	68.0	65.9	69.3	72.2	73.6	74.4	75.6	75.1	71.8	66.7	83.3	130.7
OVERALL	102.6	103.9	103.1	102.5	101.4	98.7	96.5	96.8	98.5	100.0	101.2	103.4	104.2	101.3	97.7	94.9	101.7	149.1
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	74.8	86.7	91.2	93.9	95.1	93.6	92.4	93.0	95.1	96.6	97.3	98.1	97.3	93.2	86.4	78.1		

(d) Corrected fan speed, 90 percent of design; fan physical speed, 2169 rpm; fundamental blade-passage frequency, 1518 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	76.6	75.2	74.9	74.7	75.7	75.1	76.1	76.2	79.1	77.7	78.9	80.3	82.7	82.1	84.6	86.8	79.7	127.1
63	72.8	75.1	72.8	73.9	74.4	74.6	74.4	74.8	76.6	76.1	77.9	79.5	83.1	82.9	85.6	87.1	79.5	126.9
80	78.4	77.6	74.9	74.6	74.9	74.3	73.4	74.1	76.3	76.8	78.9	80.7	83.8	85.1	87.3	88.0	80.6	128.0
100	80.0	78.6	77.8	76.5	76.0	76.1	75.5	76.3	78.8	80.0	81.6	83.6	85.3	86.8	88.0	88.4	82.2	129.6
125	83.6	85.4	84.9	82.4	81.4	80.7	80.4	80.2	81.2	82.6	83.1	84.8	85.6	86.4	87.4	87.6	83.7	131.1
160	84.8	85.8	85.1	83.4	81.8	80.9	80.6	80.8	81.4	82.3	83.4	84.2	84.3	84.3	85.3	85.8	83.2	130.6
200	84.9	84.6	81.8	79.3	78.8	78.9	78.6	78.8	79.1	79.4	80.3	82.0	82.9	84.4	85.4	84.3	81.4	128.8
250	87.6	88.8	86.3	83.4	80.9	80.1	79.1	79.3	80.6	81.6	83.1	84.9	84.9	85.1	84.9	84.0	83.4	130.8
315	87.2	87.3	85.8	83.5	83.0	81.3	81.3	81.7	83.2	83.8	84.0	85.4	84.8	85.7	84.3	83.4	84.0	131.4
400	88.5	88.7	88.2	85.5	84.2	82.5	82.2	82.9	84.0	85.2	85.7	87.6	87.2	85.7	84.2	82.7	85.5	132.9
500	88.9	88.8	88.8	86.8	85.6	83.8	84.4	85.3	86.8	87.6	87.8	88.5	88.4	86.4	84.6	83.3	86.9	134.3
630	88.6	90.1	89.7	88.4	87.1	85.2	85.2	85.9	87.6	89.1	89.1	90.2	89.2	87.9	85.6	83.5	88.1	135.5
800	90.6	92.1	92.4	91.4	88.9	87.7	87.4	88.4	89.4	90.4	90.6	92.2	91.6	89.4	86.2	84.3	90.1	137.5
1000	91.2	92.7	92.4	91.0	88.9	87.9	88.7	89.9	91.0	92.2	92.4	94.0	93.2	89.5	86.5	85.7	91.2	138.6
1250	91.0	92.8	92.8	91.5	90.1	89.3	90.0	91.0	92.6	93.8	94.1	95.7	95.0	91.1	88.1	86.5	92.7	140.1
1600	98.7	100.7	102.3	102.3	101.8	100.5	98.8	97.7	99.5	101.0	102.7	104.3	103.8	100.3	94.3	92.7	101.4	148.8
2000	95.3	96.4	96.3	95.4	95.3	93.4	92.6	92.6	94.9	96.8	97.8	99.5	99.8	94.8	91.3	89.3	96.4	143.8
2500	94.1	94.9	94.6	94.1	92.9	91.4	91.1	91.4	93.9	95.6	97.1	98.9	98.4	93.1	89.6	87.5	95.3	142.7
3150	95.8	99.2	99.4	98.2	97.0	95.8	94.3	93.7	95.3	97.5	98.5	100.0	99.3	94.8	90.8	88.9	97.7	145.1
4000	94.7	96.5	96.8	95.8	94.5	93.0	92.3	92.3	94.8	95.8	97.0	97.8	97.7	93.5	89.5	87.4	96.0	143.4
5000	93.7	94.9	94.5	95.7	94.5	92.5	91.0	90.4	92.5	94.4	96.0	98.1	96.9	93.5	90.4	86.5	95.5	142.9
6300	91.9	94.1	93.7	92.8	91.5	91.4	89.1	88.4	92.1	93.1	94.4	95.1	95.4	92.6	88.9	85.2	94.2	141.6
8000	91.8	93.7	92.8	92.7	90.7	91.2	88.1	87.7	91.8	92.8	94.0	94.3	95.2	93.0	87.7	85.1	94.4	141.8
10000	89.6	90.9	90.6	89.9	88.3	88.8	85.6	85.1	88.9	89.9	91.8	92.3	92.6	89.8	86.0	82.4	92.9	140.3
12500	87.9	89.4	88.6	88.1	86.4	86.3	83.3	82.7	86.4	88.3	91.1	91.1	91.4	88.6	85.5	80.9	92.8	140.2
16000	84.1	85.8	84.8	84.2	82.9	82.1	78.9	78.4	83.2	84.6	86.7	88.0	87.2	85.1	82.6	77.4	90.9	138.3
20000	79.6	81.1	80.6	79.9	76.5	76.7	73.5	73.6	77.3	80.4	81.9	82.6	82.8	81.4	77.7	73.4	88.8	136.2
OVERALL	105.5	107.2	107.5	106.9	106.0	104.8	103.5	103.1	105.2	106.7	108.0	109.4	109.1	105.6	102.2	100.7	107.3	154.7
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	79.3	90.8	96.3	98.7	99.9	100.0	99.7	99.8	101.9	103.2	103.9	104.5	102.8	97.5	90.5	84.1		

TABLE XI. - Concluded. NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR 95 PERCENT OF DESIGN NOZZLE AREA

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL re 0.00002 N/m^2; PWL re 0.1 pW.]

(e) Corrected fan speed, 100 percent of design; fan physical speed, 2410 rpm; fundamental blade-passage frequency, 1687 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	74.1	72.2	73.7	71.6	72.7	72.6	74.1	73.2	75.6	74.6	76.1	77.5	83.4	80.1	81.6	82.1	77.4	124.8
63	71.7	72.6	71.4	70.6	71.9	72.2	72.2	72.6	72.6	73.1	74.1	75.3	83.4	79.7	81.7	82.6	76.8	124.2
80	75.8	75.0	73.1	71.0	71.3	71.3	72.0	73.3	72.3	73.8	75.3	77.4	83.0	81.6	83.1	84.0	77.6	125.0
100	77.7	76.7	74.9	73.9	73.6	73.7	73.4	73.4	75.2	76.4	77.7	79.3	83.7	83.1	83.9	84.5	78.9	126.3
125	81.3	82.6	81.6	80.3	78.3	77.8	77.1	76.6	77.6	78.8	79.9	81.9	83.3	83.1	83.6	83.3	80.5	127.9
160	82.8	83.5	81.8	81.1	79.5	78.5	78.5	77.8	78.8	79.1	80.1	81.2	82.8	81.3	81.1	81.5	80.4	127.8
200	81.8	81.9	79.1	76.9	76.4	75.3	75.9	75.6	76.1	76.6	77.3	78.5	81.4	80.8	81.3	81.0	78.4	125.8
250	84.8	86.0	83.2	80.8	79.0	77.2	75.7	76.2	77.8	79.2	80.2	81.4	82.7	82.5	81.2	80.0	80.5	127.9
315	85.0	85.0	83.2	81.8	80.7	78.7	79.2	79.0	79.8	81.0	81.7	82.7	83.0	82.3	81.0	80.2	81.4	128.8
400	86.1	86.4	85.4	83.3	81.6	80.3	79.4	79.6	81.3	82.6	84.1	85.5	85.3	84.3	81.1	79.5	83.2	130.6
500	86.6	87.4	86.3	85.1	84.3	81.3	82.1	82.1	83.6	84.9	85.8	86.5	85.8	84.6	81.3	80.5	84.6	132.0
630	86.9	88.9	87.6	86.6	85.6	82.9	82.6	83.1	85.3	86.3	87.3	88.0	87.1	86.4	82.9	81.0	86.0	133.4
800	85.3	91.2	90.3	88.7	86.7	84.2	84.3	85.5	87.0	87.8	89.0	90.3	89.3	88.0	83.8	82.0	87.9	135.3
1000	85.8	91.5	90.3	88.8	87.3	85.2	86.0	87.2	88.5	89.8	90.5	91.9	91.0	88.3	84.3	83.6	89.1	136.5
1250	90.4	92.6	92.6	90.9	89.9	87.9	87.6	88.3	90.1	91.6	92.6	93.7	93.1	90.8	86.9	85.0	91.1	138.5
1600	96.5	99.3	99.8	99.3	98.7	96.5	95.5	92.7	94.8	97.0	98.5	100.3	99.3	96.7	93.0	89.6	97.7	145.1
2000	94.3	95.3	93.7	93.0	92.2	90.0	88.5	88.3	91.5	93.5	94.3	95.8	95.7	92.5	88.2	86.2	93.1	140.5
2500	93.6	94.5	94.1	93.3	92.8	90.3	88.6	88.8	91.5	93.1	94.6	96.2	96.1	92.5	88.3	85.7	93.4	140.8
3150	94.4	96.8	97.8	96.6	96.3	94.1	91.6	90.6	92.4	93.4	95.6	97.2	97.4	95.1	90.1	87.2	95.5	142.9
4000	94.0	95.7	95.8	95.0	94.0	92.3	89.7	88.8	91.2	92.7	93.8	94.4	94.3	92.0	87.5	84.7	93.7	141.1
5000	92.6	93.8	93.3	93.8	93.1	90.8	88.1	86.9	89.1	91.1	92.6	94.6	93.5	91.0	88.5	83.5	92.8	140.2
6300	91.4	93.1	92.9	91.9	90.7	90.4	86.9	84.9	88.3	89.4	90.9	92.0	92.1	90.3	86.9	82.5	91.8	139.2
8000	91.3	93.2	92.3	91.8	90.5	90.3	85.8	84.0	88.3	88.8	90.7	91.0	92.0	90.7	85.5	82.0	92.1	139.5
10000	89.4	90.6	90.1	89.6	87.4	87.9	83.6	81.4	85.3	85.9	88.3	88.8	89.1	87.1	83.3	79.6	90.5	137.9
12500	88.3	89.4	88.4	87.6	86.8	86.1	80.8	79.4	82.7	84.2	86.9	87.9	87.7	85.4	82.6	77.8	90.4	137.8
16000	84.4	86.2	85.1	84.2	83.5	82.0	76.6	75.0	78.8	80.4	82.8	84.2	83.5	82.7	80.1	74.3	88.6	136.0
20000	80.8	81.4	81.1	80.1	77.6	76.7	71.6	70.4	73.7	76.3	77.7	78.9	79.3	78.4	75.2	69.7	86.6	134.0
OVERALL	104.3	106.0	105.8	105.1	104.3	102.4	100.5	99.5	101.8	103.3	104.8	106.2	105.9	103.5	100.0	97.7	104.6	152.0
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	77.4	89.4	94.2	96.5	98.1	97.6	96.7	96.4	98.6	99.7	100.8	101.3	99.9	95.5	88.5	81.1		

TABLE XII. - NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR 90 PERCENT OF DESIGN NOZZLE AREA

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL re 0.00002 N/m^2; PWL re 0.1 pW.]

(a) Corrected fan speed, 60 percent of design; fan physical speed, 1449 rpm; fundamental blade-passage frequency, 1014 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	74.2	70.9	72.2	70.4	73.2	71.4	71.9	71.4	73.4	74.2	74.7	73.2	74.2	74.4	74.7	74.3	73.2	120.6
63	69.9	68.1	69.9	68.6	72.4	68.9	67.1	69.4	69.9	70.1	72.4	69.9	69.9	72.4	73.4	73.8	70.6	118.0
80	70.4	70.1	69.6	69.9	71.1	68.4	67.6	68.9	69.4	69.6	69.9	69.1	70.6	72.9	73.4	73.0	70.2	117.6
100	72.3	71.6	70.8	71.8	72.1	68.6	67.6	69.1	69.8	70.3	70.3	69.9	71.6	72.6	72.8	71.7	70.7	118.1
125	68.7	69.9	69.9	70.9	69.9	66.9	67.2	66.4	66.9	68.7	68.2	67.9	69.7	69.9	68.7	67.6	68.6	116.0
160	76.2	77.4	76.2	75.2	74.2	72.2	71.2	71.9	72.4	72.4	73.9	74.7	73.4	74.2	73.4	71.8	73.7	121.1
200	76.7	76.7	74.9	73.7	71.9	69.2	69.2	69.9	69.7	70.2	71.2	71.7	72.4	73.7	72.7	71.1	72.0	119.4
250	79.1	80.1	78.1	77.4	74.9	73.6	71.4	71.1	71.6	73.4	74.9	75.9	76.9	76.6	74.9	71.3	75.2	122.6
315	79.9	80.2	78.2	77.9	76.7	74.2	72.9	73.4	74.2	75.2	76.4	77.7	77.9	77.2	75.2	72.8	76.3	123.7
400	80.6	81.1	81.3	79.8	78.6	75.8	73.8	74.3	75.3	76.8	78.6	79.6	80.6	80.1	77.3	73.7	78.3	125.7
500	82.3	83.1	83.1	82.3	81.1	77.3	75.8	75.8	76.6	78.6	79.3	80.3	81.6	80.8	77.8	74.5	79.8	127.2
630	83.3	85.1	83.6	83.1	81.1	78.1	77.1	76.8	78.3	80.1	81.1	81.6	83.3	83.1	79.8	76.2	81.1	128.5
800	84.2	85.7	85.4	83.7	81.9	79.4	77.9	78.9	79.9	81.7	82.7	83.9	85.4	84.9	80.7	76.8	82.6	130.0
1000	86.9	91.2	89.2	88.9	86.9	84.7	83.9	82.4	84.2	85.4	88.2	90.0	89.7	88.9	84.4	82.6	87.4	134.8
1250	86.3	87.6	86.3	85.1	83.3	80.1	78.6	79.1	80.6	82.6	84.1	84.9	86.6	85.6	82.1	78.0	83.8	131.2
1600	86.4	87.9	86.9	85.4	83.9	80.2	78.4	78.7	81.2	83.4	84.7	85.2	87.7	85.9	82.7	76.6	84.3	131.7
2000	86.1	89.6	88.9	87.6	86.4	83.1	79.9	79.4	82.4	84.4	86.4	86.7	88.6	87.9	85.1	79.3	86.1	133.5
2500	87.4	88.1	86.1	84.9	83.6	79.9	77.1	77.4	79.9	82.1	84.1	85.1	87.4	86.6	83.1	77.0	84.2	131.6
3150	86.8	87.8	86.8	85.3	83.5	80.0	77.0	76.5	79.3	81.0	82.5	83.6	86.8	86.8	83.0	76.9	84.0	131.4
4000	86.0	87.0	86.3	85.0	83.3	79.8	75.5	75.3	78.8	80.8	82.5	82.3	84.8	84.3	80.8	75.7	83.2	130.6
5000	84.2	84.2	83.4	82.7	80.7	77.4	72.2	72.7	76.2	78.7	81.2	82.0	82.7	81.7	80.4	73.6	81.4	128.8
6300	82.2	83.9	82.7	81.2	79.4	76.9	72.7	70.3	74.9	76.8	78.8	79.1	80.9	80.7	78.8	71.9	80.4	127.8
8000	82.7	84.0	82.0	81.2	78.2	76.5	71.5	69.2	74.2	75.5	77.2	77.8	80.5	80.5	76.7	71.4	80.4	127.8
10000	80.8	81.1	80.3	78.5	75.8	73.8	68.0	66.5	70.8	72.5	74.6	74.9	77.5	76.8	74.8	68.8	78.7	126.1
12500	79.3	80.0	78.0	76.3	74.8	71.8	65.8	64.5	68.3	70.3	73.3	73.4	75.8	75.3	73.5	66.3	78.4	125.8
16000	75.8	76.8	74.3	73.5	71.4	67.9	62.4	59.8	64.6	66.4	68.3	70.1	71.1	72.0	71.0	63.4	76.7	124.1
20000	71.6	71.6	70.1	69.3	65.9	62.4	56.6	55.1	59.1	61.8	63.6	64.6	67.3	68.3	66.3	59.0	74.8	122.2
OVERALL	97.5	98.8	97.6	96.5	94.9	91.9	89.8	89.5	91.5	93.3	95.1	96.0	97.5	96.8	93.6	89.4	95.3	142.8
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	70.5	81.9	85.9	87.8	88.4	86.6	84.8	85.0	87.7	89.4	90.7	90.3	90.8	88.2	82.1	72.3		

TABLE XII. - Continued. NOISE OF QF-6 (1.2-PRESSURE-RATIO FAN) FOR 90 PERCENT OF DESIGN NOZZLE AREA

[Data adjusted to standard day of 15° C and 70 percent relative humidity; SPL re 0.00002 N/m^2; PWL re 0.1 pW.]

(b) Corrected fan speed, 70 percent of design; fan physical speed, 1690 rpm; fundamental blade-passage frequency, 1183 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	75.7	72.1	70.9	71.2	74.1	75.6	71.4	70.6	72.6	70.6	71.2	72.8	73.9	74.2	75.1	75.5	73.0	120.4
63	75.4	70.7	70.6	69.1	73.2	73.7	71.4	69.6	69.7	68.2	68.7	71.3	72.6	73.7	74.6	74.1	71.7	119.1
80	70.9	71.9	69.6	69.8	72.6	73.3	69.9	69.1	68.8	68.3	69.4	71.0	72.9	74.1	75.1	75.0	71.5	118.9
100	74.7	73.4	73.2	73.2	73.4	73.5	71.5	69.5	70.7	71.7	71.4	72.6	74.9	75.2	75.7	75.1	73.0	120.4
125	75.1	74.7	74.6	73.7	74.1	72.9	71.9	70.6	70.9	72.7	72.2	72.7	74.2	74.2	73.4	72.5	73.0	120.4
160	78.9	79.9	79.2	77.9	78.1	76.6	75.2	74.1	75.7	74.7	75.6	76.7	76.7	76.9	76.4	75.3	76.6	124.0
200	80.4	79.6	77.3	75.4	74.8	74.3	72.8	72.8	72.4	72.1	72.8	74.0	75.6	75.3	75.8	74.3	74.7	122.1
250	81.9	82.9	81.2	79.4	76.9	76.2	74.2	75.1	75.9	76.9	77.9	79.5	80.4	79.7	78.4	75.1	78.3	125.7
315	83.6	83.1	81.1	80.1	79.6	77.9	77.2	77.4	78.1	78.9	79.6	80.8	80.9	80.2	78.4	76.3	79.5	126.9
400	83.5	84.3	83.3	81.5	80.7	79.3	77.5	77.8	79.3	80.7	81.8	83.3	84.3	83.2	80.8	77.2	81.5	128.9
500	84.8	86.3	85.5	85.0	84.3	81.5	79.8	79.8	80.5	81.5	82.3	83.7	85.1	84.0	81.0	78.0	83.0	130.4
630	86.0	88.0	86.9	86.0	84.5	82.0	80.9	80.9	82.4	83.4	84.4	85.3	86.5	85.9	82.7	79.3	84.4	131.8
800	87.0	88.5	88.2	86.7	85.0	82.7	82.0	82.8	84.3	85.7	85.8	86.9	88.7	88.2	84.0	80.6	85.9	133.3
1000	88.5	90.0	88.7	87.8	86.3	83.8	84.0	84.3	86.3	87.5	88.0	89.8	89.8	89.5	85.2	81.9	87.6	135.0
1250	93.0	94.7	92.5	92.5	90.4	87.7	88.5	87.5	88.2	90.2	90.2	93.1	94.0	93.5	90.4	85.1	91.3	138.7
1600	90.1	91.2	90.7	89.1	87.2	84.6	82.9	83.7	86.1	87.6	88.2	89.3	90.7	89.9	85.9	81.1	88.1	135.5
2000	91.2	92.5	91.4	90.9	89.7	86.4	83.7	84.0	86.5	88.0	90.0	90.5	91.9	91.0	86.9	82.4	89.4	136.8
2500	91.7	92.7	91.6	90.9	89.6	86.6	83.6	83.2	86.1	87.6	89.7	90.8	92.6	91.9	88.2	82.6	89.7	137.1
3150	90.3	91.6	91.0	89.6	87.5	85.0	82.1	81.5	84.3	85.5	87.1	88.4	90.1	89.6	85.1	80.9	88.0	135.4
4000	89.7	91.1	90.9	89.7	87.9	85.1	81.2	80.9	83.6	85.2	87.1	87.3	88.9	88.2	84.2	79.8	87.7	135.1
5000	88.4	88.6	87.7	87.7	86.2	83.1	78.7	78.7	81.9	83.4	85.7	86.7	87.4	86.1	84.4	78.1	86.2	133.6
6300	86.8	88.4	87.4	85.9	83.8	82.8	78.6	76.5	80.4	81.6	83.3	84.1	85.2	84.8	82.3	76.4	85.1	132.5
8000	87.0	88.3	86.8	86.1	83.1	82.6	77.1	75.4	80.3	80.9	82.8	83.1	85.4	85.3	80.8	76.2	85.4	132.8
10000	85.3	85.6	84.5	83.1	80.7	80.3	74.3	72.8	77.0	77.8	79.8	80.5	82.6	81.8	78.8	73.3	83.7	131.1
12500	84.1	84.6	82.6	81.6	79.6	78.4	72.1	70.6	74.4	75.8	78.6	79.3	81.1	80.3	77.8	71.6	83.6	131.0
16000	80.1	81.3	78.8	77.8	76.4	74.4	68.7	66.4	70.9	72.1	74.4	76.3	76.2	77.1	75.3	68.0	81.8	129.2
20000	76.0	76.5	74.9	74.1	70.6	69.1	62.9	61.7	65.4	67.4	69.3	70.9	72.7	73.4	71.0	64.0	80.0	127.4
OVERALL	101.2	102.4	101.3	100.4	98.8	96.3	94.5	94.2	96.2	97.6	98.8	100.1	101.3	100.7	97.3	93.0	99.4	146.8
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	73.8	85.5	89.6	91.9	92.6	91.5	89.8	90.0	92.6	93.8	94.9	95.1	95.2	92.4	85.9	76.2		

(c) Corrected fan speed, 80 percent of design; fan physical speed, 1932 rpm; fundamental blade-passage frequency, 1352 hertz

FREQUENCY	ANGLE, DEG																AVERAGE 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 LEVEL (SPL) ON 30.5-METER RADIUS																	
50	75.7	74.0	73.5	72.8	72.2	71.5	72.2	73.2	74.5	75.2	74.3	73.6	75.2	76.5	76.5	77.9	74.3	121.7
63	76.8	74.8	72.6	70.0	72.3	71.6	71.6	72.5	73.0	72.1	75.6	71.9	75.3	76.3	77.3	77.9	73.9	121.3
80	73.0	73.5	72.0	70.4	70.7	69.5	69.2	70.2	71.4	71.5	72.2	73.1	75.5	77.2	78.5	79.1	73.4	120.8
100	77.6	77.6	76.3	75.6	72.5	72.8	72.5	72.1	74.0	75.5	74.8	75.9	78.3	78.8	79.3	78.8	75.8	123.2
125	78.2	77.8	77.5	76.8	75.3	73.7	74.2	73.0	73.5	76.0	74.7	76.1	77.5	76.8	76.5	76.6	75.7	123.1
160	83.3	84.5	83.0	81.1	79.1	78.1	77.5	76.8	78.3	78.3	80.0	79.7	79.5	80.1	79.3	79.2	79.7	127.1
200	83.0	83.2	80.5	77.8	76.0	75.3	75.0	75.7	75.5	75.5	76.3	76.6	78.3	78.3	78.8	78.0	77.5	124.9
250	86.3	87.3	84.8	82.7	80.8	78.7	76.8	77.2	77.8	79.8	80.3	81.9	82.7	81.8	80.0	77.9	81.2	128.6
315	88.8	87.2	85.0	84.0	82.7	81.0	80.3	80.8	81.7	82.5	83.3	84.1	84.3	83.2	81.5	80.1	83.1	130.5
400	87.2	88.5	87.5	86.0	84.0	82.7	81.3	82.5	84.0	86.2	88.2	88.9	89.0	88.0	84.8	81.7	86.3	133.7
500	88.7	90.3	90.2	89.8	88.5	86.8	84.3	84.3	86.0	86.5	86.8	87.9	89.7	87.5	84.2	81.9	87.5	134.9
630	89.7	91.9	90.2	90.0	88.2	85.0	83.9	84.2	86.0	87.2	88.0	89.3	90.9	89.0	85.9	83.3	88.1	135.5
800	90.4	92.5	91.7	90.7	88.5	86.2	85.4	86.5	88.4	89.2	89.9	90.8	92.4	90.9	86.5	83.7	89.5	136.9
1000	91.0	92.3	91.8	90.9	88.8	87.0	86.6	87.6	89.8	91.1	91.5	92.6	93.5	91.3	87.0	85.2	90.6	138.0
1250	95.5	96.5	94.7	94.0	93.8	90.7	89.2	90.2	91.7	92.8	95.0	95.8	97.7	95.3	91.0	87.2	94.0	141.4
1600	94.1	95.6	94.4	93.4	91.7	88.7	87.2	88.1	90.4	91.7	93.1	93.7	95.6	93.7	89.2	85.0	92.4	139.8
2000	94.7	95.8	94.3	94.0	92.7	89.7	86.8	87.5	90.7	92.2	93.3	93.9	95.5	93.0	89.5	85.4	92.7	140.1
2500	94.7	95.5	94.3	94.5	93.2	89.8	87.0	87.5	90.3	92.0	93.5	95.5	96.3	94.5	90.3	85.6	93.3	140.7
3150	94.0	95.6	94.3	93.3	91.8	89.3	86.0	86.0	88.8	90.3	91.1	92.9	94.0	92.5	87.8	83.9	91.9	139.3
4000	93.8	95.1	94.5	94.1	92.3	89.5	85.1	85.6	88.8	90.0	91.0	91.2	93.1	91.5	87.1	83.0	91.8	139.2
5000	92.3	92.6	91.3	91.8	90.3	87.1	82.6	82.9	86.5	88.0	89.8	91.2	91.3	89.1	87.1	81.2	90.2	137.6
6300	91.2	92.1	91.1	90.2	88.4	86.9	82.9	81.4	85.4	86.2	87.4	88.5	89.9	88.1	85.4	79.8	89.3	136.7
8000	91.2	92.4	90.4	90.2	87.9	87.1	81.7	80.7	85.2	85.9	87.4	87.5	89.9	88.7	84.4	79.7	89.7	137.1
10000	89.5	90.2	88.5	88.2	85.3	84.8	78.8	78.0	81.8	82.7	84.7	85.0	87.2	85.5	82.3	77.0	88.2	135.6
12500	88.2	88.4	86.5	85.5	84.2	83.0	76.9	75.8	79.5	80.9	83.2	83.5	85.3	83.7	81.2	75.5	87.8	135.2
16000	84.4	85.3	83.1	82.3	81.1	78.7	73.3	71.5	75.9	77.1	78.8	81.0	80.9	80.6	79.3	71.3	86.2	133.6
20000	80.5	80.4	78.9	78.0	75.4	73.6	67.4	66.8	70.6	72.7	74.2	75.2	77.7	76.9	74.3	67.9	84.3	131.7
OVERALL	104.7	105.8	104.5	104.0	102.5	100.0	97.4	97.9	100.4	101.6	102.9	103.9	105.3	103.4	99.7	96.2	103.1	150.5
DISTANCE	SIDELINE PERCEIVED NOISE LEVELS																	
152.5 METERS	77.4	88.8	92.7	95.6	96.2	94.8	93.2	94.1	96.9	98.1	98.9	99.3	99.0	95.2	88.3	79.5		

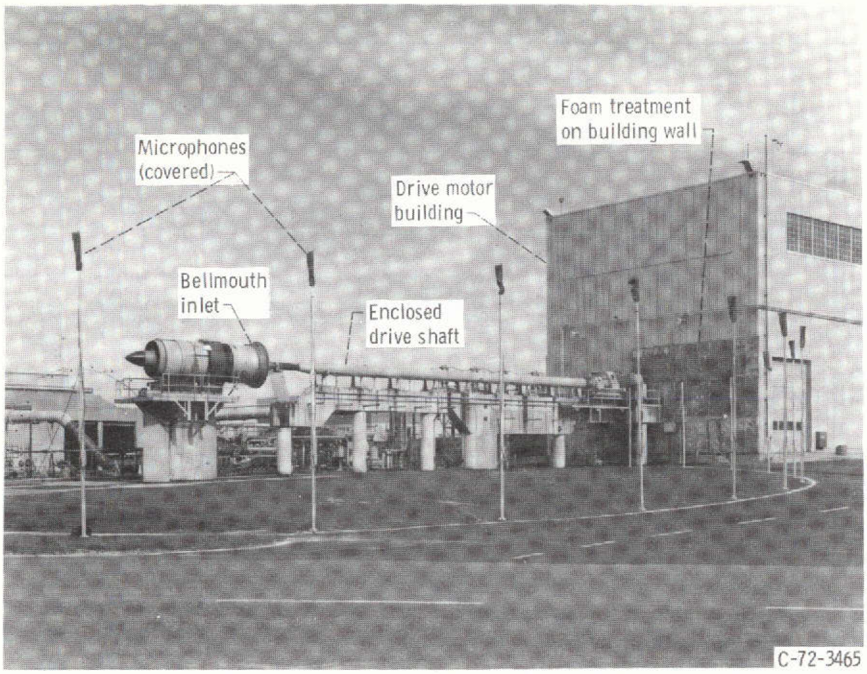


Figure 1. - Test site showing QF-6 in place.

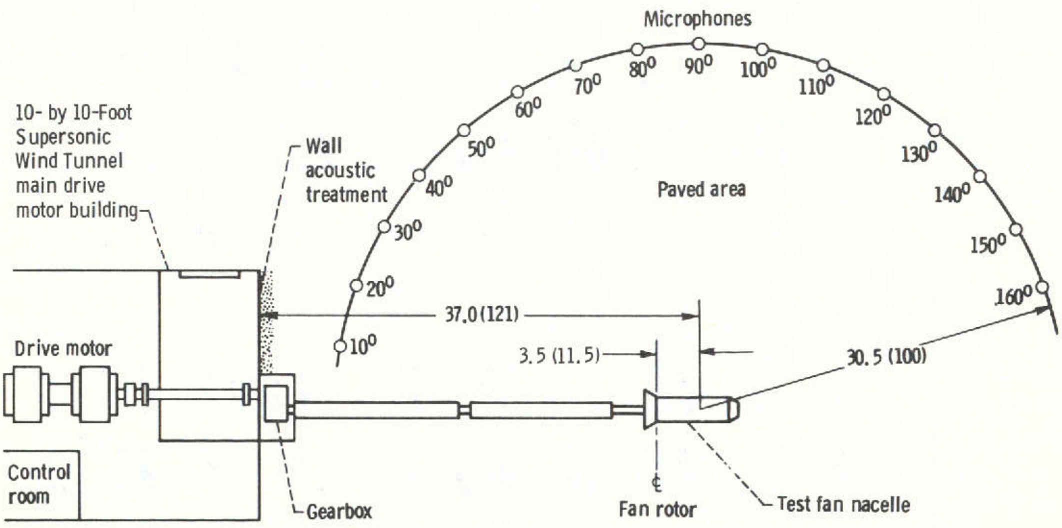


Figure 2. - Plan view of test site. (All dimensions are in m (ft).)

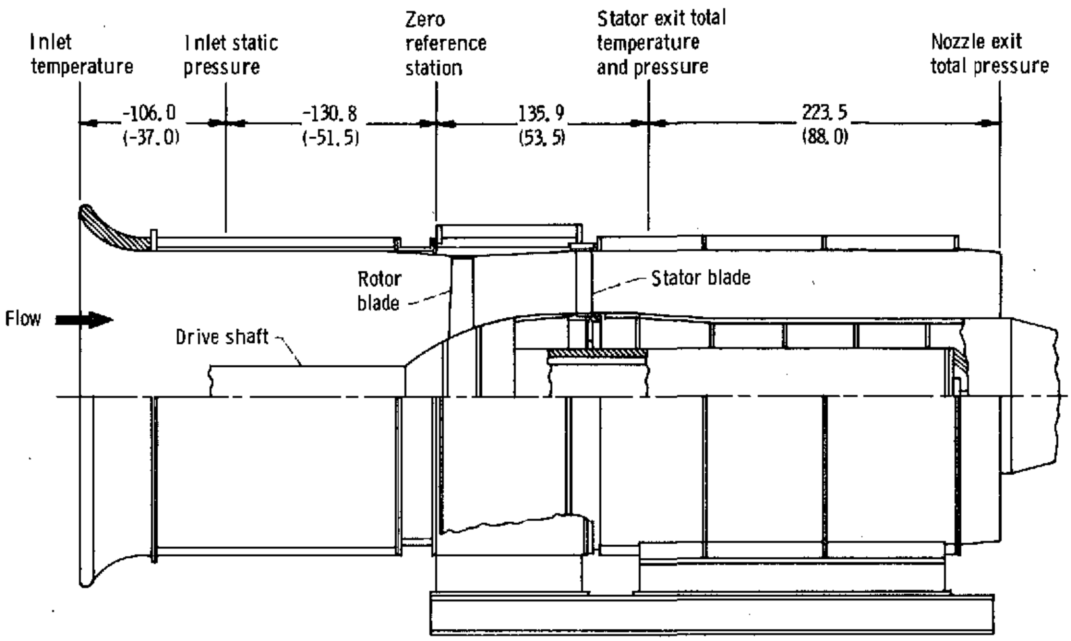


Figure 3. - Cross section of QF-6 fan stage (hard walls). (All dimensions are in cm (in.).)

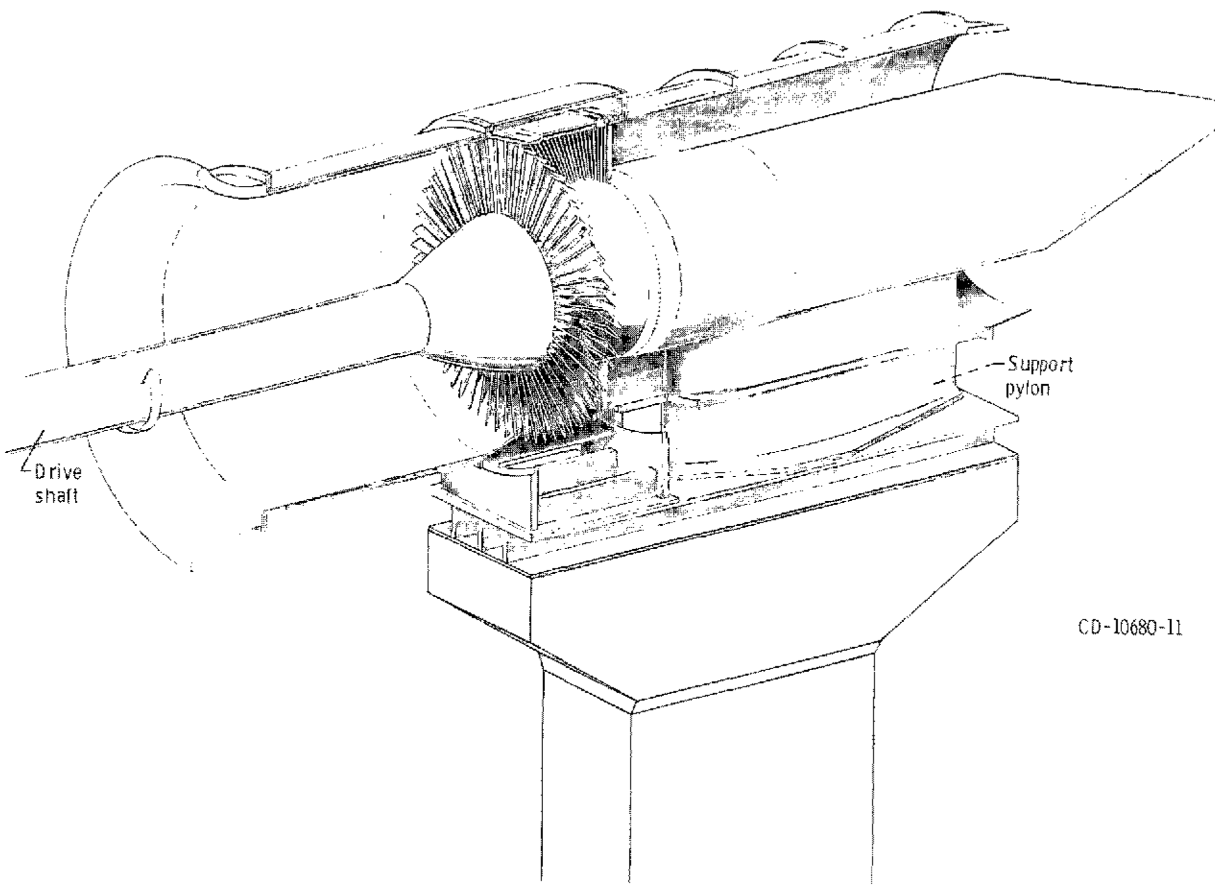


Figure 4. - Cutaway sketch of typical fan installation.

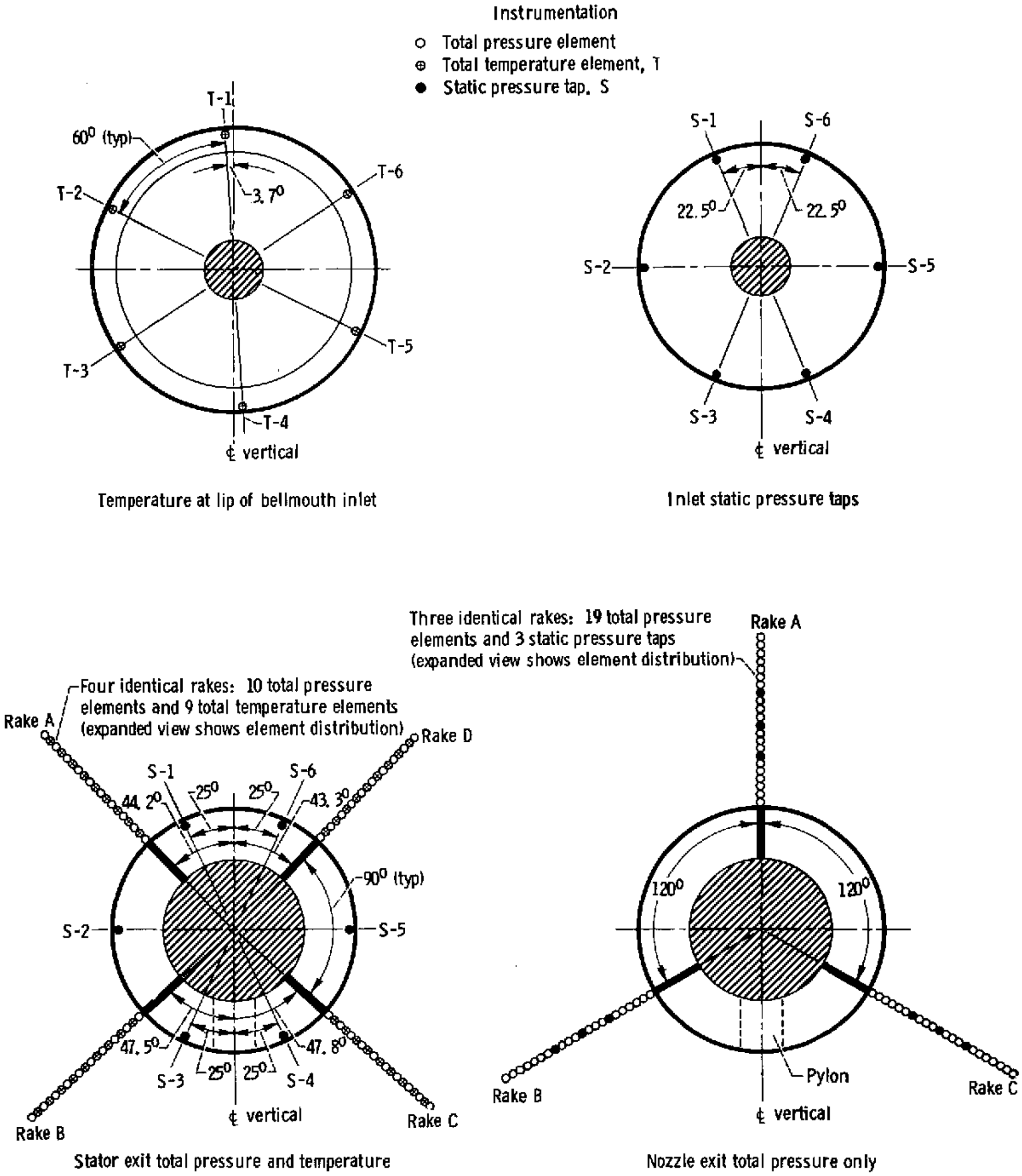


Figure 5. - Detail of fan aerodynamic instrumentation. All views looking downstream.

