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Large Scale Advanced Prop-Fan (LAP) Performance, Acoustic and Weight Estimation

Contract NAS 3-23051
February 1985

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16. Abstract

In comparison to turbo-prop applications, the Prop-Fan is designed to operate in a significantly higher range of aircraft flight speeds. Two concerns arise regarding operation at very high speeds: aerodynamic performance and noise generation. This data package covers both topics over a broad range of operating conditions for the eight (8) bladed SR-7L Prop-Fan. Operating conditions covered are: Flight Mach Number 0 - 0.85; blade tip speed 600-800 ft/sec; and cruise power loading 20-40 SHP/D^2. Prop-Fan weight and weight scaling estimates are also included.

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INTRODUCTION AND SUMMARY

This data package presents Hamilton Standard's aerodynamic and acoustic performance and weight estimates for the 8 bladed SR-7L Prop-Fan over a broad range of operating conditions as listed below. This Prop-Fan is being designed and fabricated under NASA contract NAS3-23051.

Flight Mach Number	0 - 0.85
Tip Speed, m/sec (ft/sec.)	183 - 244 (600 - 800)
Cruise Power Loading, Kw/m^2	171 - 343
(SHP/ft^2)	20 - 40

The design point for the SR-7L is a disc loading of 256.9 Kw/m^2 (32 SHP/ft^2) relative to diameter at 10,668 meters (35,000 ft) ISA and 243.8 m/sec (800 ft/sec) tip speed at 0.80 Mach number. Nondimensionally, this represents an advance ratio, J, of 3.06 and a power coefficient, Cp, of 1.448. The SR-7L has a blade activity factor, AF, of 227 and an integrated design lift coefficient, C_L , of 0.191.

The aerodynamic performance predictions are based on both theoretical and experimental data. For the 0.6 - 0.85 Mach number range, the HS-H-409 Compressible Vortex method was used to calculate performance at the design conditions. For off design conditions, performance trends were based on experimental data of the 8-bladed SR-3 tested in both the NASA LeRC 8' x 6' transonic wind tunnel and in the UTRC 8 ft. High Speed Wind Tunnel. For flight Mach numbers of 0.55 and below, the HS-H444 Propeller Performance Method was used to derive the performance data. This data was correlated with the low Mach number data on the SR-3 from the UTRC wind tunnel. Recent data on SR-3 indicates that choke exists in the blade root area with its associated losses. Alleviation of this choke would improve efficiency at higher M_N. Subsequent test data will provide us with insight for possible subsequent modifications.

The near field noise estimates are based on Hamilton Standard's theoretical calculation procedures HS-F091 which have been verified by both acoustic wind tunnel and Jetstar tests. Due to the complexity of the far field noise calculations which include the effects of ground reflection and tone and duration corrections, a graphical procedure is not feasible. Accordingly, a computer program which incorporates all of these effects has been developed (SP 06A83F).

Thus, the aerodynamic and acoustic performance included in this initial version of the data package are estimates based on theory and test data of a similar Prop-Fan configuration. Following the aerodynamic performance and acoustic tests of the aeroelastic

SR-7A model in the NASA LeRC 8' x 6' and 9' x 15' wind tunnels, the aerodynamic and acoustic performance presented herein will be revised as dictated by the experimental data. These revisions will be published as a supplement to this Data Package. Then, when the large scale LAP test program has been completed, this entire report will be revised as necessary to reflect any revisions to the weight, as well as any further modifications to the aerodynamic and acoustic performance data. The cost data will also be applied at that time.

The aerodynamic data is presented both as tables (1-9) of nondimensional propeller coefficients and as curves (figures 1-4) of net efficiency variation with power loading for several tip speeds for a range of Mach numbers. Corresponding slipstream characteristic data in terms of average swirl and incremental axial induced velocity are presented in tabular form (table 10).

The reverse thrust data is presented in figure 5. The reverse performance estimates were based on SR-3 test data available from the UTRC 8' and 18' throat tunnels and the NASA 8 x 6 and 10 x 10 tunnels. The estimated maximum negative blade angle for the SR-7L is -6° at the 75% radius. The coefficients J, C_P and C_T are the same as those used for the positive thrust performance.

The noise is presented in plots of overall near field noise level (free field), altitude correction, directivity changes and harmonic spectrum levels at near field locations. As indicated previously, far field data have not been included in the report. However, a computer program has been developed to predict the far field noise levels and is available from Hamilton Standard as a computer tape.

PERFORMANCE

PROP-FAN PERFORMANCE ESTIMATION

This data package provides the SR-7L Prop-Fan Performance in a non-dimensional coefficient format which permits the user to estimate performance over a broad range of operating conditions. The data is presented in tabular form for ease of computer application.

The performance is presented in terms of net thrust coefficient ($C_{T_{NET}}$) as a function of power coefficient (C_P) for constant values of advance ratio (J). The following tables are included:

1 Mach Number = 0
2 Mach Number = 0.1
3 Mach Number = 0.3
4 Mach Number = 0.45
5 Mach Number = 0.60
6 Mach Number = 0.70
7 Mach Number = 0.75
8 Mach Number = 0.80
9 Mach Number = 0.85
10 Slipstream Characteristics

The 0.10 to 0.85 Mach number tables also include a tabulation of net efficiency (ETA) to allow for a visual estimation of performance level.

The non-dimensional coefficients are defined in engineering terms as English Units:

$$J = \frac{101.4 M_o C_K}{ND} = \frac{101.4V}{ND}$$

$$C_P = \frac{SHP(\rho_0/\rho)}{20(ND/10{,}000)^3 D^2} = \frac{SHP(\rho_0/\rho)}{2000(N/1000)^3(D/10)^5}$$

$$T_{NET} = 66.1(ND/10{,}000)^2 D^2 C_{T_{NET}}/(\rho_0/\rho)$$

$$T_{NET} = 6610(N/1000)^2(D/10)^4 C_{T_{NET}}/(\rho_0/\rho) = 326\ SHP\eta_{NET}/V_K$$

where: T_{NET} = Uninstalled Prop-Fan net thrust, pounds

N = Prop-Fan rotational speed, rpm

D = Prop-Fan tip diameter, feet

ρ_0/ρ = Density ratio, sea level ISA to ambient conditions (ρ_0 = 0.002378 lb-sec^2/ft^4)

M_o = Free stream Mach number

C_K = Speed of sound, knots

V = Free stream velocity, true airspeed, knots

η_{NET} = Net efficiency = $(C_{T_{NET}})(J)/(C_p)$

ϕ = Average swirl angle, degrees

ΔV = Incremental induced axial velocity immediately behind disk, knots

where: ND = (TS)(60)/π

TS = Tip speed, ft per second

In SI Units:

$$J = \frac{60 M_o C_{m/s}}{ND} = \frac{60V}{ND}$$

$$C_p = \frac{K_W(\rho_0/\rho)}{5.674\left(\frac{ND}{1000}\right)^3 D^2}$$

$$T_{NET} = 340.42\left(\frac{ND}{1000}\right)^2 D^2 C_{T_{NET}}/(\rho_0/\rho) = 1000 K_W \eta_{NET}/(M_o)(C_{m/s})$$

where:

K_W = power, kilowatts

T_{NET} = Uninstalled Prop-Fan net thrust, newtons

N = Prop-Fan Rotational Speed, rpm

D = Prop-Fan Diameter, Meters

ρ_0/ρ = Density ratio, sea level ISA to ambient conditions

M_o = Free stream Mach number

$C_{m/s}$ = Speed of sound, meters per second

V = Free stream velocity, meters per second

ϕ = Average swirl angle degrees

ΔV = Incremental axial induced velocity immediately behind disk, meters per second

where:

$ND = (TS)(60)/\pi$

TS = Tip speed, meters per second

The "Net Thrust (T_{NET})" is the uninstalled thrust of the Prop-Fan rotor operating in the presence of a nacelle (including spinner). The buoyancy force between the rotor and nacelle face has been removed from the rotor thrust and therefore it should not be included in the nacelle drag. The uninstalled rotor Prop-Fan thrust is for the blades alone. Installed propulsive thrust is obtained by adding the uninstalled net thrust (T_{NET}) to the core engine jet thrust and then subtracting the drag of the spinner/nacelle and the losses due to nacelle/wing interference.

The slipstream characteristics are also presented in tabular form. Average swirl angle (ϕ) and incremental axial induced velocity immediately behind the disk over freestream velocity ($\Delta V/V$) are presented as a function of power coefficient (C_p) for given values of advance ratio (J). Theoretically the induced axial velocity doubles in the ultimate wake which is approximately two diameters downstream.

The accepted procedure for interpolation of the aerodynamic performance data at conditions not explicitly specified is as follows:

a. Calculate the advance ratio, J, utilizing the desired Mach number and tip speed (i.e., maintain tip speed constant and determine J for varying M_n).

b. Enter Tables 1-9 with the given M_n and constant power coefficient, C_p; and the calculated value of J and determine the efficiency and thrust coefficient.

The following sample problem utilizes this procedure. The computer program will automatically perform the above interpolation.

SAMPLE PROBLEM

Given: 9 foot diameter Prop-Fan
2592 SHP
800 feet per second tip speed
35,000 feet, ISA, altitude
0.770 Mach number

Calculate: Net Thrust

$ND = T.S. \times 60/\pi = 800 \times 60/\pi = 15,278.9$

$N = ND/D = 15,278.9/9 = 1697.7$

$J = (101.27)(M_o)(C_K)/(ND)$
$= (101.4)(.770)(576.3)/(15,278.9)$
$= 2.94$

$Cp = SHP(\rho_0/\rho)/2,000(D/10)^5(N/1,000)^3$
$= (2592)(3.2196)/2,000(.9)^5(1.6977)^3$
$= 1.444$

Since there is no chart for a 0.770 Mach number, it is necessary to interpolate between the available Mach number charts. This is done by keeping a constant tip speed. Therefore, the J's are ratioed to the Mach numbers. For the given C_P of 1.444:

M	J	C_T	Table
0.700	2.677	.422	6
0.750	2.869	.397	7
0.800	3.060	.375	8
0.770	2.945	.389	Interpolated

$$\text{Net Thrust} = 6605.6(N/1,000)^2(D/10)^4 C_{T_{NET}}/(\rho_0/\rho)$$

$$= (6605.6)(1.6977)^2(.9)^4(.389)/(3.2196)$$
$$= 1510 \text{ pounds}$$

In S.I. Units:

2592 SHP = 1932.85 Kw

D = 2.744 meters

$J = (60)(M_o)(C_{m/s})/ND$
$= (60)(0.770)(296.40)/(1697.7)(2.744)$
$= 2.94$

$C_p = (K_w)(\rho_0/\rho)/5.674(ND/1,000)^3 D^2$

$= \dfrac{(1932.85)(3.2196)}{5.674(1697.7 \times 2.744/1,000)^3(2.744)^2}$

$= 1.444$

$C_{T_{NET}} = .389$ (from previous solution)

$T_{NET} = (340.42)(ND/1,000)^2 D^2 C_{T_{NET}}/(\rho_0/\rho)$

$= \dfrac{(340.42)(1697.7 \times 2.744/1,000)^2(2.744)^2(.3890)}{3.2196}$

$= 6721$ newtons

Also for both units:

$\eta_{NET} = C_T J/C_p$

$= (.389)(2.945)/1.444$

$= .793$

TABLE 1. SR-7 PROP-FAN PERFORMANCE 0.00 MACH NUMBER

J = 0.0

CP	CT	ETA
0.1002	0.1972	0.0
0.1428	0.2587	0.0
0.1970	0.3206	0.0
0.2632	0.3845	0.0
0.3405	0.4454	0.0
0.4319	0.5067	0.0
0.5342	0.5619	0.0
0.6567	0.6170	0.0
0.7903	0.6641	0.0
0.9505	0.7052	0.0
1.1106	0.7394	0.0
1.2780	0.7525	0.0
1.4794	0.7515	0.0
1.6561	0.7383	0.0
1.7950	0.7226	0.0
2.0080	0.6901	0.0
0.0	0.0	0.0

TABLE 2. SR-7 PROP-FAN PERFORMANCE 0.10 MACH NUMBER

J = 0.30			J = 0.40			J = 0.50		
CP	CT	ETA	CP	CT	ETA	CP	CT	ETA
0.0400	0.0237	0.1777	0.0213	-0.0002	0.0	0.0187	-0.0001	0.0
0.0767	0.0907	0.3548	0.0460	0.0442	0.3843	0.0250	0.0030	0.0600
0.1162	0.1488	0.3842	0.0793	0.0982	0.4953	0.0540	0.0545	0.5046
0.1700	0.2210	0.3900	0.1273	0.1647	0.5175	0.0975	0.1111	0.5697
0.2393	0.3016	0.3774	0.1913	0.2375	0.4966	0.1567	0.1823	0.5817
0.3271	0.3893	0.3570	0.2707	0.3179	0.4697	0.2300	0.2574	0.5596
0.4295	0.4663	0.3257	0.3634	0.4006	0.4409	0.3193	0.3386	0.5302
0.5459	0.5408	0.2972	0.4704	0.4757	0.4045	0.4216	0.4190	0.4969
0.6760	0.6097	0.2706	0.5901	0.5471	0.3709	0.5393	0.4924	0.4565
0.8183	0.6718	0.2463	0.7247	0.6142	0.3390	0.6699	0.5622	0.4196
0.9725	0.7235	0.2232	0.8755	0.6754	0.3086	0.8202	0.6250	0.3810
1.1509	0.7630	0.1989	1.0481	0.7260	0.2771	0.9860	0.6803	0.3450
1.3271	0.7955	0.1798	1.2573	0.7668	0.2440	1.1750	0.7246	0.3083
1.4895	0.8199	0.1651	1.4008	0.7988	0.2281	1.3473	0.7624	0.2829
1.6980	0.8165	0.1443	1.6005	0.8056	0.2013	1.5293	0.7847	0.2566
1.9026	0.7968	0.1256	1.8265	0.7882	0.1726	1.7685	0.7724	0.2184
2.0053	0.7781	0.1164	2.0053	0.7664	0.1529	2.0055	0.7492	0.1868
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

J = 0.60		
CP	CT	ETA
0.0187	0.0	0.0
0.0330	0.0232	0.4219
0.0613	0.0609	0.5961
0.1170	0.1248	0.6400
0.1887	0.2015	0.6407
0.2760	0.2793	0.6072
0.3773	0.3589	0.5707
0.4930	0.4413	0.5371
0.6217	0.5144	0.4964
0.7704	0.5809	0.4524
0.9342	0.6410	0.4117
1.1258	0.6890	0.3672
1.3229	0.7299	0.3310
1.4910	0.7537	0.3033
1.7155	0.7678	0.2685
2.0053	0.7687	0.2300
0.0	0.0	0.0

TABLE 3. SR-7 PROP-FAN PERFORMANCE 0.30 MACH NUMBER

J = 1.00

CP	CT	ETA
0.0	-0.0285	0.0
0.0943	0.0574	0.6087
0.1600	0.1130	0.7062
0.2883	0.2067	0.7170
0.4375	0.3045	0.6960
0.6042	0.4004	0.6627
0.7867	0.4882	0.6206
0.9850	0.5664	0.5750
1.1925	0.6292	0.5276
1.4125	0.6710	0.4750
1.6458	0.7011	0.4260
1.8975	0.7185	0.3787
2.1267	0.7083	0.3331
0.0	0.0	0.0

J = 1.20

CP	CT	ETA
0.0	-0.0233	0.0
0.1025	0.0600	0.7024
0.2483	0.1567	0.7573
0.4142	0.2614	0.7573
0.5992	0.3615	0.7240
0.8000	0.4511	0.6766
1.0150	0.5323	0.6293
1.2425	0.6044	0.5837
1.4892	0.6636	0.5347
1.7475	0.7046	0.4838
2.1267	0.7301	0.4120
0.0	0.0	0.0
0.0	0.0	0.0
0.0	0.0	0.0

J = 1.40

CP	CT	ETA
0.0	-0.0178	0.0
0.0440	0.0118	0.3755
0.1767	0.0958	0.7590
0.3217	0.1800	0.7833
0.4808	0.2691	0.7836
0.6517	0.3517	0.7555
0.8325	0.4305	0.7240
1.0242	0.5027	0.6872
1.2225	0.5709	0.6538
1.4333	0.6264	0.6118
1.6525	0.6767	0.5733
1.8833	0.7004	0.5207
2.1308	0.7258	0.4769
0.0	0.0	0.0

J = 1.60

CP	CT	ETA
0.0	-0.0123	0.0
0.0969	0.0403	0.6654
0.2608	0.1274	0.7816
0.4383	0.2210	0.8068
0.6300	0.3113	0.7906
0.8325	0.3931	0.7555
1.0467	0.4724	0.7221
1.2692	0.5423	0.6836
1.5017	0.6038	0.6433
1.7450	0.6558	0.6013
2.1300	0.7117	0.5346
0.0	0.0	0.0

J = 1.80

CP	CT	ETA
0.0	-0.0081	0.0
0.1958	0.0844	0.7759
0.3950	0.1770	0.8066
0.6117	0.2735	0.8048
0.8408	0.3628	0.7767
1.0817	0.4488	0.7468
1.3325	0.5217	0.7047
1.5925	0.5863	0.6627
1.8633	0.6460	0.6241
2.1433	0.6910	0.5803
0.0	0.0	0.0
0.0	0.0	0.0

TABLE 4. SR-7 PROP-FAN PERFORMANCE 0.45 MACH NUMBER

J = 1.60

CP	CT	ETA
-0.0011	-0.0198	0.0
0.0504	0.0088	0.2794
0.2302	0.1034	0.7167
0.3174	0.1541	0.7768
0.4101	0.2004	0.7819
0.5300	0.2572	0.7765
0.7589	0.3575	0.7537
0.9768	0.4410	0.7224
1.2875	0.5434	0.6753
1.6308	0.6399	0.6278
1.8815	0.6886	0.5856
2.1376	0.7416	0.5551
2.5027	0.7836	0.5010
2.8787	0.8012	0.4453
3.2602	0.8135	0.3992
0.0	0.0	0.0
0.0	0.0	0.0
0.0	0.0	0.0
0.0	0.0	0.0
0.0	0.0	0.0

J = 1.80

CP	CT	ETA
-0.0011	-0.0261	0.0
0.0520	0.0025	0.0865
0.1000	0.0280	0.5040
0.1800	0.0706	0.7060
0.2300	0.0966	0.7560
0.3200	0.1433	0.8061
0.4080	0.1851	0.8166
0.5280	0.2396	0.8168
0.7590	0.3351	0.7947
0.8497	0.3691	0.7819
0.9780	0.4135	0.7610
1.2860	0.5077	0.7106
1.6300	0.5978	0.6601
1.8820	0.6558	0.6272
2.1380	0.7049	0.5935
2.5033	0.7523	0.5409
2.8767	0.7796	0.4878
3.2580	0.7884	0.4356
0.0	0.0	0.0
0.0	0.0	0.0

J = 2.00

CP	CT	ETA
-0.0010	-0.0291	0.0
0.0540	0.0	0.0
0.1090	0.0275	0.5046
0.1450	0.0438	0.6041
0.1990	0.0702	0.7055
0.2540	0.0960	0.7559
0.3310	0.1335	0.8066
0.4530	0.1872	0.8265
0.5430	0.2258	0.8317
0.7560	0.3067	0.8114
0.8510	0.3409	0.8012
0.9330	0.3691	0.7912
1.1500	0.4376	0.7610
1.5220	0.5408	0.7106
1.8750	0.6190	0.6603
2.1807	0.6782	0.6220
2.4953	0.7178	0.5753
2.8713	0.7461	0.5197
3.2527	0.7526	0.4628
0.0	0.0	0.0

J = 2.20

CP	CT	ETA
-0.0010	-0.0317	0.0
0.0630	0.0	0.0
0.1360	0.0311	0.5031
0.1860	0.0511	0.6044
0.2450	0.0786	0.7058
0.3030	0.1041	0.7558
0.3990	0.1463	0.8067
0.4940	0.1856	0.8266
0.6880	0.2601	0.8317
0.9050	0.3338	0.8114
0.9960	0.3629	0.8016
1.0870	0.3910	0.7914
1.3270	0.4590	0.7610
1.7120	0.5530	0.7106
2.1190	0.6359	0.6602
2.3673	0.6697	0.6224
2.6420	0.6945	0.5783
2.8793	0.7129	0.5447
3.2527	0.7210	0.4877
0.0	0.0	0.0

