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SUMMARY

The noise generated by supersonic-tip-speed propellers is a possible cabin environment problem for future airplanes powered by these propellers. The noise of three propeller models has been previously measured in the NASA Lewis 8-by-6-foot wind tunnel with flow parallel to the propeller axis. In flight, as a result of the induced upwash from the airplane wing, the propeller may be at an angle of attack with respect to the incoming flow. Therefore experiments were undertaken on one of the existing propeller models to determine the noise effect of operating this type of propeller at angle of attack.

Increases in the maximum blade passage noise were observed for the propeller operating at angle of attack. The noise increase was not symmetrical with one wall of the wind tunnel having significantly more noise increase than the other wall. This was apparently the result of the rotational direction of the propeller. The lack of symmetry of the noise at angle of attack points to the use of oppositely rotating propellers on opposite sides of an airplane fuselage as a way of minimizing the noise due to operation at angle of attack.

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INTRODUCTION

The noise generated by supersonic helical tip speed propellers may create a cabin noise problem for turboprop airplanes under cruise conditions. The noise of three propeller models has been previously measured in the NASA Lewis 8- by 6-foot wind tunnel and reported in references 1, 2 and 3. These tests were performed with the propeller axis parallel to the tunnel flow. In flight, as a result of the induced upwash from the airplane wing, the propellers may be at an angle of attack with respect to the incoming flow. Some experiments performed by Tanna, et al, reference 4, on a subsonic propeller operating at angle of attack have shown significant noise increases for the propeller operating at 5 and 10 degrees angle of attack. Therefore, experiments were undertaken on one of the existing supersonic helical tip speed propeller models to evaluate the noise effect of operating this type of propeller at angle of attack.

The SR-3 propeller model, shown in figure 1, was tested at angle of attack in the NASA Lewis 8- by 6-foot wind tunnel. As a result of aeroelastic constraints on this propeller model which would not necessarily be present on a full scale propeller, it was possible to test to only 4 degrees angle of attack at $J = 3.06$ at Mach 0.8 and above. Therefore the propeller was tested at 2 and 4 degrees angle of attack at all of the various tunnel velocities and propeller operating conditions. The purpose of this paper is to report the data taken under these conditions and to evaluate the effect of angle of attack on the noise of this propeller.

APPARATUS AND PROCEDURE

The eight bladed, highly swept, SR-3 propeller was used in these angle of attack experiments. This propeller is nominally 0.622 meter (24.5 in.) in diameter and was tested in the Lewis 8- by 6-foot wind tunnel. Table 1 shows some of the SR-3 propeller characteristics and more information can be obtained from references 5 and 6. A photograph of the propeller model mounted on the Lewis 1000 Hp. Propeller Test Rig, in the test section of the wind tunnel is shown in figure 1. This is a perforated-wall wind tunnel without acoustic damping material on its walls. A discussion of the possible influences of these untreated wall surfaces on the noise data can be found in reference 1 and 2. The propeller was tested at 0°, 2° and 4° angle of attack since the aeroelastic limit confined the angle of attack to less than 4° at Mach 0.8 and above.

To measure the propeller noise, pressure transducers were installed in the tunnel bleed holes visible in figure 1. Transducers were installed in both side walls of the wind tunnel as shown in figure 2. The transducers numbered 6 to 13 were installed along the propeller axis when the propeller was at 0° angle of attack. In order to obtain an angle of attack the propeller rig was pivoted about the pylon support. When this was done, in addition to putting the propeller at angle of attack, the propeller plane was moved forward and elevated in the wind tunnel. In an attempt to remain on the propeller axis and at the same positions relative to the propeller plane, new transducer positions were chosen. At 2° these transducer positions were numbered 14 to 21 and at 4° they were 22 to 29. These positions can be seen in more detail in figure 3(a). The positions are not exactly on the propeller centerlines nor are they exactly the same distances up or down stream of the propeller plane for the 2° and 4° as they were for the 0° test. This is because the transducers could only be installed through the existing tunnel wall bleed holes. The exact positions of the transducers are shown in figures 3(b) to (d). At the aft most position at 4° angle of attack (fig. 3(d)) the transducer positions 17 and 21 from the 2° centerline were fairly close to the 4° centerline and data were also taken at these positions.

Data were taken at propeller advance ratios, of 3.06, 3.26 and 3.50 with the tunnel operating at Mach numbers of 0.85, 0.8, 0.75, 0.7, 0.65 and 0.6. Data were also taken with the propeller operating at windmill conditions but no propeller noise was measureable. The data were taken with the propeller at 0°, 2° and 4° angle of attack using the transducers appropriate for the particular angle of attack (fig. 3). These acoustic tests were performed as an addendum to aerodynamic testing and not all of the transducers were working at every test condition. The data were analyzed on a narrow band basis using a 26-Hz bandwidth.

RESULTS AND DISCUSSION

The noise of the SR-3 propeller at 0°, 2° and 4° angle of attack was measured on the side walls of the Lewis 8- by 6- foot wind tunnel. The sound pressure levels for the first eight harmonics of the blade passage tone have been tabulated and are included here in tables 2, 3 and 4. Table 2 is for an advance ratio J, of 3.06, table 3 for a J of 3.26 and table 4 for a J of 3.50.

Directivity

To investigate the effect of angle of attack on propeller noise the blade passage tones of the propeller were plotted versus the position of the transducer relative to the propeller plane. The plots for the propeller operating at its design advance ratio of 3.06 are shown in figure 4. Figure 4(a) is for the tunnel Mach number of 0.85, 4(b) is for 0.80, 4(c) for 0.75 4(d) for 0.70, 4(e) for 0.65 and 4(f) is for 0.60.

In general the expected results, based on reference 4, would have been an across the board increase in blade passage noise with increasing angle of attack, i.e., at every position the noise would have gone up with angle of attack, causing a general raising of the curve. However, in looking at figure 4, no such general increase is observed. At some positions the noise goes up with increasing angle of attack, but at some of the positions, like the next to the most aft position at $M = 0.8$ (fig. 4(b)), the trend almost seems to be reversed, with the larger angles of attack giving less noise. Since the trend appears to be that the noise increases with increasing angle of attack at some positions and not at others, it may be that a directivity change is occurring as well as the noise magnitude variation. In addition, it may be that the scatter in the noise data is masking the angle of attack variation. In looking at the variation of the 0° data, comparing north with south wall data, the maximum scatter is about 4 dB. In previous data taken on the ceiling, ref. 3, the scatter was of the order of 1 dB. In any case it is difficult to draw any definite conclusions from these directivity plots and it points to the side walls of the tunnel as not being as good a noise measuring location as the tunnel ceiling.

Maximum Blade Passage Tone Variation

In order to further investigate the variation with angle of attack the noise at the maximum noise position was plotted as shown in figure 5. This maximum noise is of most interest and some definite trends are shown here. The farthest aft position was judged to have the maximum noise at all of the tunnel Mach numbers except 0.70 for which the next most aft position was the maximum. Figure 5 indicates that the noise on the north wall of the tunnel goes up with angle of attack for most of the tested Mach numbers. This increase is as much 9 dB for the noise at 4° angle of attack on the north wall of the tunnel at 0.7 tunnel Mach number. The increases are not very linear with angle of attack but this may be in part the result of the data scatter mentioned earlier. As a result of the data scatter and the limited range of the testing the results are not as conclusive as desired. However, these increases in the maximum noise indicate that the increased propeller angle of attack caused by the upwash flow over an airplane wing may have a significant effect on the noise from these propellers.

