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INTERNAL MIXER INVESTIGATION FOR JT8D ENGINE JET NOISE REDUCTION

Volume II—Appendicies A, B, C,and D

A.B. Packman and D.C. Eiler

December 1977

FINAL REPORT

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16. Abstract

A scale model experimental program was conducted to determine the noise reduction and the impact on propulsive performance that would result from installing a multi-lobed internal mixer on the JT8D engine. Long and short mixer designs were investigated. One-seventh scale mixer models, designed to permit lobe geometry variations, were fabricated and tested along with a model of the JT8D reference exhaust system.

The test results indicated that, in general, the long and short mixers produced 3-4 PNdB reduction in Peak Perceived Noise Level relative to the reference exhaust system. Exhaust system performance, in terms of improvement in cruise thrust specific fuel consumption (TSFC), and impact on takeoff thrust, was somewhat better for the long mixer than for the short mixer configurations. However, the short mixers offer significant advantages in terms of weight savings and minimized the hardware changes required for installation in the current JT8D engines. Based on the noise and performance test results in conjunction with the installation considerations, a short mixer design was recommended for evaluation in a full scale engine test.

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	*tonnes (1000 kg)*	1.1	*short tons*	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

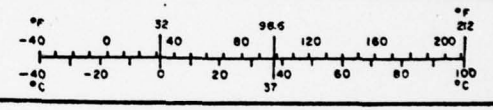

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TABLE OF CONTENTS

Section	Title
APPENDIX A	Test Conditions for Acoustic and Exit Profile Tests;
APPENDIX B	Acoustic Data, Measured Model and Scaled to JT8D Engine;
APPENDIX C	Nozzle Traverse Results; and
APPENDIX D	Hot/Cold Flow Model Tests to Determine Static Performance of 1/7-Scale JT8D Mixer Exhaust Nozzles.

APPENDIX A

TEST CONDITIONS FOR ACOUSTIC AND EXIT PROFILE TESTS

The operating condition for each test point of the configurations tested under the contract are included in this Appendix. The data are listed in the following order:

Configuration Name	Configuration Number
Basic Long Flowpath Mixer	1A
Reference Exhaust System	2Au
Reference Exhaust System (tested at ideally mixed conditions)	2Am
Shallow Scalloped Long Flowpath Mixer	3A
Scalloped Long Flowpath Mixer	4A
Cutback Scalloped Long Flowpath Mixer	5A
Cutback Unscalloped Long Flowpath Mixer	6A
Scalloped Long Flowpath Mixer with Engine Flow Simulation	7A
Cutback Scalloped Long Flowpath Mixer with 7.6 inch Engine Extension	8A
Severe Cutback Short Flowpath Mixer with Engine Flow Simulation	10A
Severe Cutback Short Flowpath Mixer	11A

NOTE: Unless noted otherwise, the long flowpath mixers were tested with a 16 inch engine extension, and the short flowpath mixer was tested without an engine extension.

The following nomenclature is used:

BPR	-	Bypass ratio, fan flowrate divided by primary flowrate
C_a	-	Speed of sound in the test chamber, ft/sec.
F_n	-	Full scale JT8D engine thrust on an FAA day, lbs
P_a	-	Static pressure in the test chamber,
P_t/P_a	-	Nozzle pressure ratio, nozzle total pressure divided by test chamber ambient pressure
RH_a	-	Relative humidity in the test chamber
T_a	-	Temperature in the test chamber, °F
T_t	-	Nozzle total temperature, °R
V	-	Jet velocity; ideally expanded to test chamber pressure, ft/sec.
V/C_a	-	Ratio of jet velocity to test chamber speed of sound
W	-	Flowrate, lbm/sec
Primary	-	Primary or inner exhaust stream
Fan	-	Fan or outer exhaust stream
Ideal Mix	-	The mass flow average value, e.g., $Vmix = \frac{W_{pri} V_{pri} + W_{fan} V_{fan}}{W_{pri} + W_{fan}}$

The full scale JT8D engine thrust, F_n, was determined as follows:

A. Reference System: The V_{pri}/C_a of each test point was related to the FAA day JT8D engine thrust by the curve of V_{pri}/C_a vs. F_n, Figure A1, developed from full scale engine test data*. Since for low bypass exhausts the jet noise is essentially independent of small variations in the secondary flow conditions, this procedure allows the model data to be scaled using primary velocity to predict the full size engine noise.

B. Mixer Nozzles: The V_{mix}/C_a of each test point was related to the FAA day JT8D engine thrust by the V_{mix}/C_a vs. F_n curve of Figure A-1, which was determined by calculating the V_{mix}/C_a for the engine operating line conditions by the formula defined in the no nenclature listed above*. For exhausts with internal mixer nozzles, the jet noise is a function of the calculated mixed velocity. This procedure allows small variations in bypass ratio and the resultant effect on mixed velocity to be accounted for correctly, thus, allowing the mixer nozzle data to be scaled properly to predict the effect of a mixer on JT8D engine noise.

The above procedure for relating JT8D engine noise with thrust is based on observations that jet noise is a direct function of the characteristic jet velocity divided by the ambient (test chamber) speed of sound, as shown in ref. 2. Since the model nozzles were tested at pressure, temperature, and density conditions simulating the JT8D engine, density effects on noise could be neglected.

*For these calculations, it was assumed that the installation of a mixer on the JT8D engine would not change the engine thrust-airflow relationship established for the baseline configuration.

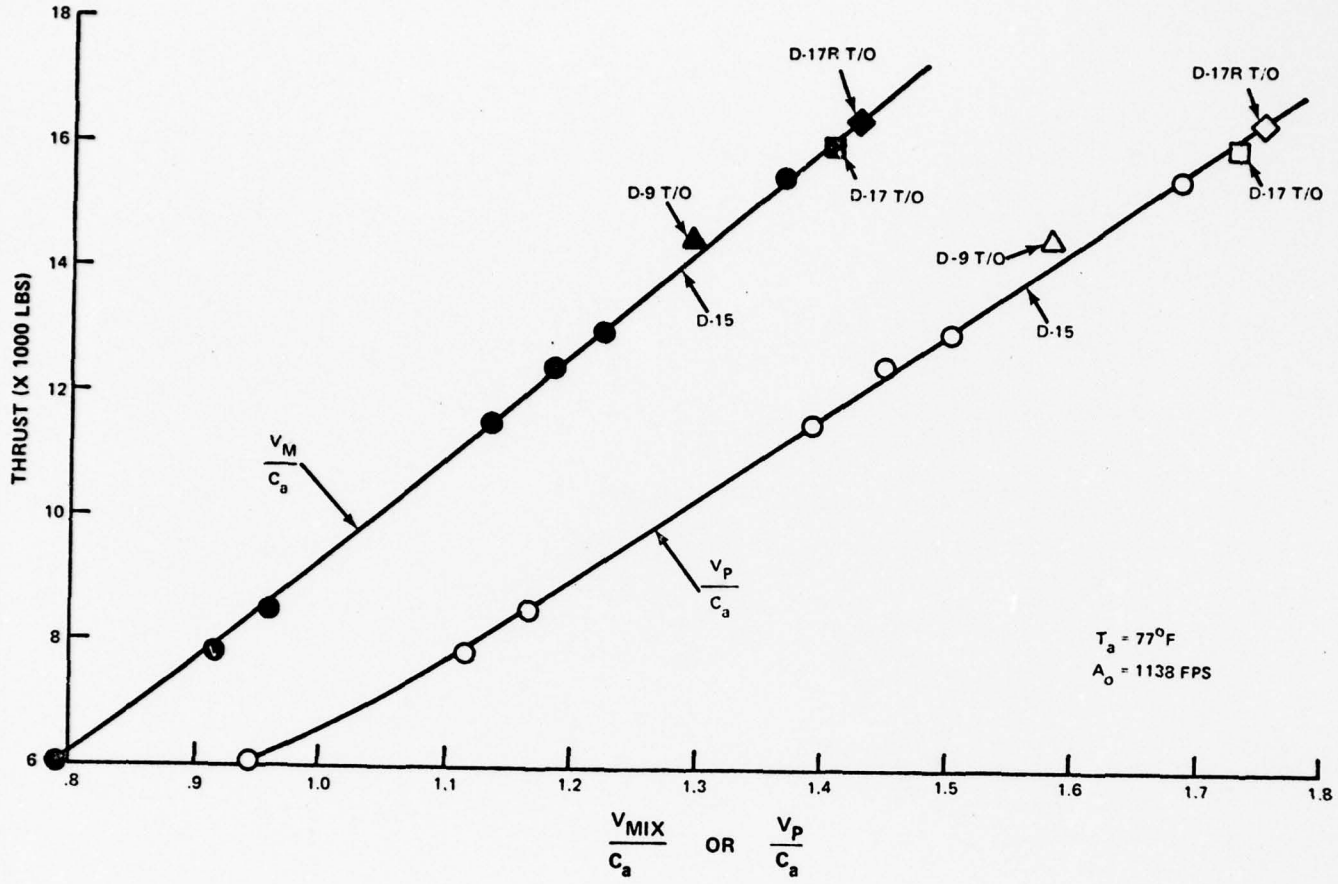


Figure A.1 Thrust vs $V/_{Ca}$ for Reference and Mixed JT8D-15

TABLE 1A

BASIC LONG FLOWPATH MIXER; WITHOUT ENGINE SECONDARY FLOW SIMULATION; CONFIGURATION 1A

Condition Number	Primary $\frac{P_T}{P_a}$	Primary T_T (°R)	Primary V (FPS)	Primary W (lb/sec)	Fan $\frac{P_T}{P_a}$	Fan T_T (°R)	Fan V (FPS)	Fan W (lb/sec)	BPR	Ideal Mix $T_{T\,mix}$ (°R)	Ideal Mix V_{mix} (FPS)	$\frac{V_{mix}}{C_a}$	Test Chamber T_a (°F)	Test Chamber P_a (PSI)	Test Chamber RH_a	F_n (lb)
5310	2.153	1616.7	1969.	3.109	2.009	710.6	1243.0	3.423	1.101	1,141.9	1,588.5	1.43	52	14.8	30	16500
5309	2.135	1606.7	1947.	3.081	1.995	700.8	1228.0	3.425	1.112	1,129.1	1,567.9	1.41	52	14.8	30	16150
5308*	2.080	1569.7	1808.	3.005	1.963	690.0	1206.0	3.433	1.143	1,100.5	1,528.9	1.38	52	14.8	31	15650
5306	1.858	1462.2	1694.	2.715	1.789	676.5	1119.0	3.225	1.188	1,035.6	1,381.8	1.24	53	14.8	29	13250
5305*	1.798	1434.3	1635.	2.622	1.741	667.4	1087.0	3.153	1.203	1,015.3	1,338.8	1.20	53	14.8	28	12600
5304	1.696	1410.4	1546.	2.345	1.740	653.8	1069.0	3.390	1.445	963.2	1,264.1	1.14	51	14.8	28	11550
5303	1.527	1316.8	1347.	2.203	1.483	625.9	897.0	2.646	1.201	939.8	1,101.5	1.99	52	14.8	27	9000
5302	1.504	1249.9	1288.	2.218	1.446	622.6	863.0	2.557	1.153	914.0	1,060.4	.96	53	14.8	26	8500
5301	1.390	1239.3	1158.	1.905	1.368	616.0	798.0	2.402	1.261	891.7	957.2	.86	51	14.8	26	6900

TABLE $2A_u$

REFERENCE EXHAUST SYSTEM WITHOUT ENGINE SECONDARY FLOW SIMULATION; CONFIGURATION $2A_u$

Condition Number	Primary $\frac{P_T}{P_a}$	Primary T_T (°R)	Primary V (FPS)	Primary W (lb/sec)	Fan $\frac{P_T}{P_a}$	Fan T_T (°R)	Fan V (FPS)	Fan W (lb/sec)	BPR	Ideal Mix $T_{T\,mix}$ (°R)	Ideal Mix Vmix (FPS)	$\frac{V_{pri.}}{C_a}$	Test Chamber T_a (°F)	Test Chamber P_a (PSI)	Test Chamber RH_a	F_n (lb)
5510	2.150	1607.7	1958	3.530	2.012	700.4	1234	3.042	.862	1187.7	1623	1.76	53	14.7	61	16500
5509	2.113	1600.2	1935	3.472	1.985	697.7	1221	3.036	.874	1179.3	1602	1.74	53	14.7	60	16250
5508*	2.057	1573.7	1886	3.339	1.915	687.8	1184	3.086	.924	1148.2	1549	1.70	54	14.7	60	15700
5507	1.993	1524.2	1819	3.290	1.806	681.1	1169	3.027	.920	1120.2	1508	1.64	53	14.7	59	14900
5506	1.862	1464.2	1700	3.058	1.790	673.9	1115	2.922	.956	1077.9	1414	1.53	53	14.7	59	13400
5505*	1.807	1435.8	1644	2.934	1.755	664.5	1089	2.960	1.009	1048.4	1365	1.48	53	14.7	58	12700
5504	1.743	1405.2	1580	2.829	1.694	647.1	1043	2.864	1.012	1023.9	1310	1.42	55	14.7	55	11900
5503	1.486	1314.6	1301	2.157	1.516	628.7	919	2.768	1.283	929.1	1086	1.17	53	14.7	62	8550
5502	1.434	1314.0	1240	2.041	1.464	617.1	872	2.653	1.300	920.1	1032	1.12	50	14.7	68	7850
5501	1.313	1265.4	1068	1.709	1.350	599.2	768	2.393	1.400	876.8	893	.96	50	14.7	68	6200

TABLE $2A_m$

REFERENCE EXHAUST SYSTEM (TESTED AT IDEALLY MIXED CONDITIONS); WITHOUT ENGINE SECONDARY FLOW SIMULATION; CONFIGURATION 2Am

Condition Number	Primary P_T/P_a	Primary T_T (°R)	Primary V (FPS)	Primary W (lb/sec)	Fan P_T/P_a	Fan T_T (°R)	Fan V (FPS)	Fan W (lb/sec)	BPR	Ideal Mix $T_{T\,mix}$ (°R)	Ideal Mix V_{mix} (FPS)	V_{mix}/C_a	Test Chamber T_a (°F)	Test Chamber P_a (PSI)	Test Chamber RH_a	F_n (lb)
7409	2.060	1156.9	1608.7	3.423	2.077	1166.8	1624.1	2.921	0.853	1161.5	1615.8	1.45	60	14.3	36	16800
7408*	2.020	1154.8	1587.0	3.370	2.036	1154.2	1595.0	2.877	0.854	1154.5	1590.7	1.42	60	14.3	35	16300
7407	1.982	1126.9	1547.6	3.367	1.983	1131.4	1551.8	2.802	0.832	1128.9	1549.5	1.39	60	14.4	34	15800
7406	1.858	1091.0	1463.2	3.156	1.881	1090.8	1476.4	2.752	0.874	1090.9	1469.4	1.32	52	14.4	70	14600
7405*	1.792	1038.7	1388.6	3.138	1.796	1035.4	1388.9	2.640	0.841	1037.2	1388.7	1.27	41	14.4	71	13800
7404	1.742	1020.0	1345.7	3.029	1.763	1016.4	1356.5	2.658	0.878	1018.3	1350.7	1.23	41	14.4	70	13100
7403	1.667	982.1	1269.4	2.915	1.689	993.9	1291.8	2.547	0.874	987.6	1279.8	1.17	41	14.4	69	12100
7402	1.487	925.8	1095.2	2.567	1494	917.6	1096.6	2.220	0.886	922.0	1095.8	1.00	41	14.4	67	9200
7401	1.436	900.2	1034.4	2.447	1.446	901.2	1044.2	2.148	0.878	900.7	1039.0	.95	42	14.4	63	8300