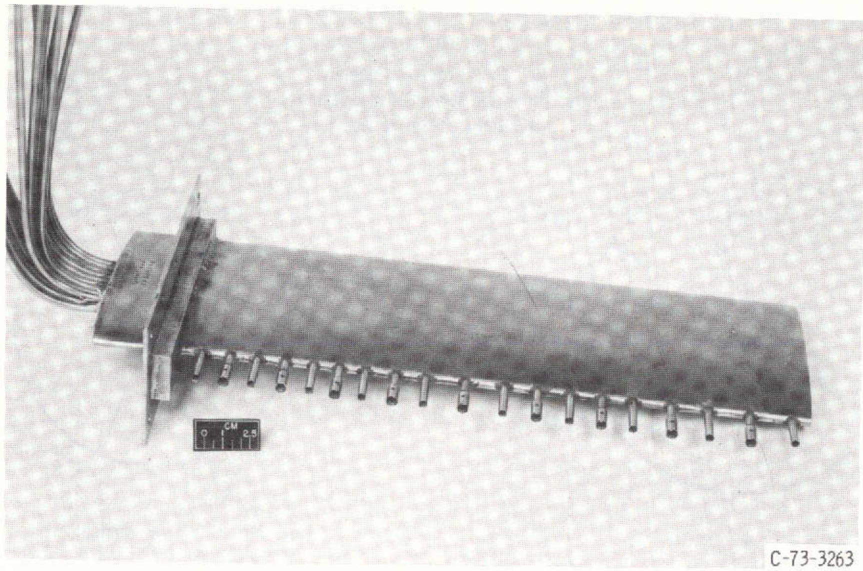


Figure 6. - Total temperature and pressure rake used at stator exit station.

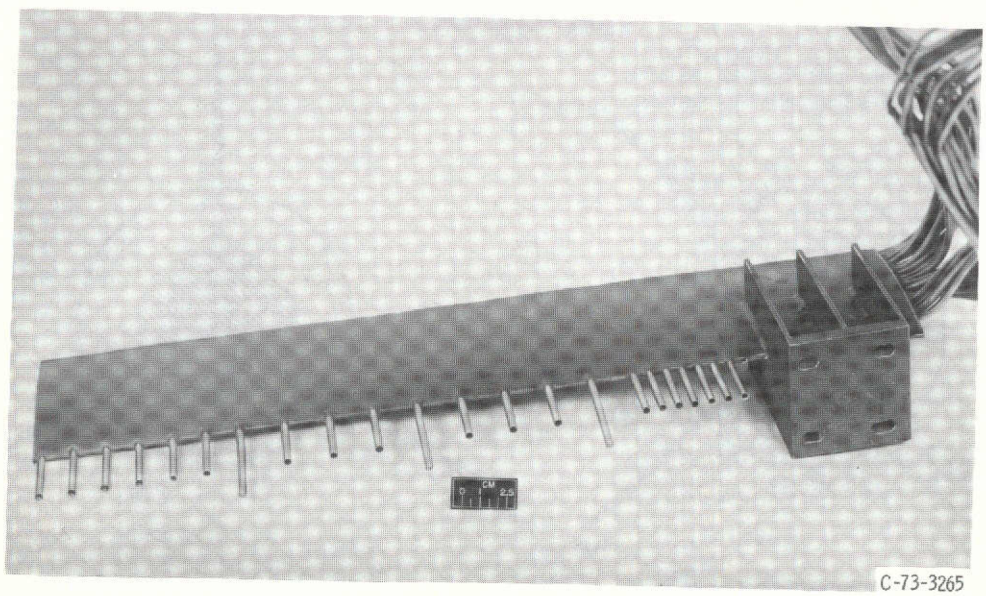


Figure 7. - Total and static pressure rake used at nozzle exit station. (Three inner total pressure elements are sketched in place.)

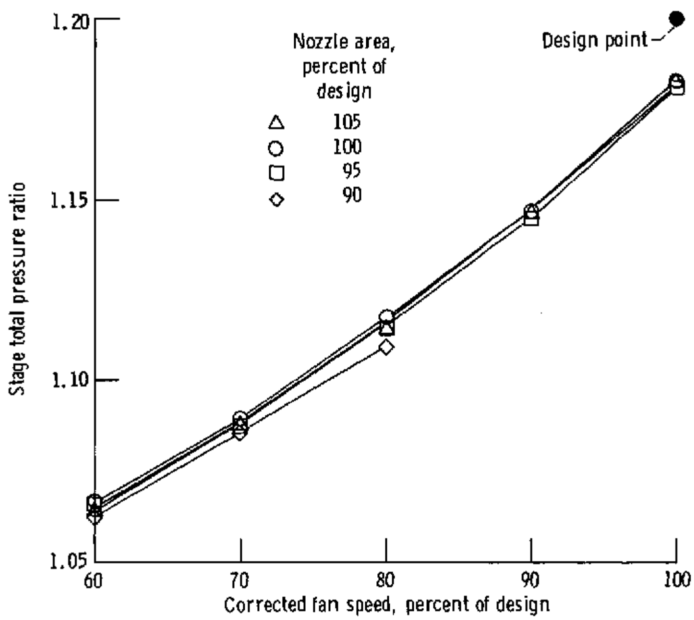


Figure 8. - Stage total pressure ratio as function of percent of corrected fan design speed.

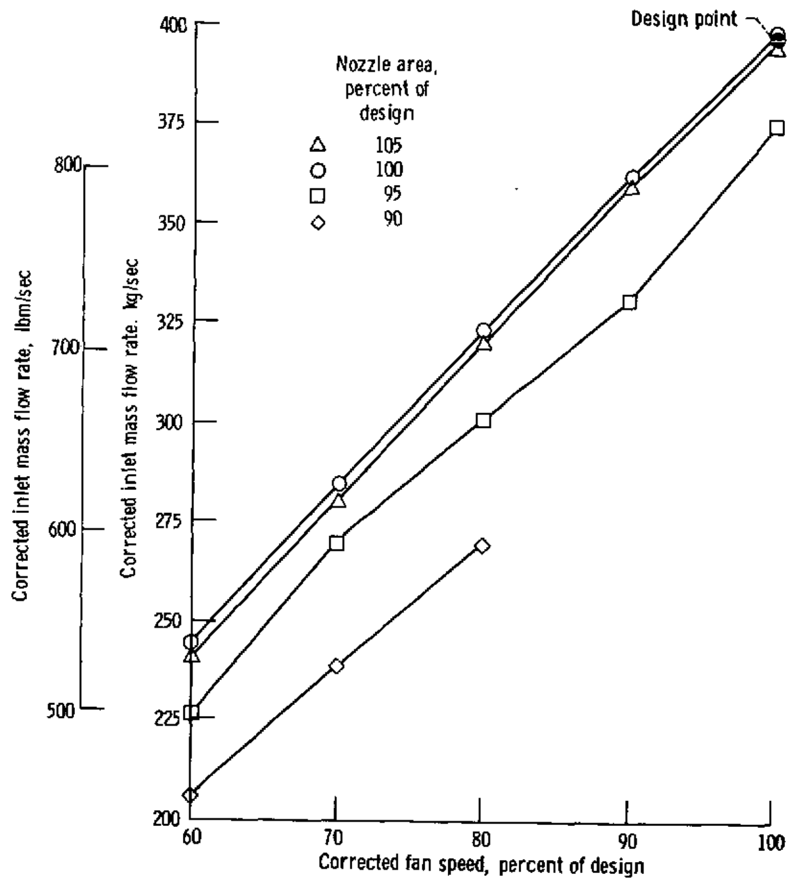


Figure 9. - Corrected inlet mass flow as function of percent of corrected fan design speed.

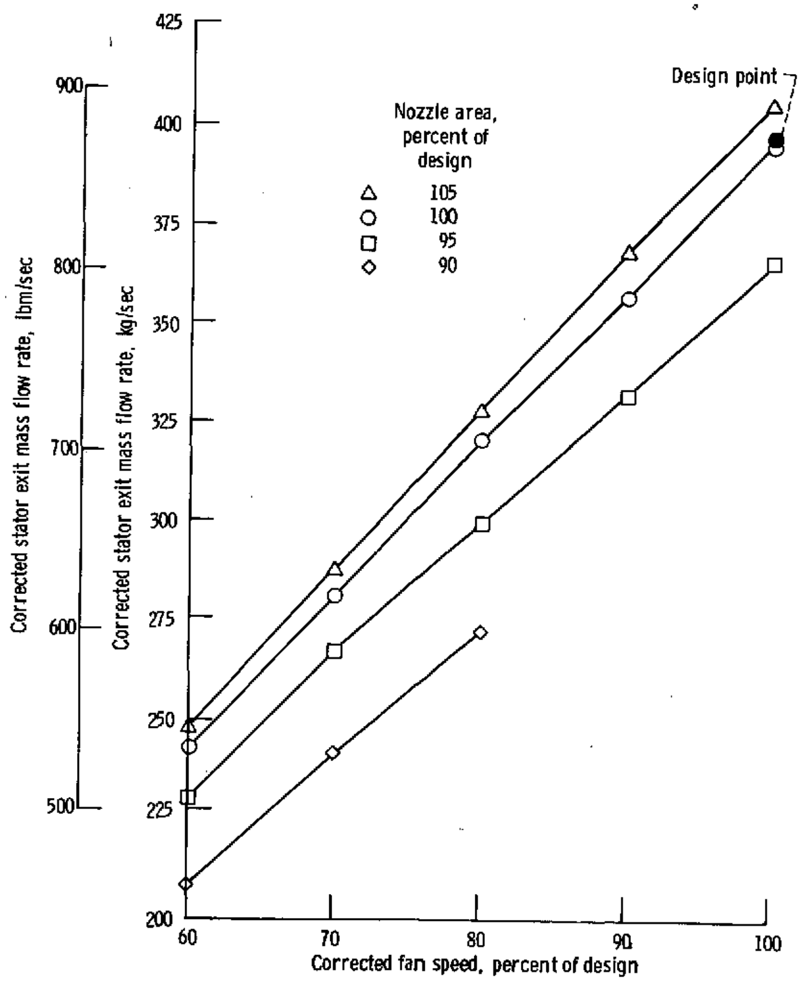


Figure 10. - Corrected stator exit mass flow rate as function of percent of corrected fan design speed.

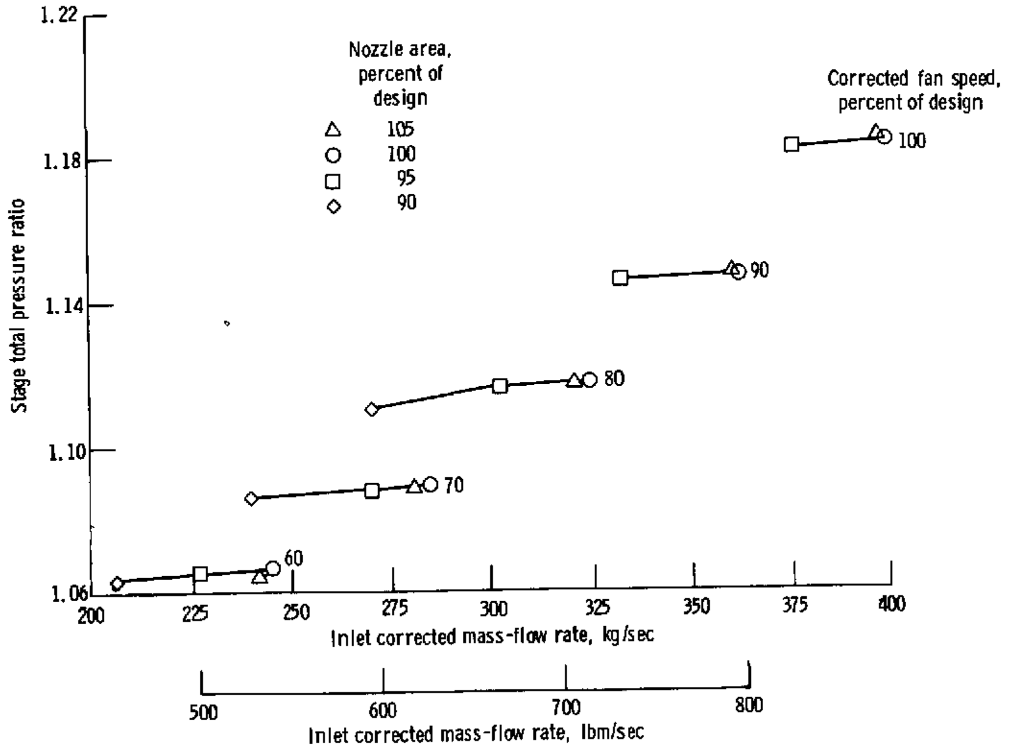


Figure 11. - Fan operating map using inlet corrected mass-flow rate.

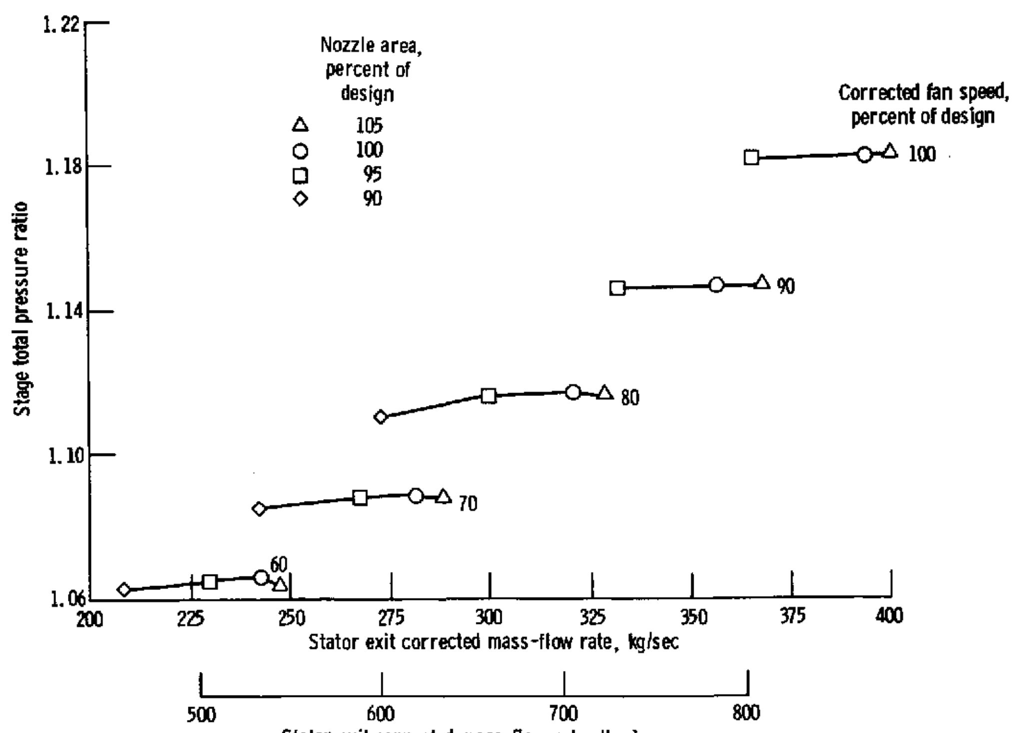


Figure 12. - Fan operating map using stator exit corrected mass-flow rate.

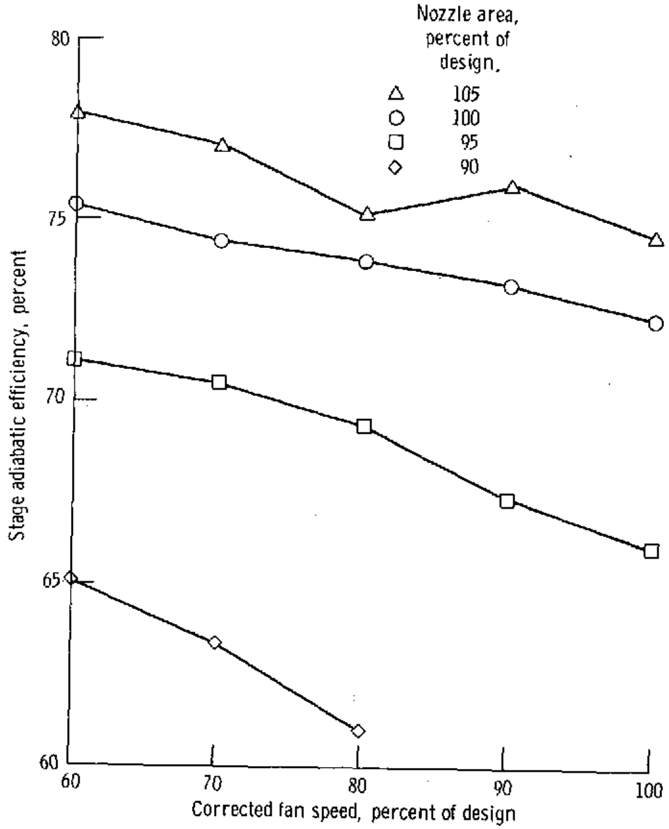


Figure 13. - Stage adiabatic efficiency as function of percent of corrected fan design speed. Design-point adiabatic efficiency, 0.879.

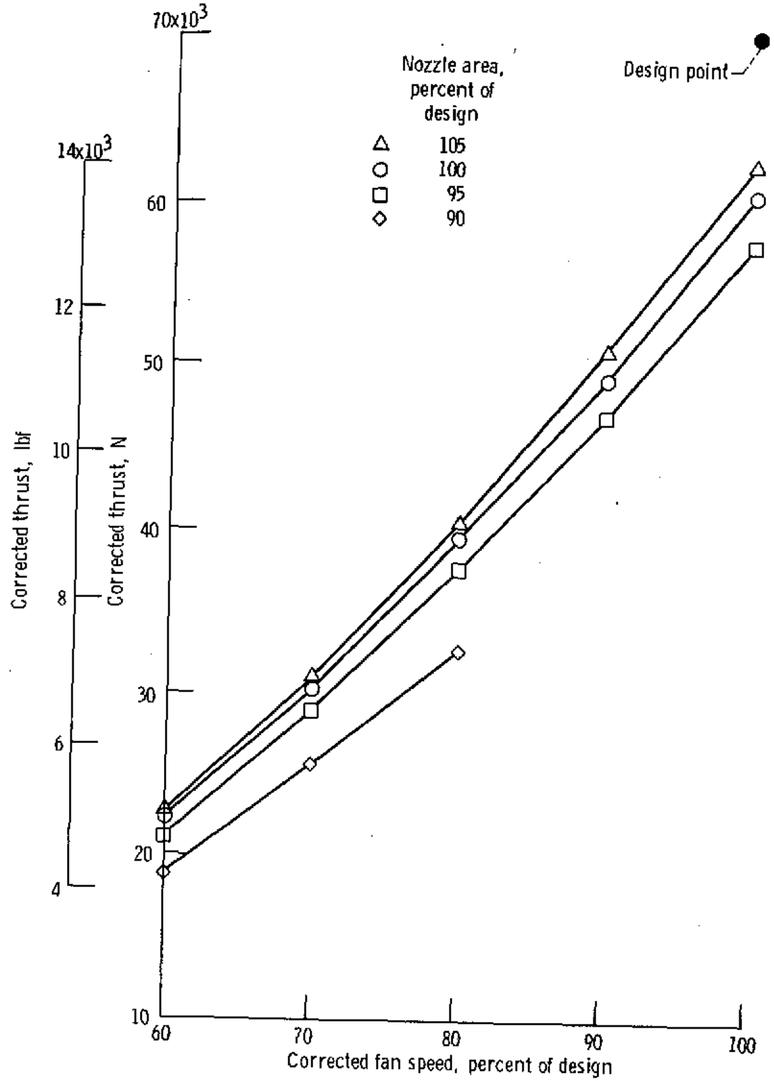


Figure 14. - Thrust as function of percent of corrected fan design speed.

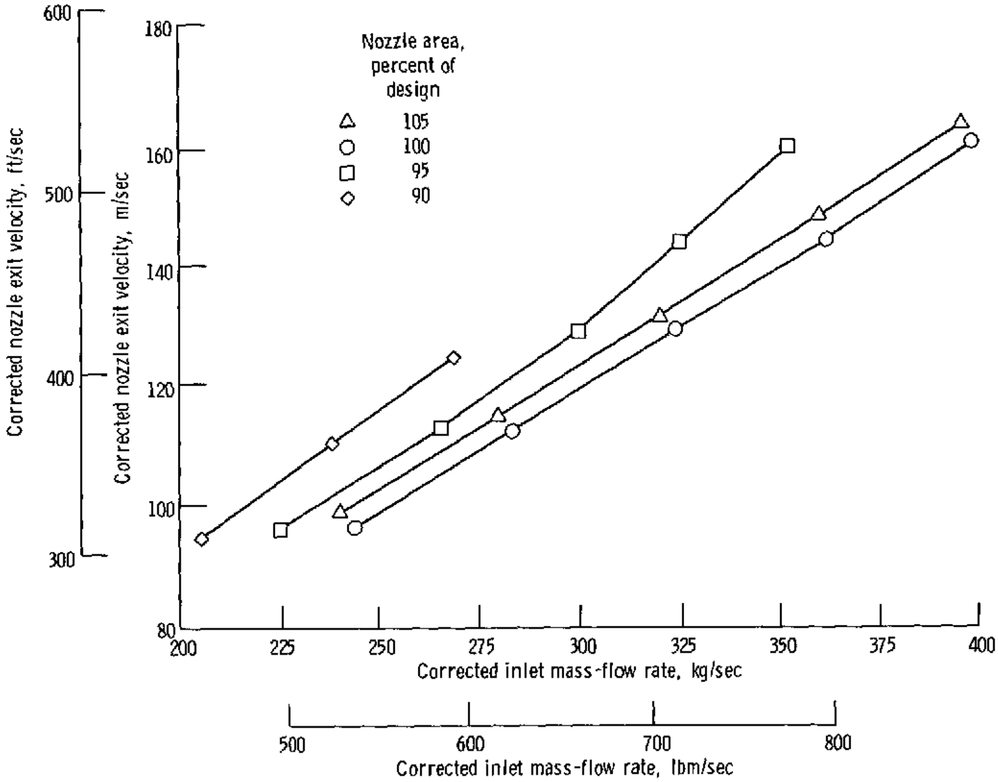


Figure 15. - Corrected nozzle exit velocity as function of corrected inlet mass-flow rate.

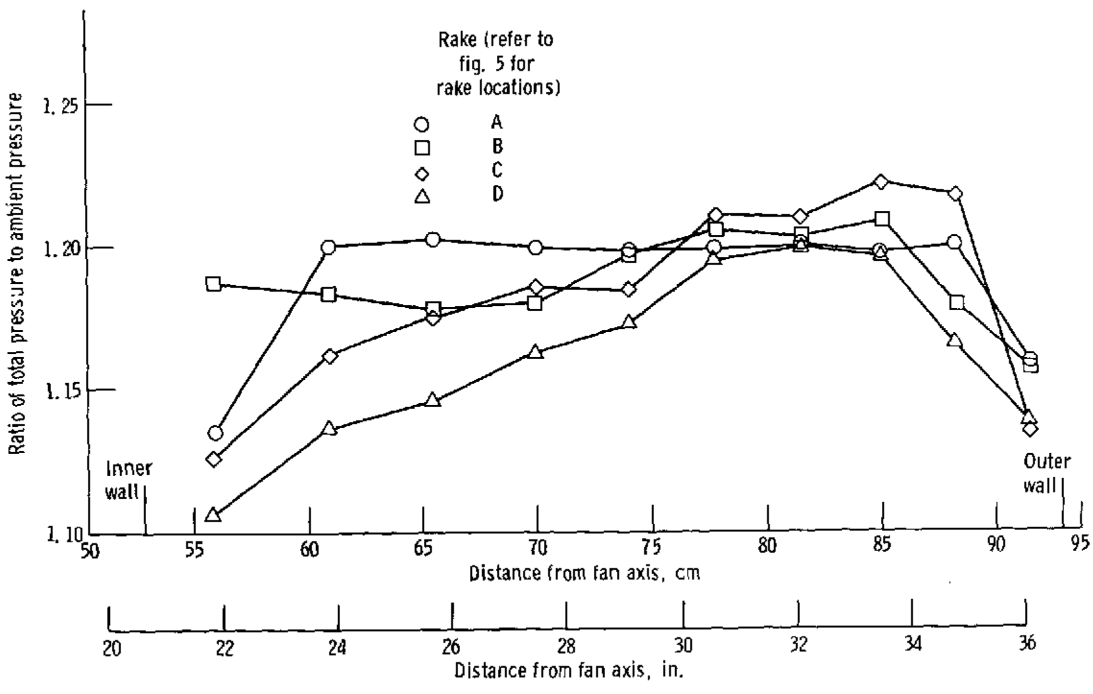


Figure 16. - Radial pressure ratio distribution at stator exit measuring station. Design speed.

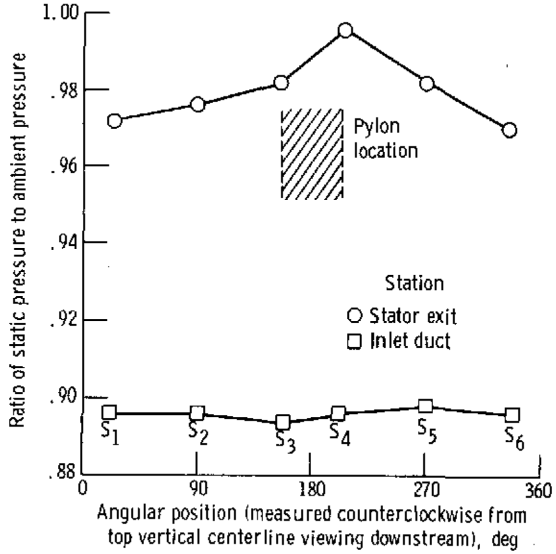
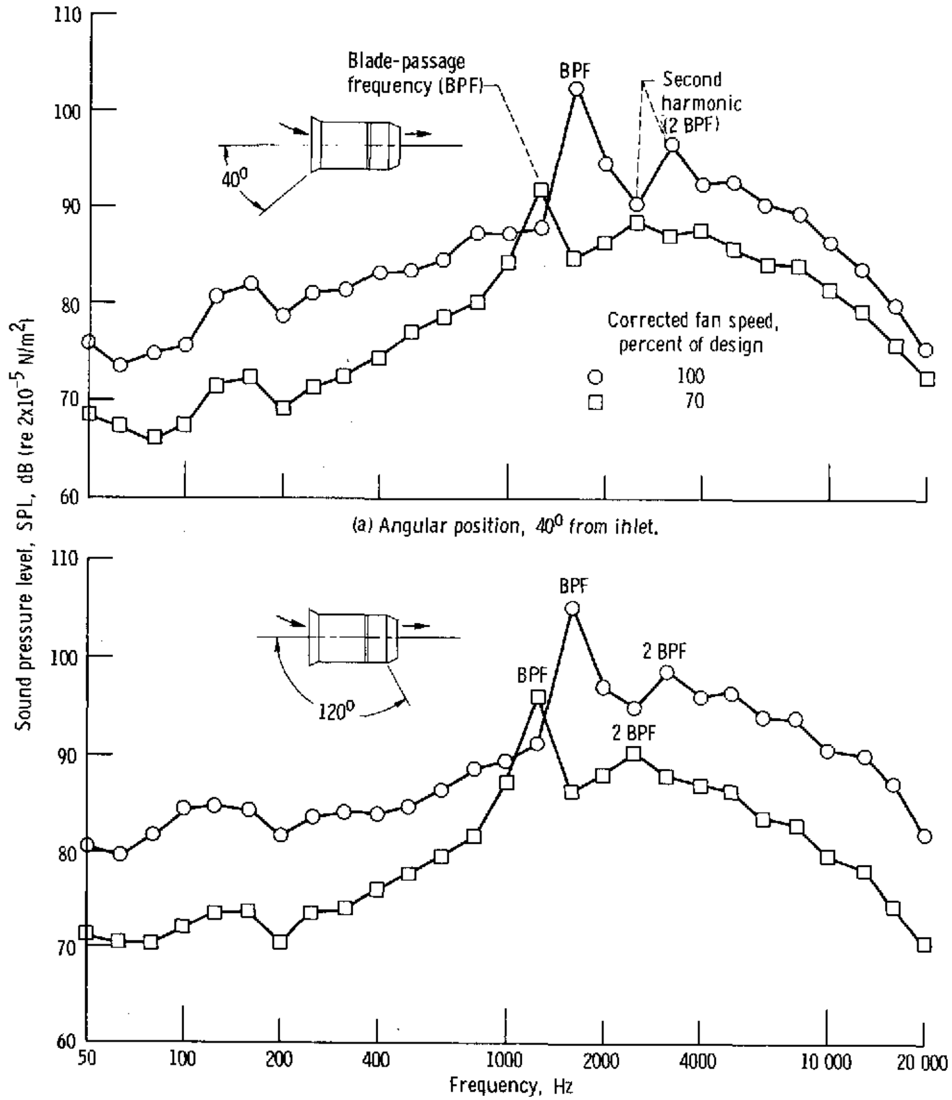


Figure 17. - Angular distribution of outer-wall static pressures. Design speed.



(b) Angular position, 120^0 from inlet.

Figure 18. - 1/3-Octave sound pressure level spectra. Design nozzle area; data adjusted to standard-day conditions.

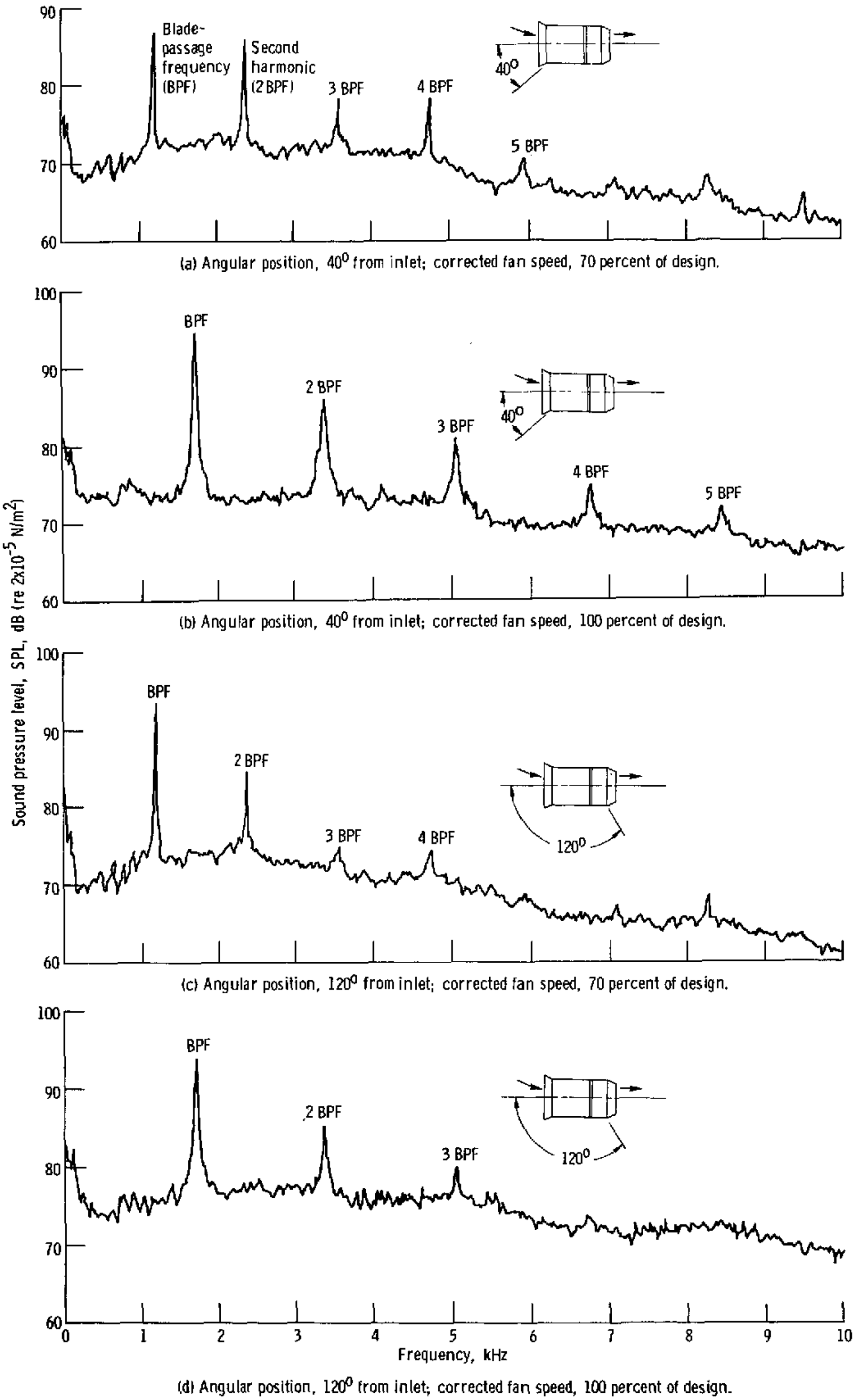


Figure 19. - Narrow-band (32-Hz bandwidth) spectra. Design nozzle area; data taken at 30.5-meter (100-ft) radius.

	Data	Broadband	Pure tone
	Sound pressure level, SPL, dB (re 2×10^{-5} N/m^2)		
Fundamental blade passage	102.4	88.6	102.2
frequency tone, 1 BPF	94.5	89.5	92.8
Second harmonic, 2 BPF	96.7	91.3	95.2
Third harmonic, 3 BPF	92.8	91.2	87.7

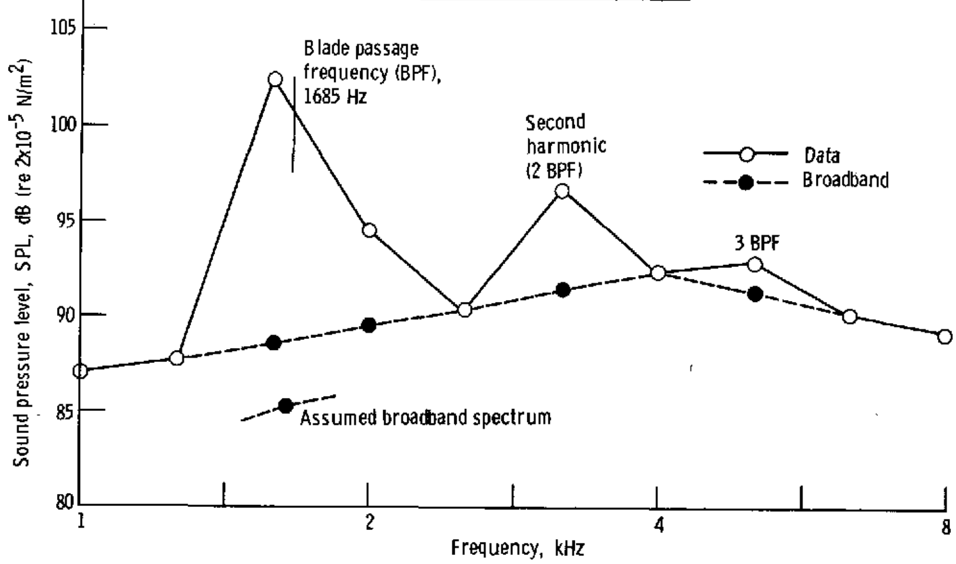
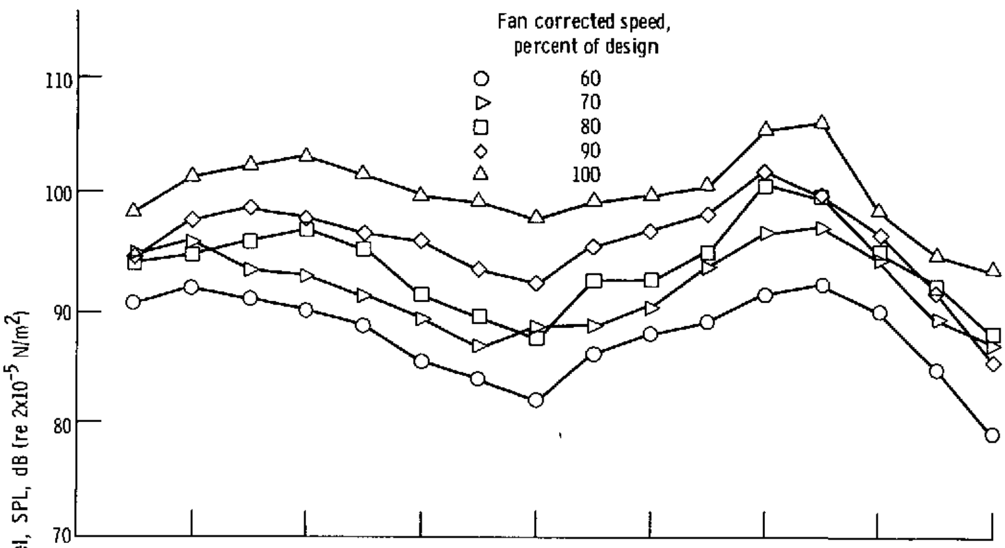
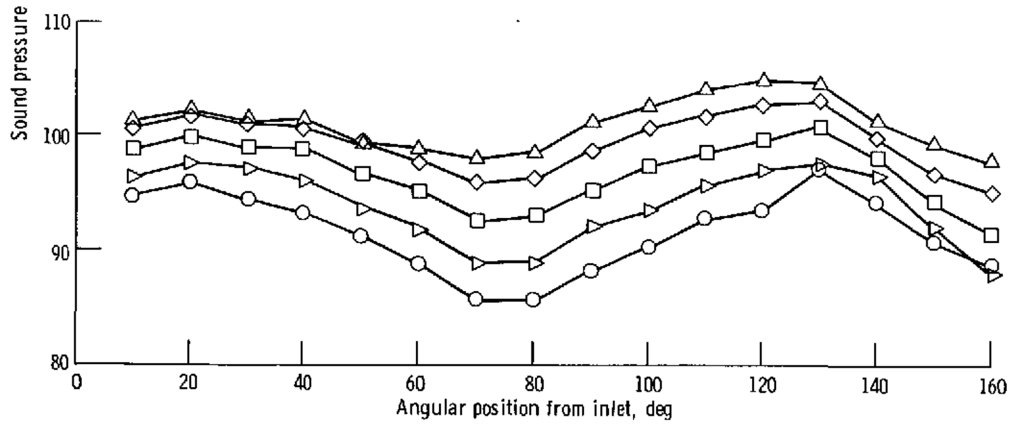


Figure 20. - Method of isolating pure-tone and broadband sound pressure levels in 1/3-octave spectra. Design nozzle area; angular position, 40° from inlet.