While the north wall of the wind tunnel showed noise increases with angle of attack, the south wall consistently showed less of a noise increase than the north wall and in some cases no increase at all or a reduction. Some of this difference may be the resullt of the data scatter mentioned earlier but this does not explain the total differences between the data on the tunnel walls. A possible explanation for this comes from looking at the shock waves on the propeller blades. As was indicated in reference 7, the shock wave striking the side wall of the tunnel originates from the suction surface of the propeller blade. The shock wave hitting the south wall of the wind tunnel comes from the blade when the blade is near the top of the tunnel and the shock wave hitting the north wall comes from the blade when the blade is near the bottom of the tunnel. When the propeller is at angle of attack the effective blade sweep is reduced on the blade at the bottom of the tunnel thereby producing stronger shock waves which then impact the north wall. This gives a noise increase on the north wall at angle of attack. The blade at the top of the wind tunnel sees an increase in its blade sweep when the propeller is at angle of attack. This would give relatively weaker shock waves and even a possible noise reduction on the south wall.

Since the noise at angle of attack does not seem to be symmetric it points to a desired orientation of the propeller with respect to the fuselage, i.e., the fuselage should be on the quieter, retreating blade side. In order to accomplish this for an airplane, where propellers would be on both sides of the fuselage, opposite directions of rotation would be needed. In other words it would be desireable for the propellers to rotate from below the wing up past the fuselage on both sides of the plane. Requiring opposite direction of rotation on either side of the fuselage might bring added mechanical complexity to the airplane but it appears to result in less noise impacting the fuselage and therefore less heavy fuselage damping materials.

CONCLUDING REMARKS

The noise of the SR-3 propeller at 2 and 4 degrees angle of attack was measured in the NASA Lewis 8- by 6-foot wind tunnel. The noise measured on the tunnel side walls did not show an increase with increased angle of attack at all of the measuring positions. However, increases were obtained at the maximum noise position on the north tunnel wall. The result indicates that the increased propeller angle of attack caused by the upwash flow over an airplane wing may have an adverse effect on the interior noise of advanced turboprop airplanes. The noise on the south wall of the wind tunnel did not increase as much with angle of attack as the noise on the north wall. This lack of symmetry of the noise at angle of attack points to the use of oppositely rotating propellers on opposite sides of an airplane fuselage as a way of minimizing the noise effect of angle of attack operation.

APPENDIX - SYMBOLS

C_p	power coefficient, $C_p = P/\rho N^3D^5$
D	propeller diameter
J	advance ratio, $J = V/ND$
M	tunnel axial Mach number
N	propeller rotational speed (revolutions/time)
P	shaft input power
V	tunnel axial velocity
ρ	density

REFERENCES

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TABLE 1. - SR-3 Propeller Design Conditions

	SR-3
Design cruise tip speed, m/sec (ft/sec)	244 (800)
Design cruise power loading, kW/m^2 (shp/ft^2)	301 (37.5)
Number of blades	8
Tip sweep angle, mid chord, deg	34
Design efficiency, percent	81
Nominal diameter, D, cm (in.)	62.2 (24.5)
Power Coefficient, c_p	1.7
Advance Ratio, J	3.06
Mach number	0.8

TABLE 2. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.06

(a1) Tunnel Mach number, 0.85; angle of attack, 0°; propeller speed, 8940 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	(b)	133.0	133.0	144.0	(c)	(c)	134.0	(c)
2	(b)	(b)	131.0	130.0	(c)	(c)	131.5	(c)
3	(b)	(b)	121.0	136.0	(c)	(c)	(b)	(c)
4	(b)	(b)	(b)	123.0	(c)	(c)	(b)	(c)
5	(b)	(b)	(b)	129.0	(c)	(c)	(b)	(c)
6	(b)	(b)	(b)	122.5	(c)	(c)	(b)	(c)
7	(b)	(b)	(b)	117.5	(c)	(c)	(b)	(c)
8	(b)	(b)	(b)	119.0	(c)	(c)	(b)	(c)

(a2) Tunnel Mach number, 0.85; angle of attack, 2°; propeller speed, 8940 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	(b)	131.0	134.5	145.0	(c)	132.0	136.0	(c)
2	(b)	(b)	131.0	132.0	(c)	(b)	129.0	(c)
3	(b)	(b)	121.5	136.5	(c)	(b)	(b)	(c)
4	(b)	(b)	(b)	125.0	(c)	(b)	(b)	(c)
5	(b)	(b)	(b)	126.0	(c)	(b)	(b)	(c)
6	(b)	(b)	(b)	124.5	(c)	(b)	(b)	(c)
7	(b)	(b)	(b)	117.0	(c)	(b)	(b)	(c)
8	(b)	(b)	(b)	115.5	(c)	(b)	(b)	(c)

(a3) Tunnel Mach number, 0.85; angle of attack, 4°; propeller speed, 8940 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	(b)	137.5	133.5	147.5	(c)	141.0	140.5	(c)	147.5	146.5
2	(b)	126.0	130.0	137.0	(c)	132.0	134.5	(c)	137.0	132.0
3	(b)	(b)	127.5	135.5	(c)	123.5	133.0	(c)	136.0	134.5
4	(b)	(b)	(b)	128.0	(c)	(b)	127.0	(c)	125.5	134.0
5	(b)	(b)	(b)	131.0	(c)	(b)	122.0	(c)	129.5	128.0
6	(b)	(b)	(b)	119.5	(c)	(b)	117.0	(c)	122.0	124.5
7	(b)	(b)	(b)	123.0	(c)	(b)	(b)	(c)	120.5	119.0
8	(b)	(b)	(b)	118.0	(c)	(b)	(b)	(c)	118.0	116.0

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.

TABLE 2. - SR-3 SOUND PRESSURE LEVELS AT A

PROPELLER ADVANCE RATIO OF 3.06

(b1) Tunnel Mach number, 0.80; angle of attack, 0°; propeller speed, 8490 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	140.5	139.0	143.0	142.5	(c)	(c)	144.0	143.0
2	122.5	129.0	133.5	135.5	(c)	(c)	134.0	133.0
3	(b)	122.5	134.5	130.5	(c)	(c)	133.0	133.5
4	(b)	(b)	125.5	132.5	(c)	(c)	126.5	133.0
5	(b)	(b)	123.5	124.0	(c)	(c)	122.5	123.5
6	(b)	(b)	120.0	124.5	(c)	(c)	119.0	126.5
7	(b)	(b)	115.0	116.0	(c)	(c)	116.0	116.0
8	(b)	(b)	(b)	118.0	(c)	(c)	(b)	(b)

(b2) Tunnel Mach number, 0.8; angle of attack, 2°; propeller speed, 8490 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	(c)	(c)	142.5	145.5	(c)	136.0	141.5	142.0
2	(c)	(c)	133.0	134.5	(c)	126.5	135.0	140.0
3	(c)	(c)	127.0	134.5	(c)	(b)	128.5	129.0
4	(c)	(c)	121.0	131.0	(c)	(b)	127.5	133.0
5	(c)	(c)	116.5	123.0	(c)	(b)	121.0	125.0
6	(c)	(c)	(b)	124.5	(c)	(b)	(b)	125.0
7	(c)	(c)	(b)	120.0	(c)	(b)	(b)	118.0
8	(c)	(c)	(b)	114.0	(c)	(b)	(b)	118.0

(b3) Tunnel Mach number, 0.80; angle of attack, 4°; propeller speed, 8490 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	(c)	(c)	143.0	147.0	(c)	138.0	138.0	143.0	148.0	144.0
2	(c)	(c)	133.5	133.0	(c)	129.0	138.5	136.5	132.0	136.5
3	(c)	(c)	130.5	135.5	(c)	122.0	129.0	125.5	136.5	124.0
4	(c)	(c)	124.0	129.0	(c)	(b)	130.0	130.0	128.0	132.0
5	(c)	(c)	120.0	126.0	(c)	(b)	123.5	126.0	128.0	127.0
6	(c)	(c)	116.0	122.5	(c)	(b)	120.0	123.5	122.0	123.0
7	(c)	(c)	(b)	118.5	(c)	(b)	115.0	123.5	118.0	120.5
8	(c)	(c)	(b)	119.0	(c)	(b)	112.0	116.0	116.5	116.0

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.