J = 2.40

CP	CT	ETA
-0.0011	-0.0344	0.0
0.0770	0.0	0.0
0.1680	0.0353	0.5043
0.2220	0.0559	0.6043
0.2940	0.0864	0.7053
0.3620	0.1140	0.7558
0.4600	0.1545	0.8061
0.5710	0.1979	0.8318
0.8020	0.2779	0.8316
1.0420	0.3523	0.8114
1.1410	0.3810	0.8014
1.2410	0.4091	0.7912
1.4900	0.4724	0.7609
1.8980	0.5621	0.7108
2.3050	0.6341	0.6602
2.5837	0.6665	0.6179
2.8767	0.6872	0.5733
3.2607	0.6958	0.5121
0.0	0.0	0.0
0.0	0.0	0.0

J = 2.60

CP	CT	ETA
0.0	-0.0365	0.0
0.0950	0.0	0.0
0.1990	0.0386	0.5043
0.2630	0.0612	0.6050
0.3440	0.0933	0.7052
0.4210	0.1224	0.7559
0.5340	0.1656	0.8063
0.6520	0.2072	0.8263
0.9240	0.2955	0.8315
1.1960	0.3733	0.8115
1.2910	0.3980	0.8015
1.3990	0.4258	0.7913
1.6620	0.4865	0.7611
2.0650	0.5645	0.7108
2.4640	0.6257	0.6602
2.7487	0.6548	0.6194
2.9993	0.6701	0.5809
3.2607	0.6736	0.5371
0.0	0.0	0.0
0.0	0.0	0.0

J = 2.80

CP	CT	ETA
0.0	-0.0386	0.0
0.1061	-0.0017	0.0
0.1833	0.0261	0.3987
0.2990	0.0646	0.6049
0.3990	0.1005	0.7053
0.4760	0.1285	0.7559
0.6020	0.1734	0.8065
0.7290	0.2152	0.8266
1.0420	0.3096	0.8319
1.3310	0.3858	0.8116
1.4220	0.4069	0.8012
1.5400	0.4352	0.7913
1.7930	0.4874	0.7611
2.2010	0.5585	0.7105
2.5900	0.6106	0.6601
2.8420	0.6315	0.6222
3.2527	0.6453	0.5555
0.0	0.0	0.0

TABLE 5. SR-7 PROP-FAN PERFORMANCE 0.60 MACH NUMBER

J = 2.00

CP	CT	ETA
0.0001	-0.0423	0.0
0.2045	0.0471	0.4606
0.4000	0.1457	0.7285
0.4592	0.1748	0.7613
0.6000	0.2324	0.7747
0.8000	0.3110	0.7775
1.0000	0.3821	0.7642
1.2000	0.4470	0.7450
1.4000	0.5056	0.7223
1.6000	0.5538	0.6922
1.8000	0.5872	0.6524
2.0000	0.6134	0.6134
2.2000	0.6376	0.5796
2.4000	0.6553	0.5461
2.6000	0.6652	0.5117
2.8000	0.6624	0.4731
3.0000	0.6522	0.4348
0.0	0.0	0.0

J = 2.20

CP	CT	ETA
0.0001	-0.0326	0.0
0.2000	0.0492	0.5412
0.4001	0.1392	0.7654
0.4594	0.1659	0.7945
0.5999	0.2201	0.8072
0.8000	0.2929	0.8055
1.0000	0.3602	0.7924
1.2000	0.4216	0.7729
1.4000	0.4786	0.7521
1.6000	0.5253	0.7223
1.8000	0.5634	0.6886
2.0000	0.5935	0.6528
2.2000	0.6241	0.6241
2.4000	0.6440	0.5903
2.6000	0.6565	0.5555
2.8000	0.6713	0.5274
3.0000	0.6765	0.4961
0.0	0.0	0.0

J = 2.40

CP	CT	ETA
0.0001	-0.0296	0.0
0.2000	0.0479	0.5748
0.4001	0.1298	0.7786
0.4594	0.1553	0.8113
0.5999	0.2052	0.8209
0.8000	0.2741	0.8223
1.0000	0.3393	0.8143
1.2000	0.3989	0.7978
1.4000	0.4536	0.7776
1.6000	0.5008	0.7512
1.8000	0.5376	0.7168
2.0000	0.5687	0.6824
2.2000	0.5994	0.6539
2.4000	0.6206	0.6206
2.6000	0.6454	0.5958
2.8000	0.6603	0.5660
3.0000	0.6683	0.5346
0.0	0.0	0.0

J = 2.60

CP	CT	ETA
0.0001	-0.0350	0.0
0.2000	0.0387	0.5031
0.4000	0.1175	0.7638
0.5999	0.1892	0.8200
0.8000	0.2570	0.8353
1.0000	0.3185	0.8281
1.2000	0.3756	0.8138
1.4000	0.4287	0.7962
1.6000	0.4785	0.7776
1.8000	0.5182	0.7485
2.0000	0.5538	0.7199
2.2000	0.5851	0.6915
2.4000	0.6132	0.6643
2.6000	0.6358	0.6358
2.8000	0.6508	0.6043
3.0000	0.6633	0.5749
0.0	0.0	0.0
0.0	0.0	0.0

J = 2.80

CP	CT	ETA
0.0001	-0.0484	0.0
0.2000	0.0321	0.4494
0.4000	0.1070	0.7490
0.6000	0.1688	0.7877
0.8000	0.2362	0.8267
1.0000	0.2990	0.8372
1.2000	0.3547	0.8276
1.4000	0.4059	0.8118
1.6000	0.4538	0.7941
1.8000	0.4990	0.7762
2.0000	0.5365	0.7511
2.2000	0.5685	0.7235
2.4000	0.5972	0.6967
2.6000	0.6216	0.6694
2.8000	0.6380	0.6380
3.0000	0.6542	0.6106
0.0	0.0	0.0
0.0	0.0	0.0

J = 3.00

CP	CT	ETA
0.0001	-0.0545	0.0
0.2000	0.0246	0.3690
0.4000	0.0969	0.7267
0.4512	0.1121	0.7453
0.6000	0.1598	0.7990
0.8000	0.2199	0.8246
1.0000	0.2804	0.8412
1.2000	0.3345	0.8363
1.4000	0.3847	0.8244
1.6000	0.4313	0.8087
1.8000	0.4757	0.7928
2.0000	0.5142	0.7713
2.2000	0.5476	0.7467
2.4000	0.5776	0.7222
2.6000	0.6017	0.6943
2.8000	0.6233	0.6678
3.0000	0.6399	0.6399
0.0	0.0	0.0

J = 3.20

CP	CT	ETA
0.0001	-0.0588	0.0
0.2000	0.0130	0.2880
0.4000	0.0853	0.6824
0.6000	0.1473	0.7856
0.8000	0.2049	0.8196
1.0000	0.2633	0.8426
1.2000	0.3157	0.8419
1.4000	0.3648	0.8338
1.6000	0.4102	0.8204
1.8000	0.4526	0.8046
2.0000	0.4929	0.7886
2.2000	0.5303	0.7713
2.4000	0.5613	0.7484
2.6000	0.5852	0.7202
2.8000	0.6119	0.6993
3.0000	0.6295	0.6715
0.0	0.0	0.0

TABLE 6. SR-7 PROP-FAN PERFORMANCE 0.70 MACH NUMBER

J = 2.60

CP	CT	ETA
0.0001	-0.0425	0.0
0.2000	0.0301	0.3913
0.4000	0.1077	0.7000
0.6000	0.1807	0.7830
0.8000	0.2462	0.8002
1.0000	0.3079	0.8005
1.2000	0.3657	0.7924
1.4000	0.4198	0.7796
1.6000	0.4642	0.7543
1.8000	0.5020	0.7251
2.0000	0.5308	0.6900
2.2000	0.5594	0.6611
2.3900	0.5776	0.6284
2.6000	0.5921	0.5921
2.8000	0.6063	0.5630
0.0	0.0	0.0

J = 2.80

CP	CT	ETA
0.0001	-0.0310	0.0
0.2000	0.0445	0.6230
0.4000	0.1045	0.7315
0.6000	0.1722	0.8036
0.8000	0.2313	0.8095
1.0000	0.2950	0.8260
1.2000	0.3487	0.8136
1.4000	0.4009	0.8018
1.[illegible]	0.4462	0.7808
1.[illegible]	0.4862	0.7563
2.0000	0.5237	0.7332
2.2000	0.5598	0.7125
2.4000	0.5905	0.6889
2.6000	0.6229	0.6708
2.8000	0.6486	0.6486
0.0	0.0	0.0

J = 3.00

CP	CT	ETA
0.0001	-0.0283	0.0
0.2000	0.0389	0.5835
0.4000	0.0964	0.7230
0.6000	0.1567	0.7835
0.8000	0.2177	0.8164
1.0000	0.2774	0.8322
1.2000	0.3286	0.8215
1.4000	0.3770	0.8079
1.6000	0.4236	0.7942
1.8000	0.4660	0.7767
2.0000	0.5066	0.7599
2.2000	0.5385	0.7343
2.4000	0.5721	0.7151
2.6000	0.6064	0.6997
2.8000	0.6294	0.6744
0.0	0.0	0.0

J = 3.20

CP	CT	ETA
0.0001	-0.0344	0.0
0.1999	0.0286	0.4578
0.4000	0.0865	0.6920
0.6000	0.1450	0.7733
0.8000	0.2036	0.8144
1.0000	0.2589	0.8285
1.2000	0.3114	0.8304
1.4000	0.3598	0.8224
1.6000	0.4041	0.8082
1.8000	0.4471	0.7948
2.0000	0.4863	0.7781
2.2000	0.5215	0.7585
2.4000	0.5540	0.7387
2.6000	0.5838	0.7185
2.8000	0.6106	0.6978
0.0	0.0	0.0

J = 3.40

CP	CT	ETA
0.0001	-0.0387	0.0
0.1999	0.0185	0.3147
0.4000	0.0782	0.6647
0.6000	0.1328	0.7525
0.8000	0.1900	0.8075
1.0000	0.2438	0.8289
1.2000	0.2927	0.8293
1.4000	0.3417	0.8298
1.6000	0.3828	0.8134
1.8000	0.4255	0.8037
2.0000	0.4665	0.7930
2.2000	0.5040	0.7789
2.4000	0.5381	0.7623
2.6000	0.5682	0.7430
2.8000	0.5955	0.7231
0.0	0.0	0.0

J = 3.50

CP	CT	ETA
0.1999	0.0146	0.2556
0.4000	0.0727	0.6361
0.6000	0.1274	0.7432
0.8000	0.1827	0.7993
1.0000	0.2365	0.8278
1.2000	0.2847	0.8304
1.4000	0.3332	0.8330
1.6000	0.3740	0.8181
1.8000	0.4164	0.8097
2.0000	0.4567	0.7992
2.2000	0.4970	0.7907
2.4000	0.5345	0.7795
2.6000	0.5658	0.7617
2.8000	0.5921	0.7401
0.0	0.0	0.0
0.0	0.0	0.0

J = 3.70

CP	CT	ETA
0.0001	-0.0623	0.0
0.1999	0.0001	0.0019
0.4000	0.0572	0.5291
0.6000	0.1126	0.6944
0.8000	0.1648	0.7622
1.0000	0.2181	0.8070
1.2000	0.2673	0.8242
1.4000	0.3142	0.8304
1.6000	0.3582	0.8283
1.8000	0.3980	0.8181
2.0000	0.4341	0.8031
2.2000	0.4711	0.7923
2.4000	0.5012	0.7727
2.6000	0.5268	0.7497
2.8000	0.5514	0.7286

TABLE 7. SR-7 PROP-FAN PERFORMANCE 0.75 MACH NUMBER

J = 2.80

CP	CT	ETA
0.0001	-0.0335	0.0
0.2000	0.0330	0.4620
0.4000	0.1013	0.7091
0.6000	0.1644	0.7672
0.8000	0.2282	0.7987
1.0000	0.2875	0.8050
1.2000	0.3439	0.8024
1.4000	0.3917	0.7834
1.6000	0.4411	0.7719
1.8000	0.4835	0.7521
2.0000	0.5225	0.7315
2.2000	0.5509	0.7011
2.3900	0.5776	0.6767
2.6000	0.6025	0.6488
2.8000	0.6239	0.6239
3.0000	0.6317	0.5896
0.0	0.0	0.0

J = 3.00

CP	CT	ETA
0.0001	-0.0387	0.0
0.2000	0.0277	0.4155
0.4000	0.0908	0.6810
0.6000	0.1548	0.7740
0.8000	0.2120	0.7950
1.0000	0.2725	0.8175
1.2000	0.3248	0.8120
1.4000	0.3757	0.8051
1.6000	0.4226	0.7924
1.8000	0.4649	0.7748
2.0000	0.5046	0.7569
2.2000	0.5387	0.7346
2.4000	0.5679	0.7099
2.6000	0.5965	0.6883
2.8000	0.6200	0.6643
3.0000	0.6364	0.6364
0.0	0.0	0.0

J = 3.20

CP	CT	ETA
0.0001	-0.0426	0.0
0.2000	0.0225	0.3600
0.4000	0.0824	0.6592
0.6000	0.1412	0.7531
0.8000	0.1993	0.7972
1.0000	0.2564	0.8205
1.2000	0.3076	0.8203
1.4000	0.3555	0.8126
1.6000	0.4026	0.8052
1.8000	0.4457	0.7924
2.0000	0.4870	0.7792
2.2000	0.5182	0.7537
2.4000	0.5496	0.7328
2.6000	0.5803	0.7142
2.8000	0.6014	0.6873
3.0000	0.6128	0.6537
0.0	0.0	0.0

J = 3.40

CP	CT	ETA
0.0001	-0.0465	0.0
0.1999	0.0139	0.2364
0.4000	0.0727	0.6180
0.6000	0.1308	0.7412
0.8000	0.1863	0.7918
1.0000	0.2393	0.8136
1.2000	0.2905	0.8231
1.4000	0.3376	0.8199
1.6000	0.3825	0.8128
1.8000	0.4255	0.8037
2.0000	0.4645	0.7896
2.2000	0.4987	0.7707
2.4000	0.5293	0.7498
2.6000	0.5566	0.7279
2.8000	0.5805	0.7049
3.0000	0.5969	0.6765
0.0	0.0	0.0

J = 3.60

CP	CT	ETA
0.0001	-0.0500	0.0
0.1999	0.0052	0.0936
0.4000	0.0645	0.5805
0.6000	0.1192	0.7152
0.8000	0.1738	0.7821
1.0000	0.2249	0.8096
1.2000	0.2728	0.8184
1.4000	0.3204	0.8239
1.6000	0.3644	0.8199
1.8000	0.4061	0.8122
2.0000	0.4457	0.8023
2.2000	0.4803	0.7859
2.4000	0.5092	0.7638
2.6000	0.5351	0.7409
2.8000	0.5582	0.7177
3.0000	0.5742	0.6890
0.0	0.0	0.0

J = 3.80

CP	CT	ETA
-0.0008	-0.0561	0.0
0.1999	-0.0004	0.0
0.4000	0.0548	0.5206
0.6000	0.1087	0.6884
0.8000	0.1607	0.7633
1.0000	0.2111	0.8022
1.2000	0.2576	0.8157
1.4000	0.3041	0.8254
1.6000	0.3471	0.8244
1.8000	0.3881	0.8193
2.0000	0.4256	0.8086
2.2000	0.4624	0.7987
2.4000	0.4947	0.7833
2.6000	0.5212	0.7618
2.8000	0.5425	0.7362
3.0000	0.5543	0.7021
0.0	0.0	0.0

J = 4.00

CP	CT	ETA
0.0001	-0.0617	0.0
0.1999	-0.0109	0.0
0.4000	0.0397	0.3970
0.6000	0.0928	0.6187
0.8000	0.1421	0.7105
1.0000	0.1917	0.7668
1.2000	0.2397	0.7990
1.4000	0.2849	0.8140
1.6000	0.3281	0.8202
1.8000	0.3651	0.8113
2.0000	0.3970	0.7940
2.2000	0.4340	0.7891
2.4000	0.4624	0.7707
2.6000	0.4889	0.7522
2.8000	0.5101	0.7287
3.0000	0.5224	0.6965
0.0	0.0	0.0

TABLE 8. SR-7 PROP-FAN PERFORMANCE 0.80 MACH NUMBER

J = 3.00

CP	CT	ETA
0.0016	-0.0663	0.0
0.2000	0.0073	0.1095
0.4000	0.0828	0.6210
0.6000	0.1469	0.7345
0.7926	0.2047	0.7748
0.8000	0.2070	0.7763
1.0014	0.2633	0.7888
1.2016	0.3174	0.7924
1.4019	0.3694	0.7905
1.5981	0.4183	0.7852
1.7984	0.4603	0.7678
1.9986	0.4963	0.7450
2.1989	0.5268	0.7187
2.4000	0.5551	0.6939
2.6000	0.5712	0.6591
2.8000	0.5857	0.6275
3.0000	0.5866	0.5866
0.0	0.0	0.0

J = 3.20

CP	CT	ETA
-0.0027	-0.0656	0.0
0.2000	0.0009	0.0144
0.4000	0.0763	0.6104
0.6000	0.1368	0.7296
0.8000	0.1941	0.7764
1.0000	0.2498	0.7994
1.2016	0.3022	0.8048
1.4019	0.3518	0.8030
1.5981	0.4010	0.8030
1.7984	0.4462	0.7939
2.0000	0.4877	0.7803
2.2000	0.5167	0.7516
2.4000	0.5402	0.7203
2.6000	0.5600	0.6892
2.8000	0.5762	0.6585
3.0000	0.5725	0.6107
0.0	0.0	0.0
0.0	0.0	0.0

J = 3.40

CP	CT	ETA
0.0	-0.0690	0.0
0.2000	-0.0054	0.0
0.4000	0.0662	0.5627
0.6000	0.1266	0.7174
0.8000	0.1818	0.7726
1.0000	0.2349	0.7987
1.2000	0.2889	0.8186
1.4000	0.3378	0.8204
1.6000	0.3867	0.8217
1.8000	0.4299	0.8120
2.0000	0.4703	0.7995
2.2000	0.5005	0.7735
2.4000	0.5256	0.7446
2.6000	0.5457	0.7136
2.8000	0.5613	0.6816
3.0000	0.5583	0.6327
0.0	0.0	0.0
0.0	0.0	0.0

J = 3.60

CP	CT	ETA
0.0	-0.0701	0.0
0.2000	-0.0106	0.0
0.4000	0.0573	0.5157
0.6000	0.1157	0.6942
0.8000	0.1692	0.7614
1.0000	0.2204	0.7934
1.2000	0.2699	0.8097
1.4019	0.3167	0.8133
1.5981	0.3611	0.8134
1.7984	0.4046	0.8099
1.9986	0.4438	0.7994
2.1989	0.4754	0.7783
2.3992	0.5024	0.7539
2.6000	0.5242	0.7258
2.8000	0.5404	0.6948
3.0000	0.5311	0.5373
0.0	0.0	0.0

J = 3.80

CP	CT	ETA
0.0	-0.0746	0.0
0.2000	-0.0162	0.0
0.4000	0.0470	0.4465
0.6000	0.1050	0.6650
0.8000	0.1565	0.7434
1.0000	0.2061	0.7832
1.2000	0.2541	0.8047
1.4000	0.2998	0.8137
1.6000	0.3511	0.8339
1.8000	0.3918	0.8271
2.0000	0.4277	0.8126
2.2000	0.4592	0.7932
2.4000	0.4811	0.7617
2.6000	0.4994	0.7299
2.8000	0.5117	0.6944
3.0000	0.5071	0.6423
0.0	0.0	0.0

J = 4.00

CP	CT	ETA
0.0	-0.0791	0.0
0.2000	-0.0183	0.0
0.4000	0.0394	0.3940
0.6000	0.0953	0.6353
0.8000	0.1451	0.7255
1.0000	0.1926	0.7704
1.2000	0.2391	0.7970
1.4000	0.2837	0.8106
1.6000	0.3329	0.8322
1.8000	0.3727	0.8282
2.0000	0.4064	0.8128
2.2000	0.4335	0.7882
2.4000	0.4524	0.7540
2.6000	0.4680	0.7200
2.8000	0.4807	0.6867
3.0000	0.4769	0.6359
0.0	0.0	0.0

J = 4.20

CP	CT	ETA
0.0	-0.0823	0.0
0.2000	-0.0231	0.0
0.4000	0.0337	0.3538
0.6000	0.0850	0.5950
0.8000	0.1340	0.7035
1.0000	0.1795	0.7539
1.2000	0.2246	0.7861
1.4000	0.2670	0.8010
1.6000	0.3136	0.8232
1.8000	0.3483	0.8127
2.0000	0.3819	0.8020
2.2080	0.4106	0.7810
2.4000	0.4263	0.7460
2.6000	0.4401	0.7109
2.8000	0.4506	0.6759
3.0000	0.4395	0.6153
0.0	0.0	0.0

