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ABSTRACT

Three supersonic helical tip speed propellers were tested in the NASA Lewis 8- by 6-Foot Wind Tunnel. This is a perforated-wall wind tunnel but it does not have acoustic damping material on its walls. The propellers were tested at tunnel through flow Mach numbers of 0.6, 0.7, 0.75, 0.8, and 0.85 with different rotational speeds and blade setting angles. The three propellers, which had approximately the same aerodynamic performance, incorporated different plan forms and different amounts of sweep and yielded different near field noise levels. The acoustically designed propeller had 45° of tip sweep and was significantly quieter at $M = 0.8$ cruise than the straight bladed propeller. The intermediate 30° tip sweep propeller, which was swept for aerodynamic purposes, exhibited noise that was between the other two propellers. Noise trends with varying helical tip Mach number and blade loading were also observed.

SUMMARY

A high tip speed turboprop engine is being considered as a propulsor for a future energy conservative airplane. When the turboprop airplane is at cruise, the combination of the airplane forward speed and the propeller rotational speed results in supersonic helical velocities over the outer portions of the propeller blades. These supersonic blade sections could generate noise that would cause a cabin environment problem. In order to explore this problem, three 0.622 meter (24.5 in.) diameter propellers were acoustically tested in the NASA Lewis 8- by 6-Foot Wind Tunnel. This is a perforated-wall wind tunnel but it does not have acoustic damping material on its walls. The propellers were tested at tunnel through flow Mach numbers of 0.6, 0.7, 0.75, 0.80, and 0.85 with different rotational speeds and blade setting angles. The three propellers, which had approximately the same aerodynamic performance, incorporated different plan forms and different amounts of sweep and yielded different near field noise levels. The acoustically designed propeller, SR-3, had 45° of tip sweep and was significantly quieter at Mach 0.8 cruise than the straight bladed propeller, SR-2. The intermediate 30° tip sweep propeller, SR-1m, which was swept for aerodynamic purposes, exhibited noise that was between the other two propellers. Enhanced pressure-time traces indicated that SR-2 and SR-1m exhibited shock-like pressure traces at Mach-0.8 cruise while the SR-3 propeller did not appear shock like. Noise trends with varying helical tip Mach number and blade loading were also observed.

INTRODUCTION

One of the candidate engines for a future energy conservative airplane is a high tip speed turboprop. When the turboprop airplane is at cruise, the combination of the airplane forward speed and the propeller rotational speed results in supersonic helical velocities over the outer portions of the propeller blades. During flight these supersonic blade sections and associated shock waves generate significant noise that might become a cabin environment noise problem.

For the purpose of obtaining a preliminary indication of the noise from this type of propeller, three propellers were tested in the NASA Lewis 8- by 6-Foot Wind Tunnel. These propellers were designed and fabricated for NASA by the Hamilton Standard Division of United Technologies Corporation. The three propellers that were tested incorporated different planforms and different amounts of sweep and were therefore expected to give different noise levels. The propellers were nominally 0.622 meter (24.5 in.) in diameter and the acoustic information was gathered as an addendum to aerodynamic testing. The Lewis 8- by 6-Foot Wind Tunnel does not have acoustic damping material on any of its walls. Some of the possible effects of the untreated test arena on the acoustic data are discussed in reference 1 and later in this report. The data reported are the first acoustic results obtained for these high speed propellers operating at design rotational speed and cruise Mach number.

APPARATUS AND PROCEDURE

Propellers

Three eight-bladed propellers designed for blade tip supersonic helical velocity at 0.8 Mach number cruise were tested in the 8 by 6 wind tunnel to obtain noise data. The propellers were nominally 0.622 meter (24.5 in.) in diameter and a photograph of the three individual blades is shown in figure 1. The three blades have been designated SR-2, SR-1m and SR-3. The SR-2 blade is similar to a conventional straight propeller blade but with a long chord and a relatively low thickness to chord ratio of 2 percent at the tip. The SR-1m blade has some sweep built into the outboard sections. This sweep was designed to reduce the normal Mach number relative to the blade, thereby delaying the formation of shocks to a higher helical tip Mach number. This sweep was primarily aerodynamic for the purpose of reducing losses on the blade and amounted to about 30° of sweep at the tip. The SR-3 propeller blade is an attempt to incorporate sweep both for aerodynamics and as a noise control measure. The SR-3 blade has about 45° of tip sweep which gives even more of a delay in shock formation and a significantly different hub to tip distribution of sweep than does SR-1m. The radial distribution of sweep on SR-3 is to provide a phase cancellation of the noise from the different radial sections and provide an additional noise reduction. Further design details of the three propellers can be found in references 2 to 4 and a comparative listing of the propellers is found in table I.

Installation and Tests

The acoustic tests were performed in the Lewis 8- by 6-Foot Wind Tunnel. A plan view of this tunnel is shown in figure 2(a) and a picture of the SR-3 propeller in the test section is shown in figure 2(b). Six pressure transducers were installed in plugs placed in the tunnel bleed holes visible in figure 2(b). The location of the transducers were limited by the location of the available bleed holes. Four transducers were installed in the top wall and two were installed in the side wall. A sketch showing the location of the six transducers is found in figure 3.

The test points reported herein are summarized in figures 4, 5 and 6 which are for propellers SR-2, SR-1m and SR-3, respectively. In these figures each test point is presented at its value of power coefficient, C_p and advance ratio J. (A symbol list with definitions are found in the appendix.) In each of these figures part (a) is for the data taken at a tunnel Mach number, M_T, of 0.8 and part (b) are the points taken at the other tunnel Mach numbers of 0.6, 0.7, 0.75, and 0.85. In part (a) the different symbols indicate different blade angles while in part (b) all of the data were taken with the same blade angle. This blade angle in part (b) is the angle which would produce the cruise conditions at a tunnel Mach number of 0.8. The 0.8 Mach number data at this angle which are shown in part (a) are also reported on part (b). In addition to the test points indicated on these figures some limited data were taken with the SR-3 propeller in a feather condition (propeller almost stationary with the tunnel operating at different Mach numbers) to obtain an indication of the tunnel background noise.

RESULTS AND DISCUSSION

The signals from the six pressure transducers and a once per revolution trigger signal were recorded on magnetic tape. Narrow band data from 0 to 10,000 Hertz, with a bandwidth of approximately 26 Hertz, were taken at all of the test points indicated in figures 4, 5 and 6. The sound pressure levels for the first eight harmonics for the tests points are tabulated in tables II, III and IV. In addition, to provide pressure-time pulse shapes, some of the test data were "signal enhanced" by averaging the pressure signals from many revolutions of the propeller using the once per revolution signal as a trigger.

Background Noise and Tunnel Wall Reflections

Two areas of concern exist about the quality of the noise data in this tunnel. These are the tunnel background noise and the tunnel wall reflections and their effect on the data. The tunnel background noise problem exists primarily because the tunnel drive compressor is so close to the test section (see fig. 2(a) that its noise might be louder than the propeller. The noise of this compressor was measured previously with nothing in the test section (ref. 5). During the present investigation baseline noise signatures were taken with the SR-3 propeller installed in the tunnel but with the blades in a feather position. Selected comparisons are made between the spectra of the SR-3 propeller at a simulated cruise condition and at the feather position in figure 7. Figure 7(a) is a comparison made at a tunnel Mach number of 0.8 at transducer position number 3. As can be seen the propeller tones are above the tunnel background. It should however be noted that the broadband noise between the tones is controlled primarily by the tunnel background. In figure 7(b), which is at a tunnel Mach number of 0.6, the propeller blade passage tone is just barely visible above the tunnel background. The harmonics of the tone have been masked by the tunnel background noise. Some of the propeller broadband noise is indicated in this figure. However the propeller broadband noise shows up at only a few test conditions and is therefore not covered in this report. At some test conditions (not shown in fig. 7) the entire propeller spectrum is masked by the tunnel background noise. In tables II, III and IV the tone levels are tabulated for those conditions where the tones are visible above the tunnel background and those where the tunnel background masks the tone have been indicated by the symbol N.V. for not visible.

The other problem that might exist with the data is reflections of the propeller noise from the walls of the tunnel. Although it is not possible to prove that the propeller noise data measured in the tunnel are free of reflection-caused errors, some indications exist that the problem is not as severe as first thought possible. Since the tunnel walls were not acoustically treated, it was possible that the reflections in this tunnel might have produced a reverberant level which would be too high to obtain useful data. Two factors indicate that this was not the case. By observing the four top wall mounted transducers a significant directivity of the blade passage tone is observed in the axial direction. For example, in table II for the SR-2 propeller simulated cruise conditions (tunnel Mach number = 0.8, 60° blade angle $J = 3.07$, $C_P = 2.04$) a 16-dB difference exists between the blade passage tone at the third and first transducer positions. At most, but not all, test conditions a reduction with distance can also be observed. Again referring to the same test condition in table II, a reduction in the blade passage tone of 7 dB can be observed between the "close" side wall transducer No. 5 and the "far" top wall transducer No. 2, both located at 90° to the propeller. This falloff of the noise with distance and the observed directivity of the noise indicate that the tunnel reflections do not everywhere dominate the direct-incidence noise signals. This gives an indication that valid information concerning the noise generated by these propellers was obtained. The strength of the reflections in the tunnel may have been affected by the tunnel bleed holes (see fig. 2(b)) acting as acoustic absorbers to improve the tunnel acoustic properties. Another possibility is that the large flow velocity and thus large convective effect in this tunnel does not allow the buildup of a high reverberent level.

Simulated Mach 0.8 Cruise

Spectra. - The most significant noise data taken during this testing were the simulated design cruise data at a tunnel Mach number of 0.8. The three propellers were all tested to simulate a cruise condition with a tip Mach number of 0.821 and a helical tip Mach number, M_H, of 1.147. In tables II, III and IV these cruise points occur at $J = 3.07$ for all propellers and at a $\beta = 60^\circ$ for SR-2 and SR-1m and $\beta = 61.3^\circ$ for SR-3.

The most complete set of directivity data is on the top wall where the four transducers are at approximately 77°, 90°, 110° and 130° angles from the inlet axis. The largest noise levels at $M = 0.8$ cruise on this top wall were obtained at the No. 3 (110°) transducer position for all of the propellers, therefore this position will be used as the comparison point for the 0.8 data. Figure 8 is a composite plot of the narrow-band spectra for this No. 3 transducer. Figure 8(a) compares SR-2 and SR-1m while 8(b) shows SR-2 and SR-3. As can be observed from figure 8(a) SR-1m is 1 to 2 dB less noisy than SR-2 at the blade passage tone and is lower at most of the harmonics with 4 x BPF being an exception. The noise reduction between SR-2 and SR-1m may be a result of the aerodynamic sweep incorporated in SR-1m. It can be observed from figure 8(b) that SR-3 is slightly more than 5 dB quieter than SR-2 at the blade passage tone. Since SR-3 incorporated sweep tailored to yield an acoustic reduction at this cruise condition, the 5 dB reduction indicates merit for this acoustic technique. Again reductions in the harmonics were present with 4 x BPF being the exception.

Directivity. - The general trend observed at the 110° angle for the Mach 0.8 cruise condition occurred at other angles also. Figure 9 is a plot of the blade passage tone for the four positions on the top wall. The noise levels measured by transducers 5 and 6, which are on a closer wall, are not presented on this figure because it is not clear how the values should be translated to the more distant top wall. This stems from an uncertainty in both the correction for attenuation with distance in this partially-reverberant tunnel and in the proper distance to use. Figure 9 shows the same general trend as figure 8 with SR-1m being slightly quieter and SR-3 being significantly quieter than SR-2. In this figure it is seen that at Mach 0.8 cruise the noise from these three propellers differs only slightly near the front (position 1) and tends to have the largest differences in the rear (position 4). The difference between SR-2 and SR-3 ranges from about 2 dB at position 1 to over 7 dB at position 4.

Pressure pulse. - Significant differences in character also existed among the "signal enhanced" pressure traces for the three propellers. These traces were taken by triggering the start of the averaging with a once per revolution signal. The signals were averaged 1024 times to obtain the traces presented in figure 10. Figure 10 presents the averaged traces for the transducer closest to the propeller which was located at position 5 (90° on the side wall). The total time for figure 10 is .003 seconds and the traces for approximately three successive propeller blades can be seen on each figure. As can be seen in figures 10(a) and (b) the traces for SR-2 and SR-1m show a steep fronted wave which approaches the classic N wave shock pattern. However, in the plot for the quieter SR-3 blade, figure 10(c), an almost sinusoidal wave was observed which is also of considerably less amplitude. These differences in the character of the traces indicate that the acoustic sweep built into SR-3 has been successful in reducing the sharp pressure rises that would normally be associated with supersonic helical tip speed propellers and which were present in SR-2 and SR-1m.

Projections to full scale. - Even though the acoustic conditions were not optimum in this tunnel, the projections of the scale model cruise condition tunnel measured data to the fuselage of a full scale airplane are of interest. In the projection of this data the sound will be assumed to scale as 10 times the log of the propeller input power ratio and the attenuation with distance as 20 times the log of the distance ratio. If the full scale noise is observed at the same normalized distance measured in propeller diameters as the scale data, the power and distance corrections cancel out. It is assumed in this projection that the "pressure doubling effect" of the wall of the tunnel is the same as that for the fuselage so no correction is necessary. The only magnitude correction to this data is then due to the differences in atmosphere conditions between the tunnel test and the 10.7 kilometer (35 000 ft) cruise condition. For the Mach 0.8 conditions the tunnel was operating at an average temperature of 279 K (503 °R) and an average pressure of 0.78×10^5 $N/_M2$ (11.3 psi). The standard conditions at 10.7 km (35 000 ft) are a temperature of 219 K (394 °R) and a pressure of 0.24×10^5 $N/_M2$ (3.46 psi). Using these conditions, figure 2.3 page 36 of reference 6 indicates that the tunnel data should be reduced by 4.5 dB. This correction is for the M = 0.8 tunnel condition and different corrections would apply at other tunnel conditions. With this correction, the projected blade passage tone levels at their maximum position (110° position 3) for the full scale propellers, measured on the airplane fuselage 1.5 diameters from the propeller tip, are from figure 9: SR-2, 145 dB; SR-1m, 143.5 dB; and SR-3, 139.5 dB.