TABLE 2. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.06

(c1) Tunnel Mach number, 0.75; angle of attack, 0°; propeller speed, 8040 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	132.0	140.0	143.0	142.0	135.5	(c)	144.0	139.5
2	126.5	133.0	136.0	135.5	128.5	(c)	139.0	135.5
3	(b)	127.0	127.0	126.0	(b)	(c)	129.5	127.5
4	(b)	121.0	129.5	130.0	(b)	(c)	130.5	131.0
5	(b)	(b)	125.0	127.5	(b)	(c)	124.5	128.5
6	(b)	(b)	123.0	121.5	(b)	(c)	123.0	124.5
7	(b)	(b)	117.5	119.5	(b)	(c)	117.0	120.0
8	(b)	(b)	116.5	113.5	(b)	(c)	115.5	116.0

(c2) Tunnel Mach number, 0.75; angle of attack, 2°; propeller speed, 8040 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	133.5	143.5	144.0	147.0	138.0	(c)	(c)	144.5
2	124.5	134.0	136.0	137.0	129.0	(c)	(c)	137.0
3	(b)	123.5	130.5	128.0	(b)	(c)	(c)	124.5
4	(b)	119.5	128.5	131.5	(b)	(c)	(c)	131.5
5	(b)	(b)	126.0	124.5	(b)	(c)	(c)	128.5
6	(b)	(b)	122.5	123.5	(b)	(c)	(c)	123.0
7	(b)	(b)	118.0	118.0	(b)	(c)	(c)	118.5
8	(b)	(b)	114.0	116.5	(b)	(c)	(c)	111.5

(c3) Tunnel Mach number, 0.75; angle of attack, 4°; propeller speed, 8040 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	137.0	141.0	145.0	145.5	(c)	137.5	138.0	138.0	147.0	142.0
2	125.5	133.5	134.0	136.5	(c)	136.0	136.5	137.0	136.0	141.0
3	(b)	127.5	133.0	128.0	(c)	130.5	128.5	128.5	129.5	126.0
4	(b)	121.5	130.0	130.5	(c)	125.5	121.5	121.5	130.0	131.0
5	(b)	118.5	128.5	124.0	(c)	121.5	122.5	122.5	125.0	128.5
6	(b)	115.0	123.0	124.0	(c)	117.0	119.0	119.0	122.0	124.5
7	(b)	(b)	121.5	119.0	(c)	114.5	118.5	118.0	119.5	120.0
8	(b)	(b)	117.0	116.0	(c)	(b)	114.0	114.0	117.5	116.5

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.

TABLE 2. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.06

(d1) Tunnel Mach number, 0.70; angle of attack, 0°; propeller speed, 7550 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	128.5	132.0	135.5	138.0	(c)	(c)	138.0	140.5
2	130.5	132.5	132.0	129.0	(c)	(c)	138.0	130.5
3	124.0	132.0	129.0	116.5	(c)	(c)	129.0	130.0
4	122.5	127.0	120.0	112.0	(c)	(c)	125.5	122.5
5	117.5	121.5	119.0	108.0	(c)	(c)	120.5	118.5
6	(b)	119.0	118.5	102.5	(c)	(c)	118.5	116.0
7	(b)	117.0	118.0	103.0	(c)	(c)	117.5	116.5
8	(b)	113.5	115.0	100.0	(c)	(c)	116.5	113.0

(d2) Tunnel Mach number, 0.70; angle of attack, 2°; propeller speed, 7550 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	130.0	138.0	140.0	140.0	129.0	134.5	136.0	138.0
2	125.0	134.5	136.0	126.5	128.0	131.5	134.5	132.5
3	122.5	126.0	131.0	125.0	125.0	130.5	129.0	130.0
4	(b)	121.0	123.0	120.5	(b)	125.5	122.5	122.5
5	(b)	117.5	123.5	120.0	(b)	121.0	120.0	121.5
6	(b)	(b)	120.0	117.0	(b)	117.0	117.5	117.5
7	(b)	(b)	118.5	113.5	(b)	113.5	116.0	116.0
8	(b)	(b)	115.5	112.0	(b)	110.5	115.0	114.0

(d3) Tunnel Mach number, 0.70; angle of attack, 4°; propeller speed, 7550 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	138.0	142.5	145.0	140.5	142.0	143.5	143.0	(c)	141.5	(c)
2	124.0	134.5	134.0	130.0	130.0	132.5	131.0	(c)	130.0	(c)
3	122.0	125.0	125.0	124.5	124.0	131.5	128.0	(c)	125.0	(c)
4	(b)	121.0	125.0	119.0	121.0	127.5	126.5	(c)	119.5	(c)
5	(b)	116.5	121.5	121.0	(b)	122.5	122.0	(c)	121.5	(c)
6	(b)	(b)	120.0	114.0	(b)	118.5	115.0	(c)	118.0	(c)
7	(b)	(b)	118.5	(b)	(b)	116.5	114.0	(c)	113.5	(c)
8	(b)	(b)	115.5	(b)	(b)	113.0	112.5	(c)	112.0	(c)

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.

TABLE 2. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.06

(e1) Tunnel Mach number, 0.65; angle of attack, 0°; propeller speed, 7070 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	131.5	132.0	133.5	136.0	133.5	(c)	135.5	135.5
2	125.5	126.0	123.0	125.0	125.0	(c)	128.0	124.0
3	(b)	121.5	121.5	116.5	(b)	(c)	(b)	(b)
4	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
5	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
6	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
7	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
8	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)

(e2) Tunnel Mach number, 0.65; angle of attack[d], 2°; propeller speed, 7070 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	132.5	132.0	(c)	135.5	133.0	131.5	(c)	134.0
2	124.0	131.0	(c)	124.5	131.0	131.5	(c)	133.0
3	(b)	122.0	(c)	(b)	124.0	120.0	(c)	124.0
4	(b)	(b)	(c)	(b)	(b)	(b)	(c)	(b)
5	(b)	(b)	(c)	(b)	(b)	(b)	(c)	(b)
6	(b)	(b)	(c)	(b)	(b)	(b)	(c)	(b)
7	(b)	(b)	(c)	(b)	(b)	(b)	(c)	(b)
8	(b)	(b)	(c)	(b)	(b)	(b)	(c)	(b)

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data
[d]No data available at 4° angle of attack.

TABLE 2. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.06

(f1) Tunnel Mach number, 0.60; angle of attack, 0°; propeller speed, 6575 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	128.5	129.5	122.0	127.0	131.0	(c)	125.5	126.0
2	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
3	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
4	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
5	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
6	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
7	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
8	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)

(f2) Tunnel Mach number, 0.60, angle of attack[d], 2°; propeller speed, 6575 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	127.5	127.0	126.0	131.0	128.5	127.0	126.0	124.5
2	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
3	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
4	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
5	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
6	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
7	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
8	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data
[d]No data available at 4° angle of attack.