TABLE 3A

SHALLOW SCALLOPED LONG FLOWPATH MIXER; WITHOUT ENGINE SECONDARY FLOW SIMULATION; CONFIGURATION 3A

Condition Number	Primary P_T/P_a	Primary T_T (°R)	Primary V (FPS)	Primary W (lb/sec)	Fan P_T/P_a	Fan T_T (°R)	Fan V (FPS)	Fan W (lb/sec)	BPR	Ideal Mix $T_{T\,mix}$ (°R)	Ideal Mix V_{mix} (FPS)	V_{mix}/C_a	Test Chamber T_a (°F)	Test Chamber P_a (PSI)	Test Chamber RH_a	F_n (lb)
5711	2.133	1617.2	1957	3.144	2.014	705.5	1241	3.291	1.047	1150.9	1591	1.44	45	14.6	44	16650
5710	2.109	1610.2	1940	3.069	1.997	699.4	1229	3.278	1.068	1139.8	1573	1.43	45	14.6	44	16500
5709*	2.037	1575.2	1877	2.966	1.946	686.2	1196	3.232	1.090	1111.6	1523	1.38	46	14.6	43	15600
5708	1.962	1530.2	1804	2.943	1.900	678.5	1170	3.219	1.094	1085.2	1478	1.34	46	14.6	41	15000
5707	1.887	1473.2	1722	2.794	1.818	680.9	1134	3.131	1.121	1054.5	1411	1.28	46	14.6	40	13950
5706*	1.784	1444.2	1634	2.594	1.744	665.4	1085	3.027	1.167	1024.8	1338	1.21	46	14.6	40	12750
5705	1.719	1432.2	1578	2.502	1.693	647.0	1042	2.999	1.199	1004.1	1286	1.17	46	14.6	39	12100
5704	1.477	1321.2	1297.	2.024	1.524	635.2	931	2.790	1.379	923.6	1085	.98	46	14.6	37	8850
5703	1.422	1304.2	1227.	2.136	1.473	622.9	885	2.664	1.247	926.1	1837	.94	47	14.6	36	8200
5712	1.305	1250.7	1052	1.536	1.356	609.7	782	2.346	1.529	863.2	889	.81	43	14.6	47	6200

TABLE 4A

DEEP SCALLOPED LONG FLOWPATH MIXER; WITHOUT ENGINE SECONDARY FLOW SIMULATION; CONFIGURATION 4A

Condition	Primary				Fan				BPR	Ideal Mix			Test Chamber			Fn
Number	P_T/Pa	T_T (°R)	V (FPS)	W (lb/sec)	P_T/Pa	T_T (°R)	V (FPS)	W (lb/sec)		$T_{T\,mix}$ (°R)	V_{mix} (FPS)	V_{mix}/C_a	T_a (°F)	P_a (PSI)	RH_a	(lb)
6120	2.145	1605.7	1957	3.239	2.001	697.7	1230	3.104	0.958	1161.4	1601.3	1.45	47	14.5	64	16800
6119	2.122	1605.7	1944	3.203	1.982	694.8	1219	3.072	0.959	1159.8	1589.1	1.44	47	14.5	63	16650
6118*	2.085	1561.7	1896	3.158	1.963	696.5	1213	3.095	0.980	1133.5	1557.9	1.41	47	14.5	62	16100
6117	1.986	1516.7	1812	3.031	1.885	681.3	1167	3.044	1.004	1098.2	1488.9	1.35	47	14.5	62	15100
6116	1.863	1466.7	1700	2.826	1.792	668.3	1111	2.952	1.044	1058.9	1399.2	1.27	47	14.5	63	13800
6115*	1.800	1436.7	1640	2.838	1.755	664.8	1089	2.909	1.025	1046.0	1361.1	1.23	47	14.5	63	13100
6114	1.747	1454.6	1612	2.586	1.711	647.7	1053	2.891	1.118	1028.7	1316.9	1.19	48	14.5	64	12400
6113	1.486	1319.8	1303	2.075	1.513	616.2	908	2.658	1.281	924.7	1081.2	0.98	48	14.5	65	8850
6112	1.451	1296.9	1256	2.038	1.472	617.1	880	2.547	1.256	918.4	1046.7	0.95	48	14.5	67	8350
6111	1.314	1258.6	1065	1.649	1.366	613.8	791	2.334	1.415	880.8	904.5	0.82	48	14.5	66	6350

TABLE 5A

CUTBACK SCALLOPED LONG FLOWPATH MIXER; WITHOUT ENGINE SECONDARY FLOW SIMULATION; CONFIGURATION 5A

Condition	Prima y				Fan				BPR	Ideal Mix			Test Chamber			Fn
Number	P_T/Pa	T_T (°R)	V (FPS)	W (lb/sec)	P_T/Pa	T_T (°R)	V (FPS)	W (lb/sec)		$T_{T\,mix}$ (°R)	V_{mix} (FPS)	V_{mix}/C_a	T_a (°F)	P_a (PSI)	RH_a	(lb)
6510	2.140	1616.7	1960	3.282	2.018	694.2	1232	3.231	0.984	1159.2	1598.9	1.44	51	14.9	18	16650
6509	2.136	1608.7	1953	3.266	2.023	701.6	1241	3.270	1.001	1154.9	1596.8	1.44	51	15.0	18	16650
6508*	2.067	1557.7	1884	3.210	1.961	689.6	1206	3.210	1.000	1123.7	1545.0	1.39	51	15.0	17	15800
6507	1.976	1524.7	1812	3.080	1.878	675.9	1159	3.121	1.013	1097.6	1483.4	1.34	51	15.0	17	14950
6506	1.872	1480.7	1716	2.829	1.801	664.0	1112	3.033	1.041	1064.1	1407.9	1.30	29	14.9	18	14750
6505*	1.806	1433.9	1644	2.714	1.756	657.8	1085	2.996	1.059	1034.7	1356.5	1.25	29	14.9	18	13400
6504	1.739	1408.1	1578	3.714	1.695	650.7	1046	2.904	1.070	1016.6	1303.0	1.20	29	14.9	18	12600
6503	1.485	1318.5	1301	2.135	1.517	625.7	918	2.717	1.273	930.5	1086.5	1.00	32	14.9	17	9200
6502	1.440	1291.4	1241	2.043	1.471	619.4	882	2.618	1.282	913.9	1039.3	0.96	32	14.9	16	8500
6501	1.310	1270.6	1067	1.701	1.361	603.0	782	2.396	1.405	880.2	900.4	0.83	34	14.9	16	6500

TABLE 6A

CUTBACK NON-SCALLOPED LONG FLOWPATH MIXER; WITHOUT SECONDARY FLOW SIMULATION; CONFIGURATION 6A

Condition Number	Primary P_T/Pa	Primary T_T (°R)	Primary V (FPS)	Primary W (lb/sec)	Fan P_T/Pa	Fan T_T (°R)	Fan V (FPS)	Fan W (lb/sec)	BPR	Ideal Mix $T_{T\,mix}$ (°R)	Ideal Mix V_{mix} (FPS)	V_{mix}/C_a	Test Chamber T_a (°F)	Test Chamber P_a (PSI)	Test Chamber RH_a	Fn (lb)
6310	2.142	1617.7	1964	3.269	1.999	697.2	1230	3.197	0.978	1162.6	1601.1	1.46	39	14.9	22	17000
6309	2.130	1604.7	1944	3.257	1.997	698.0	1229	3.215	0.987	1154.3	1588.8	1.45	38	14.9	22	16800
6308*	2.073	1570.7	1888	3.163	1.965	691.9	1207	3.226	1.020	1126.9	1544.1	1.41	39	14.9	22	16100
6307	1.975	1477.7	1781	3.061	1.870	678.1	1157	3.084	1.007	1076.5	1467.9	1.34	39	14.9	21	15000
6306	1.858	1466.7	1694	2.830	1.791	668.1	1112	3.045	1.076	1052.8	1392.3	1.27	39	14.9	21	13800
6305*	1.797	1426.3	1634	2.762	1.754	662.8	1085	3.042	1.102	1026.0	1346.2	1.23	39	14.9	21	13100
6304	1.743	1419.1	1588	2.658	1.708	649.6	1052	2.979	1.121	1012.4	1304.7	1.19	39	14.9	21	12400
6303	1.483	1333.7	1307	2.084	1.521	624.0	917	2.766	1.327	929.0	1084.6	0.99	39	14.9	21	9000
6302	1.441	1308.7	1251	2.032	1.464	619.4	877	2.592	1.276	922.3	1041.3	0.95	39	14.9	21	8350
6301	1.314	1264.2	1067	1.688	1.360	601.6	778	2.408	1.426	874.7	897.1	0.82	39	14.9	20	6350

TABLE 7A

DEEP SCALLOPED LONG FLOWPATH MIXER; WITH ENGINE SECONDARY FLOW SIMULATION; CONFIGURATION 7A

Condition Number	Primary P_T/Pa	Primary T_T (°R)	Primary V (FPS)	Primary W (lb/sec)	Fan P_T/Pa	Fan T_T (°R)	Fan V (FPS)	Fan W (lb/sec)	BPR	Ideal Mix V_{mix} (FPS)	V_{mix}/C_a	Test Chamber T_a (°F)	Test Chamber P_a (PSI)	Test Chamber RH_a	Fn (lb)
7510	2.118	1629.4	1950.3	3.172	2.000	697.5	1224.4	3.063	0.966	1593.6	1.44	49	14.5	20	16650
7509	2.136	1661.4	1980.3	3.141	1.991	691.0	1215.0	3.068	0.976	1602.3	1.45	46	14.5	19	16800
7508*	2.069	1546.7	1872.0	3.052	1.958	682.7	1193.9	3.093	1.013	1530.8	1.42	25	14.5	18	16300
7507	1.979	1518.4	1804.5	3.097	1.892	687.7	1172.1	2.932	0.947	1496.9	1.39	20	14.5	18	15800
7506	1.859	1460.0	1691.8	2.789	1.773	678.9	1108.3	2.835	1.016	1397.7	1.30	19	14.5	18	14250
7505	1.797	1438.5	1635.7	2.660	1.745	664.8	1081.9	2.874	1.080	1348.2	1.26	19	14.6	17	13600
7504	1.740	1424.0	1585.3	2.554	1.701	656.9	1052.7	2.806	1.098	1306.4	1.22	19	14.6	17	12900
7503	1.471	1324.4	1290.4	1.994	1.542	627.8	935.9	2.725	1.367	1085.7	1.01	18	14.6	17	9350
7502	1.447	1290.1	1264.9	1.980	1.492	620.5	908.3	2.628	1.327	1061.5	0.97	35	14.7	25	8700
7501	1.310	1275.1	1086.4	1.609	1.372	599.0	800.1	2.361	1.467	916.2	0.84	35	14.7	24	6650

TABLE 8A

CUTBACK SCALLOPED LONG FLOWPATH MIXER; WITH 7.6" ENGINE EXTENSION; WITHOUT ENGINE SECONDARY FLOW SIMULATION; CONFIGURATION 8A

Condition	Primary				Fan				BPR	Ideal Mix			Test Chamber			Fn
Number	P_T / Pa	T_T (°R)	V (FPS)	W (lb/sec)	P_T / Pa	T_T (°R)	V (FPS)	W (lb/sec)		$T_{T\,mix}$ (°R)	V_{mix} (FPS)	V_{mix} / C_a	T_a (°F)	P_a (PSI)	RH_a	(lb)
7610	2.141	1598.4	1950.5	3.236	2.015	693.0	1230.3	3.054	0.944	1158.7	1600.8	1.45	46	14.5	28	16800
7609	2.133	1614.0	1955.4	3.215	1.994	696.5	1225.4	3.002	0.934	1170.9	1602.9	1.45	46	14.5	27	16800
7608	2.060	1558.4	1880.7	3.125	1.959	685.2	1201.3	3.012	0.964	1129.8	1547.2	1.40	46	14.5	25	16000
7607	1.980	1521.0	1809.8	3.037	1.889	678.4	1165.2	2.916	0.960	1108.3	1494.1	1.36	45	14.5	24	15300
7606	1.859	1466.3	1698.1	2.875	1.790	667.7	1108.6	2.782	0.968	1073.5	1408.1	1.28	43	14.5	22	13950
7605	1.788	1441.7	1634.9	2.771	1.742	660.3	1079.8	2.735	0.987	1053.6	1359.2	1.24	42	14.5	21	13250
7604	1.735	1404.3	1573.4	2.699	1.694	648.8	1044.4	2.673	0.990	1028.4	1310.2	1.19	42	14.5	20	12400
7602	1.435	1313.0	1246.8	2.105	1.468	620.3	880.3	2.238	1.063	956.1	1058.0	0.96	42	14.5	19	8500
7601	1.315	1273.1	1074.5	1.797	1.356	607.3	779.7	1.722	0.958	947.3	930.3	0.85	43	14.5	18	6750

TABLE 10A

SEVERE CUTBACK SHORT FLOWPATH MIXER; WITH ENGINE SECONDARY FLOW SIMULATION; CONFIGURATION 10A

Condition	Primary				Fan				BPR	Ideal Mix			Test Chamber			Fn
Number	P_T / Pa	T_T (°R)	V (FPS)	W (lb/sec)	P_T / Pa	T_T (°R)	V (FPS)	W (lb/sec)		$T_{T\,mix}$ (°R)	V_{mix} (FPS)	V_{mix} / C_a	T_a (°F)	P_a (PSI)	RH_a	(lb)
7810	2.144	1602.0	1952.3	3.235	2.008	699.0	1231.8	2.922	0.903	1173.5	1610.4	1.44	64	14.5	21	16650
7809	2.123	1600.7	1940.8	3.206	1.982	697.4	1220.5	2.883	0.899	1173.1	1599.8	1.43	64	14.5	21	16500
7808*	2.059	1567.7	1884.5	3.108	1.948	687.1	1197.2	2.916	0.938	1141.5	1551.8	1.38	64	14.5	21	15600
7807	1.995	1519.7	1817.2	3.031	1.880	677.1	1158.9	2.843	0.938	1111.9	1498.6	1.34	63	14.5	21	15000
7806	1.860	1463.3	1697.8	2.837	1.776	667.0	1101.7	2.729	0.962	1072.9	1405.5	1.25	63	14.5	21	13400
7805*	1.798	1429.9	1635.1	2.725	1.748	657.5	1080.4	2.765	1.014	1041.0	1355.8	1.21	63	14.5	21	12750
7804	1.734	1398.7	1569.0	2.608	1.693	647.9	1042.7	2.714	7.041	1015.8	1300.6	1.16	63	14.5	21	11900
7803	1.486	1323.7	1306.0	2.084	1.509	631.1	916.6	2.474	1.187	947.8	1094.7	0.97	65	14.5	20	8700
7802	1.430	1290.1	1230.1	1.982	1.451	616.3	865.2	2.358	1.189	924.1	1031.9	0.92	65	14.5	20	7850
7801	1.309	1244.1	1052.9	1.633	1.357	596.9	773.5	2.221	1.360	871.1	891.9	0.79	65	14.5	20	6000

TABLE 11A

SEVERE CUTBACK SHORT FLOWPATH MIXER; WITHOUT ENGINE SECONDARY FLOW SIMULATION; CONFIGURATION 11A

Condition	Primary				Fan				BPR	Ideal Mix			Test Chamber			Fn
Number	P_T Pa	T_T (°R)	V (FPS)	W (lb/sec)	P_T Pa	T_T (°R)	V (FPS)	W (lb/sec)		$T_{T\,mix}$ (°R)	V_{mix} (FPS)	V_{mix} C_a	T_a (°F)	P_a (PSI)	RH_a	(lb)
7910	2.151	1622.0	1968.6	3.424	2.010	704.0	1237.0	2.864	0.836	1204.0	1635.5	1.46	62	14.6	18	17000
7909	2.137	1631.0	1966.6	3.356	1.999	704.1	1232.7	2.851	0.850	1205.1	1629.4	1.46	61	14.6	18	17000
7908*	2.070	1571.0	1893.3	3.272	1.974	692.3	1213.4	2.929	0.895	1156.0	1572.2	1.41	59	14.6	18	16100
7907	1.989	1529.4	1821.8	3.165	1.898	683.3	1174.0	2.841	0.898	1129.1	1515.3	1.36	58	14.6	18	15300
7906	1.861	1471.4	1705.8	2.921	1.794	669.3	1114.6	2.779	0.952	1080.2	1417.5	1.27	57	14.6	18	13800
7905	1.803	1443.0	1648.3	2.846	1.752	663.3	1088.7	2.728	0.958	1061.5	1374.5	1.23	56	14.6	19	13100

APPENDIX B

ACOUSTIC DATA, MEASURED MODEL AND SCALED TO JT8D ENGINE

This appendix contains the one-third octave band acoustic data obtained on the contract configurations. Two types of data are presented,

a.) Measured Model Data: The as-measured data were corrected for microphone and cable frequency response calibrations, and are presented for the microphone distance of 15 ft. used in the test. Since the test chamber is anechoic, the data are free-field and are not contaminated by sound wave reflections.