Data Trends

Variation with helical tip Mach number. - The variations of the noise with helical tip Mach number (the resultant of the axial and circumferential Mach numbers) are of particular interest for observing the behavior of the three propellers. Figure 11 is a plot of the maximum blade passage tone on the top wall versus the helical tip Mach number. These values were obtained by operating the propeller at a fixed blade setting angle at different tunnel Mach numbers. The advance ratio, J, for all of these data points was held at a nominal 3.06 to attempt to approximate the probable manner in which a given propeller would operate at the different cruise Mach numbers. This plot approximates the noise of propellers designed to operate at these different Mach numbers. On figures 4(b), 5(b), and 6(b) the test points are the cluster of points in a vertical line at an advance ratio, J, of 3.06. As can be seen this resulted in only a small variation in power coefficient for the points presented. However, a significant variation in total power does exist, so these are not constant power curves. Another method of obtaining these trends with helical tip Mach number would have been to investigate the data at a constant tunnel Mach number and varying blade setting angles, to give the same power loading. These would be represented by horizontal lines on figures 4(a), 5(a), and 6(a). Because of the lack of available data (see figs. 4(a), 5(a), 6(a), and tables II, III, and IV) and the limited helical tip Mach number range this approach was not profitable.

The data presented on figure 11 show definite trends of the data with helical tip Mach number. The plots for the three propellers all exhibit a region of sharp noise increase with increasing helical tip Mach number which is then followed by a region where the noise levels off. These curves are similar in shape to the noise curve for various existing propellers operating at different cruise Mach numbers presented in figure 20 of reference 7. Some interesting trends exist in the data on figure 11. It appears that the aerodynamic sweep of SR-1m (30° at the tip) has delayed the sharp rise of the noise to a higher helical tip Mach number. This gives the SR-1m blade a significant noise advantage over the SR-2 blade in the helical Mach number range from about 0.85 to 1.0. However as the cruise point at a tunnel Mach number of 0.8, helical tip Mach number = 1.14, is approached, the sweep benefit is lost and the SR-1m propeller is only slightly quieter than SR-2. The SR-2 and SR-1m have almost the same noise at a helical Mach number of 1.2.

The data for the SR-3 propeller shows even more of a helical tip Mach number delay in the start of the noise rise than did SR-1m. This is probably attributable to the increased amount of tip sweep, 45° for SR-3 as opposed to 30° for SR-1m. In addition to having increased sweep, the SR-3 blade had the sweep tailored to provide an additional noise reduction. This additional reduction appears to be present in the data of figure 11. Whereas both SR-1m and SR-2 tend to have the same asymtotic noise level at higher helical tip Mach numbers the SR-3 asymtote appears to be about 5 decibels lower. So the SR-3 design shows both a delay in the helical tip Mach number where the noise increases and also a lower level to which the noise rises.

The pressure-time traces of data observed above and below the sharp noise rise show large differences for the SR-2 propeller. Figure 12 shows the SR-2 enhanced pressure-time trace for the 0.857 helical Mach number case of figure 11. When figure 12 is compared with the pressure-time trace at a helical Mach number of 1.14 shown in figure 10(a), it can be seen that the trace which was a sharp shock-type N wave at 1.14 helical tip Mach number has taken on a smooth sinusoidal appearance at 0.857. This tends to indicate that the sharp rises in the noise curves of figure 11 are associated with transition from subsonic to supersonic flows on the propeller blades. This also lends some credence to the supposition that the sweeps incorporated in SR-1m and SR-3 lower the normal Mach numbers to the blades and move the noise rise to a higher helical tip Mach number.

Variation with loading. - The variation with loading at a tunnel Mach of 0.8 is shown in figure 13 where the maximum blade passage tone is plotted versus C_p. The data are all taken at a helical tip Mach number of approximately 1.14 achieved by taking test points in a vertical line at J= 3.06 on figures 4(a), 5(a), and 6(a). These points are taken at different blade setting angles and represent a considerable range of loadings with C_p varying from near 0 to over 2.0. On figure 13 the noise of all three propellers depends slightly on power coefficient with the variation in the blade passage tone being less than 10 dB reduction for the entire range. The slope of the lines appear to be almost the same for the three propellers indicating the same loading behavior. The data suggest that some reduction in noise might be achieved by decreasing the loading on the blades. At least part of the reduction, however, would probably be lost because the size of the propeller would have to be increased to provide the same total propulsive force for a given airplane.

CONCLUDING REMARKS

Three supersonic helical tip speed propellers were acoustically tested in the NASA-Lewis 8- by 6-Foot Wind Tunnel. Data are presented with the three propellers operating at a simulated cruise condition, with a tunnel Mach number of 0.8, a rotational tip Mach number of 0.821 and therefore a helical tip Mach number of 1.14. These data indicate that the straight bladed propeller, SR-2, was the noisiest. The SR-1m propeller which incorporated some aerodynamic sweep was marginally quieter than SR-2. The third propeller, SR-3, which had a sweep distribution tailored for noise reduction purposes, showed the lowest noise level. This reduction in blade passage frequency noise of SR-3 from the levels of SR-2 ranged from 2 to 7 dB at the measuring points on the top wall of the wind tunnel. The peak blade passage tone noise level on this wall was reduced over 5 dB. Enhanced pressure-time traces for SR-2 and SR-1m were "N" shaped and shock-like in nature. The SR-3 pressure traces were sinusoidal, possibly indicating that the sweep on the SR-3 blades had sufficiently reduced the velocities so that the shocks were no longer significant. Projections of this data to an airplane at M = 0.8 cruise enabled calculation of the maximum blade passage tone levels for the three propellers on a fuselage 1.5 diameters away. These levels were 145 dB for SR-2, 143.5 dB for SR-1m and 139.5 dB for SR-3.

Data were also taken at tunnel Mach numbers of 0.85, 0.75, 0.7 and 0.6. Additional data were also taken at Mach number of 0.8 with blade setting angles different than the cruise condition described above. Plots of the maximum blade passage tone noise level variation with helical tip Mach number were taken by using data obtained at simulated cruise conditions (all with J approximately equal 3.06) at the different tunnel Mach numbers. These curves exhibited an area of sharp noise rise as the helical tip Mach number was increased. When compared to the SR-2 curve, this region of sharp noise increase was delayed to a higher helical tip Mach number by the sweep built into SR-1m and higher still by that built into SR-3. In addition the SR-1m and SR-2 propellers approach the same limit after the sharp increase while SR-3 approaches a lower level. The lower noise at the limit is a result of the noise reducing sweep distribution designed into SR-3. Noise varied with loading and showed a 10 dB variation over the entire range of power coefficient tested, C_p = 0.2 to 2.0.

APPENDIX - SYMBOLS

c	speed of sound
C_p	power coefficient, $C_p = P/\rho N^3D^5$
D	propeller diameter
J	advance ratio, $J = V/ND$
M_H	helical tip Mach number (vector sum of tip rotational and tunnel axial Mach numbers)
M_T	tunnel axial Mach number
N	propeller rotational speed (revolutions/time)
P	shaft input power
V	tunnel axial velocity
Z	axial distance from propeller plane (positive downstream)
β	blade angle at 0.75 radius with respect to plane of rotation
ρ	density

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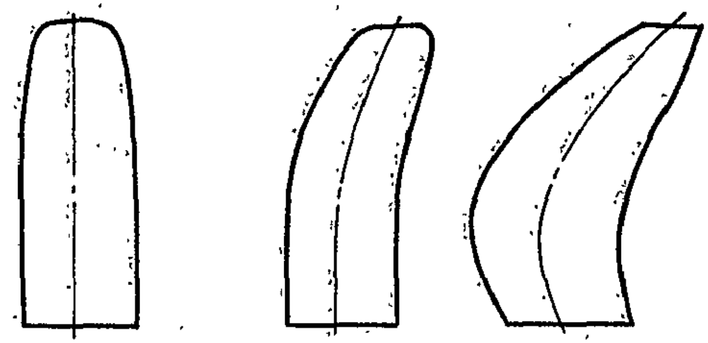
TABLE I. - COMPARISON OF PROPELLERS



	SR-2	SR-1M	SR-3
Design cruise tip speed, m/sec (ft/sec)	244 (800)	244 (800)	244 (800)
Design cruise power loading, P/D^2, kW/m^2 (shp/ft^2)	301 (37.5)	301 (37.5)	301 (37.5)
Number of blades	8	8	8
Tip sweep angle, deg	0	30	45
Design efficiency, %	77	79	81
Nominal diameter, D, cm (in.)	62.2 (24.5)	62.2 (24.5)	62.2 (24.5)

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS

Blade angle, β, deg		59°						59°						59°				
Tunnel Mach no., M_T		0.8						0.8						0.8				
Advance ratio, J		3.94						3.51						3.06				
Power coefficient, C_p		0						0.884						1.64				
Propeller rpm		6519						7321						8344				
Helical tip Mach no., M_H		1.02						1.07						1.14				
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	128.5	142.5	139	132	144.5	138.5	132.5	141	149	142	151	144
	2	NV	NV	NV	NV	NV	NV	124Ø	136.5	131.5	128	139	128.5Ø	123.5Ø	137	136.5	135.5	143	133.5
	3	NV	NV	NV	NV	NV	NV	NV	130.5	126Ø	125.5	131.5	126	NV	133	135	127.5	138.5	130
	4	NV	NV	NV	NV	NV	NV	NV	126	124	121Ø	126.5	123	NV	127.5	127	128	134	124.5
	5	NV	NV	NV	NV	NV	NV	NV	122	121.5	119.5Ø	123	NV	NV	124	125.5	125	131.5	124
	6	NV	NV	NV	NV	NV	NV	NV	119	120	117.5Ø	119.5	NV	NV	120	126	120.5	128	122.5
	7	NV	NV	NV	NV	NV	NV	NV	116.5Ø	118.5Ø	116.5Ø	NV	NV	NV	116.5	119.5	118.5	124.5	118
	8	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	114.5	121	119	122.5	116Ø