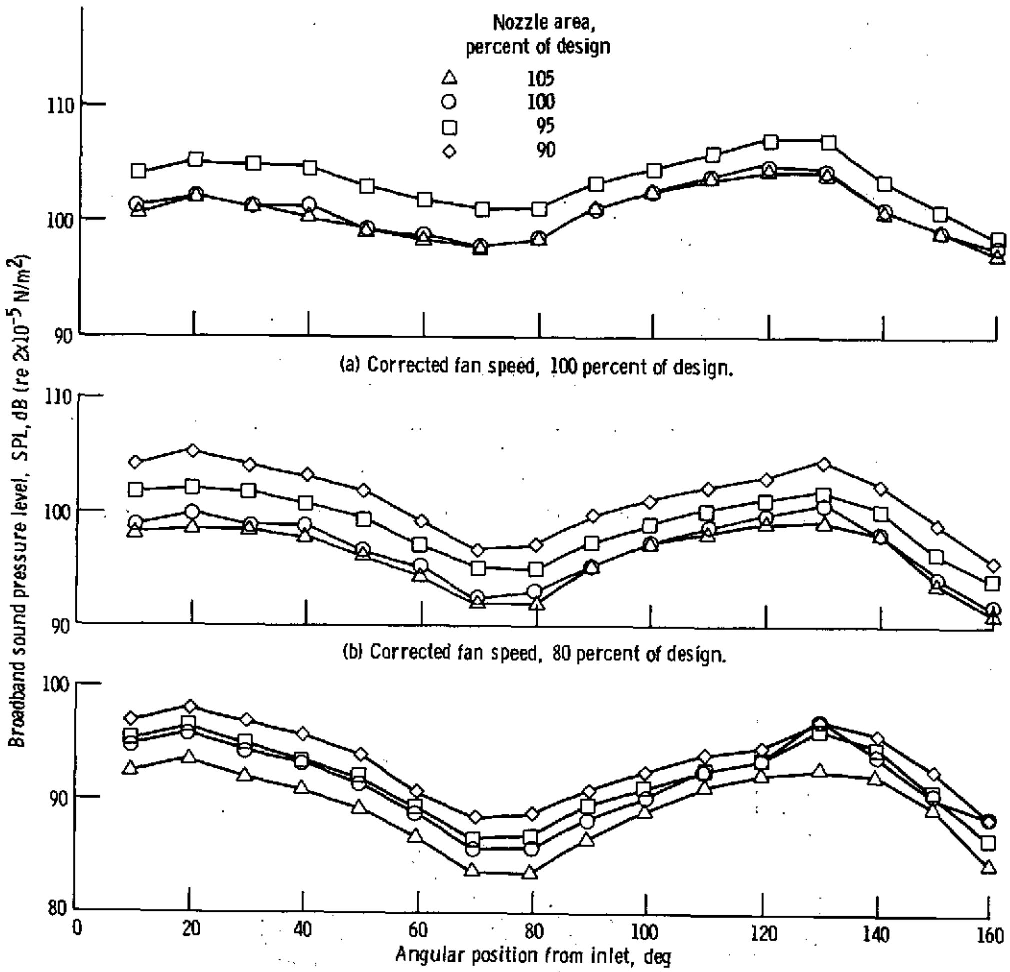


(a) Blade-passage-frequency tone and harmonics.



(b) Broadband.

Figure 21. - Angular distribution of noise components. Design nozzle area; data taken at 30.5-meter (100-ft) radius.



(c) Corrected fan speed, 60 percent of design.

Figure 22. - Effect of nozzle area on angular distribution of broadband sound pressure level (based on 1/3-octave data at 30.5-m (100-ft) radius).

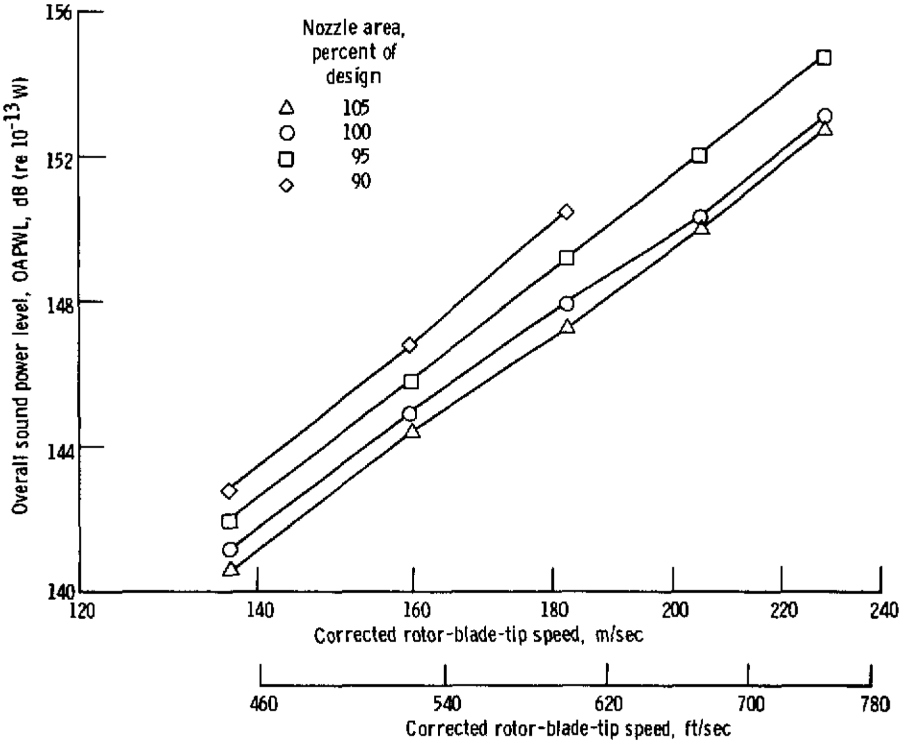


Figure 23. - Overall sound power level as function of corrected rotor-blade-tip speed.

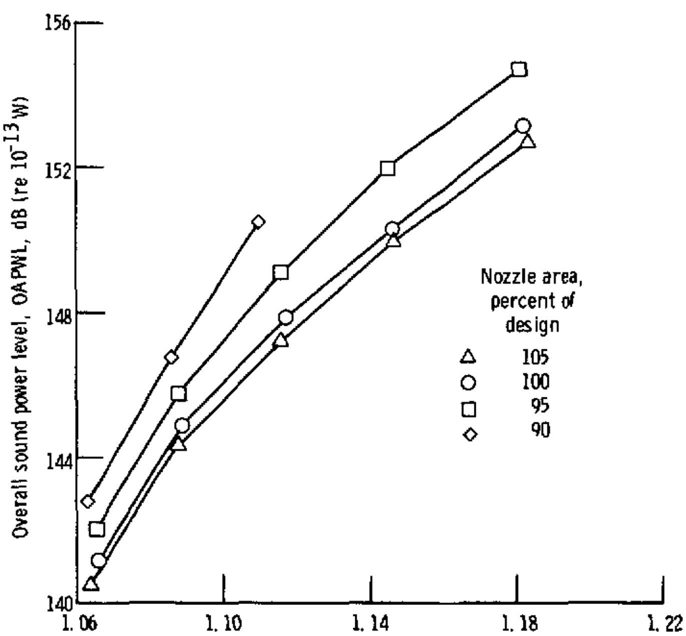


Figure 24. - Overall sound power level as function of fan stage pressure ratio.

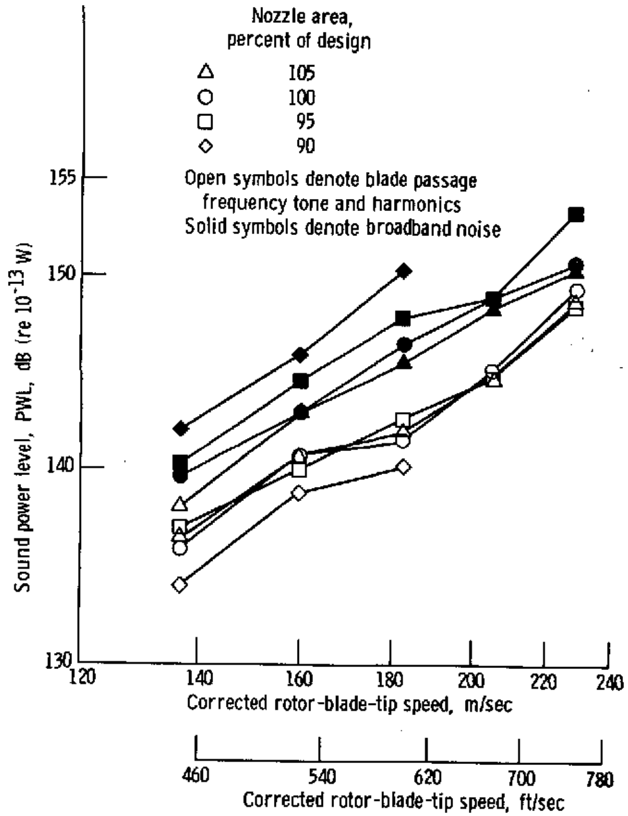


Figure 25. - Effect of corrected rotor-blade-tip speed on sound power noise components.

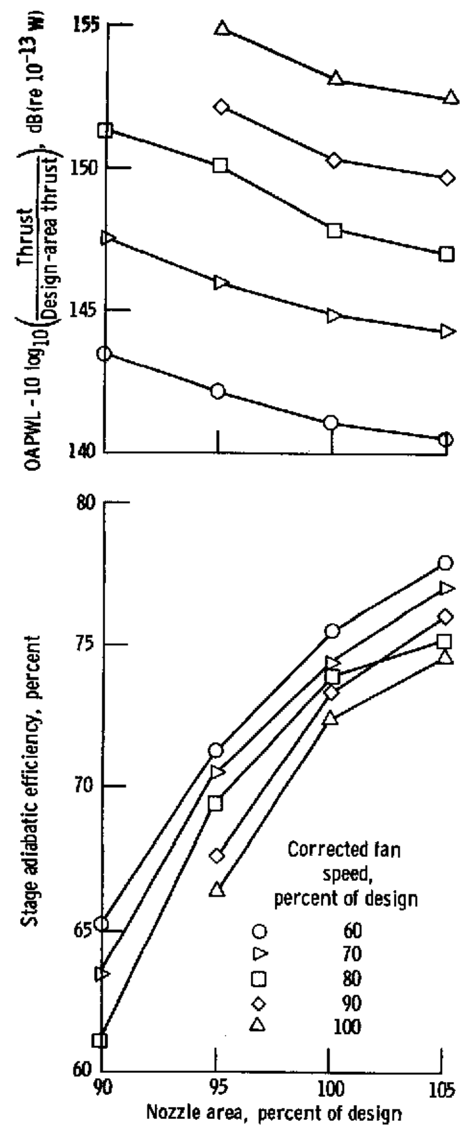


Figure 26. - Thrust-adjusted overall sound power level and efficiency as functions of nozzle area.

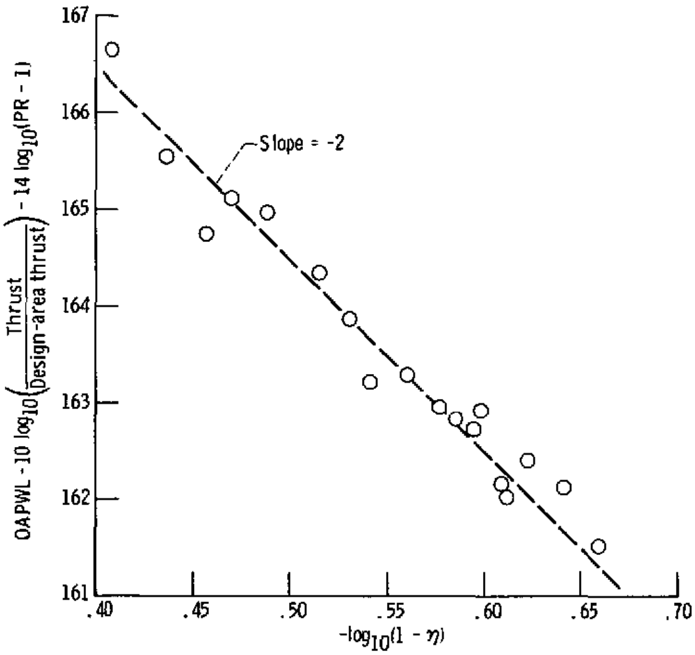
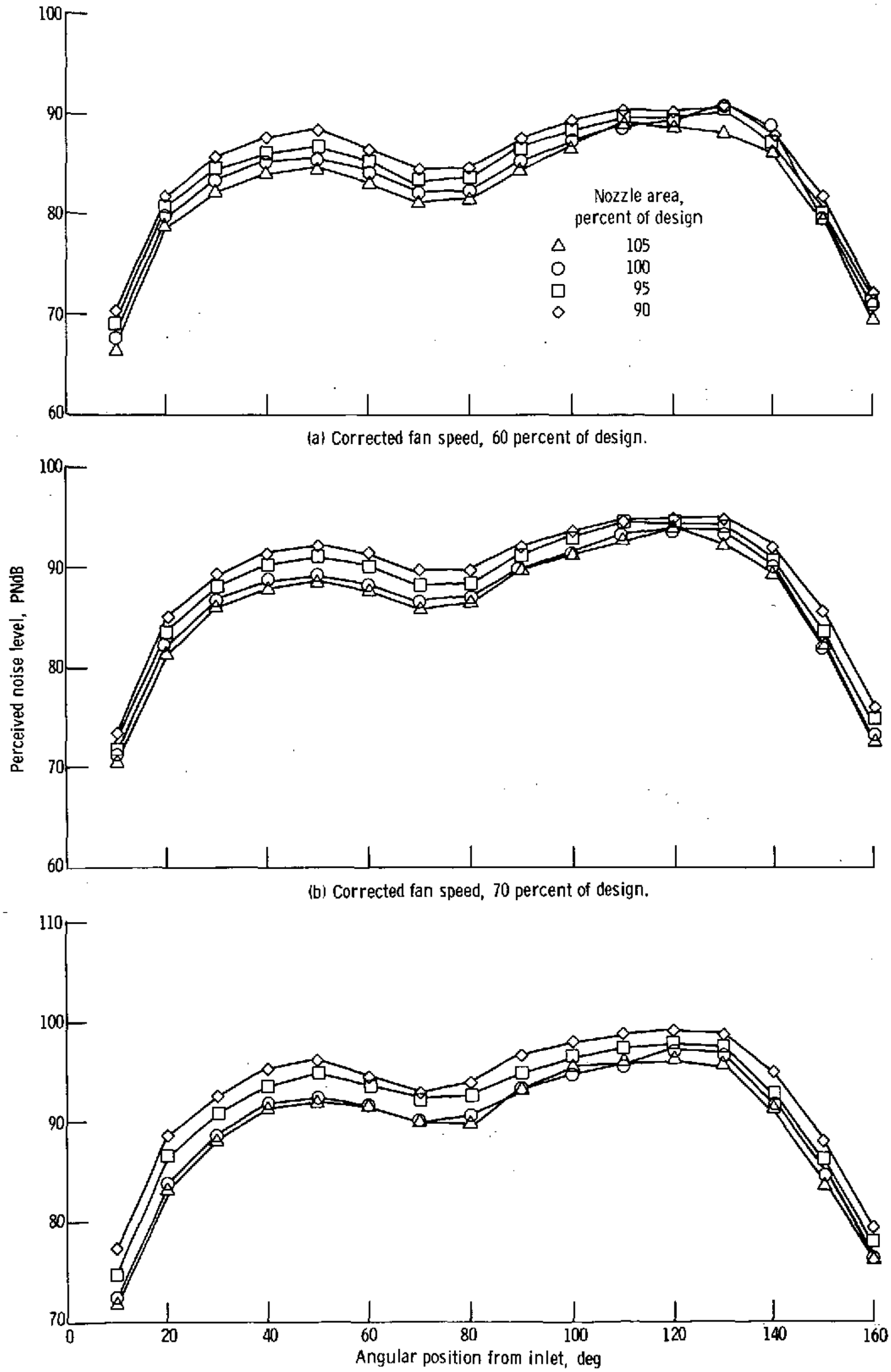


Figure 27. - Normalized overall sound power level as function of efficiency.

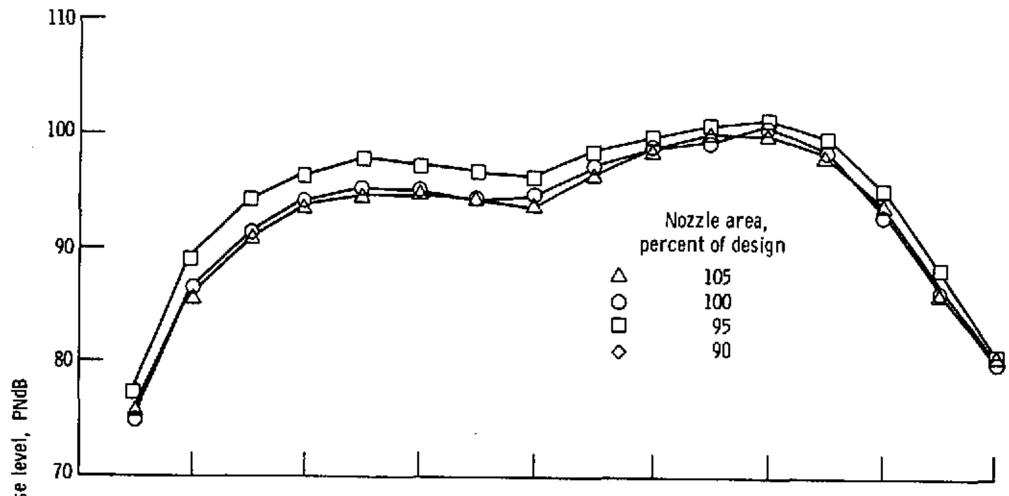


(a) Corrected fan speed, 60 percent of design.

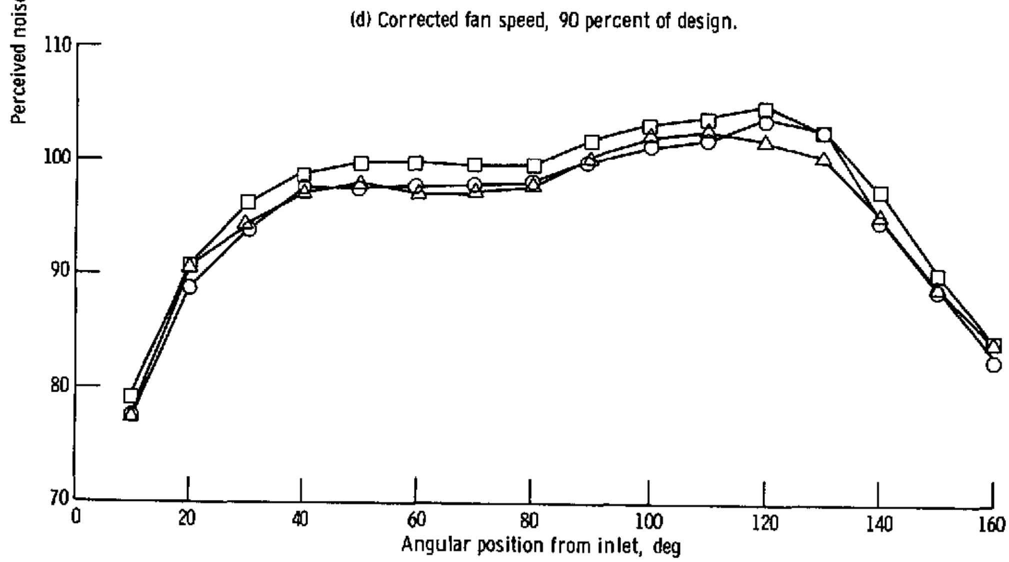
(b) Corrected fan speed, 70 percent of design.

(c) Corrected fan speed, 80 percent of design.

Figure 28. - Perceived noise level on a 152.4-meter (500-ft) sideline.



(d) Corrected fan speed, 90 percent of design.



(e) Corrected fan speed, 100 percent of design.

Figure 28. - Concluded.

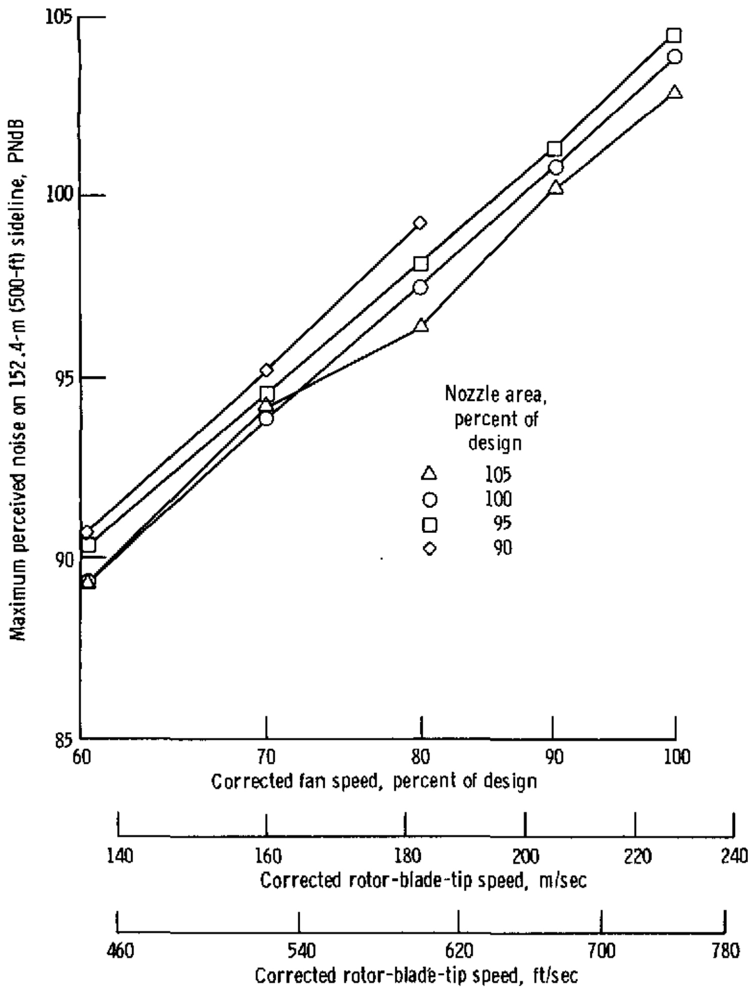


Figure 29. - Maximum perceived noise on a 152.4-meter (500-ft) sideline as function of percent of corrected fan design speed.

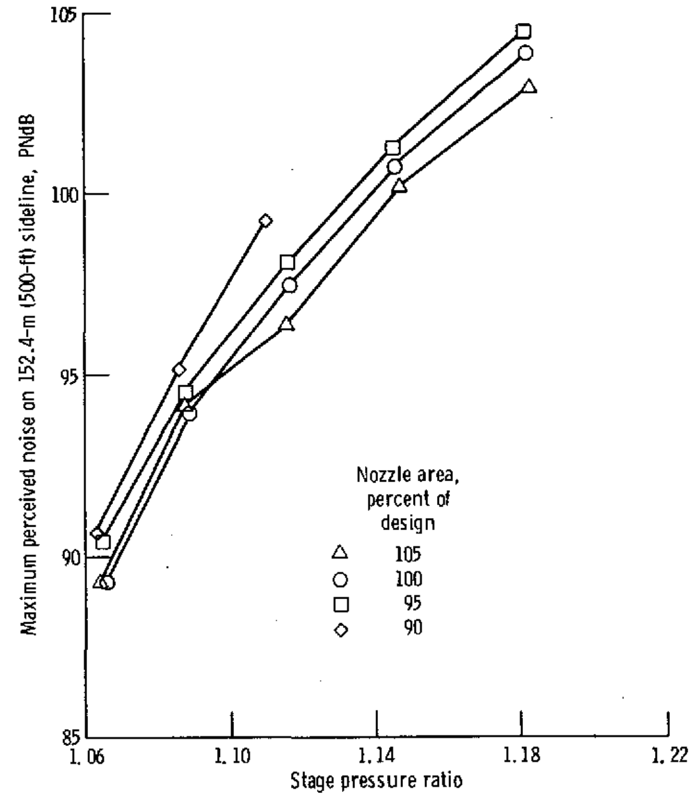


Figure 30. - Maximum perceived noise on a 152.4-meter (500-ft) sideline as function of fan stage pressure ratio.

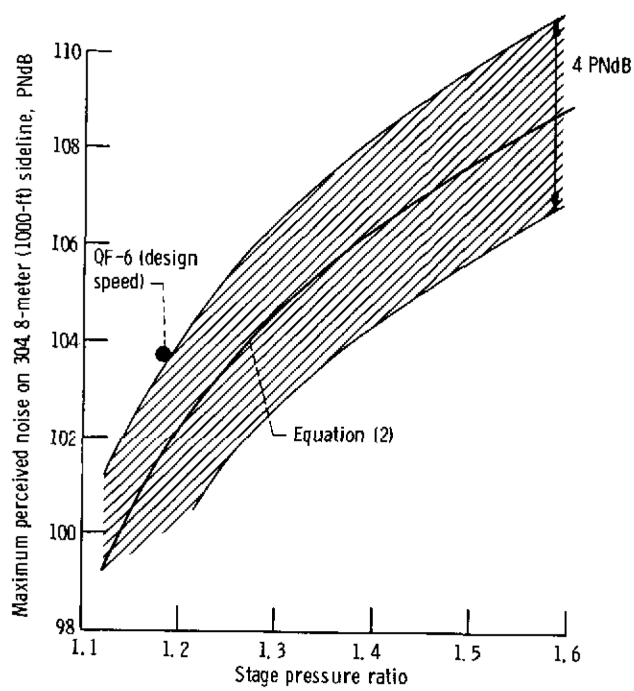


Figure 31. - Unsuppressed fan noise for 400 340-newton (90 000-lbf) takeoff thrust on 308.4-meter (1000-ft) sideline - single-stage, low-speed results.

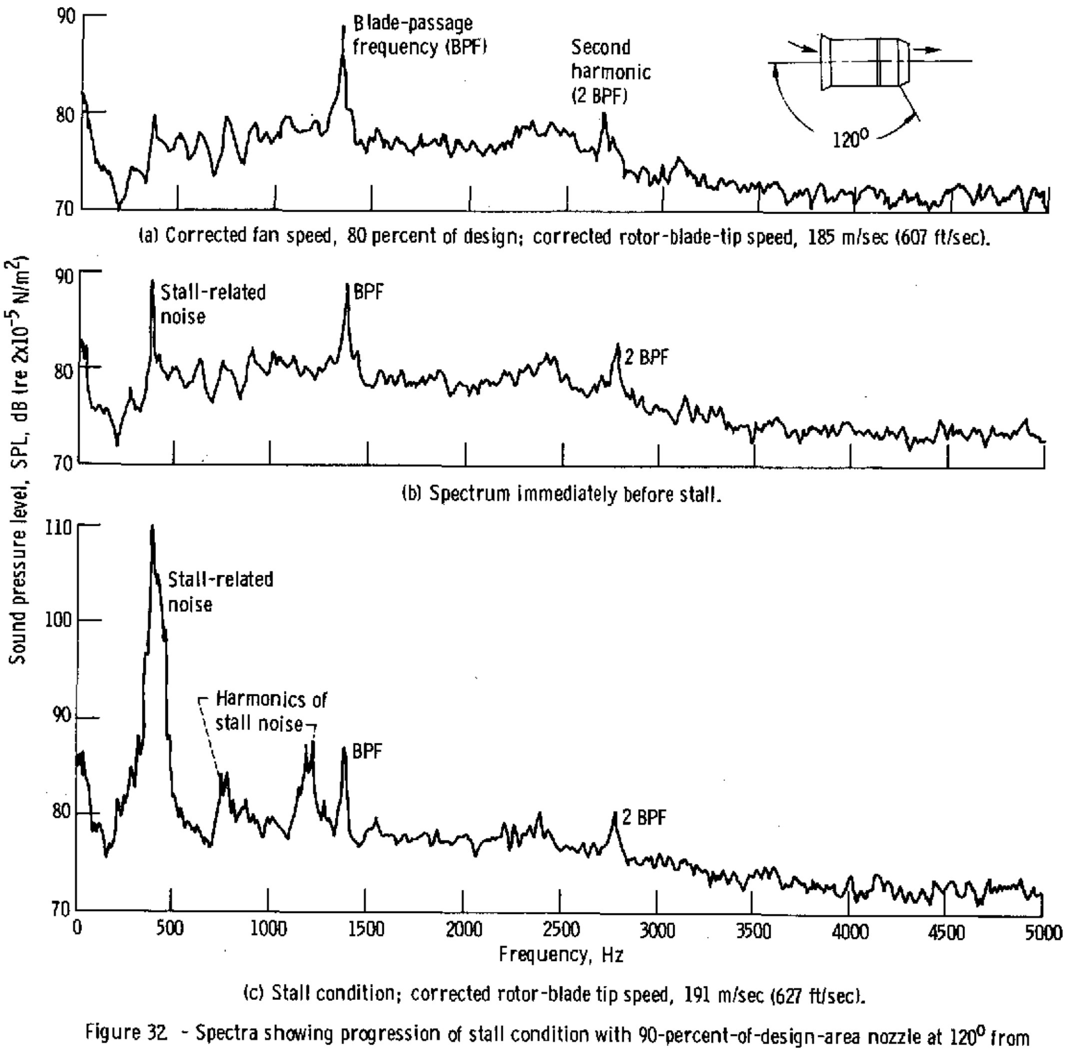


Figure 32. - Spectra showing progression of stall condition with 90-percent-of-design-area nozzle at 120° from inlet on 30.5-meter (100-ft) radius.

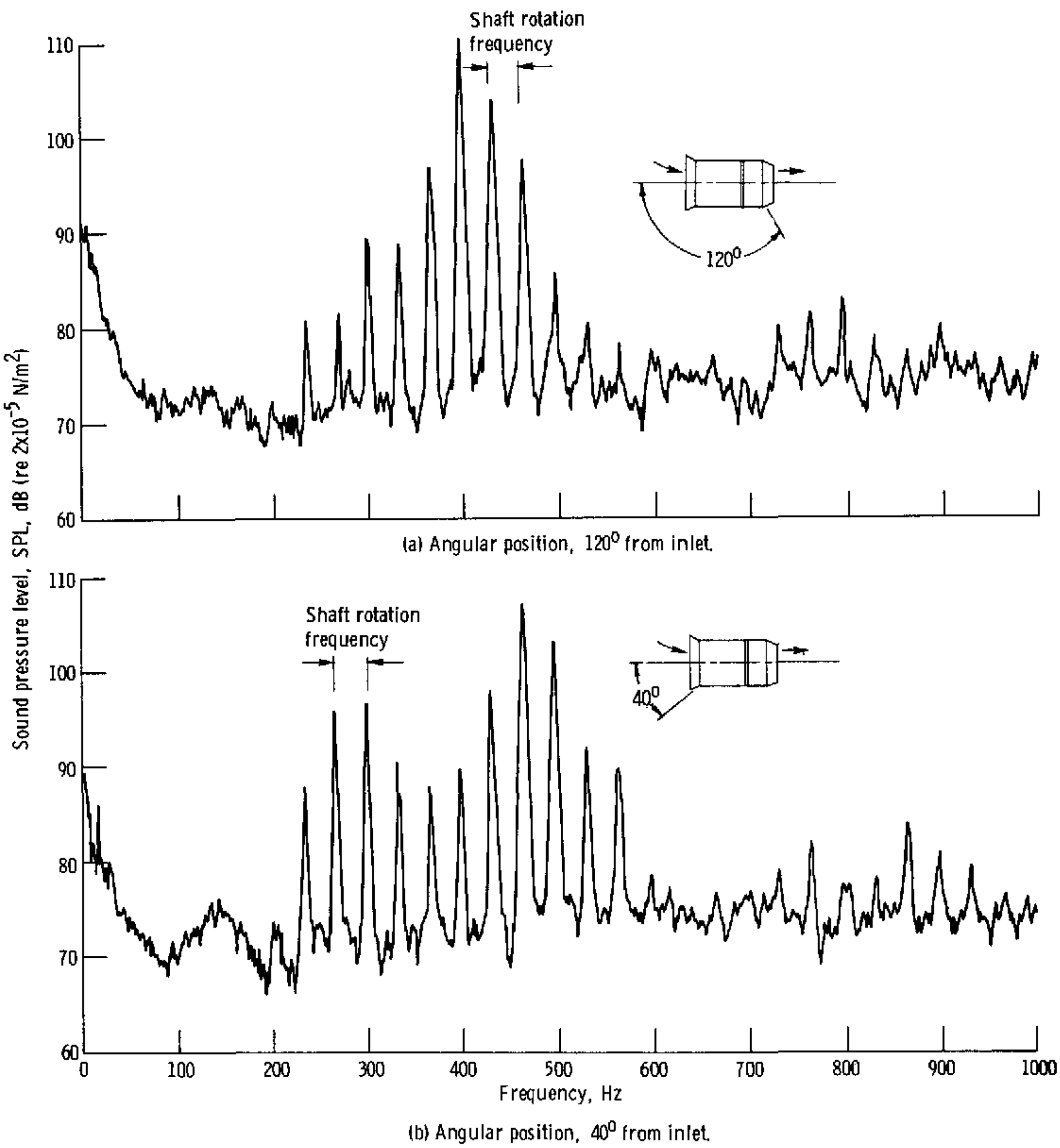


Figure 33. - Low-frequency detail of stall condition spectra for 90-percent-of-design-area nozzle on 30.5-meter (100-ft) radius. Corrected rotor-blade-tip speed, 191 m/sec (627 ft/sec).

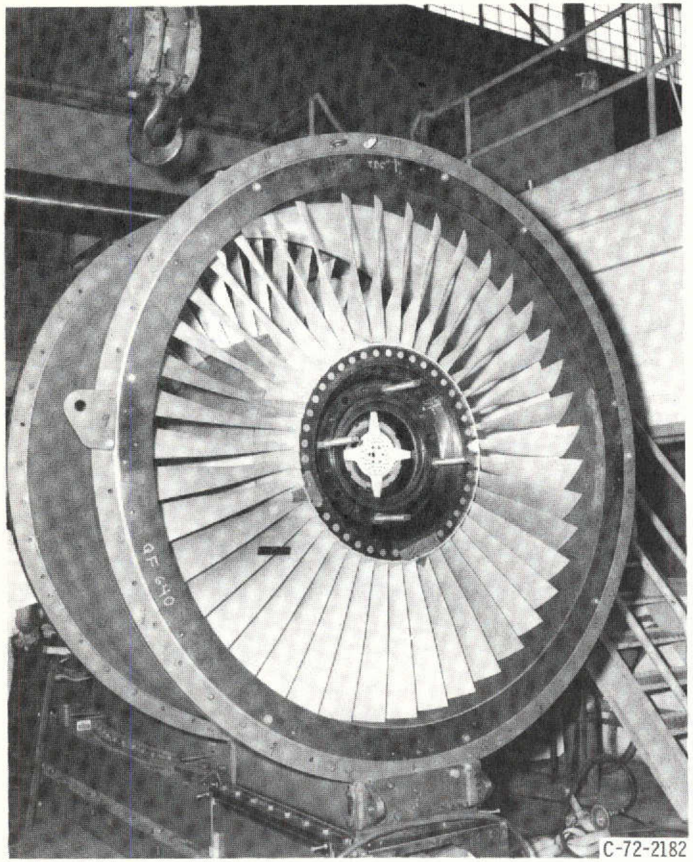
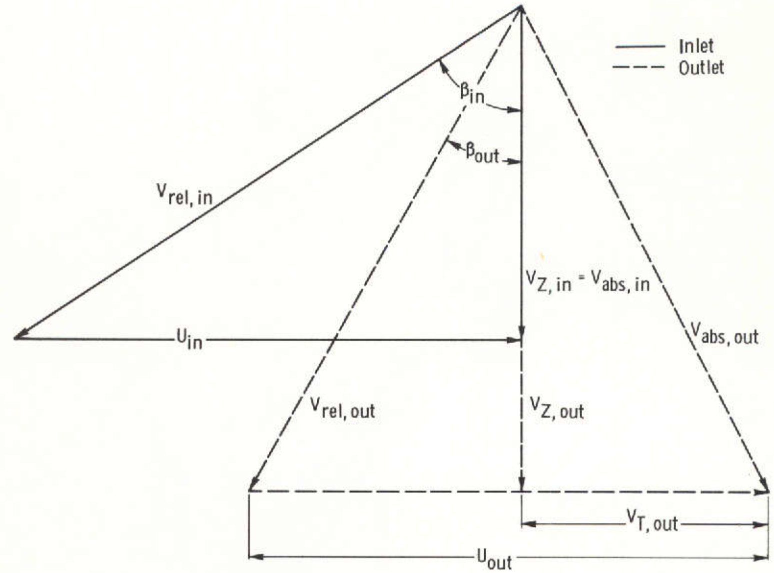
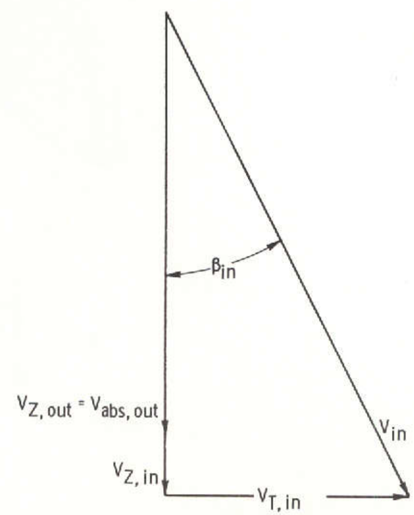


Figure 34. - Partially assembled QF-6 stage showing rotor blading.



(a) Rotor.



(b) Stator.

Figure 35. - Blade velocity diagrams. (Components are shown in axial-tangential plane. Radial component is perpendicular to this plane. Positive radial velocities are radially outward.)

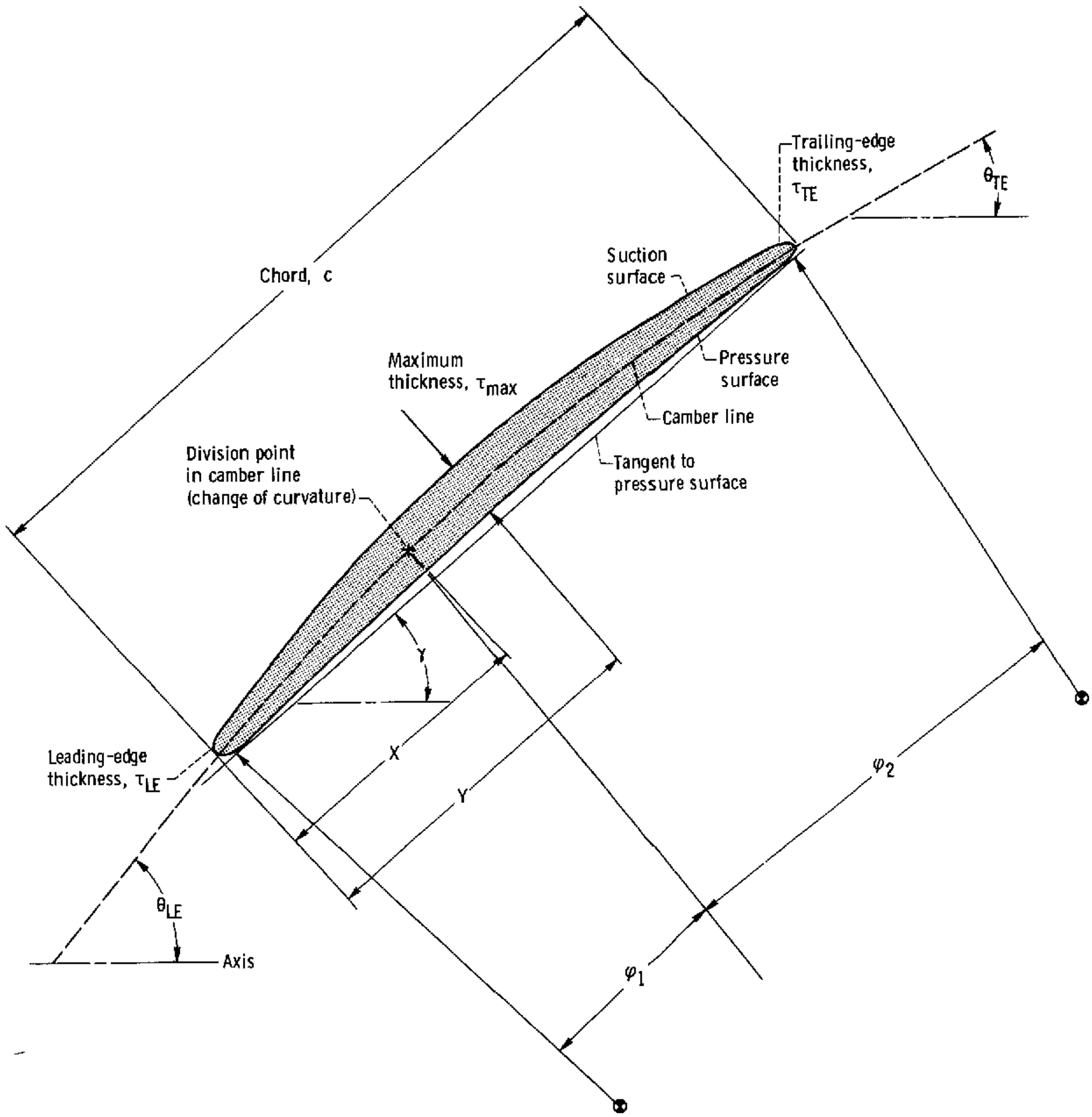


Figure 36. - Blade geometry notation.

