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INLET NOISE SUPPRESSOR PERFORMANCE WITH A TURBOJET ENGINE AS THE NOISE SOURCE

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16. Abstract

Inlet noise suppressors having a perforated plate over honeycomb wall construction were evaluated over a range of passage heights and engine speeds using a turbojet engine as a noise source. Measured sound power attenuation spectra were compared to values predicted by a combination duct propagation and wall impedance model. Noise floors existing in the experiment limited the maximum measurable attenuations to about 20 dB. The model predicted the frequencies at which peak attenuation occurs and the trends in attenuation magnitude within the limits imposed on the data by the noise floors. However, the measured attenuation bandwidths were usually substantially greater than predicted.

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INLET NOISE SUPPRESSOR PERFORMANCE WITH A TURBOJET ENGINE AS THE NOISE SOURCE

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SUMMARY

The performance of a cylindrical and various annular inlet noise suppressors was measured using a turbojet engine as the noise source. Sound power attenuation spectra were obtained by an insertion loss technique using far-field measurements. Noise from each treated inlet was compared to noise from an identical hard-walled inlet. The main geometric parameter studied was the distance between treated surfaces while the "soft" wall construction consisting of perforated plate over honeycomb was held constant throughout.

A noise floor, of undetermined origin at about 80 decibels, limited the maximum observable sound power attenuation to approximately 20 decibels at 50-percent engine speed. The floor increased with engine speed due to forward-radiated jet noise progressively decreasing the measurement range. Addition of a hard splitter in the inlet increased the noise in the spectral range from 3150 to 4000 hertz, showing that a reference hard geometry identical to the suppressed case must be used if the effects of overall inlet geometry are to be separated from the action of the soft walls.

Measured attenuations were compared to values calculated using a combination duct propagation and wall impedance model. Predicted frequencies at which peak attenuation occurs agreed well with measured peak frequencies except at the highest engine speeds, where noise floors made experimental peak determination unreliable. Trends in predicted attenuation magnitudes were followed up to the limits set by noise floors, but predicted bandwidths were in general narrower than the bandwidths of the measured spectra which showed 3 to 5 decibels attenuation persisting at both high and low frequencies.

INTRODUCTION

Noise suppressors in the form of sound-attenuating inlet and exhaust passages hold considerable promise as devices to reduce internally generated noise radiated from turbofan engines. Reductions in perceived noise levels of 10 to 15 perceived noise decibels (PNdB) have been demonstrated in flight tests on low-bypass-ratio engines (ref. 1) and in ground tests of a 182.9-centimeter (72-in.) diameter fan of a type to be used in high-bypass-ratio engines (ref. 2).

The present investigation was conducted as part of a program to develop methods of predicting noise suppressor performance. In particular, the performance of inlet suppressors having various distances between treated surfaces was measured and compared to predicted attenuation spectra. Effective distances between treated surfaces varied from 8.38 centimeters (3.30 in.) to 75.9 centimeters (29.9 in.) while lined length was constant at 76.2 centimeters (30 in.). The noise source was a turbojet engine. Helmholtz resonator arrays consisting of perforated plate backed by a honeycomb cell structure formed the acoustically "soft" suppressor walls. The wall geometric parameters were not chosen to optimize attenuation from the standpoint of reducing overall perceived noise. Rather, the study concentrated on passage geometry variations with a fixed wall construction.

Noise attenuation spectra were measured by an insertion loss technique. Far-field noise measurements were obtained for identical inlet geometries with the exception of whether the walls were "hard" or "soft." By this method effects on noise of hard-wall inlet geometry could be isolated from soft-wall effects. Some noise measurements were also made inside the engine inlet between the inlet guide vanes and the acoustically treated section.

SYMBOLS

b	depth of resonator cavities, cm (in.)
c	speed of sound, m/sec (ft/sec)
D_e	distance between treated surfaces in a duct which is symmetrical about its centerline, cm (in.)
d	hole diameter in perforated plate, cm (in.)
f	frequency
M	average steady-flow Mach number

ΔPWL	sound power attenuation, dB
ΔPWL_{peak}	peak sound power attenuation, dB
p	static pressure, N/m^2 (psia or $dynes/cm^2$)
S/A	ratio of acoustically treated surfact area to duct flow cross-sectional area
T	static temperature, ^oC (^oF)
t	thickness of perforated plate, cm (in.)
θ	specific acoustic resistance
σ	open-area ratio of perforated plate
χ	specific acoustic reactance

MEASUREMENTS OF SUPPRESSOR PERFORMANCE

Suppressor Geometry

The inlet suppressor geometries evaluated were of three basic types: a cylinder consisting of the engine inlet cowl, an annulus formed by extension of the inlet centerbody, and two annuli formed by the addition of a concentric splitter. Figure 1 shows a sectional view through the axis of the engine inlet and gives the dimensions of the various suppressor elements. The length of each of the four lined surfaces was 76.2 centimeters (30 in.). Acoustic treatment on all surfaces was identical and consisted of 8-percent-open-area perforated plate 0.051-centimeter (0.020-in.) thick having 0.127-centimeter (0.050-in.) diameter holes. This plate was bonded to a cell structure which formed cavities 2.54-centimeter (1-in.) deep and had a maximum lateral cavity dimension of 0.952 centimeter (3/8 in.).

The various combinations of treated and untreated surfaces used are summarized in table I. Surfaces are numbered from inside to outside to correspond with figure 1. The condition of each surface is specified by either an "H" to indicate a hard or untreated wall, an "S" to indicate a soft or treated wall, or a "-" to indicate that the element was omitted from the assembly. For example, H- -S refers to the annular inlet with a hard centerbody and soft cowl, and the corresponding hard reference configuration is H- -H. This type of nomenclature is used throughout the report.

Noise Source

A J-65 turbojet engine was used as the noise source and is shown in figure 2. The engine was operated over a speed range of 50 to 100 percent of rated rpm which is 8330. Since this engine has a 13-stage compressor, the noise spectrum at lower engine speeds contains several discrete frequency spikes corresponding to the blade passage frequencies and harmonics of the first few stages. At higher speeds the spectrum is dominated by the first-stage blade passage frequency and its harmonics and, thus, is very similar to a single-stage fan spectrum.

Measurement Methods

Suppressor performance is described by sound power attenuation spectra obtained from far-field measurements on homologous hard and soft inlets. As can be seen in table I, each geometry group contains a completely hard configuration which served as the unlined reference for that group. This procedure eliminates any effects of gross hard-wall geometry changes (e.g., addition of a hard splitter) on the measured performance of a particular suppressor.

Far-field sound pressure levels were measured by ten 1.27-centimeter (1/2-in.) diameter condenser microphones located on a 7.62-meter (25-ft) radius at 10° increments in the inlet quadrant, as shown in figure 3. The microphones were in a horizontal plane through the engine centerline located at a height of 110.5 centimeters (43.5 in.) above the asphalt surface of the test area. A 1/3-octave analysis was performed on at least three samples from each microphone output with an averaging time of approximately 1.5 second per sample. The far-field spectra were numerically integrated over the inlet hemisphere to obtain inlet power spectra. Taking differences between power spectra from any two configurations gave the spectral sound power attenuation.

The presence of the hard reflecting ground plane modifies the measured spectra by interference between direct and reflected signals. For the source and microphone heights of 110.5 centimeters (43.5 in.) and the separation distance of 7.62 meters (25 ft), the first dip in the spectrum due to destructive interference is expected at about 550 hertz. Some of the data show a dip in this region, but no correction was applied because of the uncertainty of determining its magnitude.

The maximum inlet attenuations which can be measured depend on the degree to which noise radiated from sources other than the inlet can be eliminated from the forward measuring quadrant. In an effort to reduce forward-radiated exhaust noise, a 7.62-meter (25-ft) long exhaust collector was used, as shown in figures 2 and 3. The effects of the collector on the 1/3-octave sound pressure level (SPL) spectra at 90° are shown in figure 4 for the two extremes in engine speed. Two effects combine to reduce the SPL at 90° when the collector is present. The increase in distance from the exhaust plane to the 90° microphone corresponds to a decrease in SPL of about 4 decibels. This is roughly the change observed at 50-percent speed (see fig. 4). At 100-percent speed the reductions produced by the collector were greater (7 to 12 dB in the frequency range 1000 to 3150 Hz) indicating that exhaust noise directivity was a factor.

It is expected that exhaust noise will be dominated by jet noise at lower frequencies and will contain some higher frequency discrete tones corresponding to the turbine blade passage frequencies. These frequencies for the two-stage turbine are 7636 and 5206 hertz at 50-percent speed and 15 272 and 10 412 hertz at 100-percent speed. Figure 4 shows that the collector reduced the sound levels across the entire spectrum including the 1/3-octave bands containing first-stage compressor blade passage frequencies (2568 Hz at 50-percent speed and 5137 Hz at 100-percent speed). Since compressor tones are not expected to be strong in the exhaust, it is possible that the contents of the 2500-hertz band at 50-percent speed and the 5000-hertz band at 100-percent speed are controlled by difference tones between the two turbine stages (2430 Hz at 50-percent speed and 4860 Hz at 100-percent speed).

While the levels at 90° are indicators of the collector effectiveness in decreasing exhaust noise, the power spectra in the forward hemisphere are the fundamental data used to determine suppressor performance. Power spectra for the same configurations and speeds as figure 4 are shown in figure 5. At 50-percent speed, the power spectrum was essentially unchanged by the exhaust collector. Therefore, the power is controlled by sources other than the exhaust jet or turbine discrete tones. At 100-percent speed, power at the higher frequencies is also insensitive to the presence of the collector, indicating dominance by discrete tones radiated from the inlet. But, at frequencies less than 4000 hertz, the collector produced significant reductions associated with decreases in forward-radiated jet noise which was important at all angles in the inlet quadrant.

In addition to the far-field array, 1.27-centimeter (1/2-in.) condenser microphones were also located flush on the inlet wall and in a radially traversing probe as shown in figure 1. The probe microphone was mounted inside a truncated cone which was pointed downstream. Its purpose was to provide a comparison of the signal characteristics at one radial position relative to another.

ATTENUATION PREDICTIONS

The theory used to calculate sound power attenuation is described in references 3 and 4 and applied to fan data in reference 2. There are two main parts: a propagation analysis for waves in a soft-walled duct and a semiempirical impedance model for specifying the wall boundary conditions. The propagation analysis assumes that there is a uniform steady flow across the duct and that the initial condition at the duct entrance is a plane pressure wave. A rectangular duct analysis was used to approximate the propagation in the annular geometries. Nonlinear behavior of resistance based on orifice velocity and effects of mean flow are included in the impedance model (refs. 2 and 5).

Input parameters to the analysis include the passage geometry, Mach number, and gas properties in the duct. The overall sound pressure level in the duct is also required as the amplitude specification in the impedance model. Table II summarizes the engine conditions and aerodynamic parameters associated with the soft-wall configurations reported herein. The overall sound pressure levels in the inlet were calculated from overall sound power levels obtained from the far-field measurements and the inlet cross-sectional areas. The levels corresponding to the hard reference configurations (i.e., the levels experienced by the liner at the end nearest the source) are tabulated in table II. Values obtained from the flush microphone showed a maximum deviation of 3 decibels from the calculated overall sound pressure levels (OASPL).

Calculated attenuation spectra for the five soft-wall configurations at 50-percent engine speed are shown in figure 6. The attenuation values ΔPWL are divided by the ratio of lined surface area to flow passage cross-sectional area S/A. The passage dimension D_e is the equivalent distance between treated surfaces for a lined duct which is symmetrical about the passage centerline. Effective passage heights D_e and area ratios S/A are listed in table II. The locus of maximum possible attenuations for $S/A = 4$ as calculated in reference 3 is included in figure 6. Multiple attenuation peaks of lower magnitude which occur at higher frequencies for each configuration are not shown. A secondary peak occurring on the high-frequency side of the H- -S and ---S spectra results from a shift in acoustic mode content required to satisfy the plane-wave entrance condition as fD_e/C increases.

Typical characteristics of the calculated wall resistance and reactance are shown in figure 7. The resistance varies with frequency because the model assumes that it depends on the component of orifice velocity at each frequency, and each velocity component is partially determined by the overall sound pressure level specified. On the other hand, if the resistance were assumed to depend on root-mean-square orifice velocity produced by the simultaneous action of pressure components at all frequencies, resistance would remain nearly constant independent of frequency. Large excursions in resistance and reactance occur in the vicinity of frequencies where the backing cavity depth b is equal to multiples of half wavelengths. For the case shown in figure 7, the 2.54-centimeter (1-in.) cavity depth is equal to $\lambda/2$, λ, and $(3/2)\lambda$ at frequencies of 6573, 13 147, and 19 720 hertz, respectively. The infinities in calculated reactance at these frequencies are removed in the actual situation by distributed resistance in the cavities, which is not taken into account in the model. Also noted in figure 7 is the calculated frequency of peak attenuation for the annular S- -S configuration. The frequency of peak damping at 1250 hertz lies below the resonant frequency ($\chi = 0$ at 2140 Hz), and this characteristic is a typical result of the duct propagation analysis.

RESULTS AND DISCUSSION

One-third octave sound pressure level data for the conditions listed in table II are tabulated in the appendix. The hard-wall reference data are also included. In the following sections, some hard-wall results are discussed first, followed by the dependence of suppressor performance on passage height and engine speed.

Hard Wall

The possibility that the hard centerbody or splitter may affect the inlet noise was investigated by comparing the power spectra for the three hard configurations. Only at 90- and 100-percent engine speeds were any significant differences noted and those were associated with the splitter. Figure 8 illustrates the behavior at 100-percent speed. Addition of the splitter increases the low-frequency noise about 3 decibels; but, more significantly, noise in the range 3150 to 4000 hertz is as much as 8 decibels higher. This result shows that hard-wall geometry alone can affect radiated noise. If effects of soft walls are to be isolated under such conditions, the reference hard-passage geometry must be identical to the suppressed case.

Radial surveys with the probe, in general, showed less than 5-decibel variations in overall sound pressure levels at any engine speed and inlet geometry. However, some differences in spectral content were found, namely, a variation in the strength of multiple pure tones with radius. Figure 9 shows two 50-hertz bandwidth spectra at 100-percent speed for the hard cylindrical inlet ---H. Multiple pure tones at multiples of shaft rotation frequency (139 Hz) are very strong 2.54 centimeters (1 in.) from the cowl (fig. 9(a)), while only a few remain at 18.5 centimeters (7.3 in.) from the engine axis (fig. 9(b)).

Attenuation Dependence on Passage Height

Measured and calculated sound power attenuation spectra are given in figures 10(a) to (e) for 50-percent engine speed and five effective passage heights corresponding to the soft configurations of table I. In this series, the ratio of treated area to flow cross-sectional area S/A progressively increases and effective passage height decreases. Although measured values of a fraction of a decibel are not significant, the ordinates include the decade from 0.1 to 1.0 decibel to show the high-frequency attenuation peaks predicted by the theory. Comparisons between the predicted and measured attenuations may be divided into magnitude, tuning, and bandwidth considerations.