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		4.18						3.50						3.27					
Power coefficient, C_P		0						1.32						1.73					
Propeller rpm		6152						7322						7840					
Helical tip Mach no., M_H		1.00						1.07						1.11					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	132	145	139.5	136.5	144.5	141	136.5	148.5	148	134	149	140.5
	2	NV	NV	NV	NV	NV	NV	124Ø	139	134	128	137	128.5Ø	124.5Ø	137.5	132.5	132	141	133.5
	3	NV	NV	NV	NV	NV	NV	NV	136	126	126	129.5	126.5Ø	NV	132	129	127.5	136	127.5
	4	NV	NV	NV	NV	NV	NV	NV	131	123.5	121Ø	124	123Ø	NV	127	124.5	123.5	132.5	124.5
	5	NV	NV	NV	NV	NV	NV	NV	128	120.5Ø	120.5Ø	122.5	122Ø	NV	123.5	124.5	121	128	122Ø
	6	NV	NV	NV	NV	NV	NV	NV	124	120.5	NV	NV	NV	NV	120	122	118.5	124.5	121Ø
	7	NV	NV	NV	NV	NV	NV	NV	120.5	118.5	NV	NV	NV	NV	117.5	122	NV	121.5	NV
	8	NV	NV	NV	NV	NV	NV	NV	117.5	117.5	NV	NV	NV	NV	116Ø	120	NV	119.5	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						57°						57°					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		3.07						3.61						3.07					
Power coef- ficient, C_p		2.04						0						1.07					
Propeller rpm		8328						7063						8339					
Helical tip Mach no., M_H		1.14						1.05						1.14					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL dB ref. $2x10^{-5}$ N/m^2	1(BPF)	133	141	149.5	142.5	148	139Ø	135.5	140	129.5Ø	127Ø	145	130.5	131.5	138.5	146.5	136.5	146	139.5
	2	124Ø	137	135.5	134	138.5Ø	135.5Ø	NV	131.5	127.5	127Ø	135	NV	NV	136	136	133	139.5	133.5
	3	122Ø	131.5	132.5	129.5	132.5	128.5	NV	128	125.5Ø	125.5Ø	127.5	NV	NV	130.5	132	126.5	134	126.5
	4	NV	126.5	128	126	128.5	126.5	NV	120.5Ø	122.5Ø	121Ø	NV	NV	NV	124.5	121.5Ø	124.5	130	122.5Ø
	5	NV	122.5	125	123.5	123.5	124	NV	118.5Ø	122.5	NV	NV	NV	NV	121	126	122.5	125	121.5Ø
	6	NV	119	124	121	120.5	120.5	NV	117Ø	120Ø	NV	NV	NV	NV	117.5	123.5	120	121.5	NV
	7	NV	116	121.5	118.5	117.5Ø	118	NV	NV	NV	NV	NV	NV	NV	NV	119	116Ø	119	NV
	8	NV	NV	117.5Ø	116.5	NV	116Ø	NV	NV	NV	NV	NV	NV	NV	NV	121	115.5Ø	116.5Ø	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE II - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		57°						54°						54°				
Tunnel Mach no., M_T		0.8						0.8						0.8				
Advance ration, J		2.82						3.15						3.07				
Power coef ficient, C_p		1.46						0						0.190				
Propeller rpm		9002						8143						8340				
Helical tip Mach no., M_H		1.18						1.13						1.14				
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m^2	1(BPF)	132.5	144	145	147	145	138	133	145.5	138	129.5	148	140	134.5	141	138	136.5	144.5	134.5
	2	NV	137	138.5	137	139.5	133	NV	134	134	127.5	138.5	129.5	NV	134	131	126.5Ø	139	127.5
	3	NV	132.5	130.5	132.5	133.5	127	NV	130	128	124.5	134	128.5	NV	130	131.5	127.5	134	127
	4	NV	127.5	131	131.5	129	126.5	NV	127.5	129	125	132	123.5	NV	124.5	126	126.5	129.5	124
	5	NV	123	129	125	124.5	125	NV	123	122.5	119Ø	127	124	NV	120.5	124.5	122.5	125	120.5Ø
	6	NV	119.5	122	120.5	121.5	122	NV	119	122	119	124	119.5Ø	NV	117.5Ø	NV	119.5	122	118.5Ø
	7	NV	116	119	119	118.5	118	NV	116Ø	NV	117.5	120.5	116.5Ø	NV	NV	121	117.5	119	NV
	8	NV	113.5Ø	120.5	118	116	117.5	NV	114Ø	119	115.5Ø	118.5	NV	NV	NV	117.5	115.5	117	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		54°						61°						61°					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		2.83						4.34						3.76					
Power coefficient, C_p		0.658						0						1.12					
Propeller rpm		9012						5873						6783					
Helical tip Mach no., M_H		1.19						.982						1.04					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m^2	1(BPF)	130.5	139.5	143	144	145	136	NV	NV	NV	NV	NV	NV	136.5Ø	138Ø	136Ø	138.5Ø	141.5Ø	NV
	2	NV	134	134	130.5	139	131.5	NV	NV	NV	NV	NV	NV	NV	133.5	131.5	NV	129Ø	NV
	3	NV	129.5	132.5	130	134	126	NV	NV	NV	NV	NV	NV	NV	127	NV	NV	NV	NV
	4	NV	125	129.5	125.5	130	123.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	5	NV	121	125	123.5	126	122	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	6	NV	117	124	120.5	122	119.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	7	NV	114.5Ø	120.5	118	119.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	8	NV	NV	117.5	118	116.5	116.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		61°						61°						60°					
Tunnel Mach no., M_T		0.8						0.8						0.85					
Advance ratio, J		3.51						3.26						4.05					
Power coefficient, C_p		1.60						2.05						0					
Propeller rpm		7276						7839						6655					
Helical tip Mach no., M_H		1.07						1.11						1.07					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL dB ref. 2×10^{-5} N/m^2	1(BPF)	130.5	145.5	143	137	146.5	141.5	135	150	149.5	134	150	141.5	NV	NV	NV	135.5Ø	142	NV
	2	NV	139	132.5	126Ø	137	128.5	124Ø	140	134.5	133.5	142.5	137	NV	NV	NV	131Ø	133	NV
	3	NV	134	125.5Ø	125.5Ø	132	126Ø	NV	135.5	129	129	137	128.5	NV	NV	129	127Ø	128.5	NV
	4	NV	130.5	123.5	121Ø	127.5	NV	NV	131	125Ø	124	134.5	126.5	NV	NV	127	123	125Ø	125.5
	5	NV	127.5	NV	120.5Ø	124	NV	NV	127	126	120.5	130	NV	NV	NV	123.5	122.5	122.5Ø	120.5Ø
	6	NV	123.5	120.5Ø	NV	120.5Ø	NV	NV	123	123.5	119	126	NV	NV	NV	121Ø	NV	NV	NV
	7	NV	120	118.5Ø	NV	NV	NV	NV	119.5	123	117.5Ø	123.5	NV	NV	NV	NV	NV	NV	NV
	8	NV	117	NV	NV	NV	NV	NV	117	122.5	116.5Ø	121.5	NV	NV	NV	NV	NV	NV	NV

Code:
- BT, Bad transducer
- NV, Not visible above tunnel background
- Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.85						0.85						0.85					
Advance ratio, J		3.49						3.26						3.07					
Power coef- ficient, C_P		1.22						1.60						1.89					
Propeller rpm		7716						8254						8798					
Helical tip Mach no., M_H		1.14						1.17						1.21					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m2	1(BPF)	NV	135.5	145.5	132	143	131.5	NV	138.5	144.5	142.5	143.5	140	124.5Ø	138	149.5	142	141	146.5
	2	NV	130	131	132	137	133.5	NV	128	136.5	133.5	135	135.5	NV	127.5	140.5	137.5	132	134
	3	NV	124Ø	132	125	132	128	NV	123Ø	128	130	129.5	133.5	NV	NV	137	134.5	126	128.5
	4	NV	120Ø	124.5	123	128	122	NV	119Ø	129.5	121.5Ø	124.5	123.5	NV	NV	132	127.5	NV	125
	5	NV	NV	121.5Ø	120	124	120Ø	NV	NV	129.5	120Ø	121Ø	125.5	NV	NV	129	124.5	NV	127
	6	NV	NV	126	NV	120.5	NV	NV	NV	126	120.5	NV	121	NV	NV	125	123.5	NV	122
	7	NV	NV	119.5Ø	117.5Ø	117.5	NV	NV	NV	120	118.5	NV	117Ø	NV	NV	121.5	120	NV	119
	8	NV	NV	117.5Ø	NV	NV	NV	NV	NV	118.5	117	NV	115Ø	NV	NV	120.5	117Ø	NV	118.5

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.75						0.75						0.75					
Advance ratio, J		4.17						3.49						3.26					
Power coefficient, C_P		0						1.23						1.68					
Propeller rpm		5804						6887						7399					
Helical tip Mach no., M_H		0.937						1.00						1.04					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	141	139	145.5	132.5	143	129.5Ø	137.5	139.5	132.5Ø	145	150	144
	2	NV	NV	NV	NV	NV	NV	124.5Ø	134.5	128.5	128.5	133	NV	133	137.5	138	128.5	141.5	131
	3	NV	NV	NV	NV	NV	NV	NV	128	126Ø	NV	127	NV	124.5	131	129.5	124	138.5	127.5
	4	NV	NV	NV	NV	NV	NV	NV	120.5	NV	NV	127.5	NV	NV	129	125.5	124	135	125
	5	NV	NV	NV	NV	NV	NV	NV	118Ø	NV	NV	126.5	NV	NV	128	122	120	133	123
	6	NV	NV	NV	NV	NV	NV	NV	118.5	NV	NV	123	NV	NV	124	NV	117.5	128.5	119Ø
	7	NV	NV	NV	NV	NV	NV	NV	116.5	NV	NV	116.5	NV	NV	119	NV	117	126.5	117.5Ø
	8	NV	NV	NV	NV	NV	NV	NV	114.5	NV	NV	114.5	NV	NV	117	NV	115	124.5	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60^{o}						60^{o}						60^{o}					
Tunnel Mach no., M_T		0.75						0.7						0.7					
Advance ratio, J		3.06						4.16						3.49					
Power coefficient, C_P		2.05						0						1.18					
Propeller rpm		7876						5452						6494					
Helical tip Mach no., M_H		1.07						0.872						0.937					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	140	148.5	149	135.5	153	149	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	2	132.5	143	136	130.5	144	132	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	3	124	139	131	130.5	137	132	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	4	NV	136	128.5	125	133	126	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	5	NV	133	127.5	125.5	131.5	125	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	6	NV	129.5	123.5	119	129	123	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	7	NV	127	123.5	119.5	126	118.5Ø	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	8	NV	125	121Ø	117.5	123	115.5Ø	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.7						0.7						0.7					
Advance ratio, J		3.26						3.06						2.92					
Power coefficient, C_p		1.62						1.97						2.20					
Propeller rpm		6974						7413						7738					
Helical tip Mach no., M_H		0.969						0.999						1.02					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m^2	1(BPF)	135	141.5	142.5	128.5	141.5	144	146	145.5	149.5	136	148.5	142.5	141.5	140.5	148	145.5	152	145.5
	2	128.5	135	131.5	125Ø	139	129	135	141	133	129	140.5	129	131	142.5	138.5	134	141.5	136
	3	125.5	132	124.5Ø	123.5Ø	130.5	125	130	137.5	127.5	126.5	138.5	128	128	135	131	127.5	140.5	128
	4	121.5	127.5	121.5Ø	119.5Ø	126	NV	122.5	130	124	124	132	123	122	131.5	126.5	125	134.5	123.5
	5	NV	127.5	120.5Ø	NV	126.5	119Ø	119.5	129.5	122.5	118.5Ø	131.5	121Ø	119.5	129.5	124.5	124	133	123.5
	6	NV	124	NV	NV	125.5	117Ø	NV	126	121	116.5Ø	127.5	119.5Ø	NV	126.5	121.5	120	131.5	121
	7	NV	121	NV	NV	121.5	NV	NV	124	119.5	116.5Ø	126.5	117.5Ø	NV	125	119.5	117	129	121
	8	NV	117.5	NV	NV	119.5	NV	NV	122.5	116.5Ø	114.5Ø	124	116Ø	NV	122.5	118Ø	116	125	116

Code:
- BT, Bad transducer
- NV, Not visible above tunnel background
- Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.6						0.6						0.6					
Advance ratio, J		4.15						3.50						3.25					
Power coef- ficient, C_p		0						1.13						1.48					
Propeller rpm		4742						5655						6064					
Helical tip Mach no., M_H		0.750						0.809						0.834					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	2	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	3	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	4	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	6	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	7	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
	8	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Concluded.

Blade angle, β, deg		60°						60°					
Tunnel Mach no., M_T		0.6						0.6					
Advance ratio, J		3.06						2.71					
Power coefficient, C_P		1.81						2.33					
Propeller rpm		6491						7295					
Helical tip Mach no., M_H		0.863						0.920					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number												
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	131.5	135	128.5	125Ø	137	131	147	145	146	132.5	141	138.5
	2	122Ø	120.5Ø	122.5Ø	NV	NV	NV	126	140	130	127	139.5	133
	3	NV	NV	NV	NV	NV	NV	134	129	128.5	122.5	133	126.5
	4	NV	NV	NV	NV	NV	NV	129.5	129.5	119.5Ø	121.5	133.5	119Ø
	5	NV	NV	NV	NV	NV	NV	125.5	124	120	118.5	130	117Ø
	6	NV	NV	NV	NV	NV	NV	122	121.5	117	115	128	117.5
	7	NV	NV	NV	NV	NV	NV	122	119.5	116.5	113.5	127	114Ø
	8	NV	NV	NV	NV	NV	NV	120	120	113	111.5Ø	125	113

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		4.06						3.50						3.25					
Power coefficient, C_P		0						1.00						1.41					
Propeller rpm		6362						7326						7850					
Helical tip Mach no., M_H		1.01						1.07						1.10					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	128	140.5	138.5	132.5	141	138	130	146	143	131.5	149	140
	2	NV	NV	NV	NV	NV	NV	NV	134.5	130	126.5	135.5	NV	NV	137	132.5	127	138.5	132.5
	3	NV	NV	NV	NV	NV	NV	NV	129	127Ø	NV	129	NV	NV	131	129	124.5	132.5	125.5Ø
	4	NV	NV	NV	NV	NV	NV	NV	124	123.5Ø	NV	125	NV	NV	125	127.5	122.5	129	126
	5	NV	NV	NV	NV	NV	NV	NV	120.5	122.5Ø	NV	122	NV	NV	121	124.5	123.5	124.5	122
	6	NV	NV	NV	NV	NV	NV	NV	117.5Ø	121Ø	NV	NV	NV	NV	117.5	123	118.5	121	NV
	7	NV	NV	NV	NV	NV	NV	NV	NV	119.5Ø	NV	NV	NV	NV	NV	119Ø	117	118Ø	NV
	8	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	119Ø	NV	116.5Ø	NV