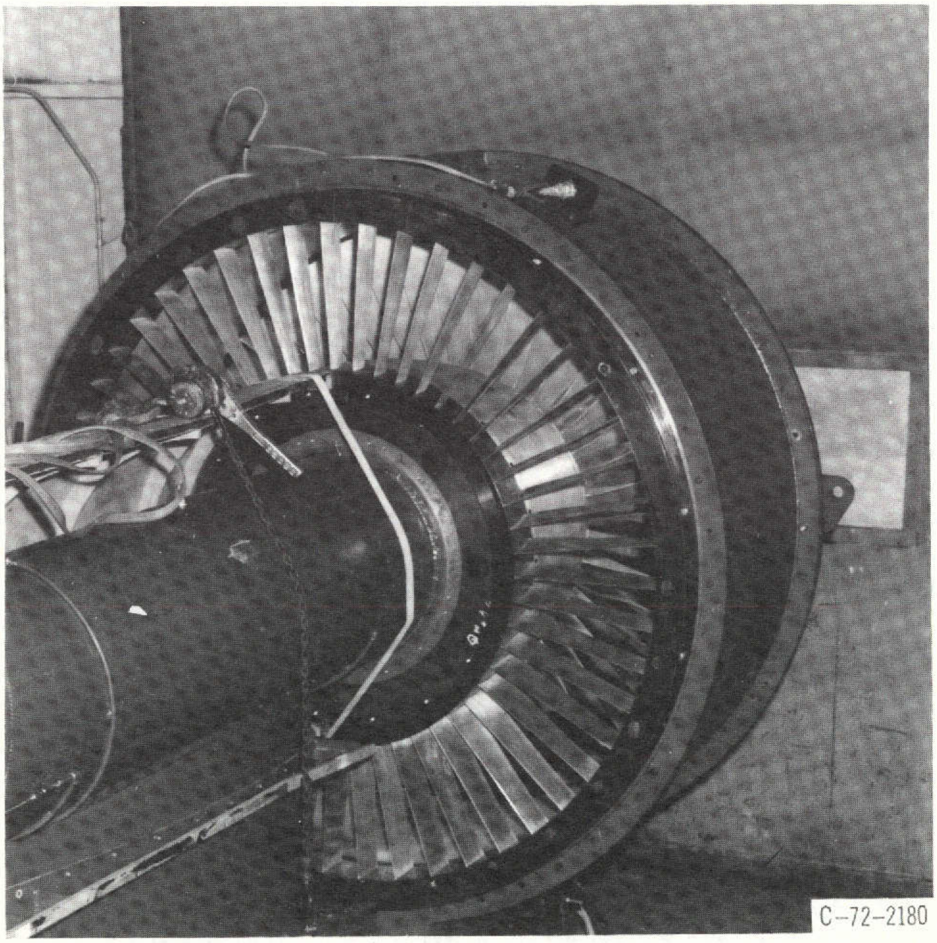
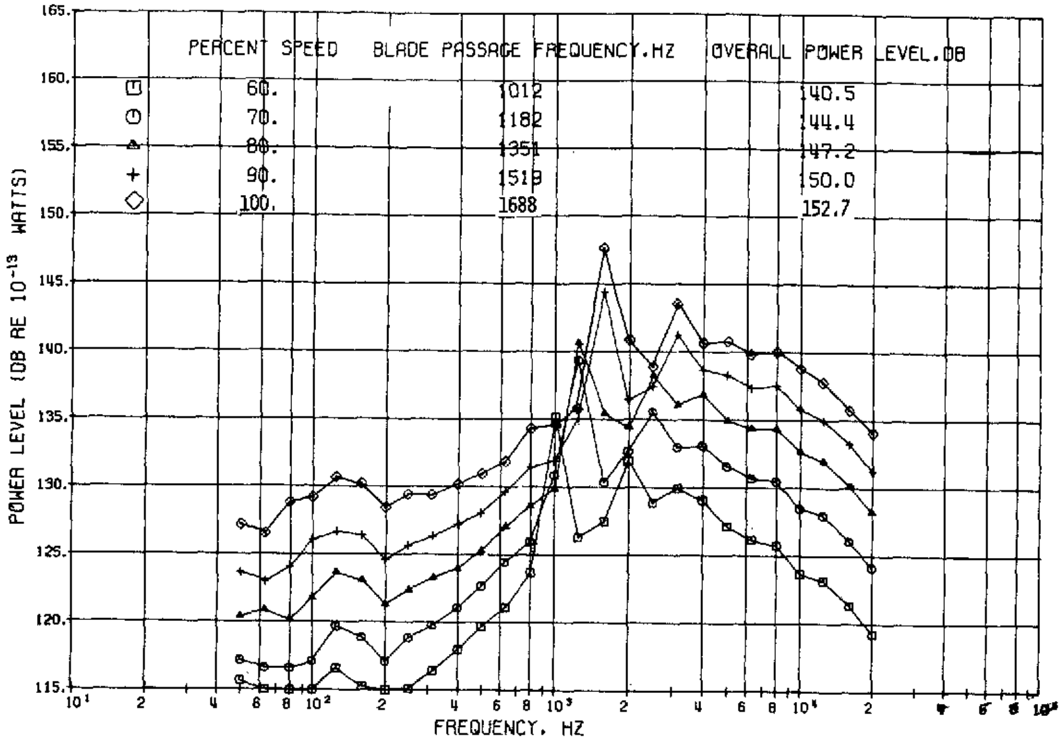
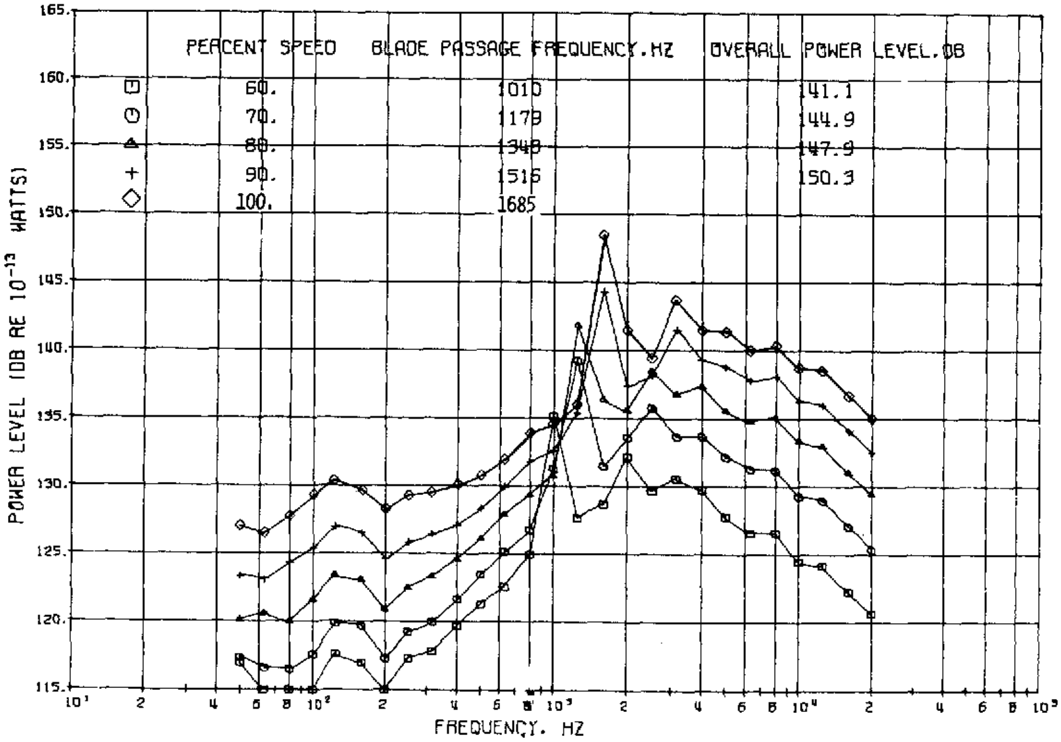


Figure 37. - Partially assembled QF-6 stage showing stator blading.

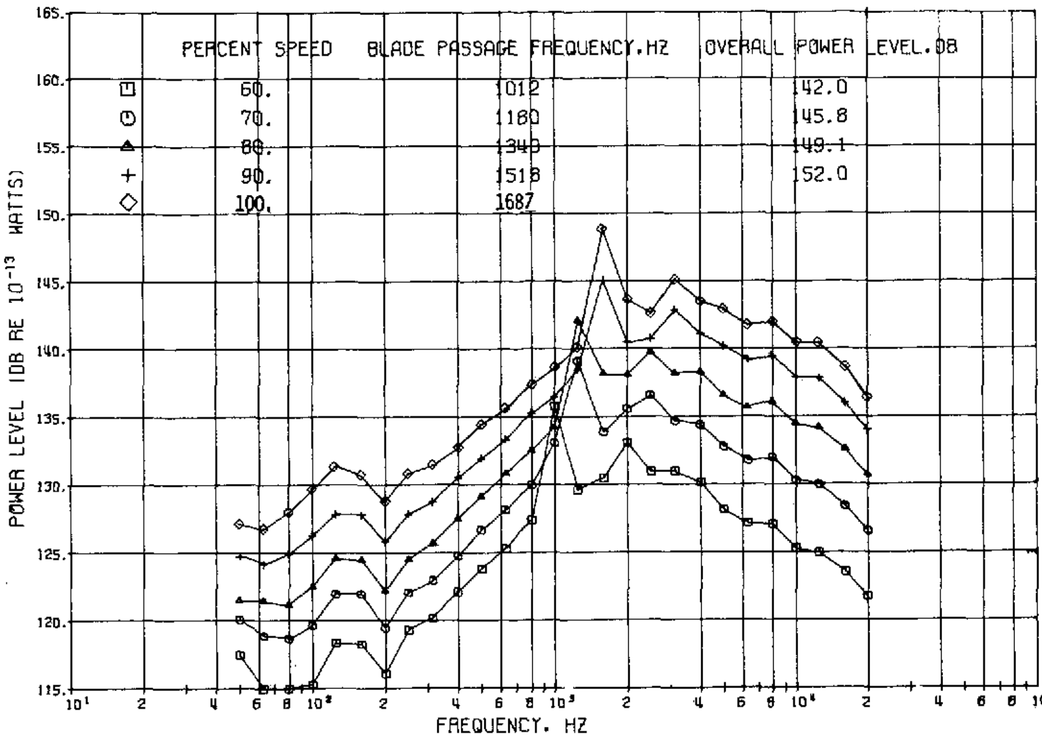


(a) Nozzle area, 105 percent of design.

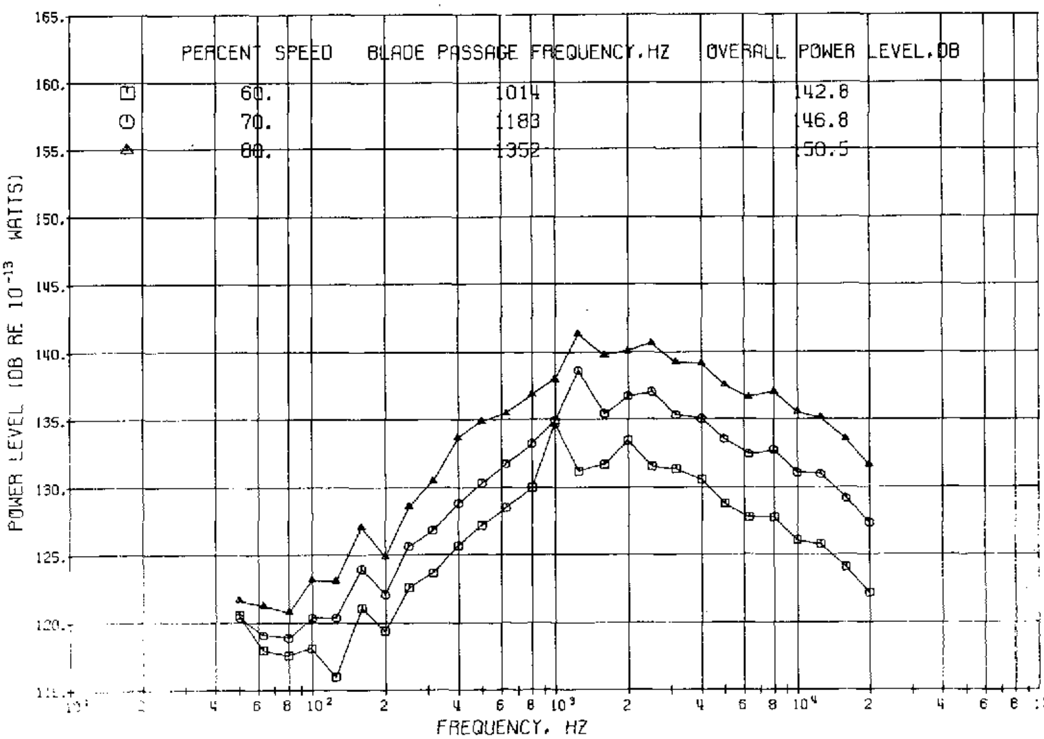


(b) Design nozzle area.

Figure 38. - Power spectrum for QF-6.

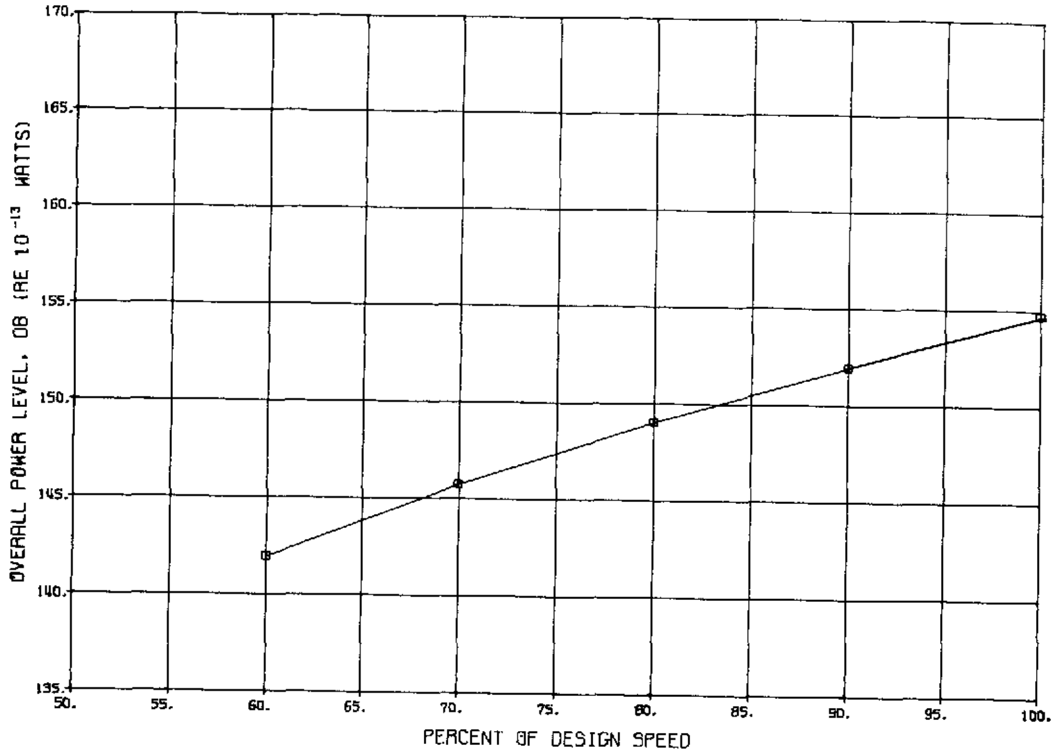


(c) Nozzle area, 95 percent of design.

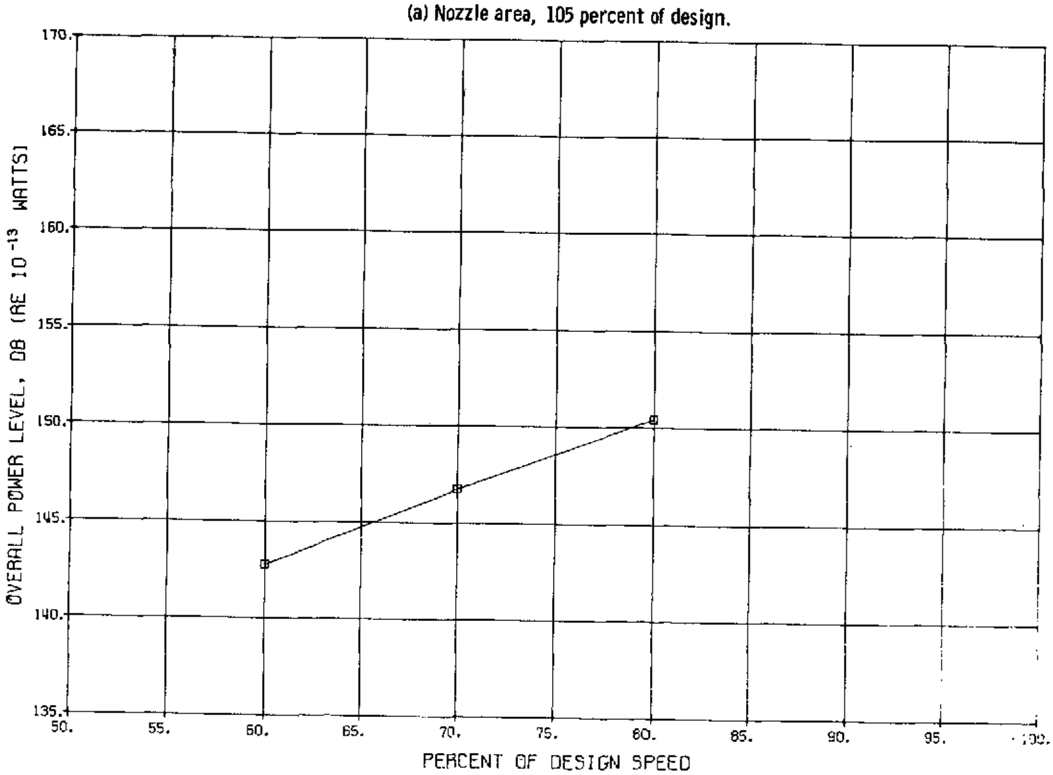


(d) Nozzle area, 90 percent of design.

Figure 38. - Concluded.

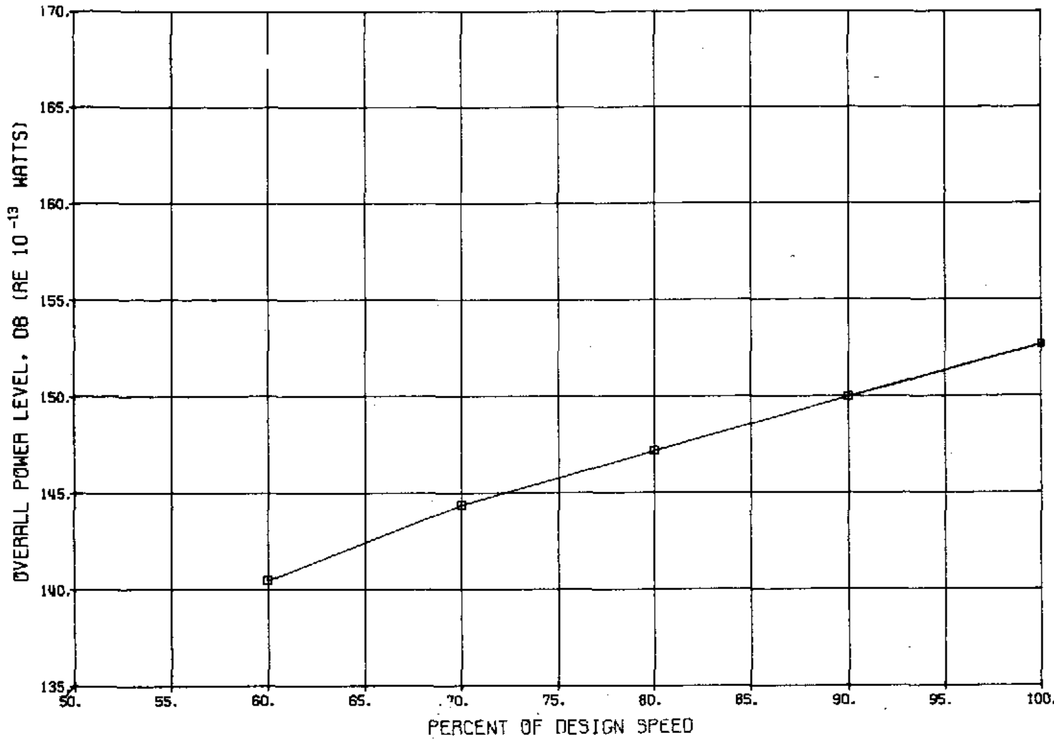


(a) Nozzle area, 105 percent of design.

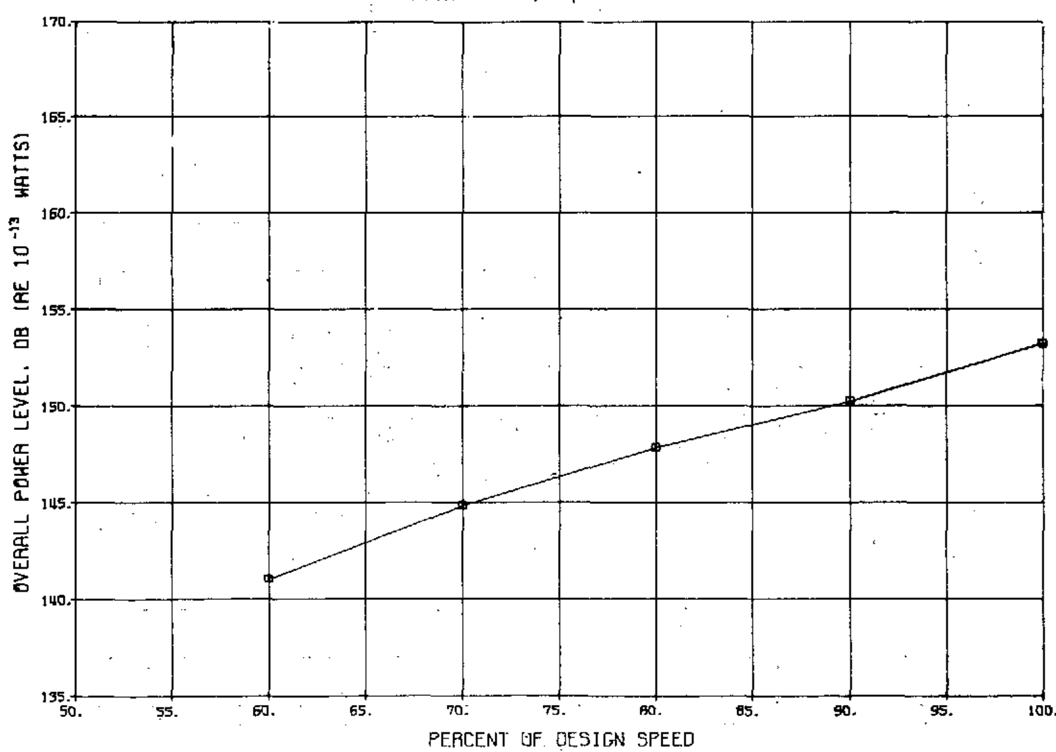


(b) Design nozzle area.

Figure 39. - Overall sound power level of QF-6 as function of corrected fan design speed.

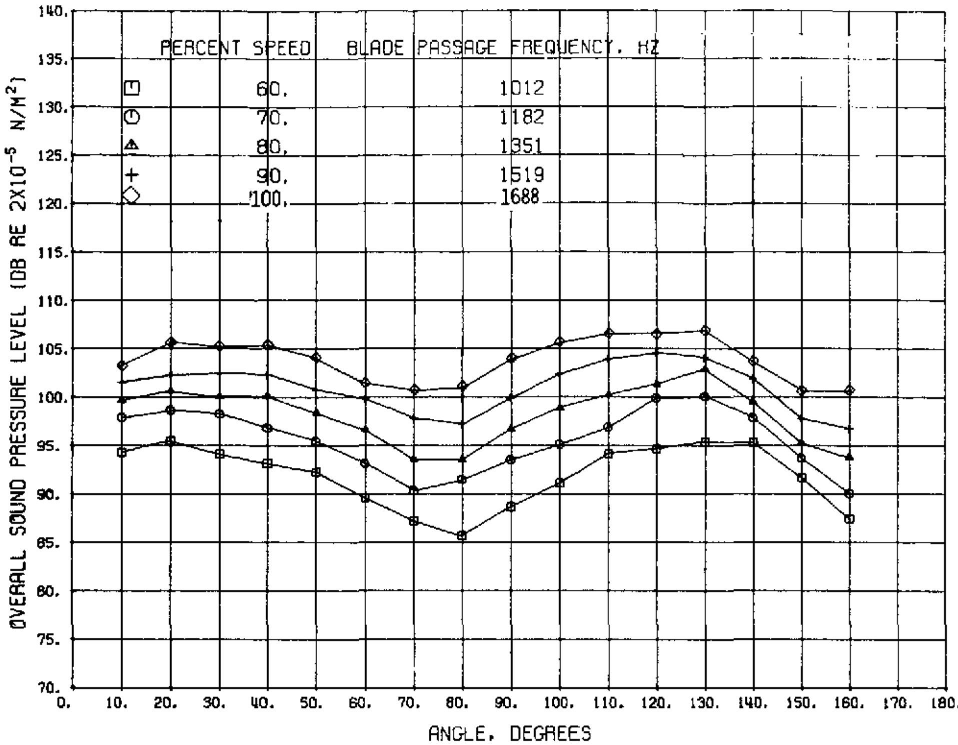


(c) Nozzle area, 95 percent of design.

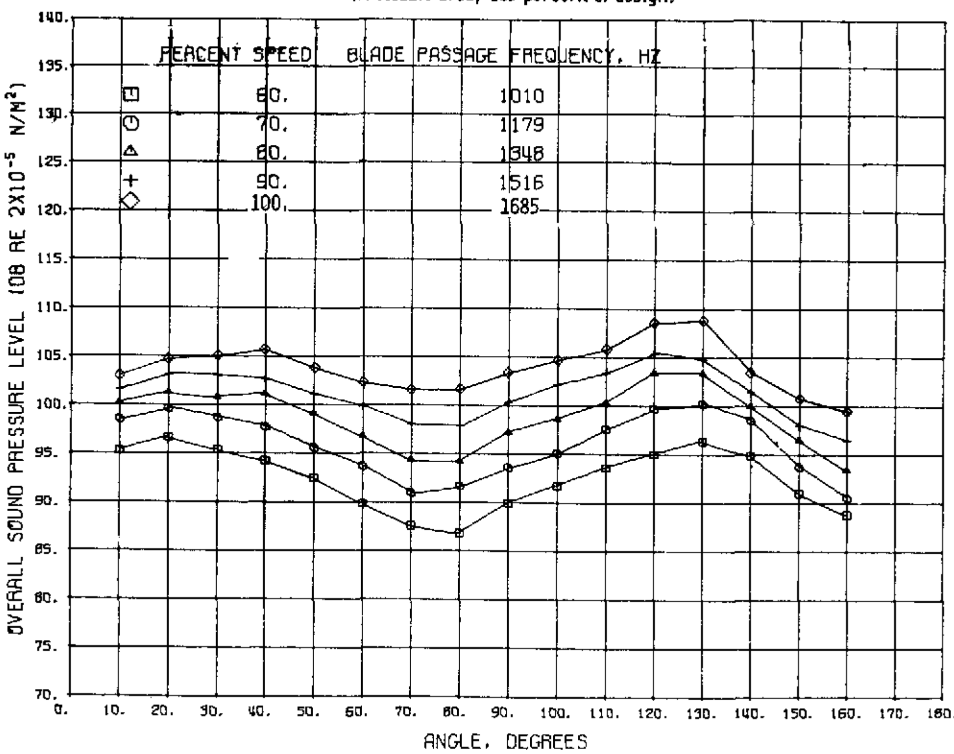


(d) Nozzle area, 90 percent of design.

Figure 39. - Concluded.

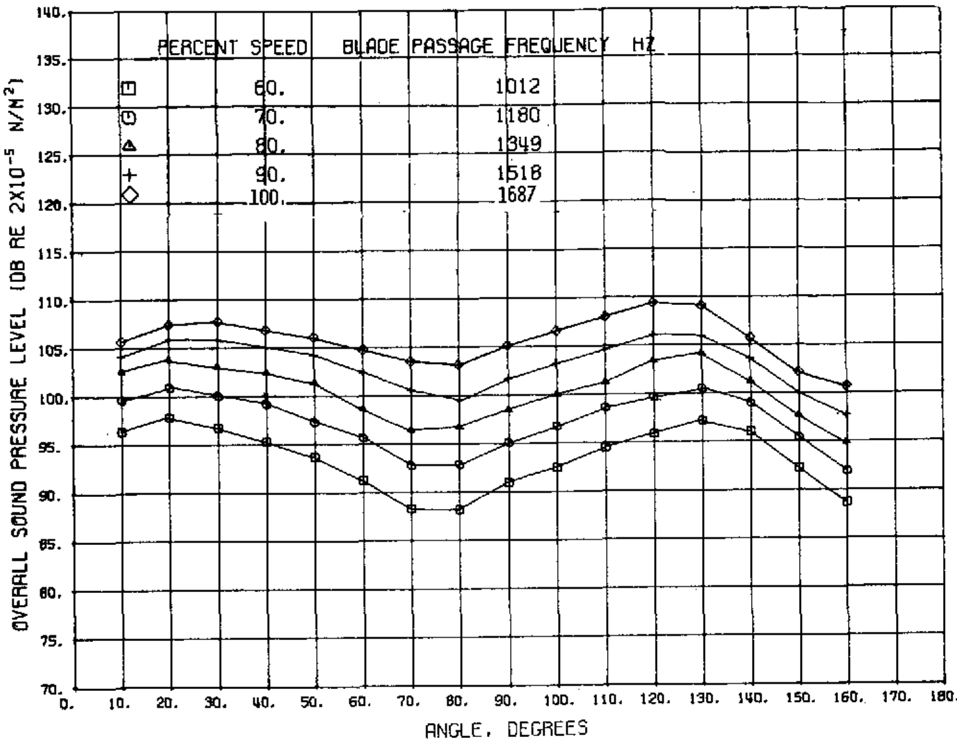


(a) Nozzle area, 105 percent of design.

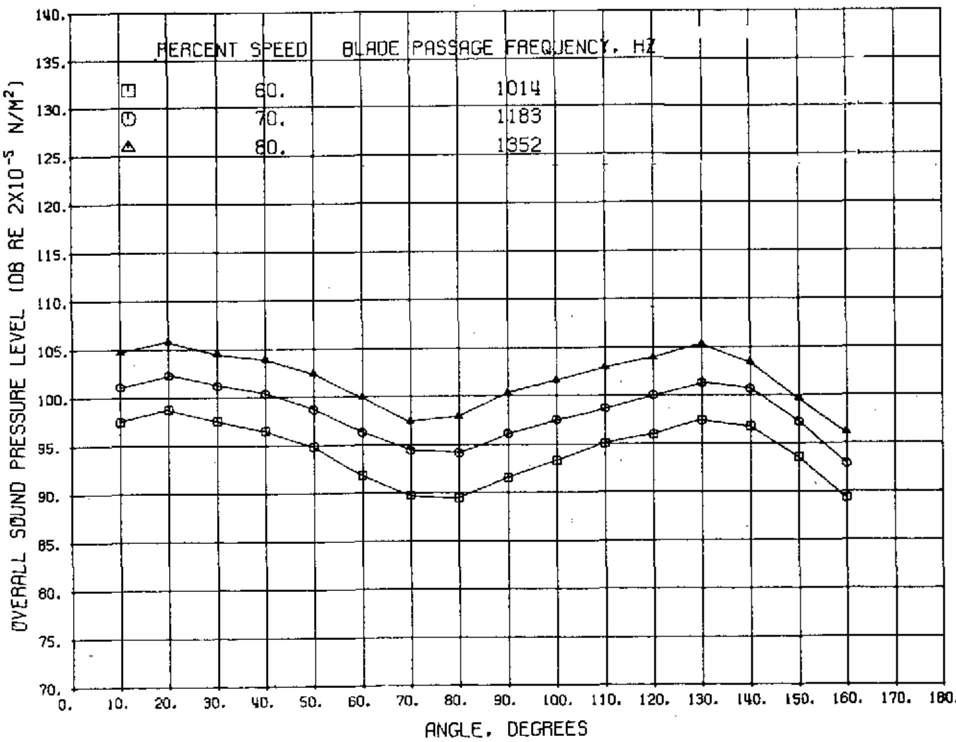


(b) Design nozzle area.

Figure 40. - Overall sound pressure level of QF-6 as function of angular position from inlet on 30.5-meter (100-ft) radius.

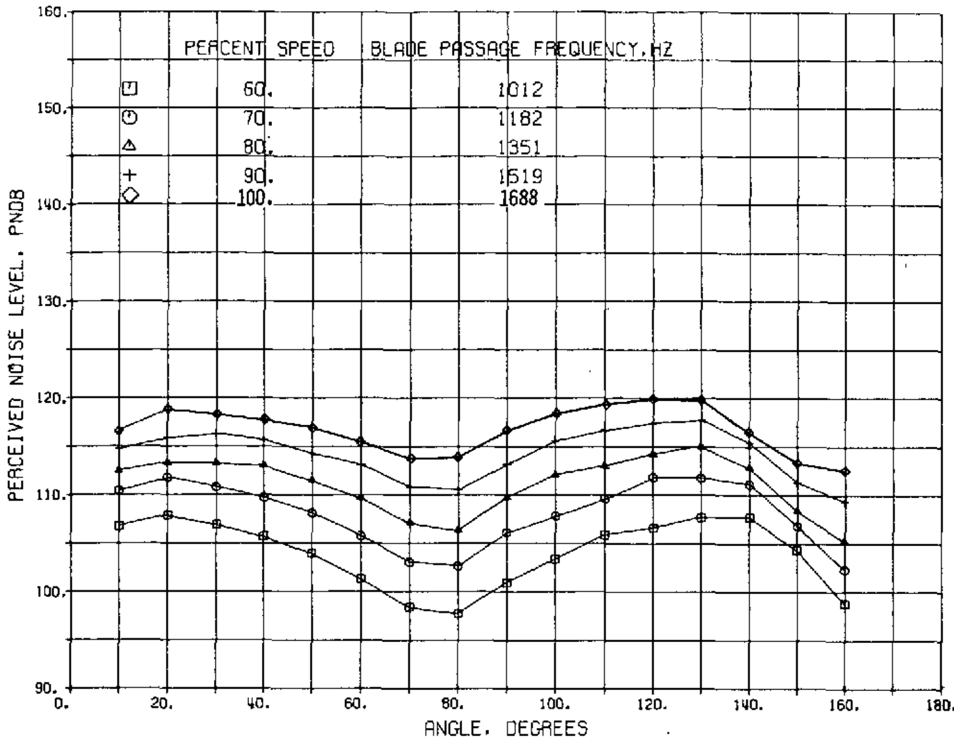


(c) Nozzle area, 95 percent of design.

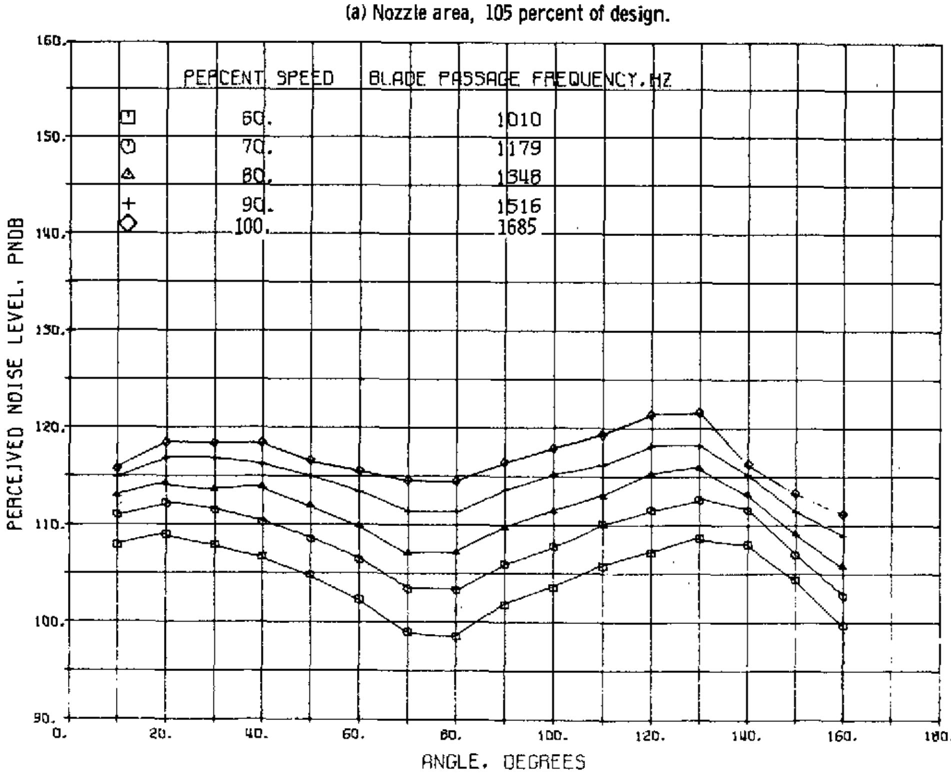


(d) Nozzle area, 90 percent of design.

Figure 40. - Concluded.

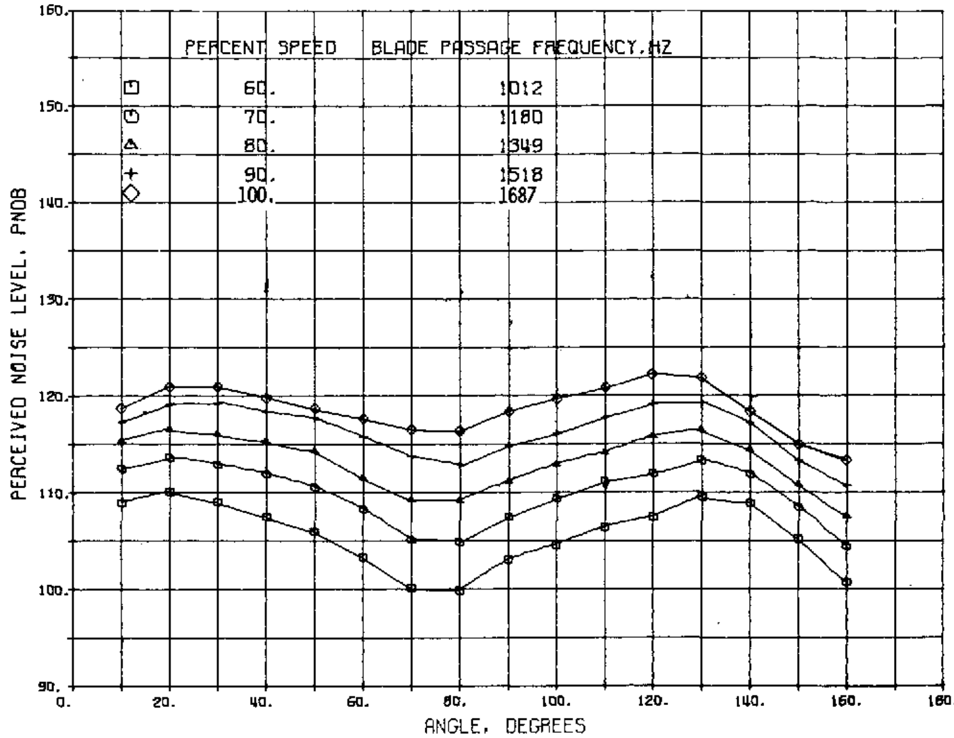


(a) Nozzle area, 105 percent of design.

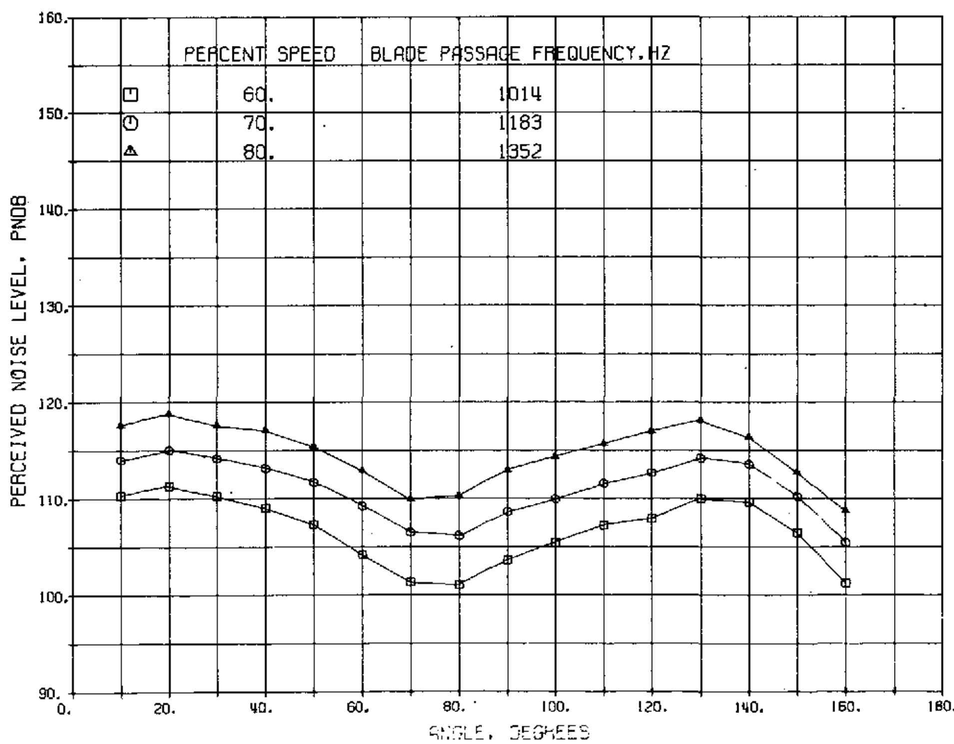


(b) Design nozzle area.