Increased S/A and decreased passage height are both variations which lead to increased predicted attenuations, as indicated in figure 6. The data of figures 10(a) to (e) roughly follow this predicted trend at lower S/A values, but predicted attenuations are much higher than measured for larger S/A configurations. Note in particular in figure 10(e) the roughly constant attenuations observed in the 1250- to 2500-hertz range for the fully lined concentric annuli, SSSS.

The attenuation magnitude characteristics displayed in figures 10(a) to (e) are summarized in figure 11(a) and (b). Figure 11(a), where peak attenuations are plotted against S/A, shows the divergence between theory and experiment as S/A is increased. Maximum attenuations of approximately 20 decibels are observed. Another measure of attenuation magnitude is the ΔPWL at an attenuation bandwidth of 1 octave, as shown in figure 11(b). The divergence between theory and experiment with increasing S/A is again evident, with the maximum measured value being about 18 decibels.

This property of the data, where increasing amounts of treatment on walls in closer proximity produce no increase in measured damping, points toward the existence of a noise floor in the experiment. A similar situation was observed in suppressor tests on a full-scale fan (ref. 2). Although figure 5 showed that the hard-walled power spectrum at 50-percent speed was not controlled by exhaust noise, it gave no information about the levels where noise from sources other than the inlet become dominant. Minimum sound pressure levels reached with the treated annulus, S- -S, at 50-percent speed are shown in figure 12 where angular variations are also shown for the hard-wall reference, H- -H. The levels are for the 1250-hertz, 1/3-octave band which corresponds to the frequency range of peak attenuation. Minimum decibel levels in the low 80's are nearly constant over the range of angles to 80°. At 90°, the fact that the lined inlet was about 2 decibels noisier than the hard inlet is best interpreted as the uncertainty in determining absolute levels for the two data sets. The origin of the floor at roughly 80 decibels for the 1250 hertz band is unknown. It is definitely above background levels for the site when the engine is not in operation. The behavior of the noise floor at frequencies where maximum damping was observed for the HSSH and SSSS configurations was very similar to the S- -S case shown in figure 12.

One criterion of ability to predict tuning is to compare the predicted frequency at peak attenuation with measured values. The results for the data of figures 10(a) to (e) are plotted in figure 13. With the exception of the ---S configuration (S/A = 4.01), the agreement between theoretical and experimental peak frequencies is good.

Prediction of the shape or bandwidth of the attenuation spectra is much less satisfactory. In general, the measured spectra are much broader than predicted except for the H- -S configuration. In addition to the main peak between 1 and 2 kilohertz (figs. 10(a) to (e)), additional peaks are predicted at the higher frequencies. These auxiliary peaks are related to the excursions of resistance and reactance which occur at successive cavity resonances (e.g., fig. 7). With the exception of the SSSS configuration (fig. 10(e)), the calculated magnitudes are much below the measurements, but the frequencies of the second peak are fairly well predicted (figs. 10(c) to (e)). Since the experimental values are for 1/3-octave bands, the spectral detail becomes progressively poorer at high frequencies and the correspondence between calculated and measured peaks is blurred.

Measured attenuations which are several decibels above the calculated values at both high and low frequencies echo the findings of reference 2. This effect is summarized for the 50-percent-speed data in figure 14, where the bandwidth (in octaves) at $\Delta PWL = 3$ decibels for the main attenuation peak is plotted against S/A. While the operation of locating the 3-decibel points on the measured attenuations is subject to uncertainties, particularly for the HSSH configuration, the overall trend in figure 14 is clear. Predicted bandwidths increase from 1 to about 3 octaves, but the measured bandwidths are wider and are roughly constant at 4 octaves with the exception of the H- -S configuration at $S/A = 4.88$.

At present, no satisfactory modifications of the attenuation analysis which will predict this broadband behavior have been found. Changes in the impedance model, such as using a nearly constant resistance determined from root-mean-square orifice velocity or a smoothing of the reactance at high frequencies to account for distributed resistance in the cavities, have been explored. Initial results show that such modifications of the impedance model do lower predicted peak attenuations and raise predicted attenuations at the frequency extremes but the changes are not of the magnitude required to bring about agreement with the measurements. While impedance modeling deserves further work, the assumptions invoked in the propagation analysis also need reexamination.

Attenuation Dependence on Engine Speed

The important parameters in the inlet which depend on engine speed and can affect suppressor performance are gas properties, Mach number, and noise spectrum. Table II shows that the significant parameter change with speed for the S- -S configuration is the Mach number. The spectrum changes are indicated by the variation of the first-stage blade passage frequency, but overall sound pressure level remains nearly constant. Figures 15(a) to (e) show the measured and calculated attenuation spectra at

10-percent speed increments from 60 to 100 percent. Figure 10(c) at 50-percent speed completes the data for the full speed range with the S- -S configuration.

The predicted and measured values at the main attenuation peak diverge as speed is increased, as shown in the figure 15 series. Figures 16(a) and (b) summarize these trends in attenuation magnitudes. Measured peak attenuations in figure 16(a) are approximately constant at 20 decibels at less than 70-percent speed but decrease at higher speeds. On the other hand, predicted values are all greater than 30 decibels. In figure 16(b), where attenuations at 1 octave bandwidth are plotted, theory and experiment agree at lower speeds but diverge at higher speeds. No experimental points are plotted at 90- and 100-percent speed because the first attenuation peak at 1 octave bandwidth is poorly defined at these two speeds.

The disparity between measurements and predictions as speed increases suggests the presence of a noise floor set by a source other than the inlet whose level rises with speed. Such a source is the jet noise component of exhaust noise, which increases in level and shifts to higher frequencies as speed increases. As discussed in connection with the effects of the exhaust collector, jet noise was an important contributor to the noise in the inlet quadrant at 100-percent speed. While the collector substantially reduced the jet noise in the 1- to 2-kilohertz range where peak attenuations occur, the reduction proved to be insufficient to provide a measurement range comparable to the 20 decibels realized at 50-percent speed.

Figure 17 shows the angular variation of sound pressure levels in the 1250-hertz band for the hard and soft annular inlets at three engine speeds. At 60-percent speed the minimum SPL's were in the low 80's and were nearly independent of angle, as was found for the 50-percent-speed case shown in figure 12. At 80- and 100-percent speed, the hard-wall reference levels decrease at forward angles, indicating that lower broadband levels occur at 1250 hertz as the inlet noise spectrum becomes dominated by the spike at first-stage compressor blade passage frequency. However, at 100-percent speed, hard-wall levels at the rearward angles do not drop off, suggesting that jet noise may be influential. That this is the case is borne out by the directionality of the sound field for the soft inlet at 80- and 100-percent speed. Levels remain nearly independent of speed at 0° and 10°, but increase at higher angles which are most susceptible to jet noise influence. Thus the difference in SPL values between H- -H and S- -S configurations decrease with increasing speed, accounting for the behavior of the sound power attenuations.

The theory predicts that the frequency at maximum damping remains nearly constant with variations in speed for the S- -S configuration. Up to 80-percent speed, the measured peak frequency agrees; but at 80 percent and beyond, the measured peak in the 1- to 2-kilohertz range shifts and becomes poorly defined (see fig. 15(e)). This is a consequence of the speed-dependent noise floor.

Measured bandwidths of attenuation are, in general, greater than calculated values. This is most clearly shown at speeds less than 80 percent, where the situation is much the same as was described for all the configurations at 50-percent speed. At the higher speeds, the shapes of the measured attenuation spectra are strongly influenced by the exhaust noise at frequencies less than a few thousand hertz. This situation obscures any comparisons between theory and experiment.

CONCLUDING REMARKS

The limitations on the measurement range such as those existing in this experiment represent one of the major problems encountered in insertion loss methods of measuring noise suppressor performance. Extraneous sources and transmission paths set minimum sound pressure levels in the far field, and these unwanted contributors are often difficult to identify and suppress. Moreover, their existence and character may become evident only after heavily suppressing the source of interest; that is, in retrospect, as was the case reported herein. An iterative process of source identification and suppression is required to improve the situation and this was beyond the scope of the present investigation.

SUMMARY OF RESULTS

Inlet noise suppressors having a perforated plate over honeycomb construction were evaluated over a range of passage heights and engine speeds using a turbojet engine as a noise source. The measured sound power attenuation spectra were compared to the values predicted by a combination duct-propagation and wall-impedance model. The results and conclusions are as follows:

1. Predicted frequencies at which peak attenuation occurs agreed well with measurements, except at the highest engine speeds.

2. A noise floor, of unknown origin, limited the maximum observable sound power attenuations to approximately 20 decibels at 50-percent engine speed. The floor increased with speed because of forward-radiated exhaust noise, and the measurement range was progressively reduced. Trends in attenuation magnitude predicted for changing passage height were followed up to the limits set by noise floors.

3. Measured attenuation spectra were, in general, broader than predicted, with values of 3 to 5 decibels persisting at both high and low frequencies.

4. The addition of a hard splitter in the inlet produced increased noise at 90- and 100-percent engine speed, particularly in the spectral range 3150 to 4000 hertz. This

result emphasizes the importance of establishing a reference hard-passage geometry which is identical to the suppressed case if the effects of soft walls are to be isolated.

5. Radial probe measurements in the inlet showed that overall sound pressure levels varied less than 5 decibels along the radius, but the amplitude of multiple pure tones increased from a minimum near the center to a maximum near the wall.

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APPENDIX - SOUND PRESSURE LEVEL DATA

One-third octave sound pressure level data in the forward quadrant are presented for the turbojet engine at several engine speeds with various inlet noise suppressor and hard-wall configurations (see tables I and II). The data in decibels referenced to 2×10^{-5} newtons per square meter (0.0002 μbar) were taken at 7.62-meter (25-ft) radius and are corrected to standard-day conditions (15° C (59° F) with 70-percent relative humidity).

---H 50-Percent Speed

	ANGLE	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		120.5	122.4	120.5	121.1	120.0	118.1	112.9	108.0	104.7	101.7
BAND	FREQUENCY										
1	50	85.8	85.5	84.8	84.0	84.3	84.3	84.5	82.5	83.3	83.0
2	63	85.5	86.0	85.0	85.5	86.8	86.8	87.0	85.5	86.3	85.5
3	80	88.3	88.3	87.8	88.0	88.5	87.0	86.8	86.5	86.0	87.5
4	100	90.5	90.3	90.3	88.5	90.3	87.8	87.8	86.3	87.0	85.5
5	125	92.0	92.0	91.5	91.8	91.0	89.8	88.8	87.5	87.3	56.8
6	160	94.8	93.5	94.0	93.0	91.5	89.8	88.8	87.3	86.0	85.5
7	200	95.3	95.3	95.3	94.5	92.0	90.0	90.5	87.8	86.8	87.3
8	250	96.5	95.8	94.8	93.8	91.5	90.3	88.3	87.0	85.5	85.3
9	315	97.0	97.0	97.5	97.0	95.8	93.3	92.0	89.8	88.8	86.8
10	400	96.3	96.3	96.3	96.0	93.8	92.0	89.0	87.8	86.0	85.0
11	500	94.3	95.3	95.0	94.5	93.0	90.5	89.0	86.8	83.8	81.5
12	630	93.5	94.5	94.8	93.8	92.0	90.0	86.8	84.3	82.3	81.8
13	800	97.3	97.8	98.8	98.3	96.5	93.3	90.8	87.8	85.8	83.5
14	1000	102.3	103.8	104.0	102.8	101.0	97.8	95.0	92.0	89.8	86.5
15	1250	105.8	106.0	106.0	104.8	103.0	100.8	97.8	94.3	91.0	87.8
16	1600	107.0	106.8	106.0	105.3	105.0	102.0	98.8	95.0	91.0	87.5
17	2000	107.0	109.0	108.0	108.8	107.3	105.0	101.0	97.0	92.3	88.8
18	2500	109.1	111.3	110.3	110.3	111.3	110.1	104.8	100.6	94.3	92.3
19	3150	113.7	115.0	114.5	114.7	114.0	112.2	106.7	101.2	96.2	92.7
20	4000	113.8	116.5	113.8	113.3	111.0	108.8	102.0	97.5	93.5	90.0
21	5000	110.2	112.2	108.9	111.2	112.2	108.9	103.7	97.2	97.4	90.4
22	6300	110.1	112.4	109.4	111.6	110.9	109.9	103.9	96.9	94.1	90.1
23	8000	110.1	112.6	107.3	110.1	105.8	104.8	99.1	92.3	90.6	89.3
24	10000	107.9	109.1	108.9	109.6	105.1	103.6	99.1	92.1	88.1	85.1

---S 50-Percent Speed

ANGLE		0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		118.2	120.6	118.7	119.2	117.3	121.5	109.5	104.9	101.5	99.6
BAND	FREQUENCY										
1	50	77.0	79.0	84.3	79.0	80.0	81.3	79.0	81.7	83.3	83.0
2	63	78.3	80.7	85.3	79.3	81.7	83.7	82.3	83.3	84.0	84.7
3	80	82.3	85.3	86.7	83.7	86.0	85.0	83.3	83.0	84.0	85.3
4	100	86.7	87.0	88.0	85.0	86.7	86.3	86.3	84.0	85.7	85.7
5	125	88.7	90.7	90.7	88.7	87.3	86.4	85.3	85.0	85.7	85.7
6	160	91.0	92.7	92.0	90.7	87.3	86.4	86.3	87.0	85.3	83.3
7	200	92.0	93.3	92.3	91.3	88.0	87.5	87.0	84.0	85.7	85.7
8	250	93.0	94.7	92.7	92.0	89.7	89.0	88.3	86.0	85.3	83.7
9	315	93.7	94.7	94.3	93.3	92.0	90.5	88.7	86.0	86.7	84.0
10	400	92.3	94.3	93.3	92.0	89.3	88.2	87.0	85.0	83.7	81.0
11	500	90.0	90.7	90.3	89.7	87.3	86.3	85.3	81.7	79.7	78.0
12	630	89.0	90.0	89.7	89.3	86.7	84.0	82.0	80.0	80.0	77.0
13	800	92.3	94.0	93.3	93.3	90.3	87.5	85.3	83.7	82.0	80.0
14	1000	96.0	96.3	96.7	96.7	95.0	93.0	90.3	87.3	85.3	83.0
15	1250	97.0	99.0	99.0	98.0	96.7	94.0	91.3	88.0	85.3	84.3
16	1600	101.0	101.3	100.3	99.7	96.3	94.0	91.0	86.7	84.7	83.0
17	2000	103.0	105.0	103.0	102.3	99.3	96.5	93.3	90.0	86.7	84.0
18	2500	107.3	108.3	108.3	107.3	104.3	100.3	96.7	94.3	90.0	90.0
19	3150	110.1	111.1	110.7	111.1	108.7	104.9	101.1	95.4	92.7	90.7
20	4000	110.7	116.7	112.4	111.1	107.1	103.9	100.7	94.7	91.1	88.7
21	5000	109.3	110.6	109.6	111.6	112.6	107.6	102.6	98.6	93.6	89.3
22	6300	107.8	108.8	108.5	109.8	110.1	106.3	102.5	97.8	91.8	88.2
23	8000	107.7	109.4	108.7	107.7	102.4	98.3	94.4	87.4	86.0	84.4
24	10000	107.5	107.5	106.5	109.2	104.5	100.9	97.5	89.8	86.2	83.5
25	12500	105.1	106.1	104.1	106.1	101.1	97.6	94.4	86.1	84.1	82.1
26	16000	103.2	104.2	101.6	104.6	98.6	95.3	91.6	84.9	81.9	78.9
27	20000	100.9	101.9	97.9	101.2	94.9	91.7	86.9	80.5	77.9	78.5