TABLE 9. SR-7 PROP-FAN PERFORMANCE 0.85 MACH NUMBER

J = 3.00			J = 3.20			J = 3.40		
CP	CT	ETA	CP	CT	ETA	CP	CT	ETA
0.0	-0.0626	0.0	0.0	-0.0630	0.0	0.0	-0.0683	0.0
0.2000	0.0115	0.1725	0.2000	0.0090	0.1440	0.2000	0.0015	0.0255
0.4000	0.0776	0.5820	0.4000	0.0678	0.5424	0.4000	0.0589	0.5006
0.6000	0.1413	0.7065	0.6000	0.1297	0.6917	0.6000	0.1190	0.6743
0.8000	0.1989	0.7459	0.8000	0.1864	0.7456	0.8000	0.1738	0.7386
1.0000	0.2519	0.7557	1.0000	0.2384	0.7629	1.0000	0.2252	0.7657
1.2000	0.3034	0.7585	1.2000	0.2889	0.7704	1.2000	0.2742	0.7769
1.4000	0.3531	0.7566	1.4000	0.3371	0.7705	1.4000	0.3211	0.7798
1.6000	0.3995	0.7491	1.6000	0.3824	0.7648	1.6000	0.3652	0.7760
1.8000	0.4401	0.7335	1.8000	0.4262	0.7577	1.8000	0.4088	0.7722
2.0000	0.4751	0.7126	2.0000	0.4612	0.7379	2.0000	0.4471	0.7601
2.2000	0.5017	0.6841	2.2000	0.4883	0.7103	2.2000	0.4733	0.7325
2.4000	0.5215	0.6519	2.4000	0.5092	0.6789	2.4000	0.4931	0.6986
2.6000	0.5349	0.6172	2.6000	0.5242	0.6452	2.6000	0.5089	0.6655
2.8000	0.5421	0.5808	2.8000	0.5334	0.6096	2.8000	0.5195	0.6308
3.0000	0.5429	0.5429	3.0000	0.5369	0.5727	3.0000	0.5249	0.5949
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

J = 3.60			J = 3.80			J = 4.00		
CP	CT	ETA	CP	CT	ETA	CP	CT	ETA
0.0	-0.0735	0.0	0.0	-0.0622	0.0	0.0	-0.0670	0.0
0.2000	-0.0022	0.0	0.2000	-0.0052	0.0	0.2000	-0.0117	0.0
0.4000	0.0529	0.4761	0.4000	0.0447	0.4247	0.4000	0.0366	0.3660
0.6000	0.1086	0.6516	0.6000	0.0980	0.6207	0.6000	0.0880	0.5867
0.8000	0.1613	0.7259	0.8000	0.1491	0.7082	0.8000	0.1378	0.6890
1.0000	0.2113	0.7607	1.0000	0.1979	0.7520	1.0000	0.1851	0.7404
1.2000	0.2587	0.7761	1.2000	0.2441	0.7730	1.2000	0.2301	0.7670
1.4000	0.3046	0.7833	1.4000	0.2888	0.7839	1.4000	0.2733	0.7809
1.6000	0.3479	0.7828	1.6000	0.3311	0.7864	1.6000	0.3151	0.7877
1.8000	0.3884	0.7768	1.8000	0.3708	0.7828	1.8000	0.3538	0.7862
2.0000	0.4290	0.7722	2.0000	0.4105	0.7799	2.0000	0.3918	0.7836
2.2000	0.4596	0.7521	2.2000	0.4425	0.7643	2.2000	0.4232	0.7695
2.4000	0.4801	0.7201	2.4000	0.4632	0.7334	2.4000	0.4449	0.7415
2.6000	0.4957	0.6864	2.6000	0.4783	0.6991	2.6000	0.4605	0.7085
2.8000	0.5067	0.6515	2.8000	0.4882	0.6626	2.8000	0.4699	0.6713
3.0000	0.5131	0.6157	3.0000	0.4926	0.6240	3.0000	0.4733	0.6311
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

J = 4.20			J = 4.40		
CP	CT	ETA	CP	CT	ETA
0.0	-0.0700	0.0	0.0	-0.0700	0.0
0.2000	-0.0174	0.0	0.2000	-0.0235	0.0
0.4000	0.0282	0.2961	0.4000	0.0214	0.2354
0.6000	0.0784	0.5488	0.6000	0.0687	0.5038
0.8000	0.1263	0.6631	0.8000	0.1145	0.6297
1.0000	0.1724	0.7241	1.0000	0.1591	0.7000
1.2000	0.2167	0.7585	1.2000	0.2027	0.7432
1.4000	0.2587	0.7761	1.4000	0.2443	0.7678
1.6000	0.2990	0.7849	1.6000	0.2840	0.7810
1.8000	0.3375	0.7875	1.8000	0.3217	0.7864
2.0000	0.3740	0.7854	2.0000	0.3568	0.7850
2.2000	0.4043	0.7718	2.2000	0.3859	0.7718
2.4000	0.4266	0.7465	2.4000	0.4088	0.7495
2.6000	0.4426	0.7150	2.6000	0.4253	0.7197
2.8000	0.4528	0.6792	2.8000	0.4355	0.6844
3.0000	0.4571	0.6399	3.0000	0.4393	0.6443
0.0	0.0	0.0	0.0	0.0	0.0

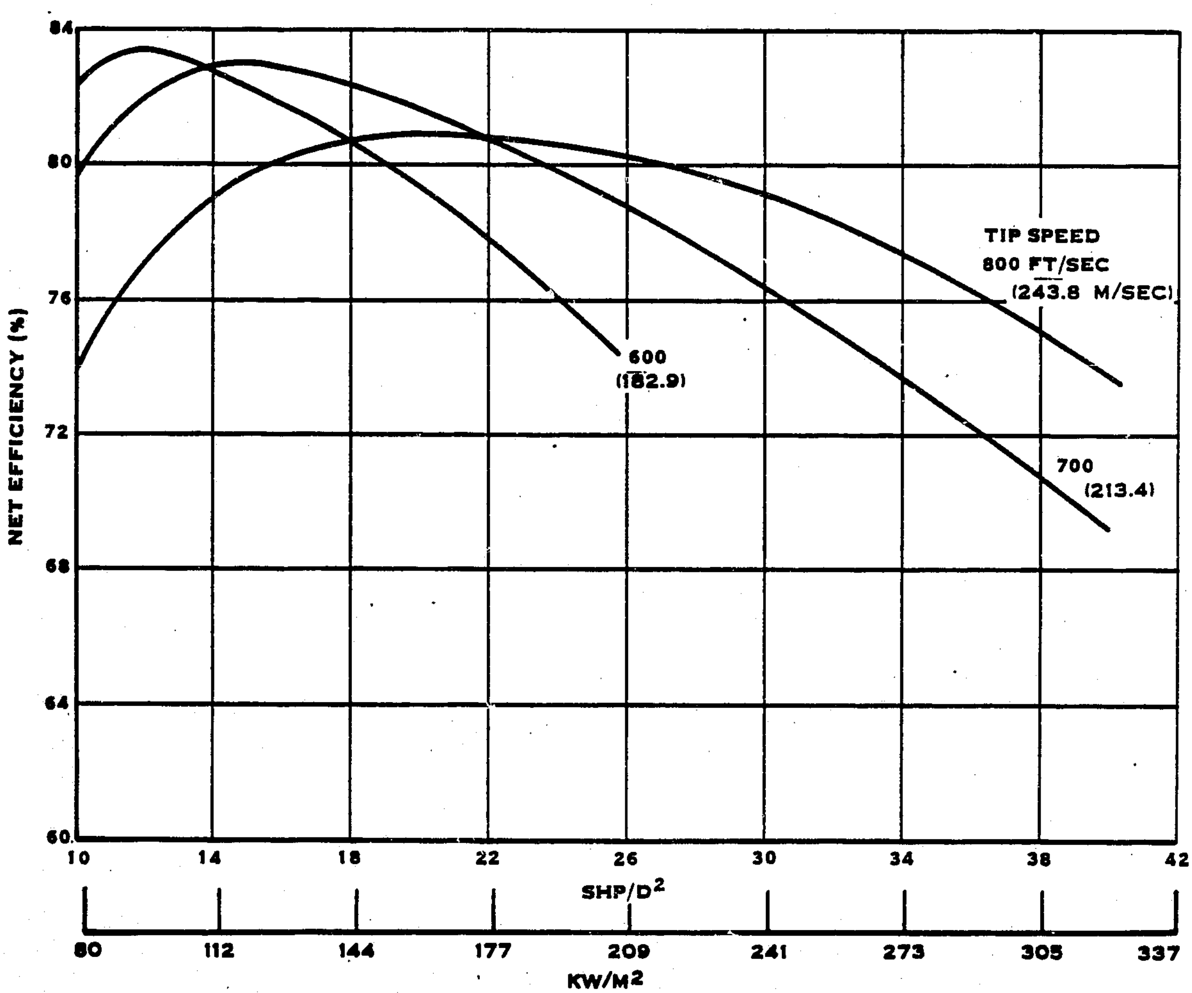


FIGURE 1. NET EFFICIENCY VS. SHP/D^2 AND TIP SPEED
0.70 MACH NUMBER AT 35,000 FT ISA
SR-7 PROP-FAN

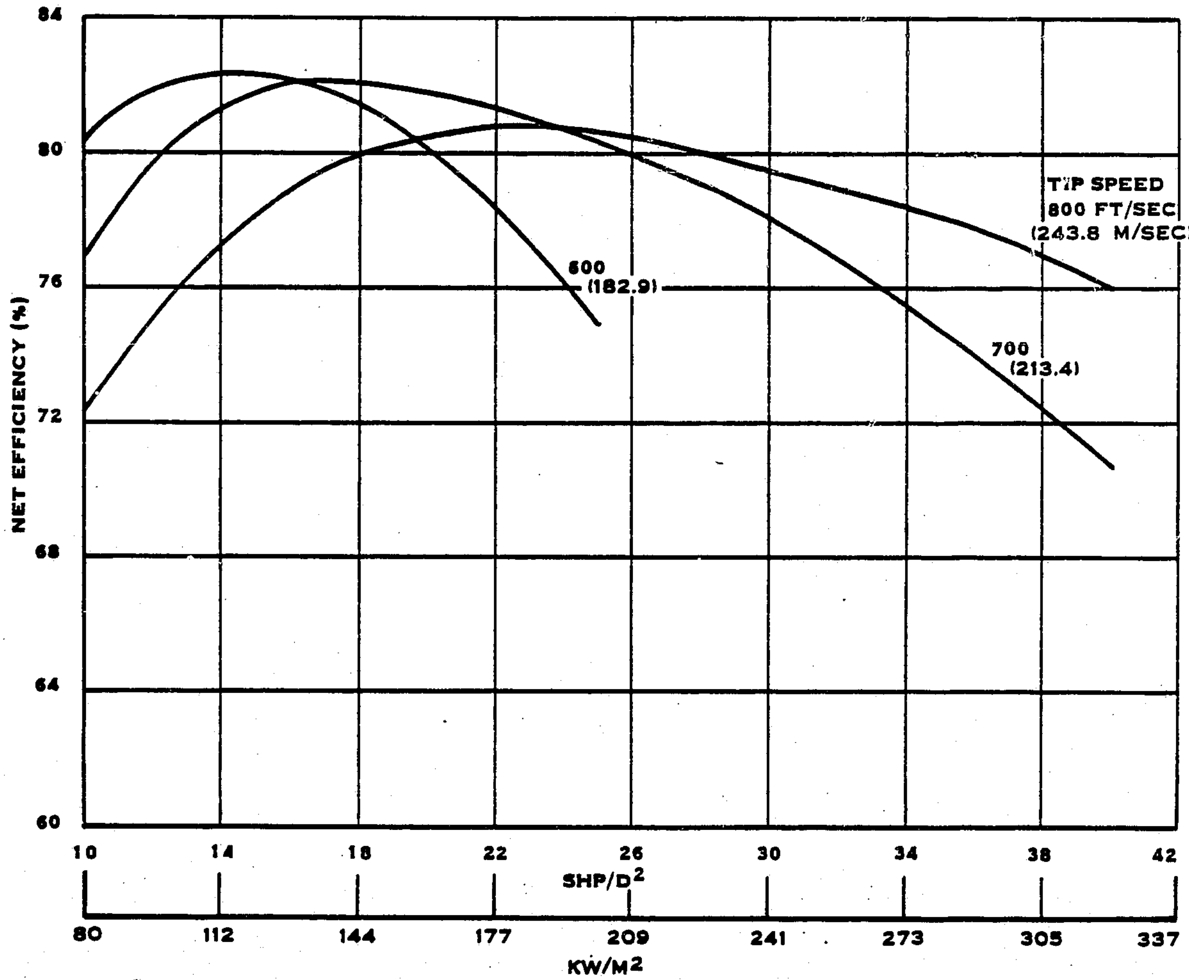


FIGURE 2. NET EFFICIENCY VS. SHP/D^2 AND TIP SPEED
0.75 MACH NUMBER AT 35,000 FT ISA
SR-7 PROP-FAN

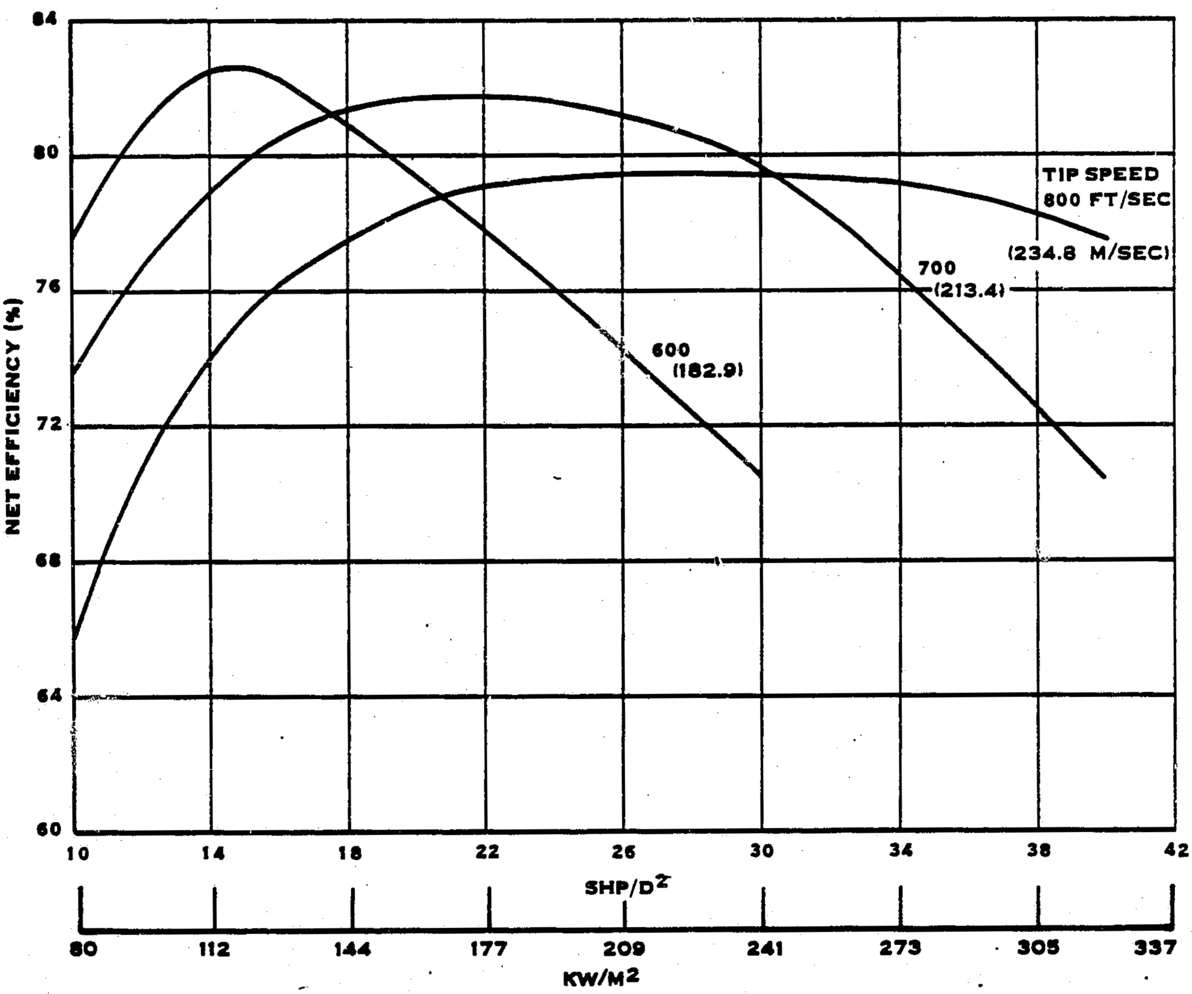


FIGURE 3. NET EFFICIENCY VS. SHP/D^2 AND TIP SPEED
0.80 MACH NUMBER AT 35,000 FT ISA
SR-7 PROP-FAN

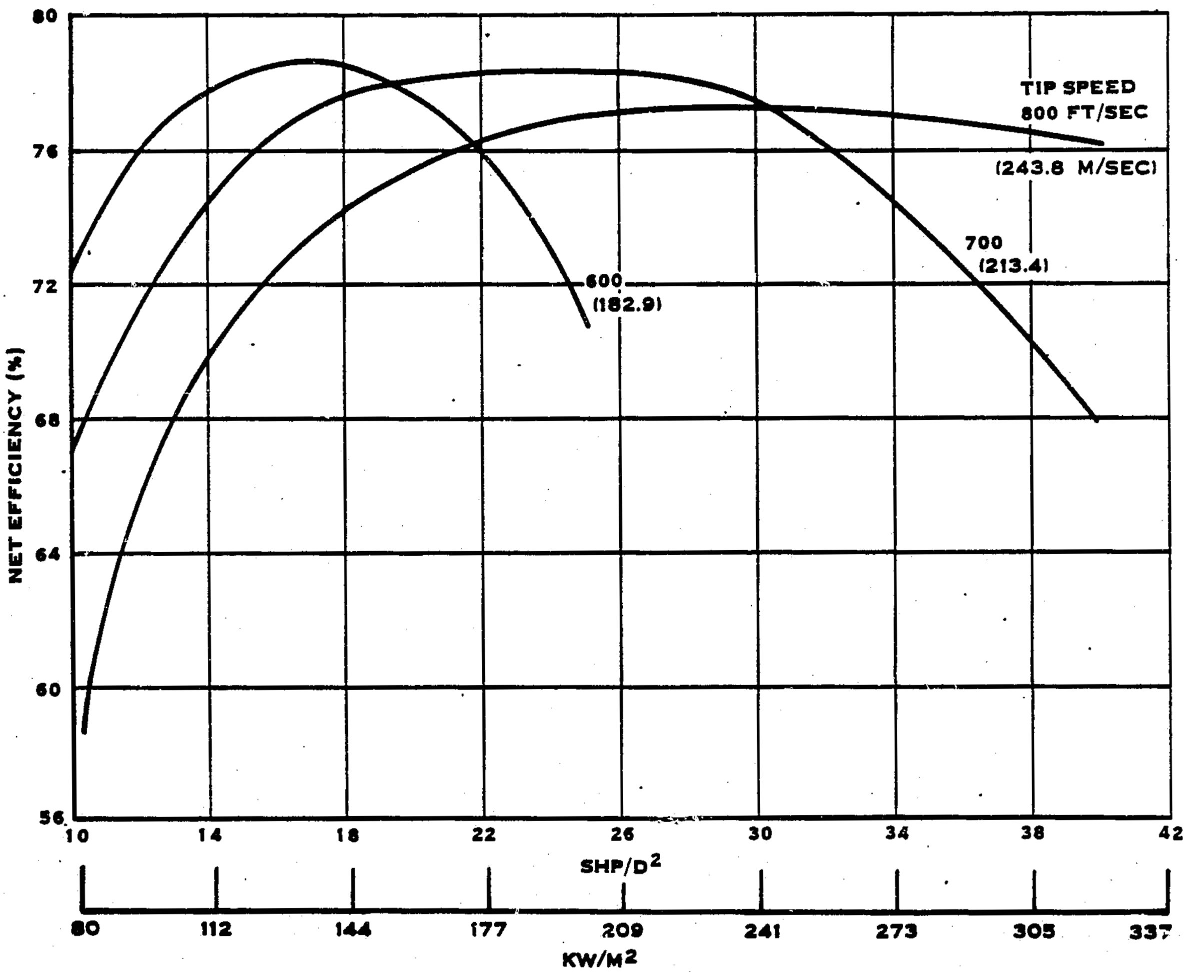


FIGURE 4. NET EFFICIENCY VS. SHP/D^2 AND TIP SPEED
0.85 MACH NUMBER AT 35,000 FT ISA
SR-7 PROP-FAN

TABLE 10

SLIPSTREAM CHARACTERISTICS

J	Cp	Ø	ΔV/V
0.4	0.2	16.00	0.7750
	0.4	18.60	0.9400
	0.6	21.20	1.0760
	0.8	23.80	1.2100
	1.0	26.40	1.3300
	1.2	29.00	1.4450
0.6	0.2	13.65	0.4080
	0.4	15.80	0.5100
	0.6	17.95	0.5930
	0.8	20.10	0.6740
	1.0	22.25	0.7450
	1.2	24.40	0.8050
	1.4	26.55	0.9090
	1.6	28.70	0.9210
0.8	0.2	10.90	0.2350
	0.4	12.92	0.2800
	0.6	14.94	0.3600
	0.8	16.96	0.4160
	1.0	18.98	0.4700
	1.2	21.00	0.5000
	1.4	23.02	0.5450
	1.6	25.04	0.5750
1.6	0.2	3.87	0.0540
	0.4	5.30	0.0710
	0.6	6.73	0.0810
	0.8	8.17	0.1000
	1.0	9.60	0.1150
	1.2	11.03	0.1290
	1.4	12.47	0.1460
	1.6	13.90	0.1630
	1.8	15.33	0.1800
	2.0	16.77	0.1970