Code:
BD, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						62°					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		3.08						2.91						4.55					
Power coefficient, C_p		1.60						1.82						0					
Propeller rpm		8347						8850						5631					
Helical tip Mach no., M_H		1.14						1.18						0.970					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	131	143	148	140	149	144.5	130.5	145.5	144.5	145	150.5	139.5	NV	NV	NV	NV	NV	NV
	2	NV	134	131	129	139	133	NV	136.5	142	135.5	140.5	136	NV	NV	NV	NV	NV	NV
	3	NV	130	130	131	133	133	NV	132	134	134.5	134	133	NV	NV	NV	NV	NV	NV
	4	NV	124.5	129.5	126.5	130	127	NV	126.5	129	130.5	130.5	129	NV	NV	NV	NV	NV	NV
	5	NV	120	123.5	126	124	124	NV	122	129	128.5	124.5	127.5	NV	NV	NV	NV	NV	NV
	6	NV	116.5	122.5	120	120.5	122	NV	118	126	125	121	123	NV	NV	NV	NV	NV	NV
	7	NV	NV	119	118	118.5∅	118	NV	115∅	123.5	123.5	118.5	119.5	NV	NV	NV	NV	NV	NV
	8	NV	NV	118.5	118.5	NV	117.5	NV	NV	120.5	122.5	116.5∅	118∅	NV	NV	NV	NV	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
∅, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		62°						62°						62°					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		3.76						3.49						3.27					
Power coefficient, C_p		1.31						1.69						1.97					
Propeller rpm		6786						7295						7832					
Helical tip Mach no., M_H		1.04						1.07						1.11					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m^2	1(BPF)	134.5Ø	137Ø	134Ø	140Ø	143Ø	137Ø	128	140	141.5	133.5	143	140	134	145.5	151	BT	146	140.5
	2	NV	132	130	128.5Ø	135.5	NV	NV	133.5	131.5	126.5Ø	137.5	127.5Ø	NV	136	132.5	BT	139.5	137
	3	NV	127.5	126.5Ø	NV	131.5	NV	NV	129	126.5	124.5Ø	133.5	129	NV	130	130.5	BT	133.5	126.5
	4	NV	121	123Ø	NV	126.5	NV	NV	123.5	126.5	122Ø	129	121.5Ø	NV	125	128.5	BT	130	128
	5	NV	NV	NV	NV	124	NV	NV	119.5	125	119.5Ø	126	119.5Ø	NV	121	126.5	BT	126.5	122
	6	NV	NV	NV	NV	120.5	NV	NV	NV	123	NV	122	117.5Ø	NV	117.5	124.5	BT	122.5	122.5
	7	NV	NV	NV	NV	117.5Ø	NV	NV	NV	120	NV	119	118.5Ø	NV	115Ø	121.5	BT	119	NV
	8	NV	NV	NV	NV	115.5Ø	NV	NV	NV	118.5	NV	116.5	114.5Ø	NV	NV	119.5	BT	117Ø	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		58°						58°						58°					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		3.66						3.07						2.84					
Power coefficient, C_P		0						1.05						1.36					
Propeller rpm		6985						8302						9004					
Helical tip Mach no., M_H		1.05						1.14						1.19					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	129Ø	139Ø	135.5Ø	BT	145.5Ø	NV	128.5	142	145	BT	148	140.5	129.5	143	144	BT	146.5	140.5
	2	NV	133	129	BT	140.5	NV	NV	135	132.5	BT	142	129	NV	133.5	135	BT	140.5	136
	3	NV	129	126.5	BT	133.5	NV	NV	128.5	130.5	BT	135	128	NV	128	130	BT	134	129
	4	NV	122.5	NV	BT	126.5	NV	NV	124.5	123.5	BT	132.5	123.5	NV	123	133	BT	130.5	128.5
	5	NV	119.5Ø	NV	BT	126.5	NV	NV	119.5	127	BT	127	121.5	NV	118.5	130	BT	126	126.5
	6	NV	NV	NV	BT	121	NV	NV	116.5	122	BT	123.5	119.5	NV	NV	122.5	BT	122	121.5
	7	NV	NV	NV	BT	117.5	NV	NV	NV	119.5	BT	120	115.5	NV	NV	122.5	BT	118.5	118.5
	8	NV	NV	NV	BT	115.5Ø	NV	NV	NV	119.5	BT	117.5	114.5	NV	NV	125	BT	116Ø	117

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		55°						55°						55°					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		3.21						3.07						2.84					
Power coefficient, C_p		0						0.282						0.663					
Propeller rpm		7964						8316						8991					
Helical tip Mach no., M_H		1.12						1.14						1.19					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	133	143.5	142	BT	147.5	134.5	130.5	142	139.5	BT	146	136	130.5	139	144	BT	146	134.5
	2	NV	131.5	131.5	BT	138.5	128	NV	135.5	136	BT	144	131	NV	133.5	133.5	BT	140.5	130.5
	3	NV	128.5	132	BT	135	134.5	NV	129	127	BT	136	125∅	NV	128	134.5	BT	134.5	129
	4	NV	123	122.5∅	BT	132	128	NV	124	126.5	BT	131	122.5	NV	123	125	BT	129.5	121.5∅
	5	NV	118.5∅	127	BT	127	127.5	NV	121	128.5	BT	129	120∅	NV	118.5	127	BT	125.5	122.5
	6	NV	NV	NV	BT	123	122	NV	116.5	120∅	BT	124	118∅	NV	115.5∅	120.5∅	BT	121.5	118.5
	7	NV	NV	NV	BT	120.5	120	NV	114∅	124	BT	121	116∅	NV	NV	122	BT	118.5	NV
	8	NV	NV	NV	BT	118	NV	NV	NV	118∅	BT	118	114∅	NV	NV	120	BT	116	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
∅, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.85						0.85						0.85					
Advance ratio, J		3.84						3.50						3.28					
Power coefficient, C_p		0						0.642						1.02					
Propeller rpm		7045						7674						8246					
Helical tip Mach no., M_H		1.09						1.14						1.17					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	NV	136Ø	129.5Ø	129.5Ø	143Ø	135.5Ø	NV	129.5	142.5	132	137.5	133.5	NV	131.5	143.5	142.5	135.5	135.5
	2	NV	126Ø	135	131	132.5	NV	NV	NV	139	136	131.5	129.5	NV	NV	129.5	136.5	129.5	134
	3	NV	NV	132	128	130	NV	NV	NV	128.5Ø	NV	126.5	126.5Ø	NV	NV	133.5	126.5	NV	129
	4	NV	NV	123	NV	124	NV	NV	NV	129	126.5	NV	122.5	NV	NV	127.5	125	NV	122
	5	NV	NV	125.5	NV	NV	NV	NV	NV	122.5Ø	120	NV	NV	NV	NV	129	124	NV	120
	6	NV	NV	125	NV	NV	NV	NV	NV	127	NV	NV	NV	NV	NV	124	122	NV	NV
	7	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	123	118	NV	NV
	8	NV	NV	120.5	NV	NV	NV	NV	NV	123	NV	NV	NV	NV	NV	123.5	119	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.85						0.75						0.75					
Advance ratio, J		3.07						4.13						3.49					
Power coefficient, C_P		1.31						0						1.18					
Propeller rpm		8779						5848						6912					
Helical tip Mach no., M_H		1.21						.937						1.01					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	124.5Ø	134.5	149.5	138	139	145	NV	NV	NV	NV	NV	NV	136.5Ø	136.5Ø	141Ø	131.5Ø	139Ø	131Ø
	2	NV	NV	137	136	130	136	NV	NV	NV	NV	NV	NV	128	132	128.5Ø	126.5Ø	130	NV
	3	NV	NV	128.5	136	124Ø	127	NV	NV	NV	NV	NV	NV	NV	130	126.5Ø	NV	127.5	NV
	4	NV	NV	129.5	127.5	121Ø	123	NV	NV	NV	NV	NV	NV	NV	123.5	NV	NV	124	NV
	5	NV	NV	127.5	128.5	NV	122.5	NV	NV	NV	NV	NV	NV	NV	121.5	NV	NV	122	NV
	6	NV	NV	126.5	123	NV	120.5	NV	NV	NV	NV	NV	NV	NV	119.5	NV	NV	120Ø	NV
	7	NV	NV	125	119	NV	117	NV	NV	NV	NV	NV	NV	NV	116.5Ø	NV	NV	117.5Ø	NV
	8	NV	NV	122.5	121.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	115Ø	nv	nv	115.5Ø	nv

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.

TABLE II. - PROPELLER SR-2 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		57°						54°						54°					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		2.82						3.15						3.07					
Power coefficient, C_p		1.46						0						0.190					
Propeller rpm		9002						8143						8340					
Helical tip Mach no., M_H		1.18						1.13						1.14					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	132.5	144	145	147	145	138	133	145.5	138	129.5	148	140	134.5	141	138	136.5	144.5	134.5
	2	NV	137	138.5	137	139.5	133	NV	134	134	127.5	138.5	129.5	NV	134	131	126.5∅	139	127.5
	3	NV	132.5	130.5	132.5	133.5	127	NV	130	128	124.5	134	128.5	NV	130	131.5	127.5	134	127
	4	NV	127.5	131	131.5	129	126.5	NV	127.5	129	125	132	123.5	NV	124.5	126	126.5	129.5	124
	5	NV	123	129	125	124.5	125	NV	123	122.5	119∅	127	124	NV	120.5	124.5	122.5	125	120.5∅
	6	NV	119.5	122	120.5	121.5	122	NV	119	122	119	124	119.5∅	NV	117.5∅	NV	119.5	122	118.5∅
	7	NV	116	119	119	118.5	118	NV	116∅	NV	117.5	120.5	116.5∅	NV	NV	121	117.5	119	NV
	8	NV	113.5∅	120.5	118	116	117.5	NV	114∅	119	115.5∅	118.5	NV	NV	NV	117.5	115.5	117	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
∅, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°				
Tunnel Mach no., M_T		0.75						0.75						0.75				
Advance ratio, J		3.29						3.07						2.90				
Power coefficient, C_P		1.49						1.74						1.94				
Propeller rpm		7381						7864						8344				
Helical tip Mach no., M_H		1.04						1.07						1.10				
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	135.5	137.5	136	142	143	142	137	147	147.5	132	146.5	146	138	152	148	139.5	154.5	145.5
	2	129	133	136	128.5	138.5	128	128	138.5	131.5	129	139	129	130.5	140	136	131	144	132
	3	123.5Ø	131	127	126	135.5	NV	NV	133	126.5	126	135	129	123Ø	134.5	133.5	128	138	129
	4	NV	126	122.5Ø	121.5	132.5	NV	NV	129.5	128.5	122.5	132.5	124	NV	132	130.5	129.5	135.5	129
	5	NV	124	122.5	119Ø	130	NV	NV	127	127.5	124	130.5	120.5	NV	129	129	124.5	133.5	123
	6	NV	120.5	120.5Ø	NV	126.5	NV	NV	123	124.5	119	126	120.5	NV	125.5	125	121.5	129.5	123.5
	7	NV	117.5	NV	NV	124	NV	NV	120	121.5	117.5	122.5	117	NV	122	122	120	126.5	118.5
	8	NV	115	NV	NV	121.5	NV	NV	117.5	120	116	120	114.5	NV	119.5	120.5	118	123.5	117.5

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.7						0.7						0.7					
Advance ratio, J		4.13						3.48						3.26					
Power coefficient, C_p		0						1.16						1.50					
Propeller rpm		5509						6487						6960					
Helical tip Mach no., M_H		0.880						0.943						0.971					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	133	139	140.5	127.5	140	141
	2	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	124.5	131.5	132	126	133.5	127.5
	3	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	123Ø	127	124.5Ø	NV	127	NV
	4	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	121	NV	NV	121Ø	NV
	5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	120.5	NV	NV	118.5	NV
	6	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	118	NV	NV	117.5	NV
	7	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	116	NV	NV	115.5	NV
	8	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	113	NV	NV	113.5	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.7						0.7						0.6					
Advance ratio, J		3.04						2.86						4.14					
Power coefficient, C_p		1.78						2.07						0					
Propeller rpm		7404						7962						4760					
Helical tip Mach no., M_H		0.999						1.04						0.756					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	140	139.5	145.5	131.5	144	138	142.5	140	143.5	141	151	144.5	NV	NV	NV	NV	NV	NV
	2	132.5	138.5	132.5	125	134	129	133	135	138.5	131	143	132.5	NV	NV	NV	NV	NV	NV
	3	127.5	132	127	125	131.5	125Ø	125.5	137	130	129	140.5	129.5	NV	NV	NV	NV	NV	NV
	4	121	125	122.5Ø	121.5	126	121Ø	121.5Ø	132	125	125.5	136	127	NV	NV	NV	NV	NV	NV
	5	NV	125	121.5Ø	NV	124	118.5Ø	NV	129.5	124	124	134	122	NV	NV	NV	NV	NV	NV
	6	NV	120.5	119.5Ø	NV	120.5	117Ø	NV	126	123.5	118.5	130	121.5	NV	NV	NV	NV	NV	NV
	7	NV	119.5	118Ø	NV	117.5	NV	NV	123	118.5	119.5	126	117.5Ø	NV	NV	NV	NV	NV	NV
	8	NV	117.5	NV	NV	116.5	NV	NV	121	116.5	115.5Ø	123	115.5Ø	NV	NV	NV	NV	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		60°						60°						60°					
Tunnel Mach no., M_T		0.6						0.6						0.6					
Advance ratio, J		3.50						3.24						3.08					
Power coefficient, C_P		1.14						1.45						1.70					
Propeller rpm		5649						6074						6927					
Helical tip Mach no., M_H		0.810						0.834						0.857					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	124.5Ø	124Ø	129	124.5Ø	128	128.5
	2	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	122Ø	NV	NV	123Ø	NV
	3	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	4	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	6	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	7	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	8	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.

TABLE III. - PROPELLER SR-1m SOUND PRESSURE LEVELS - Concluded.