Atmospheric absorption corrections were used to analytically correct data from test chamber conditions to FAA day (77°F, 70% relative humidity). These corrections were obtained from the formulas of ref. (3). The SPL values from 100 to 80,000 Hz were integrated to provide Overall Sound Pressure Levels (OSPL) for each angle.

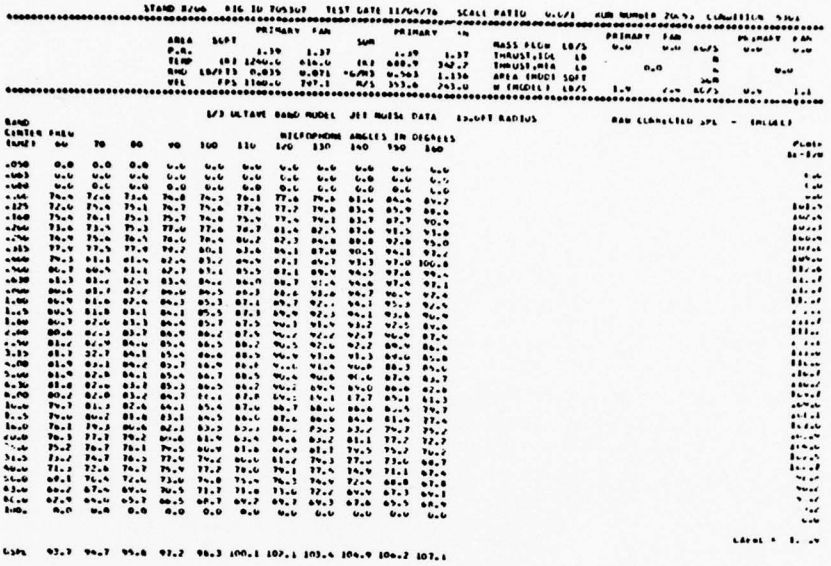
b.) Data Scaled To Predict Full Size JT8D Engine: In order to scale model data to predict full size engine noise, it is necessary first to eliminate the effects of atmospheric absorption on the measured noise spectra. This is done by determining the reduction of SPL levels due to the atmospheric absorption present during the model test, and adding these values to the measured levels, thus producing the true source noise spectra. Since the data were corrected to reflect the atmospheric absorption that would occur on an FAA day to present the model data on a consistent basis in step a.), the additional correction to obtain the true source spectra was added to the FAA day model data. Then the data were scaled to JT8D engine size (7 times linear model dimensions) by reducing the frequency values by a factor of 7.0 and by adding the factor 20 log(7) to the SPL level of each third-octave band. The scaled data then were extrapolated to 1200 ft. linear distance by subtracting $20 \log \frac{1200}{15 \sin\theta}$ to account for spherical divergence. Atmospheric attenuation corrections necessary to present the full scale data on an FAA day were applied per ref. 3. The Overall Sound Pressure Level (OASPL) and Perceived Noise Levels (PNL) for each angle are listed at the bottom of the SPL values for each angle. Also listed are the PNL values for 400, 2000, 4000, and 6000 foot linear distances.

The heading information at the top of the data sheets contains pertinent nozzle information in both U.S. customary units as well as the International System of Units (S.I.). However, a more complete listing of conditions is presented in Appendix A. The identification number for each data point is found in the top right hand corner of each data table listed after condition.

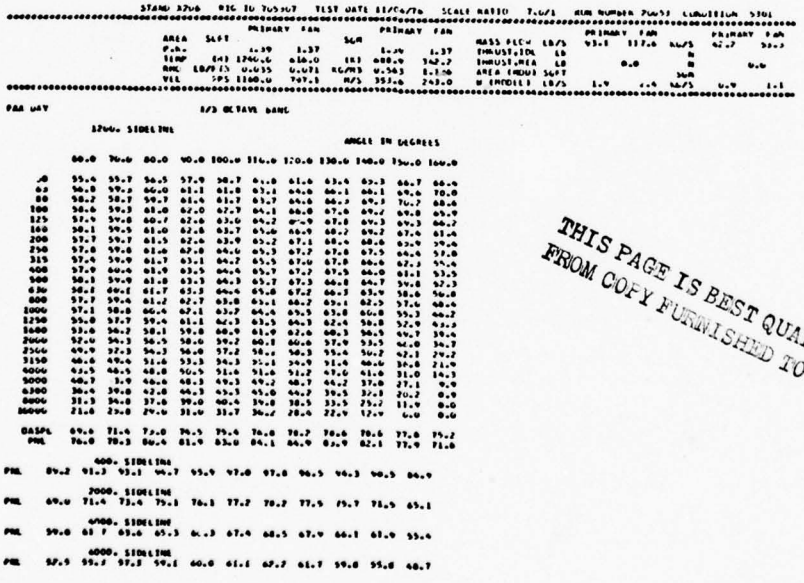
To facilitate use of the acoustic data, the sheets have been assembled by increasing condition numbers. Thus, to locate the data for a particular configuration and operating conditions, first find the condition number from the tables of Appendix A.

Basic Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 1A; Condition 5301

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled To Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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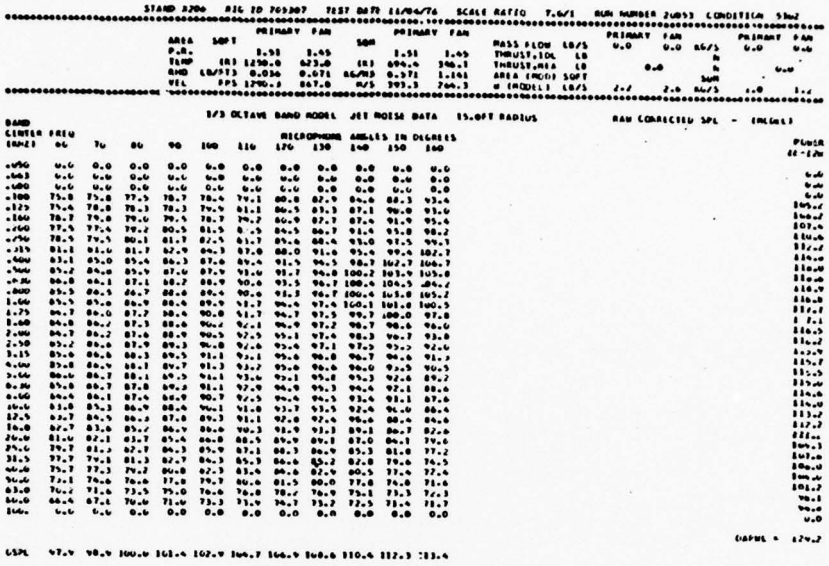
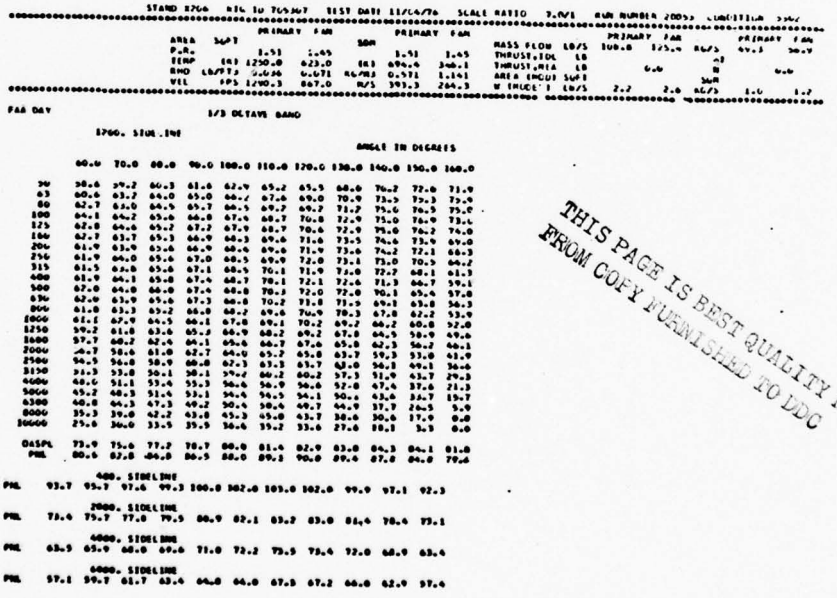
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Configuration 1A; Condition 5302

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled To Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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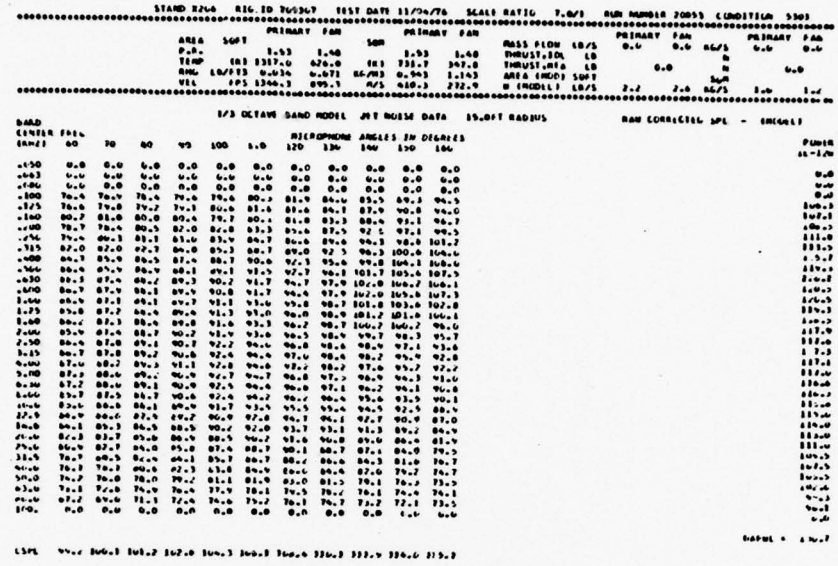
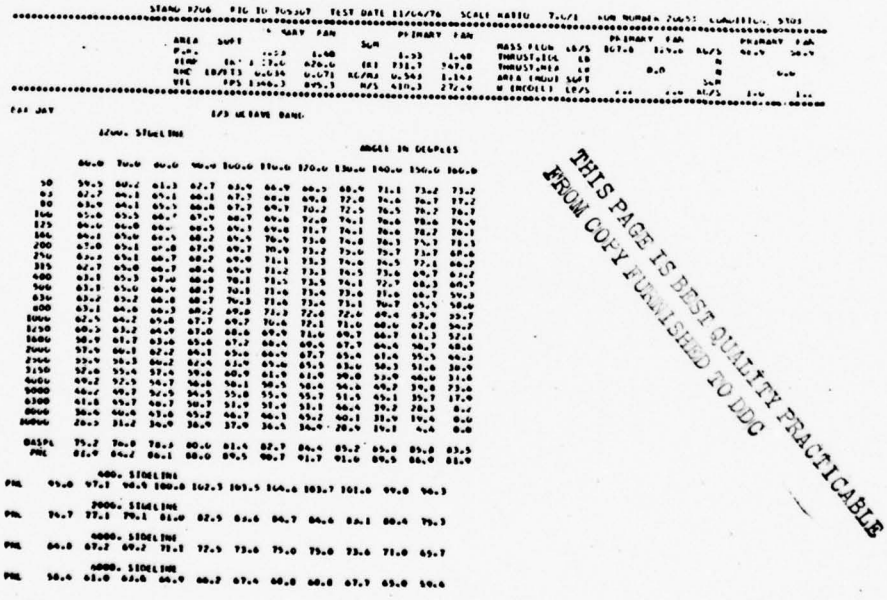
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Basic Lobed Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 1A; Condition 5303

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled To Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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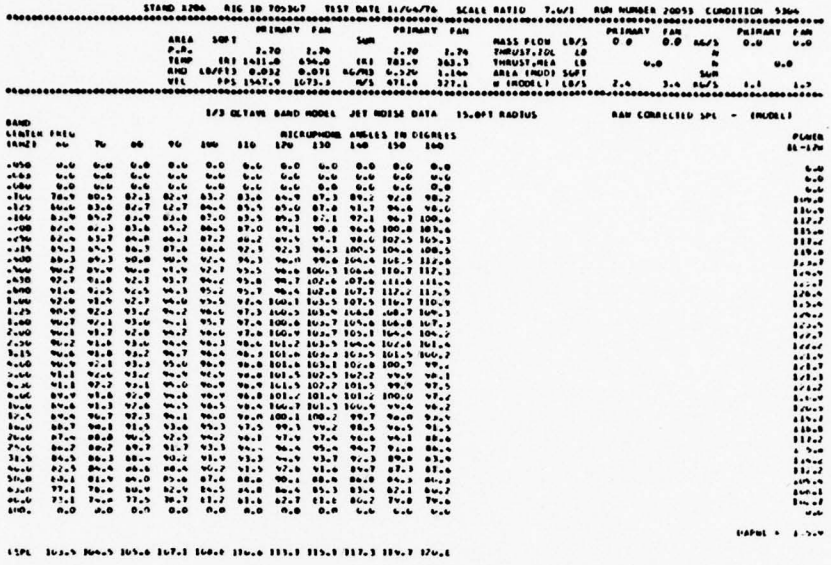
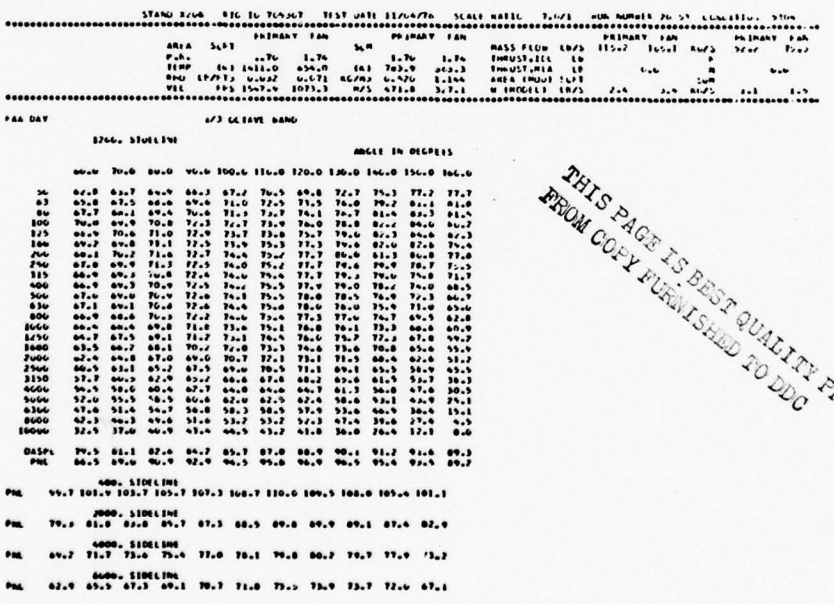
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Basic Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 1A; Condition 5304