H--H 50-Percent Speed

ANGLE		0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		122.0	121.9	121.7	122.2	120.2	117.5	113.5	108.0	105.9	98.6
BAND	FREQUENCY										
1	50	85.7	86.0	83.0	83.7	83.7	86.7	85.0	83.0	83.7	80.3
2	63	86.3	86.7	84.3	86.7	85.7	88.3	88.7	88.0	86.0	81.7
3	80	87.7	87.0	88.7	90.0	88.0	87.0	87.7	86.3	87.3	83.7
4	100	90.0	90.3	91.7	91.7	89.7	90.7	89.3	88.7	87.7	82.3
5	125	92.7	92.3	92.7	91.0	90.0	90.3	88.0	88.0	88.0	83.7
6	160	93.7	93.7	93.3	93.7	94.0	91.7	89.0	88.0	87.0	82.7
7	200	95.7	95.0	94.7	94.7	94.3	90.7	90.3	88.0	88.7	84.3
8	250	96.7	95.3	95.3	95.7	95.0	93.7	91.3	90.3	89.3	83.7
9	315	97.3	98.0	98.0	98.0	96.7	94.0	92.3	90.3	89.3	83.3
10	400	96.0	97.0	97.0	96.0	95.7	92.0	90.0	89.0	87.7	82.3
11	500	93.3	94.3	95.0	95.7	94.3	91.3	89.3	87.0	85.7	79.0
12	630	94.0	94.0	95.0	94.3	92.3	90.7	86.0	83.7	83.3	78.7
13	800	98.3	98.7	99.0	98.7	97.0	93.7	90.7	88.0	86.7	30.7
14	1000	105.0	104.3	104.7	104.0	102.0	98.0	94.3	92.0	91.0	82.7
15	1250	107.0	107.0	106.0	105.0	103.7	100.7	98.0	94.3	92.3	84.0
16	1600	106.0	106.0	106.0	106.0	104.7	101.7	98.0	94.3	93.0	83.7
17	2000	109.0	108.7	109.0	108.0	107.0	105.0	101.7	96.0	93.7	85.0
18	2500	109.0	111.0	111.6	110.6	109.6	106.0	103.6	98.3	96.3	87.6
19	3150	113.7	114.7	115.7	114.4	113.4	110.4	108.4	101.4	97.4	89.4
20	4000	115.0	115.3	114.0	114.0	110.0	107.7	103.0	97.7	95.0	87.0
21	5000	110.5	110.2	111.2	112.5	112.8	109.5	103.8	98.8	96.5	88.5
22	6300	111.6	111.0	110.6	114.0	111.6	109.6	103.0	97.6	96.0	87.0
23	8000	112.8	111.1	110.1	111.1	107.1	105.1	99.1	92.8	92.4	85.4
24	10000	110.1	109.1	108.8	111.1	107.1	105.1	99.4	91.8	88.8	83.1
25	12500	108.8	107.5	105.5	107.8	103.5	102.2	97.8	88.2	86.8	81.8
26	16000	107.1	105.8	103.4	106.8	101.8	98.8	91.8	86.4	82.8	79.8
27	20000	104.1	102.8	99.8	103.8	98.8	95.8	89.4	81.8	80.1	77.1

S--S 50-Percent Speed

BAND	FREQUENCY	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
	ANGLE	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		117.8	118.3	118.9	117.6	114.0	114.1	109.8	103.4	100.6	102.6
1	50	79.7	79.3	77.7	80.0	82.0	81.0	79.0	80.0	80.3	85.0
2	63	81.7	79.3	82.3	79.7	81.0	82.3	82.0	81.3	81.0	87.0
3	80	84.0	84.3	86.7	82.3	83.0	83.3	80.7	80.7	83.3	86.0
4	100	88.3	87.0	88.7	86.0	86.0	86.3	85.0	84.7	84.7	87.7
5	125	90.7	90.3	91.7	89.7	87.0	88.3	85.7	84.7	85.7	89.3
6	160	92.7	91.7	94.0	90.0	89.0	89.0	87.0	84.0	84.7	87.3
7	200	92.7	92.0	92.3	90.3	89.0	89.0	86.0	83.7	85.3	90.0
8	250	93.7	93.0	95.0	92.0	90.0	91.0	89.0	87.0	85.3	87.7
9	315	95.0	94.0	96.3	92.7	92.0	91.7	88.0	85.7	86.0	88.3
10	400	93.7	92.3	95.3	93.0	91.0	90.3	86.7	84.0	84.3	86.0
11	500	90.0	89.7	93.0	89.7	88.0	88.0	85.0	82.0	80.7	83.0
12	630	88.7	89.0	91.0	88.3	87.0	86.3	81.3	79.0	78.3	81.0
13	800	90.3	90.0	93.0	90.0	88.0	88.3	83.3	81.7	80.3	83.7
14	1000	90.7	90.0	91.3	88.0	88.0	88.7	84.0	81.3	82.0	85.0
15	1250	82.3	81.7	82.3	80.3	81.0	84.0	82.0	81.7	82.0	86.0
16	1600	95.7	93.0	93.0	90.0	87.0	87.0	83.3	81.7	82.0	85.3
17	2000	101.7	100.0	102.0	99.3	96.0	95.0	90.3	86.7	85.0	86.7
18	2500	104.3	105.3	109.0	106.0	103.3	106.3	97.6	94.3	88.6	91.3
19	3150	109.7	109.4	112.4	111.1	107.7	105.7	99.4	92.7	89.7	92.7
20	4000	111.7	114.7	111.4	110.0	104.0	104.0	99.0	93.0	91.0	92.0
21	5000	109.2	108.2	111.3	109.3	107.3	108.9	104.3	96.3	93.6	92.3
22	6300	107.1	106.8	108.8	108.8	105.8	105.8	104.4	97.4	91.4	91.4
23	8000	106.3	106.6	107.3	105.3	99.3	97.0	93.3	85.6	86.0	90.6
24	10000	107.4	105.4	106.4	106.4	101.4	100.4	97.4	88.4	84.4	86.4
25	12500	105.0	103.3	104.3	103.0	100.0	97.0	94.0	85.0	82.0	85.0
26	16000	102.4	101.4	101.4	102.4	96.4	94.4	91.4	82.4	78.4	84.1
27	20000	99.7	98.7	97.7	99.0	93.7	89.7	87.7	78.7	76.7	81.7

H--S 50-Percent Speed

BAND	FREQUENCY	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
	ANGLE	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		120.2	120.5	119.7	120.4	116.9	115.4	111.0	105.7	100.8	100.4
1	50	85.0	95.0	82.0	83.0	84.0	83.0	83.0	81.0	84.0	85.0
2	63	87.0	87.0	87.0	88.0	87.0	88.0	89.0	89.0	88.0	90.0
3	80	84.0	80.0	85.0	84.0	85.0	86.0	89.0	84.0	84.0	88.0
4	100	90.0	91.0	92.0	92.0	89.0	89.0	88.0	88.0	86.0	88.0
5	125	92.0	93.0	93.0	91.0	91.0	91.0	90.0	89.0	86.0	89.0
6	160	94.0	94.0	94.0	93.0	93.0	92.0	91.0	89.0	86.0	85.0
7	200	94.0	95.0	94.0	93.0	93.0	90.0	91.0	89.0	86.0	87.0
8	250	95.0	96.0	95.0	95.0	94.0	93.0	92.0	89.0	85.0	85.0
9	315	96.0	97.0	96.0	96.0	94.0	92.0	92.0	89.0	85.0	86.0
10	400	95.0	95.0	95.0	95.0	94.0	90.0	91.0	88.0	85.0	83.0
11	500	93.0	94.0	94.0	93.0	92.0	89.0	88.0	86.0	82.0	81.0
12	630	92.0	92.0	92.0	92.0	90.0	87.0	85.0	82.0	82.0	80.0
13	800	92.0	93.0	95.0	93.0	91.0	88.0	85.0	83.0	81.0	80.0
14	1000	96.0	97.0	98.0	96.0	93.0	91.0	90.0	86.0	83.0	82.0
15	1250	98.0	99.0	100.0	99.0	97.0	95.0	93.0	89.0	84.0	85.0
16	1600	102.0	102.0	101.0	100.0	98.0	95.0	92.0	89.0	84.0	84.0
17	2000	105.0	105.0	105.0	105.0	100.0	97.0	94.0	91.0	85.0	84.0
18	2500	109.3	108.3	108.3	108.3	105.3	101.3	97.3	94.3	87.3	86.3
19	3150	112.7	112.7	111.7	112.7	110.7	108.7	104.7	97.7	90.7	89.7
20	4000	114.0	115.0	113.0	113.0	108.0	105.0	101.0	96.0	90.0	88.0
21	5000	110.2	110.2	111.2	111.2	109.2	108.2	104.2	98.2	92.2	88.2
22	6300	109.7	109.7	109.7	112.7	108.7	109.7	103.7	96.7	90.7	88.7
23	8000	109.2	110.2	108.2	108.2	102.2	99.2	94.2	90.2	88.2	88.2
24	10000	108.3	108.3	108.3	109.3	105.3	102.3	96.3	90.3	84.3	83.3
25	12500	106.8	106.8	105.8	106.8	102.8	99.8	93.8	86.8	82.8	81.8
26	16000	105.2	104.2	103.2	106.2	99.2	96.2	89.2	84.2	79.2	80.2
27	20000	101.3	101.3	100.3	103.3	95.3	93.3	86.3	80.3	77.3	79.3

H--H 60-Percent Speed

BAND	FREQUENCY	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		125.2	125.2	125.8	126.1	124.3	122.0	117.6	110.9	109.0	105.4
1	50	86.3	88.0	87.3	88.3	87.3	86.0	83.0	84.7	83.3	83.3
2	63	85.3	87.3	86.7	88.3	88.0	86.0	85.3	86.7	85.7	88.3
3	80	88.0	90.3	90.3	89.3	89.7	89.0	90.0	91.7	92.0	91.3
4	100	93.7	93.0	91.3	92.7	91.7	89.0	91.3	88.3	87.0	88.3
5	125	94.3	95.7	96.0	93.7	93.0	91.3	91.0	90.3	90.7	90.7
6	160	96.7	96.7	96.0	95.3	94.0	92.0	92.3	90.0	89.0	87.7
7	200	96.0	96.3	95.3	95.0	93.0	91.0	91.7	90.0	88.7	86.3
8	250	98.3	97.3	97.0	97.3	97.0	93.3	93.7	92.7	90.7	88.7
9	315	98.0	98.7	99.3	100.0	97.7	95.3	93.0	92.0	90.0	88.7
10	400	98.0	99.0	99.3	99.0	96.7	94.7	92.0	91.0	88.0	89.0
11	500	96.0	97.3	97.3	97.7	95.3	93.7	91.7	90.0	87.3	86.0
12	630	95.0	96.3	97.3	95.3	94.3	91.0	88.7	85.7	84.7	84.7
13	800	99.7	99.0	100.3	99.0	97.3	94.0	91.7	88.0	87.0	86.0
14	1000	106.0	106.3	106.0	105.0	104.0	100.3	97.0	94.0	91.3	89.7
15	1250	109.3	109.3	108.3	107.3	106.3	103.7	100.0	97.0	94.3	90.7
16	1600	108.3	109.0	108.0	107.7	107.0	103.0	100.0	96.3	93.3	90.0
17	2000	109.3	109.3	110.0	109.0	108.0	106.0	103.0	98.0	94.3	91.0
18	2500	110.3	110.6	111.0	111.3	109.3	106.3	103.0	97.3	94.6	91.0
19	3150	113.7	115.0	115.0	117.7	116.0	113.4	110.0	102.7	100.7	96.0
20	4000	118.0	117.0	119.3	117.0	114.3	111.7	107.3	100.7	98.3	96.0
21	5000	117.8	116.5	115.2	115.2	112.2	110.2	105.2	99.8	97.5	93.2
22	6300	115.6	117.6	120.6	120.0	119.6	117.3	112.3	104.6	103.6	97.0
23	8000	114.1	115.1	113.1	115.4	114.1	113.4	108.1	100.1	97.8	94.1
24	10000	114.4	114.8	113.1	115.1	111.1	108.8	104.1	95.8	92.8	91.8
25	12500	113.5	112.5	111.5	114.5	110.5	108.5	104.5	94.2	91.5	89.2
26	16000	112.1	111.8	109.4	112.8	108.1	105.4	98.8	91.4	87.8	88.4
27	20000	109.8	109.1	106.8	110.4	105.8	102.4	96.4	87.4	82.4	82.4

S--S 60-Percent Speed

BAND	FREQUENCY	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		121.8	120.1	121.0	120.9	117.2	116.3	112.0	102.8	100.4	105.0
1	50	86.0	82.7	81.7	82.7	79.0	83.7	84.3	78.7	81.0	85.7
2	63	84.3	83.3	83.7	85.0	82.0	86.7	86.0	81.0	85.3	88.7
3	80	88.0	86.0	84.0	85.7	85.0	86.3	84.7	81.0	83.0	87.7
4	100	91.3	90.0	88.3	87.3	89.0	88.7	88.3	83.7	84.7	89.0
5	125	92.7	92.0	92.0	92.0	91.0	91.3	88.7	85.7	85.7	91.3
6	160	93.3	93.0	94.0	91.7	91.0	92.0	88.7	85.7	84.7	89.0
7	200	94.0	93.7	93.0	90.7	90.0	90.7	89.0	85.0	84.7	88.0
8	250	95.0	94.3	94.7	93.7	93.0	93.3	91.7	86.3	85.3	89.7
9	315	95.3	94.7	96.0	94.7	93.0	94.0	90.7	85.3	85.0	90.0
10	400	95.0	95.0	96.0	94.3	92.0	91.3	89.0	84.0	83.7	89.0
11	500	92.3	91.7	92.3	92.7	90.0	90.3	87.3	82.0	81.7	85.3
12	630	89.7	89.7	91.0	88.7	87.0	87.7	83.3	78.0	78.3	82.7
13	800	88.3	88.0	90.0	88.7	87.0	87.7	84.0	78.7	80.3	84.7
14	1000	88.0	87.7	87.7	83.3	86.0	87.3	84.0	79.7	82.0	86.7
15	1250	82.3	81.3	83.0	81.0	82.0	85.0	83.0	81.3	81.7	87.7
16	1600	94.0	92.3	91.3	89.0	87.0	87.0	86.0	82.0	82.3	88.3
17	2000	101.3	100.0	100.0	98.7	95.0	94.7	90.7	84.0	84.0	87.7
18	2500	104.3	104.0	104.0	102.3	99.3	99.3	94.0	87.6	85.6	89.0
19	3150	109.7	108.7	111.7	109.4	107.7	109.4	102.7	95.1	90.1	95.1
20	4000	116.0	113.0	114.0	112.4	108.0	106.4	102.0	93.0	91.0	95.4
21	5000	115.9	113.3	113.3	112.3	109.3	107.3	103.3	93.6	90.6	94.3
22	6300	111.1	111.8	115.1	115.8	111.8	111.1	106.8	96.4	92.4	97.4
23	8000	110.3	109.3	108.3	109.3	106.3	104.3	100.6	90.0	88.6	93.3
24	10000	112.1	110.4	109.4	110.4	105.4	104.4	101.1	89.4	85.4	91.8
25	12500	109.0	108.0	107.6	110.0	106.0	103.0	100.0	87.3	85.3	89.0
26	16000	106.7	107.4	105.4	108.4	102.4	100.4	97.4	85.1	81.1	87.4
27	20000	104.7	104.0	96.7	99.7	100.7	96.7	94.0	80.3	77.3	83.7