Blade angle, β, deg		60°					
Tunnel Mach no., M_T		0.6					
Advance ratio, J		2.66					
Power coefficient, C_P		2.24					
Propeller rpm		7412					
Helical tip Mach no., M_H		0.927					
Transducer		1	2	3	4	5	6
	Harmonic number						
Sound pressure level of harmonic, SPL, dB ref: 2×10^{-5} N/m^2	1(BPF)	138	148	140	142	148.5	142.5
	2	132	141	136	133.5	138.5	133
	3	126.5	130.5	128	121∅	127.5	123.5
	4	123.5	127	122	118.5	126	119.5
	5	121	125.5	121.5	118	126.5	118
	6	119	122	118	116.5	124.5	117
	7	118.5	120.5	116	113.5	119.5	114
	8	116	117	114	112	114.5	111∅

Code:
BT, Bad transducer
NV, Not visible above tunnel background
∅, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS

Blade angle, β, deg		61.3						61.3						61.3					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		4.31						3.48						3.24					
Power coefficient, C_p		0						1.35						1.61					
Propeller rpm		6041						7395						7930					
Helical tip Mach no., M_H		0.993						1.07						1.10					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	127.5	135.5	137.5	133	137.5	136	128.5	139.5	141.5	128Ø	141.5	134.5
	2	NV	NV	NV	NV	NV	NV	NV	131	127.5	125Ø	131	127.5Ø	NV	132	136	129	132.5	134
	3	NV	NV	NV	NV	NV	NV	NV	125.5	125Ø	124.5Ø	NV	127Ø	NV	125.5	126	124	126	127
	4	NV	NV	NV	NV	NV	NV	NV	121Ø	127	122.5Ø	NV	122Ø	NV	121	130	127	123Ø	127.5
	5	NV	NV	NV	NV	NV	NV	NV	118.5Ø	125.5	120Ø	NV	NV	NV	NV	123.5	122.5	NV	122Ø
	6	NV	NV	NV	NV	NV	NV	NV	NV	121.5	118Ø	NV	119.5Ø	NV	NV	121	118.5	NV	120Ø
	7	NV	NV	NV	NV	NV	NV	NV	NV	119	NV	NV	118Ø	NV	NV	118	116.5	NV	118Ø
	8	NV	NV	NV	NV	NV	NV	NV	NV	117.5	NV	NV	NV	NV	NV	117	116	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		61.3						61.3						63.3					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		3.07						2.96						4.78					
Power coefficient, C_p		1.78						1.87						0					
Propeller rpm		8452						8747						5374					
Helical tip Mach no., M_H		1.14						1.16						0.950					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	130.5	140	144	135	140.5	137.5	132	136.5	145	142.5	137.5	137	NV	NV	BT	NV	NV	NV
	2	NV	129	131.5	132.5	129	130	NV	128.5	136.5	136	129Ø	128	NV	NV	BT	NV	NV	NV
	3	NV	125.5	127.5	127	126Ø	133	NV	124.5	130	126.5	124.5Ø	130	NV	NV	BT	NV	NV	NV
	4	NV	120	130	128.5	NV	126	NV	118.5Ø	131.5	126.5	NV	122.5	NV	NV	BT	NV	NV	NV
	5	NV	NV	125.5	125.5	NV	122.5	NV	NV	128.5	123	NV	122	NV	NV	BT	NV	NV	NV
	6	NV	NV	125	120	NV	121	NV	NV	124	123.5	NV	119.5	NV	NV	BT	NV	NV	NV
	7	NV	NV	119	118.5	NV	117.5	NV	NV	121	121.5	NV	NV	NV	NV	BT	NV	NV	NV
	8	NV	NV	121.5	119	NV	NV	NV	NV	119.5	117.5	NV	NV	NV	NV	BT	NV	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		63.3						63.3						63.3					
Tunnel Mach no., M_T		0.8						0.8						0.8					
Advance ratio, J		4.07						3.49						3.27					
Power coefficient, C_p		1.33						1.97						2.19					
Propeller rpm		6324						7360						7884					
Helical tip Mach no., M_H		1.00						1.07						1.10					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	NV	NV	BT	NV	NV	NV	127.5	137.5	BT	132	138	135.5	129	141.5	BT	130.5	143.5	137
	2	NV	NV	BT	NV	NV	NV	NV	133	BT	126Ø	134	132	NV	132	BT	131	139	137
	3	NV	NV	BT	NV	NV	NV	NV	126	BT	124.5Ø	125.5Ø	127.5	NV	125.5	BT	124.5	131.5	130
	4	NV	NV	BT	NV	NV	NV	NV	121	BT	123.5Ø	122.5Ø	124.5	NV	120.5Ø	BT	127.5	126	124.5
	5	NV	NV	BT	NV	NV	NV	NV	118.5	BT	120Ø	NV	121	NV	NV	BT	120	123.5	123
	6	NV	NV	BT	NV	NV	NV	NV	NV	BT	119Ø	NV	120	NV	NV	BT	119	119	121.5
	7	NV	NV	BT	NV	NV	NV	NV	NV	NV	NV	NV	118.5	NV	NV	BT	117	116	118.5
	8	NV	NV	BT	NV	NV	NV	NV	NV	BT	NV	NV	NV	NV	NV	BT	116	NV	NV

Code:
- BT, Bad transducer
- NV, Not visible above tunnel background
- Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		59.3						59.3						59.3				
Tunnel Mach no., M_T		0.8						0.8						0.8				
Advance ratio, J		3.91						3.07						2.86				
Power coefficient, C_p		0						1.23						1.43				
Propeller rpm		6586						8387						9012				
Helical tip Mach no., M_H		1.02						1.14						1.18				
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	129	142.5	142.5	134.5	142.5	138.5	130.5	137	140.5	143.5	142	142
	2	NV	NV	NV	NV	NV	NV	NV	129.5	132	132.5	133.5	128.5	NV	129.5	130.5	132.5	130.5	130.5
	3	NV	NV	NV	NV	NV	NV	NV	126	126	126.5	127	126.5	NV	122	135	128.5	125.5	125.5
	4	NV	NV	NV	NV	NV	NV	NV	119.5	129	126	122	122.5Ø	NV	119	132	131.5	121.5	NV
	5	NV	NV	NV	NV	NV	NV	NV	NV	125.5	128	119.5	121Ø	NV	NV	121.5Ø	125	NV	NV
	6	NV	NV	NV	NV	NV	NV	NV	NV	123.5	118	NV	120.5Ø	NV	NV	127.5	122.5	NV	NV
	7	NV	NV	NV	NV	NV	NV	NV	NV	120.5	119.5	NV	116Ø	NV	NV	122	120.5	NV	NV
	8	NV	NV	NV	NV	NV	NV	NV	NV	119	117	NV	NV	NV	NV	121.5	119	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		54						54						61.3					
Tunnel Mach no., M_T		0.8						0.8						0.85					
Advance ratio, J		2.99						2.86						4.12					
Power coefficient, C_p		0						0.19						0					
Propeller rpm		8614						9000						6632					
Helical tip Mach no., M_H		1.16						1.18						1.07					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	Harmonic number																		
	1(BPF)	131	133.5	140.5	134	143.5	135.5	128.5	141	135	139	146.5	133	NV	NV	NV	NV	NV	NV
	2	NV	130	133.5	133.5	136	128.5	NV	133	132.5	133	136	133.5	NV	NV	NV	NV	NV	NV
	3	NV	122.5	126.5	123.5Ø	128.5	130	NV	125	130.5	124.5	127.5	123.5	NV	NV	NV	NV	NV	NV
	4	NV	NV	129.5	123.5	124	123	NV	120Ø	128	130.5	123	125.5	NV	NV	NV	NV	NV	NV
	5	NV	NV	121.5	124.5	119.5Ø	119.5Ø	NV	116.5Ø	NV	120.5	118.5	119.5	NV	NV	NV	NV	NV	NV
	6	NV	NV	120.5	117.5Ø	NV	118.5Ø	NV	NV	122	120	NV	117.5	NV	NV	NV	NV	NV	NV
	7	NV	NV	117	118	NV	NV	NV	NV	NV	119.5	NV	NV	NV	NV	NV	NV	NV	NV
	8	NV	NV	118	116Ø	NV	NV	NV	NV	117.5Ø	117	NV	NV	NV	NV	NV	NV	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		61.3						61.3						61.3					
Tunnel Mach no., M_T		0.85						0.85						0.85					
Advance ratio, J		3.51						3.25						3.07					
Power coefficient, C_p		1.01						1.31						1.50					
Propeller rpm		7758						8363						8870					
Helical tip Mach no., M_H		1.13						1.17						1.21					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	NV	131.5	141.5	127	140	129	NV	136.5	141.5	139	142	133	NV	136	144.5	134	143	138
	2	NV	124Ø	133.5	132.5	128.5	129.5	NV	125.5Ø	132.5	136	130	127.5	NV	126Ø	132	132	133	129
	3	NV	NV	130	124.5	NV	126.5Ø	NV	122Ø	134	128.5	NV	131	NV	NV	136	135.5	125.5	125.5
	4	NV	NV	128.5	127.5	NV	124.5	NV	NV	124	124	NV	121.5Ø	NV	NV	125	126	121	124.5
	5	NV	NV	125	121	NV	120Ø	NV	NV	129.5	123	NV	123	NV	NV	127	127	NV	120.5Ø
	6	NV	NV	123	118.5	NV	118.5Ø	NV	NV	122	124.5	NV	119.5	NV	NV	125.5	121.5	NV	119.5
	7	NV	NV	122	116.5	NV	NV	NV	NV	122	118.5	NV	NV	NV	NV	118Ø	120	NV	116.5
	8	NV	NV	119	NV	NV	NV	NV	NV	121.5	117.5	NV	NV	NV	NV	122	120	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		61.3						61.3						61.3					
Tunnel Mach no., M_T		0.75						0.75						0.75					
Advance ratio, J		4.28						3.50						3.25					
Power coefficient, C_P		0						1.31						1.58					
Propeller rpm		5720						6976						7496					
Helical tip Mach no., M_H		0.929						1.00						1.04					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	131	130.5	138	129	135	130	130	132	132.5	137.5	140.5	138
	2	NV	NV	NV	NV	NV	NV	127.5	131	126.5Ø	126.5Ø	133	NV	126.5	134	136.5	129	139	128
	3	NV	NV	NV	NV	NV	NV	NV	128	126Ø	NV	128.5	NV	NV	127.5	124.5Ø	124.5Ø	133	125.5Ø
	4	NV	NV	NV	NV	NV	NV	NV	120.5Ø	121.5Ø	NV	124	NV	NV	123	123Ø	121.5Ø	128.5	122Ø
	5	NV	NV	NV	NV	NV	NV	NV	119Ø	120Ø	NV	123	NV	NV	119.5	124.5	119Ø	125.5	120.5Ø
	6	NV	NV	NV	NV	NV	NV	NV	118Ø	118.5Ø	NV	121	NV	NV	117	122	117Ø	123.5	118Ø
	7	NV	NV	NV	NV	NV	NV	NV	115.5Ø	NV	NV	117.5	NV	NV	114.5	119	NV	120	NV
	8	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	115.5	NV	NV	NV	118	NV	118	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		61.3						61.3						61.3					
Tunnel Mach no., M_T		0.75						0.75						0.7					
Advance ratio, J		3.05						2.92						4.32					
Power coefficient, C_P		1.79						1.95						0					
Propeller rpm		7990						8412						5323					
Helical tip Mach no., M_H		1.07						1.10						.864					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2	1(BPF)	133.5	140.5	145	129	141	142.5	134.5	144	146.5	138.5	148	143.5	NV	NV	NV	NV	NV	NV
	2	128.5	137.5	136.5	133.5	140	132	126Ø	138.5	139	132	142	133	NV	NV	NV	NV	NV	NV
	3	NV	129	129	125.5	131.5	128	NV	129.5	129.5	126.5	132	129.5	NV	NV	NV	NV	NV	NV
	4	NV	125.5	130	122.5	128	128.5	NV	126	130	125.5	130	126.5	NV	NV	NV	NV	NV	NV
	5	NV	120.5	125	122	123	121.5	NV	121.5	125.5	121	125	123.5	NV	NV	NV	NV	NV	NV
	6	NV	118	125	120.5	121	120	NV	117.5	123	121.5	122.5	122.5	NV	NV	NV	NV	NV	NV
	7	NV	115.5	121.5	116.5	118.5	118	NV	115Ø	119.5	118	119.5	123	NV	NV	NV	NV	NV	NV
	8	NV	113.5Ø	120.5	116	115.5	114	NV	113.5Ø	119.5	116.5	117	115.5	NV	NV	NV	NV	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg	61.3						61.3						61.3					
Tunnel Mach no., M_T	0.7						0.7						0.7					
Advance ratio, J	3.50						3.26						3.06					
Power coefficient, C_P	1.33						1.60						1.84					
Propeller rpm	6550						7042						7510					
Helical tip Mach no., M_H	0.936						0.969						1.00					
Transducer	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Sound pressure level of harmonic, SPL, dB ref. 2×10^{-5} N/m^2 — Harmonic number																		
1(BPF)	NV	NV	NV	NV	NV	NV	130.5	133.5	138.5	125ø	136.5	141	133	139.5	138	135	137.5	135.5
2	NV	NV	NV	NV	NV	NV	124.5	133.5	128.5	124ø	132	126.5ø	133.5	136.5	138	125	137.5	129.5
3	NV	NV	NV	NV	NV	NV	NV	127.5	124	NV	125.5	NV	125.5	133	124.5	123ø	131.5	127.5
4	NV	NV	NV	NV	NV	NV	NV	122.5	NV	NV	120ø	118.5	121ø	127	122	120.5ø	128.5	121.5
5	NV	NV	NV	NV	NV	NV	NV	119	NV	NV	NV	NV	NV	124	123	119	125.5	118.5
6	NV	NV	NV	NV	NV	NV	NV	117	NV	NV	117.5	NV	NV	119.5	118ø	117	120.5	117
7	NV	NV	NV	NV	NV	NV	NV	114ø	NV	NV	116	NV	NV	117.5	120.5ø	115	118	115
8	NV	NV	NV	NV	NV	NV	NV	112ø	NV	NV	115	NV	NV	115	NV	114.5	115.5	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS - Continued.

Blade angle, β, deg		61.3						61.3						61.3					
Tunnel Mach no., M_T		0.7						0.6						0.6					
Advance ratio, J		2.85						4.38						3.51					
Power coef-ficient, C_p		2.07						0						1.39					
Propeller rpm		8068						4562						5712					
Helical tip Mach no., M_H		1.04						.740						.810					
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m^2	1(BPF)	136.5	139.5	135.5	133.5	146.5	137	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	2	129	135	135	131	141.5	129.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	3	124.5	131.5	130.5	124.5	134.5	128.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	4	120	129	128	123.5	130.5	122	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	5	NV	124	123	119.5	129	126	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	6	NV	121	125	119	125	119.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	7	NV	117.5	123.5	117	121.5	116.5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV
	8	NV	115	120.5	115.5	119	115	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

TABLE IV. - PROPELLER SR-3 SOUND PRESSURE LEVELS - Concluded.