TABLE 3. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.26

(a1) Tunnel Mach number, 0.85; angle of attack, 0°; propeller speed, 8390 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	(b)	128.5	138.0	142.0	(b)	(c)	138.0	(c)
2	(b)	(b)	127.5	135.5	(b)	(c)	129.0	(c)
3	(b)	(b)	(b)	134.0	(b)	(c)	(b)	(c)
4	(b)	(b)	(b)	128.0	(b)	(c)	(b)	(c)
5	(b)	(b)	(b)	128.5	(b)	(c)	(b)	(c)
6	(b)	(b)	(b)	116.5	(b)	(c)	(b)	(c)
7	(b)	(b)	(b)	122.5	(b)	(c)	(b)	(c)
8	(b)	(b)	(b)	113.5	(b)	(c)	(b)	(c)

(a2) Tunnel Mach number, 0.85; angle of attack, 2°; propeller speed, 8390 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	(b)	128.0	139.5	143.0	(c)	127.5	139.5	(c)
2	(b)	(b)	128.0	135.0	(c)	(b)	131.0	(c)
3	(b)	(b)	(b)	135.5	(c)	(b)	123.5	(c)
4	(b)	(b)	(b)	124.0	(c)	(b)	(b)	(c)
5	(b)	(b)	(b)	128.5	(c)	(b)	(b)	(c)
6	(b)	(b)	(b)	117.5	(c)	(b)	(b)	(c)
7	(b)	(b)	(b)	119.5	(c)	(b)	(b)	(c)
8	(b)	(b)	(b)	116.5	(c)	(b)	(b)	(c)

(a3) Tunnel Mach number, 0.85; angle of attack, 4°; propeller speed, 8390 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	125.5	135.5	138.0	146.5	(c)	141.0	142.5	(c)	146.0	(c)
2	(b)	124.0	131.0	138.5	(c)	128.0	135.0	(c)	139.5	(c)
3	(b)	(b)	128.0	133.5	(c)	(b)	131.5	(c)	135.0	(c)
4	(b)	(b)	122.5	133.0	(c)	(b)	124.5	(c)	131.0	(c)
5	(b)	(b)	118.0	128.0	(c)	(b)	121.0	(c)	128.0	(c)
6	(b)	(b)	(b)	125.0	(c)	(b)	115.0	(c)	121.0	(c)
7	(b)	(b)	(b)	122.0	(c)	(b)	(b)	(c)	123.0	(c)
8	(b)	(b)	(b)	115.0	(c)	(b)	(b)	(c)	114.5	(c)

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.

TABLE 3. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.26

(b1) Tunnel Mach number, 0.80; angle of attack, 0°; propeller speed, 7990 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	129.0	137.0	138.5	144.0	131.0	(c)	141.0	143.5
2	(b)	128.0	136.0	133.0	(b)	(c)	134.5	134.0
3	(b)	124.5	130.5	124.0	(b)	(c)	131.0	125.0
4	(b)	(b)	129.0	129.0	(b)	(c)	127.5	130.0
5	(b)	(b)	123.5	124.5	(b)	(c)	125.0	125.0
6	(b)	(b)	119.0	120.5	(b)	(c)	(b)	123.5
7	(b)	(b)	(b)	119.0	(b)	(c)	(b)	120.5
8	(b)	(b)	(b)	115.0	(b)	(c)	(b)	116.0

(b2) Tunnel Mach number, 0.80; angle of attack, 2°; propeller speed, 7990 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	134.5	131.0	142.5	146.0	(b)	133.0	136.5	143.5
2	(b)	122.5	132.0	132.0	(b)	135.5	134.5	136.0
3	(b)	(b)	126.5	130.5	(b)	(b)	126.5	126.0
4	(b)	(b)	119.0	128.5	(b)	(b)	126.5	129.5
5	(b)	(b)	(b)	122.5	(b)	(b)	(b)	126.5
6	(b)	(b)	(b)	124.0	(b)	(b)	(b)	119.5
7	(b)	(b)	(b)	(b)	(b)	(b)	(b)	119.5
8	(b)	(b)	(b)	(b)	(b)	(b)	(b)	115.0

(b3) Tunnel Mach number, 0.80; angle of attack, 4°; propeller speed, 7990 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	128.5	131.0	143.0	145.5	(c)	136.5	141.0	140.0	146.5	139.0
2	(b)	(b)	127.5	135.5	(c)	130.0	137.0	133.5	135.0	133.5
3	(b)	(b)	128.0	131.0	(c)	(b)	128.5	124.0	133.5	125.5
4	(b)	(b)	124.0	129.0	(c)	(b)	125.5	126.5	128.5	127.5
5	(b)	(b)	119.5	124.0	(c)	(b)	123.5	126.5	125.5	118.0
6	(b)	(b)	(b)	119.5	(c)	(b)	118.0	123.5	121.0	121.5
7	(b)	(b)	(b)	119.5	(c)	(b)	116.0	120.0	118.5	118.5
8	(b)	(b)	(b)	113.5	(c)	(b)	(b)	116.0	114.5	116.0

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.

TABLE 3. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.26

(c1) Tunnel Mach number, 0.75; angle of attack, 0°; propeller speed, 7550 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	131.5	137.5	143.5	137.5	135.0	(c)	145.0	143.0
2	123.5	130.5	131.5	133.5	129.5	(c)	131.5	134.0
3	(b)	124.0	124.5	124.0	123.0	(c)	128.0	124.0
4	(b)	121.5	127.0	126.5	(b)	(c)	127.5	127.5
5	(b)	(b)	122.0	123.5	(b)	(c)	123.0	125.5
6	(b)	(b)	120.5	120.5	(b)	(c)	121.0	122.5
7	(b)	(b)	116.0	117.0	(b)	(c)	117.5	120.5
8	(b)	(b)	115.0	113.5	(b)	(c)	115.0	117.5

(c2) Tunnel Mach number, 0.75; angle of attack, 2°; propeller speed, 7550 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	136.5	137.0	142.5	136.5	134.0	133.5	138.0	138.5
2	126.5	133.5	136.0	134.0	126.0	130.5	131.5	134.0
3	(b)	124.5	126.0	125.5	(b)	126.0	125.5	127.5
4	(b)	120.0	129.0	126.0	(b)	121.0	124.5	126.0
5	(b)	(b)	124.0	125.5	(b)	(b)	122.5	126.0
6	(b)	(b)	121.0	120.0	(b)	(b)	120.0	122.0
7	(b)	(b)	117.5	117.0	(b)	(b)	116.0	118.0
8	(b)	(b)	114.5	116.0	(b)	(b)	113.0	115.5

(c3) Tunnel Mach number, 0.75; angle of attack, 4°; propeller speed, 7550 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	138.0	137.0	142.5	140.5	138.0	138.0	141.5	138.5	142.0	140.5
2	124.5	132.5	133.0	135.0	132.0	126.5	131.0	131.0	136.5	133.0
3	(b)	127.0	127.0	124.5	123.0	128.0	124.0	128.0	124.0	125.0
4	(b)	122.5	130.0	123.5	(b)	122.5	122.5	123.5	123.0	125.5
5	(b)	119.0	124.5	126.0	(b)	118.5	122.0	121.5	126.0	126.5
6	(b)	114.5	124.5	120.5	(b)	116.5	119.0	122.5	117.0	123.5
7	(b)	(b)	120.0	117.0	(b)	(b)	114.0	119.5	117.5	118.5
8	(b)	(b)	118.0	115.5	(b)	(b)	111.5	115.5	115.5	115.5

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.