Figure 41. - Perceived noise level on 30.5-meter (100-ft) radius.

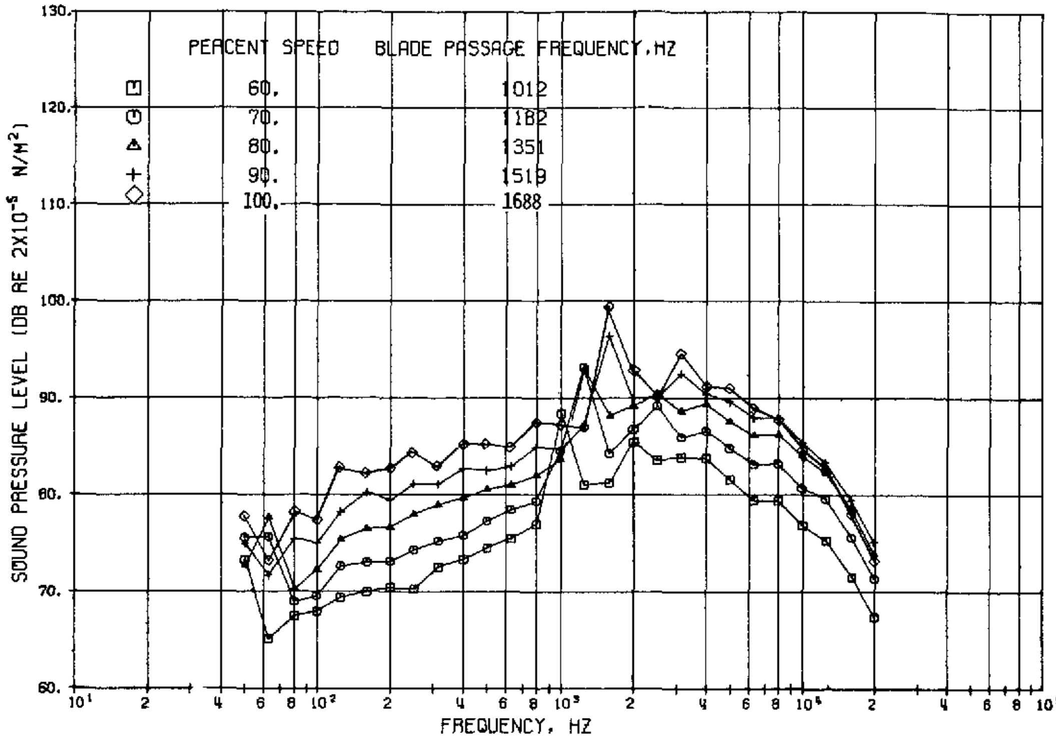


(c) Nozzle area, 95 percent of design.

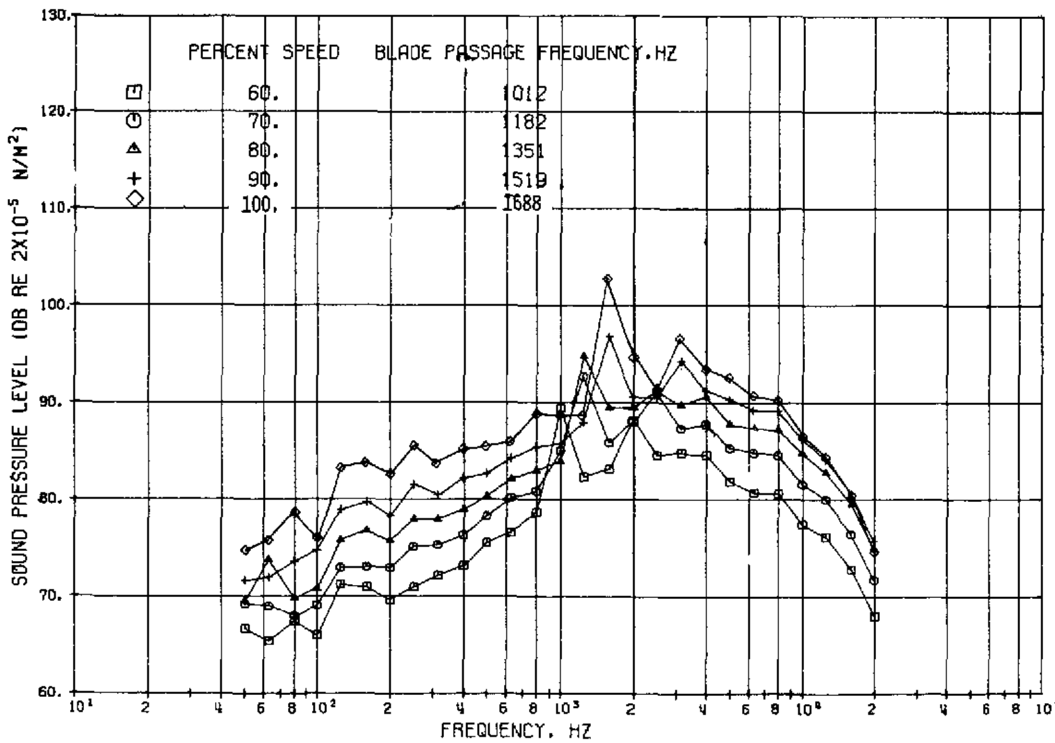


(d) Nozzle area, 90 percent of design.

Figure 41. - Concluded.

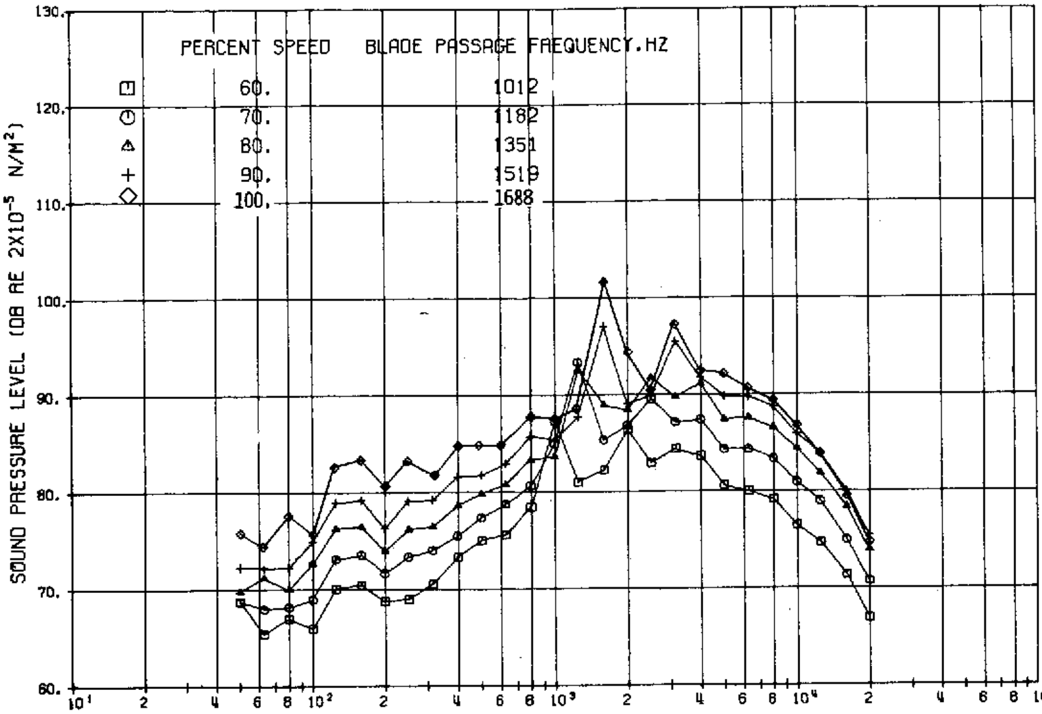


(a) 10°.

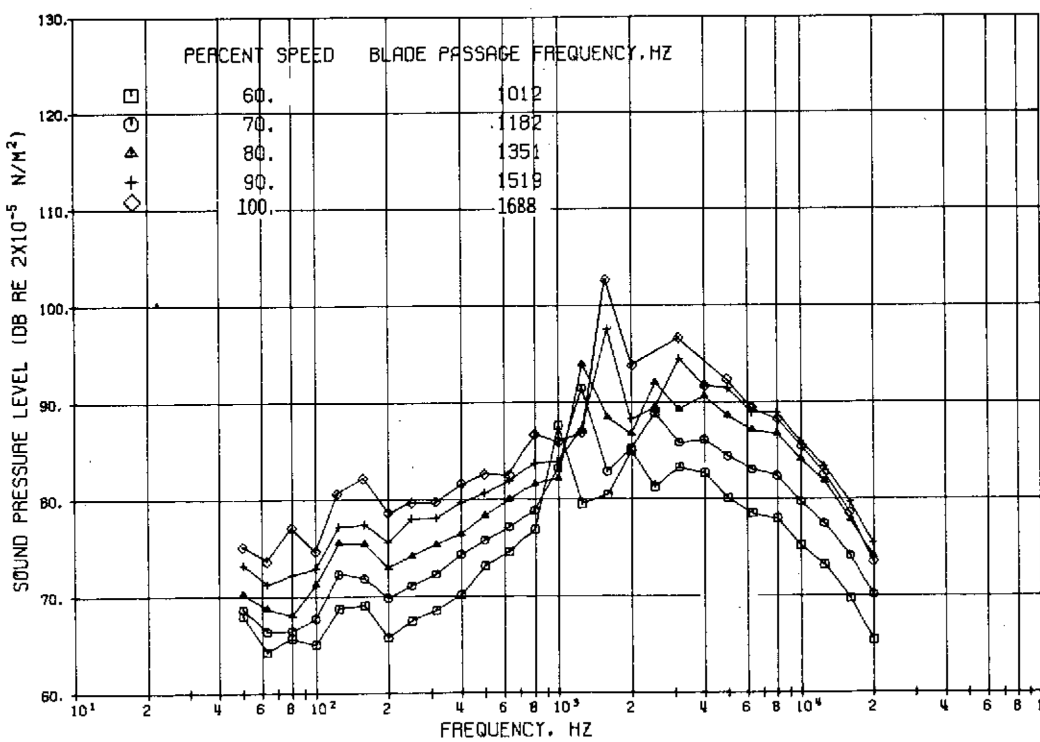


(b) 20°.

Figure 42. - 1/3-Octave-band spectra on 30.5-meter (100-ft) radius for 105 percent of design nozzle area - at various angular positions from inlet.

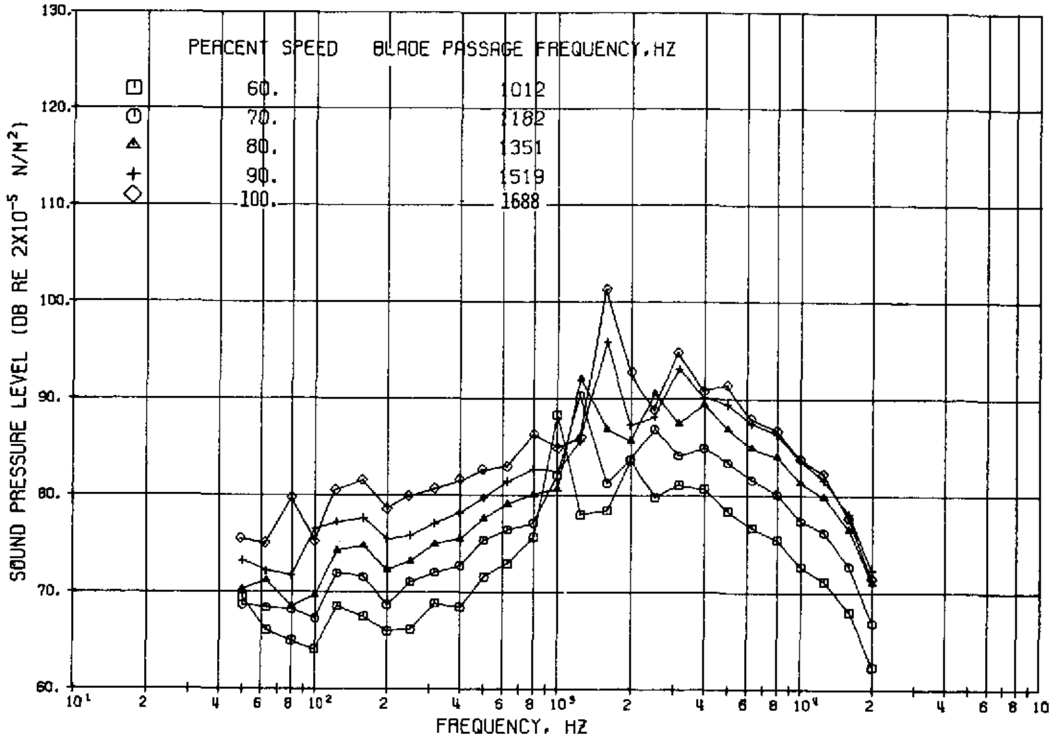


(c) 30°.

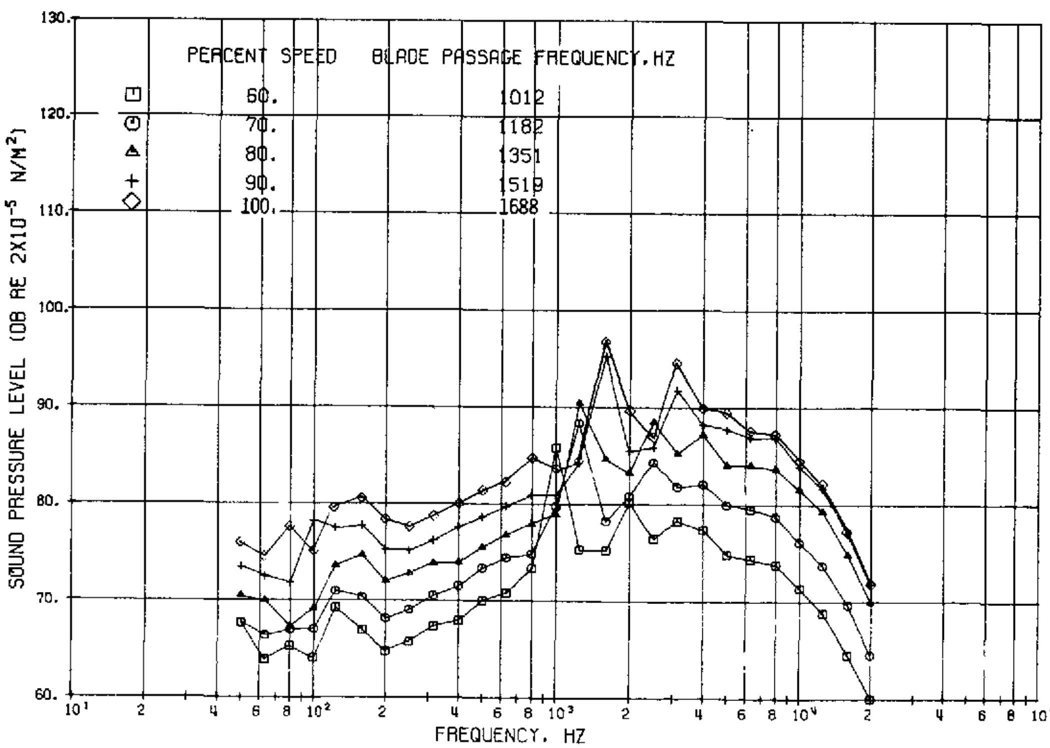


(d) 40°.

Figure 42. - Continued.

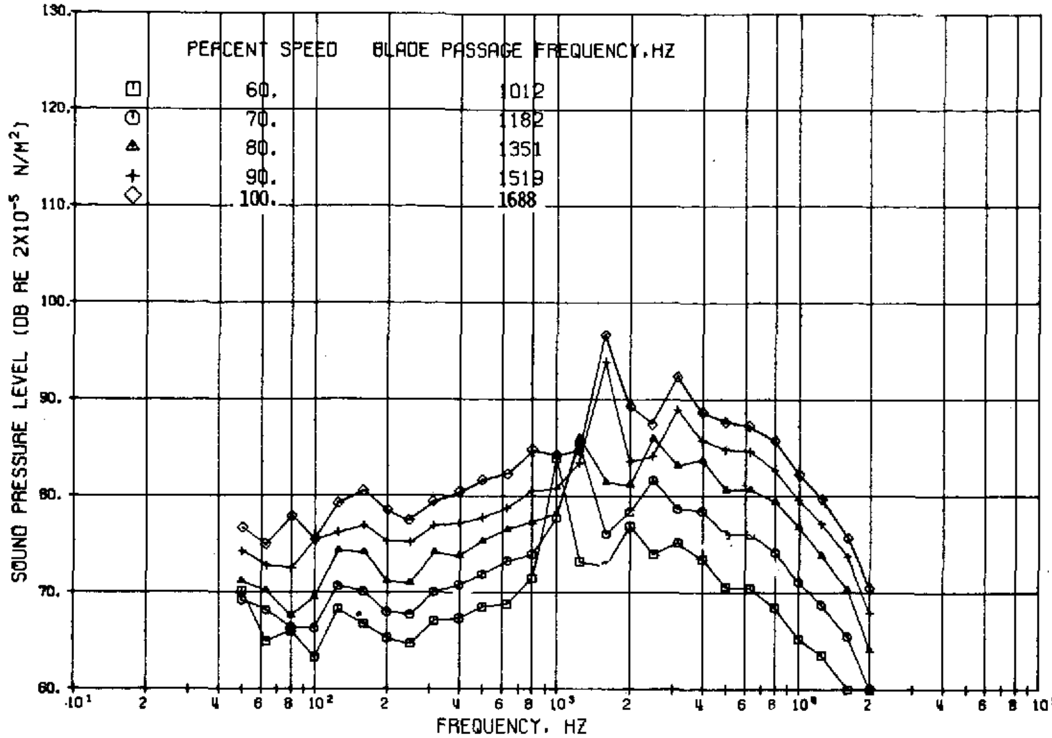


(e) 50°.

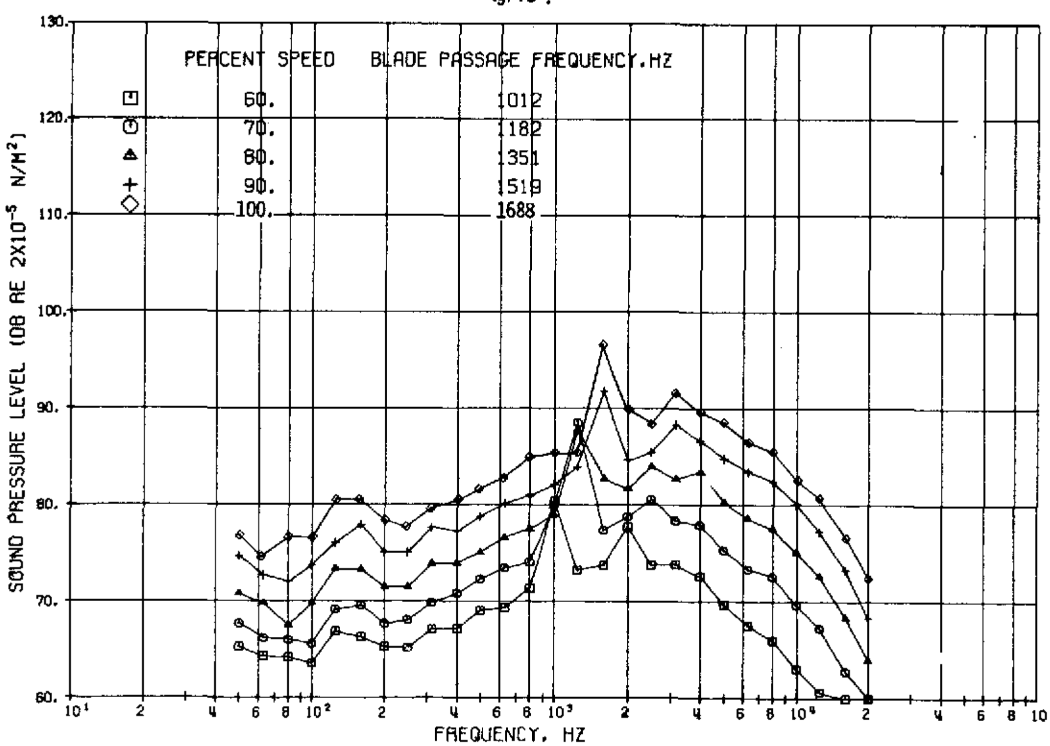


(f) 60°.

Figure 42. - Continued.

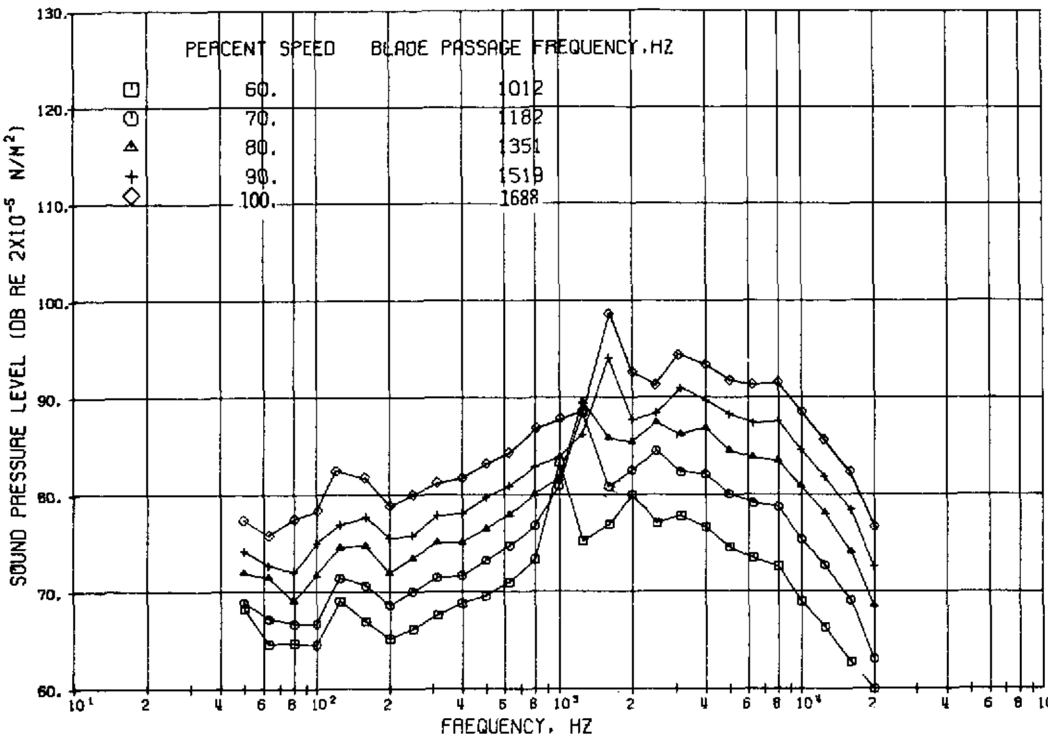


(g) 70°.

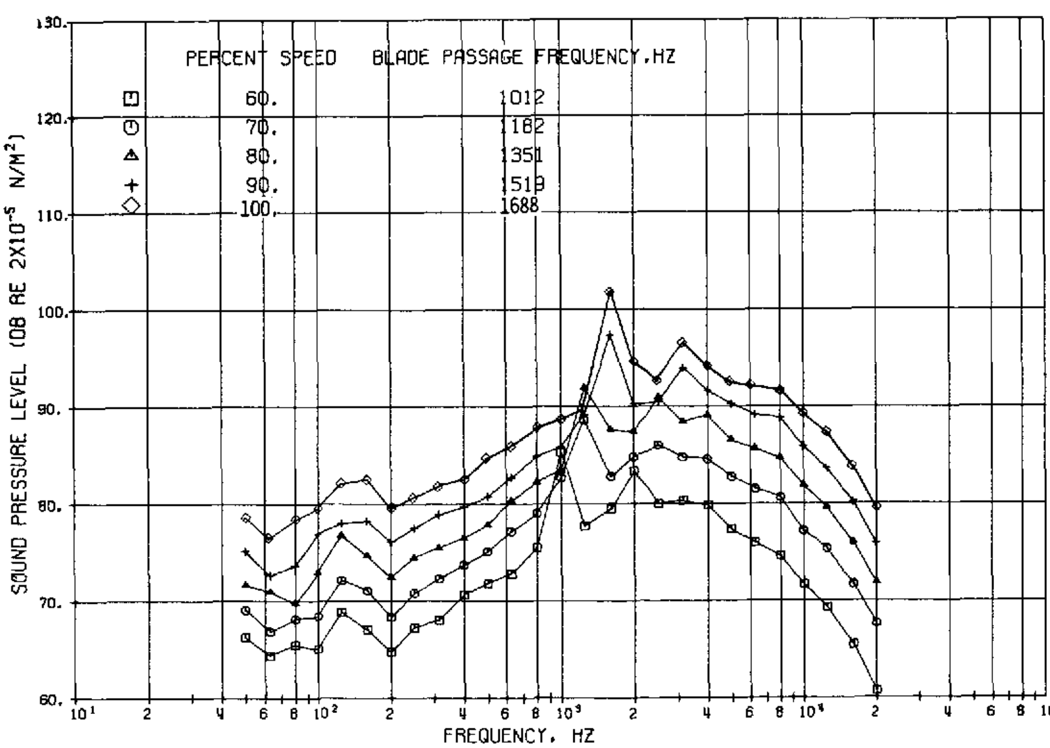


(h) 80°.

Figure 42. - Continued.

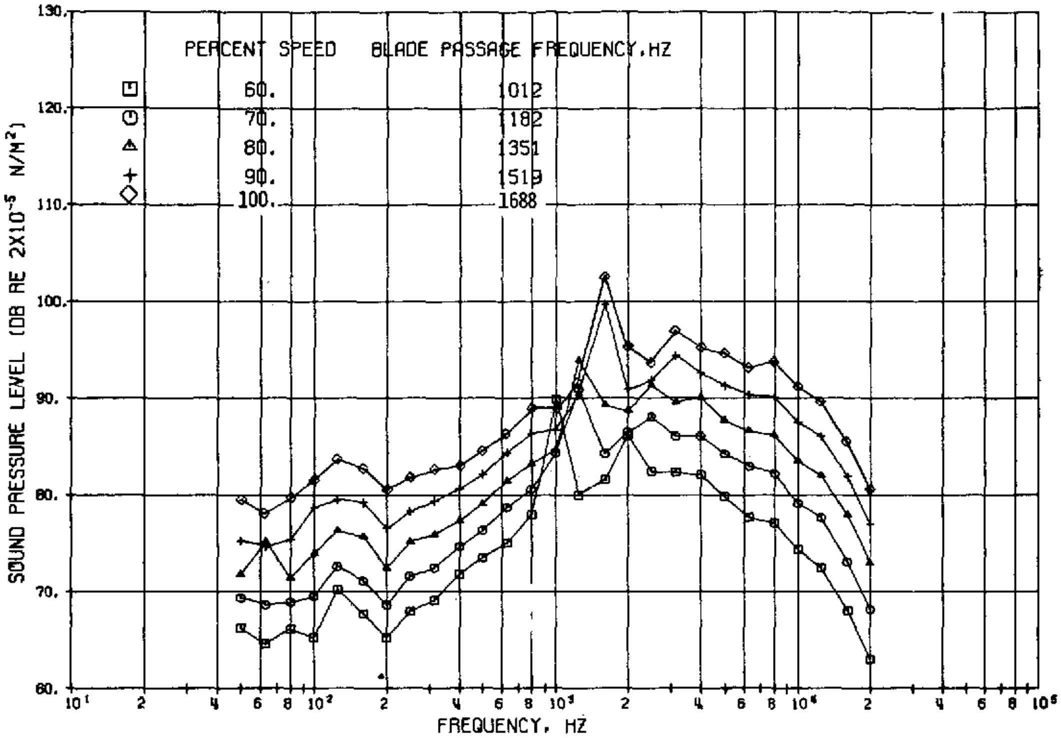


(i) 90°.

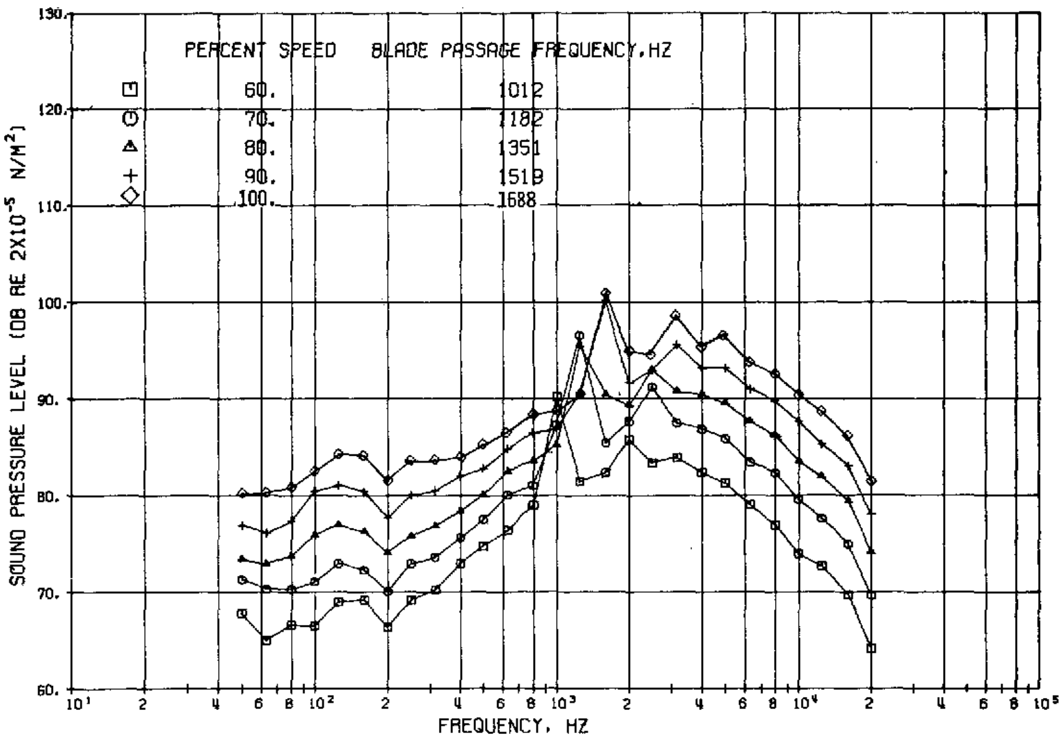


(j) 100°.

Figure 42. - Continued.

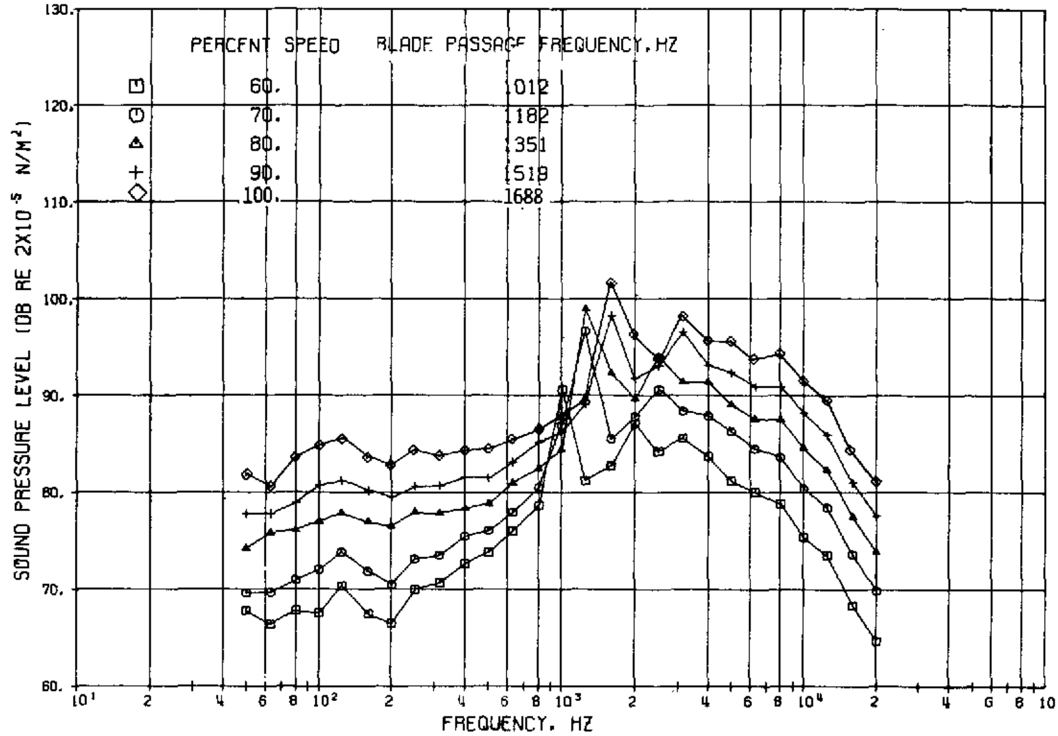


(k) 110°.

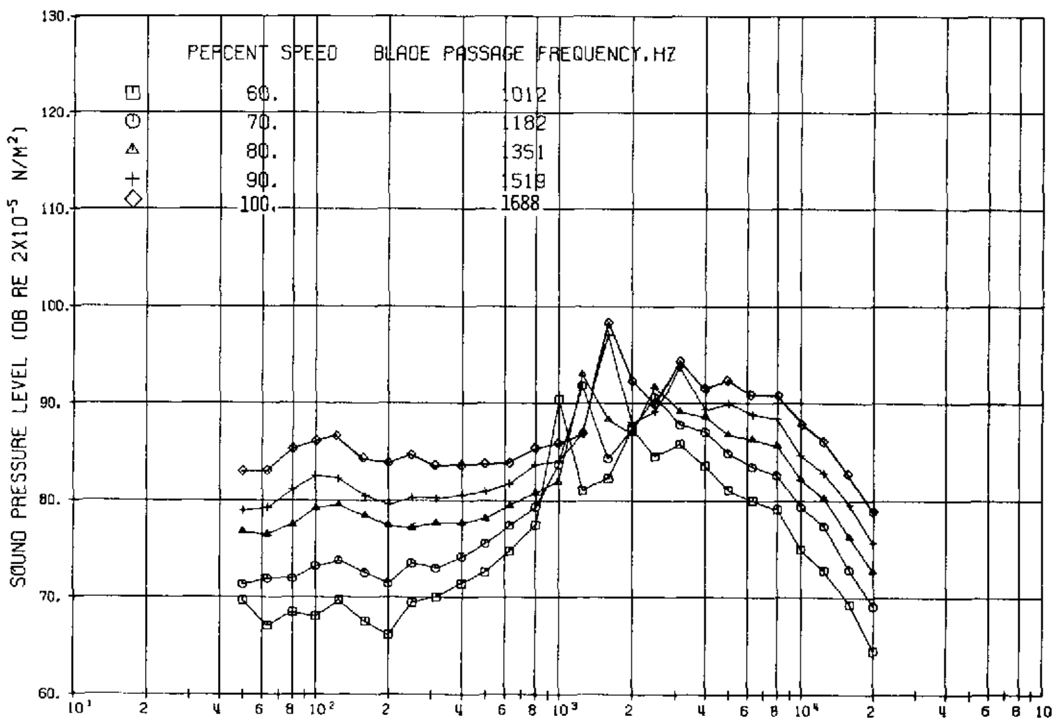


(l) 120°.

Figure 42. - Continued.

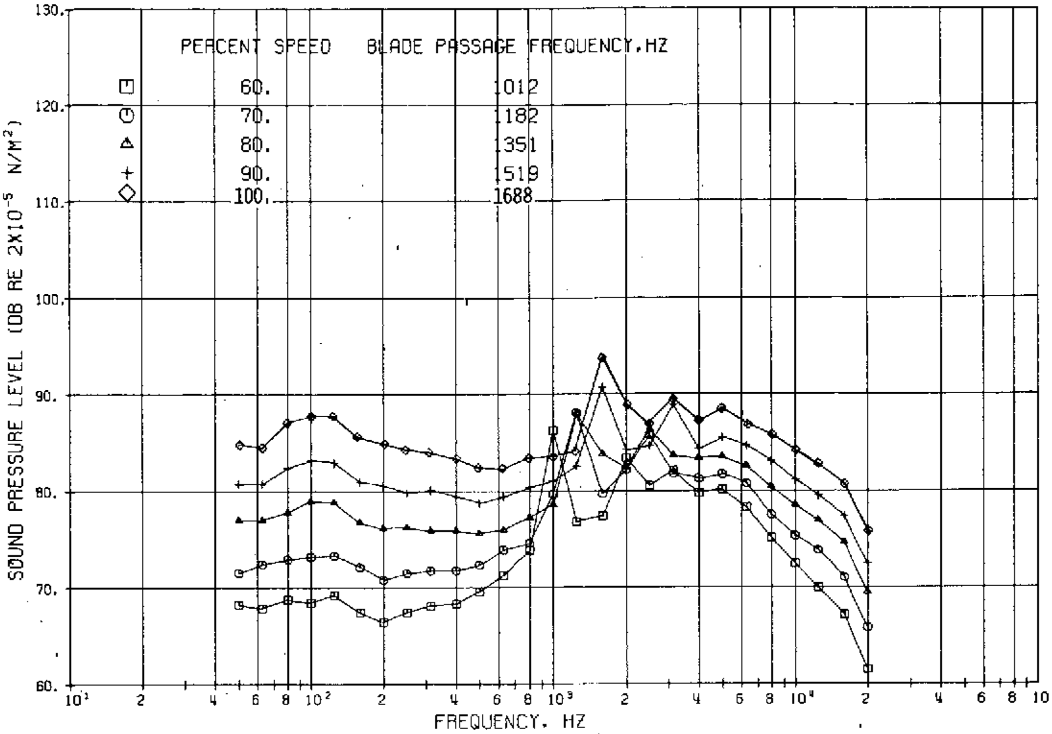


(m) 130°.

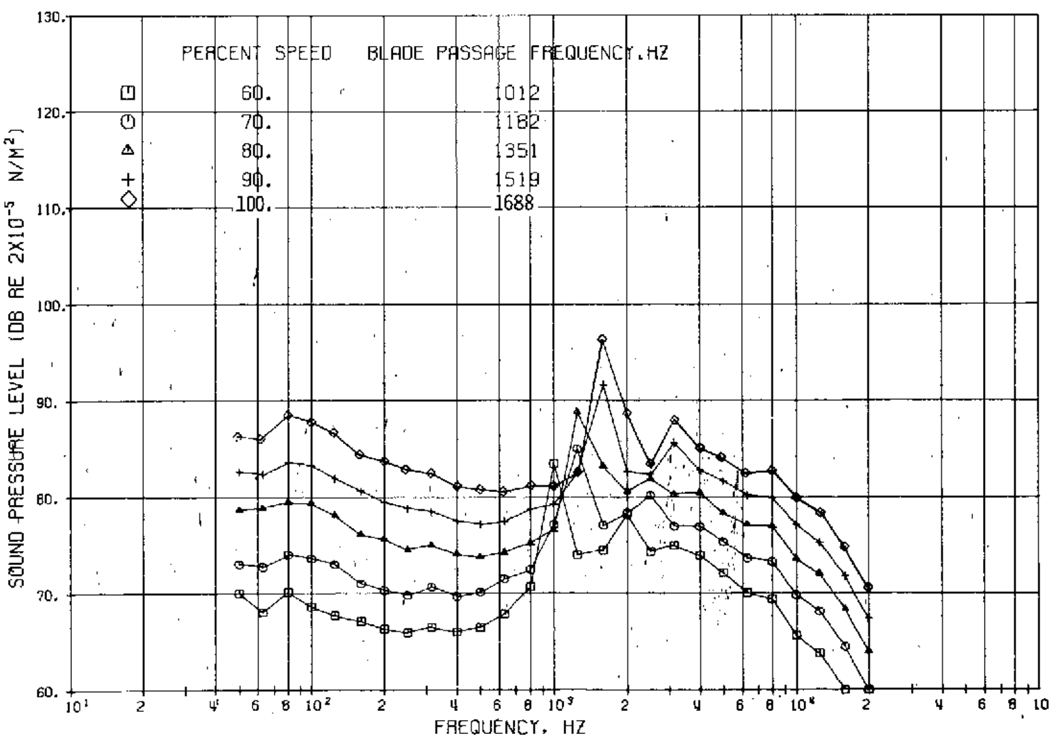


(n) 140°.