H--H 70-Percent Speed

BAND	FREQUENCY	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		125.4	125.8	125.8	126.7	124.4	121.7	118.3	111.8	109.1	106.3
1	50	84.3	86.3	88.7	86.7	87.3	84.7	85.3	86.3	85.3	84.3
2	63	86.3	88.0	88.7	87.7	87.7	87.3	86.3	87.0	85.3	87.7
3	80	90.3	90.0	91.0	90.0	90.3	88.7	88.7	88.7	88.0	87.7
4	100	94.7	93.3	92.3	93.3	92.7	92.0	93.0	92.3	91.7	90.7
5	125	95.7	95.0	95.0	94.3	94.0	92.7	94.3	91.3	90.7	89.7
6	160	96.3	98.0	97.0	97.0	96.0	94.3	96.0	92.7	92.7	90.0
7	200	98.3	97.7	97.0	96.0	95.0	92.7	91.0	91.0	89.7	88.3
8	250	97.3	98.0	97.3	98.3	96.0	95.0	94.7	92.7	91.7	89.7
9	315	99.3	99.3	100.7	99.7	98.7	96.0	94.7	93.0	91.0	91.0
10	400	99.7	99.7	100.0	99.0	98.0	96.0	93.0	92.3	90.7	91.0
11	500	98.0	98.7	99.0	99.7	98.3	95.0	93.7	92.0	90.0	89.3
12	630	96.0	97.7	98.0	97.0	95.3	93.0	91.0	88.0	86.0	87.0
13	800	100.0	100.0	101.0	100.0	98.0	95.7	92.0	90.0	88.7	88.0
14	1000	105.0	105.0	106.0	104.7	103.0	100.3	98.0	95.0	92.0	89.3
15	1250	109.0	110.0	110.0	109.0	108.0	105.0	102.3	98.7	95.7	92.7
16	1600	110.0	109.3	110.0	109.3	108.0	104.7	102.0	98.0	95.0	92.0
17	2000	110.7	110.0	110.3	110.0	109.0	106.7	103.7	99.3	95.7	92.0
18	2500	110.3	110.6	111.0	110.6	110.0	106.3	103.3	97.6	95.0	92.0
19	3150	113.4	114.0	116.0	115.4	112.7	109.7	109.4	101.4	99.7	94.4
20	4000	115.0	116.7	116.7	117.0	116.0	111.7	109.0	101.7	98.3	95.7
21	5000	116.8	116.2	116.2	116.2	113.2	111.5	107.2	101.2	98.2	94.5
22	6300	116.6	117.5	118.3	118.0	115.6	113.3	110.0	102.0	99.6	94.6
23	8000	115.8	117.1	117.8	119.8	118.1	115.1	110.8	104.1	100.8	97.4
24	10000	116.1	116.1	114.4	117.1	114.1	112.8	108.1	100.1	97.1	95.1
25	12500	114.8	114.5	113.5	115.5	111.5	109.2	106.5	96.8	93.8	92.5
26	16000	113.8	113.1	111.8	114.8	110.8	107.8	101.8	95.8	91.4	91.8
27	20000	111.8	111.8	108.8	112.8	108.8	105.1	100.1	91.1	86.4	86.8

S--S 70-Percent Speed

BAND	FREQUENCY	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		120.7	119.9	119.7	120.4	116.5	116.1	112.8	104.1	103.5	106.5
1	50	85.7	85.3	82.3	81.7	81.0	87.0	86.0	82.3	82.3	86.3
2	63	87.0	85.3	84.3	82.3	85.0	86.3	87.0	85.3	84.7	87.7
3	80	87.3	86.3	87.0	85.0	82.0	85.0	86.3	84.3	83.7	86.7
4	100	91.7	91.3	90.3	88.0	89.0	91.3	91.3	89.3	89.0	92.7
5	125	93.7	93.0	93.3	90.7	90.0	91.7	92.3	87.7	87.7	89.7
6	160	96.0	94.7	94.7	91.7	92.0	92.0	93.3	87.3	87.3	89.3
7	200	96.3	96.7	96.0	93.7	93.0	94.0	93.0	89.3	89.0	89.7
8	250	96.3	94.7	96.0	98.3	93.0	98.3	96.0	90.7	89.7	94.0
9	315	95.3	95.0	95.3	94.3	94.0	95.0	93.0	87.0	88.0	91.7
10	400	95.0	94.7	96.0	93.7	92.0	92.7	90.7	86.7	87.0	90.0
11	500	92.7	91.7	93.3	91.3	90.0	92.0	88.7	84.7	85.0	87.0
12	630	88.7	88.3	89.3	88.3	87.0	88.3	84.7	80.0	80.7	85.0
13	800	87.3	86.3	87.7	85.3	86.0	87.0	84.7	81.0	83.7	87.3
14	1000	86.0	84.3	84.7	82.7	83.0	86.7	85.0	82.3	85.0	88.7
15	1250	82.0	80.0	81.7	80.3	82.0	86.7	86.3	84.3	85.3	89.0
16	1600	95.0	92.0	90.3	88.0	86.0	89.7	90.7	86.7	88.0	91.3
17	2000	101.3	100.0	99.3	96.7	93.0	94.0	91.0	86.7	88.0	90.0
18	2500	103.6	102.6	102.6	101.0	97.3	98.3	93.3	88.3	88.3	90.3
19	3150	107.7	108.4	108.4	105.7	103.7	104.1	99.1	90.7	90.7	93.7
20	4000	111.0	110.7	111.7	109.4	107.0	106.4	102.0	93.0	93.4	95.7
21	5000	113.6	112.6	111.3	111.6	109.3	107.3	104.3	93.6	92.3	94.6
22	6300	111.8	112.1	111.8	112.1	107.8	108.8	104.1	94.4	91.8	94.1
23	8000	110.3	110.0	110.6	113.0	108.3	107.6	103.3	95.3	95.6	98.6
24	10000	113.1	111.4	110.1	112.1	107.4	108.1	105.8	95.4	93.4	96.4
25	12500	111.0	109.0	108.6	110.6	106.0	104.0	102.0	91.0	89.3	92.6
26	16000	108.4	107.4	107.4	110.4	104.4	102.4	100.4	89.4	86.4	92.1
27	20000	106.7	104.7	104.7	107.0	102.7	99.0	97.3	85.3	82.3	87.7

H--H 80-Percent Speed

BAND	FREQUENCY	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		123.8	124.3	125.6	125.2	122.7	121.0	116.9	111.2	109.9	108.6
1	50	85.3	86.3	85.3	85.0	84.7	84.3	86.3	84.7	85.7	84.7
2	63	87.0	87.3	87.3	87.7	87.0	87.7	87.0	86.0	85.7	86.7
3	80	89.3	89.3	90.3	88.0	88.3	88.3	87.3	86.7	88.0	87.7
4	100	91.3	93.3	92.3	92.7	92.0	91.0	91.3	90.7	91.3	91.7
5	125	92.3	93.3	92.7	92.3	92.0	91.3	92.0	90.7	91.0	90.3
6	160	92.3	93.0	93.3	92.7	92.7	91.7	90.7	91.0	89.0	88.0
7	200	93.0	93.3	93.3	94.3	94.0	91.0	91.0	90.7	91.0	91.3
8	250	92.7	93.3	92.7	93.7	92.0	91.3	91.3	92.3	90.7	90.7
9	315	92.3	92.3	92.0	92.7	92.3	91.3	91.0	90.3	88.7	89.3
10	400	90.7	91.7	92.7	92.7	92.3	90.3	90.3	90.3	89.0	90.0
11	500	90.0	91.0	92.3	92.7	92.0	91.0	91.3	90.3	89.0	88.7
12	630	89.3	90.0	91.3	92.0	91.0	89.3	88.7	86.3	85.3	87.0
13	800	93.0	93.0	94.3	94.0	93.0	91.0	89.0	87.3	88.0	88.3
14	1000	98.7	99.3	99.7	98.7	97.3	95.0	93.3	91.3	90.3	90.0
15	1250	103.3	103.7	102.7	102.3	102.0	99.3	97.3	94.0	91.7	90.7
16	1600	107.7	107.0	106.0	106.0	105.0	102.3	99.3	96.3	94.0	92.7
17	2000	110.0	111.3	112.3	110.3	108.3	105.0	102.7	99.3	97.3	94.3
18	2500	107.3	107.3	107.6	107.0	105.3	102.0	99.3	96.0	94.6	92.3
19	3150	110.0	109.7	109.4	109.4	107.4	104.0	102.4	96.4	94.4	92.7
20	4000	114.0	117.0	121.3	115.3	117.7	116.0	111.7	105.0	102.7	99.3
21	5000	111.8	111.8	112.5	112.5	109.8	108.2	103.2	98.5	97.2	94.2
22	6300	112.6	113.6	113.0	113.6	110.6	108.6	103.6	98.3	97.0	95.6
23	8000	115.4	116.7	118.7	119.4	115.4	113.4	108.7	102.4	101.1	99.7
24	10000	114.1	113.8	113.4	115.1	112.1	111.1	107.1	101.8	101.8	101.1
25	12500	116.8	116.2	114.2	117.2	112.8	112.2	108.8	100.2	99.2	97.8
26	16000	114.1	112.8	111.4	114.8	109.8	107.4	102.1	97.4	96.8	98.1
27	20000	110.8	110.8	109.1	113.1	107.8	104.8	100.1	92.8	91.1	92.1

S--S 80-Percent Speed

BAND	FREQUENCY	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		118.1	117.3	118.2	120.0	115.3	113.7	112.3	104.3	107.0	107.2
1	50	82.0	78.0	79.3	80.0	80.0	83.0	80.7	81.0	83.0	82.3
2	63	86.0	78.3	81.7	82.0	83.0	85.0	83.3	81.0	84.0	84.7
3	80	87.0	84.7	83.7	82.3	81.0	83.7	83.0	80.3	82.3	84.0
4	100	91.0	88.7	87.7	88.0	89.0	90.0	89.3	85.0	88.3	89.0
5	125	93.0	85.7	87.3	86.3	86.0	90.7	88.3	85.3	89.0	87.7
6	160	95.0	87.0	86.0	86.7	87.0	90.7	87.7	85.7	87.7	88.3
7	200	94.0	88.3	88.3	88.0	88.0	90.3	89.7	87.7	90.3	88.3
8	250	96.0	87.0	87.3	88.7	88.0	91.0	89.3	86.7	89.3	90.0
9	315	95.0	86.3	86.3	88.3	87.0	90.0	87.3	84.0	88.3	90.0
10	400	93.0	86.0	87.7	87.7	87.0	89.3	88.3	87.0	88.3	90.0
11	500	90.0	81.3	85.0	84.3	85.0	90.0	89.3	85.7	87.3	88.3
12	630	87.0	77.3	80.3	82.0	84.0	88.7	85.7	82.3	83.0	86.3
13	800	87.0	77.3	80.0	82.0	83.0	87.7	85.0	82.7	86.3	87.7
14	1000	85.0	79.3	82.0	83.0	84.0	88.7	86.7	84.3	88.0	89.3
15	1250	83.0	77.0	81.7	81.3	84.0	89.0	88.3	86.3	88.0	89.7
16	1600	90.0	90.0	87.0	85.0	86.0	90.3	90.0	88.0	89.3	91.0
17	2000	96.0	96.0	95.0	91.7	89.0	92.0	91.3	89.3	92.7	91.3
18	2500	96.3	94.3	94.6	93.0	90.3	92.3	91.3	88.6	90.3	90.6
19	3150	100.7	101.7	101.4	98.7	103.7	94.4	90.4	88.1	89.4	91.4
20	4000	112.0	111.7	108.7	115.7	104.0	106.0	107.0	94.7	101.0	95.4
21	5000	108.2	106.6	108.3	104.9	102.3	100.9	96.9	90.6	93.2	93.3
22	6300	106.8	105.8	105.8	105.1	101.8	101.8	98.8	91.8	92.8	93.4
23	8000	110.3	109.0	113.3	112.3	110.3	106.3	103.6	94.3	96.6	98.3
24	10000	108.4	107.1	110.4	109.4	104.4	105.4	104.4	98.4	100.1	101.4
25	12500	109.0	110.0	107.6	111.6	107.0	106.6	104.3	93.0	95.0	95.3
26	16000	106.4	106.1	107.1	109.7	106.4	102.4	100.7	92.7	93.4	96.4
27	20000	105.7	96.0	103.7	107.7	102.7	98.7	96.7	87.0	88.3	91.3