TABLE 3. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.26

(d1) Tunnel Mach number, 0.7; angle of attack, 0°; propeller speed, 7090 rpm

Harmonic	Sound pressure level, dB (ref. $2x10^{-5}$ N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	132.5	132.0	(c)	133.5	128.0	(c)	130.0	132.0
2	127.5	130.0	(c)	121.5	126.5	(c)	134.0	128.0
3	125.5	129.5	(c)	(b)	124.5	(c)	125.0	125.5
4	(b)	120.0	(c)	(b)	(b)	(c)	(b)	(b)
5	(b)	117.0	(c)	(b)	(b)	(c)	(b)	(b)
6	(b)	(b)	(c)	(b)	(b)	(c)	(b)	(b)
7	(b)	(b)	(c)	(b)	(b)	(c)	(b)	(b)
8	(b)	(b)	(c)	(b)	(b)	(c)	(b)	(b)

(d2) Tunnel Mach number, 0.7; angle of attack, 2°; propeller speed, 7090 rpm

Harmonic	Sound pressure level, dB (ref. $2x10^{-5}$ N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	135.0	139.0	140.0	134.0	133.5	138.5	141.5	133.5
2	124.5	133.0	131.0	129.0	128.5	132.0	136.5	132.5
3	(b)	124.0	126.0	124.0	123.0	125.5	126.5	125.5
4	(b)	119.0	121.0	(b)	(b)	118.5	(b)	(b)
5	(b)	(b)	120.5	(b)	(b)	(b)	(b)	(b)
6	(b)	(b)	117.5	(b)	(b)	(b)	(b)	(b)
7	(b)	(b)	115.0	(b)	(b)	(b)	(b)	(b)
8	(b)	(b)	113.0	(b)	(b)	(b)	(b)	(b)

(d3) Tunnel Mach number, 0.7; angle of attack, 4°; propeller speed, 7090 rpm

Harmonic	Sound pressure level, dB (ref. $2x10^{-5}$ N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	139.0	139.5	138.0	136.0	133.0	134.0	135.0	132.5	136.0	135.0
2	126.5	130.0	131.0	129.0	131.5	130.0	136.0	131.0	132.0	130.5
3	122.0	126.0	123.0	(b)	123.5	127.5	122.0	127.0	124.0	125.5
4	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
5	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
6	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
7	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
8	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.

TABLE 3. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.26

(e1) Tunnel Mach number, 0.65; angle of attack, 0°; propeller speed, 6640 rpm

Harmonic	Sound pressure level, dB (ref. $2x10^{-5}$ N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	128.5	131.5	132.5	126.5	125.0	(c)	131.0	126.0
2	(b)	123.0	124.5	(b)	121.5	(c)	123.0	(b)
3	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
4	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
5	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
6	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
7	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
8	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)

(e2) Tunnel Mach number, 0.65; angle of attack, 2°; propeller speed, 6640 rpm

Harmonic	Sound pressure level, dB (ref. $2x10^{-5}$ N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	125.0	(c)	133.0	131.5	124.0	127.5	132.0	134.0
2	122.0	(c)	124.0	(b)	(b)	(b)	(b)	123.0
3	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)
4	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)
5	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)
6	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)
7	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)
8	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)

(e3) Tunnel Mach number[d], 0.65; angle of attack, 4°; propeller speed, 6640 rpm

Harmonic	Sound pressure level, dB (ref. $2x10^{-5}$ N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	123.5	127.5	(c)	132.0	124.5	127.5	132.5	134.0	132.0	134.0
2	124.0	126.0	(c)	(b)	122.5	122.0	123.5	122.0	(b)	123.5
3	(b)	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
4	(b)	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
5	(b)	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
6	(b)	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
7	(b)	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
8	(b)	(b)	(c)	(b)	(b)	(b)	(b)	(b)	(b)	(b)

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.
[d]No data available at a tunnel Mach number of 0.60.

TABLE 4. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.5

(a1) Tunnel Mach number, 0.85; angle of attack, 0°; propeller speed, 7810 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	No data available							
2								
3								
4								
5								
6								
7								
8								

(a2) Tunnel Mach number, 0.85; angle of attack[d], 2°; propeller speed, 7810 rpm

Harmonic	Sound pressure level, dB (ref. 2×10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	(c)	126.5	138.0	141.0	123.0	125.0	139.0	138.5
2	(c)	(b)	123.5	138.0	(b)	(b)	129.5	134.0
3	(c)	(b)	(b)	131.5	(b)	(b)	(b)	133.0
4	(c)	(b)	(b)	129.5	(b)	(b)	(b)	126.0
5	(c)	(b)	(b)	124.5	(b)	(b)	(b)	127.0
6	(c)	(b)	(b)	121.5	(b)	(b)	(b)	120.0
7	(c)	(b)	(b)	118.0	(b)	(b)	(b)	118.5
8	(c)	(b)	(b)	(b)	(b)	(b)	(b)	117.0

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data
[d]No data available at 4° angle of attack.

TABLE 4. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.5

(b1) Tunnel Mach number, 0.80; angle of attack, 0°; propeller speed, 7430 rpm

Harmonic	Sound pressure level, dB (ref. $2x10^{-5}$ N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	129.5	137.0	141.0	135.5	128.5	(c)	143.0	(c)
2	(b)	130.5	135.0	133.5	(b)	(c)	138.5	(c)
3	(b)	124.0	127.0	124.0	(b)	(c)	127.5	(c)
4	(b)	(b)	127.5	125.5	(b)	(c)	126.5	(c)
5	(b)	(b)	121.0	124.0	(b)	(c)	121.5	(c)
6	(b)	(b)	120.0	119.0	(b)	(c)	119.5	(c)
7	(b)	(b)	116.0	115.5	(b)	(c)	116.0	(c)
8	(b)	(b)	112.5	115.5	(b)	(c)	(b)	(c)

(b2) Tunnel Mach number, 0.8; angle of attack, 2°; propeller speed, 7430 rpm

Harmonic	Sound pressure level, dB (ref. $2x10^{-5}$ N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	128.5	133.0	140.0	144.0	129.5	131.0	137.0	141.0
2	(b)	123.5	131.0	132.5	(b)	125.5	133.0	133.0
3	(b)	(b)	124.5	125.5	(b)	(b)	127.5	124.0
4	(b)	(b)	(b)	125.5	(b)	(b)	122.5	122.0
5	(b)	(b)	(b)	125.0	(b)	(b)	120.5	125.5
6	(b)	(b)	(b)	117.0	(b)	(b)	116.0	120.0
7	(b)	(b)	(b)	117.5	(b)	(b)	114.0	116.5
8	(b)	(b)	(b)	113.5	(b)	(b)	111.0	114.5

(b3) Tunnel Mach number, 0.80; angle of attack, 4°; propeller speed, 7430 rpm

Harmonic	Sound pressure level, dB (ref. $2x10^{-5}$ N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	128.5	131.5	141.5	143.5	128.0	136.0	137.5	136.5	144.0	137.0
2	(b)	124.0	126.0	134.0	(b)	131.0	136.0	134.0	133.5	134.0
3	(b)	(b)	126.0	125.0	(b)	124.5	128.0	126.0	127.5	124.0
4	(b)	(b)	124.0	123.0	(b)	120.5	121.5	126.0	124.0	126.0
5	(b)	(b)	119.5	123.0	(b)	(b)	122.0	123.5	125.0	124.5
6	(b)	(b)	(b)	116.5	(b)	(b)	118.0	120.0	117.0	120.0
7	(b)	(b)	(b)	115.5	(b)	(b)	115.0	116.5	118.0	115.0
8	(b)	(b)	(b)	113.5	(b)	(b)	112.0	113.5	113.5	(b)

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.