J	Cp	Ø	ΔV/V
1.0	0.2	8.50	0.1460
	0.4	10.40	0.1900
	0.6	12.30	0.2310
	0.8	14.20	0.2700
	1.0	16.10	0.3060
	1.2	18.00	0.3370
	1.4	19.90	0.3740
	1.6	21.80	0.3990
	1.8	23.70	0.4270
1.2	0.2	6.62	0.1040
	0.4	8.32	0.1350
	0.6	10.02	0.1610
	0.8	11.72	0.1910
	1.0	13.46	0.2160
	1.2	15.16	0.2450
	1.4	16.88	0.2700
	1.6	18.58	0.2960
	1.8	20.24	0.3200
1.4	0.2	5.15	0.0730
	0.4	6.70	0.0970
	0.6	8.25	0.1180
	0.8	9.80	0.1400
	1.2	11.35	0.1560
	1.4	12.90	0.1790
	1.6	14.45	0.1980
	1.8	16.00	0.2200
2.0	0.2	2.20	0.0240
	0.4	3.43	0.0354
	0.6	4.66	0.0470
	0.8	5.89	0.0587
	1.0	7.12	0.0683
	1.2	8.35	0.0780
	1.4	9.58	0.0875
	1.6	10.81	0.0960
	1.8	12.04	0.1050
	2.0	13.27	0.1150
	2.2	14.50	0.1300

TABLE 10 (CONTINUED)

SLIPSTREAM CHARACTERISTICS

J	Cp	Ø	ΔV/V	J	Cp	Ø	ΔV/V
1.8	0.2	2.85	0.0400	2.2	0.2	1.70	0.0140
	0.4	4.18	0.0500		0.4	2.83	0.0255
	0.6	5.50	0.0617		0.6	3.96	0.0365
	0.8	6.83	0.0723		0.8	5.09	0.0474
	1.0	8.15	0.0840		1.0	6.22	0.0554
	1.2	9.48	0.0960		1.2	7.35	0.0635
	1.4	10.80	0.1110		1.4	8.48	0.0697
	1.6	12.13	0.1220		1.6	9.61	0.0770
	1.8	13.45	0.1380		1.8	10.74	0.0835
	2.0	14.78	0.1530		2.0	11.87	0.0910
					2.2	13.00	0.0990
2.4	0.2	1.40	0.0100	2.8	0.2	0.89	0.0065
	0.4	2.43	0.0200		0.4	1.74	0.0130
	0.6	3.46	0.0290		0.6	2.58	0.0193
	0.8	4.49	0.0382		0.8	3.43	0.0248
	1.0	5.52	0.0453		1.0	4.27	0.0305
	1.2	6.55	0.0525		1.2	5.12	0.0360
	1.4	7.58	0.0583		1.4	5.96	0.0410
	1.6	8.61	0.0640		1.6	6.81	0.0466
	1.8	9.64	0.0700		1.8	7.65	0.0510
	2.0	10.67	0.0755		2.0	8.50	0.0560
	2.2	11.70	0.0810		2.2	9.34	0.0600
2.6	0.2	1.12	0.0078	3.0	0.2	0.80	0.0052
	0.4	2.05	0.0160		0.4	1.56	0.0105
	0.6	2.97	0.0235		0.6	2.31	0.0160
	0.8	3.90	0.0300		0.8	3.07	0.0206
	1.0	4.82	0.0370		1.0	3.82	0.0253
	1.2	5.75	0.0435		1.2	4.58	0.0298
	1.4	6.67	0.0495		1.4	5.33	0.0349
	1.6	7.60	0.0550		1.6	6.09	0.0392
	1.8	8.52	0.0605		1.8	6.84	0.0435
	2.0	9.45	0.0660		2.0	7.60	0.0480
	2.2	10.37	0.0710		2.2	8.35	0.0510

TABLE 10 (CONTINUED)

SLIPSTREAM CHARACTERISTICS

J	Cp	Ø	ΔV/V	J	Cp	Ø	ΔV/V
3.2	0.2	0.70	0.0041	3.6	0.2	0.51	0.0027
	0.4	1.40	0.0086		0.4	1.09	0.0065
	0.6	2.10	0.0134		0.6	1.68	0.0095
	0.8	2.80	0.0176		0.8	2.27	0.0123
	1.0	3.50	0.0215		1.0	2.85	0.0150
	1.2	4.20	0.0252		1.2	3.44	0.0181
	1.4	4.90	0.0295		1.4	4.03	0.0210
	1.6	5.60	0.0330		1.6	4.61	0.0241
	1.8	6.30	0.0369		1.8	5.20	0.0275
	2.0	7.00	0.0405		2.0	5.79	0.0300
	2.2	7.70	0.0440		2.2	6.37	0.0330
3.4	0.2	0.60	0.0034	3.8	0.2	0.35	0.0025
	0.4	1.24	0.0075		0.4	0.90	0.0055
	0.6	1.88	0.0113		0.6	1.45	0.0079
	0.8	2.52	0.0149		0.8	2.00	0.0105
	1.0	3.16	0.0177		1.0	2.55	0.0126
	1.2	3.80	0.0215		1.2	3.10	0.0154
	1.4	4.44	0.0246		1.4	3.65	0.0175
	1.6	5.08	0.0281		1.6	4.20	0.0208
	1.8	5.72	0.0336		1.8	4.75	0.0244
	2.0	6.36	0.0374		2.0	5.25	0.0277
	2.2	7.00	0.0405		2.2	5.80	0.0310
4.0	0.2	0.30	0.0022	4.4	0.2	0.25	0.0020
	0.4	0.80	0.0046		0.4	0.63	0.0038
	0.6	1.30	0.0067		0.6	1.02	0.0051
	0.8	1.80	0.0090		0.8	1.40	0.0067
	1.0	2.30	0.0110		1.0	1.79	0.0079
	1.2	2.80	0.0132		1.2	2.17	0.0095
	1.4	3.30	0.0154		1.4	2.56	0.0109
	1.6	3.80	0.0175		1.6	2.94	0.0124
	1.8	4.30	0.0200		1.8	3.33	0.0141
	2.0	4.80	0.0220		2.0	3.71	0.0157
	2.2	5.30	0.0240		2.2	4.10	0.0174
4.2	0.2	0.30	0.0020	4.6	0.2	0.23	0.0019
	0.4	0.74	0.0040		0.4	0.57	0.0028
	0.6	1.18	0.0056		0.6	0.90	0.0046
	0.8	1.62	0.0079		0.8	1.23	0.0057
	1.0	2.06	0.0091		1.0	1.57	0.0067
	1.2	2.50	0.0114		1.2	1.90	0.0076
	1.4	2.94	0.0128		1.4	2.23	0.0086
	1.6	3.38	0.0148		1.6	2.57	0.0095
	1.8	3.82	0.0165		1.8	2.90	0.0107
	2.0	4.26	0.0179		2.0	3.23	0.0118
	2.2	4.70	0.0192		2.2	3.57	0.0131

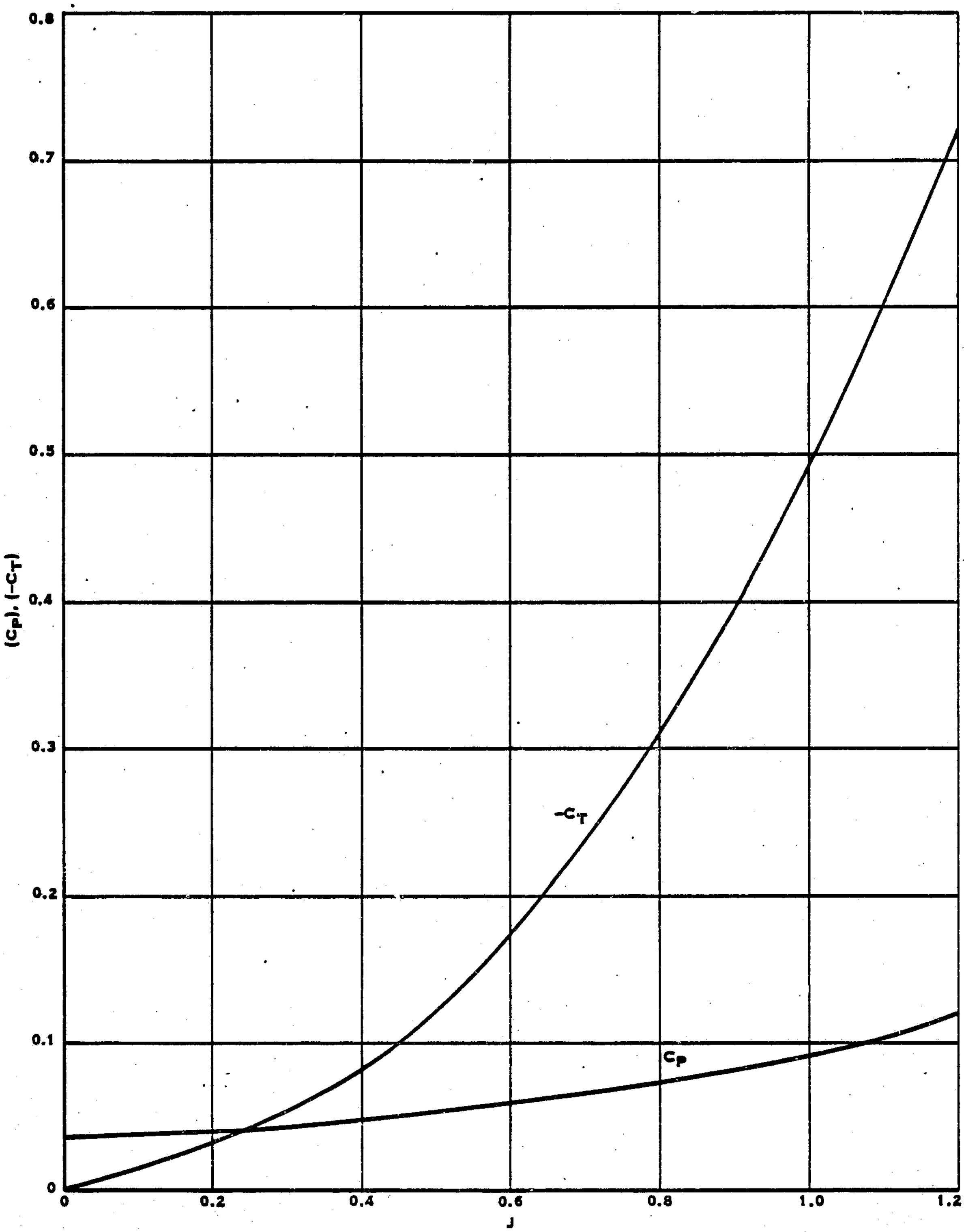


FIGURE 5. REVERSE THRUST, C_P & $-C_T$ VS. J

ACOUSTIC

SR-7L PROP-FAN NEAR-FIELD NOISE ESTIMATION AT CRUISE

The attached noise generalization is for the SR-7L Prop-Fan configuration. It allows estimation of free field overall noise level and spectrum level at near-field locations where an aircraft fuselage would be located. Noise can be estimated at forward speeds of 0.6 to 0.85 Mach number, tip speeds from 183-244 m/sec (600 to 800 ft/sec) at cruise altitudes from 3,048-12,192 m (10,000 to 40,000 ft). The levels fore and aft of the peak noise location near the plane of rotation are presented for tip clearances (the distance from the fuselage to the Prop-Fan tip) from 0.2 to 0.8 Prop-Fan diameters.

The near-field noise prediction procedure is based on calculations made with the theoretical Prop-Fan prediction procedure developed by Hamilton Standard. The computer results have been generalized for the SR-7L Prop-Fan configuration. Acoustic calculations have been referenced to an altitude of 35,000 feet (10,668 m).

Near-field noise generated by a Prop-Fan may be estimated as follows:

1. Determine the cruise power loading, SHP/D^2 (Kw/m^2), and tip speed as described in the aerodynamic performance section.

2. If the cruise altitude is 10,668 m (35,000 feet), the maximum sideline overall sound pressure level at 0.8 diameters from the Prop-Fan tips can be determined directly from Figures 6, 7, and 8.

If the cruise altitude is other than 10,668 m (35,000 ft) the actual cruise condition must first be adjusted to the equivalent condition at 10,668 m (35,000 ft), the noise levels determined as above, then corrected to the actual cruise condition. The equivalent condition at 10,668 m (35,000 ft) results in identical spanwise lift distribution, angle of attack, and efficiency. With equivalent aerodynamic operating conditions, the noise correction is determined from the ratio of acoustic impedance at the two altitudes (ρc^2). This correction procedure has been generalized, and may be accomplished as follows:

a. Determine the tip speed correction factor, K_{TS}, for the actual cruise altitude from Figure 9. Multiply the actual tip speed by K_{TS} to obtain an equivalent tip speed for 10,668 m (35,000 ft).feet.

b. Determine the power loading correction factor, K_{HP}, for the actual altitude from Figure 10. Multiply the actual Kw/m^2, (SHP/D^2) by K_{HP} to obtain the equivalent Kw/m^2 (SHP/D^2) for 10,668 m (35,000 ft).

c. The maximum sideline overall sound pressure level at 0.8 diameters tip clearance for the equivalent operating condition at 10,668 m (35,000 ft) is determined from Figures 6, 7, or 8 at the equivalent tip speed and power loading from a and b.

d. The maximum sideline noise level from c is adjusted from 10,668 m (35,000 ft) to the actual altitude by adding to it the ΔdB noise correction from Figure 11. The adjusted noise level is the maximum sideline noise level at the actual altitude and operating conditions at 0.8 diameters tip clearance.

3. If the noise at a measurement point fore or aft of the peak, or a tip clearance of other than 0.8 diameters is to be estimated, add the partial levels from Figures 12, 13, 14, 15, 16 or 17 to the maximum sideline noise level from Step 2.

4. The spectrum levels relative to the overall sound pressure level are shown in Figures 18, 19, 20, 21, 22, 22A and 23 and 23A for 0.6, 0.65, 0.7, 0.75, 0.8, and 0.85 cruise Mach numbers respectively as a function of tip speed. For altitudes other than 10,668 m (35,000 ft) use the equivalent tip speed defined in Step 2a to calculate the spectrum levels.

In using the attached curves for SR-7L Prop-Fan noise prediction, the reader is cautioned that they are only a generalization of levels predicted using the Hamilton Standard Prop-Fan noise prediction computer program. The noise produced by a Prop-Fan is a complex function of configuration variables such as sweep distribution, twist distribution, thickness, and planform, as well as operating variables such as cruise Mach number, rotational tip speed, and power absorbed. Furthermore, the noise spectrum varies with fore and aft distance, and tip clearance. It is obvious then that any data pack will include some simplifying generalizations. The attached data pack information contains some of these generalizations. However, the information presented is based on theoretical predictions using the SR-7 geometry. The information on overall free field noise in Figures 6-8 are plots of theoretical predictions at 0.8 diameter tip clearance. The spectrum information of Figures 18-23A are plots of theoretical predictions for the disc loading, cruise Mach number, altitude, and tip speed stated on each figure. If maximum fore and aft overall noise levels at 0.8 diameter tip clearance are predicted using Figures 6-8, the levels will be the same as those predicted using the basic Prop-Fan theory. If noise spectrum information is predicted using Figures 18-23A, the levels will be the same as those predicted using the Prop-Fan theory only at (1) the disc loading stated on each figure, (2) 0.8 diameter tip clearance and (3) the fore and aft location of the peak overall noise level. Some degradation from exact theoretical predictions should be expected when Figures 12-17 are used to adjust for tip clearance and fore and aft location and Figures 18-23A are used as spectrum levels for conditions and locations other than those stated on the figures.

SAMPLE ESTIMATE OF SR-7L PROP-FAN NEAR-FIELD NOISE

To assist those using the SR-7L Prop-Fan near-field noise generalization, the following sample calculation is provided:

- Disc loading: 256.9 Kw/m^2 (32.0 SHP/ft^2)
- Tip Speed: 244 m/sec (800 ft/sec)
- Cruise Mach Number: 0.8
- Tip Clearance: 0.4 Diameter
- Fore and Aft Location: 0.5 Diameter Forward
- Altitude: 7,620 m (25,000 ft)

Step 1. The cruise condition is 256.9 Kw/m^2 (32.0 SHP/ft^2, 244 m/sec (800 ft/sec), at 7620 m (35,000 ft) altitude.

Step 2a. At 7620 m (25,000 ft) altitude, the tip speed is given as 244 m/sec (800 ft/sec). From Figure 9 at 7620 m (25,000 ft) the tip speed correction factor, K_{TS}, is 0.9575. Multiply the tip speed at 7620 m (25,000 ft) by 0.9575 to obtain an equivalent tip speed of 234 m/sec (766 ft/sec) at 10,668 m (35,000 ft).

Step 2b. At 7620 m (25,000 ft) altitude the disk power loading is 256.9 Kw/m^2 (32.0 SHP/ft^2). From Figure 8 at 7620 m (25,000 ft) the disk power loading correction factor, K_{HP}, is .608. Multiply the disk power loading at 7620 m (25,000 ft) by 0.608 to obtain an equivalent disk power loading of 161.7 Kw/m^2 (19.5 SHP/ft^2) at 10,668 m (35,000 ft).

Step 2c. The equivalent operating condition at 10,668 m (35,000 ft) is 161.7 Kw/m^2 (19.5 SHP/ft^2) (Step 2b) at 234 m/sec (766 ft/sec) tip speed (Step 2a) for a cruise Mach number of 0.8. Interpolating between Figures 7 and 8, the maximum sideline overall sound pressure level at 0.8 diameters tip clearance for the equivalent operating condition at 10,668 m (35,000 ft) is 143.4 dB.

Step 2d. From Figure 11 the altitude correction to the maximum sideline noise level at 0.8 diameters tip clearance for the equivalent operating condition is +4.0 dB. The maximum sideline noise level at 0.8 diameters tip clearance for the actual altitude and operating conditions is 143.4 dB +4.0 dB = 147.4 dB.

Step 3. For a tip clearance of 0.4 diameter and a fore and aft distance of 0.5 diameter forward of the plane of rotation, Figure 16 indicates that the level from Step 2d should be reduced by 18 dB. The overall sound pressure level at 0.4 diameters tip clearance at 0.5 diameters forward of the plane of rotation for 7620 m (25,000 ft) altitude, 256.9 Kw/m^2 (32.0 SHP/ft^2), 244 m/sec (800 ft/sec) and 0.8 cruise Mach number is 147.4 dB - 18 dB = 129.4 dB.