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled To Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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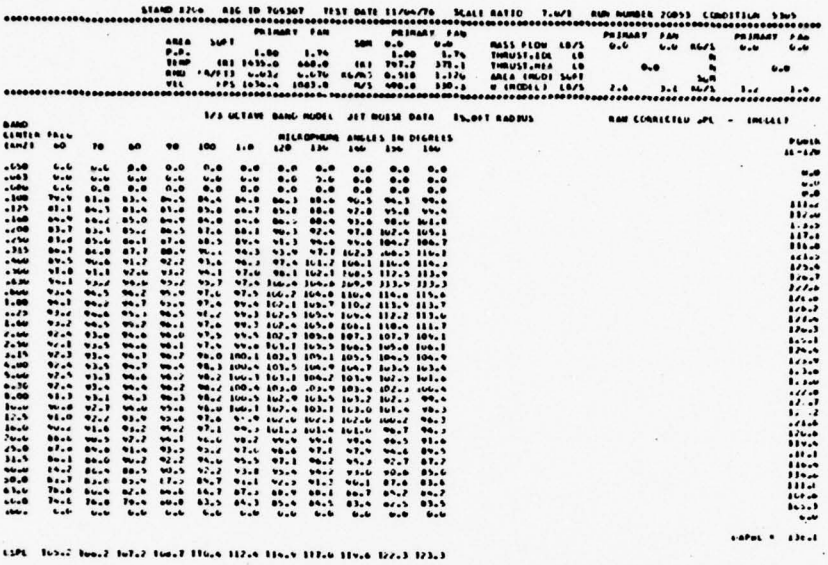
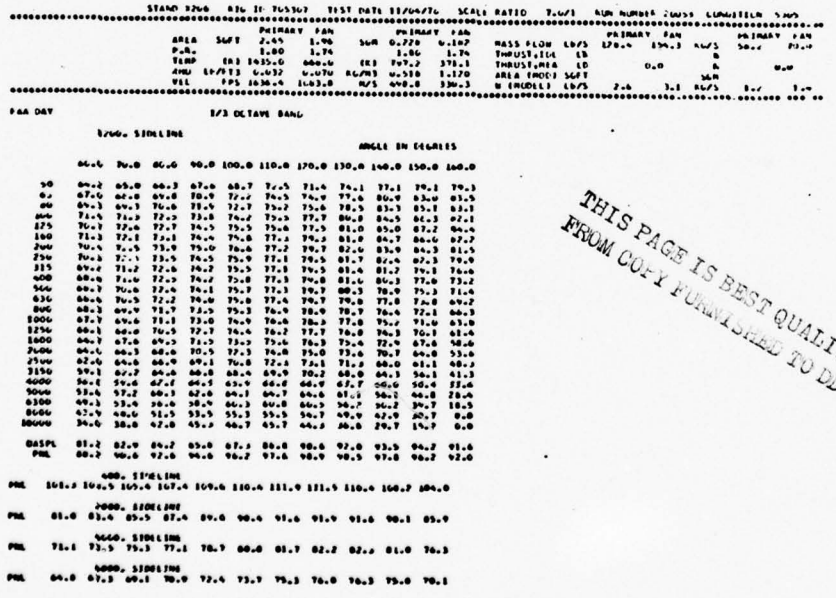
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Basic Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 1A; Condition 5305

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled To Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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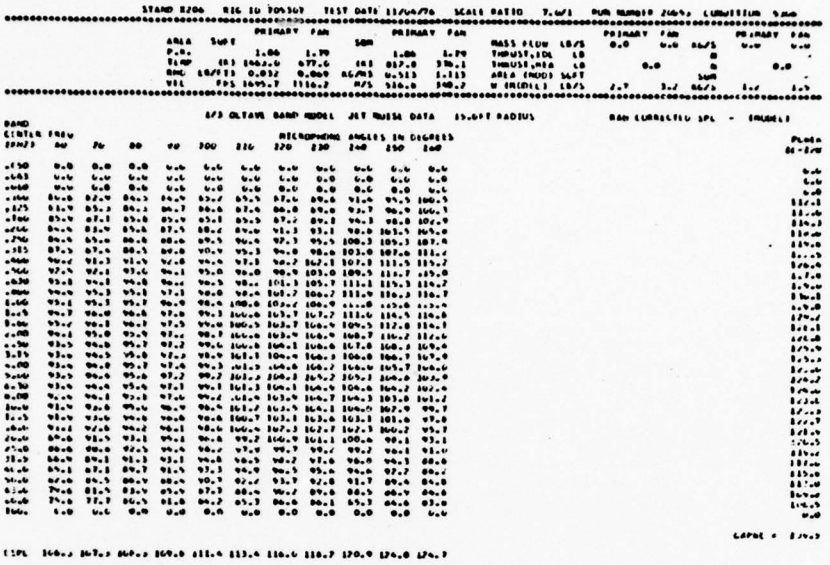
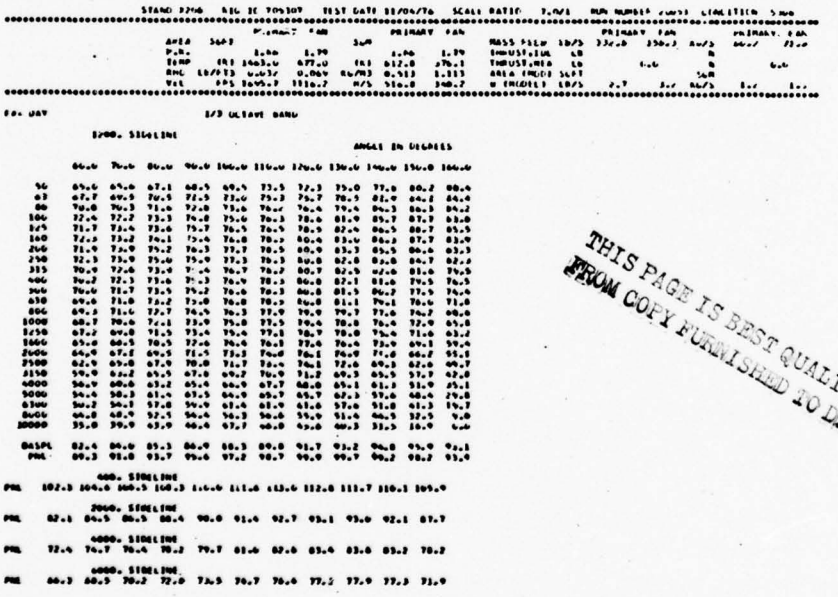
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Basic Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 1A; Condition 5306

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled To Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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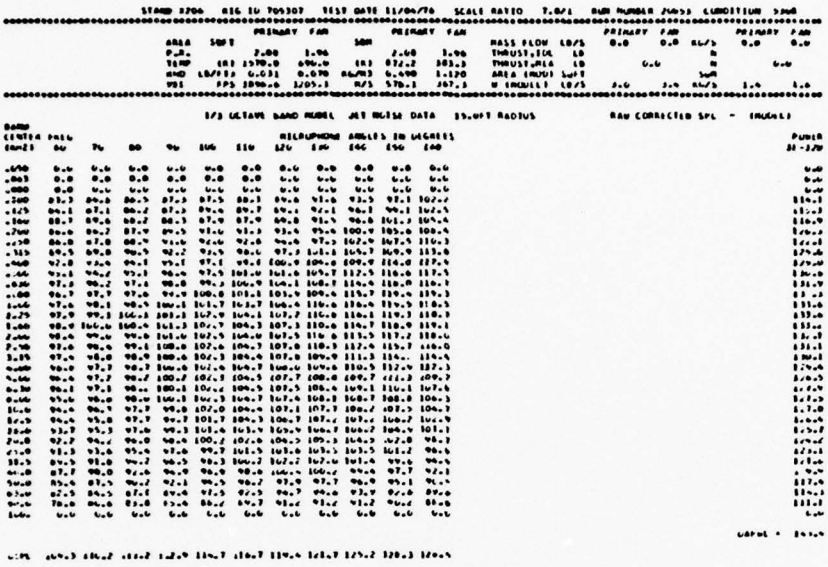
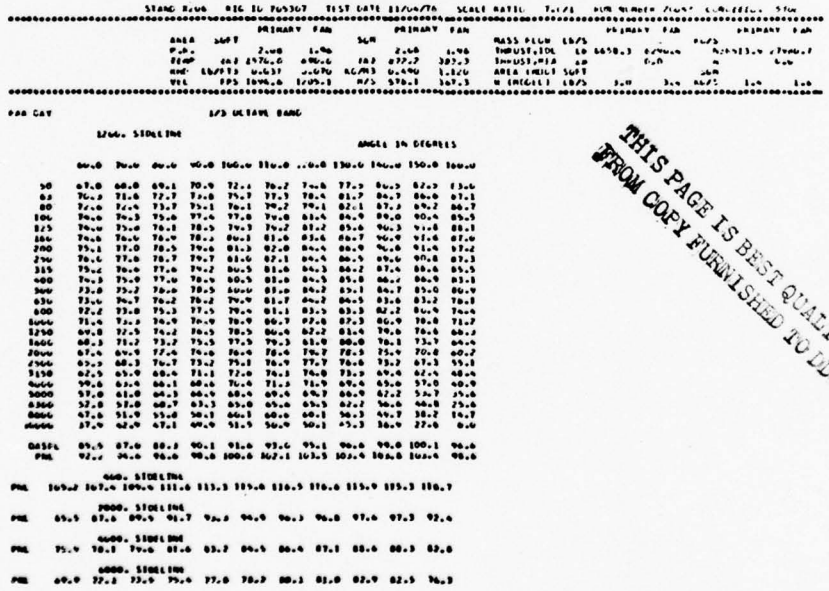
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Basic Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 1A; Condition 5308

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled To Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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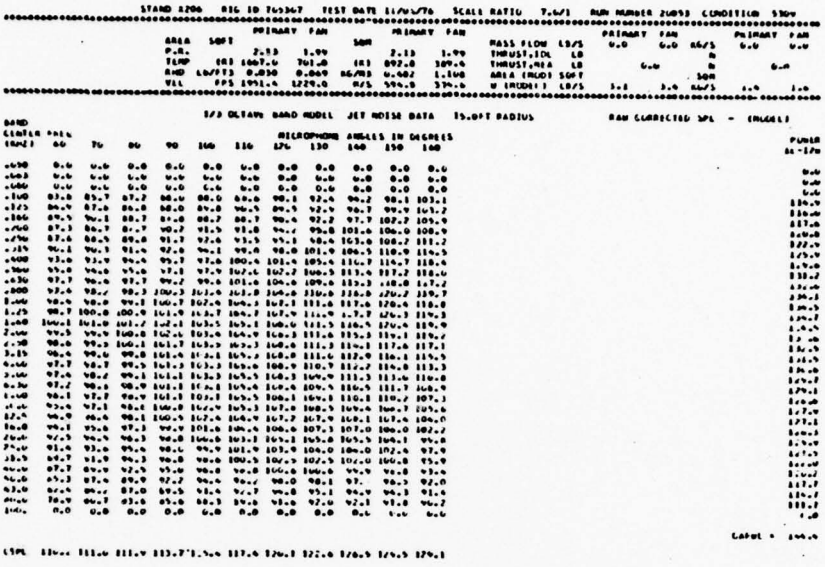
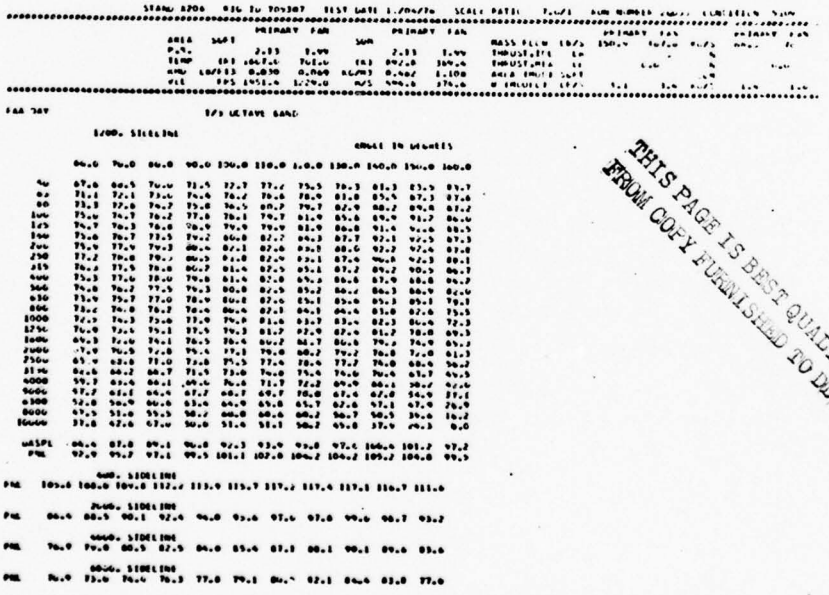
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Basic Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 1A; Condition 5309

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled To Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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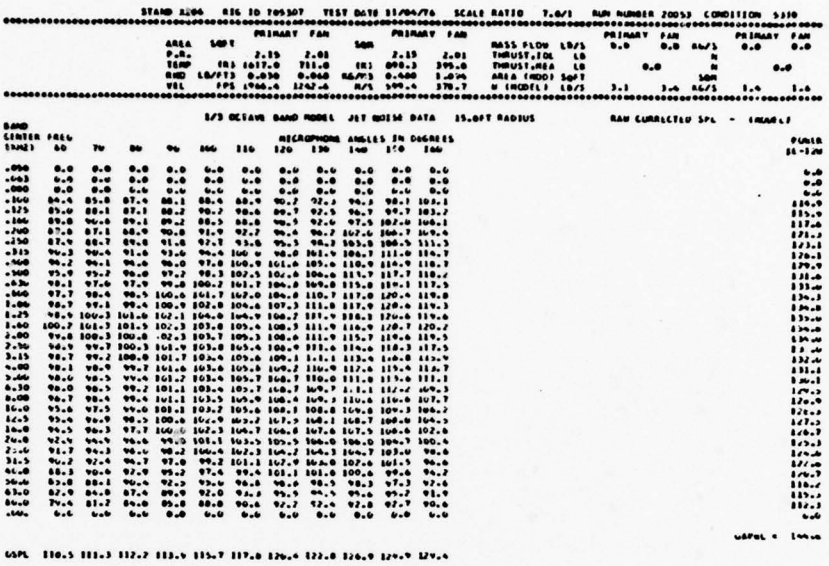
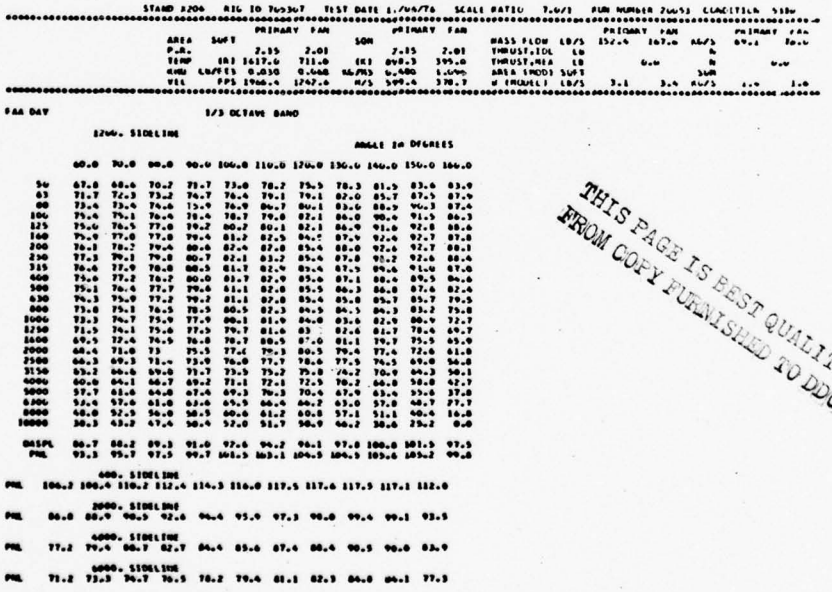
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Basic Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 1A; Condition 5310