TABLE 4. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.5

(c1) Tunnel Mach number, 0.75; angle of attack, 0°; propeller speed, 7040 rpm

Harmonic	Sound pressure level, dB (ref. 2x10⁻⁵ N/m²) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)[a]	126.5	135.5	(c)	132.5	129.5	(c)	136.0	133.5
2	124.0	131.0	(c)	125.5	(b)	(c)	134.0	130.0
3	(b)	127.0	(c)	125.0	(b)	(c)	127.0	126.0
4	(b)	121.5	(c)	120.0	(b)	(c)	125.0	121.5
5	(b)	118.0	(c)	119.0	(b)	(c)	123.0	121.5
6	(b)	116.0	(c)	116.0	(b)	(c)	119.5	118.0
7	(b)	(b)	(c)	112.5	(b)	(c)	117.0	116.0
8	(b)	(b)	(c)	111.0	(b)	(c)	115.0	113.0

(c2) Tunnel Mach number, 0.75; angle of attack, 2°; propeller speed, 7040 rpm

Harmonic	Sound pressure level, dB (ref. 2x10⁻⁵ N/m²) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	128.0	136.0	139.0	135.0	128.5	133.5	136.0	133.0
2	123.5	125.0	134.0	128.0	125.0	129.5	131.0	128.0
3	(b)	(b)	126.0	124.5	(b)	124.0	128.0	124.5
4	(b)	(b)	122.0	120.5	(b)	(b)	121.5	121.0
5	(b)	(b)	121.5	119.5	(b)	(b)	121.0	121.0
6	(b)	(b)	117.0	118.0	(b)	(b)	119.0	119.0
7	(b)	(b)	(b)	(b)	(b)	(b)	115.5	116.0
8	(b)	(b)	(b)	(b)	(b)	(b)	113.0	114.0

(c3) Tunnel Mach number, 0.75; angle of attack, 4°; propeller speed, 7040 rpm

Harmonic	Sound pressure level, dB (ref. 2x10⁻⁵ N/m²) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	(c)	138.0	142.5	136.5	136.0	(c)	137.0	140.0	135.5	139.0
2	(c)	125.5	130.5	129.0	125.0	(c)	132.5	129.0	131.0	130.0
3	(c)	(b)	123.5	(b)	(b)	(c)	125.5	125.5	125.5	125.0
4	(c)	(b)	122.5	(b)	(b)	(c)	122.0	124.0	(b)	121.5
5	(c)	(b)	121.0	(b)	(b)	(c)	119.5	119.5	(b)	119.0
6	(c)	(b)	(b)	(b)	(b)	(c)	116.5	116.0	(b)	117.5
7	(c)	(b)	(b)	(b)	(b)	(c)	114.5	114.5	(b)	114.5
8	(c)	(b)	(b)	(b)	(b)	(c)	111.5	112.5	(b)	112.5

[a] Blade passage frequency.
[b] Tone not visible.
[c] No data.

TABLE 4. - SR-3 SOUND PRESSURE LEVELS AT A PROPELLER ADVANCE RATIO OF 3.5

(d1) Tunnel Mach number, 0.7; angle of attack, 0°; propeller speed, 6595 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -							
	6	7	8	9	10	11	12	13
1(BPF)	(b)	129.5	131.0	132.0	(b)	(c)	131.5	130.5
2	(b)	126.5	128.0	124.5	(b)	(c)	126.0	125.0
3	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
4	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
5	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
6	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
7	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)
8	(b)	(b)	(b)	(b)	(b)	(c)	(b)	(b)

(d2) Tunnel Mach number, 0.7; angle of attack, 2°; propeller speed, 6595 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -							
	14	15	16	17	18	19	20	21
1(BPF)	128.0	130.5	131.5	133.0	(b)	130.0	130.5	131.0
2	124.0	125.5	124.5	125.5	(b)	128.0	130.5	126.5
3	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
4	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
5	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
6	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
7	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
8	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)

(d3) Tunnel Mach number[d], 0.7; angle of attack, 4°; propeller speed, 6595 rpm

Harmonic	Sound pressure level, dB (ref. 2x10^{-5} N/m^2) for transducer position of -									
	22	23	24	25	26	27	28	29	17	21
1(BPF)	131.0	133.0	135.0	132.0	130.0	133.0	133.0	130.0	134.0	128.0
2	123.0	129.0	126.0	124.5	(b)	124.5	124.5	127.5	124.0	124.5
3	(b)	123.5	124.5	(b)	(b)	(b)	(b)	123.0	(b)	123.0
4	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
5	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
6	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
7	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)
8	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)	(b)

[a]Blade passage frequency.
[b]Tone not visible.
[c]No data.
[d]No data available at tunnel Mach numbers of 0.65 and 0.60.

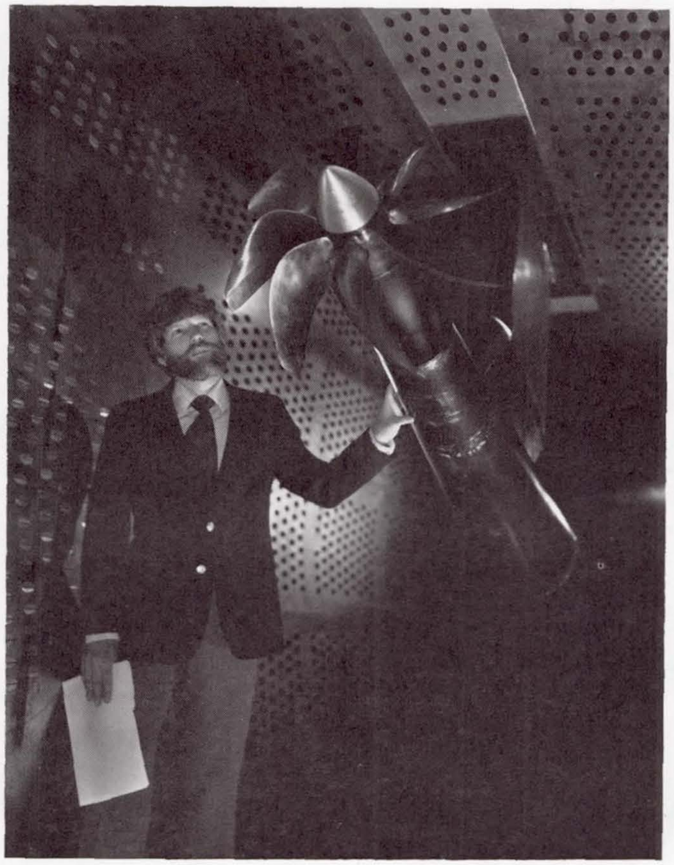


Figure 1. - SR-3 propeller at angle of attack.