Figure 42. - Continued.

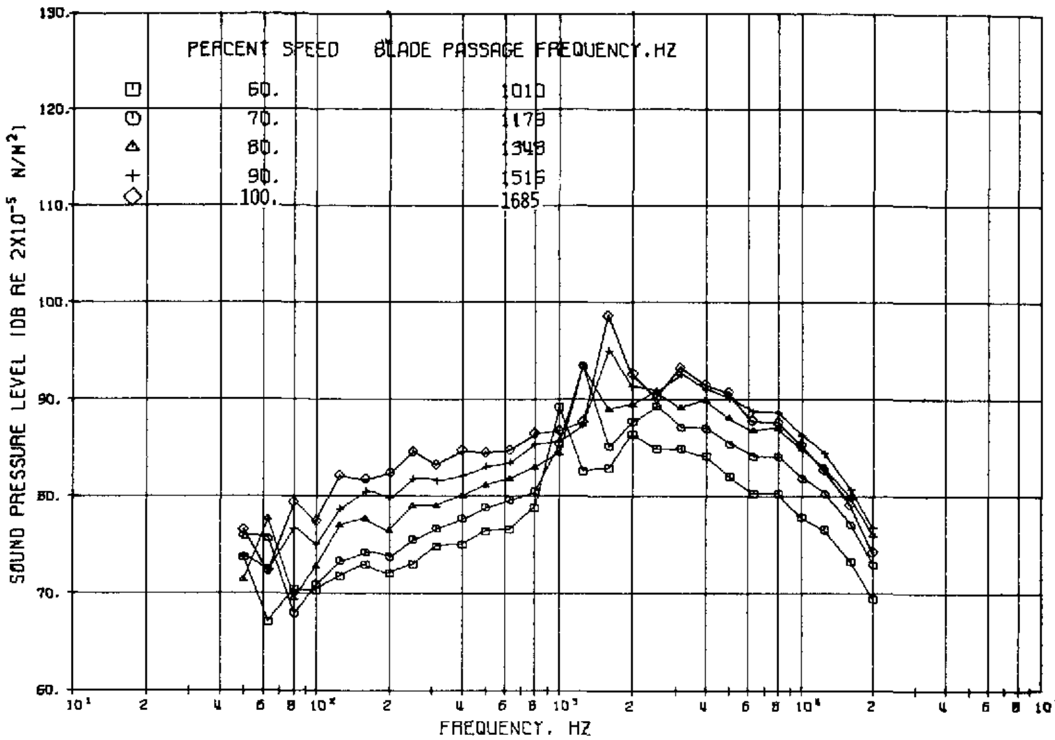


(o) 150°.

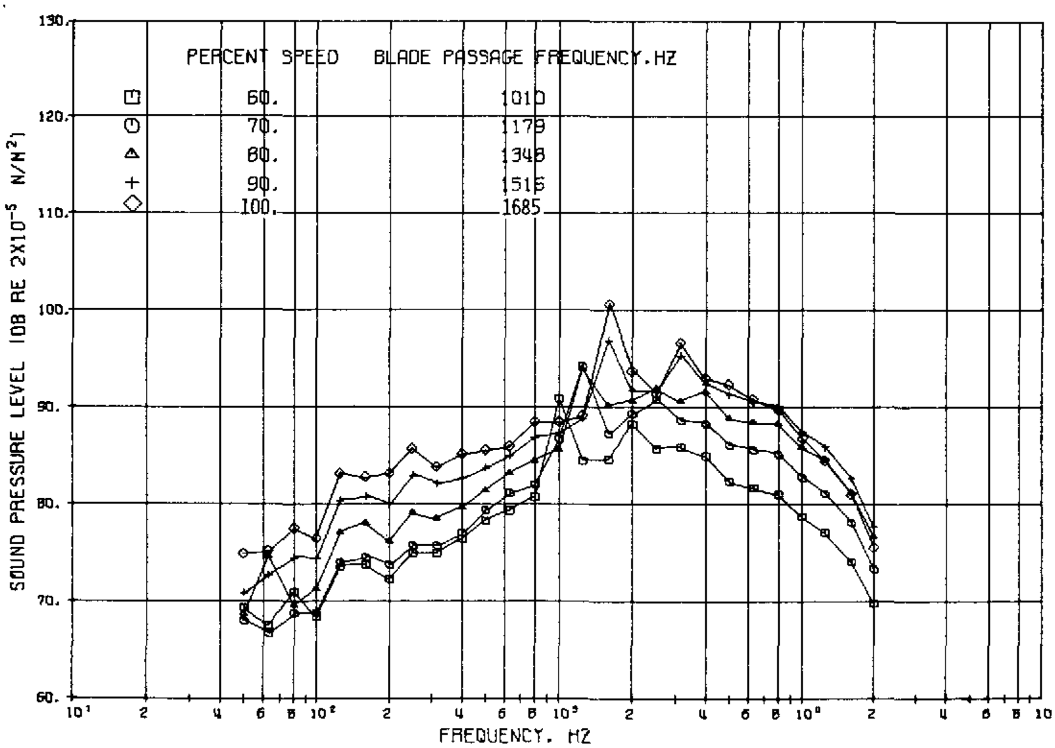


(p) 160°.

Figure 42. - Concluded.

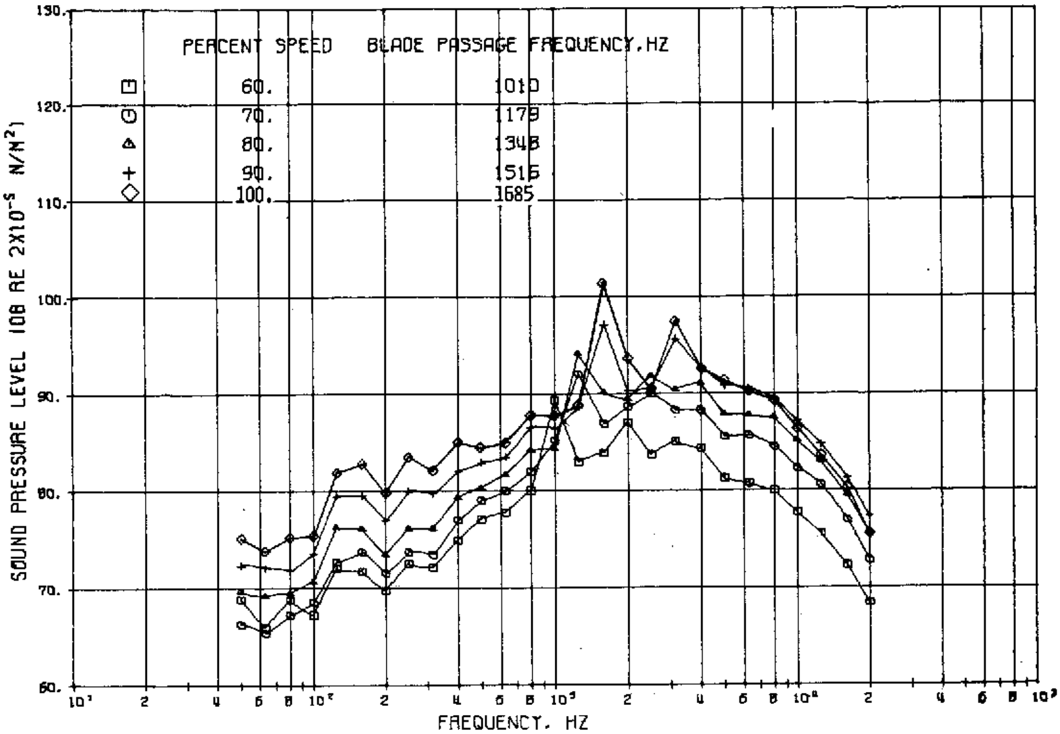


(a) 10°.

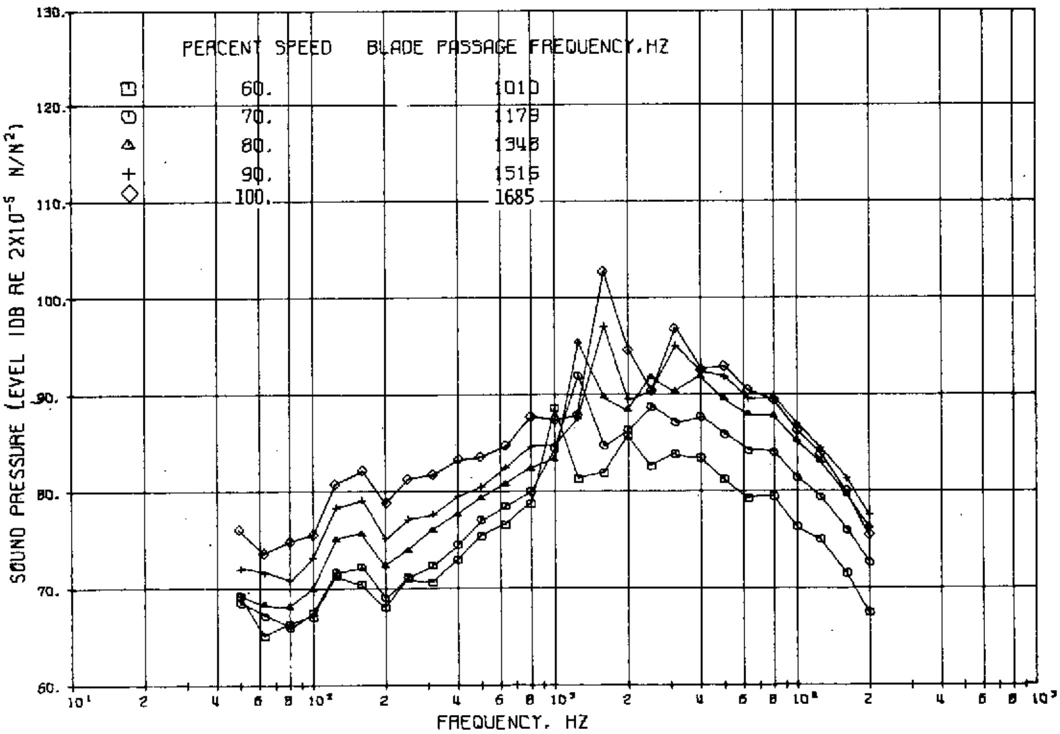


(b) 20°.

Figure 43. - 1/3-Octave-band spectra on 30.5-meter (100-ft) radius for design nozzle area - at various angular positions from inlet.

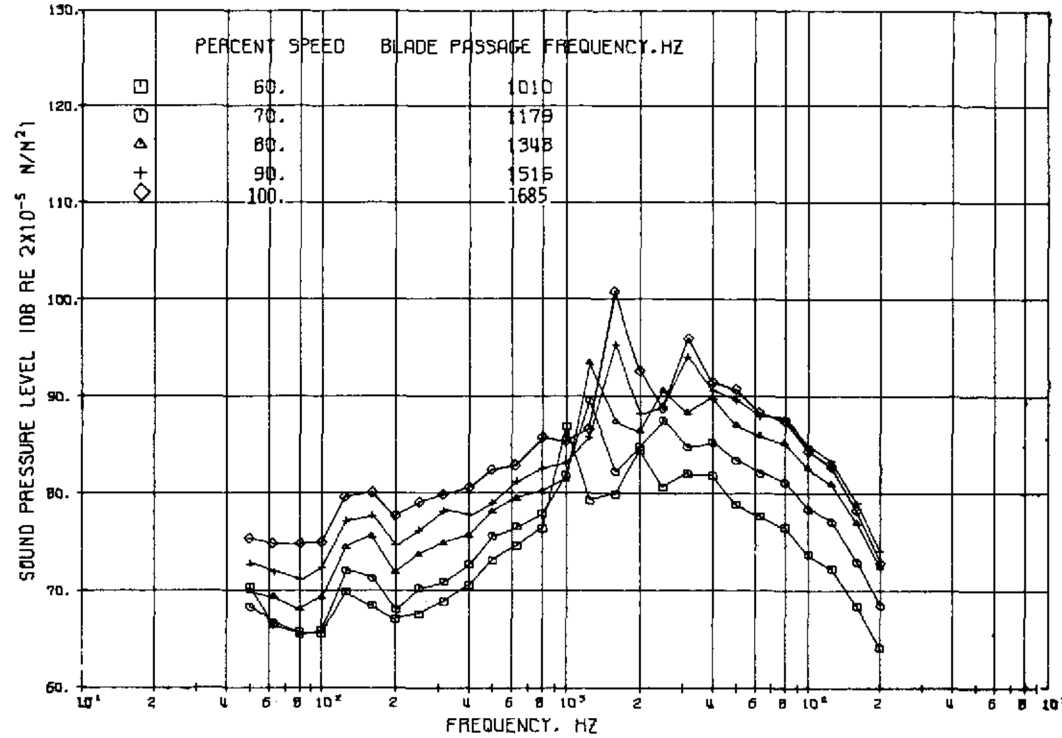


(c) 30°.

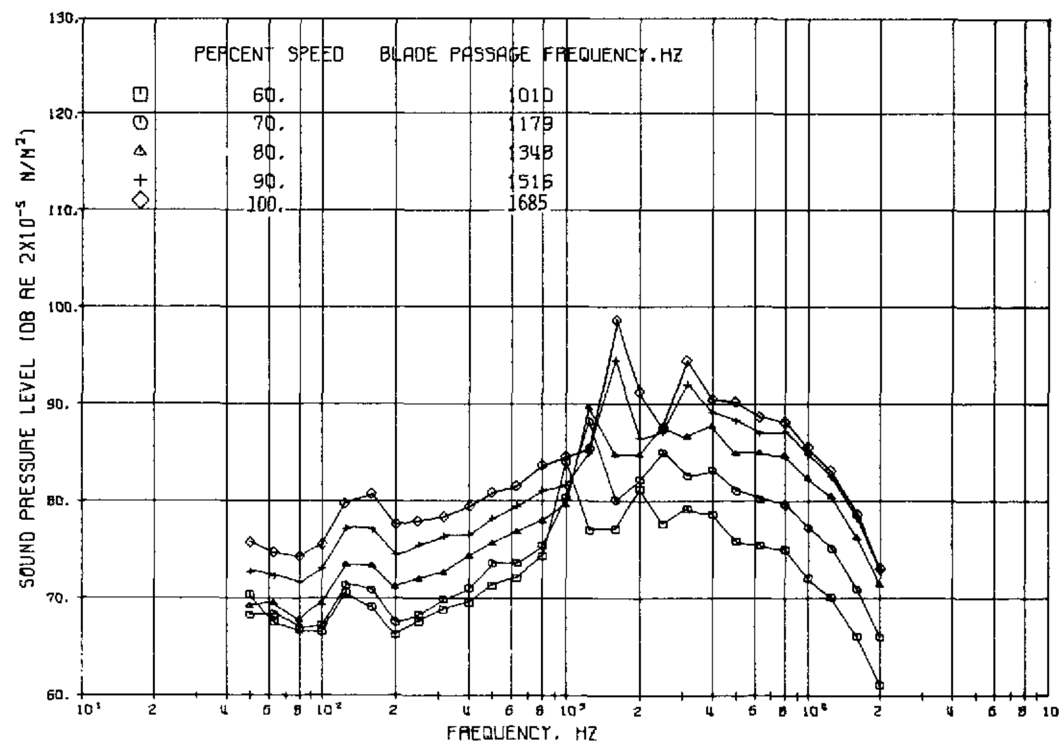


(d) 40°.

Figure 43. - Continued.

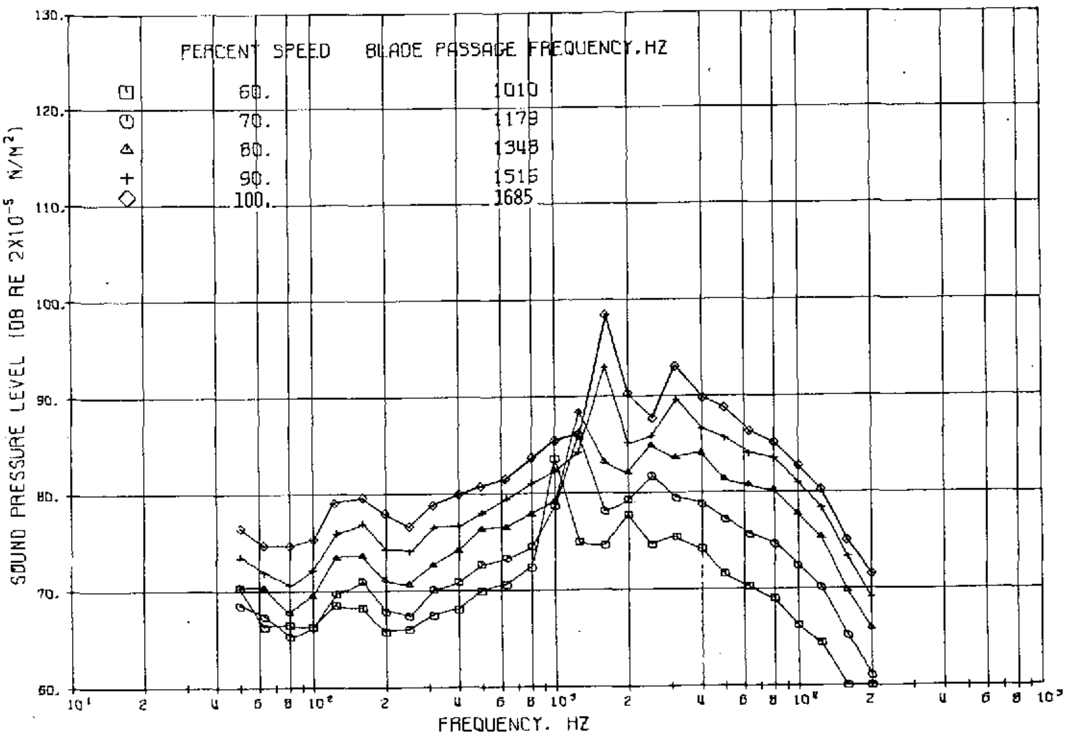


(e) 50°.

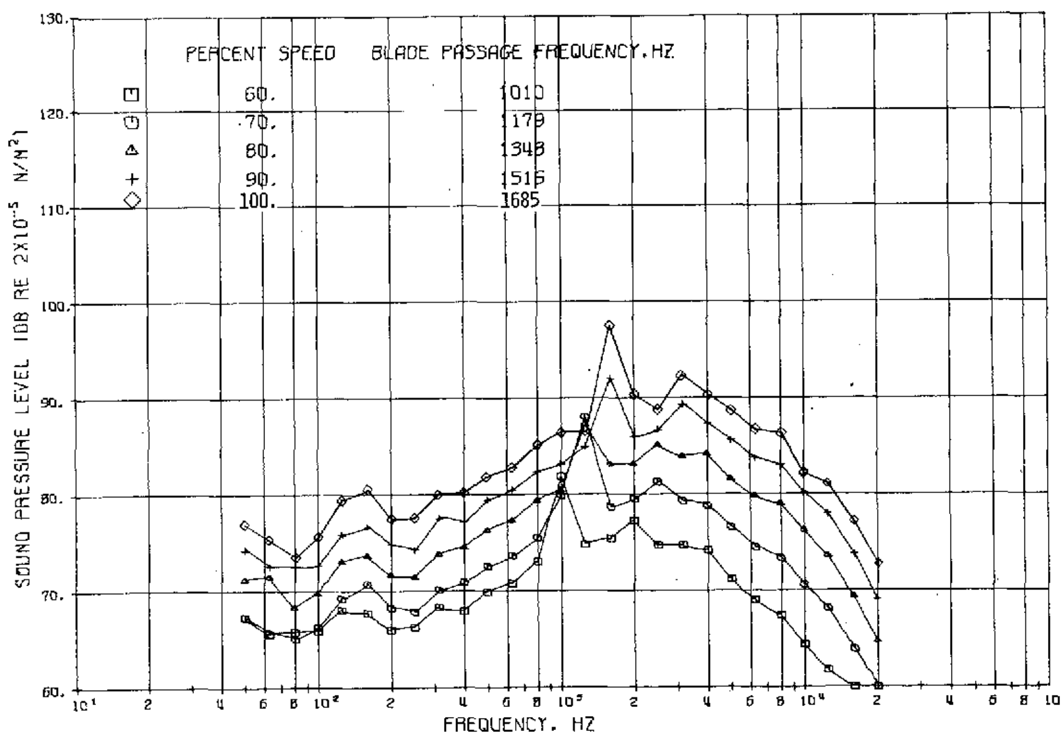


(f) 60°.

Figure 43. - Continued.

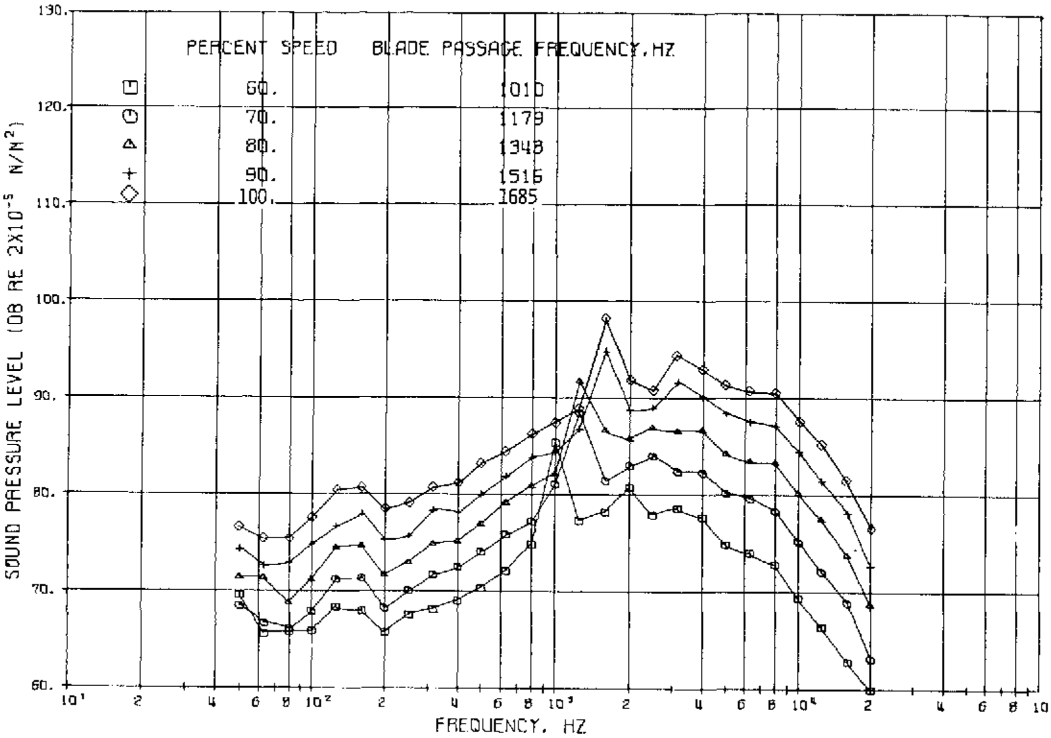


(g) 70°.

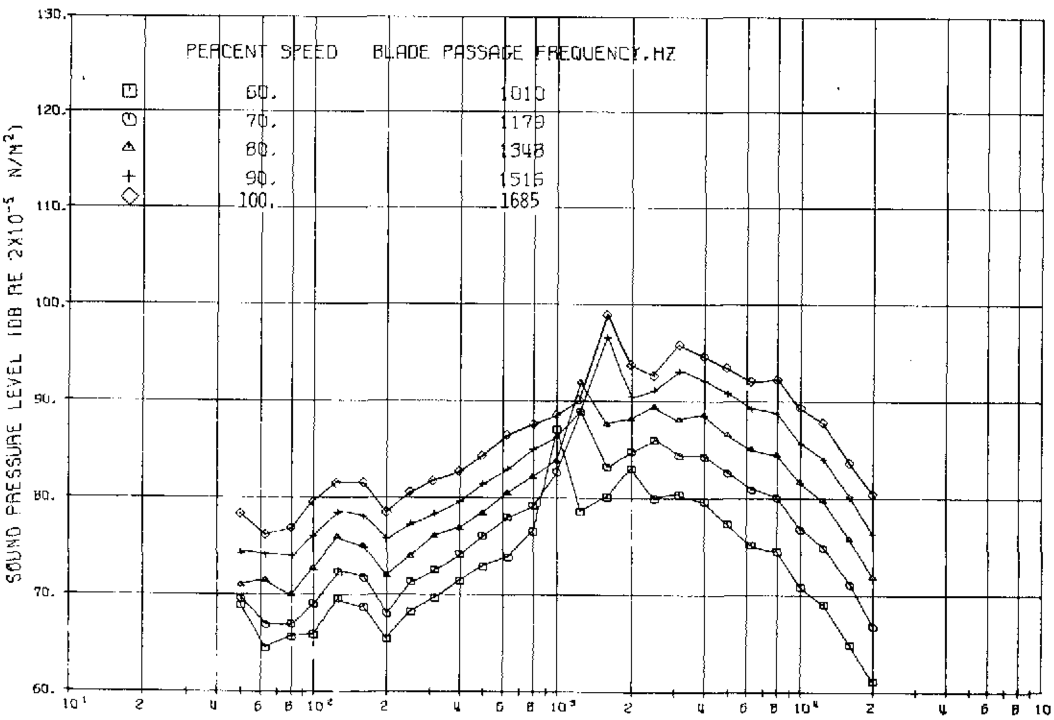


(h) 80°.

Figure 43. - Continued.

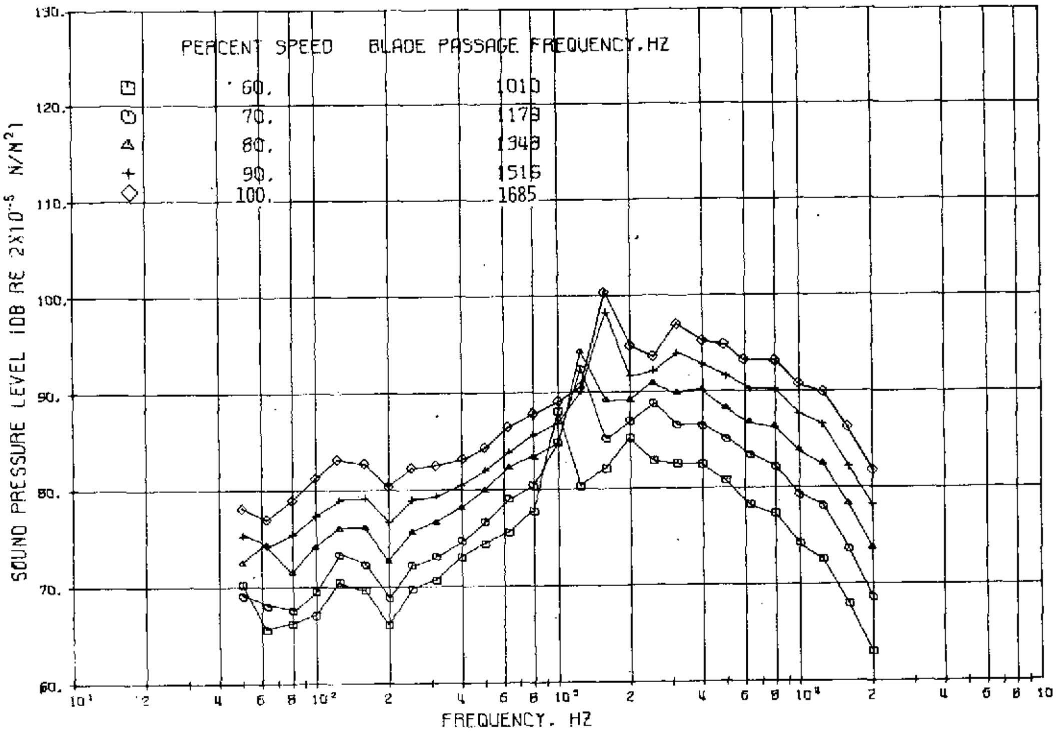


(i) 90°.

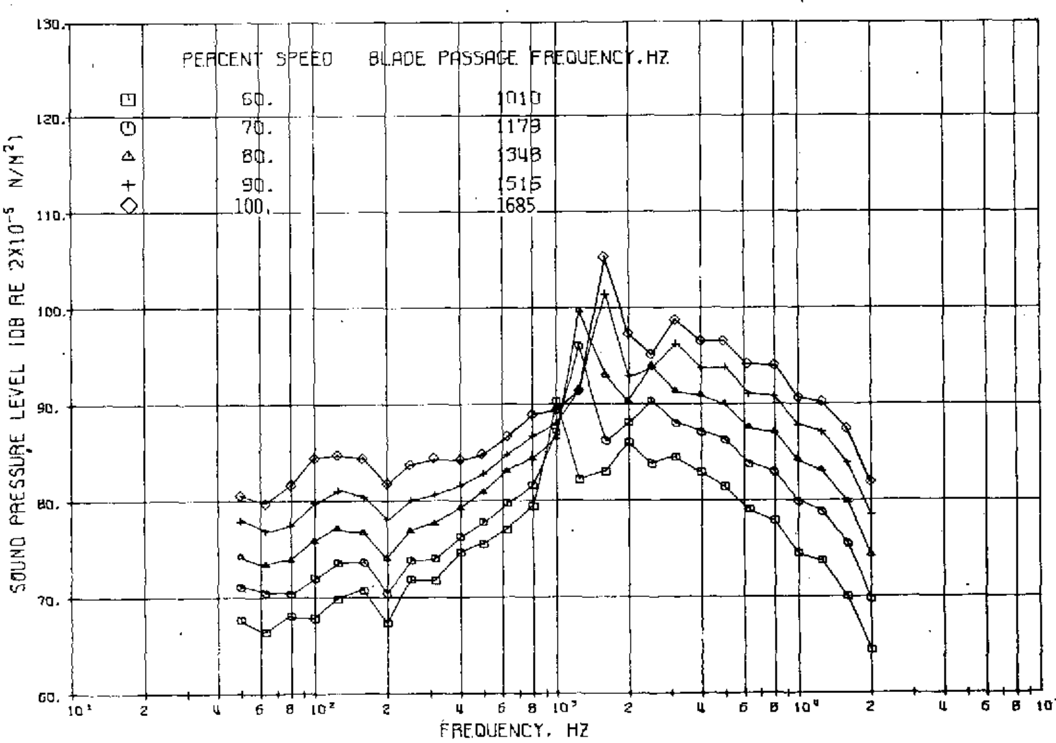


(j) 100°.

Figure 43. - Continued.

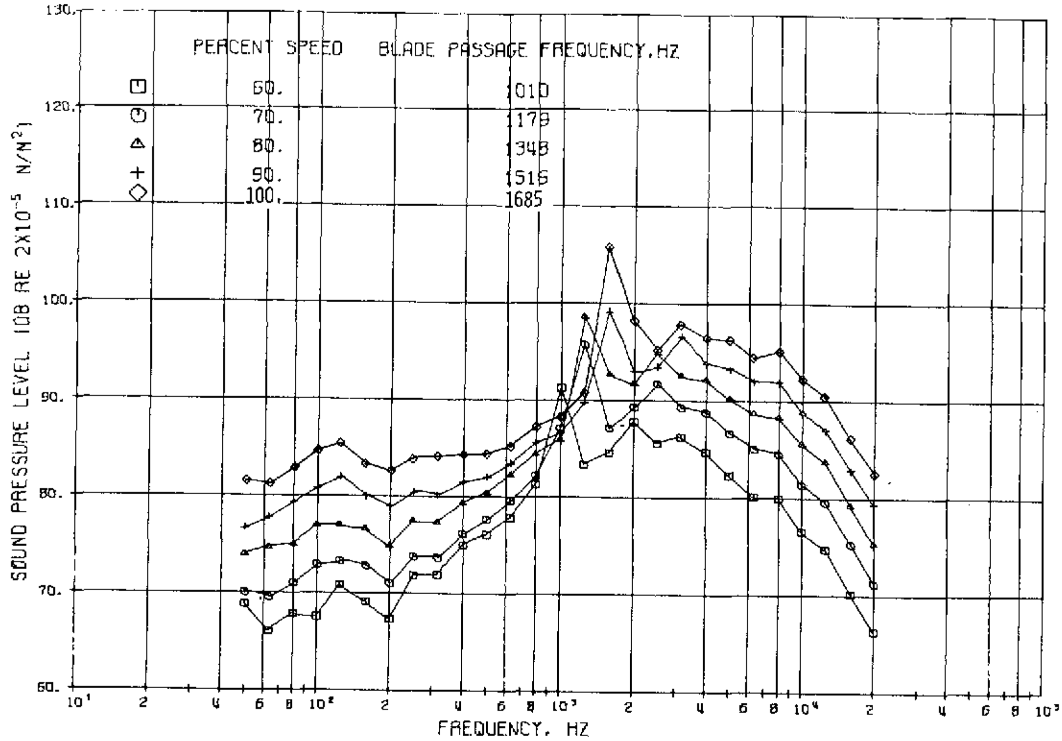


(k) 110°.

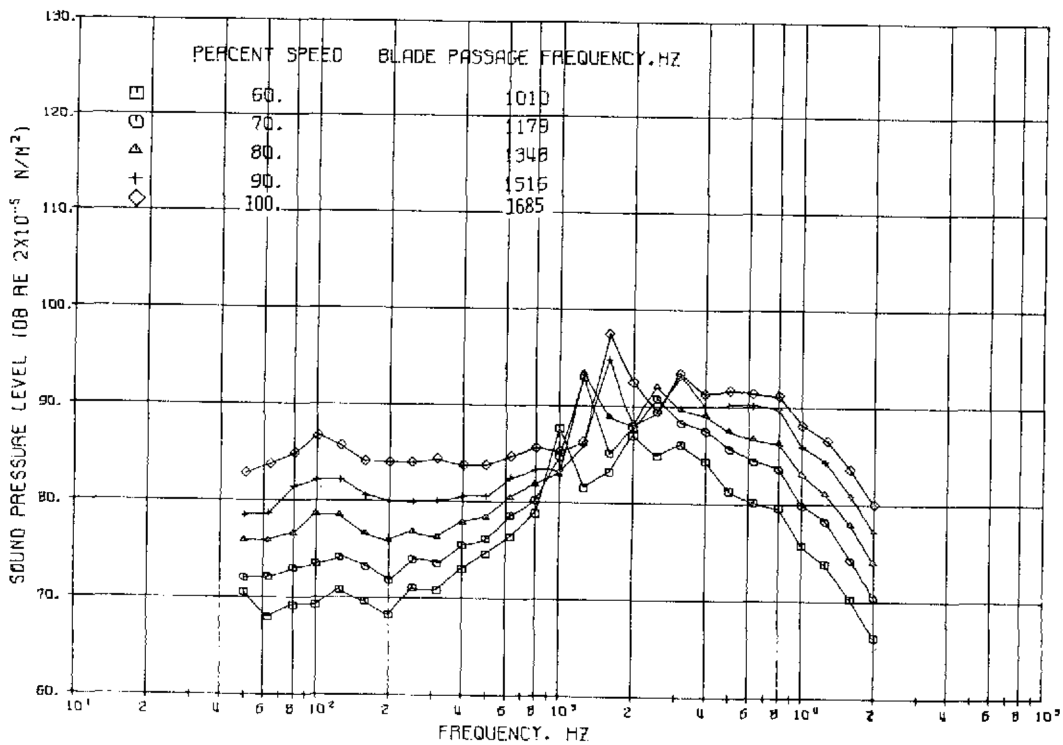


(l) 120°.

Figure 43. - Continued.

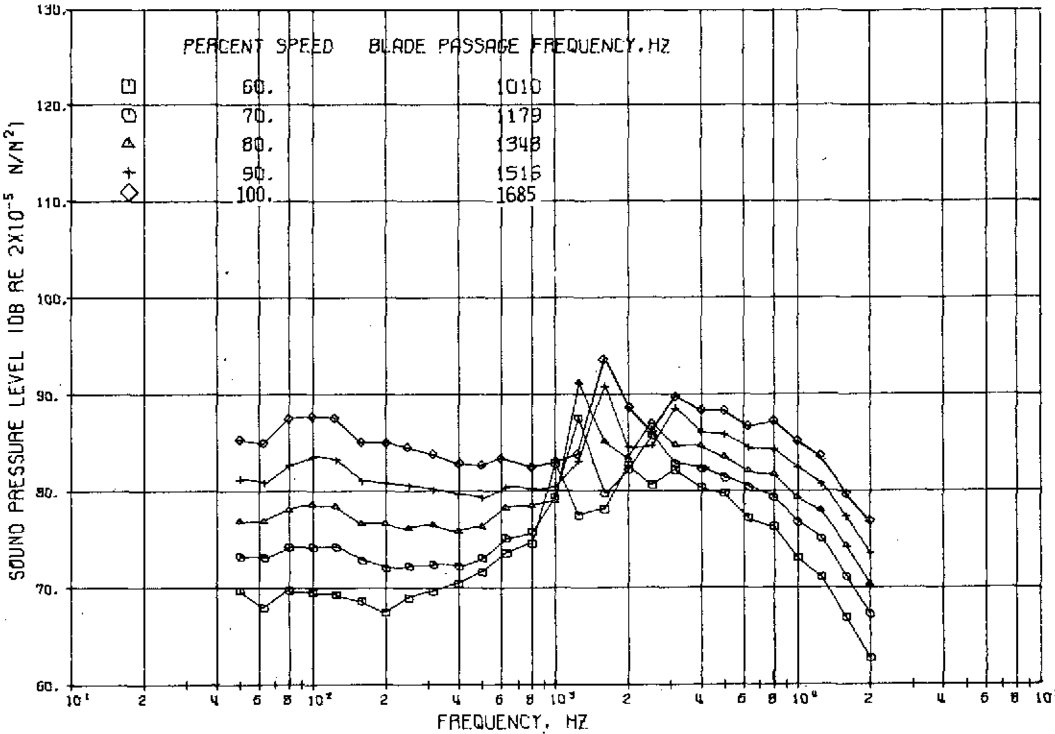


(m) 130°.

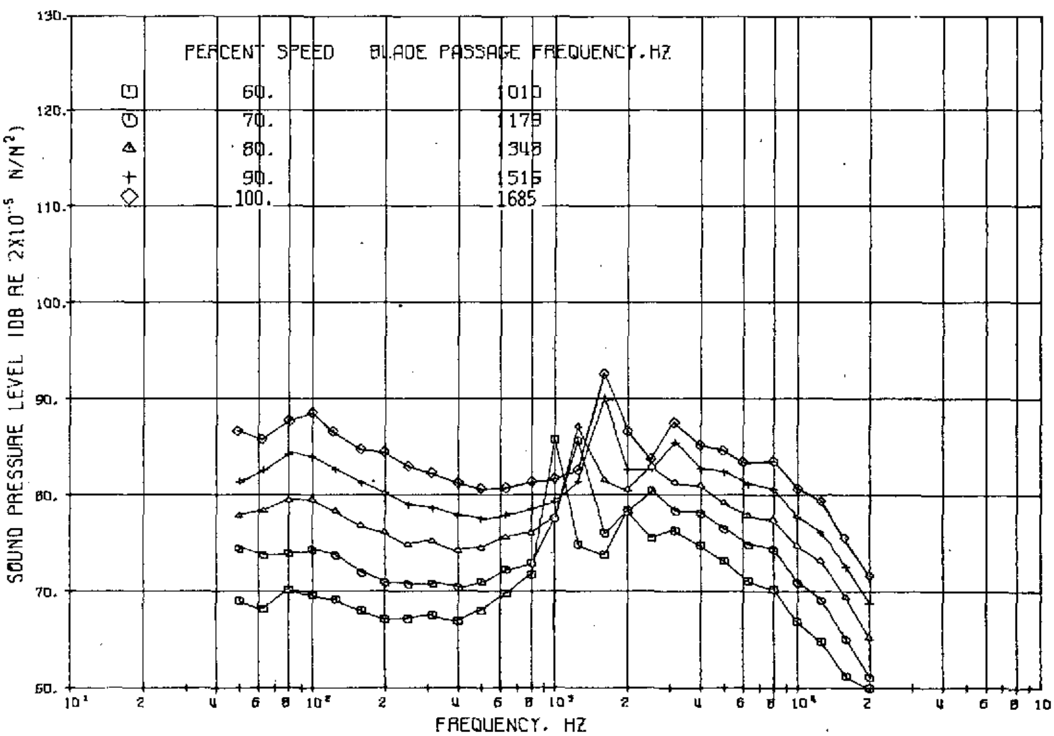


(n) 140°.