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled To Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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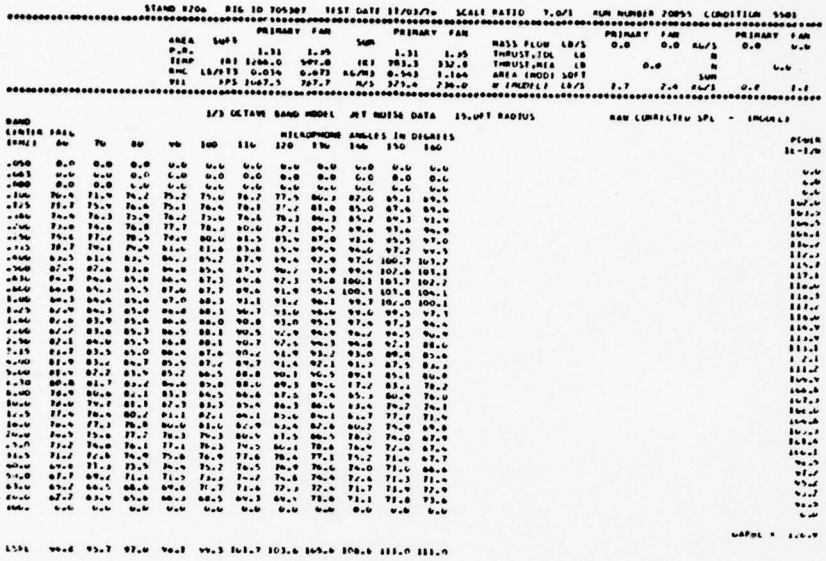
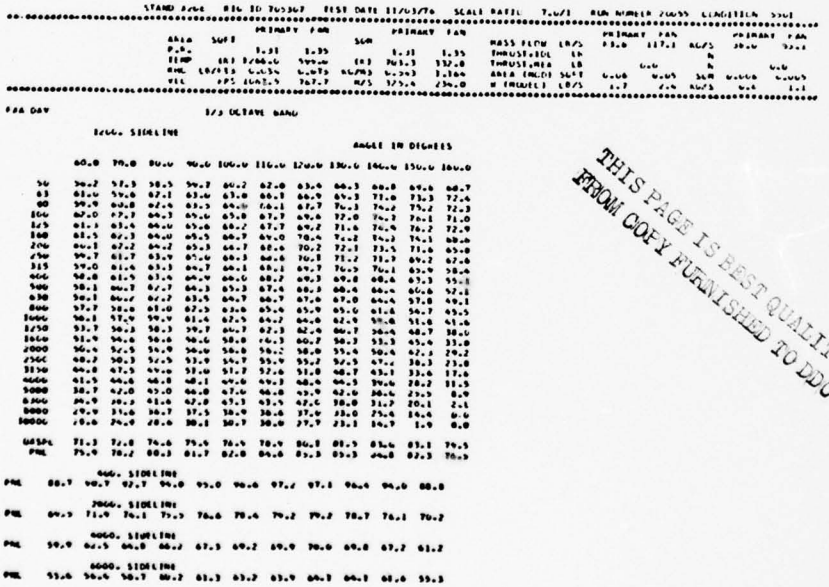
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Without Engine Secondary Flow Simulation; Configuration 2Au; Condition 5501

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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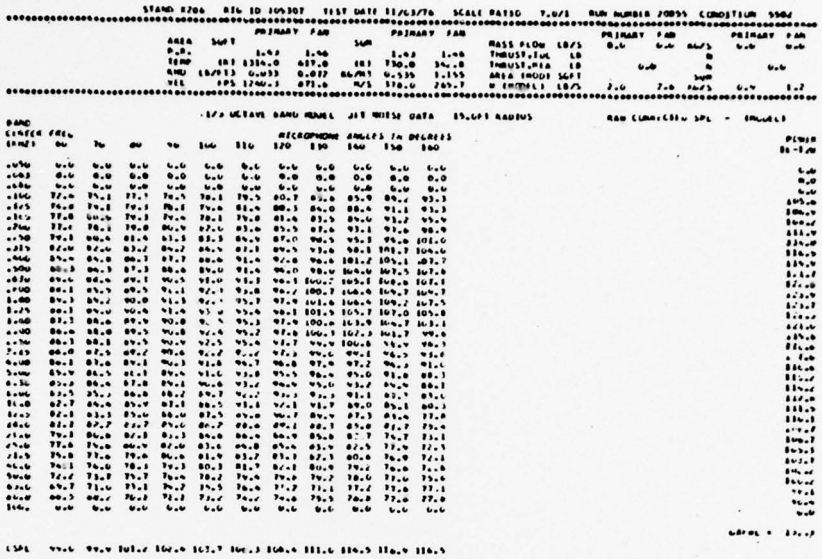
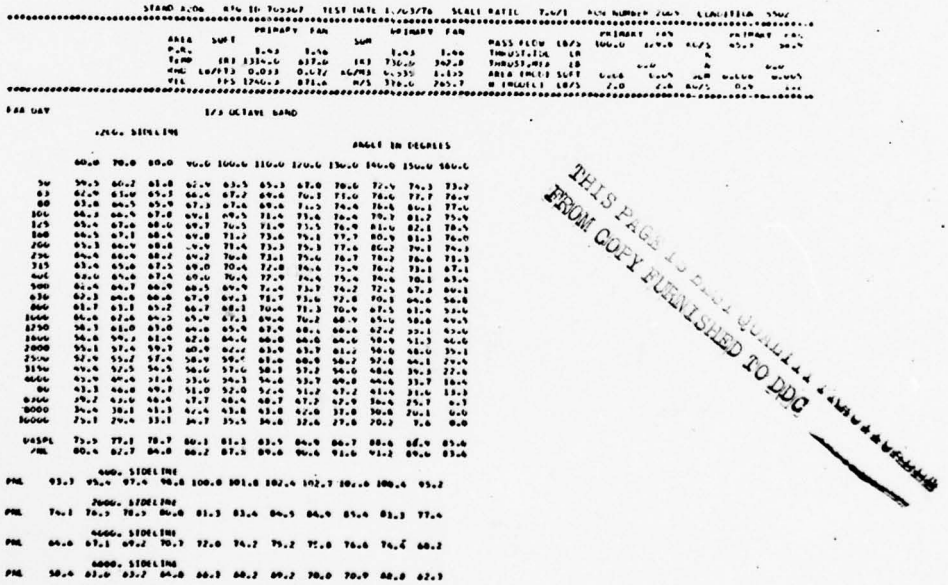
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Without Engine Secondary Flow Simulation; Configuration 2Au; Condition 5502

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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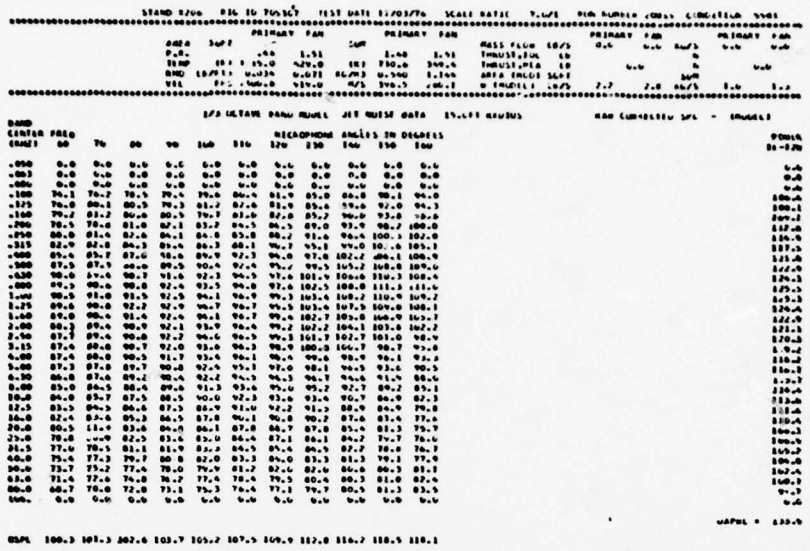
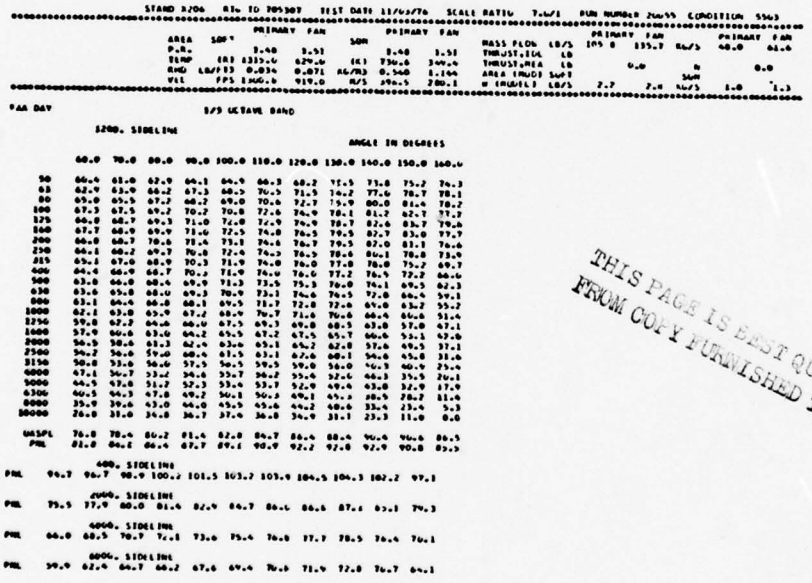
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Configuration 2Au; Condition 5503

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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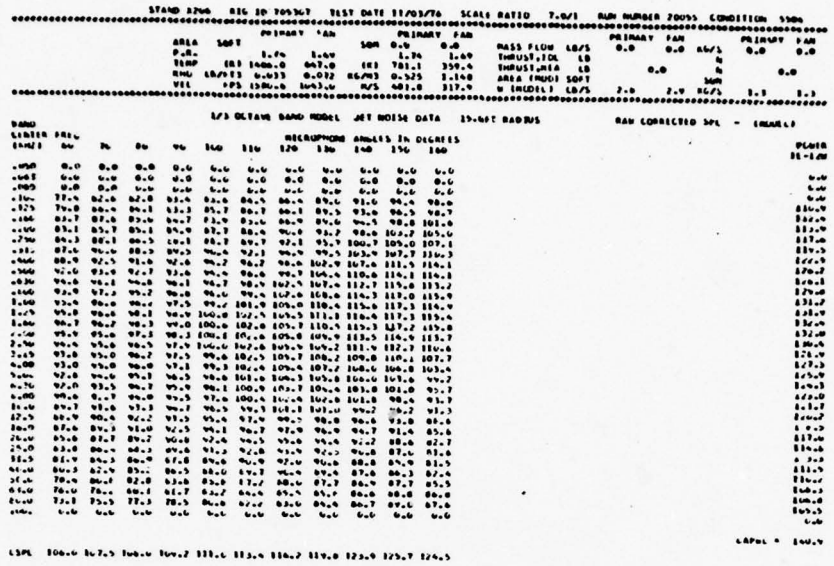
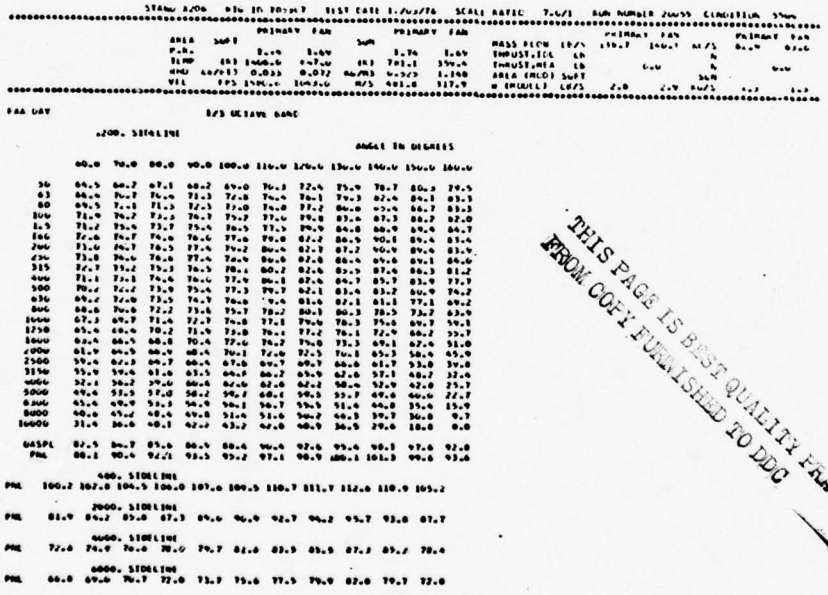
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Without Engine Secondary Flow Simulation; Configuration 2Au; Condition 5504

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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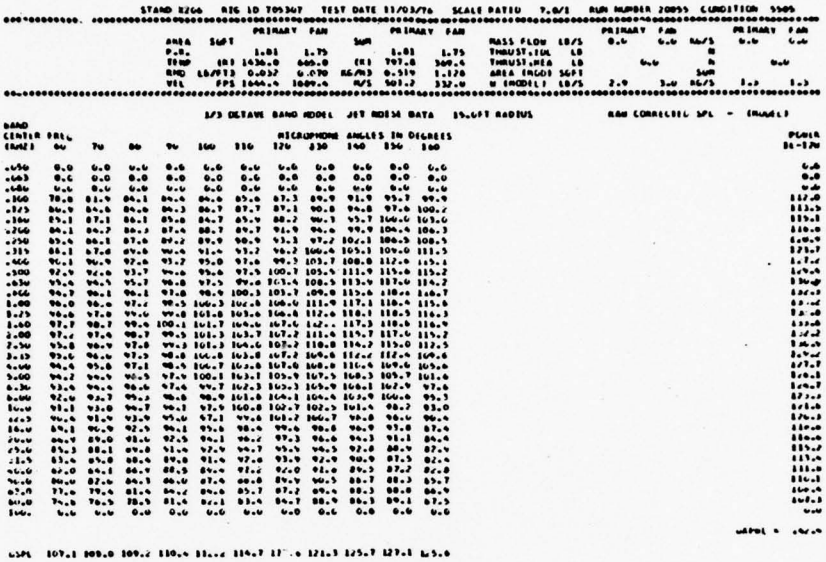
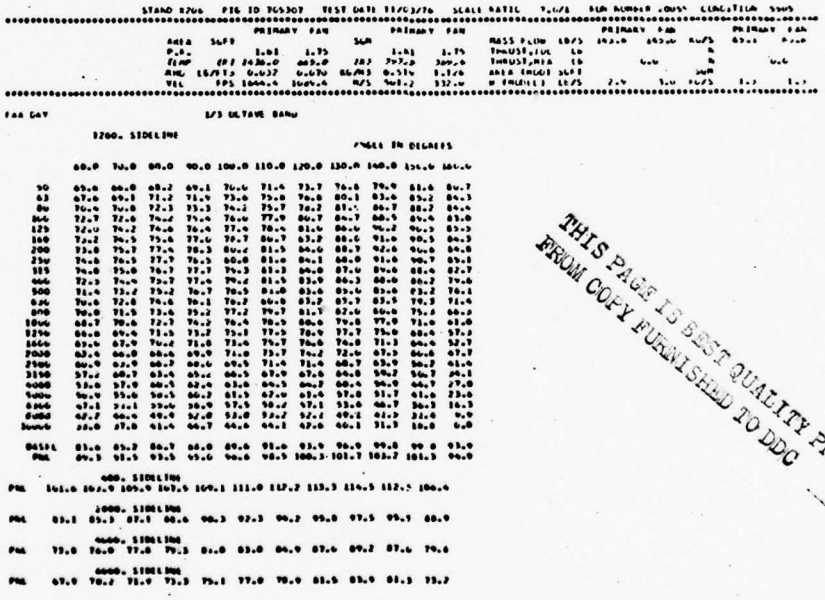
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Without Engine Secondary Flow Simulation; Configuration 2Au; Condition 5505