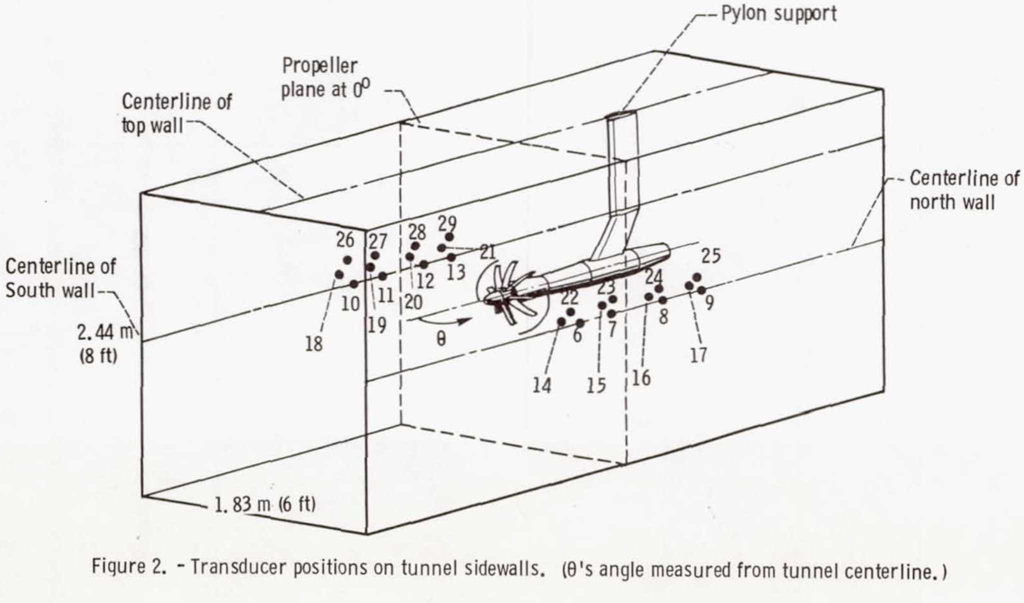
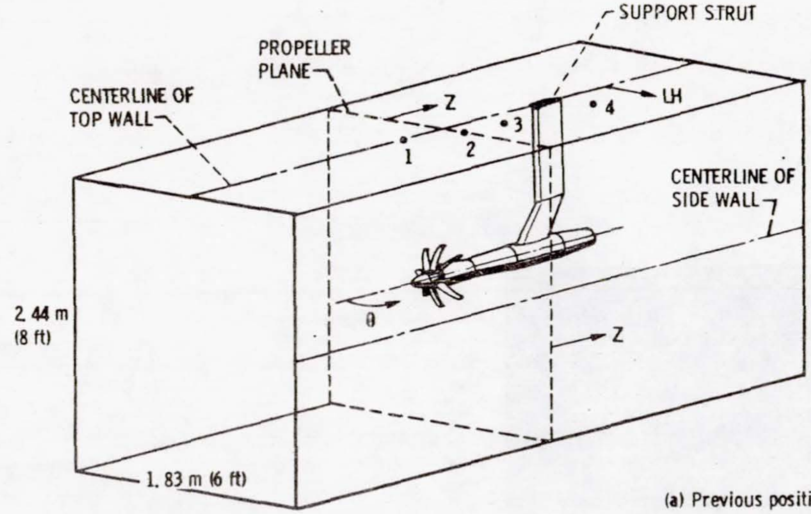
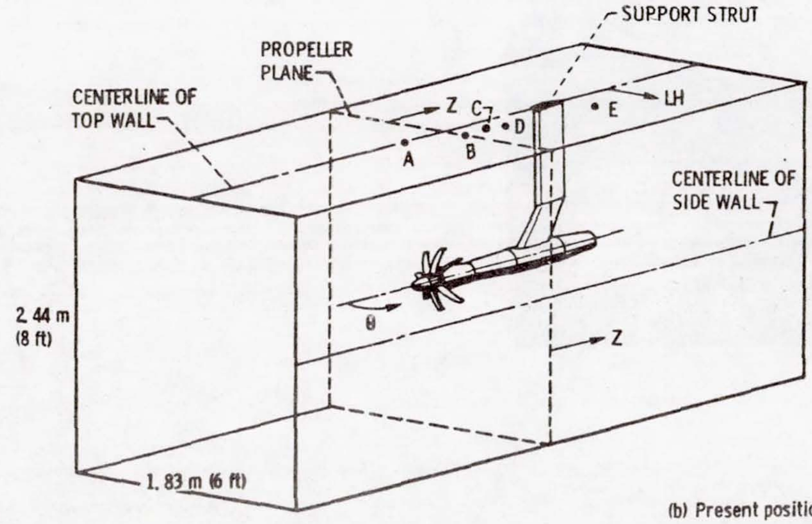


Figure 2. - Transducer positions on tunnel sidewalls. (θ's angle measured from tunnel centerline.)



POSITION	TRANSDUCER			
	1	2	3	4
	TRANSDUCER POSITION, cm (in.)			
Z LH	-27.7(-10.9) 2.54(1.0)	0.953(0.375) 10.2(4.0)	45.2(17.8) 7.62(3.0)	104.4(41.1) 31.5(12.4)
NOMINAL ANGLE, θ, deg.	77	90	110	130

(a) Previous positions.



POSITION	TRANSDUCER				
	A	B	C	D	E
	TRANSDUCER POSITION, cm (in.)				
Z LH	33.0(13.0) 4.83(1.9)	0.953(0.375) 10.2(4.0)	23.9(9.4) 2.54(1.0)	45.2(17.8) 7.62(3.0)	107.4(42.3) 31.5(12.4)
NOMINAL ANGLE, θ, deg.	75	90	101	110	131

(b) Present positions.

Figure 2. - Pressure transducer positions.

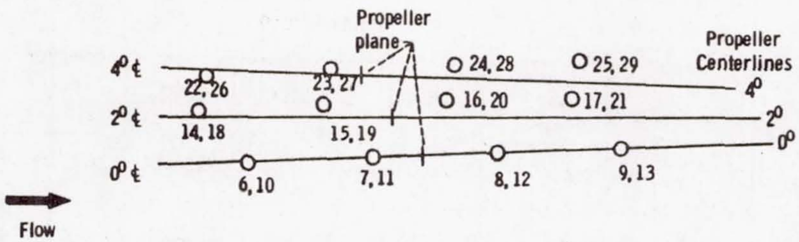
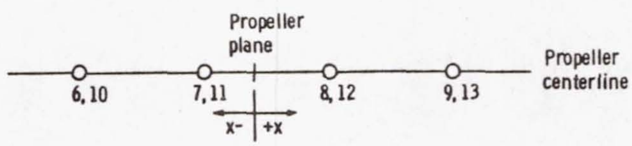


Figure 3. - Transducer positions (North wall transducer, south wall transducer) a general layout.

0^0 Positions



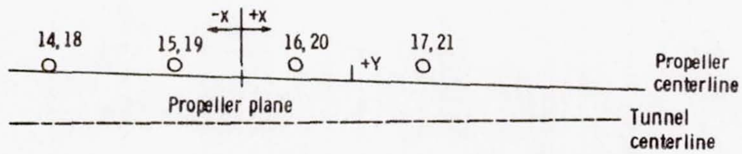
Position (cm, in)

Transducer (North wall, South wall)	6, 10	7, 11	8, 12	9, 13
Position, x	-23.4, -9.2	-5.6, -2.2	12.2, 4.8	30.0, 11.8
Propeller diameters, x/D	-0.376	-0.090	0.196	0.482
Approximate angle, θ	75.7	86.5	97.6	108.1

(b) 0^0 positions.

Figure 3. - Continued.

2° positions



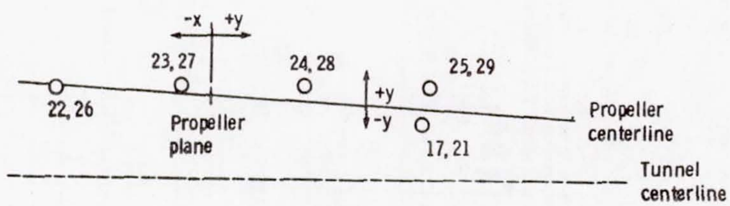
Position (cm, in)

Transducer (North wall, South wall)	14,18	15,19	16,20	17,21
Position, x	-25.7, -10.1	-8.1, -3.2	9.7, 3.8	27.2, 10.7
Position, y	1.0, 0.4	1.5, 0.6	2.0, 0.8	3.0, 1.2
Propeller diameters, x/D	-.412	-0.131	0.155	0.437
Approximate angle θ (using x only)	74.3	84.9	96.0	106.6

(c) 2° positions

Figure 3. - Continued.