H--H 90-Percent Speed

BAND	FREQUENCY	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		122.0	123.7	125.0	124.6	121.3	120.7	115.5	112.3	111.2	111.4
1	50	86.0	87.0	85.7	87.0	86.0	85.0	86.7	86.3	87.0	87.0
2	63	86.3	87.0	87.0	87.0	87.3	87.7	87.0	87.3	89.0	89.3
3	80	89.3	88.0	89.3	87.7	88.7	88.7	89.0	87.7	89.3	91.3
4	100	89.7	89.7	89.7	90.3	89.0	89.7	90.7	90.3	91.3	91.7
5	125	92.0	91.3	90.7	90.0	92.3	91.7	91.3	91.3	91.7	92.3
6	160	92.7	91.7	91.7	91.7	94.7	92.0	92.3	93.3	92.7	93.3
7	200	92.7	92.7	92.0	93.3	94.0	92.0	93.7	93.7	93.7	93.0
8	250	95.3	93.7	93.0	95.0	94.0	94.3	94.3	94.0	93.7	94.0
9	315	94.0	92.7	92.0	93.7	94.0	94.0	93.3	93.0	93.3	94.3
10	400	91.0	90.7	93.7	94.7	94.7	94.3	95.0	95.0	94.0	94.7
11	500	90.0	92.3	93.0	93.3	95.0	94.3	96.0	94.3	92.7	93.3
12	630	88.0	89.3	91.0	93.3	94.3	93.7	94.3	92.0	91.7	93.3
13	800	89.3	89.7	91.7	93.0	94.0	93.3	93.0	92.0	93.0	94.3
14	1000	94.0	94.0	95.3	96.0	95.3	94.0	93.7	93.7	94.0	94.3
15	1250	104.7	101.7	109.0	108.7	105.3	97.3	95.7	95.7	94.3	94.3
16	1600	98.0	98.3	98.7	98.7	99.0	97.0	97.0	97.0	96.0	97.0
17	2000	99.0	99.0	99.0	99.0	98.7	98.3	98.3	97.3	96.7	97.0
18	2500	98.3	98.3	98.3	98.6	98.3	97.3	99.0	98.0	97.6	97.6
19	3150	99.7	100.7	101.4	101.4	100.4	99.0	99.7	98.0	97.4	98.7
20	4000	111.0	112.7	114.3	111.7	110.3	111.0	105.0	100.7	98.7	99.3
21	5000	118.8	119.8	122.5	119.8	117.5	118.2	111.2	106.2	102.8	100.5
22	6300	106.6	107.6	106.6	109.0	104.6	104.0	101.0	98.6	99.3	99.0
23	8000	108.7	111.1	109.7	112.4	108.1	105.7	101.7	100.1	100.4	100.4
24	10000	113.4	117.8	117.4	119.1	114.8	111.4	107.1	104.4	103.1	103.8
25	12500	111.2	112.2	111.5	114.2	110.2	108.8	104.5	99.8	100.5	100.8
26	16000	108.8	109.8	108.4	112.1	107.4	106.1	101.1	97.8	96.8	97.8
27	20000	107.8	108.8	107.8	111.8	106.4	103.8	99.1	95.4	95.1	94.4

S--S 90-Percent Speed

BAND	FREQUENCY	0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		114.4	113.2	117.0	119.0	113.2	114.1	111.2	105.1	108.3	113.1
1	50	81.3	81.3	79.3	81.7	86.0	87.3	85.0	82.3	86.7	89.0
2	63	84.0	83.7	85.3	83.0	85.0	88.0	86.3	83.0	88.3	92.0
3	80	86.0	84.3	86.3	85.7	82.0	87.3	84.3	83.3	86.0	90.3
4	100	88.3	87.7	88.0	87.3	88.0	91.7	89.7	86.0	91.0	94.3
5	125	90.3	89.0	89.7	91.0	92.0	97.0	93.7	89.7	93.3	97.7
6	160	91.0	89.7	89.0	90.0	90.0	94.7	92.0	88.3	92.7	96.3
7	200	91.7	90.3	90.3	92.3	93.0	94.3	93.0	89.0	93.3	96.7
8	250	92.3	90.7	91.3	93.0	91.0	95.7	93.7	89.3	93.3	97.0
9	315	92.7	89.7	89.7	91.7	92.0	95.3	94.0	88.7	93.3	98.3
10	400	90.3	88.0	90.7	92.3	92.0	95.3	94.0	89.7	93.7	98.0
11	500	86.3	86.3	89.0	89.7	92.0	96.3	94.7	89.3	92.7	97.0
12	630	83.7	81.7	86.3	88.0	91.0	95.3	91.7	87.0	90.3	95.7
13	800	84.7	82.3	86.0	88.0	90.0	94.3	92.0	86.3	92.3	96.3
14	1000	84.3	83.0	86.0	88.0	89.0	93.7	91.7	87.0	92.7	97.0
15	1250	81.7	81.7	85.3	86.3	89.0	94.0	92.7	89.0	93.0	98.0
16	1600	84.3	83.0	86.7	87.3	89.0	94.3	94.7	90.3	94.3	99.3
17	2000	88.0	87.7	88.7	89.0	90.0	94.7	95.0	90.3	95.3	98.7
18	2500	88.3	88.3	89.3	89.6	90.3	94.3	95.0	92.0	95.6	99.3
19	3150	91.1	89.4	90.1	92.7	90.7	94.7	96.7	92.4	93.1	99.7
20	4000	102.0	98.0	104.7	107.7	98.0	103.0	98.4	93.4	96.7	102.4
21	5000	109.9	104.9	112.3	116.3	107.3	109.9	101.6	94.6	97.6	101.6
22	6300	99.8	100.4	99.8	101.1	94.8	97.4	97.8	92.8	96.1	100.8
23	8000	101.3	101.0	104.0	103.6	100.3	98.6	99.0	93.0	96.0	102.0
24	10000	108.4	108.1	112.1	109.8	108.4	106.8	105.4	97.1	99.1	104.8
25	12500	103.6	104.0	106.3	108.3	102.0	100.0	100.0	92.6	95.3	100.0
26	16000	102.4	102.4	104.4	106.4	100.4	100.1	99.4	90.4	91.7	97.7
27	20000	102.3	104.7	103.7	107.3	102.7	99.3	97.7	87.7	89.7	95.7

H--H 100-Percent Speed

BAND	FREQUENCY	ANGLE 0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		121.8	120.5	122.2	123.5	119.8	117.5	115.3	113.8	113.6	113.9
1	50	89.7	90.0	89.7	88.7	89.0	90.7	90.7	91.0	91.7	91.7
2	63	91.7	88.7	91.7	91.7	91.7	93.0	91.3	93.3	92.3	92.3
3	80	93.0	93.3	93.0	92.0	93.0	92.7	93.0	93.7	93.7	93.3
4	100	93.7	93.7	94.3	93.0	93.7	94.0	94.7	95.3	95.7	96.3
5	125	96.3	96.7	94.7	96.3	97.0	97.0	96.0	98.3	96.7	97.7
6	160	97.0	96.7	96.3	98.3	99.7	97.0	97.3	99.3	98.3	98.0
7	200	99.0	98.7	98.0	99.0	99.3	97.3	99.0	99.0	98.0	98.3
8	250	101.0	99.7	98.7	101.7	99.7	99.7	99.0	99.7	98.3	99.3
9	315	99.3	98.3	99.0	99.7	99.7	99.7	99.0	99.0	98.3	99.7
10	400	94.3	94.7	97.0	98.7	100.0	100.0	99.7	100.0	98.7	99.7
11	500	93.3	95.7	97.0	99.3	101.0	100.7	101.7	99.0	97.3	98.3
12	630	91.7	93.0	95.0	98.0	99.3	99.0	99.3	97.3	97.3	98.3
13	800	94.3	95.3	99.3	101.0	100.7	99.7	99.0	97.0	97.7	99.0
14	1000	97.3	95.3	96.3	98.3	98.0	98.0	98.0	97.3	98.3	99.0
15	1250	99.0	100.0	100.0	100.3	99.0	98.0	98.7	98.3	97.3	98.0
16	1600	97.3	99.7	99.3	100.0	99.0	98.0	98.3	98.7	98.0	99.7
17	2000	97.0	98.3	98.7	99.0	100.0	99.0	99.3	99.0	99.0	100.0
18	2500	95.0	96.0	97.0	98.3	98.3	97.6	99.3	99.3	100.3	100.6
19	3150	96.0	97.7	98.4	100.0	99.4	99.0	100.4	99.0	99.0	99.7
20	4000	101.7	102.0	104.0	105.0	103.3	103.0	102.7	100.7	100.3	102.3
21	5000	119.2	117.5	120.5	121.2	117.2	113.5	109.5	106.2	105.2	103.5
22	6300	107.3	106.6	108.0	109.0	107.0	107.0	103.0	101.6	103.0	102.6
23	8000	102.4	103.4	102.1	105.1	103.1	103.1	100.1	100.1	101.4	101.4
24	10000	115.1	113.8	113.4	115.8	110.8	108.4	106.1	102.8	102.4	102.4
25	12500	105.8	104.8	104.8	107.8	103.5	103.8	102.5	99.8	101.5	101.2
26	16000	110.7	109.4	108.4	112.1	106.4	103.8	98.8	97.8	96.8	97.8
27	20000	105.1	105.4	104.1	107.8	102.4	99.4	95.8	94.8	94.8	94.4

S--S 100-Percent Speed

BAND	FREQUENCY	ANGLE 0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		115.4	112.4	118.0	118.2	116.0	114.2	112.2	98.6	111.0	114.8
1	50	87.0	84.7	85.0	90.3	86.0	90.0	89.7	87.0	90.3	93.7
2	63	89.0	88.7	89.7	91.3	90.0	93.3	90.3	91.3	93.3	95.0
3	80	89.3	89.0	88.3	90.3	85.0	90.7	89.0	87.7	90.0	94.3
4	100	93.0	92.0	91.0	92.3	92.0	97.0	93.0	92.3	96.0	97.7
5	125	94.3	94.7	93.3	94.3	95.0	99.7	96.3	94.3	96.3	99.0
6	160	95.7	94.3	96.0	95.3	98.0	99.3	97.3	95.3	98.7	101.0
7	200	97.0	96.0	97.3	98.7	98.0	100.3	99.3	95.7	99.3	102.0
8	250	98.0	98.0	98.3	99.3	98.0	101.0	99.3	96.0	99.3	101.7
9	315	97.3	95.0	96.7	96.0	98.0	100.3	98.7	96.3	99.0	103.0
10	400	91.7	91.0	94.7	96.0	97.0	100.7	99.7	97.3	97.3	102.0
11	500	91.0	90.3	94.3	96.0	98.0	101.0	98.3	95.7	96.7	100.7
12	630	88.7	86.0	91.7	94.0	95.0	100.3	96.0	92.3	95.0	99.0
13	800	88.0	86.0	91.0	93.7	95.0	99.7	95.3	91.7	95.7	99.0
14	1000	86.3	85.3	90.0	92.0	94.0	97.0	93.3	92.0	95.7	99.7
15	1250	85.0	84.3	88.3	90.0	92.0	97.0	93.0	93.0	95.0	99.3
16	1600	85.3	85.0	88.3	88.3	92.0	96.0	94.3	93.0	96.0	100.0
17	2000	86.0	86.7	89.7	89.3	92.0	95.0	95.7	93.3	97.0	100.3
18	2500	86.0	86.0	89.3	89.3	91.3	94.3	94.3	93.6	96.3	100.3
19	3150	84.1	90.1	90.4	86.7	90.7	94.1	94.7	91.7	94.7	100.4
20	4000	94.4	95.0	97.0	98.0	96.0	95.4	95.4	95.0	99.0	103.0
21	5000	113.6	107.9	116.9	115.9	113.3	108.6	105.6	97.9	99.6	103.3
22	6300	101.1	100.4	102.8	103.1	98.8	98.8	98.8	95.1	97.8	101.8
23	8000	95.0	94.0	95.3	94.0	92.3	93.3	96.6	94.3	96.3	101.3
24	10000	106.1	105.1	106.4	109.4	109.4	104.8	102.8	97.4	98.4	102.4
25	12500	99.3	98.0	99.3	102.0	99.0	98.0	99.0	95.0	97.0	102.0
26	16000	101.4	103.1	102.4	108.1	101.4	100.1	99.1	92.4	91.4	97.4
27	20000	97.7	98.7	97.0	103.7	97.7	94.7	94.0	88.7	89.7	94.7

HHHH 50-Percent Speed

ANGLE		0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		123.6	124.4	123.2	123.4	122.4	119.4	115.8	110.8	101.0	100.7
BAND	FREQUENCY										
1	50	84.3	85.3	86.3	85.0	85.0	84.0	83.3	85.0	83.7	79.7
2	63	86.3	88.0	88.0	88.7	88.0	88.0	89.0	89.3	88.0	82.7
3	80	89.7	92.0	89.7	89.3	89.3	89.3	89.7	89.7	88.0	84.0
4	100	94.0	95.0	94.7	94.3	93.7	92.7	92.7	92.0	91.0	84.7
5	125	96.0	96.3	94.3	95.3	94.0	93.0	92.3	92.0	90.7	84.7
6	160	96.3	96.7	95.7	96.3	95.3	93.3	92.3	91.0	89.0	83.7
7	200	96.7	97.7	97.0	96.7	95.7	95.0	94.3	92.7	90.0	86.7
8	250	97.3	98.0	97.0	97.7	96.3	95.0	93.3	91.7	90.3	84.7
9	315	99.0	99.7	99.0	98.7	97.7	95.0	93.7	92.0	90.0	84.7
10	400	98.0	98.7	98.7	97.7	96.0	93.3	91.7	90.7	88.3	83.0
11	500	95.7	97.7	97.7	97.0	94.7	92.0	91.3	89.3	86.0	81.0
12	630	95.0	96.7	96.7	96.0	94.7	91.7	89.3	85.7	84.7	80.3
13	800	101.7	101.3	101.0	100.3	99.3	96.7	94.0	92.0	87.7	82.7
14	1000	106.7	107.7	107.0	105.7	103.7	101.3	99.3	96.7	92.7	86.3
15	1250	108.3	108.7	108.3	106.3	105.3	103.3	101.0	98.3	93.7	87.3
16	1600	108.3	108.3	108.3	107.3	107.0	104.7	101.3	97.7	93.0	85.7
17	2000	109.0	110.0	110.3	110.3	109.0	106.7	103.3	99.3	93.7	87.3
18	2500	111.0	113.3	112.3	112.0	113.6	109.6	104.0	100.3	95.0	90.0
19	3150	115.0	116.7	117.0	115.4	116.4	112.7	109.7	103.7	97.0	91.0
20	4000	117.3	118.7	115.7	115.0	112.3	109.3	106.3	101.3	95.3	89.3
21	5000	112.5	113.5	112.8	113.8	114.5	111.2	107.8	101.5	95.5	89.2
22	6300	112.0	113.0	112.3	114.3	112.3	110.6	106.6	99.3	94.6	90.0
23	8000	114.8	113.4	111.4	112.1	108.8	106.4	101.8	95.1	91.8	89.1
24	10000	111.1	111.5	109.8	111.8	108.5	105.8	100.8	94.5	88.8	85.8
25	12500	110.2	109.6	106.9	109.2	105.6	103.2	98.2	91.5	86.6	84.6
26	16000	108.2	107.2	103.9	107.5	102.5	100.2	93.9	89.2	83.2	81.9
27	20000	105.3	104.0	100.3	104.3	99.6	96.3	89.5	85.0	80.3	78.6