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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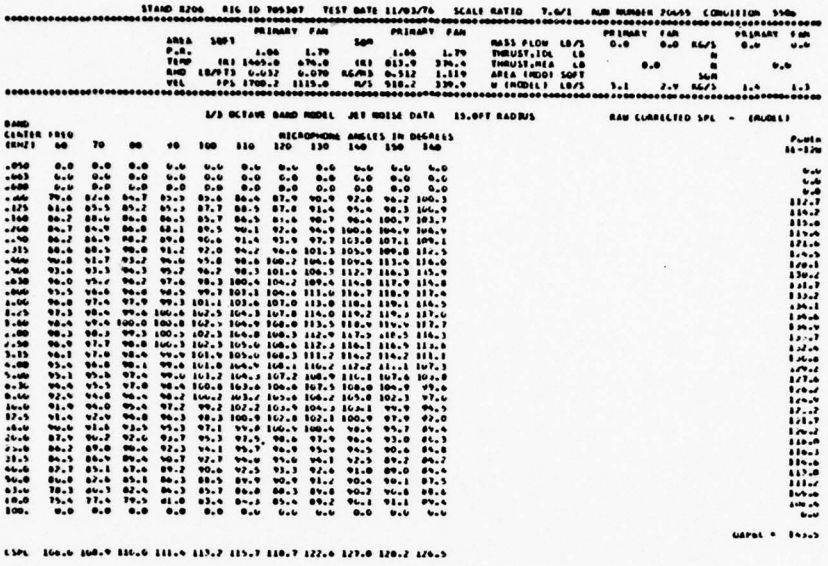
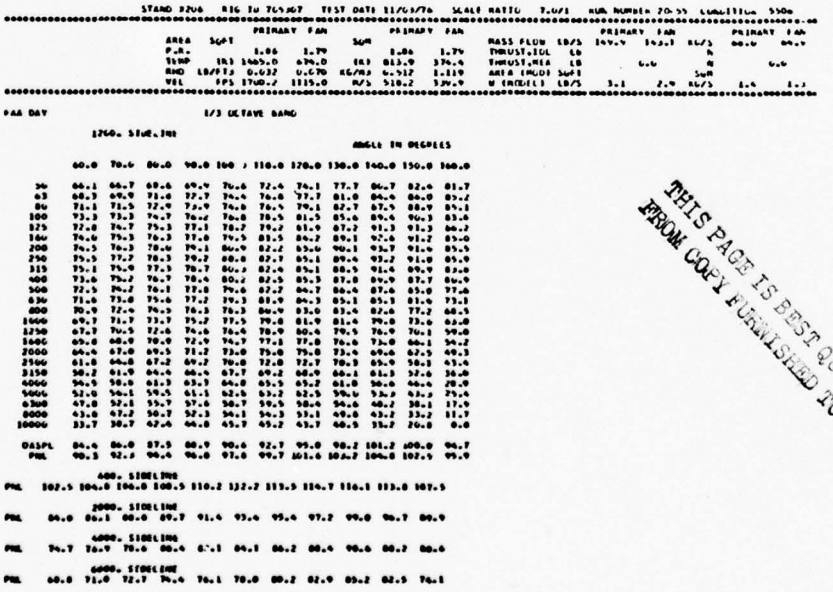
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Without Engine Secondary Flow Simulation; Configuration 2Au; Condition 5506

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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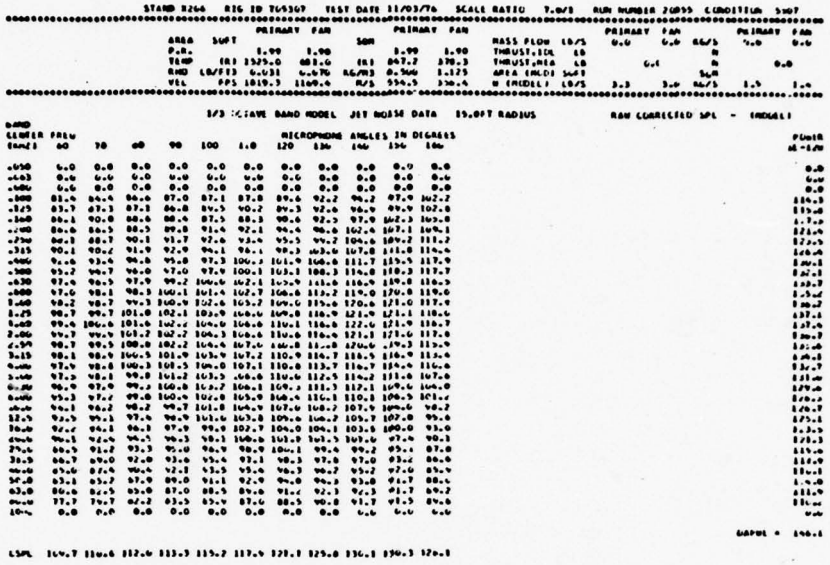
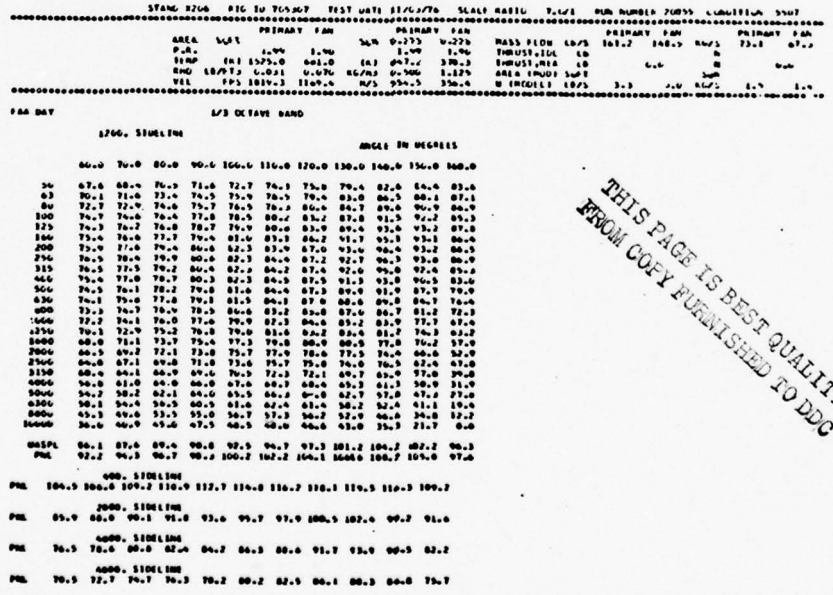
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Without Engine Secondary Flow Simulation; Configuration 2Au; Condition 5507

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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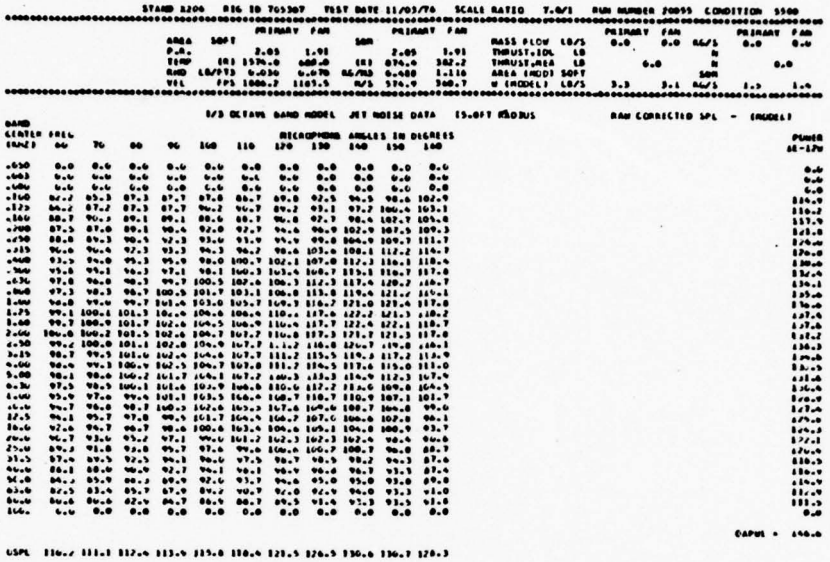
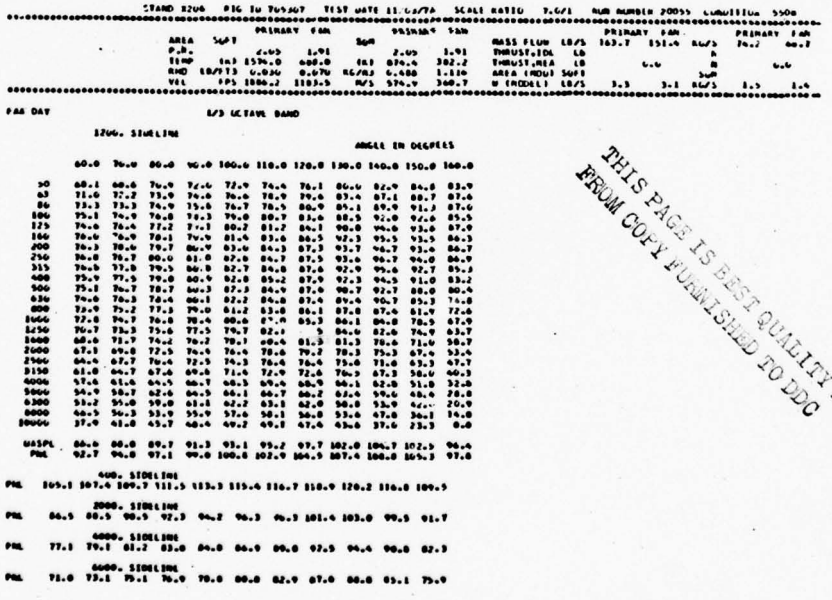
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Without Engine Secondary Flow Simulation; Configuration 2Au; Condition 5508

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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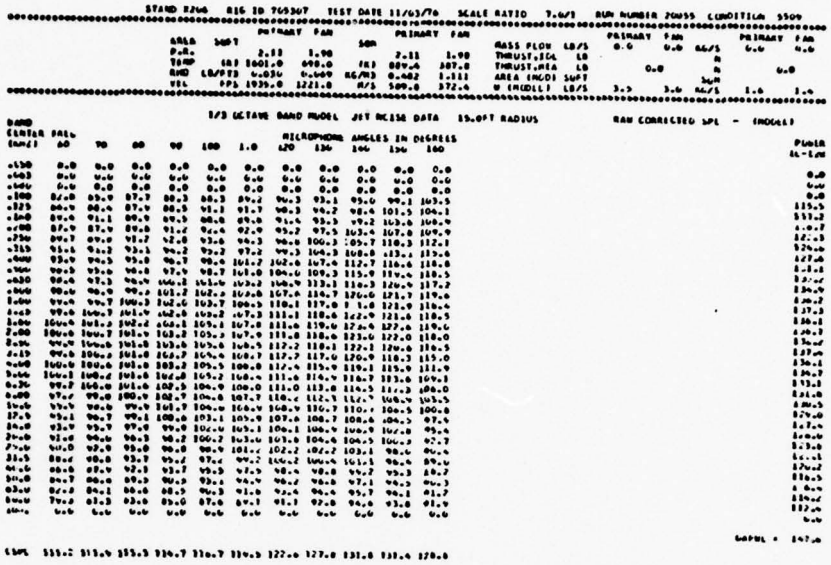
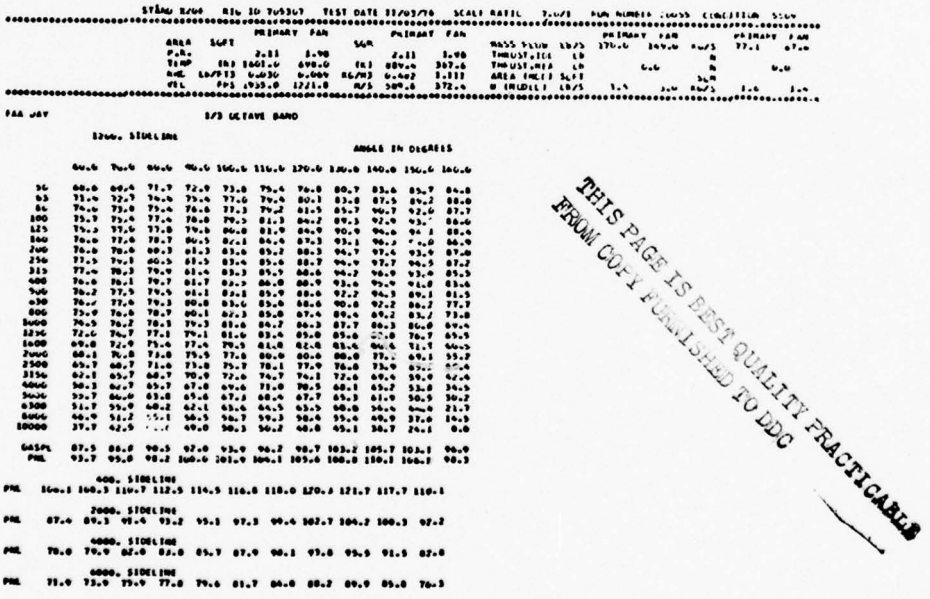
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

...System Without Engine Secondary Flow Simulation;
Configuration 2Au; Condition 5509

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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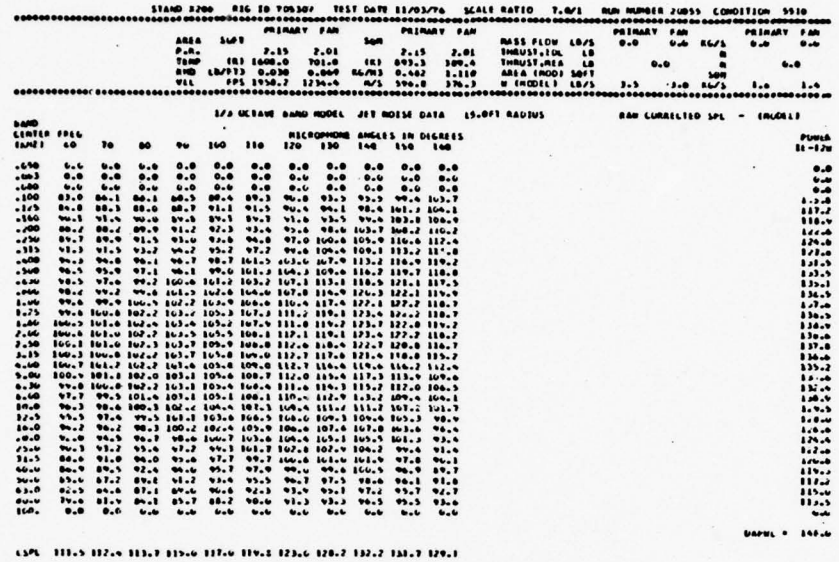
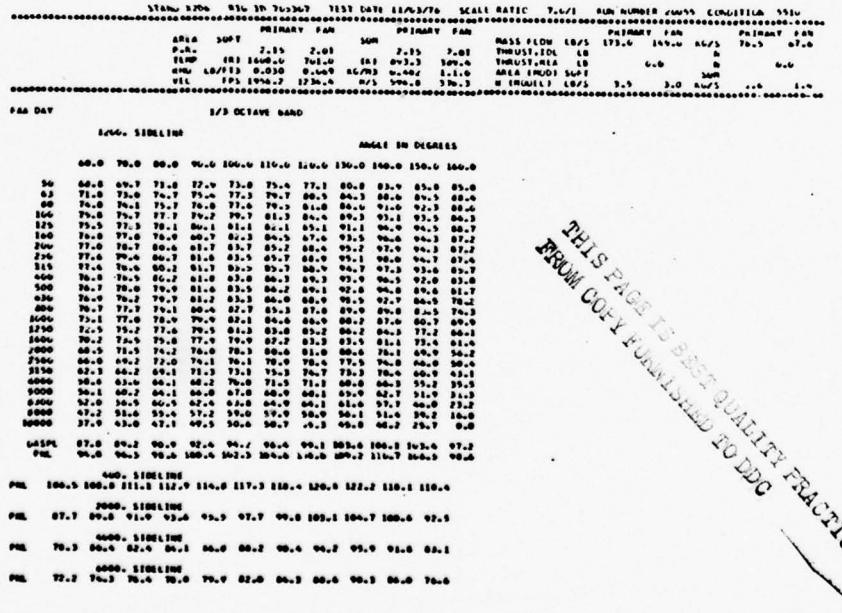
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Without Engine Secondary Flow Simulation; Configuration 2Au; Condition 5510