Step 4. The spectrum levels are determined by adding the spectrum level corrections for the equivalent tip speed of 234 m/sec (766 ft/sec) interpolated from Figure 22 to the overall noise level from Step 3 as tabulated below:

Blade Passage Frequency	Level Relative to Overall Sound Pressure Level	Sound Pressure Level of Blade Passage Frequency Harmonics
(BPF)	- 1.5 dB	127.9 dB
2 x BPF	- 6.8 dB	122.6 dB
3 x BPF	-12.4 dB	117.0 dB
4 x BPF	-18.3 dB	111.1 dB
5 x BPF	-20.6 dB	108.8 dB
6 x BPF	-19.1 dB	110.3 dB
7 x BPF	-22.7 dB	106.7 dB
8 x BPF	-26.1 dB	103.3 dB
9 x BPF	-24.7 dB	104.7 dB
10 x BPF	-28.1 dB	101.3 dB

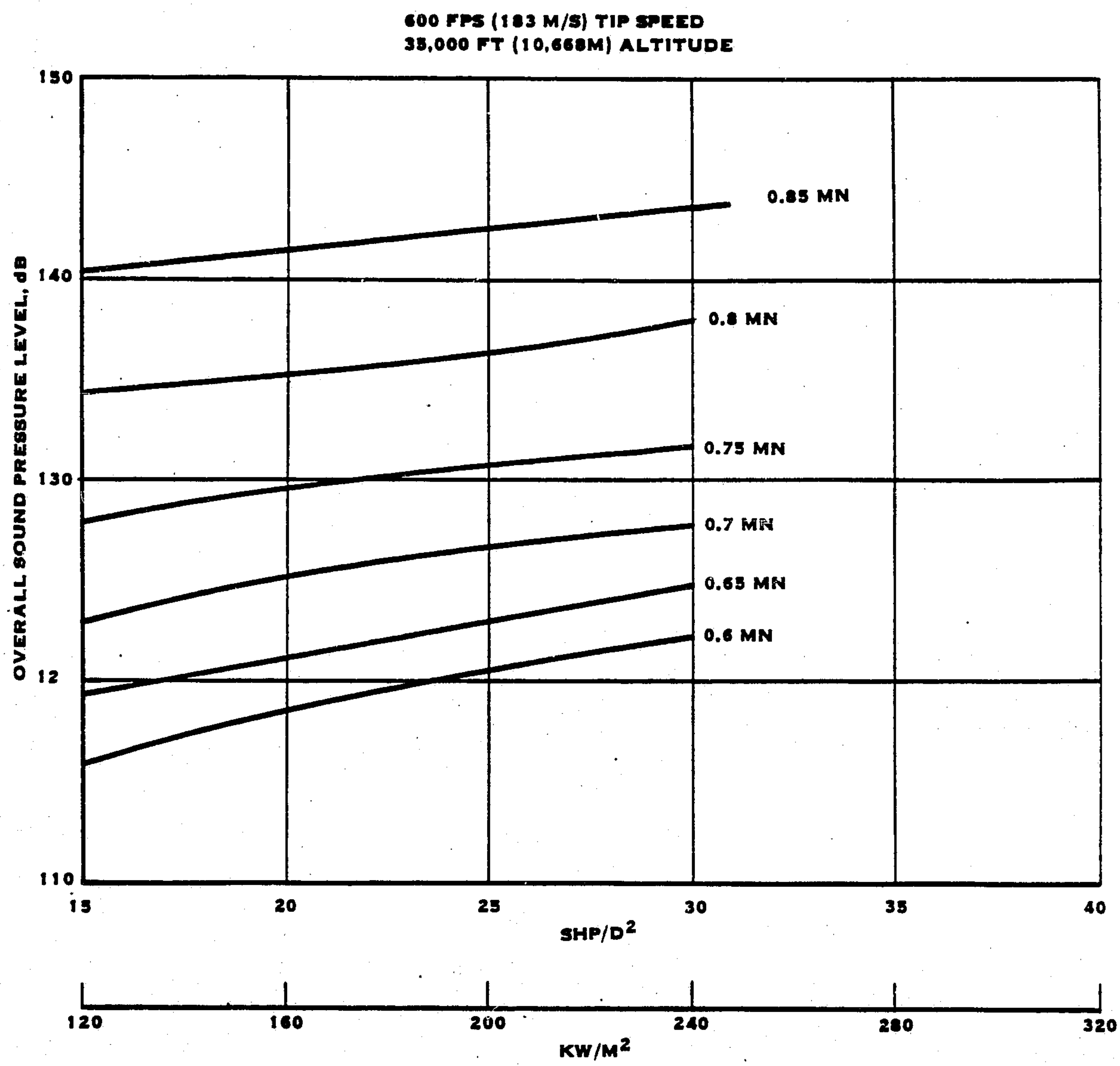


FIGURE 6. PEAK OVERALL FREE FIELD NOISE LEVELS AT 0.8 DIAMETERS BLADE TIP CLEARANCE

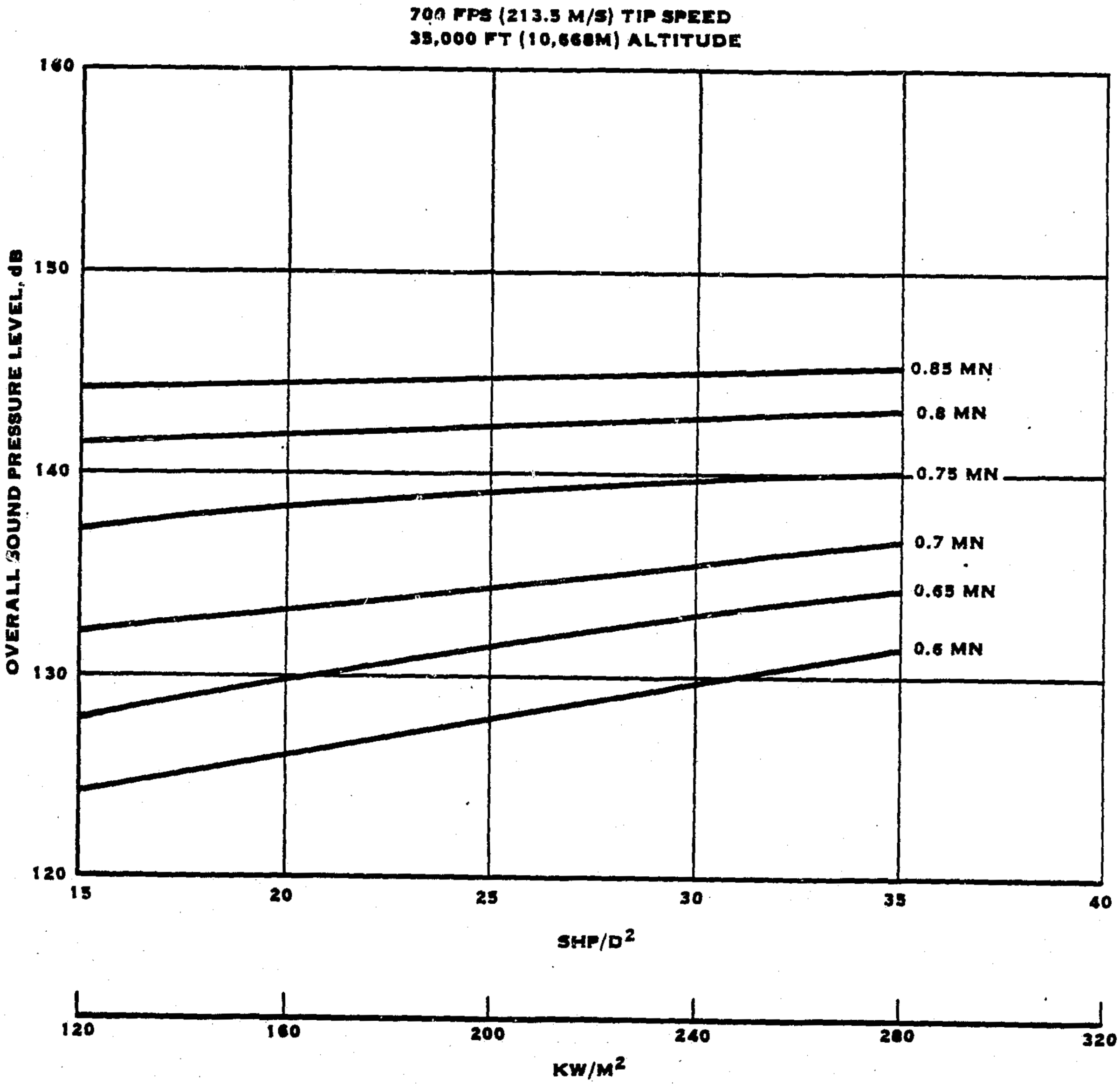


FIGURE 7. PEAK OVERALL FREE FIELD NOISE LEVELS AT 0.8 DIAMETERS BLADE TIP CLEARANCE

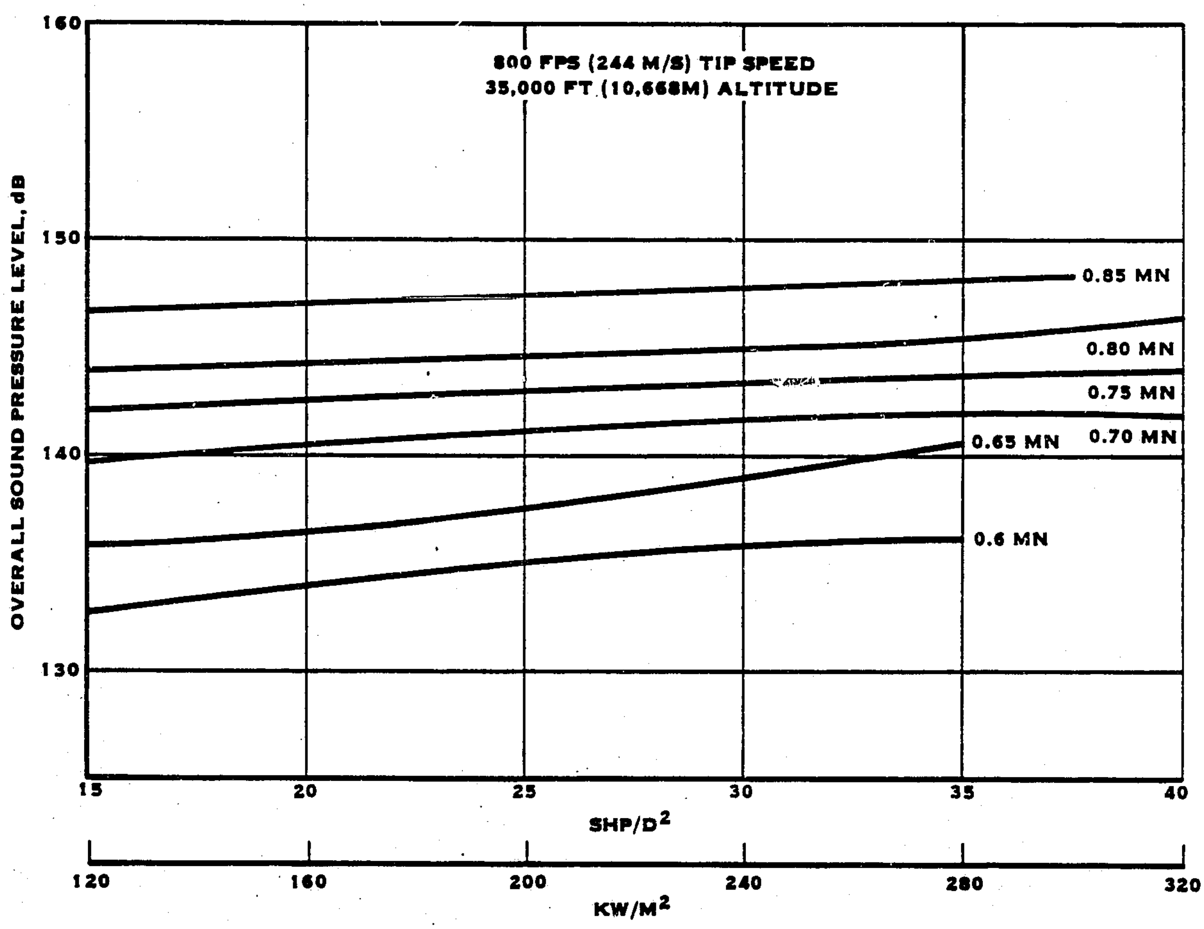


FIGURE 8. PEAK OVERALL FREE FIELD NOISE LEVELS AT 0.8 DIAMETERS BLADE TIP CLEARANCE

CORRECTION FOR THE EFFECT OF ALTITUDE ON TIP ROTATIONAL SPEED AT CONSTANT ADVANCE RATIO, J, AND CONSTANT FLIGHT MACH NUMBER

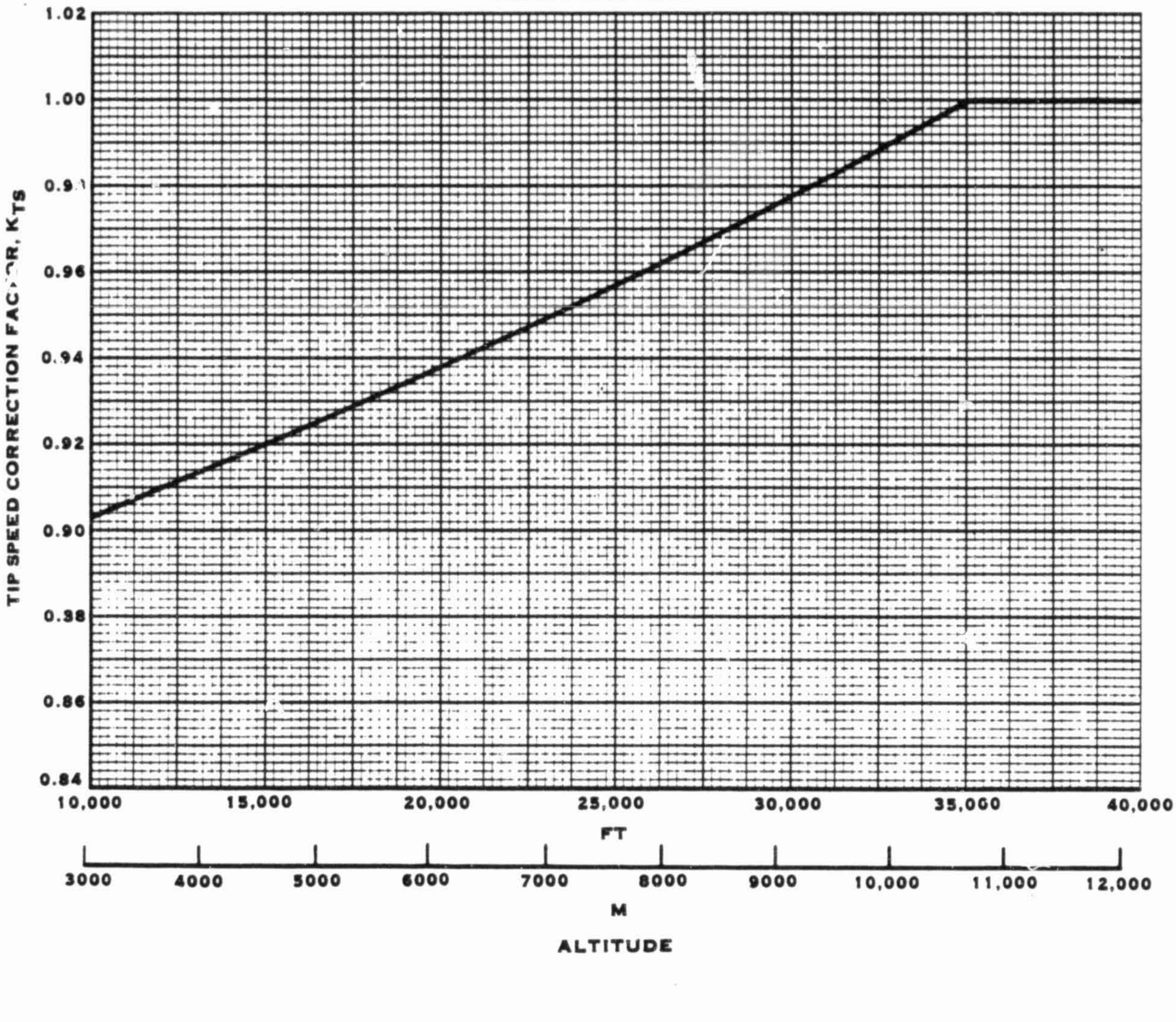


FIGURE 9

CORRECTION FOR THE INFLUENCE OF ALTITUDE ON SHP/D^2 AT CONSTANT POWER COEFFICIENT, CP, CONSTANT ADVANCE RATIO, J, AND CONSTANT FLIGHT MACH NUMBER

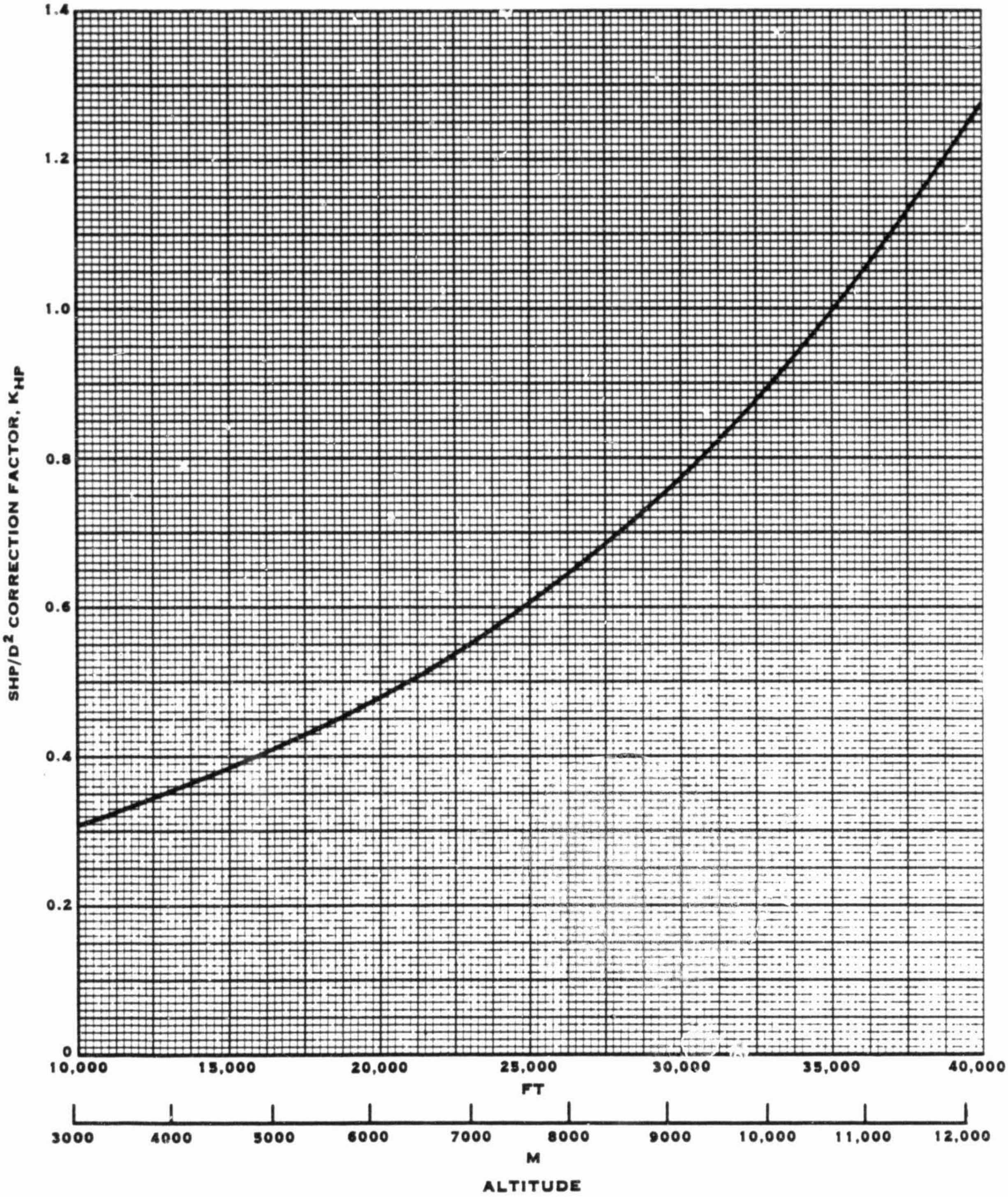


FIGURE 10

CORRECTION FOR THE INFLUENCE OF ALTITUDE ON NEAR FIELD CRUISE NOISE LEVEL AT CONSTANT POWER COEFFICIENT, CP, CONSTANT ADVANCE RATIO, J, AND CONSTANT FLIGHT MACH NUMBER