Blade angle, β, deg		61.3						61.3						61.3				
Tunnel Mach no., M_T		0.6						0.6						0.6				
Advance ratio, J		3.26						3.05						2.70				
Power coefficient, C_p		1.66						1.89						2.31				
Propeller rpm		6144						6538						7449				
Helical tip Mach no., M_H		0.838						0.863						0.929				
Transducer		1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
	Harmonic number																		
Sound pressure level of harmonic, SPL, dB ref. $2x10^{-5}$ N/m^2	1(BPF)	NV	NV	NV	NV	NV	NV	126.5	128.5	127.5	124.5Ø	133.5	128	134.5	141.5	138.5	139.5	143	139.5
	2	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	122.5	NV	127	136.5	133	132	133.5	130.5
	3	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	122	125	124.5	122	124	121Ø
	4	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	119	118.5	NV	116.5	122	118Ø
	5	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	117	116	119	115.5	118.5	115Ø
	6	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	116	114	117	114.5	117.5	NV
	7	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	114	112.5	NV	NV	113.5	112.5Ø
	8	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	NV	112.5	111.5	NV	NV	112.5	NV

Code:
BT, Bad transducer
NV, Not visible above tunnel background
Ø, Data questionable (various reasons, including tone is too close to tunnel background or falls on top of compressor tone, malfunctioning transducer, etc.)

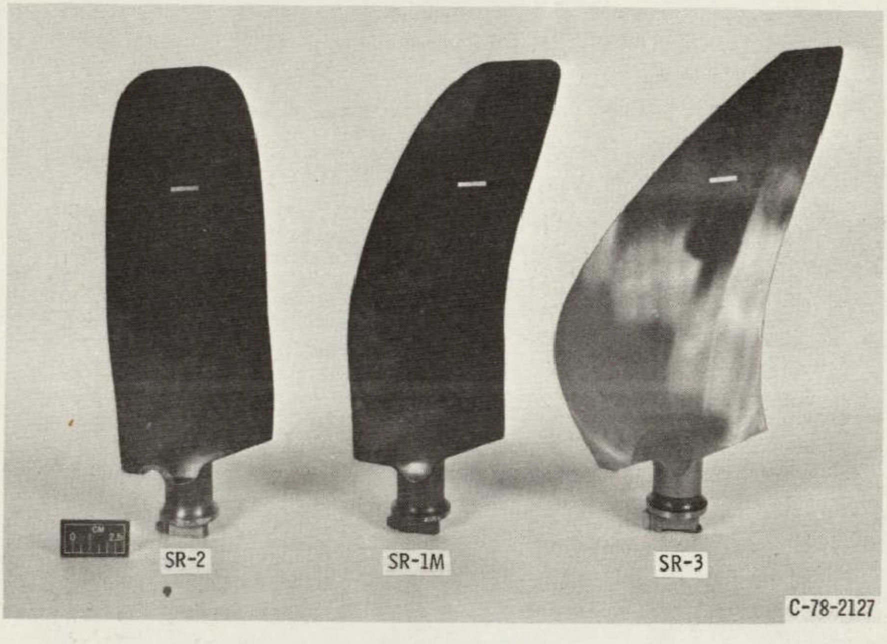
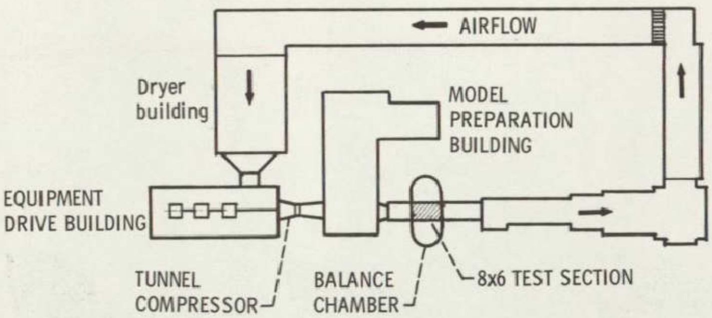


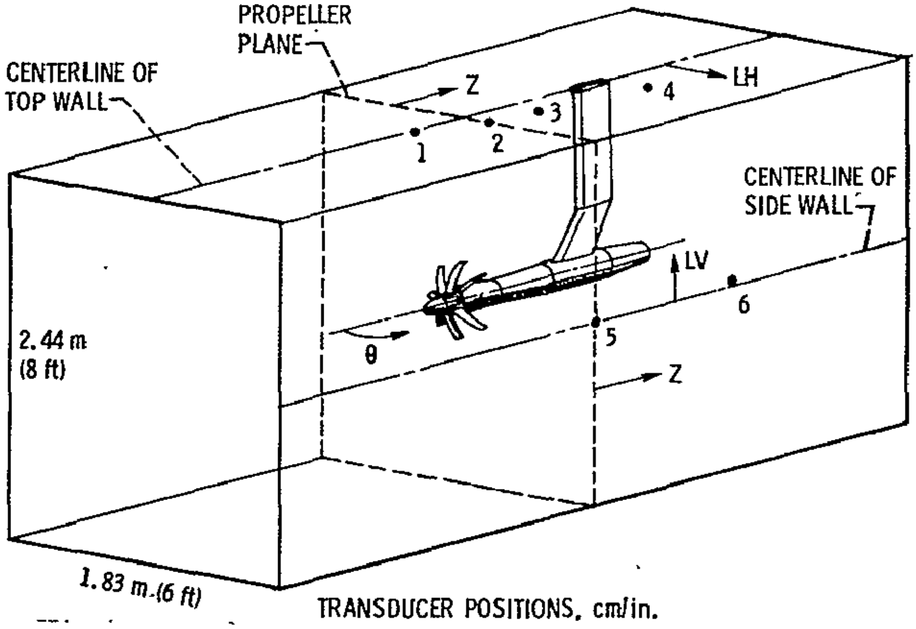
Figure 1. - Propeller blades.



(a) PLAN VIEW OF 8x6 WIND TUNNEL.

(b) PROPELLER SR-3 IN TUNNEL.

Figure 2.



TRANSDUCER POSITIONS, cm/in.

POSITIONS	1		2		3		4		5		6	
Z	-27.7	-10.9	0.953	0.375	45.2	17.8	104.4	41.1	-0.15	-0.06	105.4	41.5
LH	2.54	1.0	10.2	4.0	7.62	3.0	31.5	12.4	91.4	36.0	91.4	36.0
LV	121.9	48.0	121.9	48.0	121.9	48.0	121.9	48.0	6.35	2.5	1.78	0.7
NOMINAL ANGLE, θ	77^0		90^0		110^0		130^0		90^0		139^0	

Figure 3. - Pressure transducer positions.

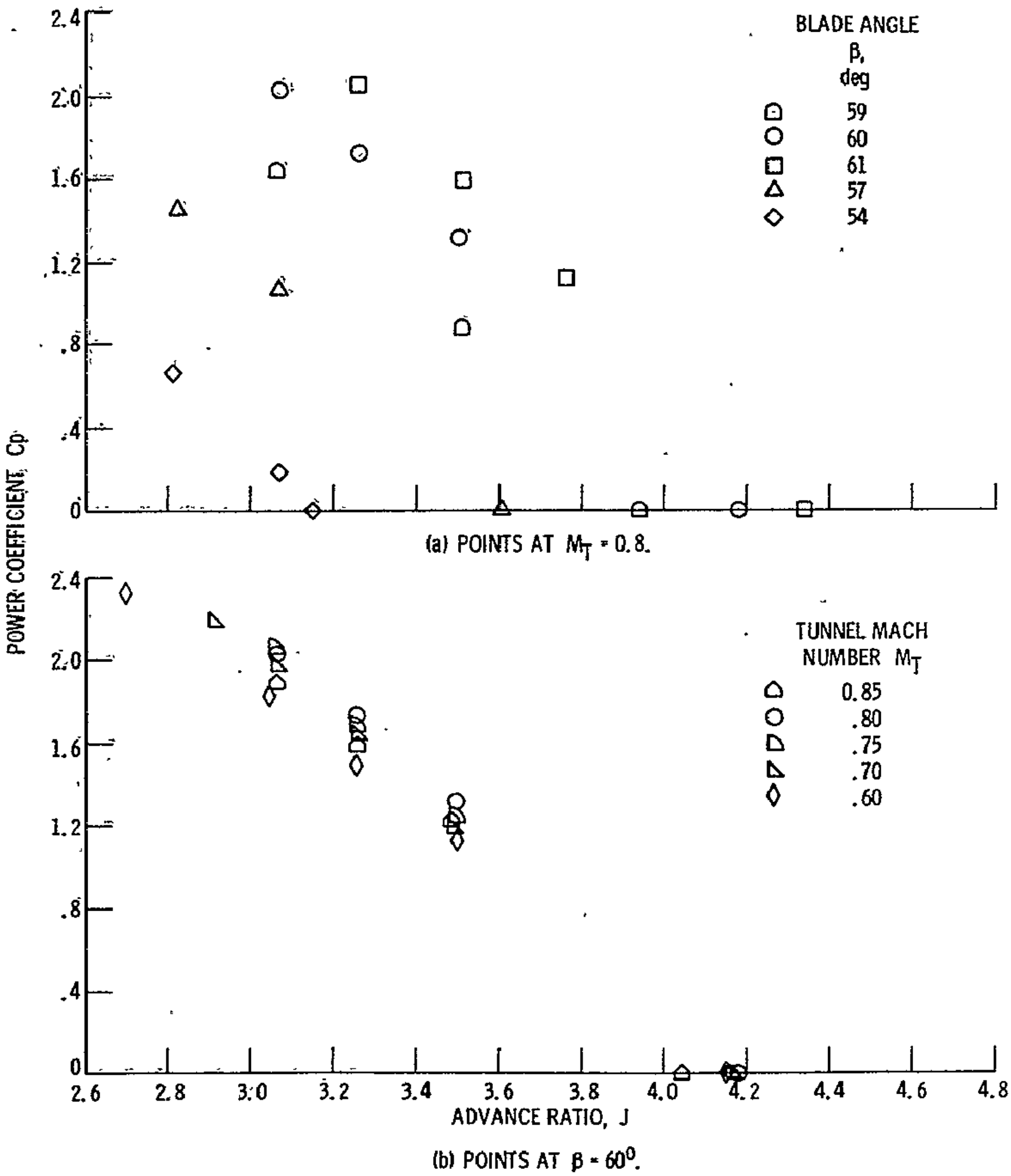
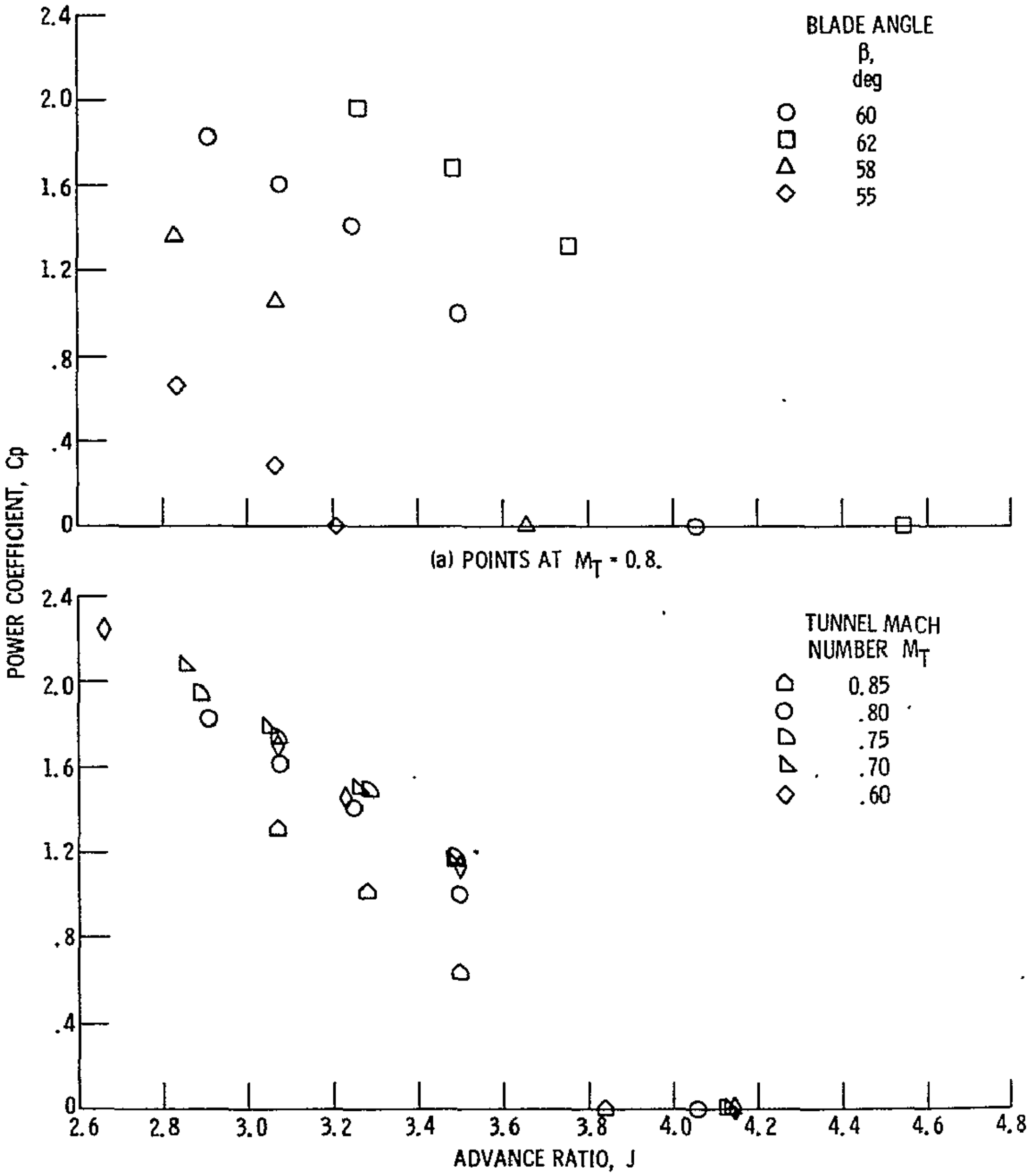


Figure 4. - Test conditions for SR-2.