HSSH 50-Percent Speed

ANGLE		0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		117.9	118.5	117.1	117.2	117.0	113.3	110.2	99.9	96.5	94.8
BAND	FREQUENCY										
1	50	82.7	82.0	82.3	82.7	83.3	81.0	81.3	76.0	75.0	77.3
2	63	83.7	85.0	85.3	85.0	85.3	84.0	86.0	81.0	80.7	80.7
3	80	86.7	87.7	87.0	87.3	86.0	85.3	87.3	82.3	80.0	82.7
4	100	90.7	91.0	91.0	92.0	89.3	88.7	89.3	83.7	81.0	81.7
5	125	92.3	92.3	91.3	91.3	90.3	89.3	88.7	82.7	81.3	80.7
6	160	94.7	95.3	93.3	92.3	91.7	89.3	89.7	82.0	79.7	79.7
7	200	93.3	94.3	94.0	93.7	92.3	90.3	89.7	82.3	80.7	82.0
8	250	95.0	95.3	94.0	94.7	93.3	91.3	90.3	84.0	80.7	81.0
9	315	96.0	95.0	95.7	95.0	94.0	92.3	91.0	83.7	81.3	81.0
10	400	94.3	95.0	95.7	95.3	93.0	90.3	89.7	82.7	80.3	79.0
11	500	91.0	92.7	92.7	92.7	90.3	88.0	88.0	80.3	77.3	75.7
12	630	88.7	90.3	91.0	90.7	89.7	86.7	85.0	77.7	75.0	75.7
13	800	91.7	93.0	93.0	93.7	92.7	89.3	87.7	80.7	77.7	76.0
14	1000	94.3	96.0	95.3	95.3	93.7	91.3	89.3	82.0	79.0	77.7
15	1250	90.7	91.0	90.0	89.3	88.0	86.0	85.7	80.0	78.0	77.3
16	1600	80.3	82.0	81.3	82.7	83.0	81.7	84.0	79.7	78.3	77.3
17	2000	94.0	94.3	93.7	93.0	90.7	88.3	87.7	81.0	79.7	78.3
18	2500	104.0	105.3	103.0	105.3	106.3	102.6	96.6	87.6	84.3	81.0
19	3150	110.0	110.4	109.4	110.0	108.7	105.0	101.4	91.0	86.4	83.0
20	4000	111.3	114.0	110.7	109.7	107.7	103.0	99.7	90.3	86.0	83.0
21	5000	108.5	108.8	108.2	109.5	111.5	106.8	105.2	93.5	88.2	84.2
22	6300	108.6	108.3	108.0	109.0	109.7	107.6	103.7	91.0	87.3	83.6
23	8000	108.1	106.4	105.8	104.4	102.4	98.4	94.4	84.1	84.1	83.8
24	10000	106.2	106.2	106.2	105.8	104.5	99.8	95.8	83.5	81.8	79.8
25	12500	106.9	104.3	104.3	103.3	101.3	96.6	93.3	81.9	80.9	77.9
26	16000	103.3	100.6	101.3	99.6	97.6	91.9	88.6	78.6	78.9	76.6
27	20000	100.7	97.7	99.1	96.7	93.7	88.4	85.4	75.7	75.1	74.1

SSSS 50-Percent Speed

ANGLE		0.	10.	20.	30.	40.	50.	60.	70.	80.	90.
COMPUTED OASPL		118.6	120.3	118.3	119.5	118.1	114.6	112.1	105.8	103.0	101.3
BAND	FREQUENCY										
1	50	84.0	85.0	86.3	85.0	85.0	84.0	83.0	83.3	83.0	80.3
2	63	85.7	89.0	88.0	88.0	87.0	86.3	87.7	87.3	88.0	89.3
3	80	89.0	90.3	89.7	90.7	88.7	88.7	89.3	88.3	90.0	88.7
4	100	91.7	92.3	91.0	92.3	90.3	90.0	90.0	89.3	89.3	88.3
5	125	93.7	94.3	94.3	93.3	92.3	91.0	91.0	90.0	88.7	88.7
6	160	94.7	95.3	95.0	94.7	93.0	90.0	90.3	88.7	87.7	87.0
7	200	95.0	95.0	95.7	94.3	93.3	91.3	91.3	88.0	88.7	88.0
8	250	96.0	96.3	94.3	95.3	94.3	92.0	90.7	89.3	89.0	87.0
9	315	96.0	97.0	95.3	95.7	94.3	92.0	91.0	89.0	88.7	85.3
10	400	94.3	94.3	94.3	94.0	92.3	89.3	89.0	87.3	85.7	83.7
11	500	91.0	91.7	91.0	92.0	89.0	87.3	88.3	83.3	82.3	79.7
12	630	89.3	89.7	89.3	90.7	87.7	85.3	85.3	82.3	81.7	79.3
13	800	91.3	91.0	91.3	91.0	89.7	87.7	86.7	84.0	83.3	82.0
14	1000	90.7	92.0	91.0	89.7	88.0	86.0	87.7	86.3	85.3	84.7
15	1250	84.0	84.4	83.4	84.4	84.4	84.0	87.0	87.0	85.4	84.7
16	1600	81.4	82.0	81.7	84.4	84.4	85.4	88.0	85.4	85.0	84.4
17	2000	82.1	82.4	84.1	85.7	86.4	86.4	88.4	86.7	86.4	84.7
18	2500	91.4	91.4	90.1	90.1	90.1	90.1	89.4	89.1	87.7	87.1
19	3150	107.9	107.5	107.2	105.9	102.2	98.2	96.5	92.5	90.2	88.9
20	4000	112.6	116.6	111.9	110.9	106.6	102.9	100.6	94.5	91.9	89.2
21	5000	110.5	112.2	113.2	115.2	115.2	111.2	108.5	100.5	96.2	91.2
22	6300	109.1	109.8	109.4	112.1	111.7	108.8	105.8	98.8	94.1	91.1
23	8000	108.7	107.4	105.4	105.4	100.4	98.4	96.4	92.0	87.4	88.4
24	10000	108.9	109.6	107.2	109.2	105.6	102.9	99.5	91.6	87.6	87.6
25	12500	107.1	108.4	105.4	106.1	102.4	100.4	98.4	83.8	85.4	85.8
26	16000	105.8	105.8	102.1	104.8	100.1	96.8	94.1	86.5	83.1	83.8
27	20000	102.8	102.8	98.8	101.8	95.8	92.2	89.8	82.8	80.5	81.8

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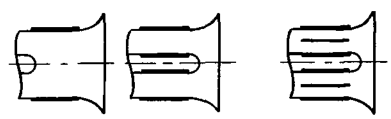
TABLE I. - NOISE SUPPRESSOR CONFIGURATIONS

[H denotes hard wall; S denotes soft wall; - denotes omitted.]



Treated surface		Cylinder		Annulus			Concentric annuli		
1	Centerbody	-	-	H	H	S	H	H	S
2	Splitter inside surface	-	-	-	-	-	H	S	S
3	Splitter outside surface	-	-	-	-	-	H	S	S
4	Cowl	H	S	H	S	S	H	H	S

TABLE II. - ENGINE AERODYNAMIC AND ACOUSTIC PARAMETERS

Configuration	Engine speed, percent	Inlet static temperature		Inlet static pressure		Inlet Mach number	Inlet overall sound pressure level, dB	First-stage blade passage frequency, Hz	Ratio of treated surface area to flow cross-sectional area, S/A	Distance between treated surfaces in symmetrical duct, D_e		Treated area, S	
		^oC	^oF	N/m^2	psi					cm	in.	m^2	ft^2
S- -S	50	6.7	44	97 970	14.21	0.092	145	2568	6.95	21.97	8.65	2.586	27.84
↓	60	6.1	43	97 420	14.13	.127	148	3082	↓	↓	↓	↓	↓
	70	5.5	42	96 460	13.99	.175	149	3596					
	80	3.9	39	94 390	13.69	.249	148	4110					
	90	1.1	34	91 420	13.26	.328	147	4623					
	100	-1.7	29	88 110	12.78	.402	146	5137					
---S	50	7.2	45	98 390	14.27	.076	143	2568	4.01	75.95	29.9	1.818	19.57
H--S	↓	16.1	61	98 040	14.22	.091	145	↓	4.88	43.94	17.3	1.818	19.57
HSSH		20.0	68	98 390	14.27	.119	147		9.12	16.76	6.60	2.585	27.83
SSSS		1.1	34	99 280	14.40	.123	147		18.25	8.38	3.30	5.171	55.67

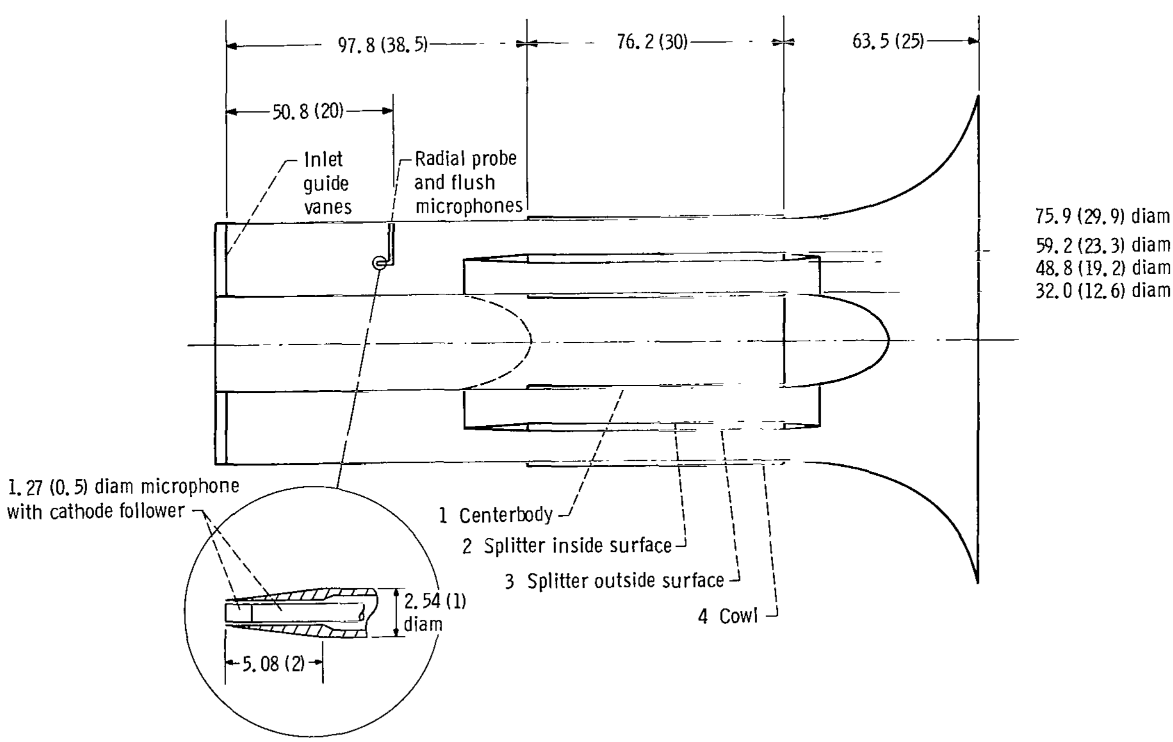


Figure 1. - Inlet and suppressor geometry. (Dimensions are in cm (in.).)

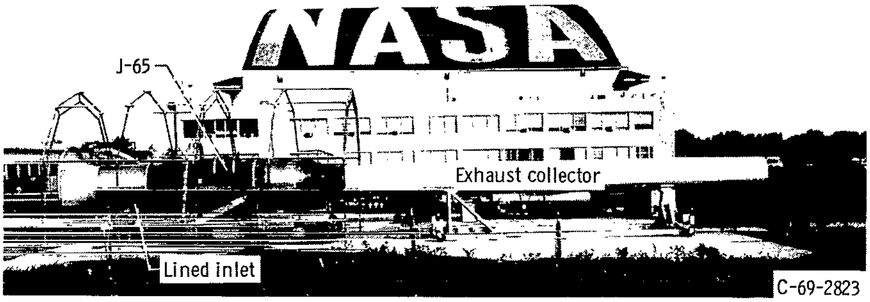


Figure 2. - J-65 Turbojet engine with lined inlet and exhaust collector.

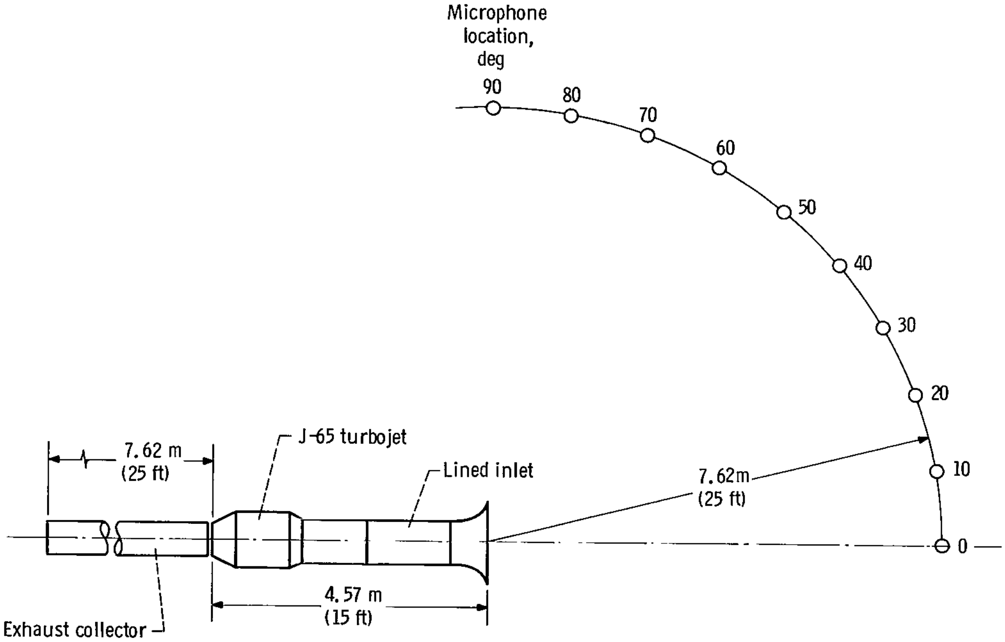


Figure 3. - Plan of test site.

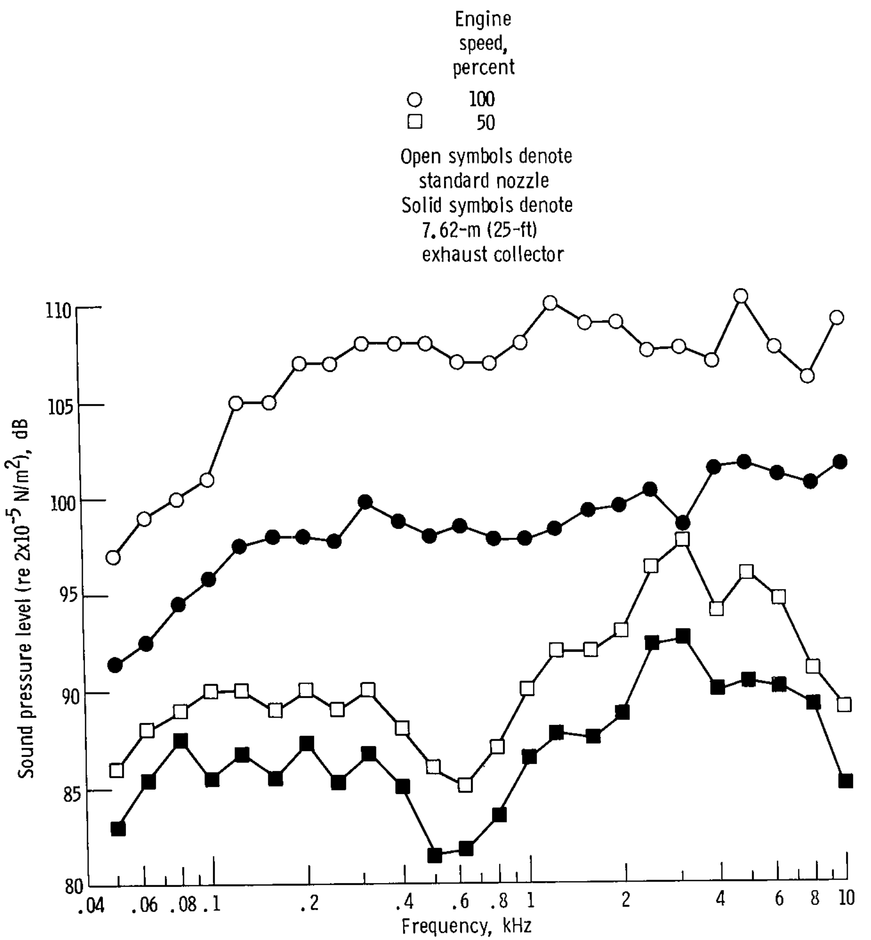


Figure 4. - Effect of exhaust collector on 1/3-octave sound pressure levels at 90° microphone. Configuration, ---H. 7.62 m (25 ft) radius.