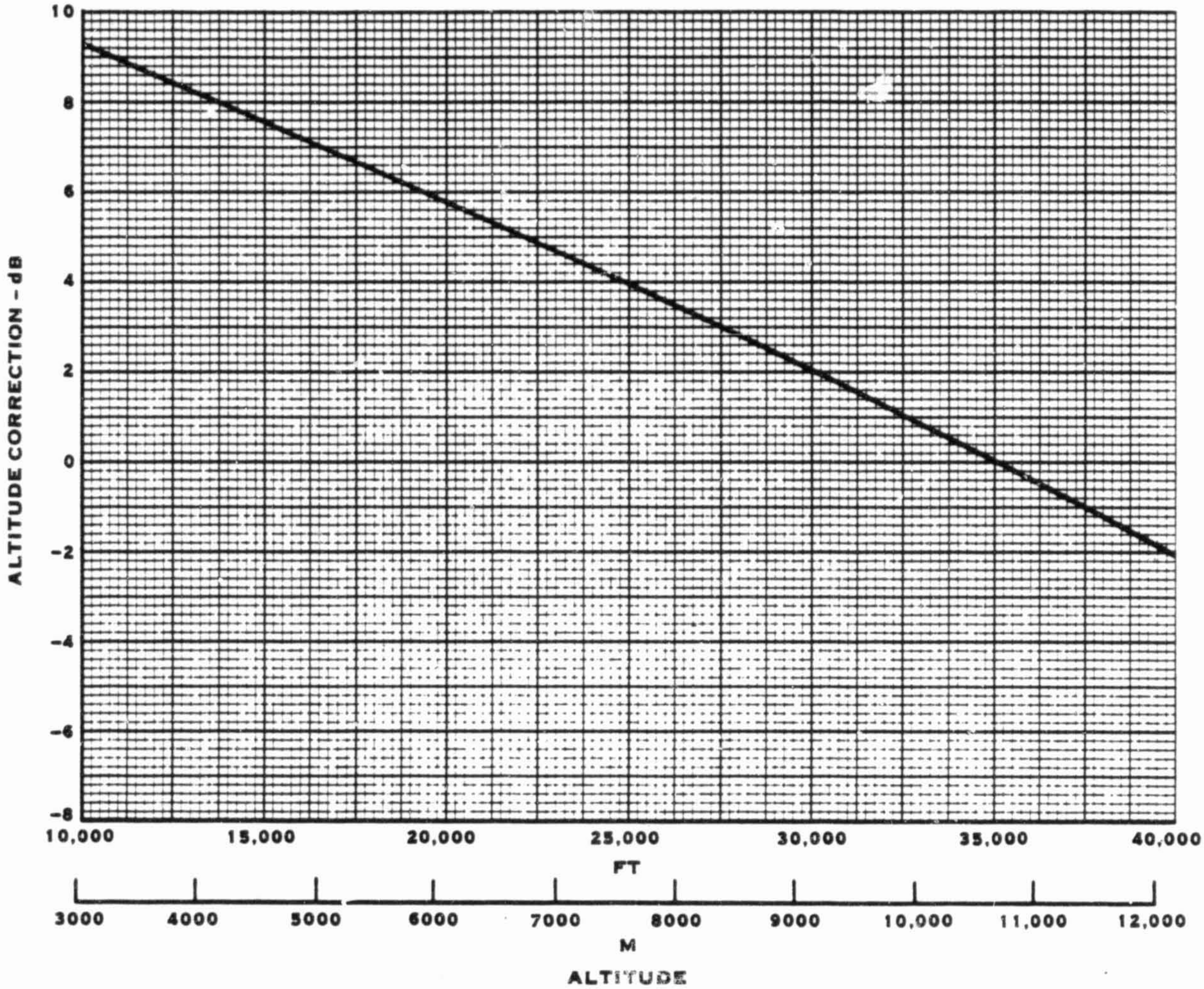


FIGURE 11

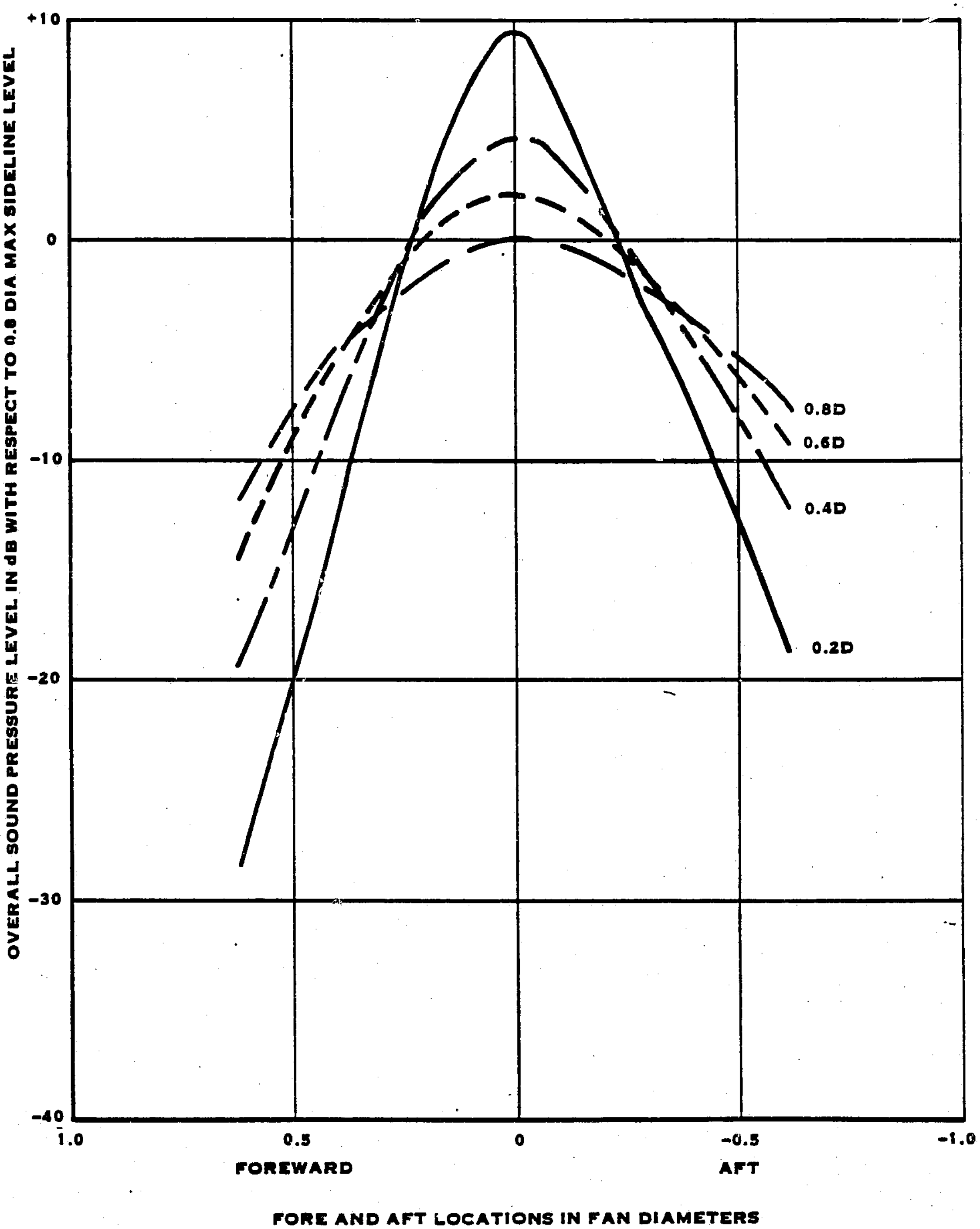


FIGURE 12. DIRECTIVITY AS A FUNCTION OF TIP CLEARANCE 0.6 MN

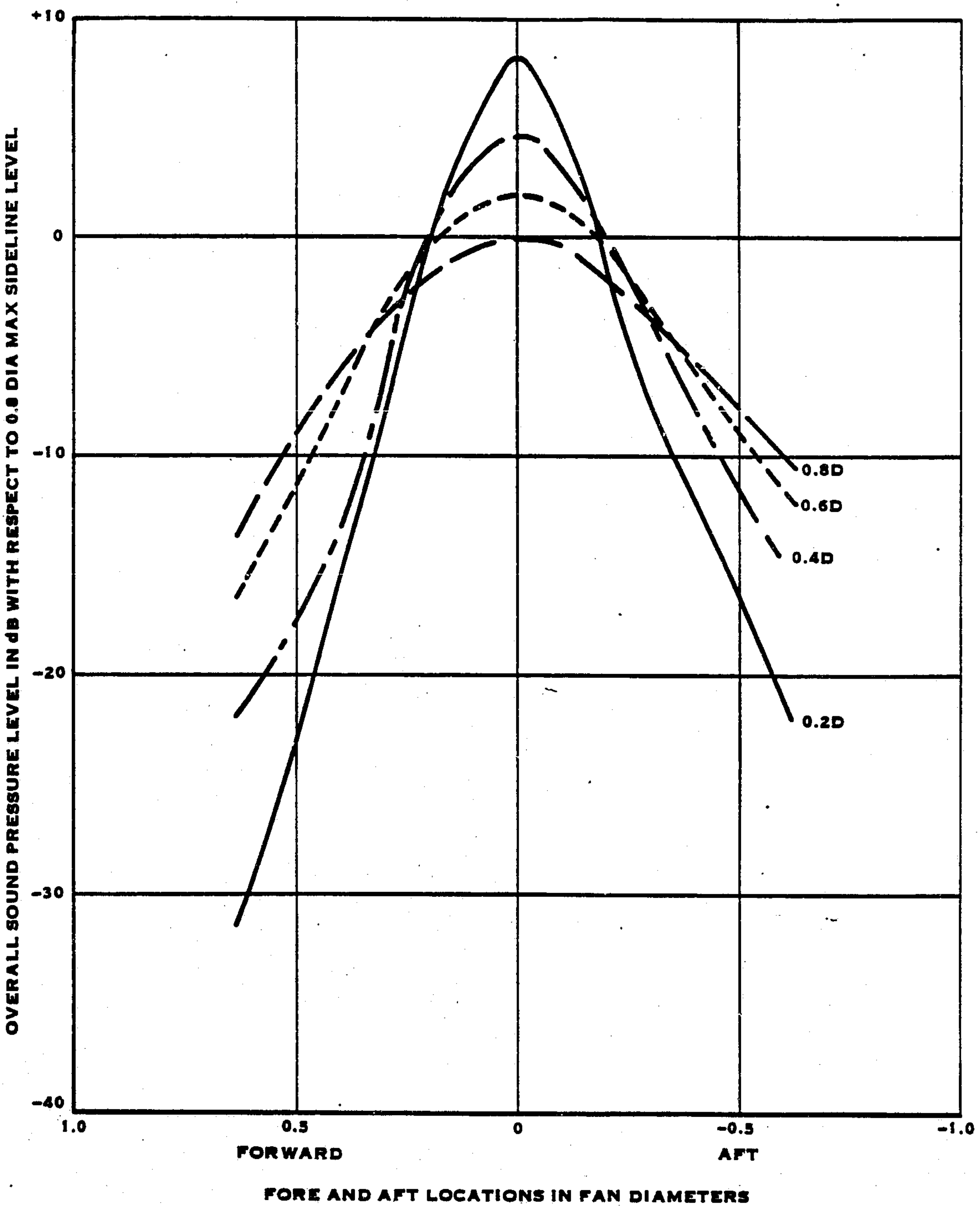


FIGURE 13. DIRECTIVITY AS A FUNCTION OF TIP CLEARANCE 0.65 MN

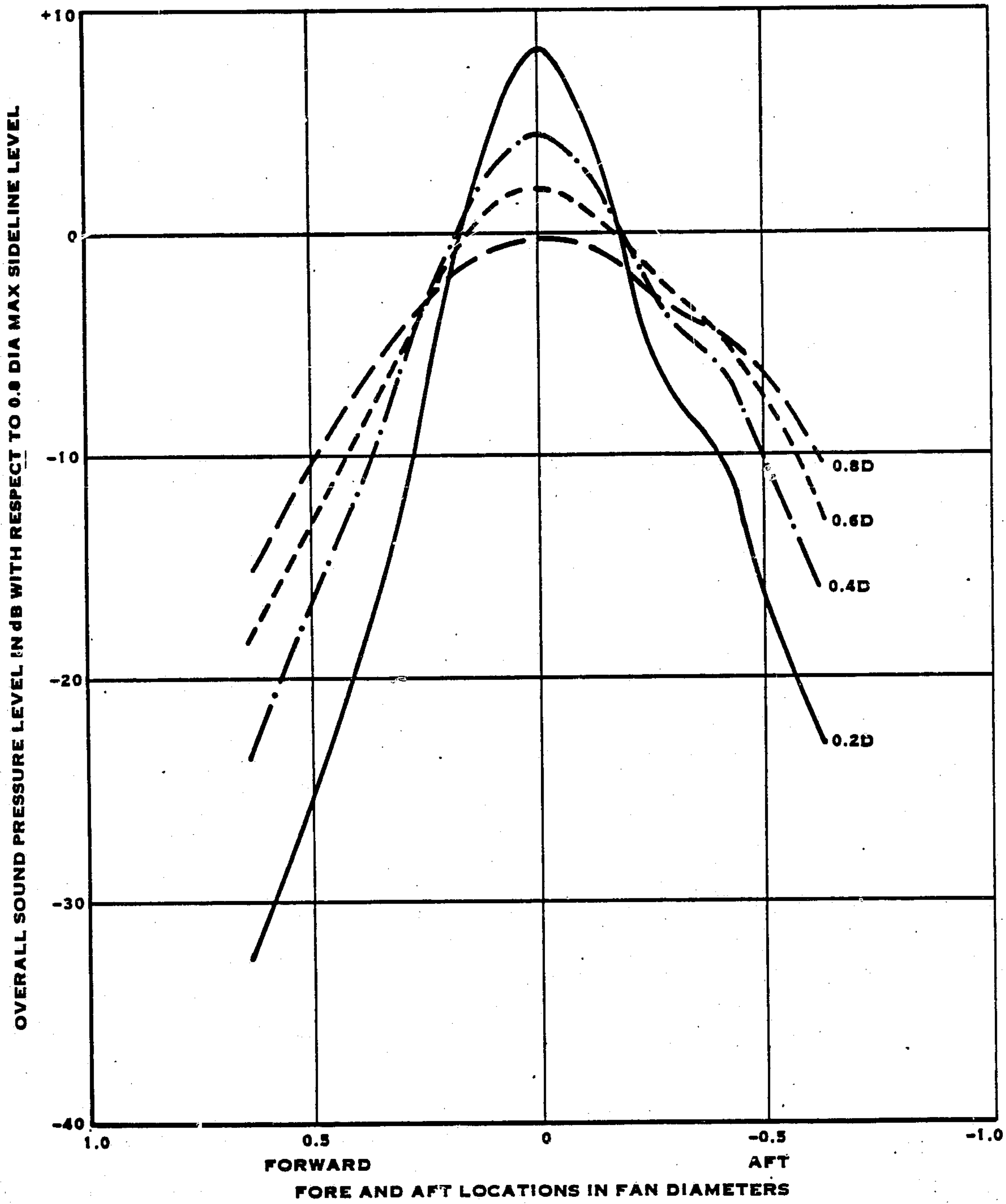


FIGURE 14. DIRECTIVITY AS A FUNCTION OF TIP CLEARANCE 0.7 MN

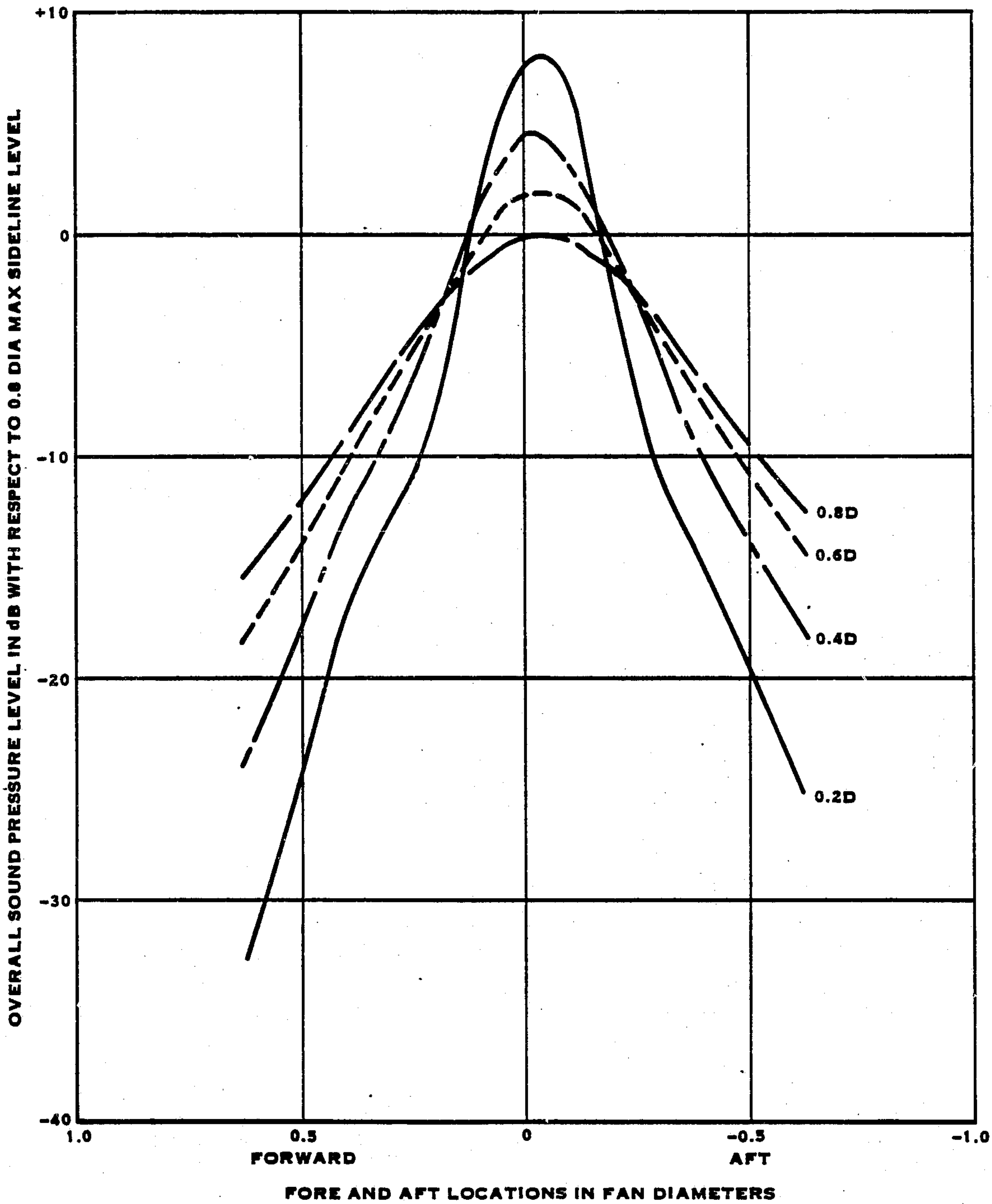


FIGURE 15. DIRECTIVITY AS A FUNCTION OF TIP CLEARANCE 0.75 MN

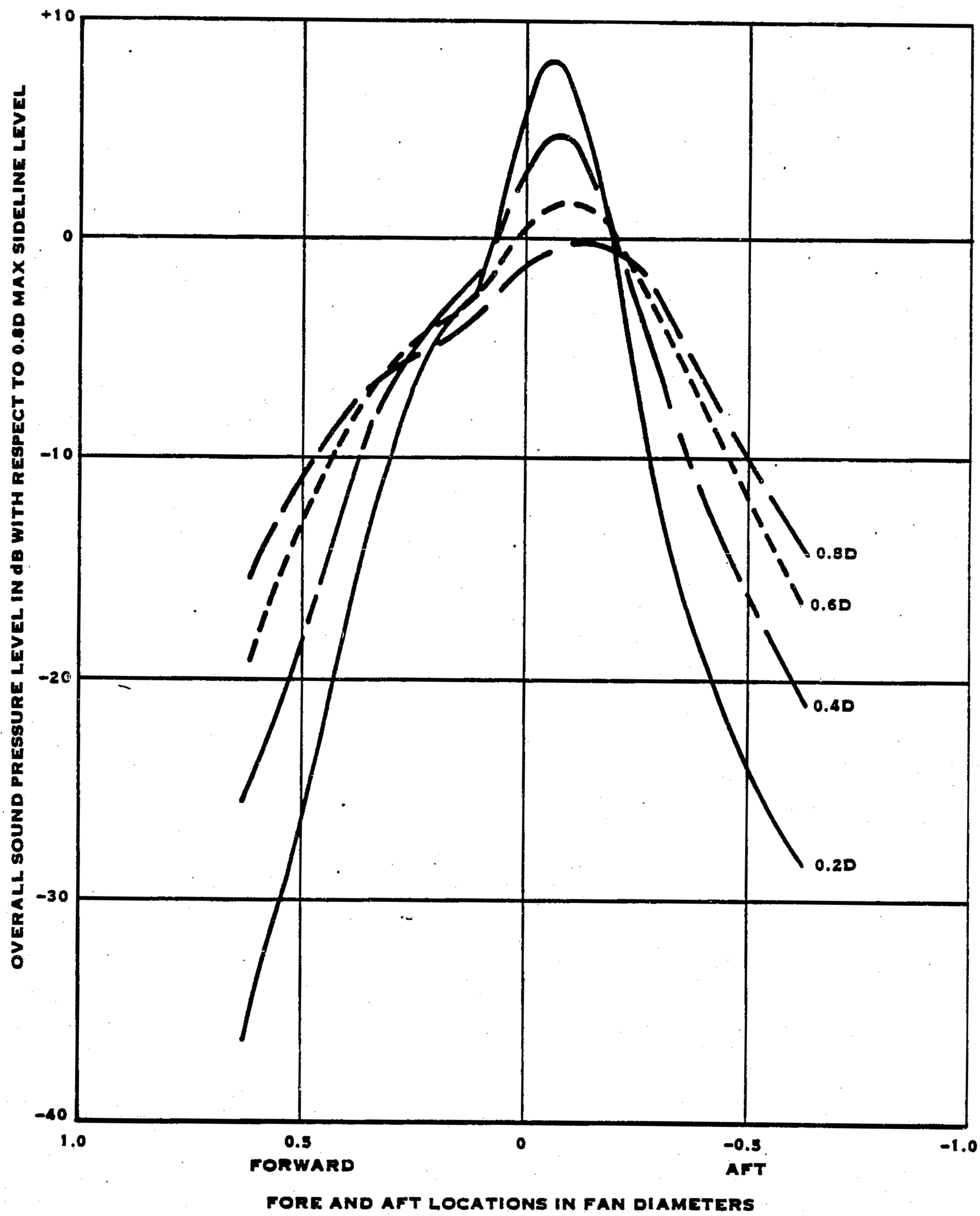


FIGURE 16. DIRECTIVITY AS A FUNCTION OF TIP CLEARANCE 0.8 MN

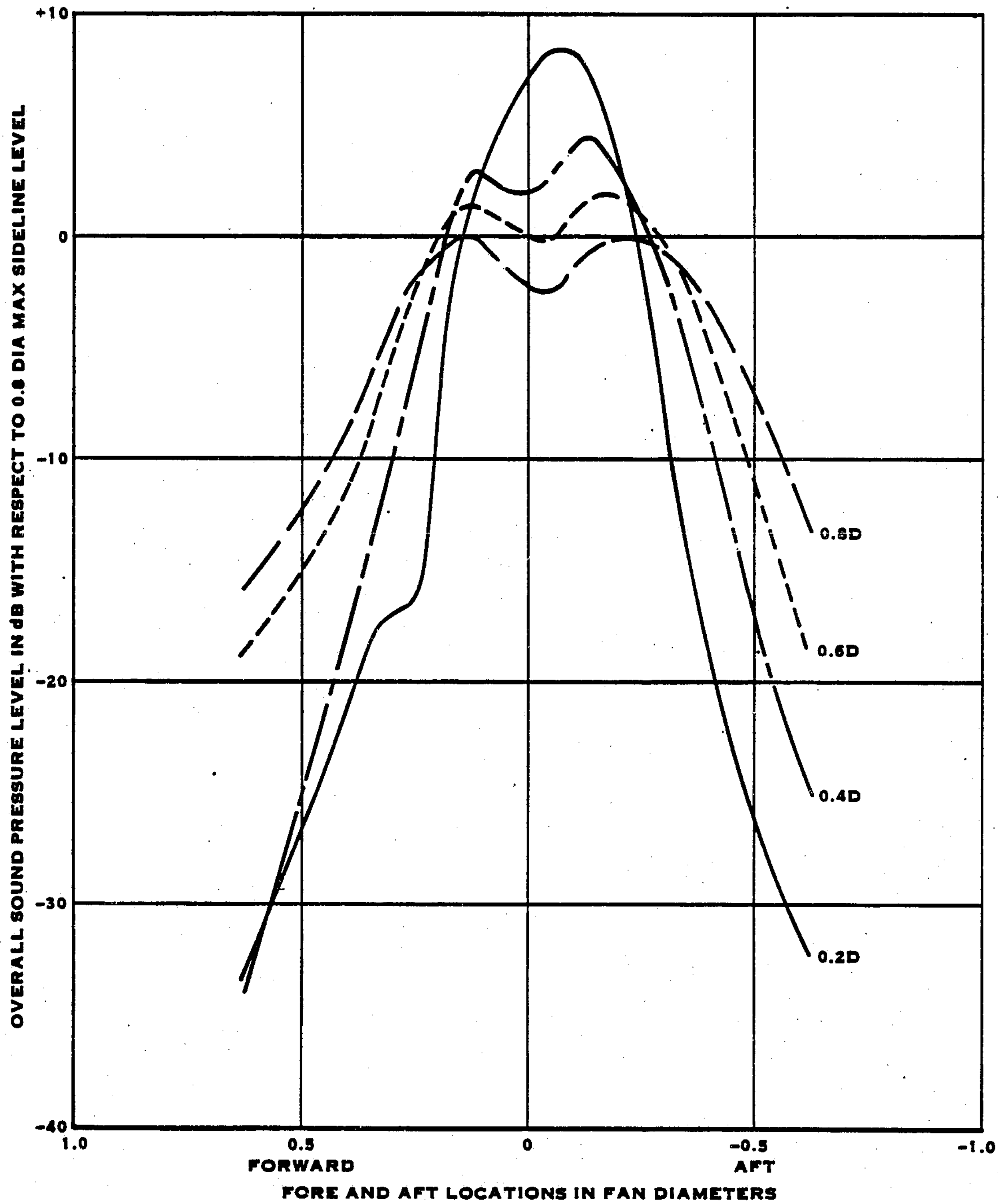


FIGURE 17. DIRECTIVITY AS A FUNCTION OF TIP CLEARANCE 0.85 MN

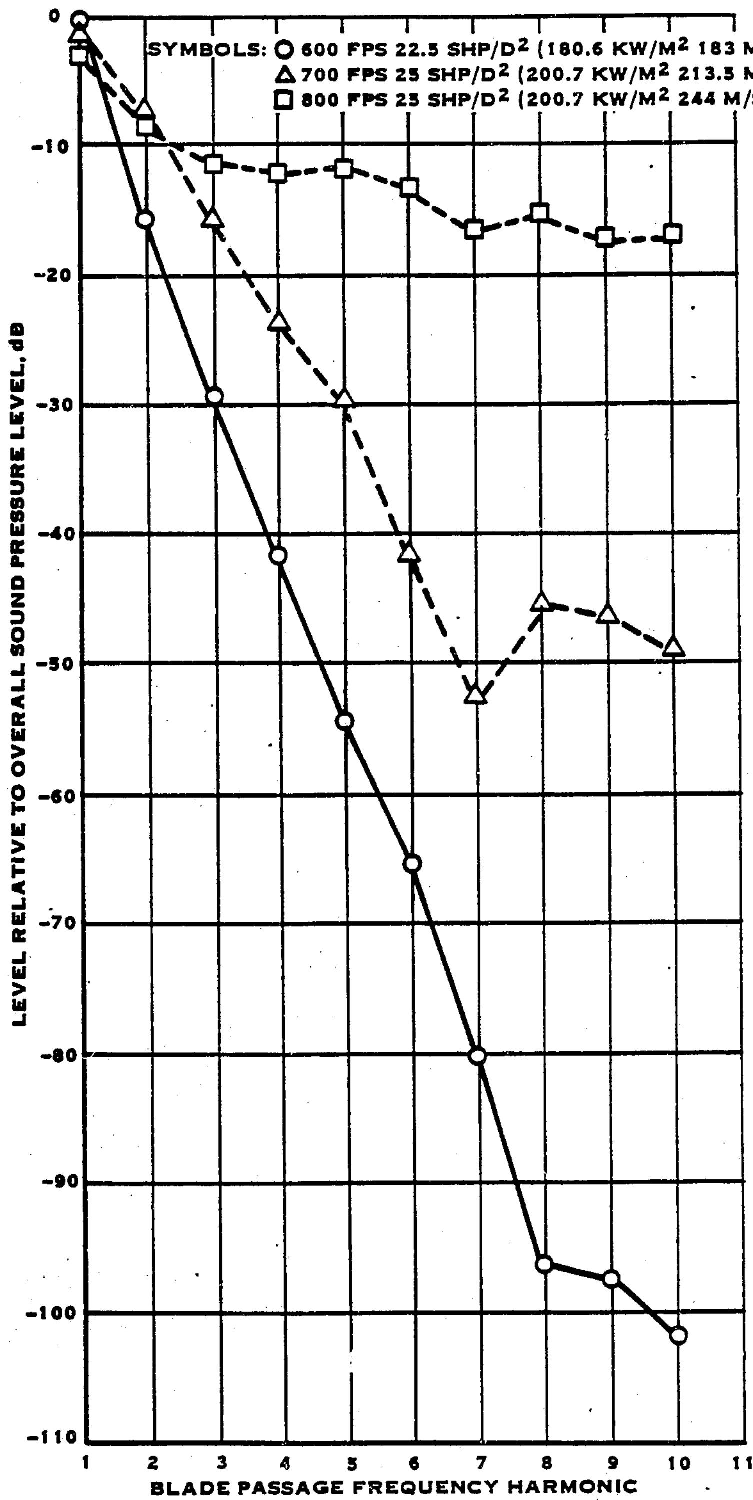