(b) POINTS AT β = 60°.

Figure 5. - Test conditions for SR-1M.

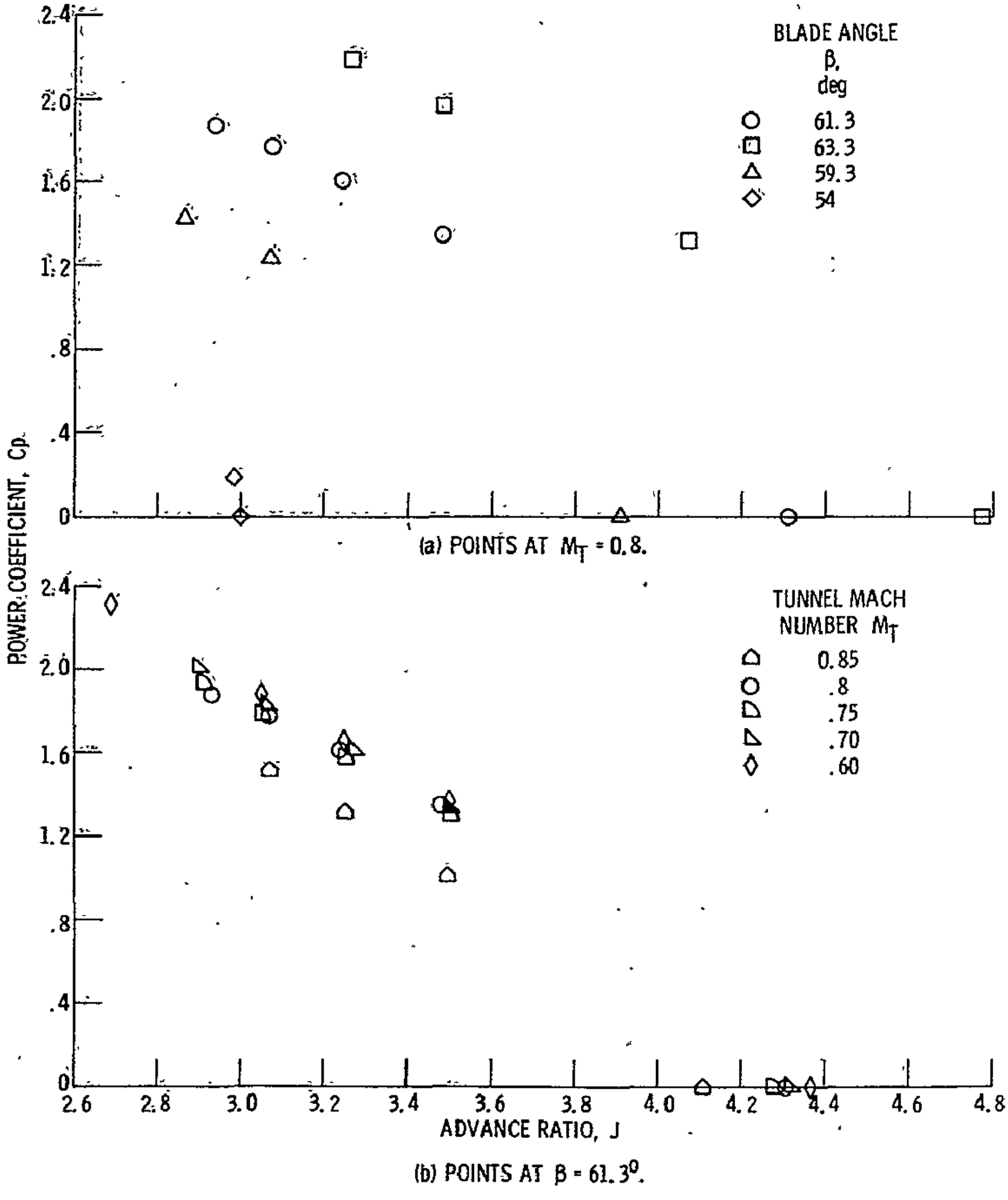


Figure 6. - Test conditions for SR-3.

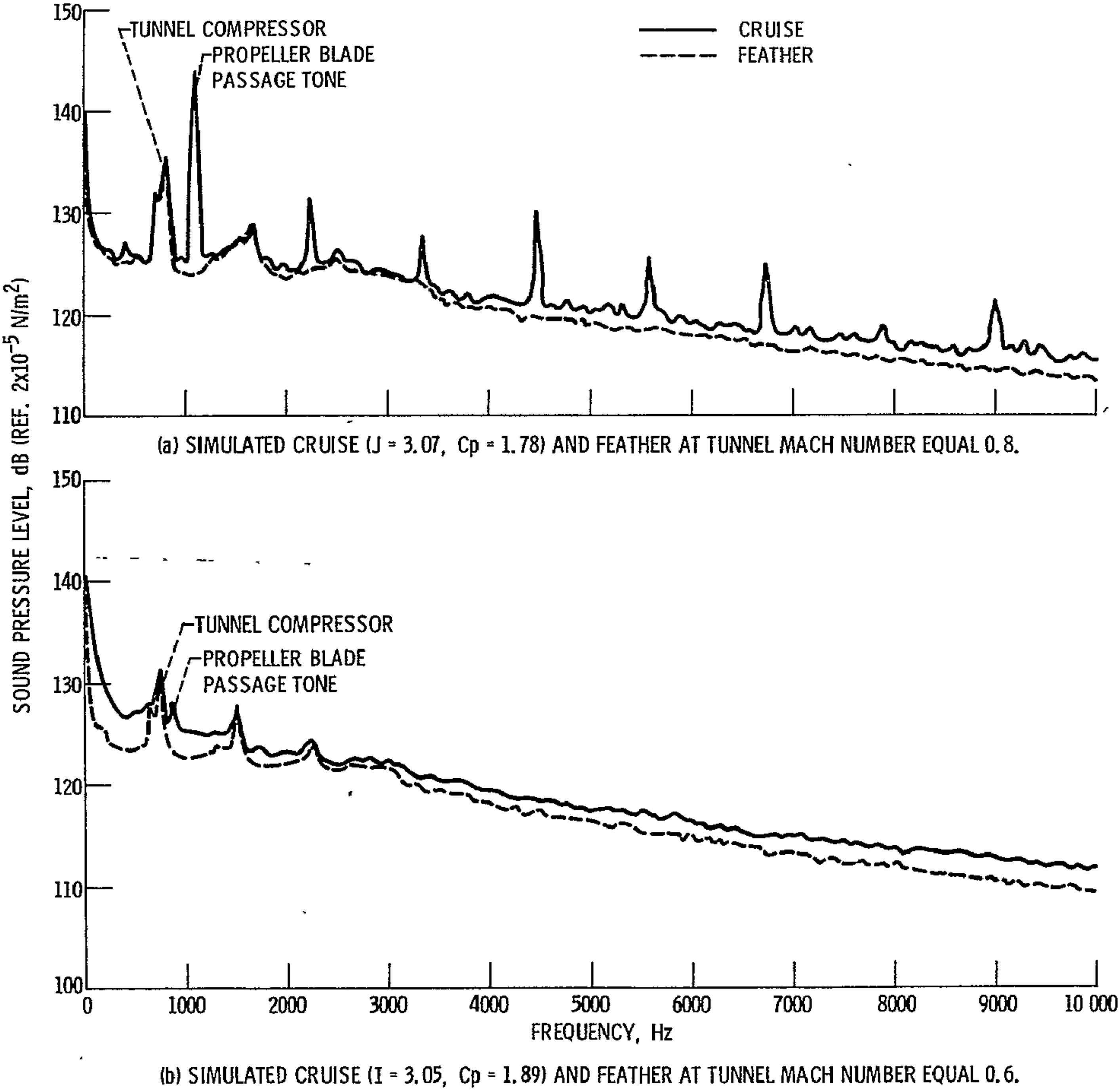


Figure 7. - Comparison of SR-3 propeller under power and at feather, transducer 3.

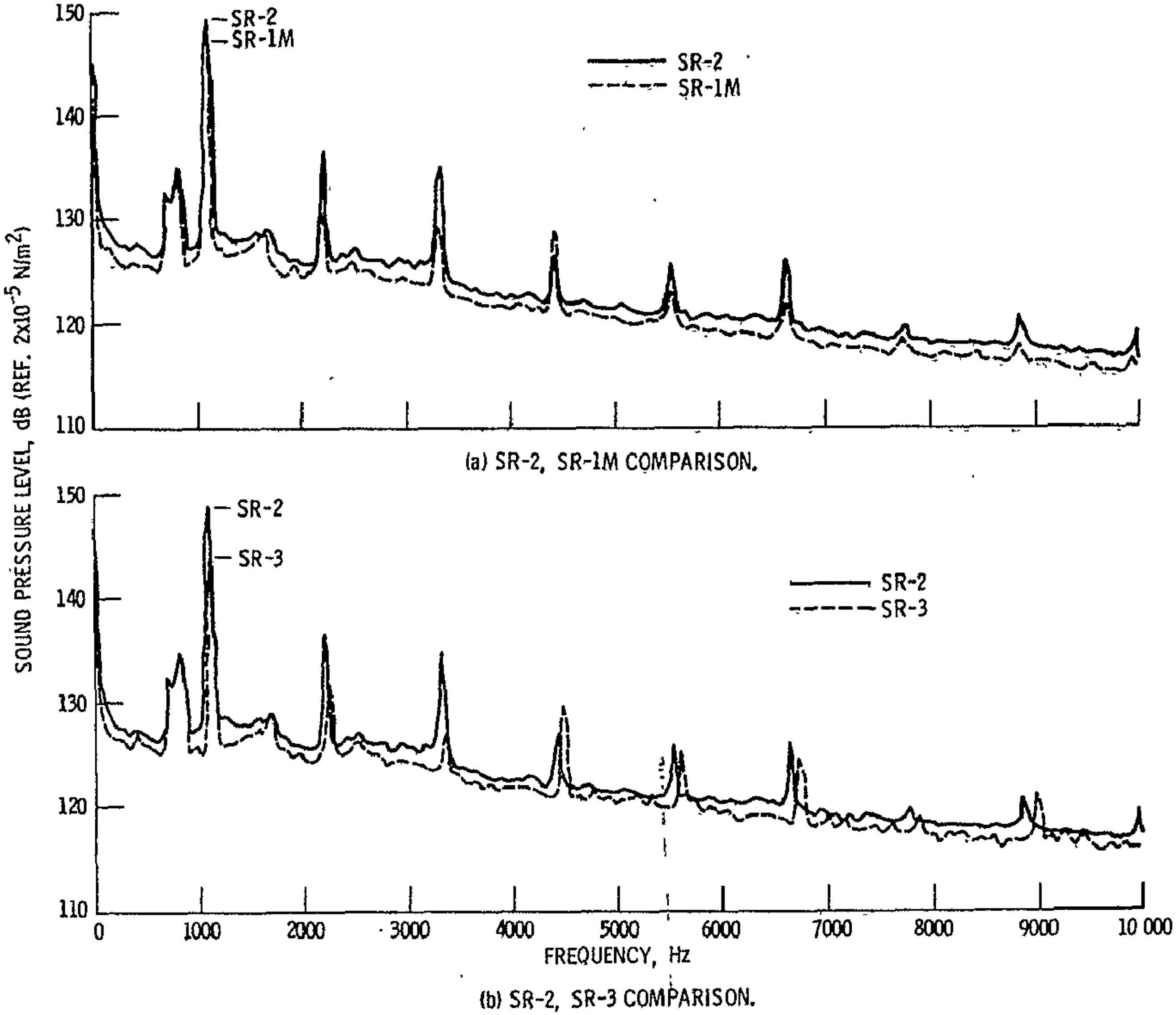


Figure 8. - Comparison of propellers at transducer position 3 for Mach - 0.8 cruise condition.