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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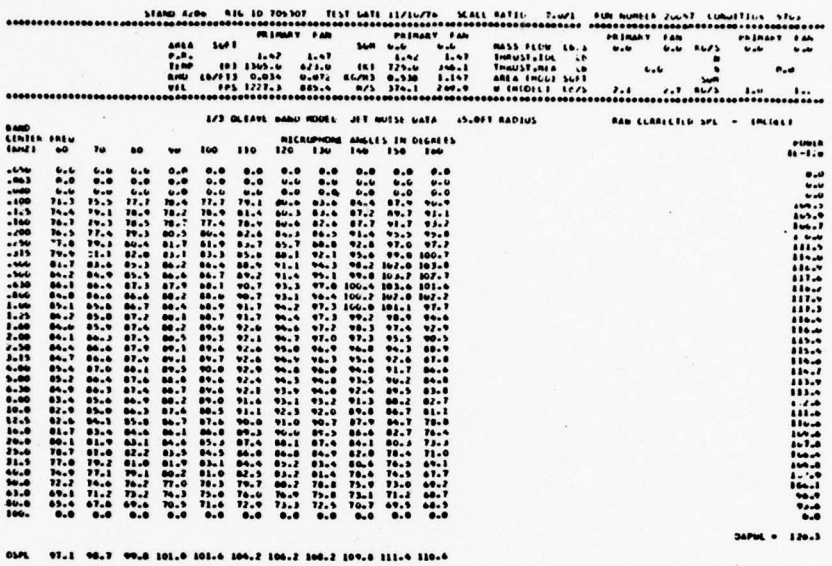
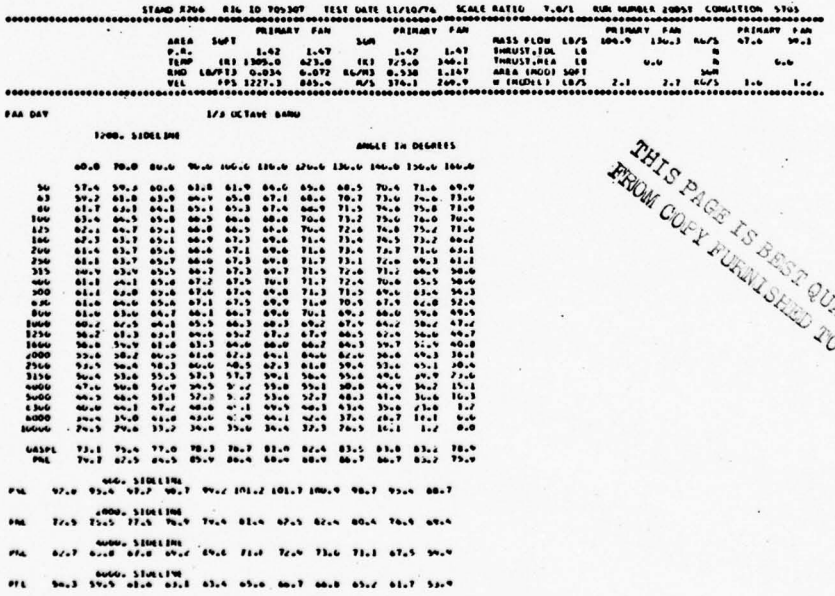
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Shallow Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 3A; Condition 5703

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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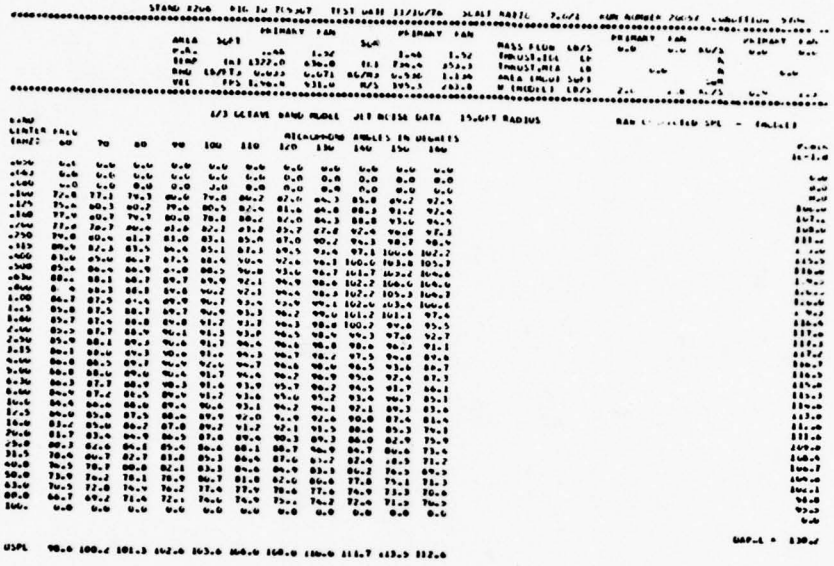
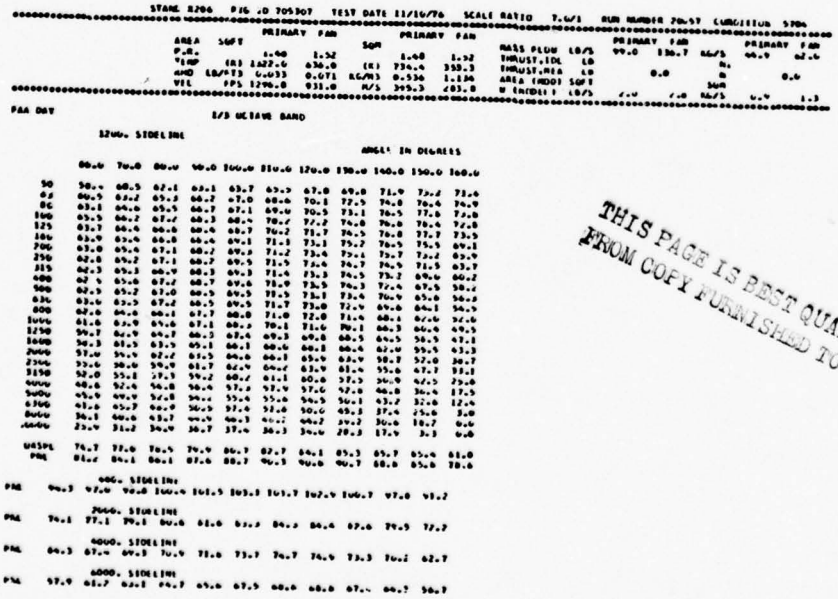
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Shallow Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 3A; Condition 5704

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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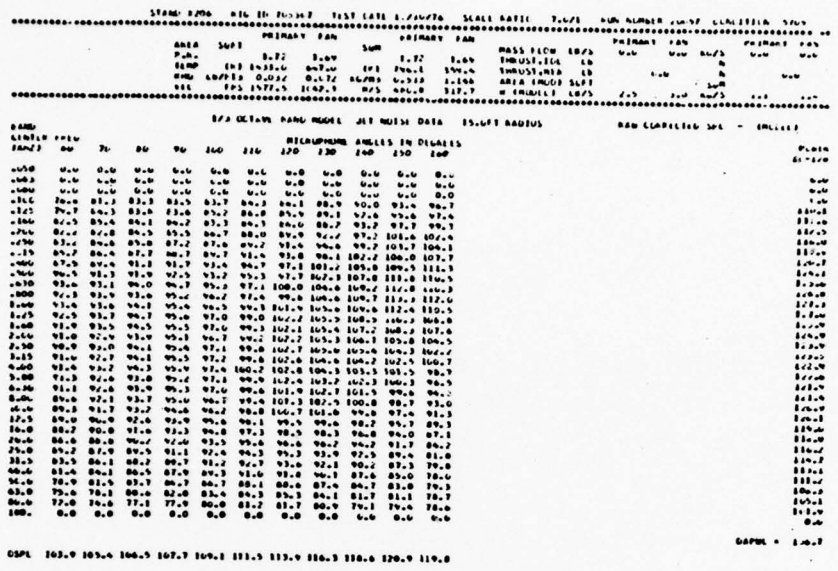
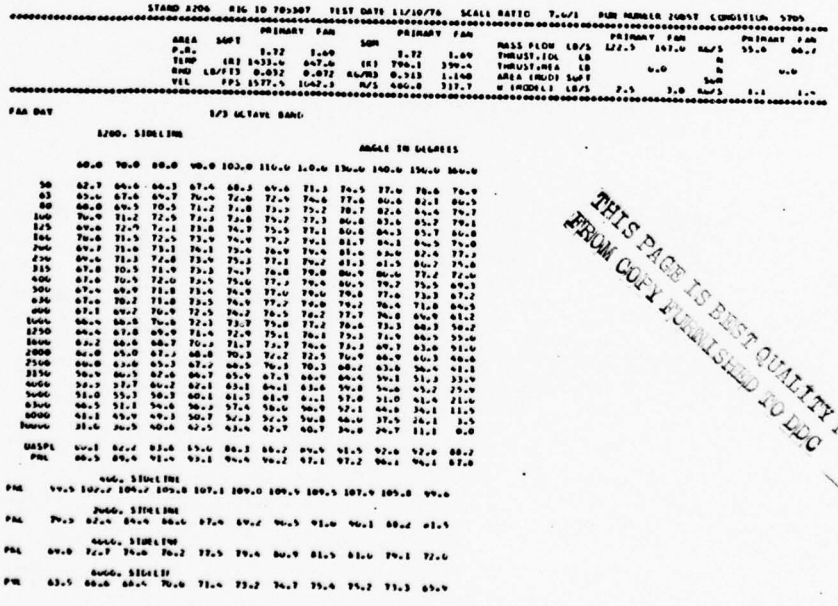
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Shallow Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 3A; Condition 5705

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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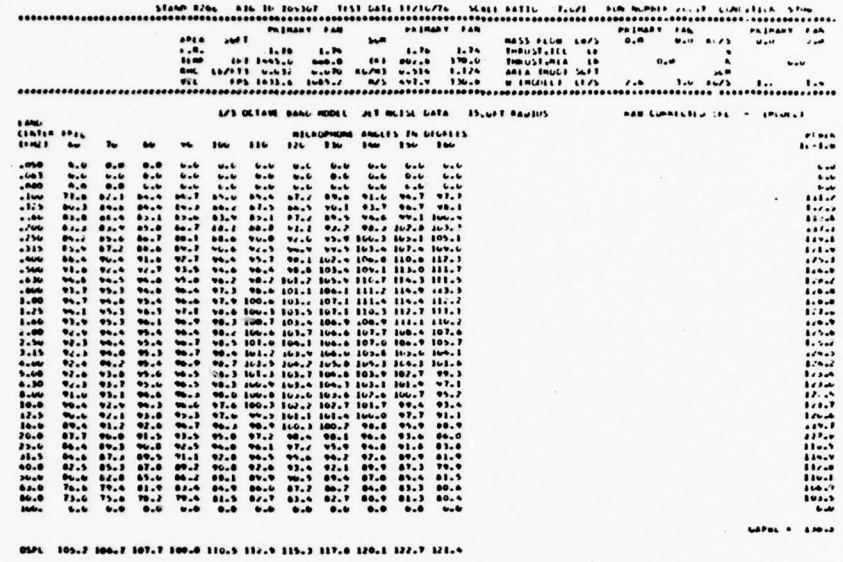
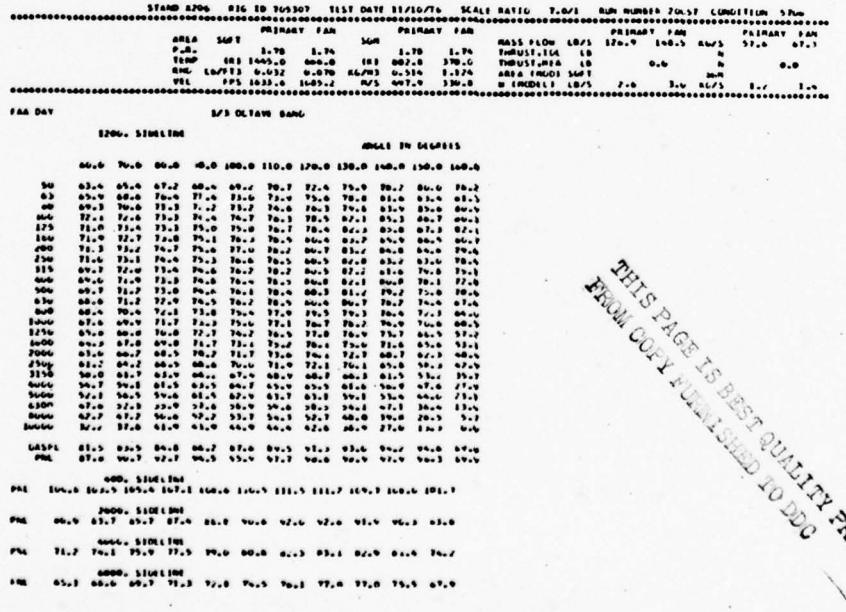
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Shallow Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 3A; Condition 5706

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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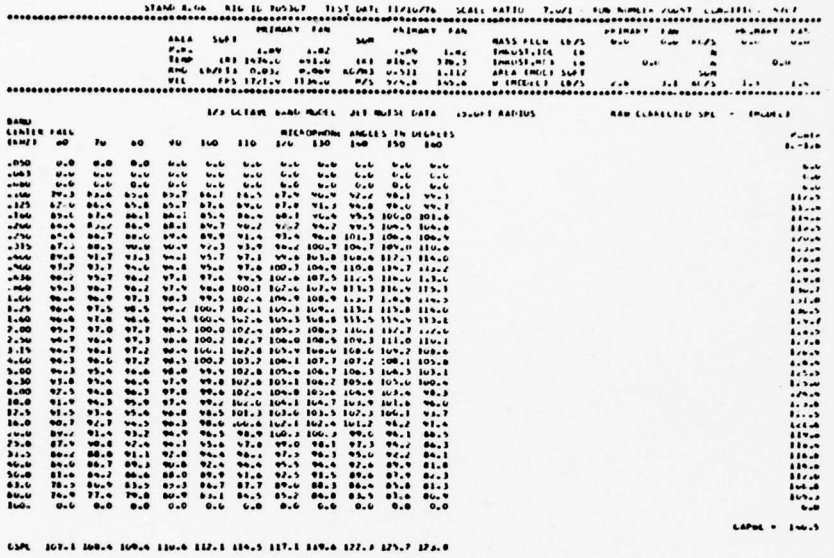
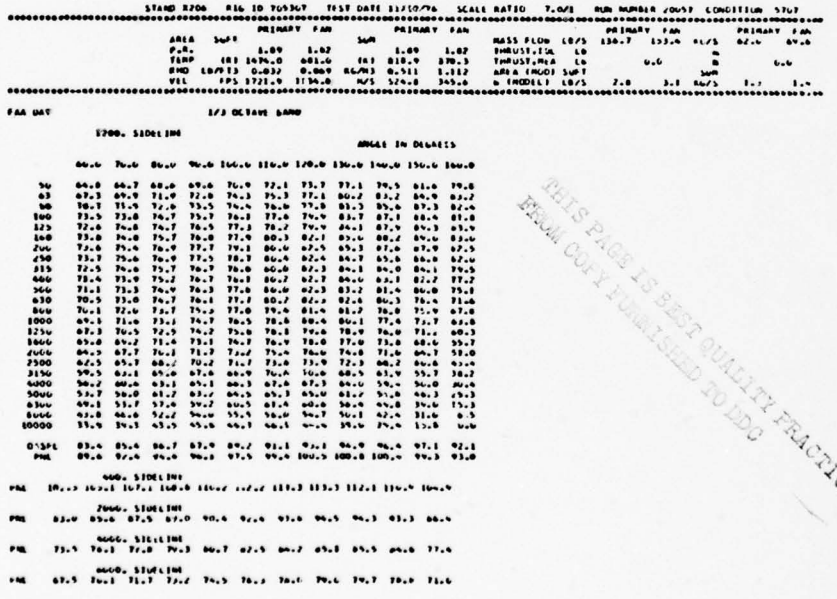
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Shallow Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 3A; Condition 5707