Figure 43. - Continued.

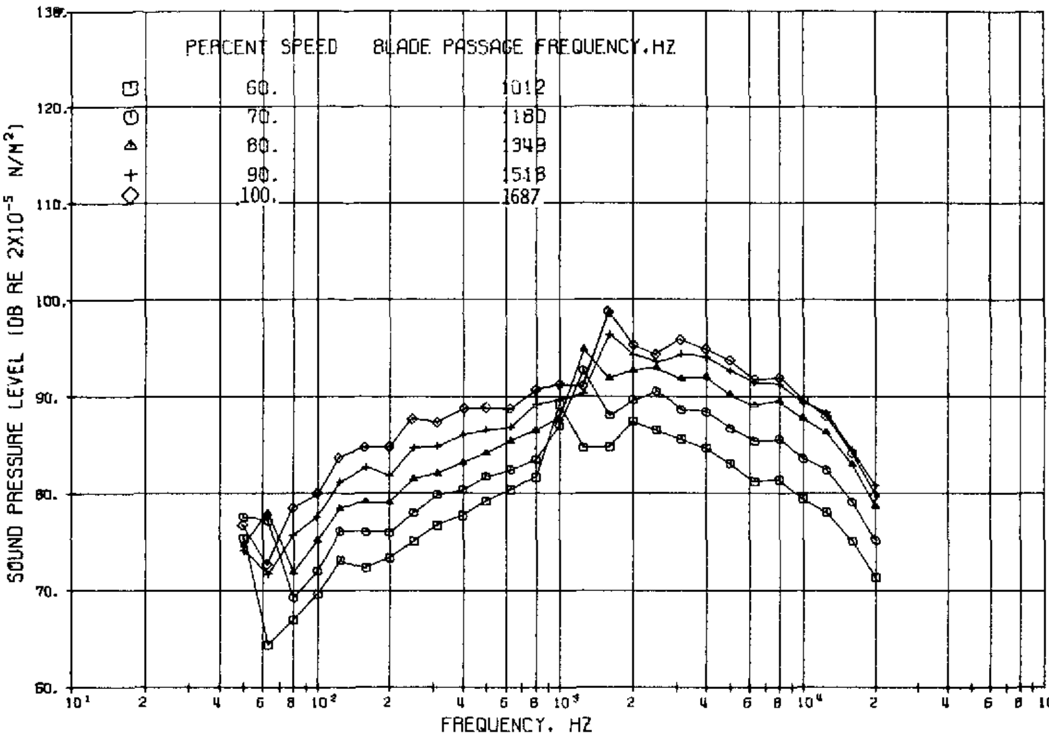


(o) 150°.

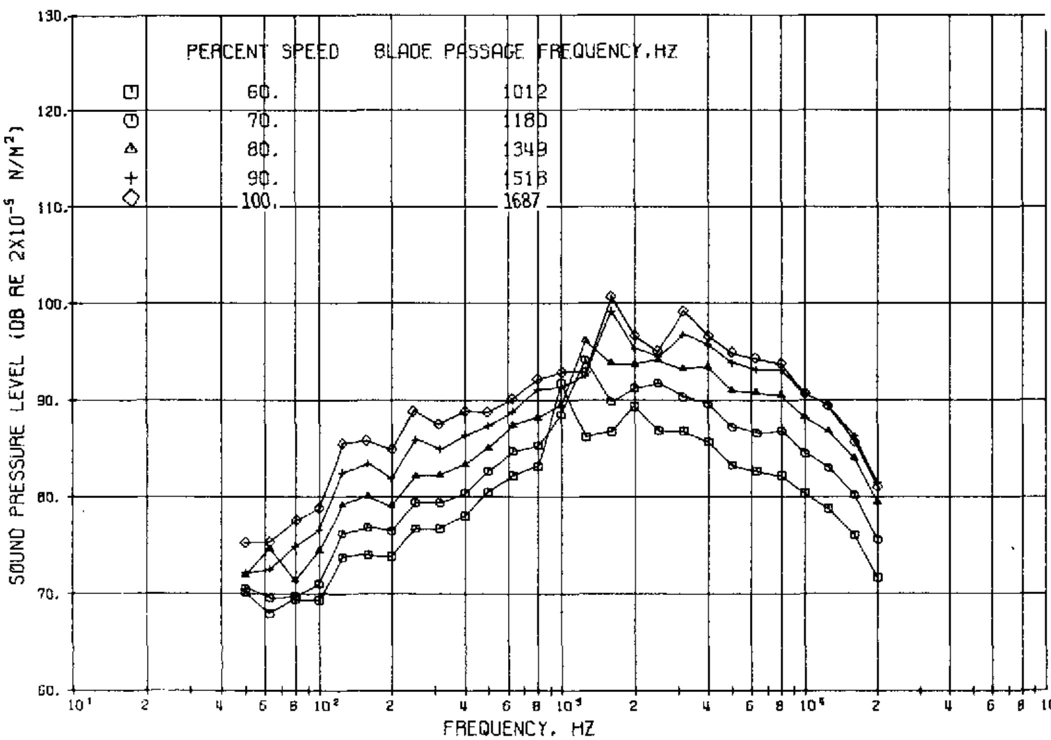


(p) 160°.

Figure 43. - Concluded.

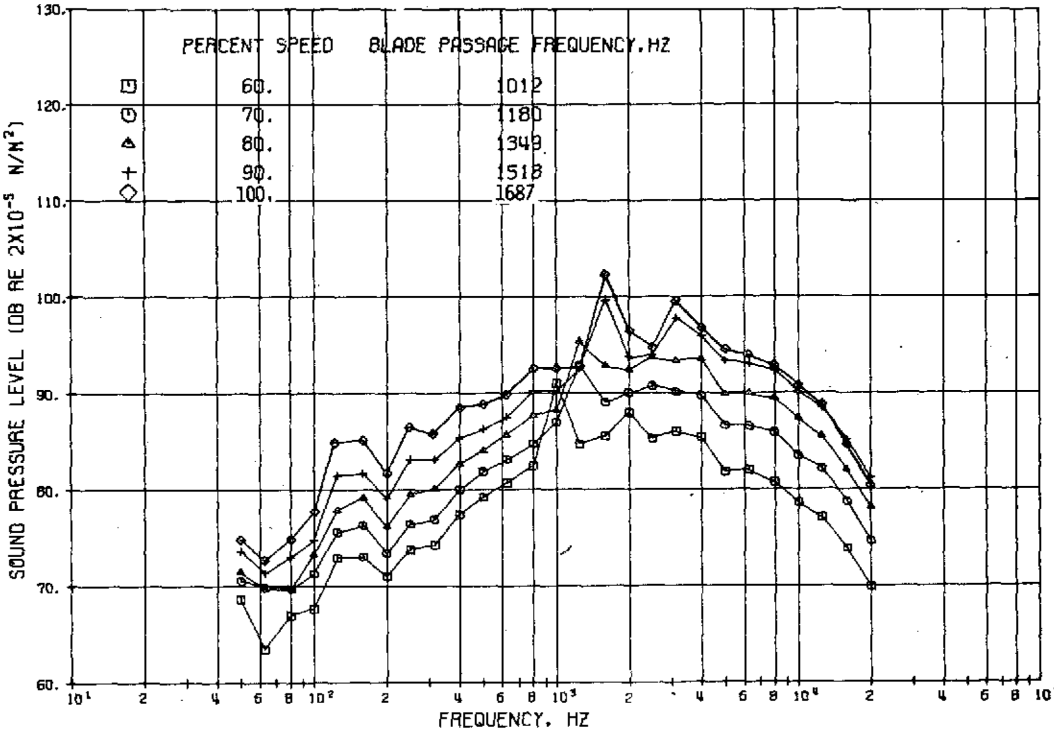


(a) 10°.

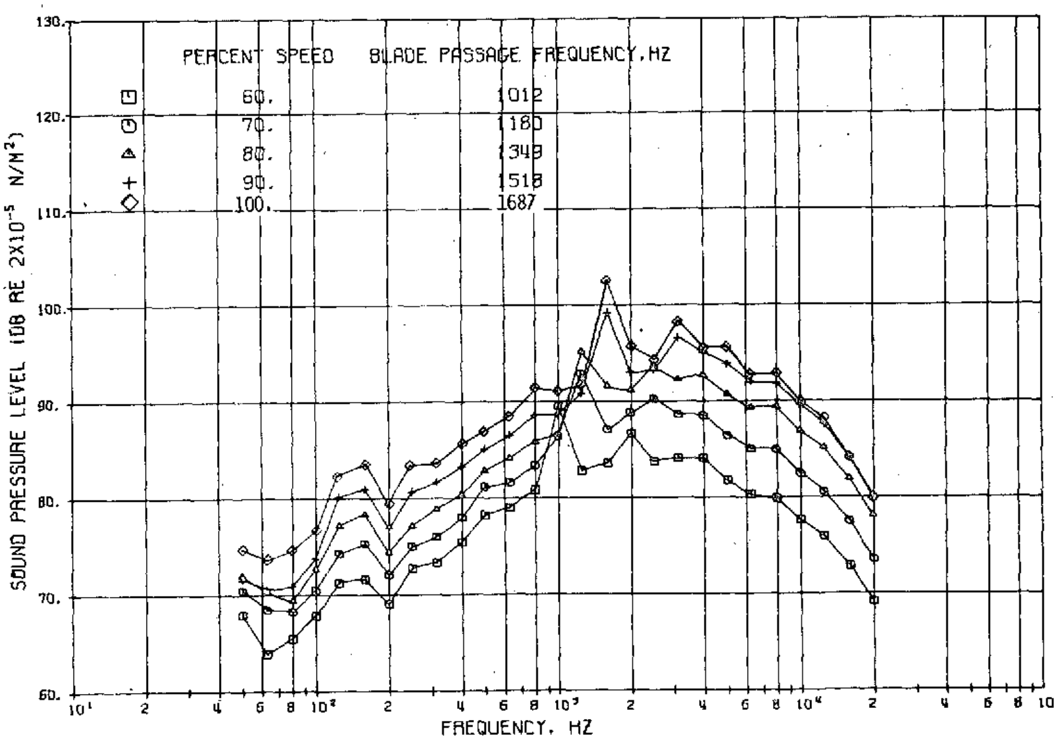


(b) 20°.

Figure 44. - 1/3-Octave-band spectra on 30.5-meter (100-ft) radius for 95 percent of design nozzle area - at various angular positions from inlet.

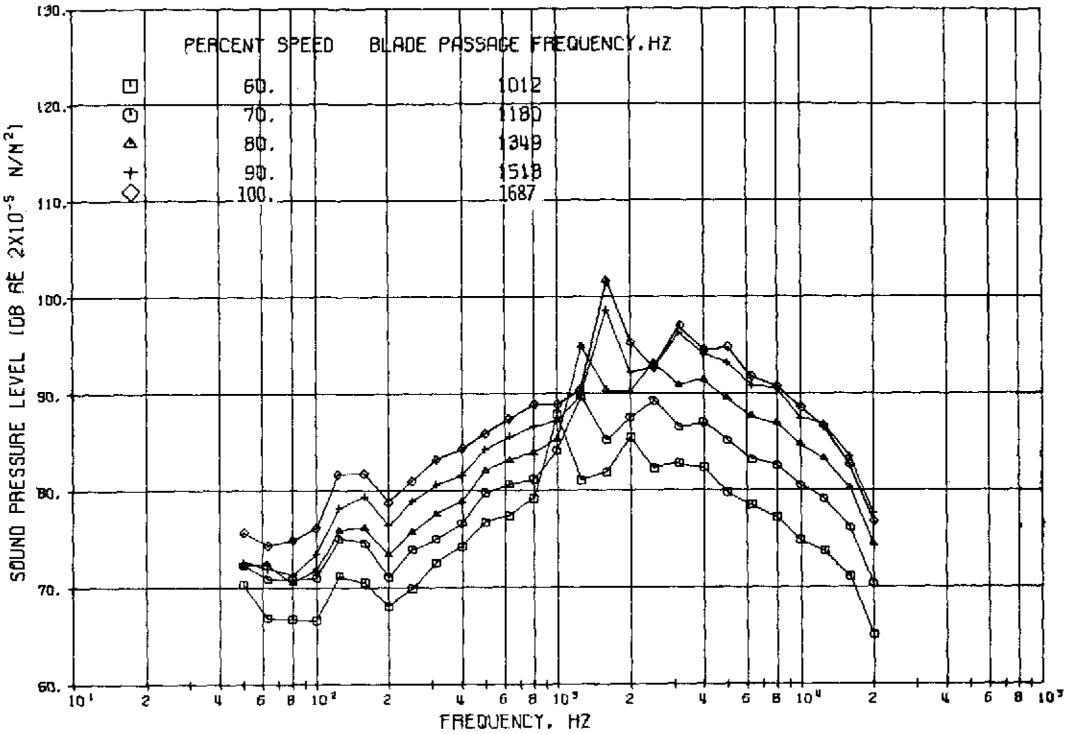


(c) 30°.

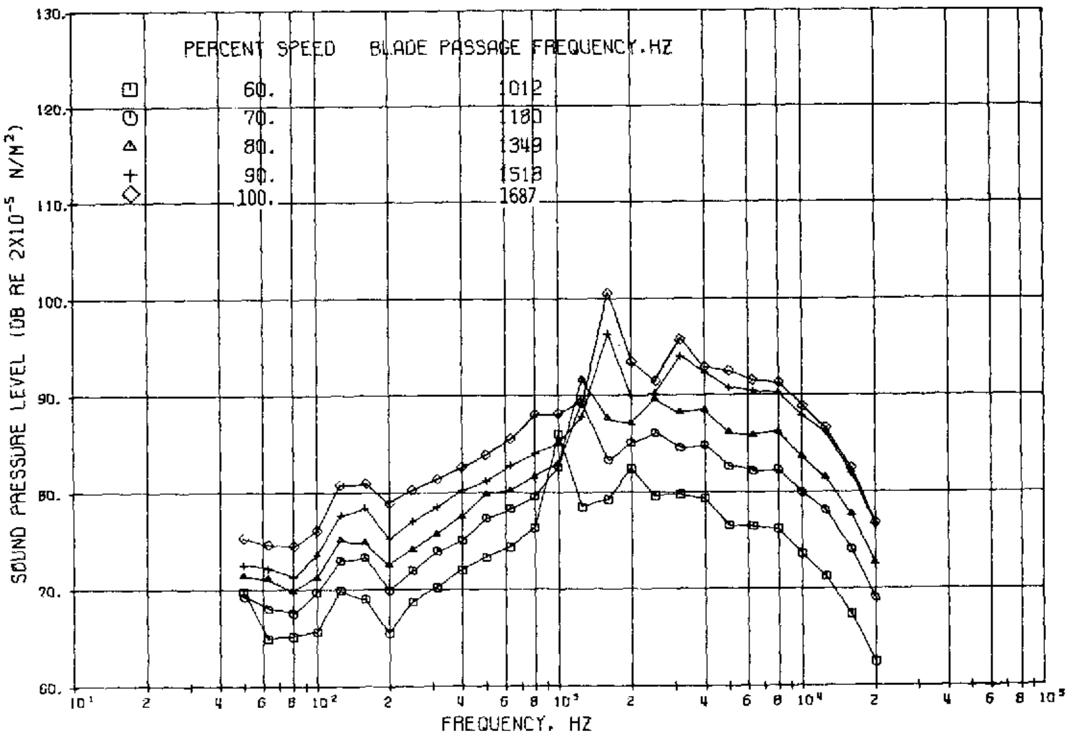


(d) 40°.

Figure 44. - Continued.

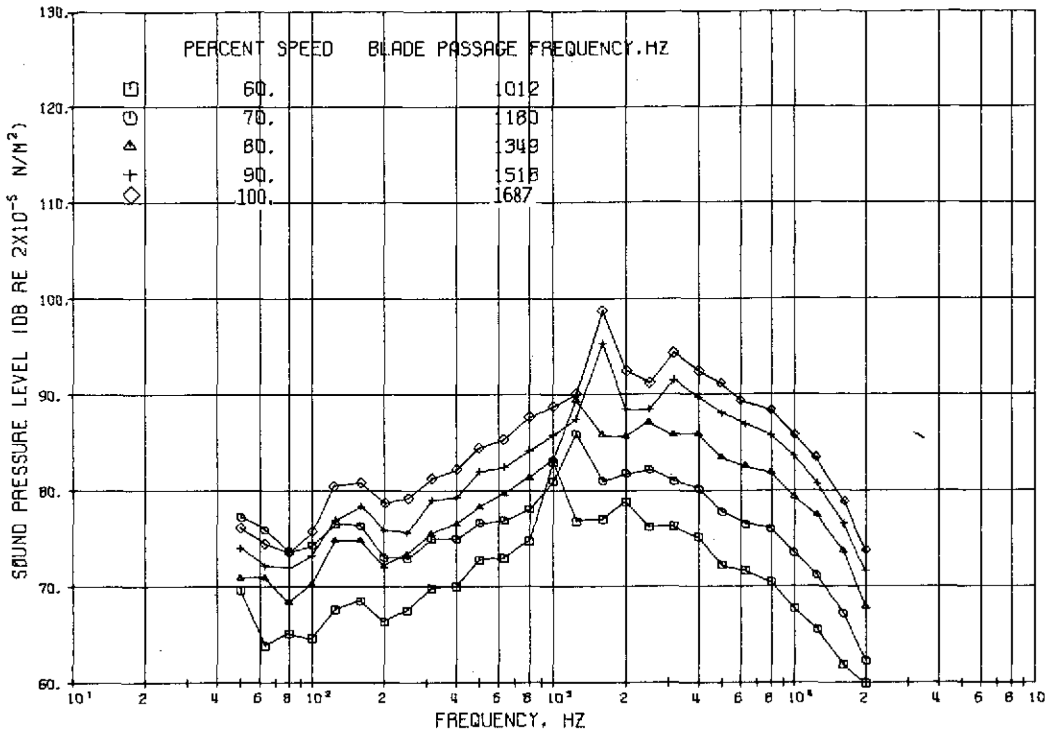


(e) 50°.

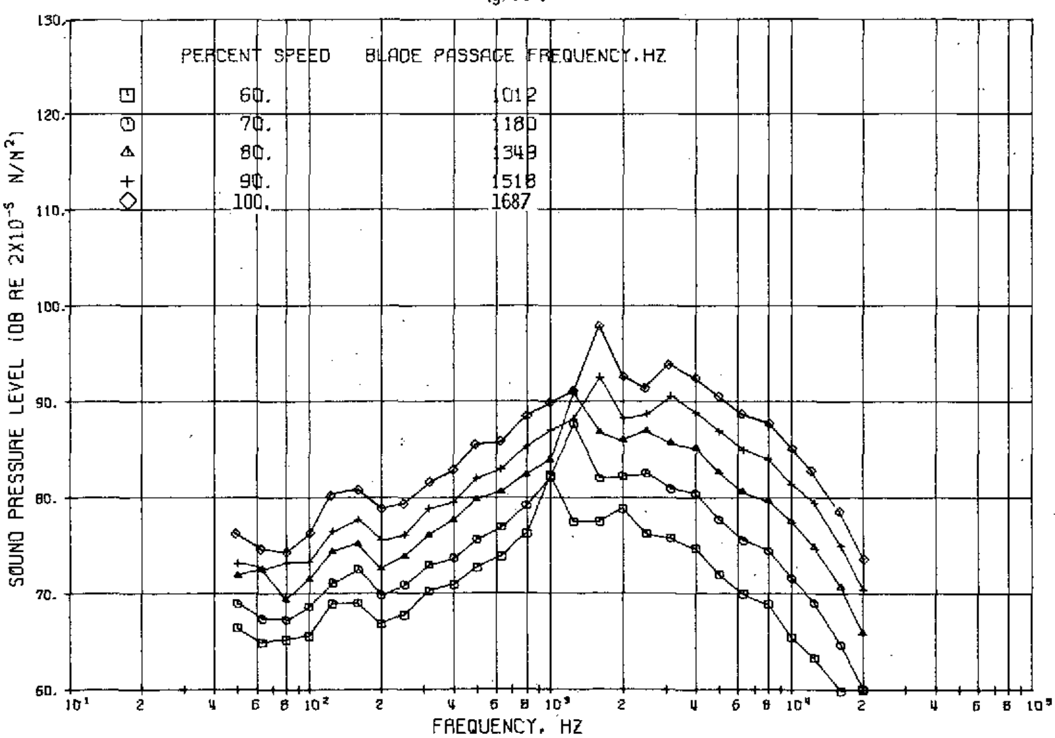


(f) 60°.

Figure 44. - Continued.

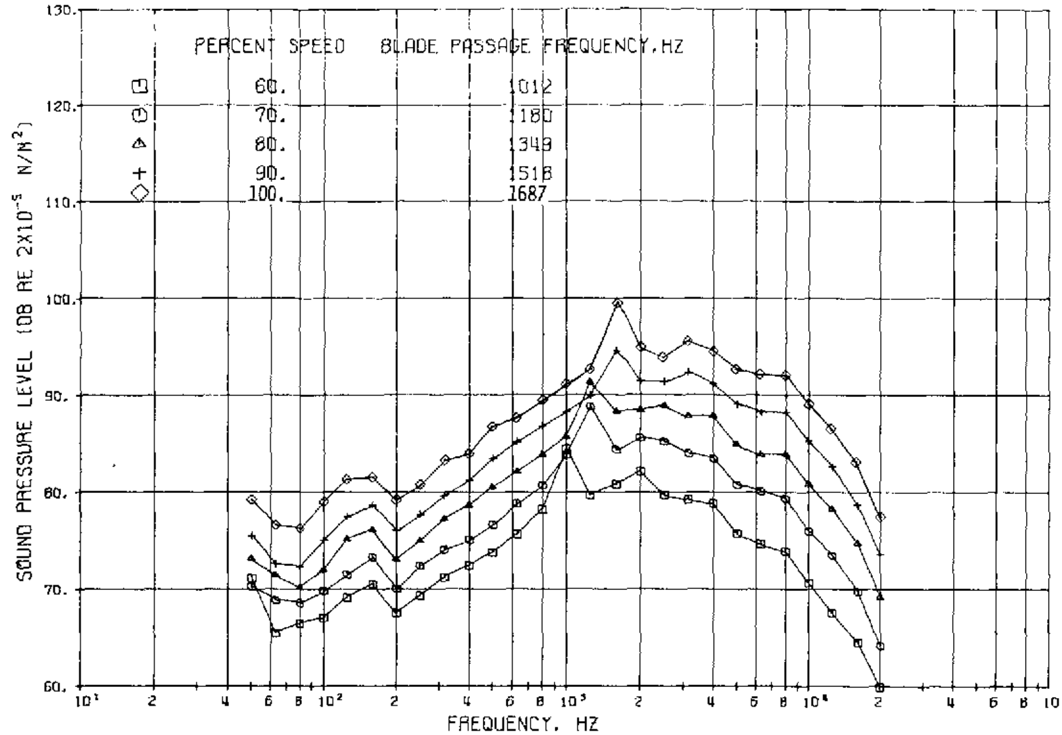


(g) 70°.

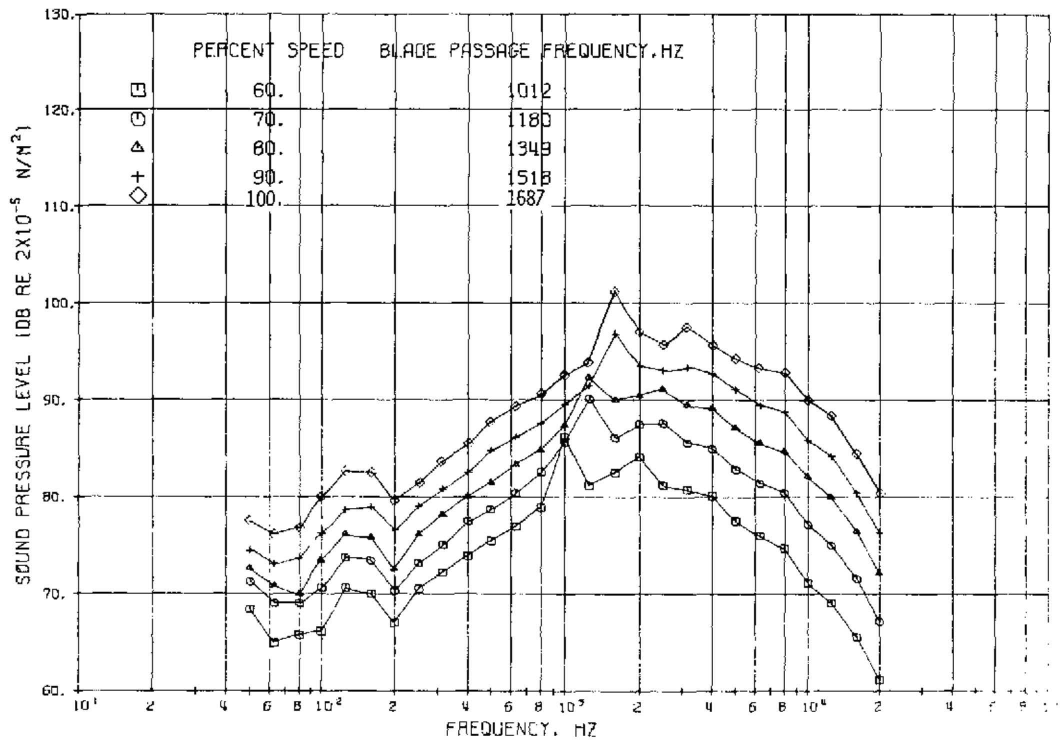


(h) 80°.

Figure 44. - Continued.

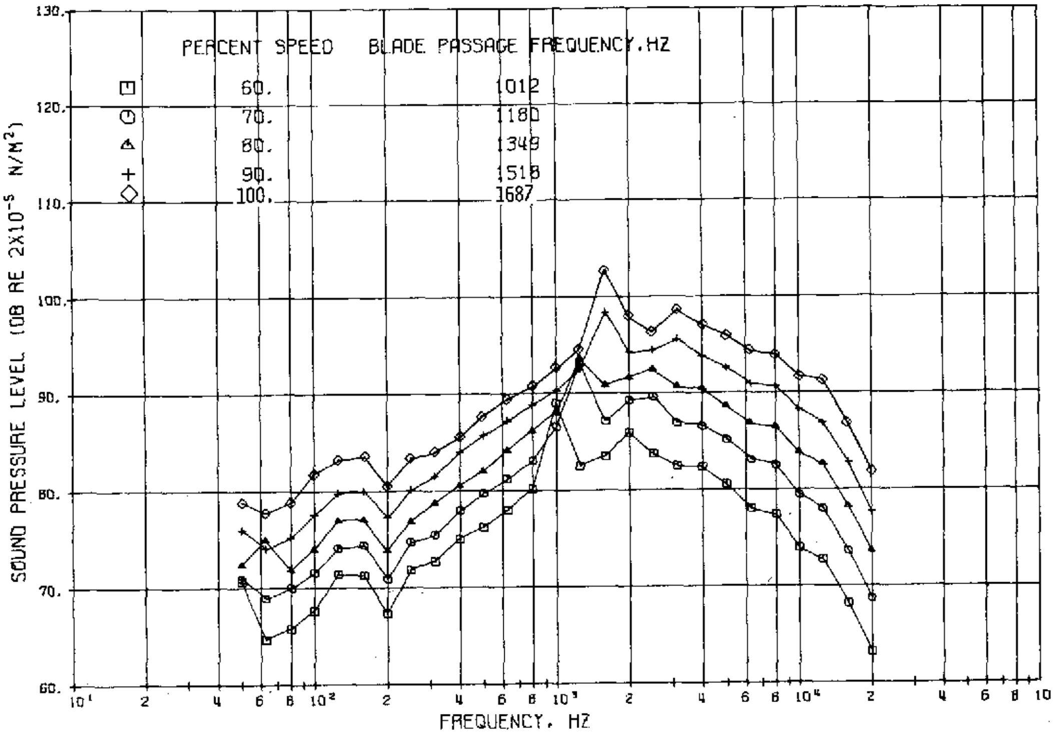


(i) 90°.

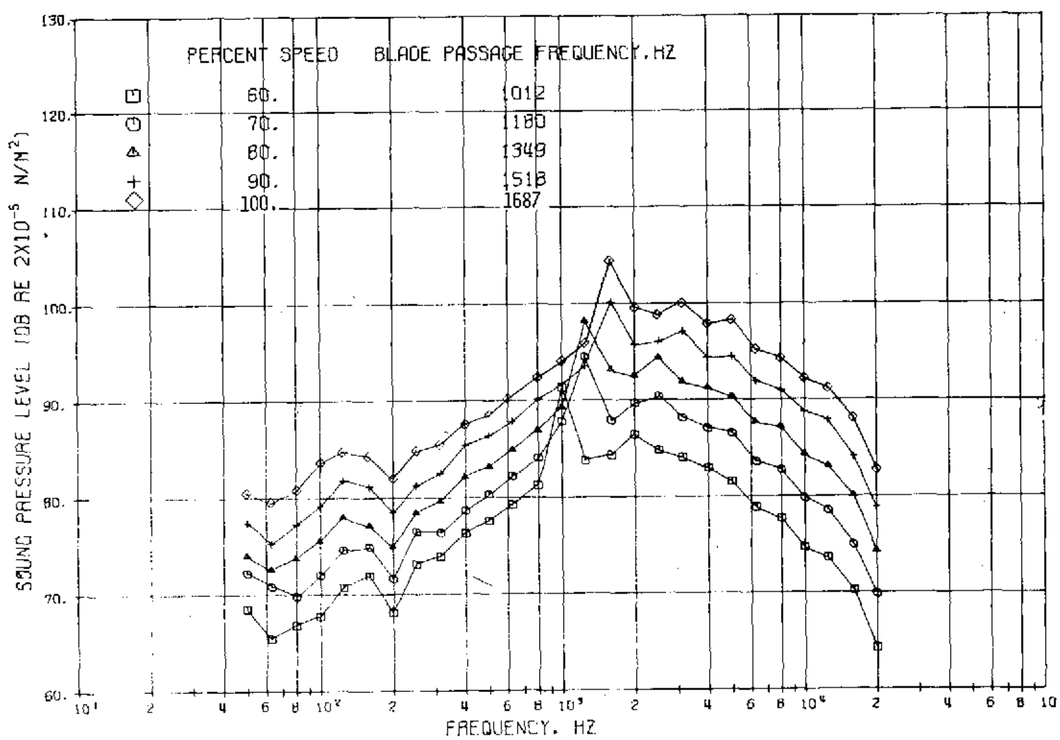


(j) 100°.

Figure 44. - Continued.

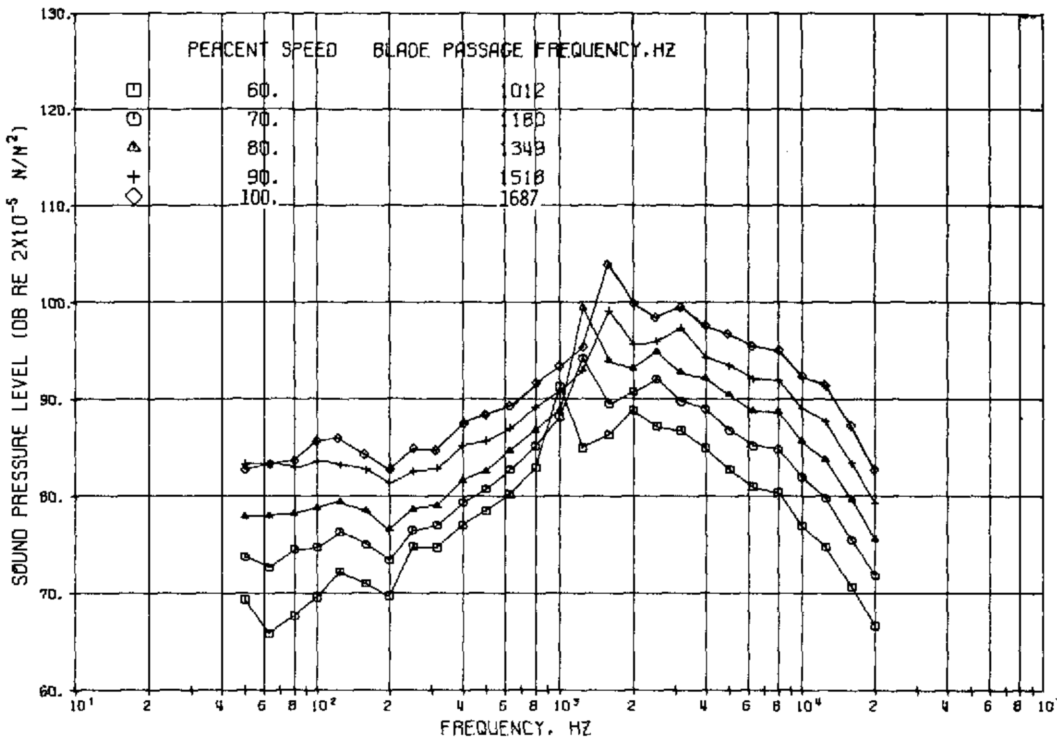


(k) 110°.

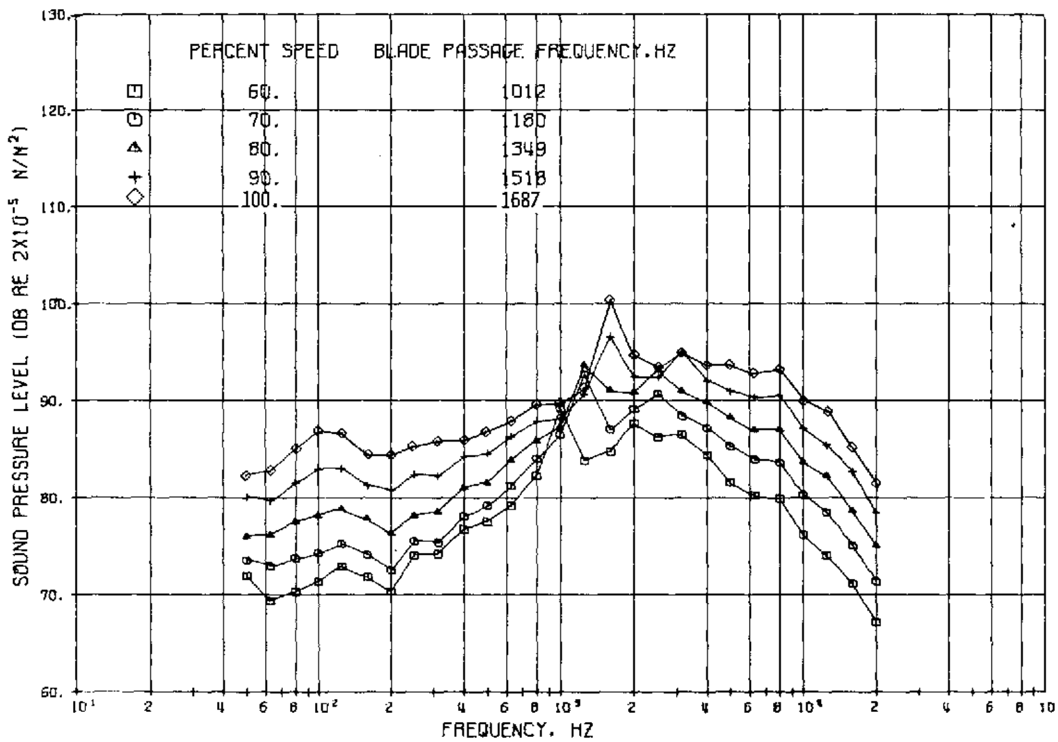


(l) 120°.

Figure 44. - Continued.

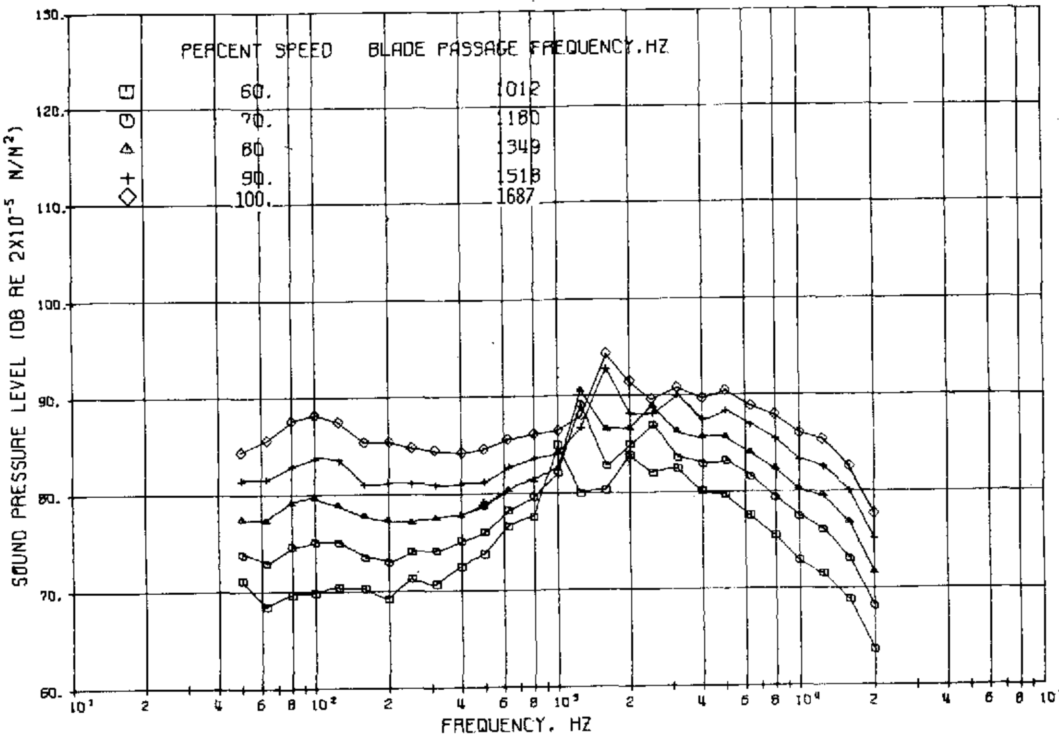


(m) 130°.

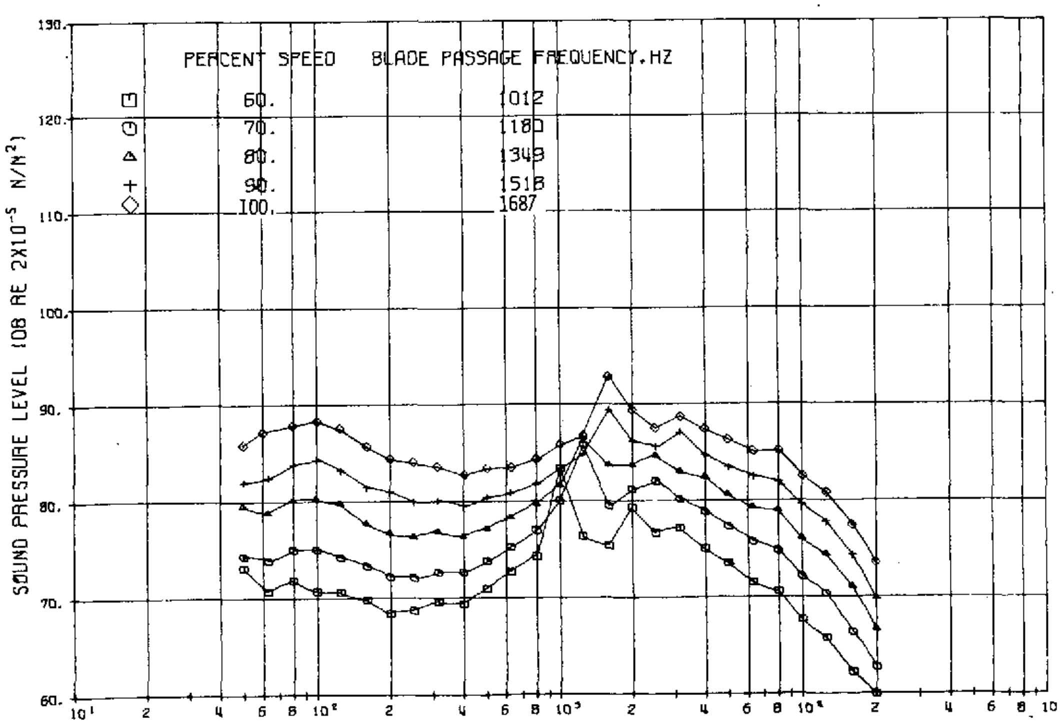


(n) 140°.

Figure 44. - Continued.