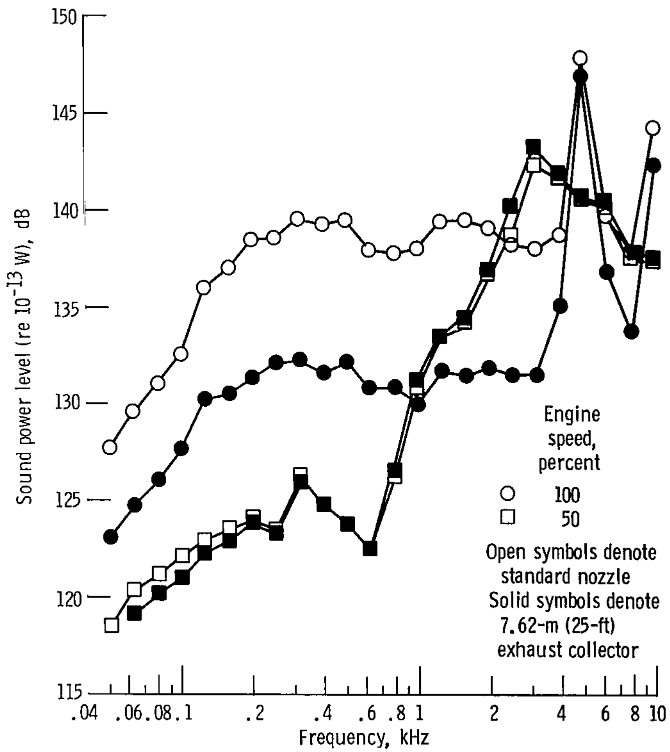


Figure 5. - Effect of exhaust collector on power spectra for inlet hemisphere. Configuration, ---H.

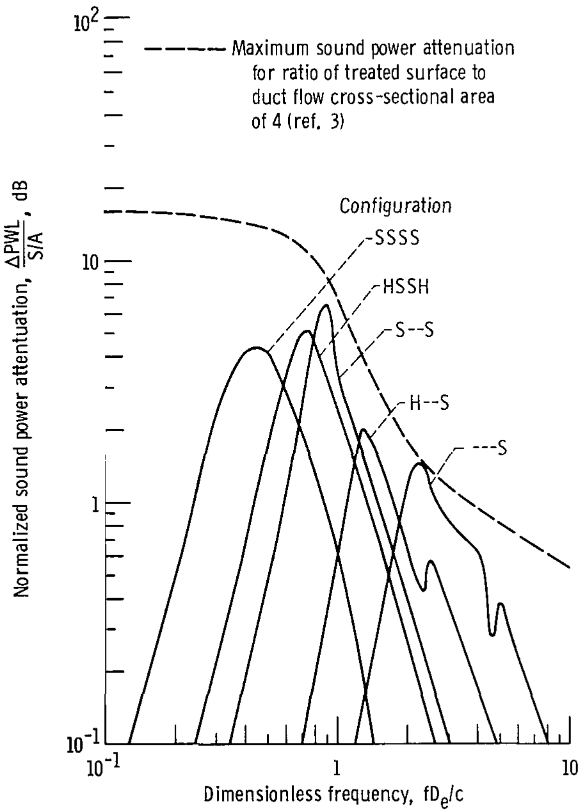


Figure 6. - Calculated attenuation spectra at 50-percent engine speed.

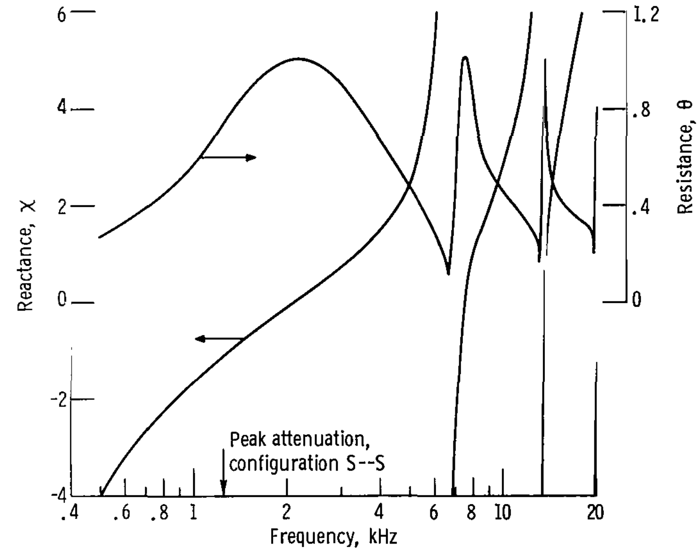


Figure 7. - Calculated resistance and reactance of perforated plate - honeycomb wall construction. Open-area ratio of perforated plate, 0.08; thickness of perforated plate, 0.051 centimeter (0.02 in.); hole diameter, 0.127 centimeter (0.05 in.); depth of resonator cavities, 2.54 centimeter (1 in.); average steady-flow Mach number, 0.092; overall sound pressure level, 145 decibels; static temperature, 6.7° C (44° F); static pressure, 9.797×10^4 newtons per square meter (14.21 psi).

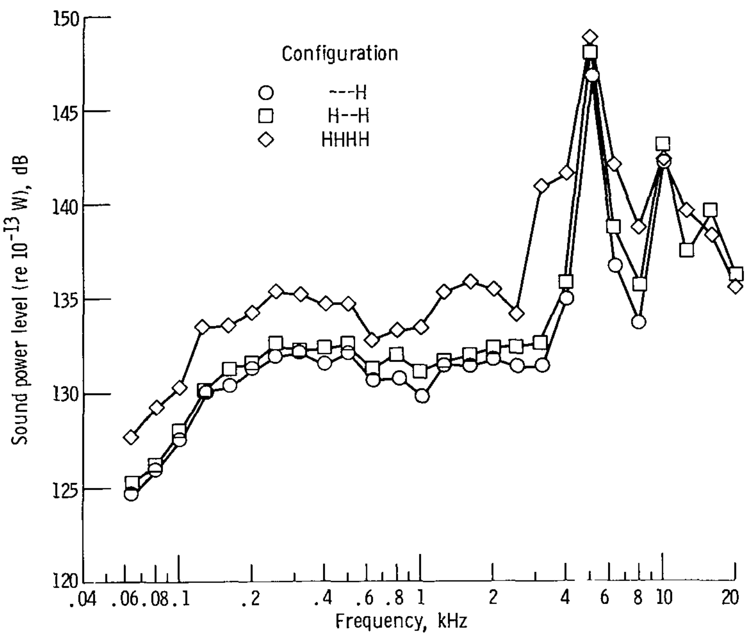
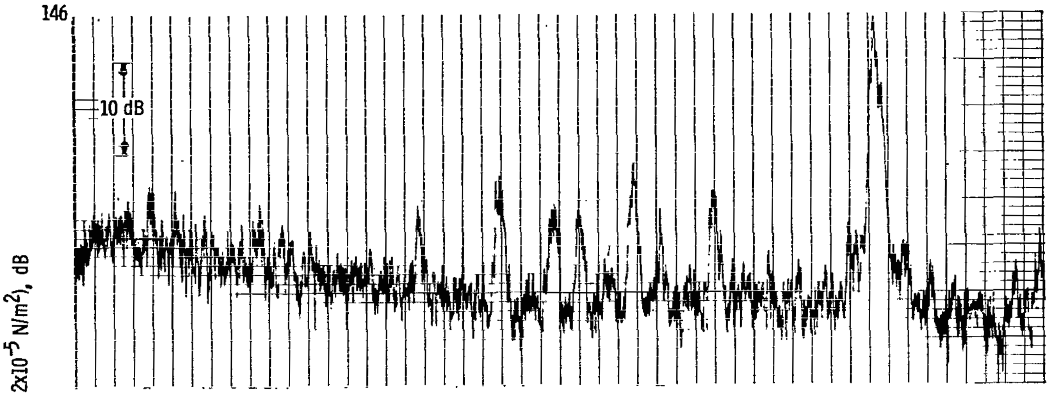
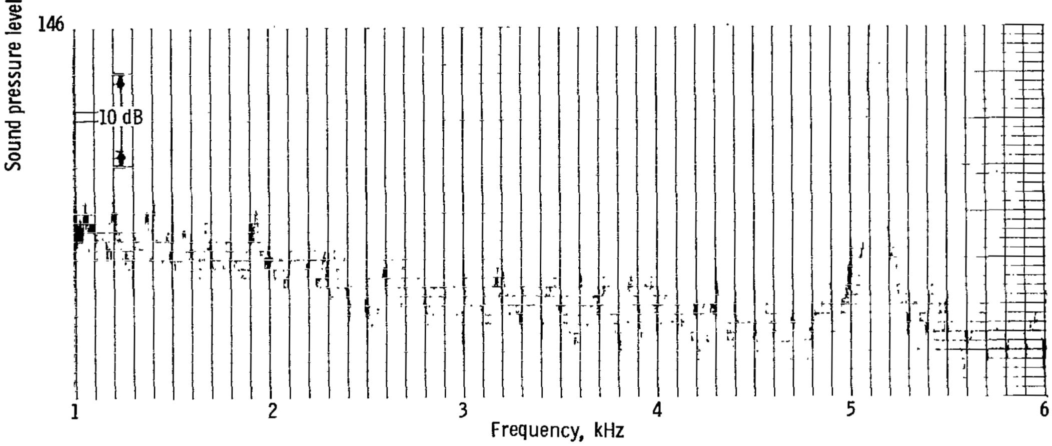


Figure 8. - Hard-wall power spectra at 100-percent engine speed.

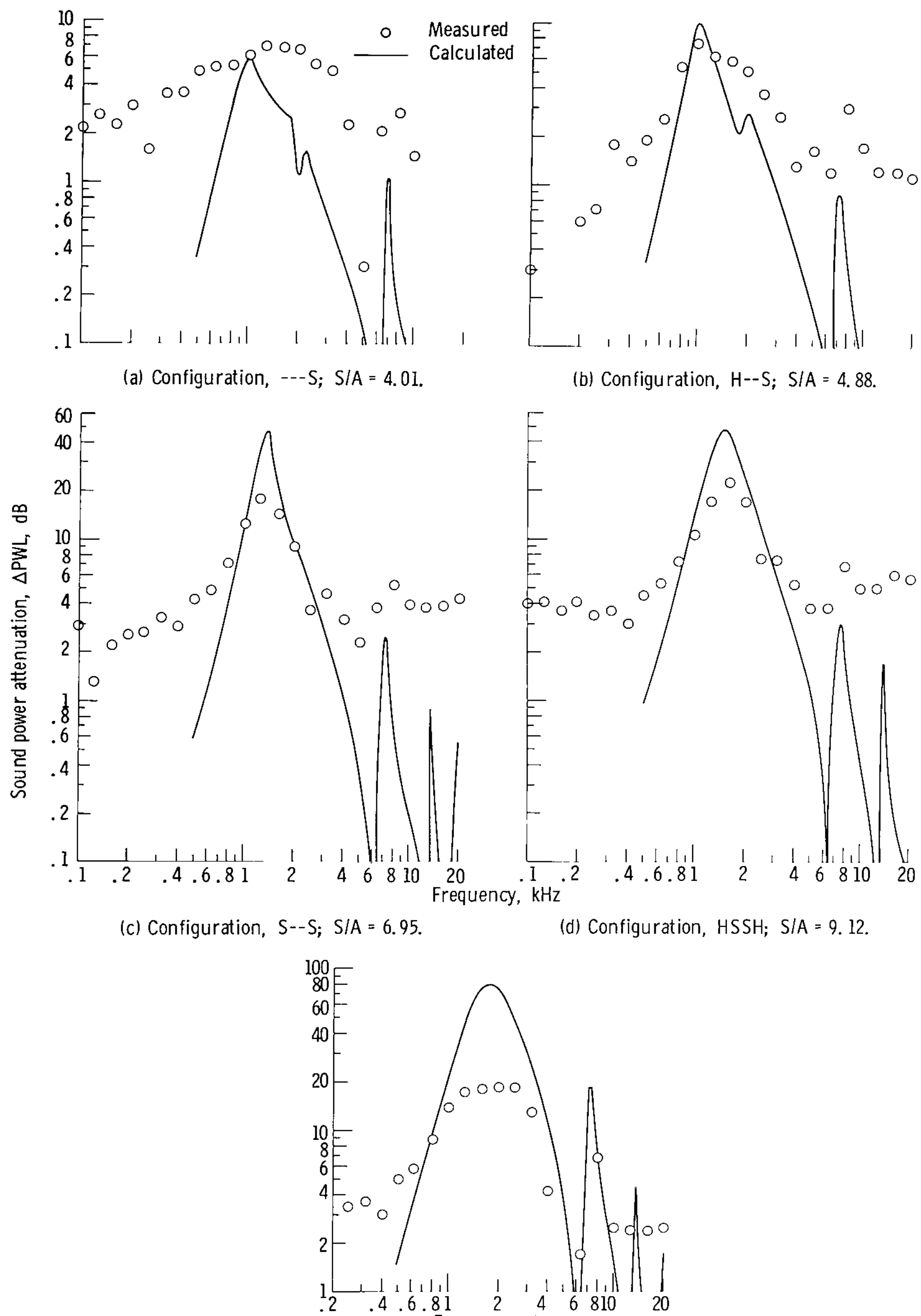


(a) 2.54 Centimeters (1 in.) from cowl.



(b) 18.5 Centimeters (7.3 in.) from engine axis.

Figure 9. - 50-Hertz narrowband spectra of radial probe microphone. Engine speed, 100 percent; configuration, ---H.



(a) Configuration, ---S; S/A = 4.01.