FIGURE 18. LEVEL OF BLADE PASSAGE FREQUENCY HARMONICS RELATIVE TO OVERALL SOUND PRESSURE LEVELS
0.6 MN, 0.8 DIAMETER TIP CLEARANCE, 35,000 FT (10,668M)

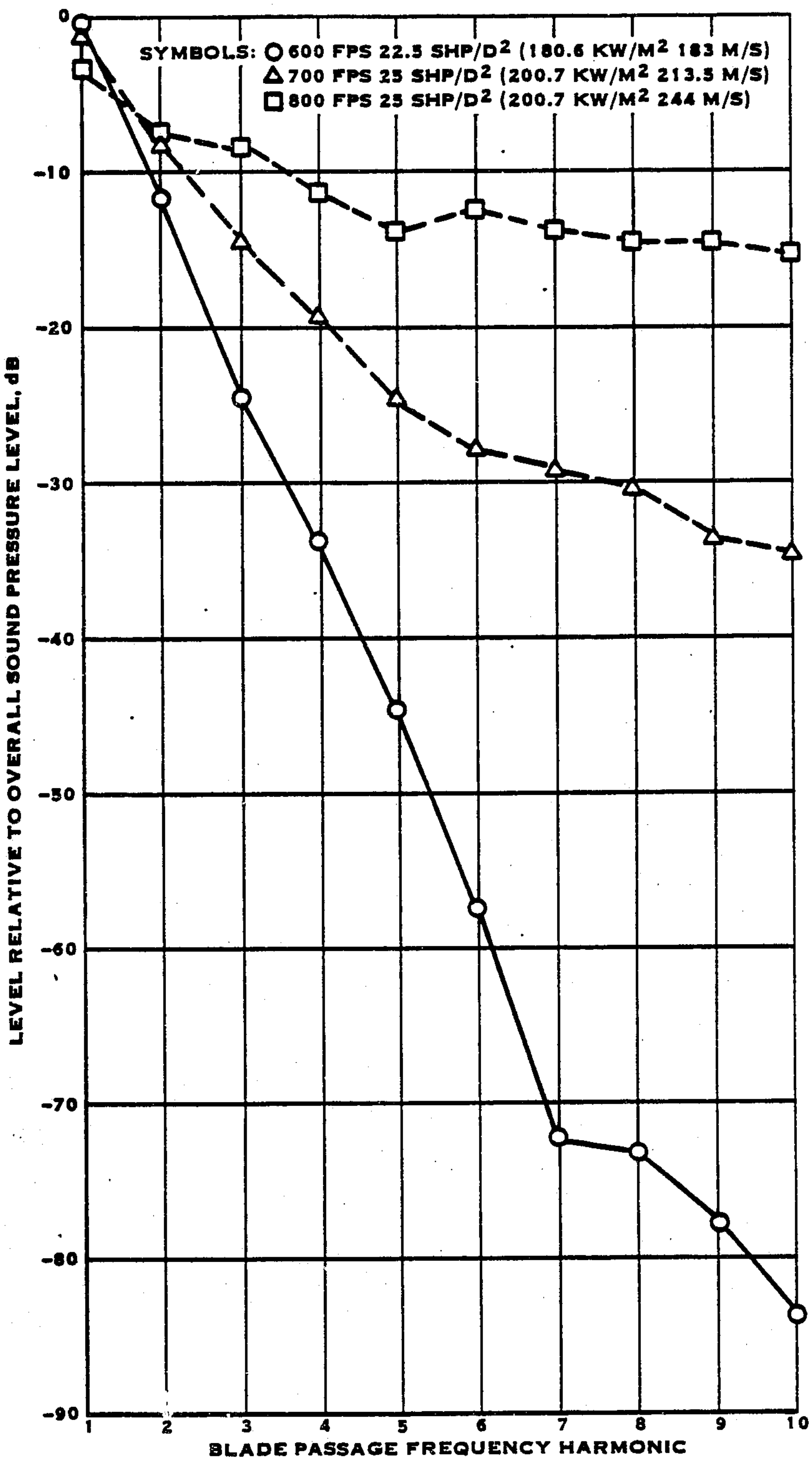


FIGURE 19. LEVEL OF BLADE PASSAGE FREQUENCY HARMONICS RELATIVE TO OVERALL SOUND PRESSURE LEVELS
0.65 MN, 0.8 DIAMETER TIP CLEARANCE, 35,000 FT (10,668M)

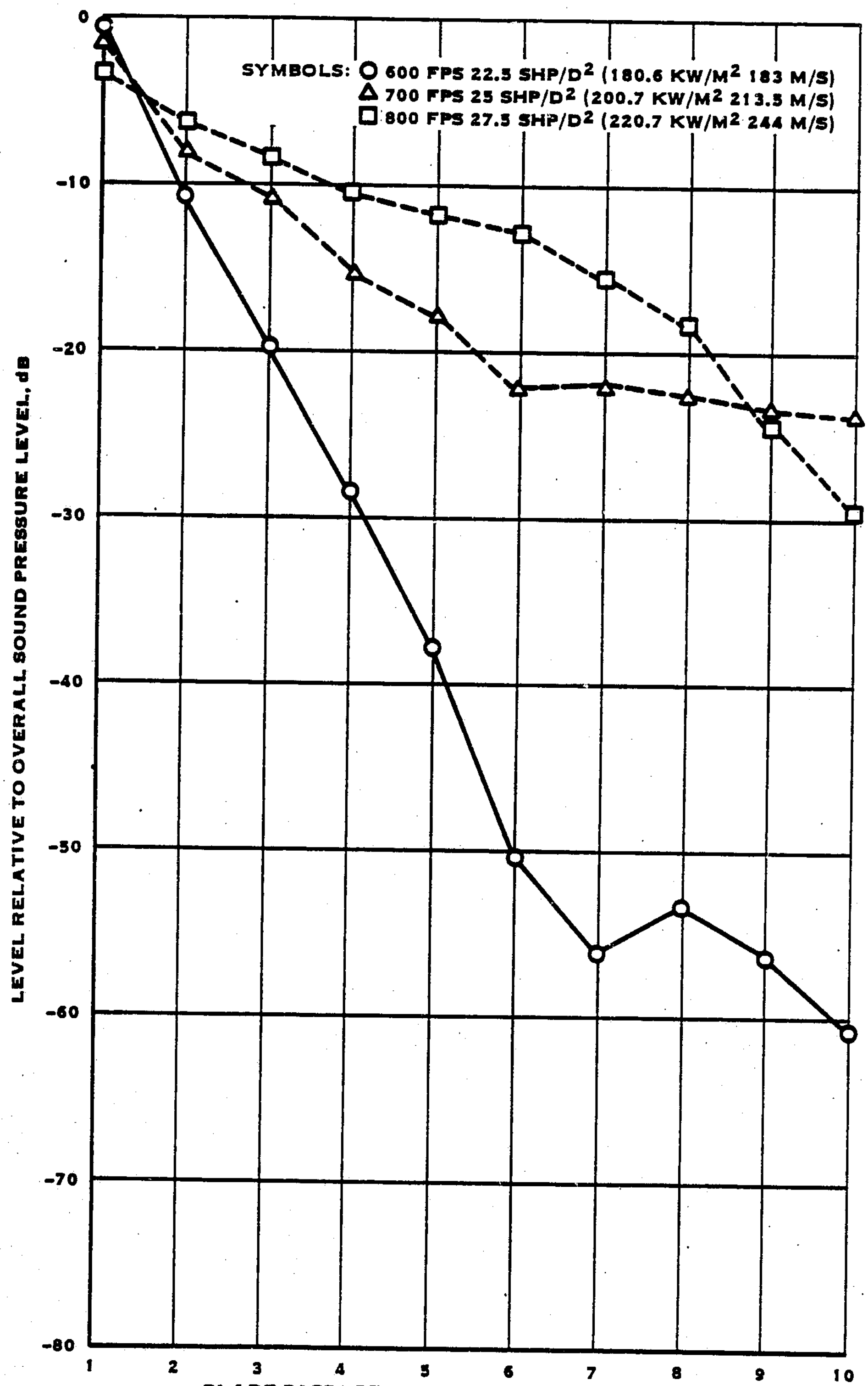


FIGURE 20. LEVEL OF BLADE PASSAGE FREQUENCY HARMONICS RELATIVE TO OVERALL SOUND PRESSURE LEVEL
0.7 MN, 0.8 DIAMETER TIP CLEARANCE, 35,000 FT (10,668M)

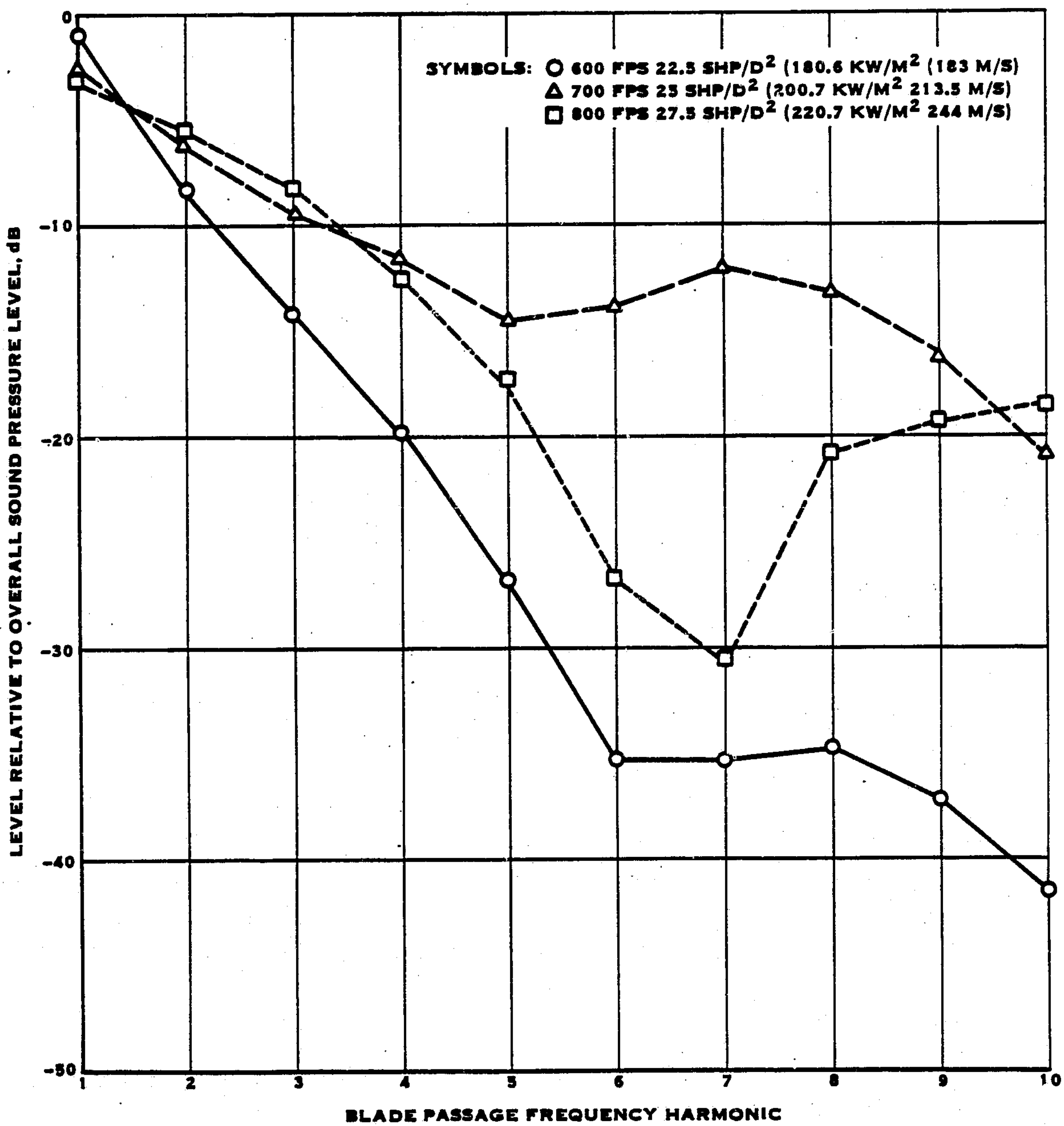


FIGURE 21. LEVEL OF BLADE PASSAGE FREQUENCY HARMONICS RELATIVE TO OVERALL SOUND PRESSURE LEVEL
0.75 MN, 0.8 DIAMETER TIP CLEARANCE, 35,000 FT (10,668M)