4° positions



Position (cm, in)

Transducer (North wall, South wall)	22,26	23,27	24,28	25,29	17,21
Position, x	-19.6, -7.7	-2.0, -0.8	15.5, 6.1	32.8, 12.9	31.5, 12.4
Position, y	-0.5, -0.2	1.0, 0.4	2.0, .8	3.3, 1.3	-1.5, -0.6
Propeller diameters x/D	-0.314	-.033	0.249	0.527	0.506
Approximate angle θ (using x only)	77.9	88.7	99.6	109.7	109.0

(d) 4° positions

Figure 3. - Concluded.

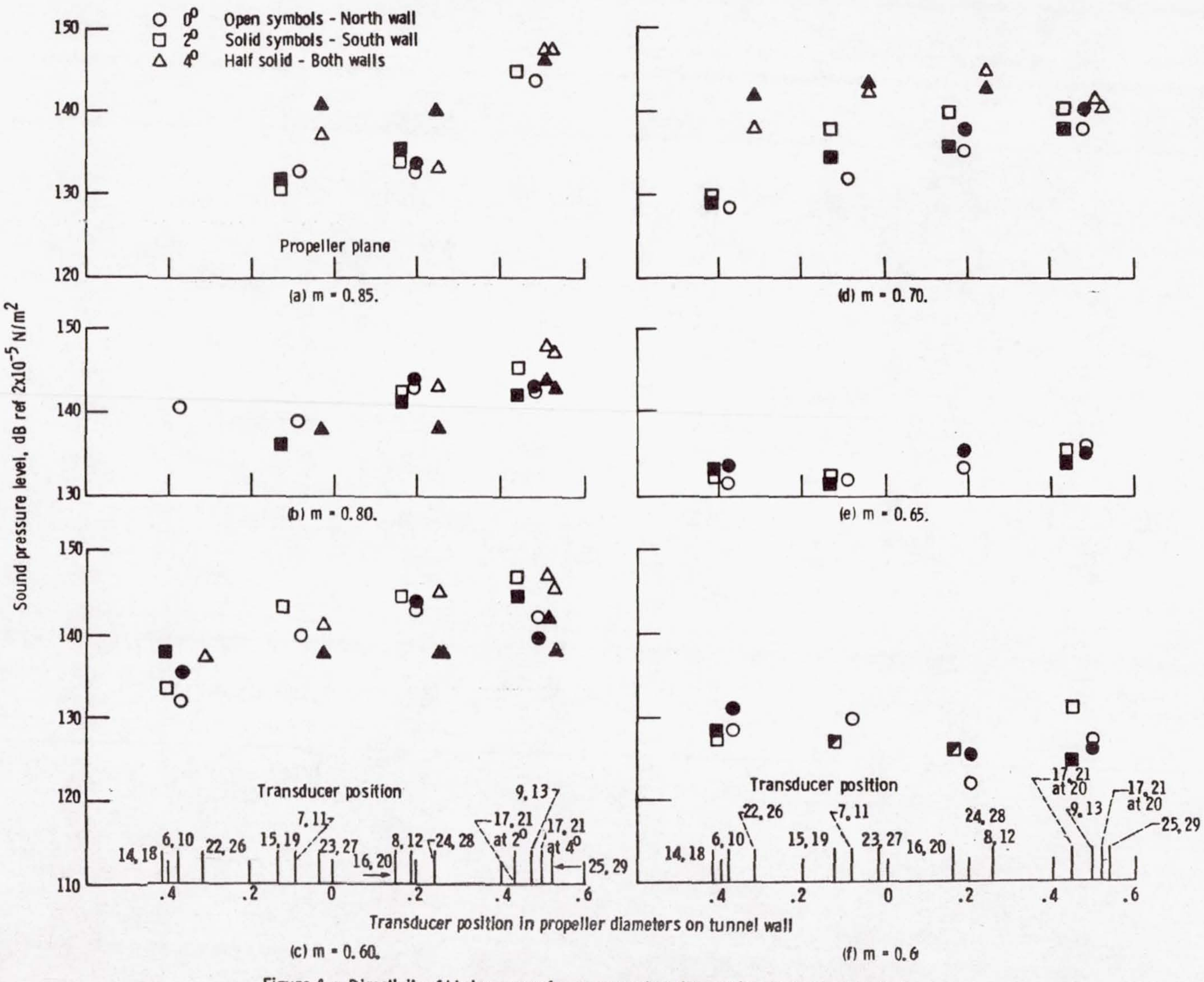


Figure 4. - Directivity of blade passage frequency noise with varying angle attack at J = 3.

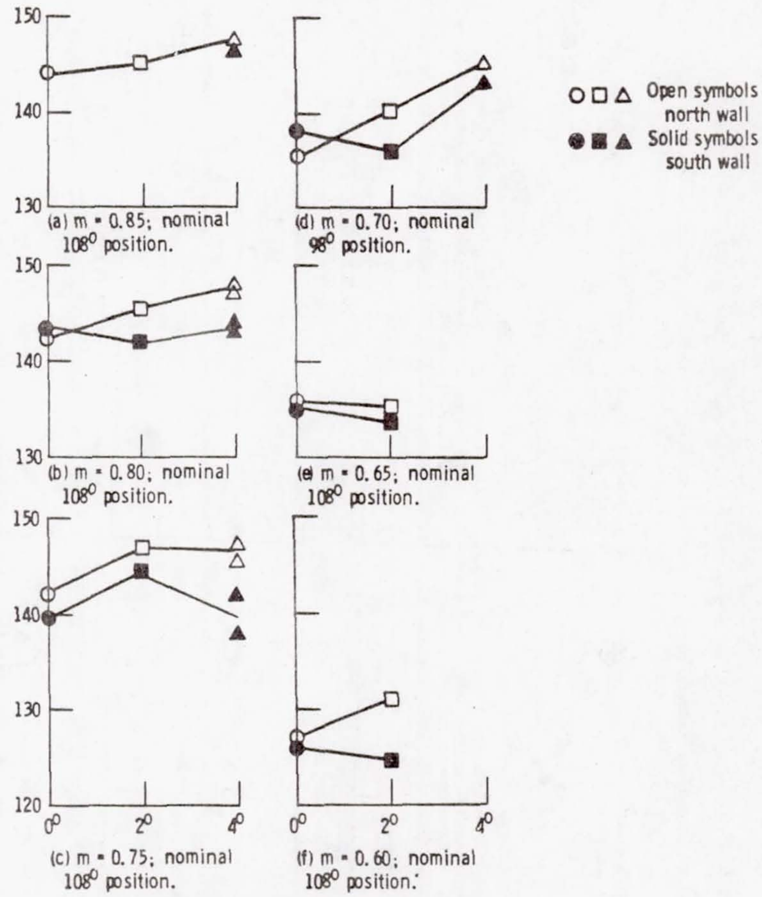


Figure 5. - Blade passage frequency noise at maximum noise position at J = 3.06.

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15. Supplementary Notes

16. Abstract

The noise generated by supersonic-tip-speed propellers is a possible cabin environment problem for future airplanes powered by these propellers. The noise of three propeller models has been previously measured in the NASA Lewis 8- by 6-foot wind tunnel with flow parallel to the propeller axis. In flight, as a result of the induced upwash from the airplane wing, the propeller may be at an angle of attack with respect to the incoming flow. Therefore experiments were undertaken on one of the existing propeller models to determine the noise effect of operating this type of propeller at angle of attack. Increases in the maximum blade passage noise were observed for the propeller operating at angle of attack. The noise increase was not symmetrical with one wall of the wind tunnel having significantly more noise increase than the other wall. This was apparently the result of the rotational direction of the propeller. The lack of symmetry of the noise at angle of attack points to the use of oppositely rotating propellers on opposite sides of an airplane fuselage as a way of minimizing the noise due to operation at angle of attack.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
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