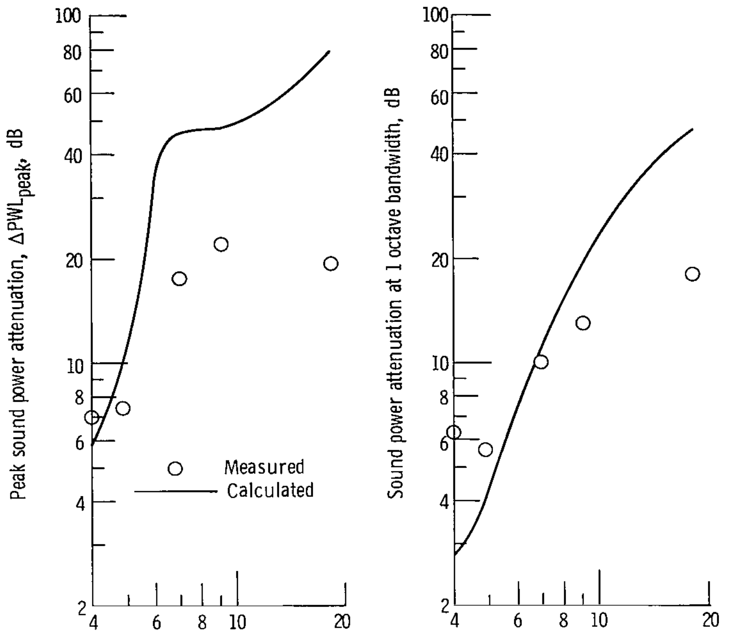
(b) Configuration, H--S; S/A = 4.88.

(c) Configuration, S--S; S/A = 6.95.

(d) Configuration, HSSH; S/A = 9.12.

(e) Configuration, SSSS; S/A = 18.25.

Figure 10. - Sound power attenuation spectra for various inlet geometries at 50-percent engine speed. (S/A is the ratio of treated surface area to duct flow cross-sectional area.)



(a) Peak attenuation.

(b) Attenuation at 1-octave bandwidth.

Figure 11. - Attenuation magnitudes at 50-percent engine speed.

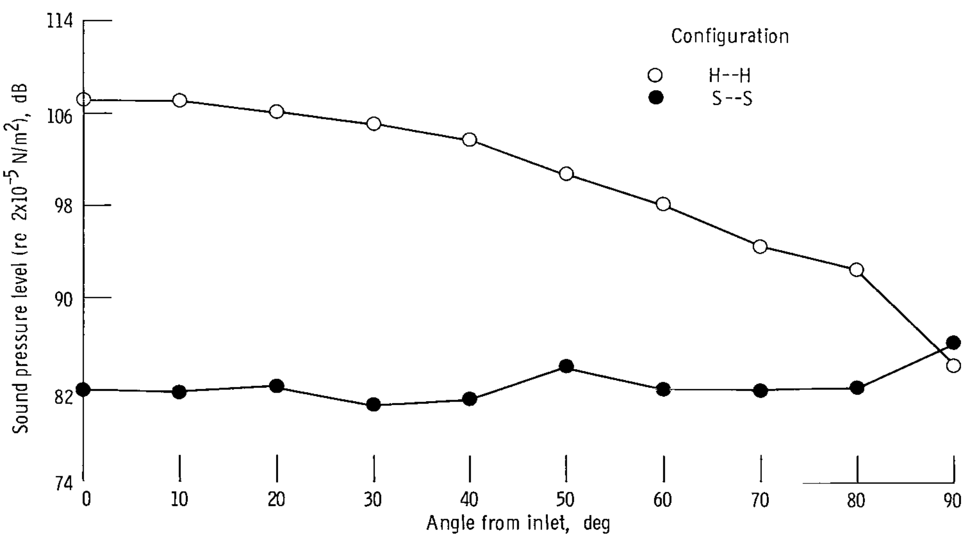


Figure 12. - Angular variation of sound pressure level in 1250-hertz 1/3-octave band for hard and soft annular inlets at 50-percent engine speed. 7.62 m (25 ft) radius.

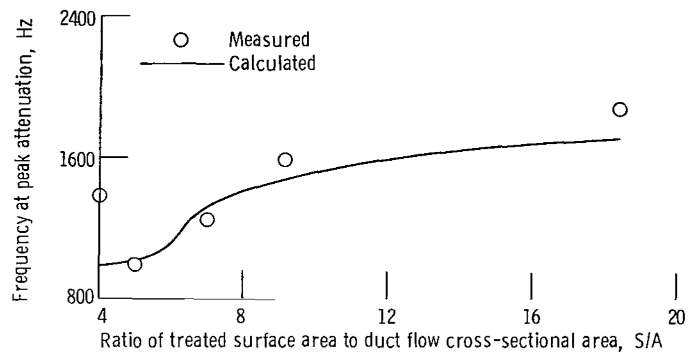


Figure 13. - Frequency at peak attenuation, at 50-percent engine speed.

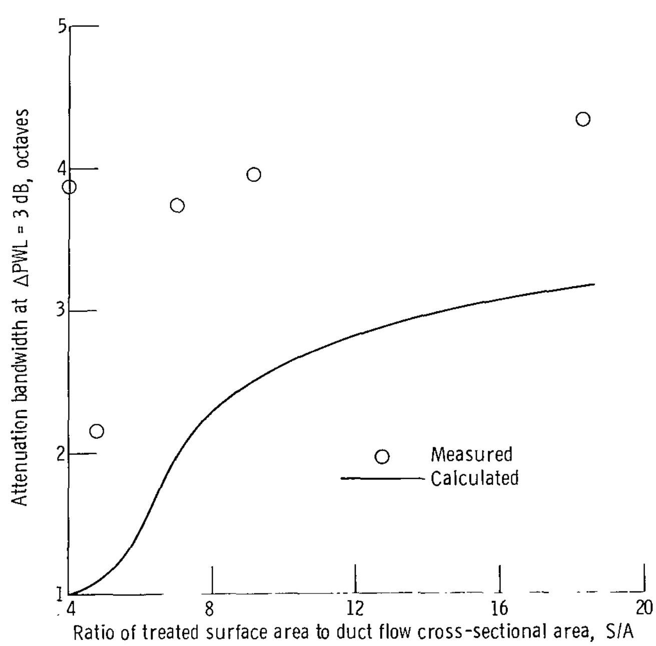
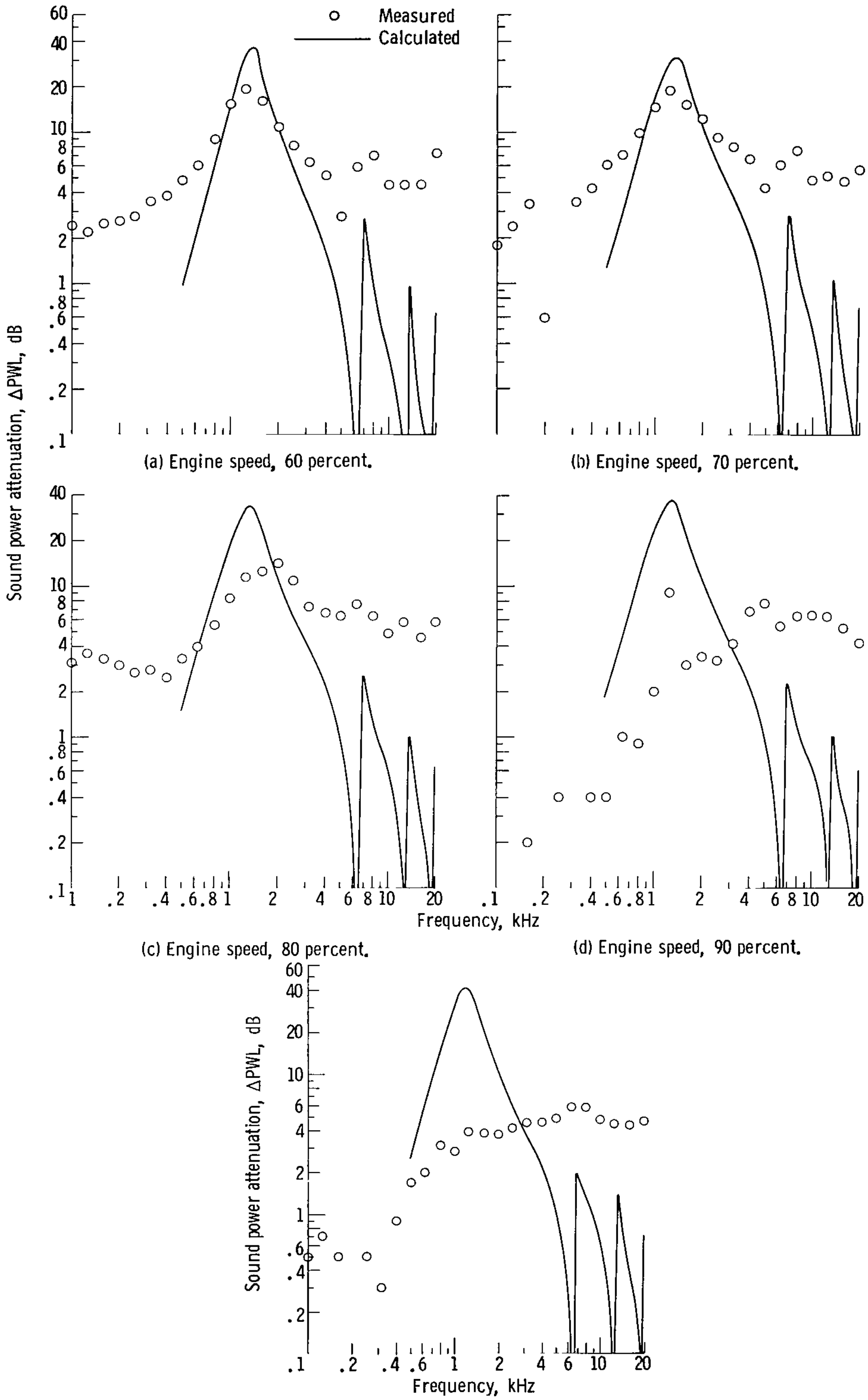


Figure 14. - Attenuation bandwidths at 50-percent engine speed.



(a) Engine speed, 60 percent.

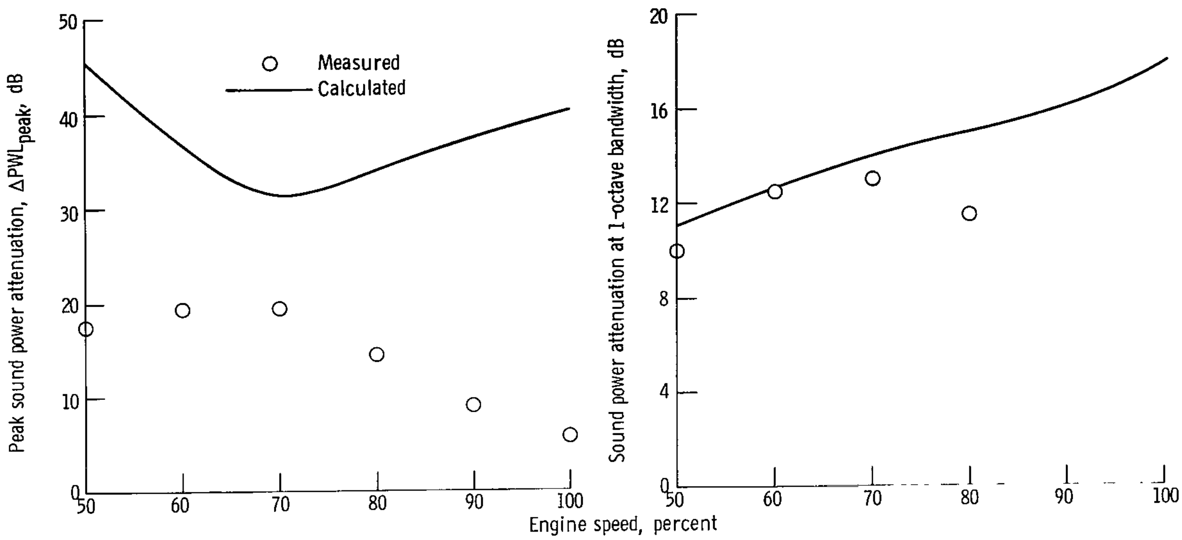
(b) Engine speed, 70 percent.

(c) Engine speed, 80 percent.

(d) Engine speed, 90 percent.

(e) Engine speed, 100 percent.

Figure 15. - Sound power attenuation spectra for configuration S--S as function of engine speed.



(a) Peak attenuation.

(b) Attenuation at 1-octave bandwidth.

Figure 16. - Attenuation magnitudes as function of engine speed.

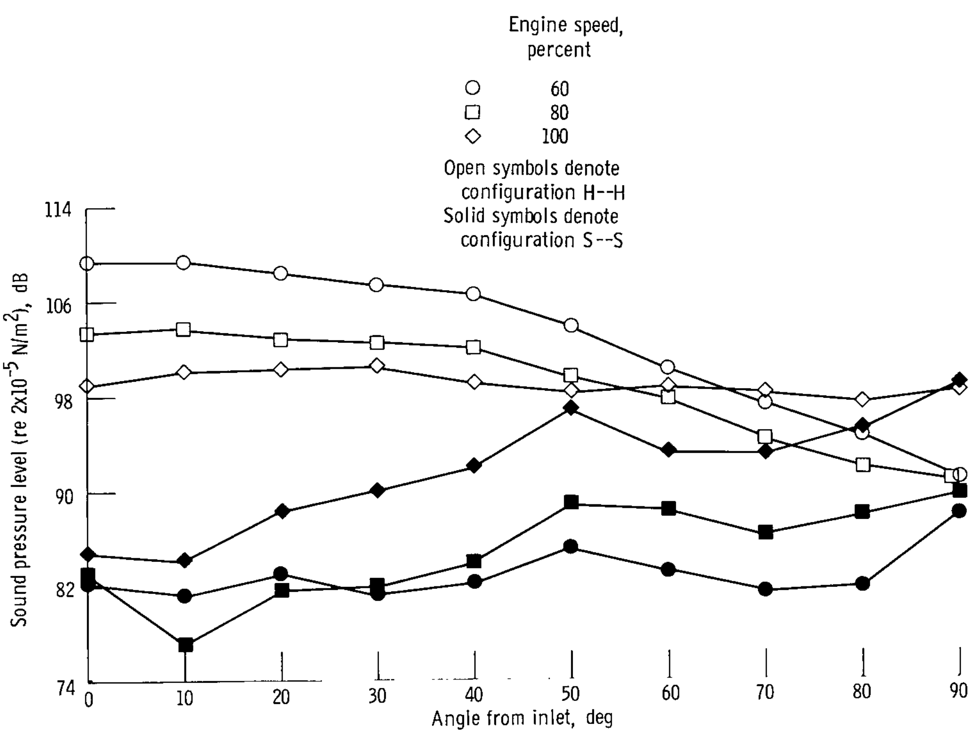


Figure 17. - Angular variation of sound pressure level in 1250-hertz 1/3-octave band for hard and soft annular inlets, engine speed as parameter. 7.62 m (25 ft) radius.

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