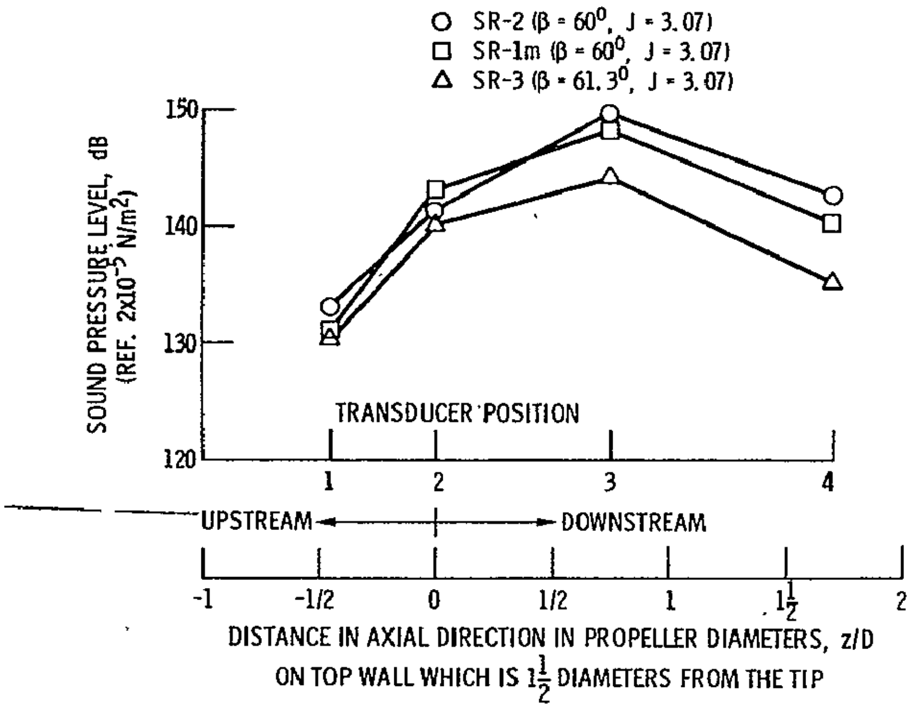
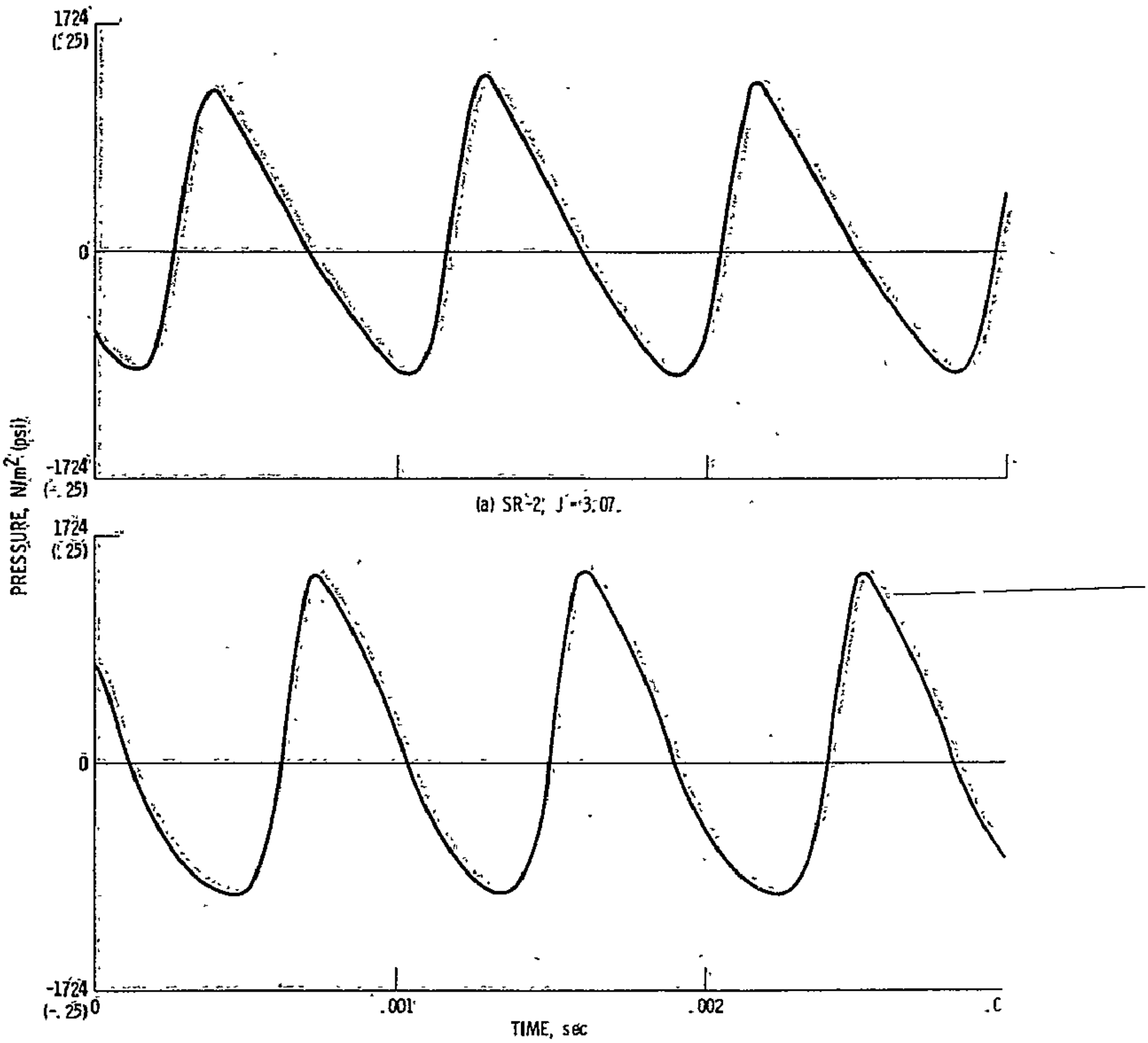
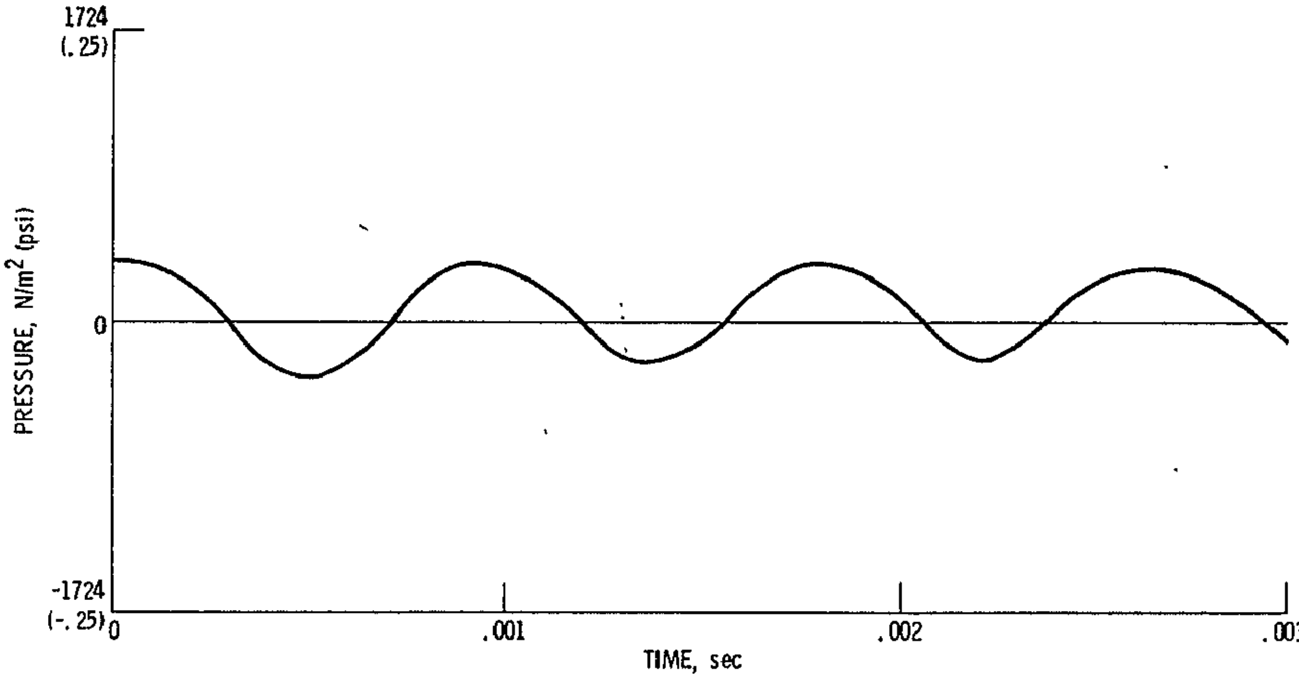


Figure 9. - Sideline blade passage tone comparisons at a tunnel Mach number of 0.8.



(b) SR-1M, J = 3.08.

Figure 10. - Average pressure signal at transducer 5 for tunnel Mach number of 0.8.



(c) SR-3, J = 3.07.

Figure 10. - Concluded.

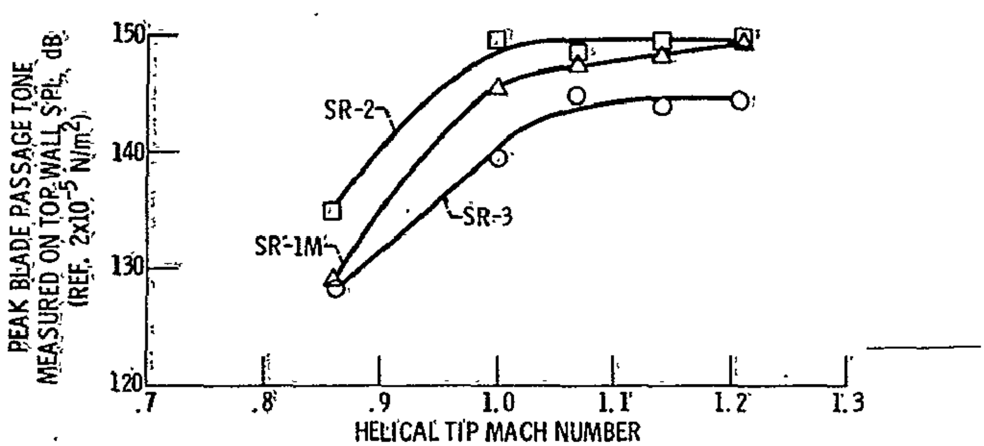


Figure 11. - Maximum blade passage tone variation with helical tip Mach number. (All at nominal advance ratio of 3.06.)

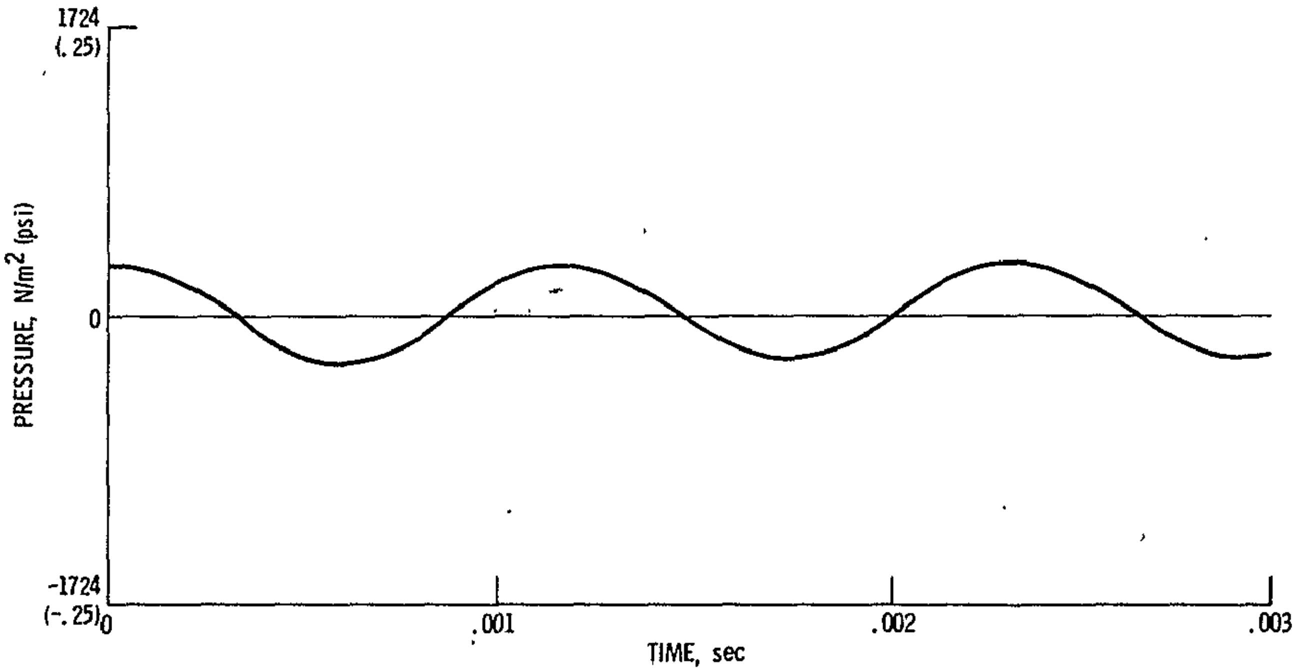


Figure 12. - Average pressure signal at transducer 5 for tunnel Mach number of 0.6 SR-2, J = 3.06.

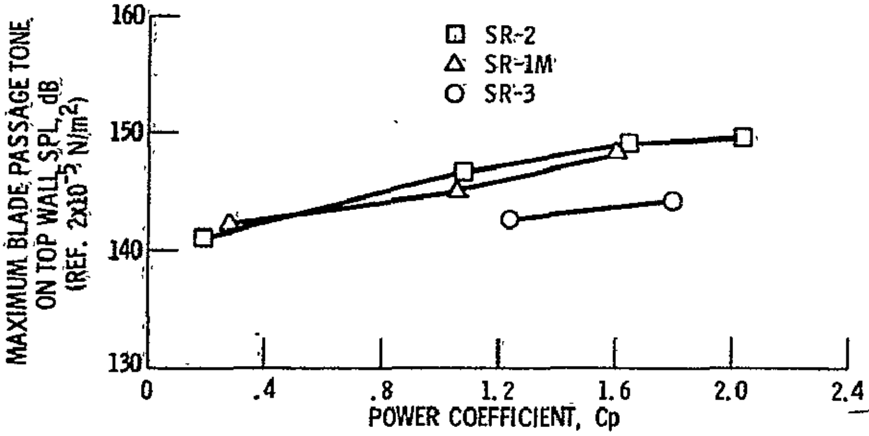


Figure 13. - Variation of maximum blade passage tone with power coefficient at a tunnel Mach number of 0.8 and a nominal advance ratio of 3.06.

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15 Supplementary Notes

16 Abstract

Three supersonic helical tip speed propellers were tested in the NASA Lewis 8- by 6-Foot Wind Tunnel. This is a perforated-wall wind tunnel but it does not have acoustic damping material on its walls. The propellers were tested at tunnel through flow Mach numbers of 0.6, 0.7, 0.75, 0.8, and 0.85 with different rotational speeds and blade setting angles. The three propellers, which had approximately the same aerodynamic performance, incorporated different plan forms and different amounts of sweep and yielded different near field noise levels. The acoustically designed propeller had 45° of tip sweep and was significantly quieter at $M = 0.8$ cruise than the straight bladed propeller. The intermediate 30° tip sweep propeller, which was swept for aerodynamic purposes, exhibited noise that was between the other two propellers. Noise trends with varying helical tip Mach number and blade loading were also observed.

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