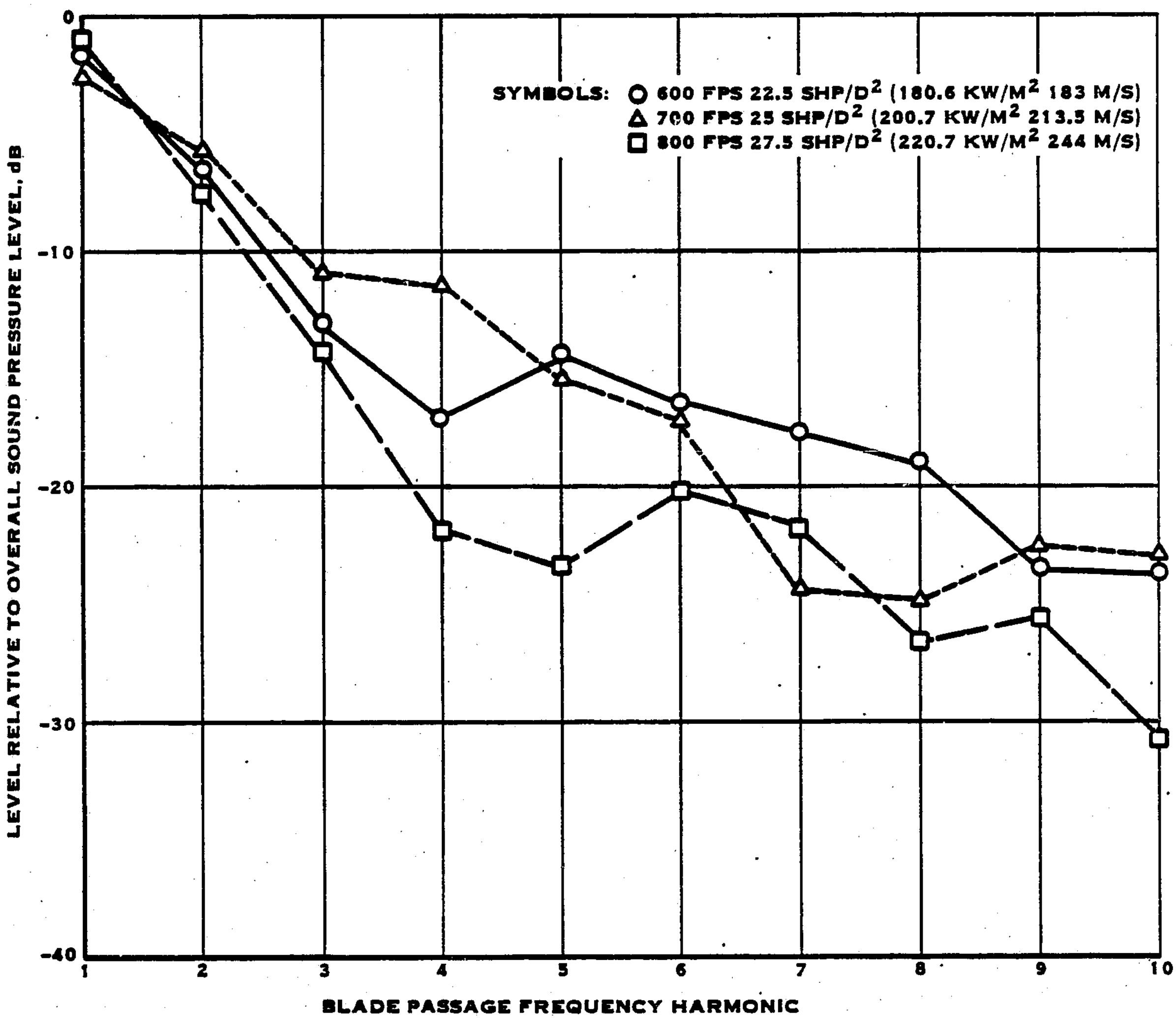


FIGURE 22. LEVEL OF BLADE PASSAGE FREQUENCY HARMONICS RELATIVE TO OVERALL SOUND PRESSURE LEVEL
0.8 MN, 0.8 DIAMETER TIP CLEARANCE, 35,000 FT (10,668M)

FIGURE 22A. LEVEL OF BLADE PASSAGE FREQUENCY HARMONIC RELATIVE TO OVERALL SOUND PRESSURE LEVELS
0.8 MN, 0.8 DIAMETER TIP CLEARANCE, 35,000 FT (10,668M)

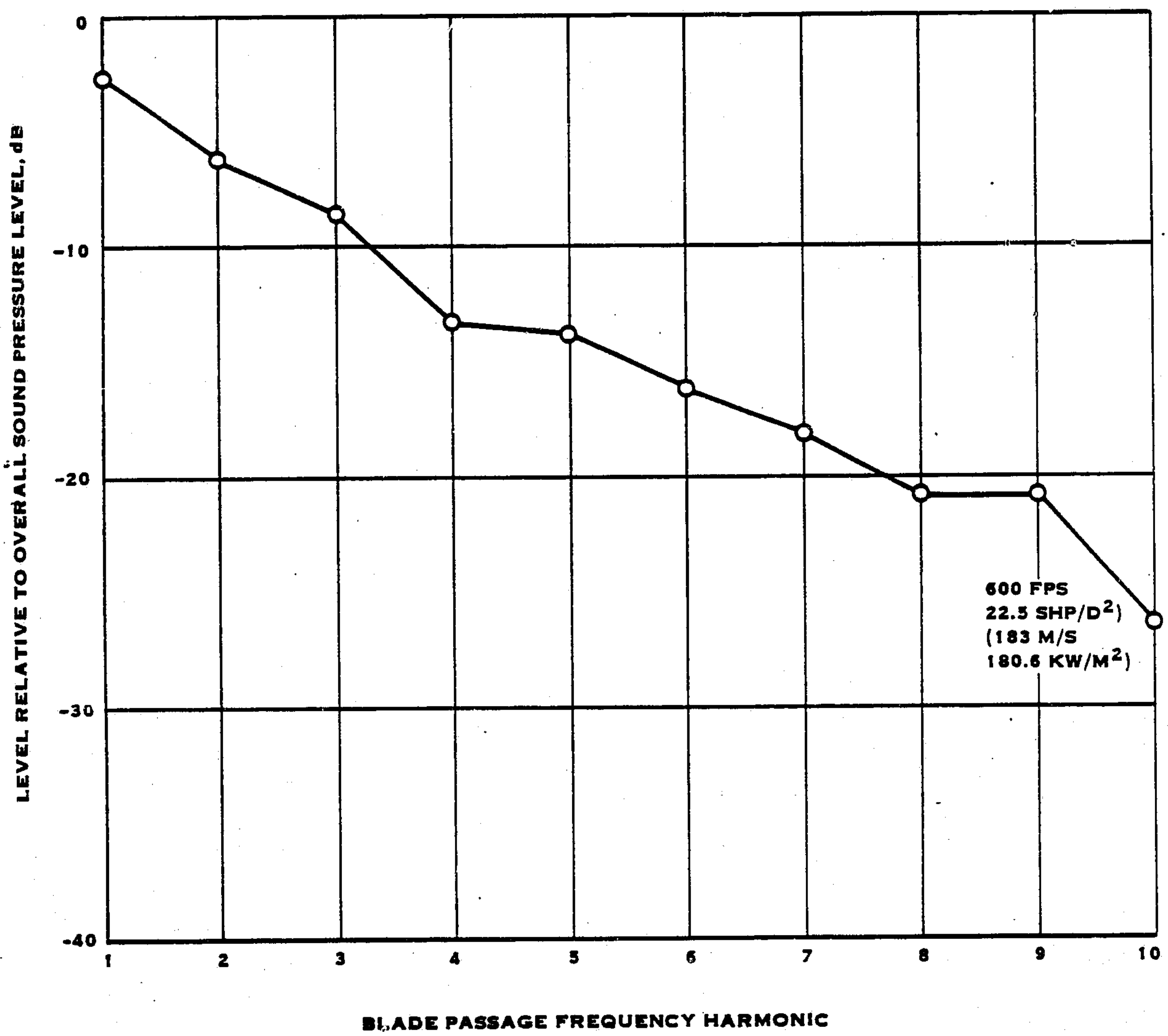


FIGURE 23. LEVEL OF BLADE PASSAGE FREQUENCY HARMONIC RELATIVE TO OVERALL SOUND PRESSURE LEVELS
0.85 MN, 0.8 DIAMETER TIP CLEARANCE, 35,000 FT (10,668M)

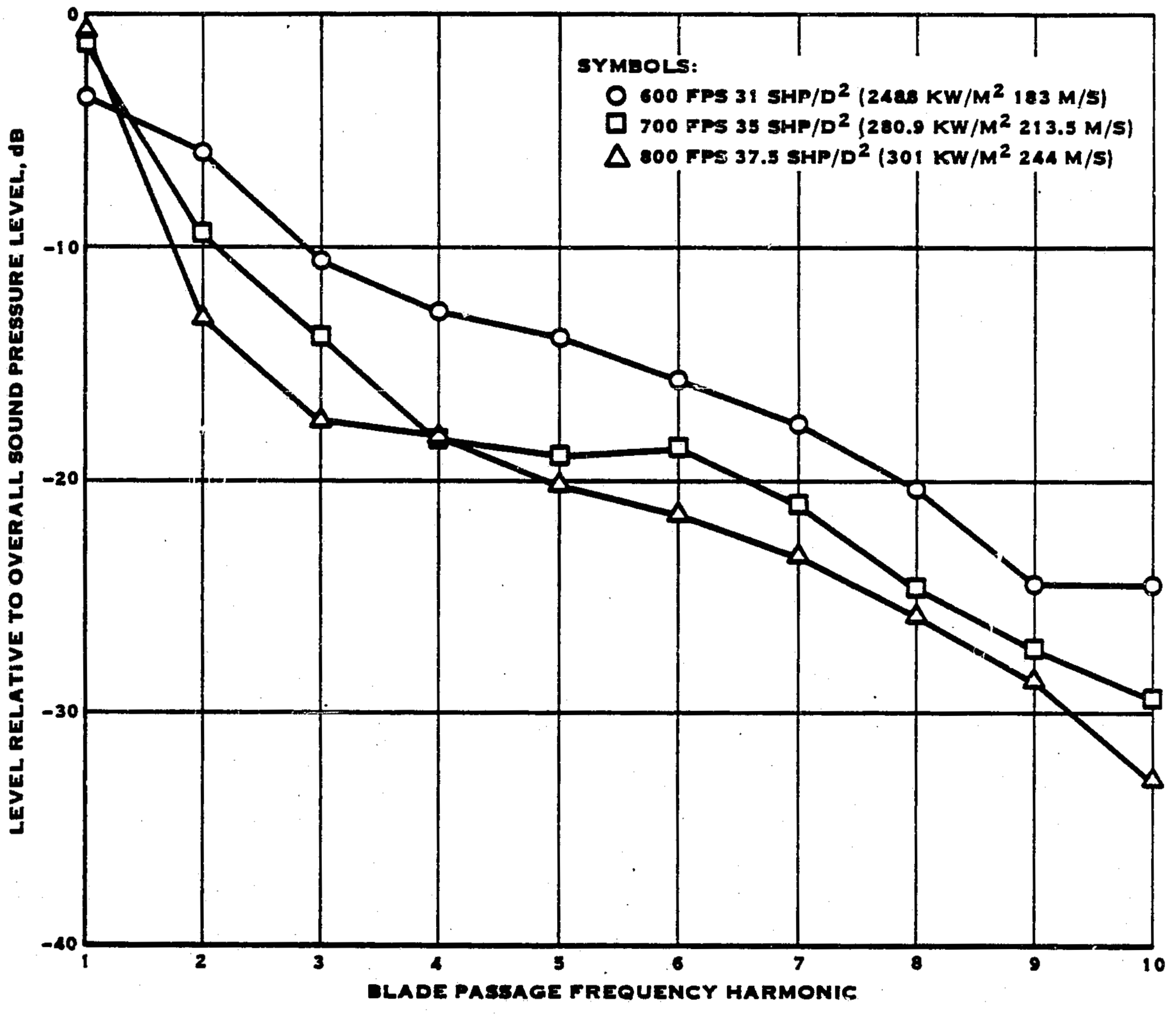


FIGURE 23A. LEVEL OF BLADE PASSAGE FREQUENCY HARMONIC RELATIVE TO OVERALL SOUND PRESSURE LEVELS
0.85 MN, 0.8 DIAMETER TIP CLEARANCE, 35,000 FT (10,668M)

SR-7L PROP-FAN FAR-FIELD NOISE ESTIMATION FOR NOISE CERTIFICATION

Estimation of SR-7L Prop-Fan noise in the far-field is more complicated than estimation of noise in the near-field due to additional considerations, such as atmospheric attentuation and ground reflection effects. In addition, noise certification limits are in terms of Effective Perceived Noise Level (EPNL) which includes tone and duration corrections. These are dependent on the spectrum characteristics as well as flight speed and altitude over the measuring microphone. It is thus not practical to devise simple graphical procedures to provide reasonable estimates of Prop-Fan EPNL.

In place of a graphical procedure, Hamilton Standard has developed a FORTRAN computer program SP06A8'F which will calculate the EPNL of the SR-7L Prop-Fan during take-off and approach. This program includes all the currently known components of Prop-Fan noise which are significant during low flight speed operation. In addition, the computer program will calculate ground reflection effects, so that noise estimates representative of that which would be measured for noise certification, with a microphone located over a ground plane, can be made. Finally, the computer program has provision for inputing engine noise, so that the noise of a complete full scale propulsor can be estimated.

Table XI presents sample representative takeoff and approach noise levels as calculated by SP 06A83F. These calculaions were made for Prop-Fan noise only, and do not include any engine noise.

TABLE XI. SR7 FAR-FIELD NOISE PREDICTIONS
(SP 06A83F Sample Calculation)
(For 2-Engine Aircraft 13.9 Foot Diameter Prop-Fans)

Conditions	$\frac{SHP}{D^2}$	Tip Speed (fps)	Aircraft Height Above Ground (ft)	EPNL Free-Field	EPNL 4 ft Micro-phone	FAR-36 Stage-3 Limit
Cut-Back Power Take-off (0.20MN)	41.6	700	2750	75.4	80.3	89.9
Approach (0.20MN)	16.8	650	394	79.3	81.8	99.5

WEIGHT

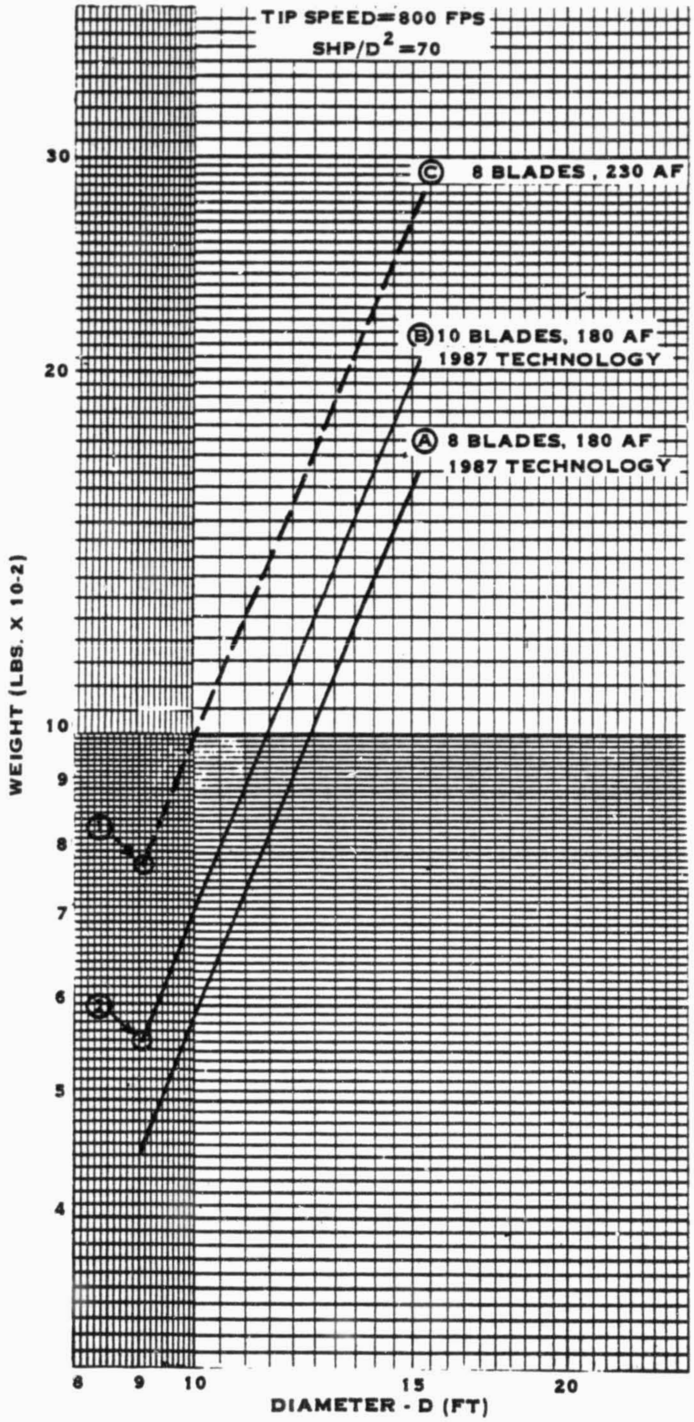
PROP-FAN WEIGHT ESTIMATION

Data package SP 06A83 reflects Hamilton Standards most recent estimates for Prop-Fans. The technology time frame chosen is 1987 which means that a technology freeze occurs in that year, and a production development program initiated then would incorporate the technology level reflected by these weight estimates.

Weight relationships were generated for a Prop-Fan with both eight (8) and ten (10), 180AF blades with 1987 technology incorporated. These relationships are represented by curves A and B of Figure 24. A weight relationship was also generated for the current technology LAP with a 230AF blade configuration and an advanced pitch change system. This is represented by curve C of Figure 24. For comparison purposes, both the LAP configuration and the equivalent solidity, 1987 technology Prop-Fan configuration are depicted.

Curves A & B of Figure 24 provide uninstalled 1987 technology rotor weight estimates. These weights are consistent with data package SP 06A82. The weights assure a blade technology with advanced airfoils, a hollow titanium spar, 8 lb density foam fill, a fiberglass shell, and a titanium sheath; a steel disc; a 4750 psi advanced technology pitch change system with onboard power for ice protection; and a fiberglass spinner.

The power loading, (SHP/D^2), term used on the rotor weight curve in Figure 24 is based on the maximum power delivered to the rotor. The tip speed, (T.S.), that should be used for rotor weights is the maximum at which the rotor normally operates. The weight curve in Figure 24 is plotted for a tip speed of 800 ft/sec and a power loading of 70 HP/ft^2. Rotor weights for other tip speeds and power loadings can be obtained by utilizing the conversion formulae provided on the curve notes.



- WEIGHT INCLUDES: BLADES, HUB, RETENTION, ACTUATOR, CONTROL, SPINNER, DEICING
- WT. AT ALL OTHER VALUES OF T.S., $WT._{TS}$

  $$WT_{TS} = WT_{800}\left[\frac{TS}{800}\right]^{0.3}$$

- WT. AT ALL OTHER VALUES OF SHP/D^2, WT_{SHP}

  $$WT_{SHP/D^2} = WT_{70}\left[\frac{SHP/D^2}{70}\right]^{0.3}$$

NOTES

① PROP. FAN DESIGN WITH LAP BLADE AND ADVANCED PITCH CHANGE MECHANISM

② PROP. FAN DESIGN WITH ADVANCED TECHNOLOGY FOR THE SAME TOTAL SOLIDITY AS LAP

FIGURE 24. PROP-FAN WEIGHT VS. DIAMETER

SAMPLE WEIGHT CALCULATION

GIVEN: Diameter, D = 13 ft.

Max. operating horsepower to the Prop-Fan = 10985

8 blades

T.S. = 700 ft./sec.

CALCULATE: $\frac{SHP}{D^2} = \frac{10985}{(13)^2} = 65.0$

Rotor weight from Figure 24 for $\frac{SHP}{D^2} = 70$ and

T.S. = 800 ft./sec. is 1160 pounds

Correcting weight for $\frac{SHP}{D^2} = 65.0$

$$WT_{65} = 1160 \left|\frac{65}{70}\right|^{0.3} = 1134 \text{ lbs.}$$

Correcting weight for T.S. = 700 ft./sec.

$$WT_{700} = 1134 \left|\frac{700}{800}\right|^{0.3} = 1089 \text{ lbs.}$$

Therefore the rotor weight for the above condition is 1089 lbs.