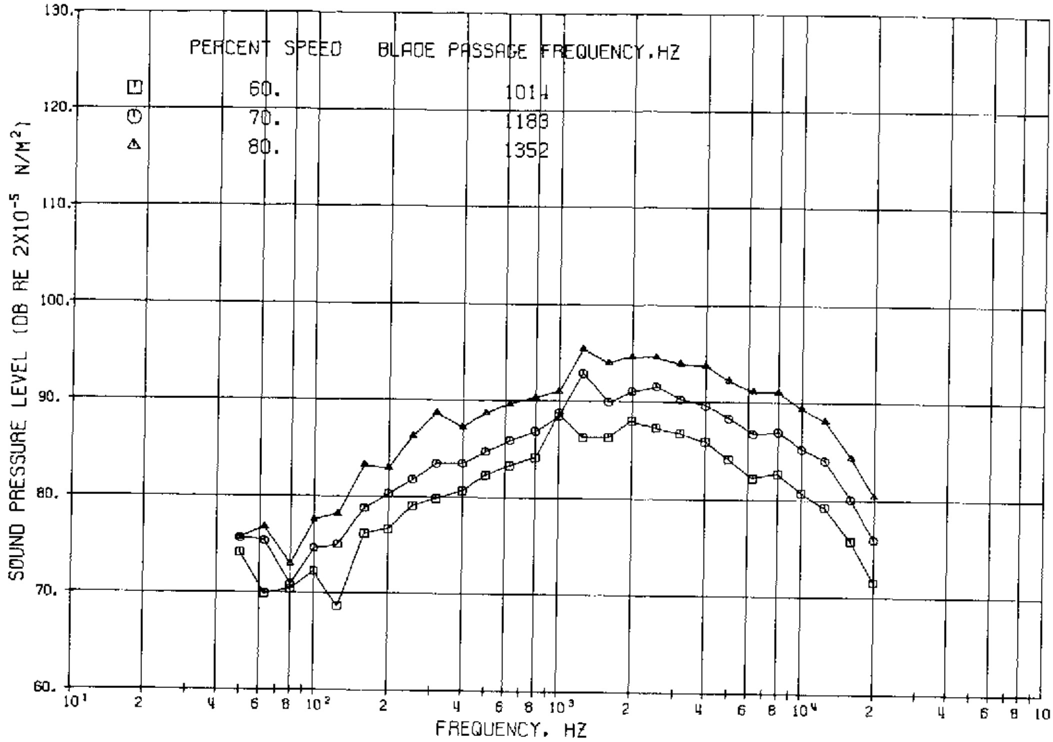


(o) 150°.

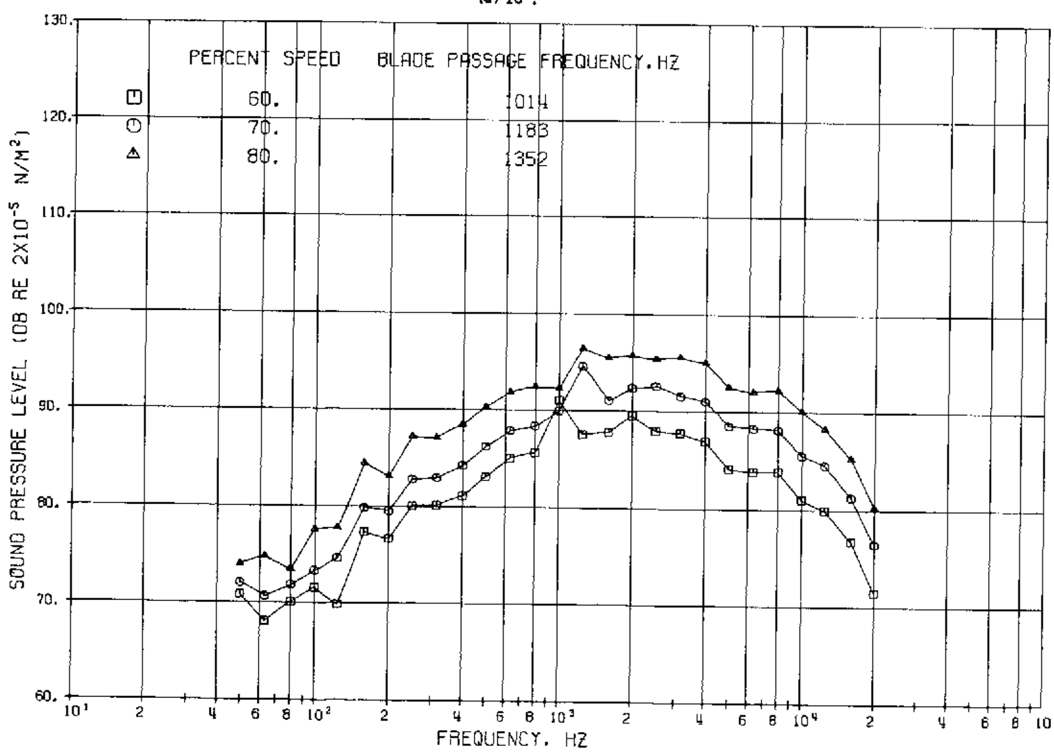


(p) 160°.

Figure 44. - Concluded.

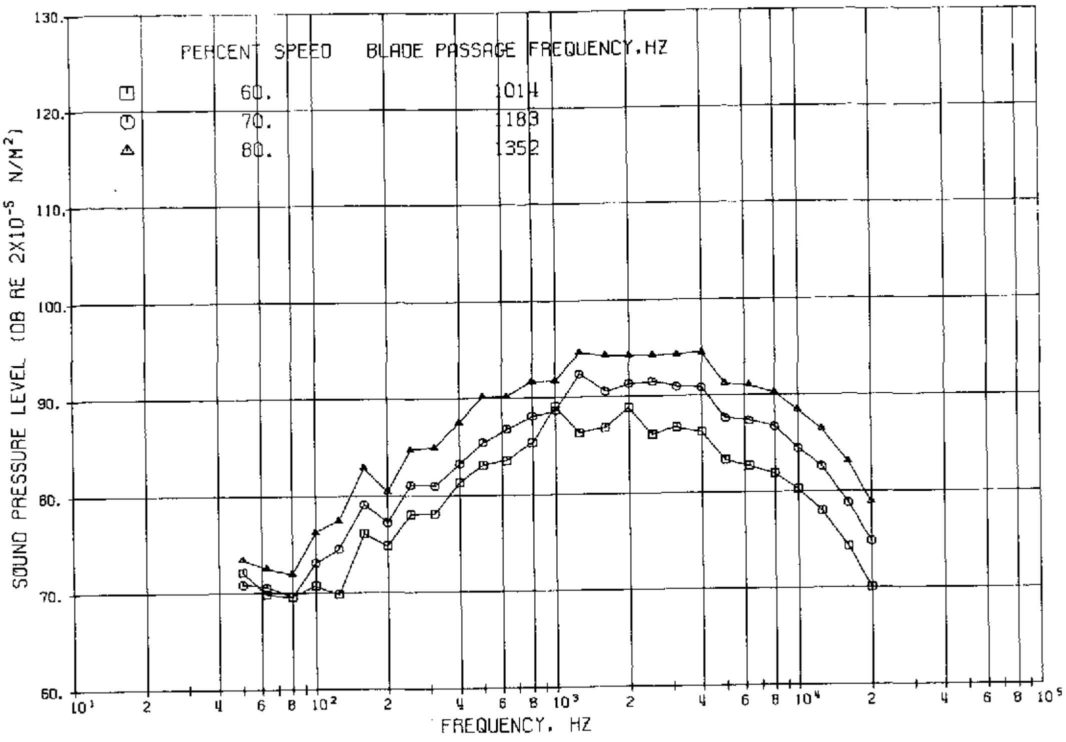


(a) 10°.

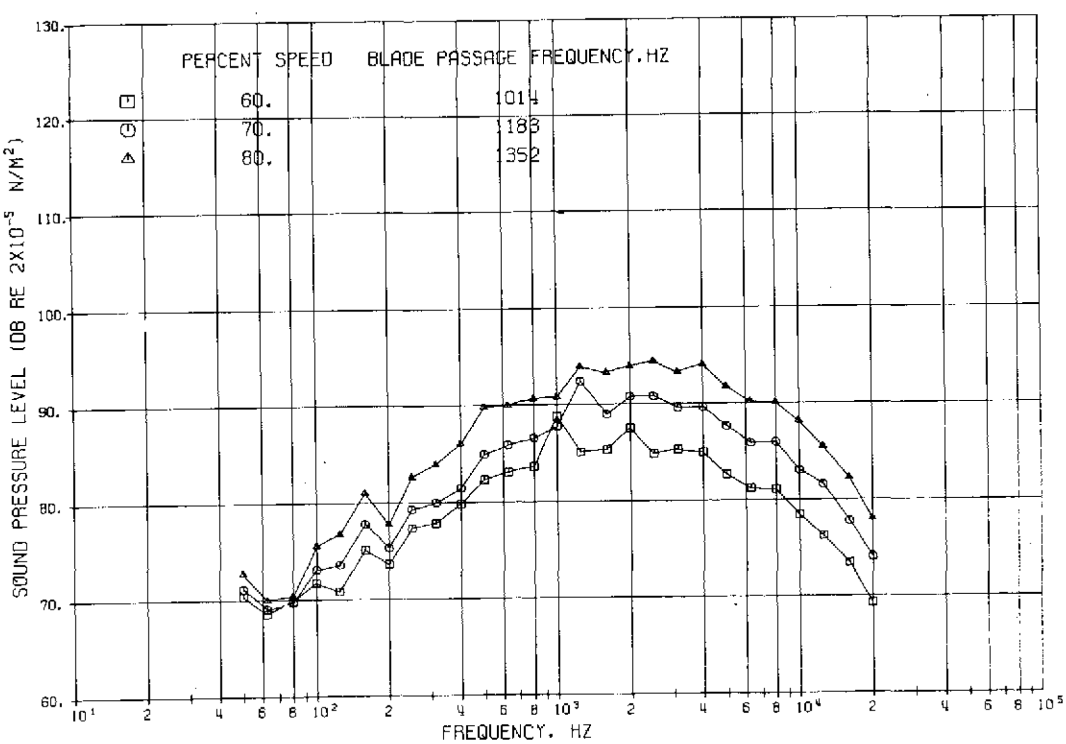


(b) 20°.

Figure 45. - 1/3-Octave-band spectra on 30.5-meter (100-ft) radius for 90 percent of design nozzle area - at various angular positions from inlet.

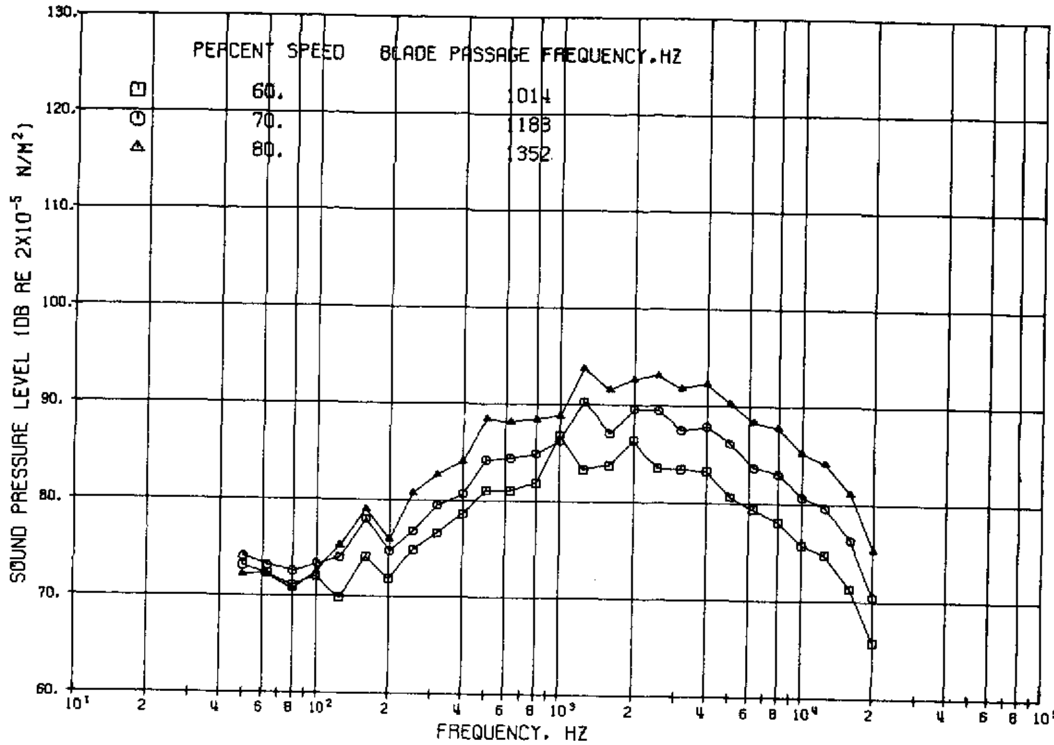


(c) 30°.

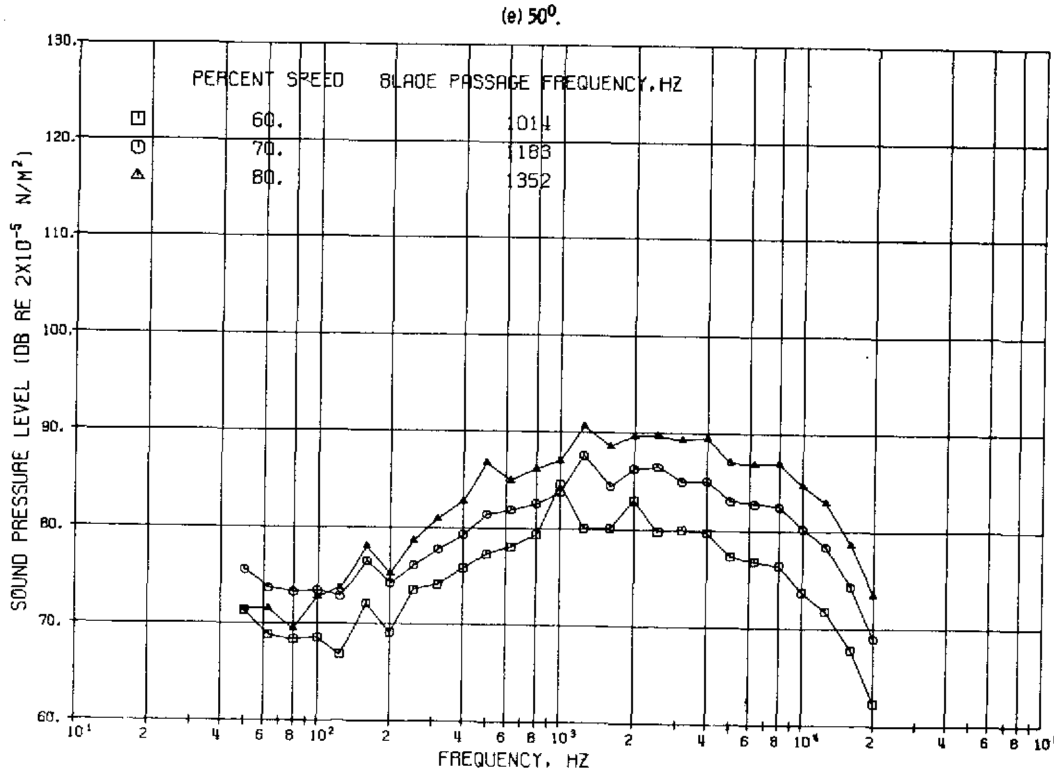


(d) 40°.

Figure 45. - Continued.

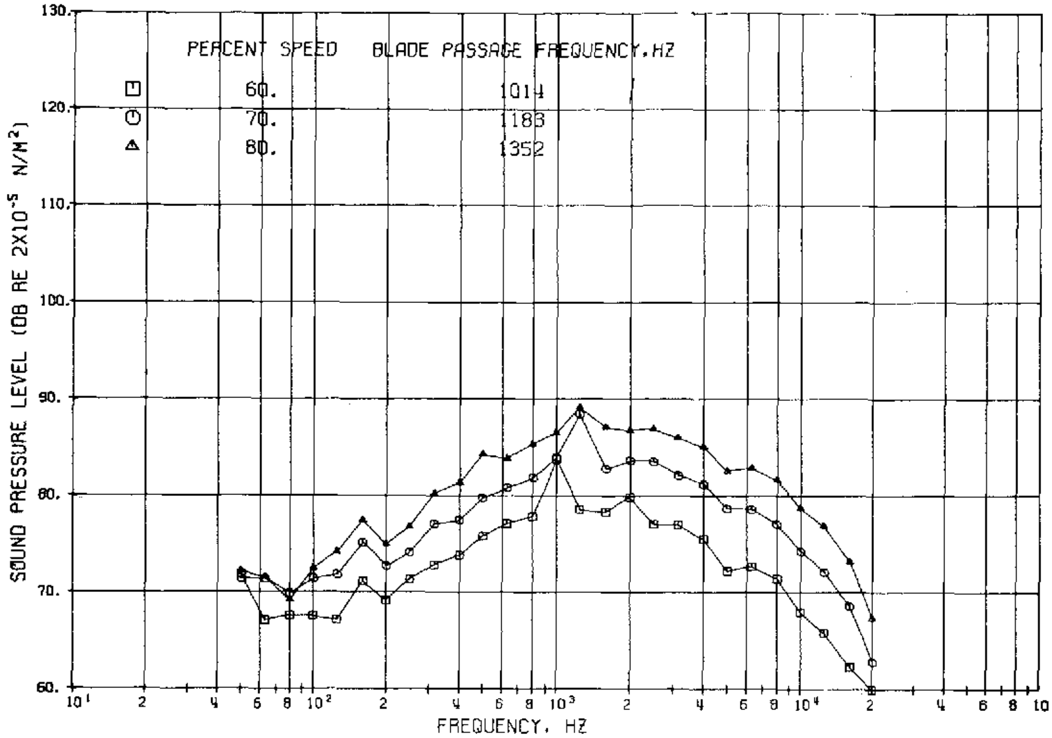


(e) 50°.

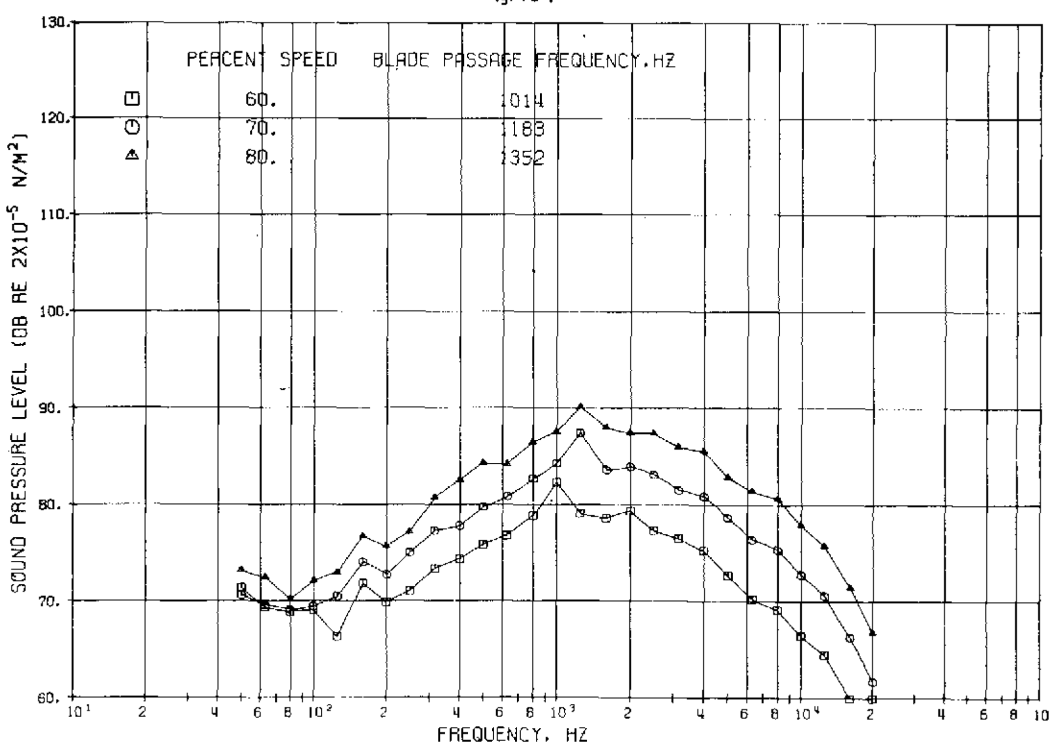


(f) 60°.

Figure 45. - Continued.

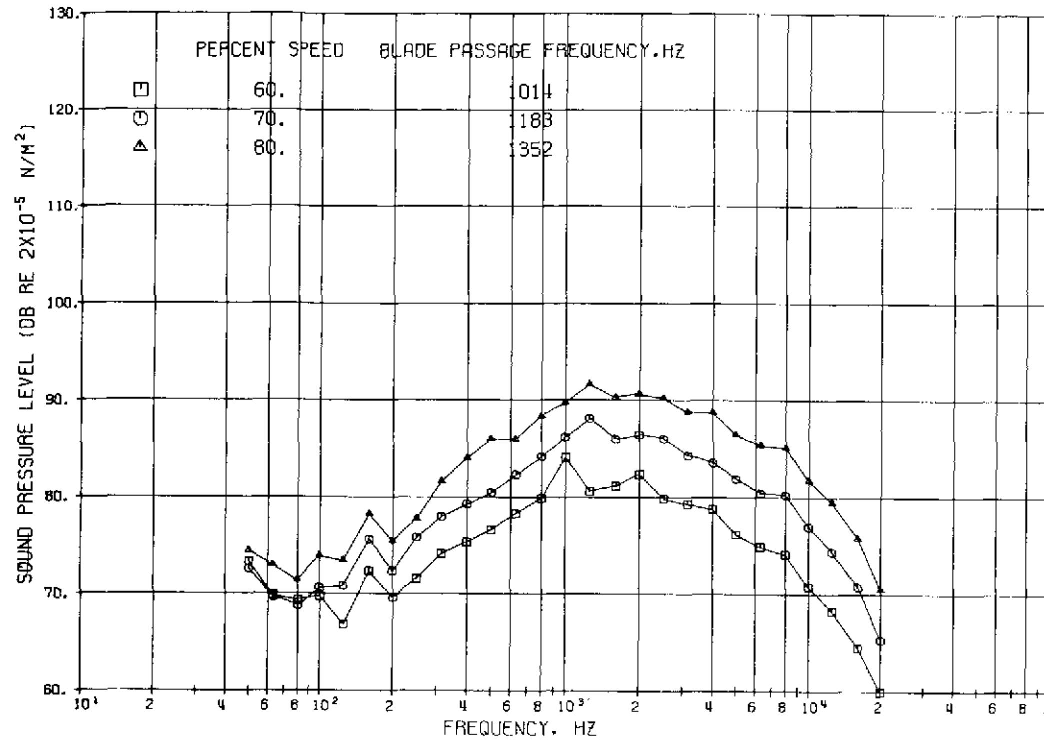


(g) 70°.

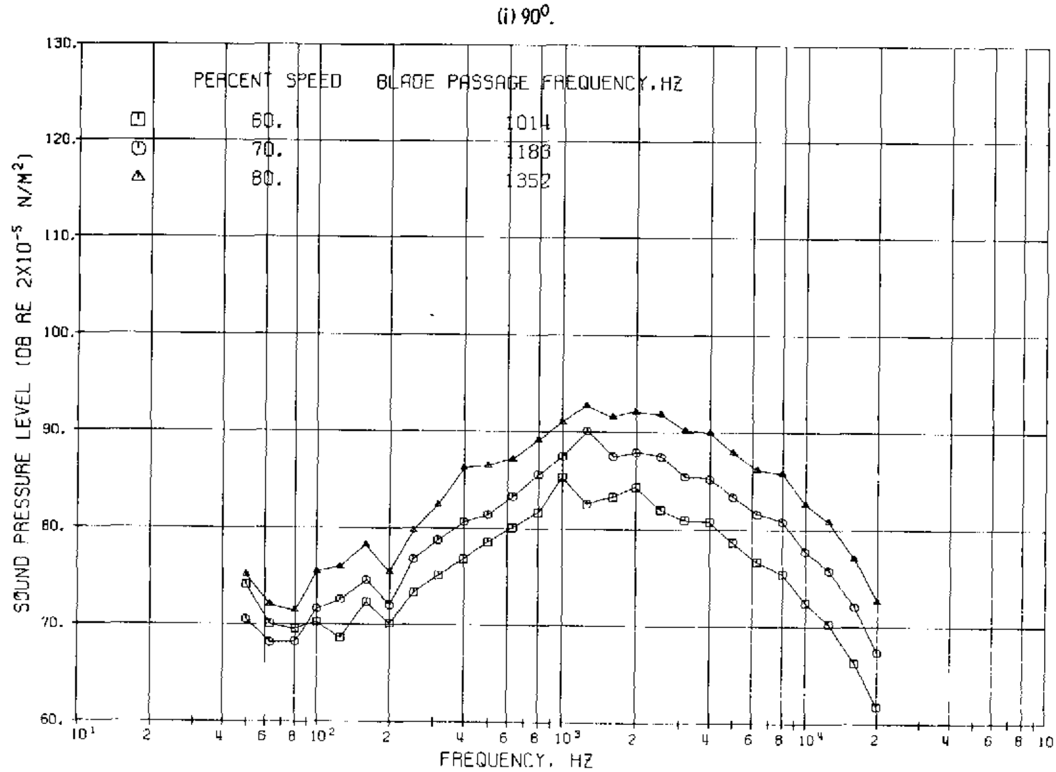


(h) 80°.

Figure 45. - Continued.

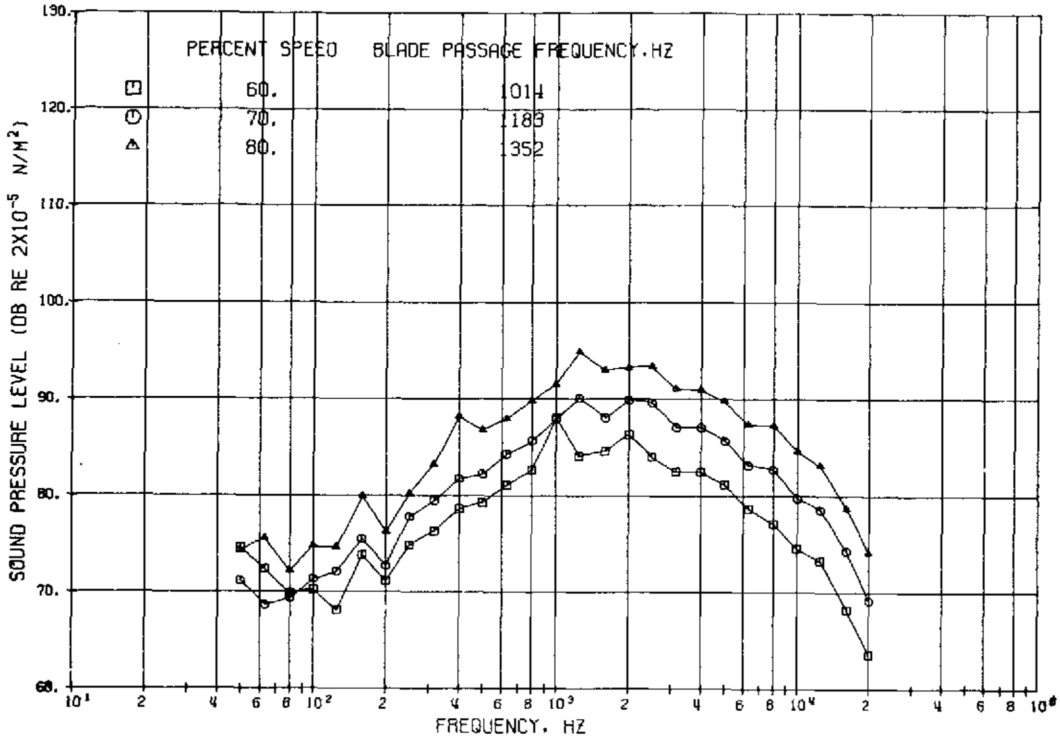


(i) 90°.

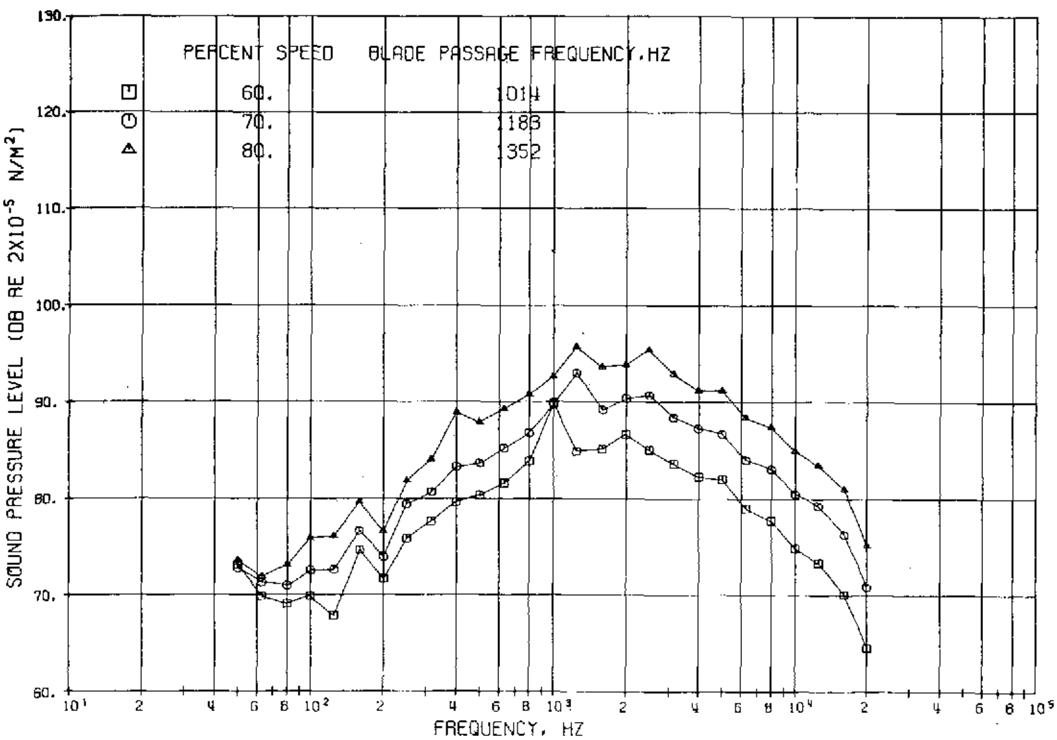


(j) 100°.

Figure 45. - Continued.

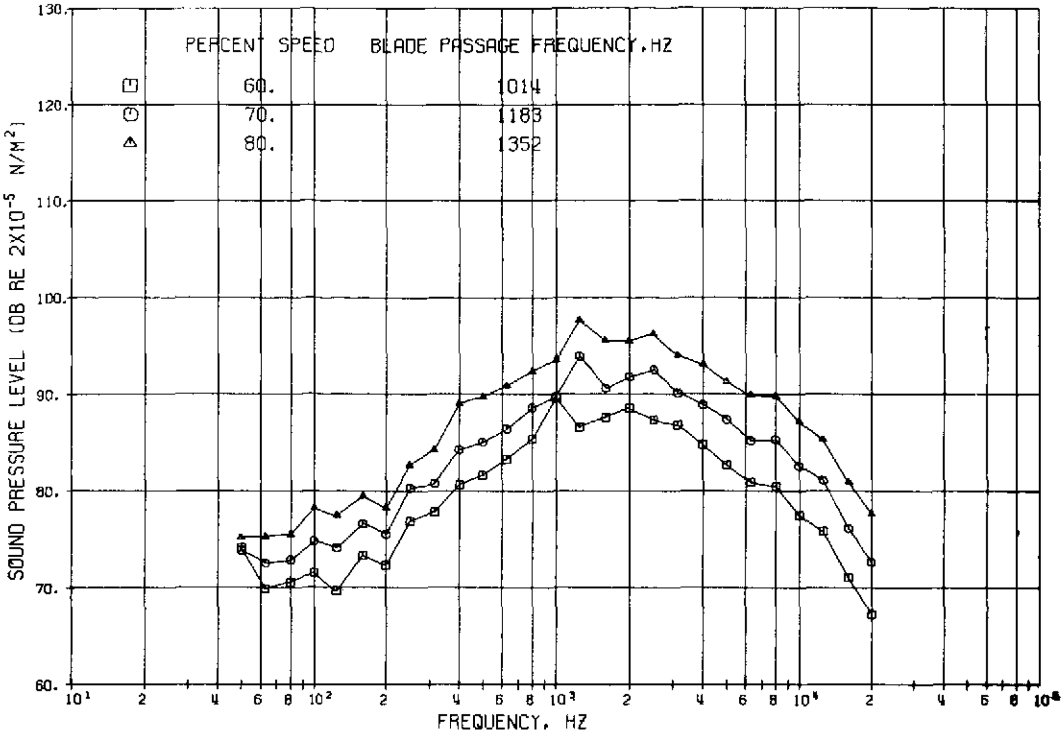


(k) 110°.

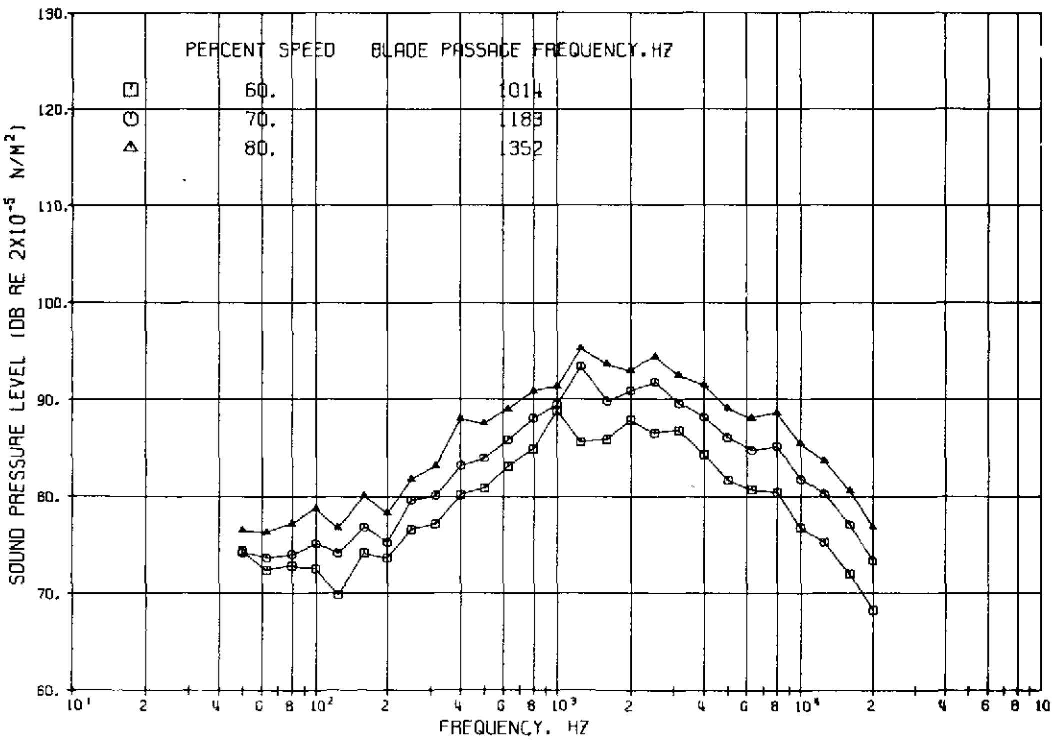


(l) 120°.

Figure 45. - Continued.

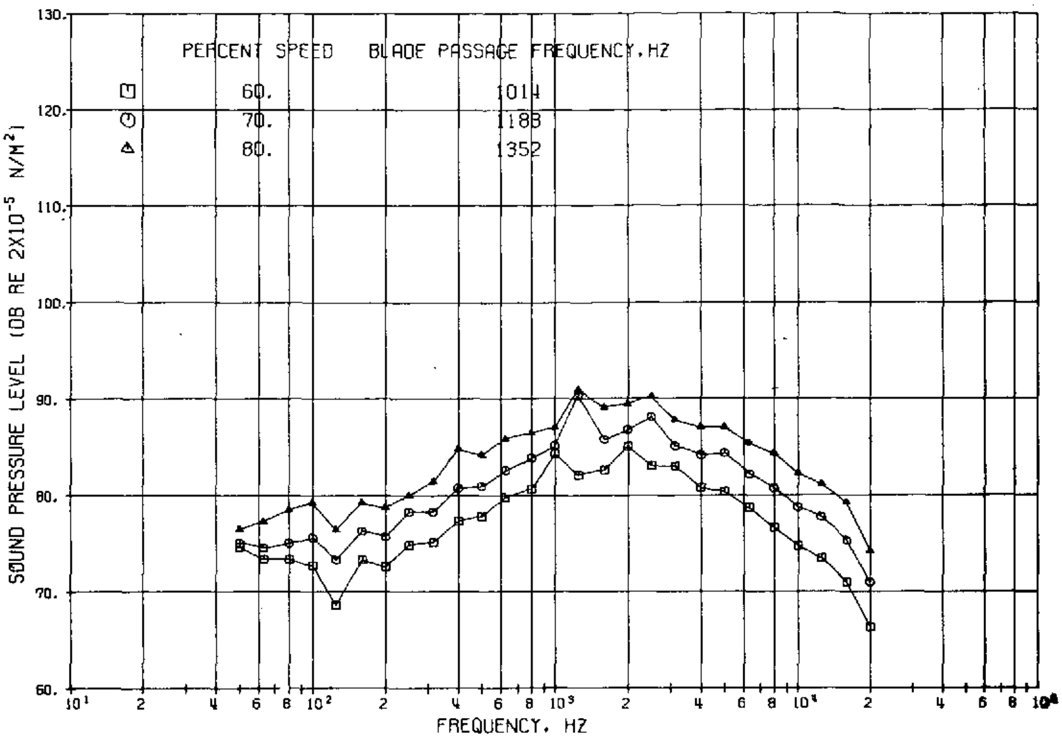


(m) 130°.

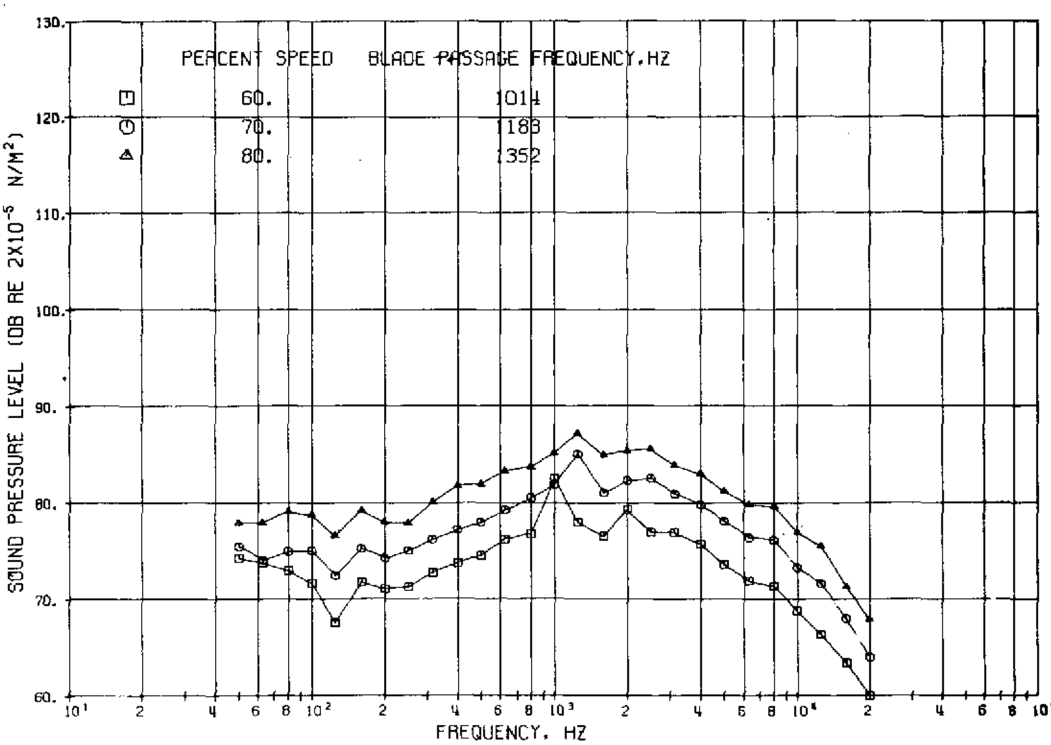


(n) 140°.

Figure 45. - Continued.



(o) 150°.



(p) 160°.

Figure 45. - Concluded.