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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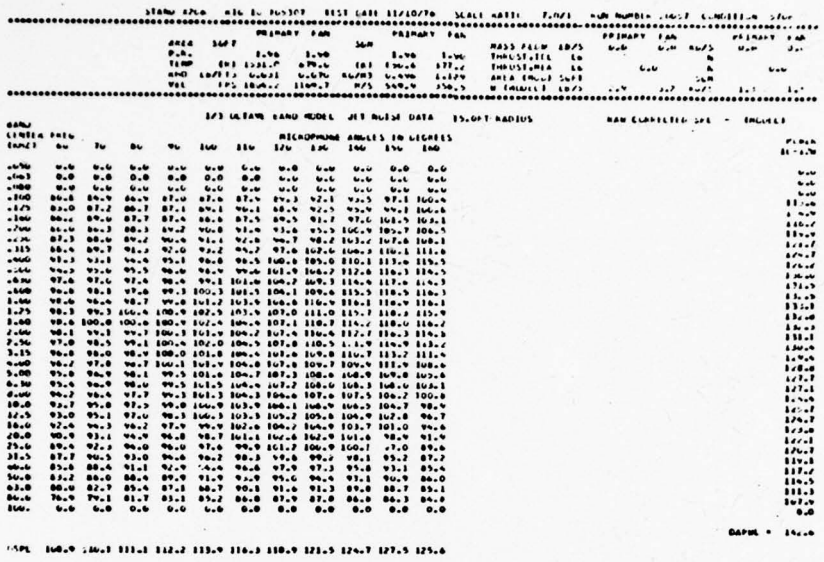
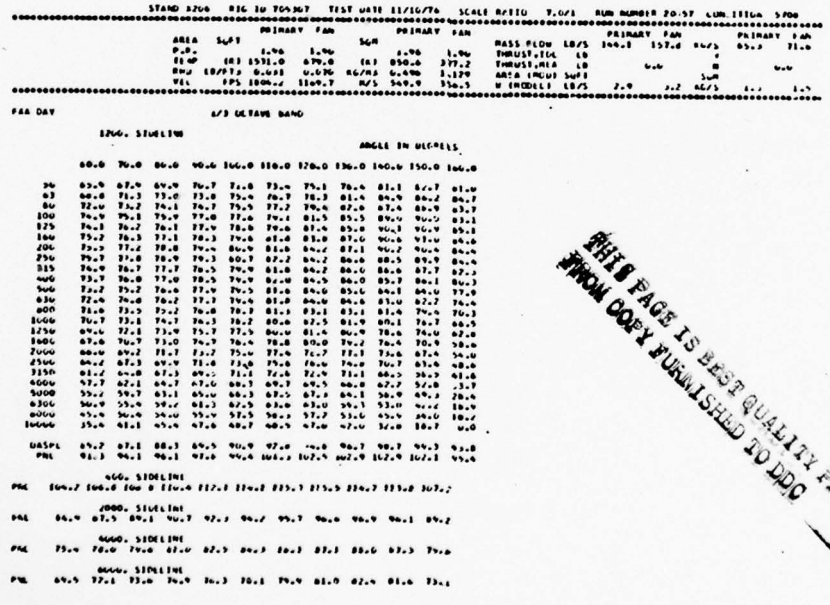
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Shallow Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 3A; Condition 5708

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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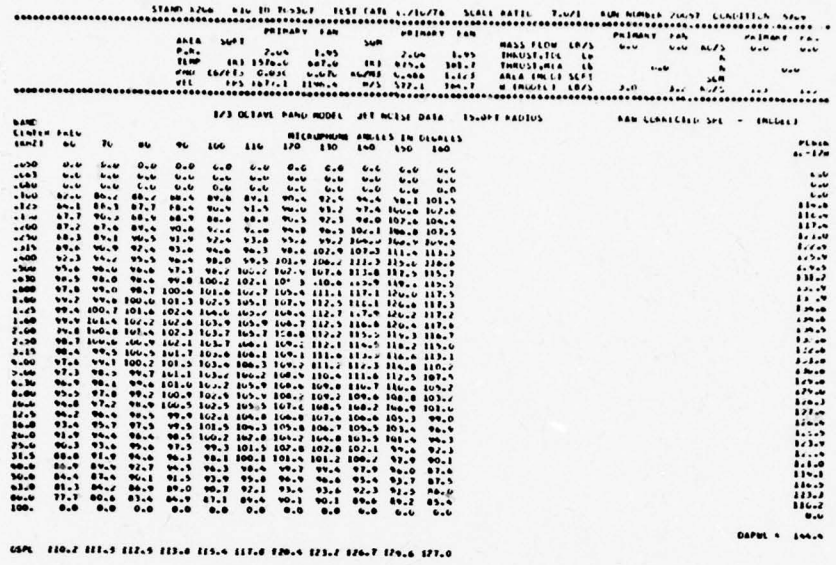
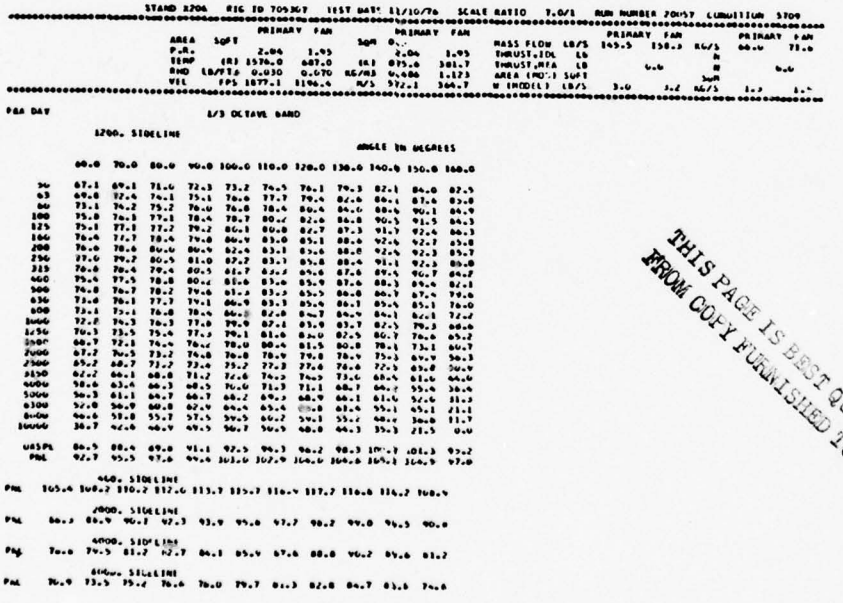
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Flow Simulation; Configuration 3A; Condition 5709

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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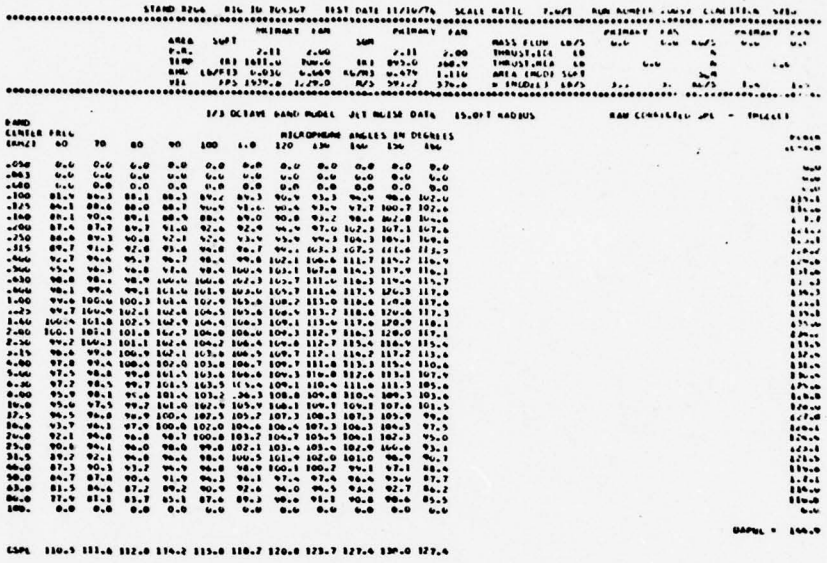
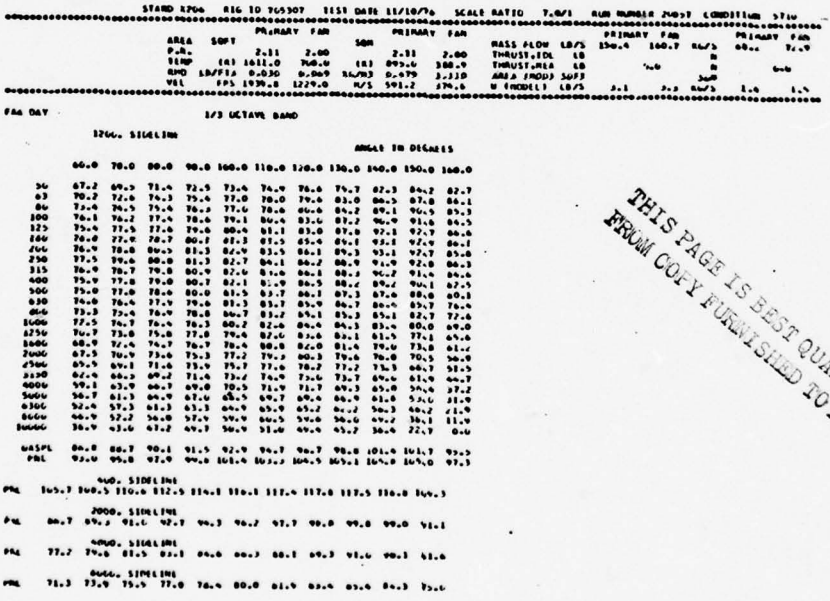
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Flow Simulation; Configuration 3A; Condition 5710

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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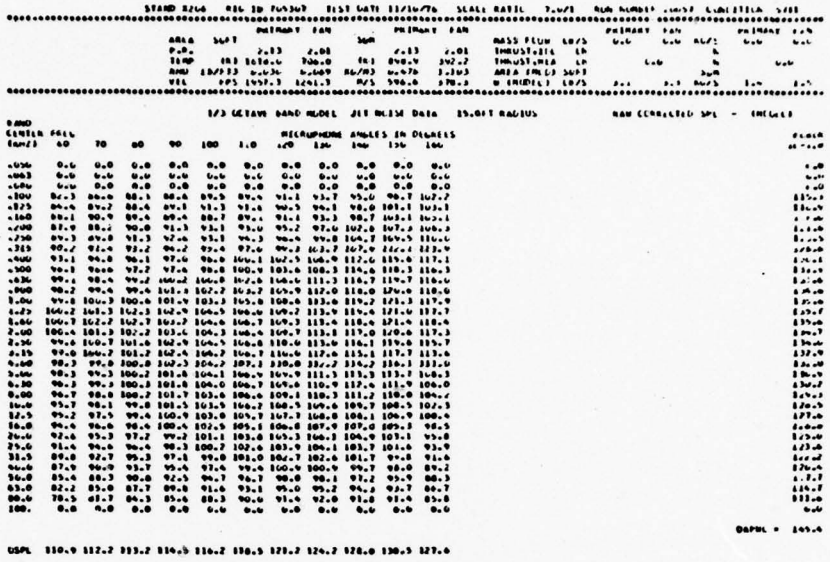
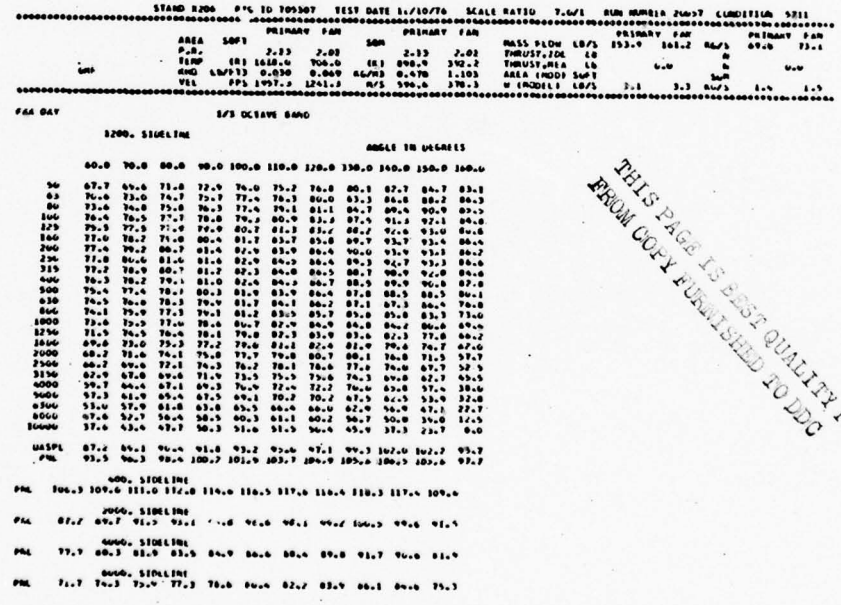
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Shallow Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 3A; Condition 5711

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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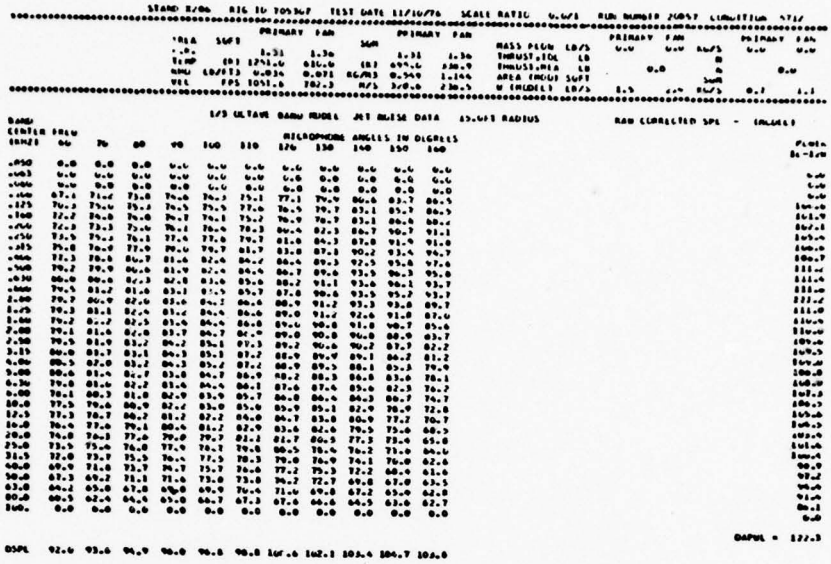
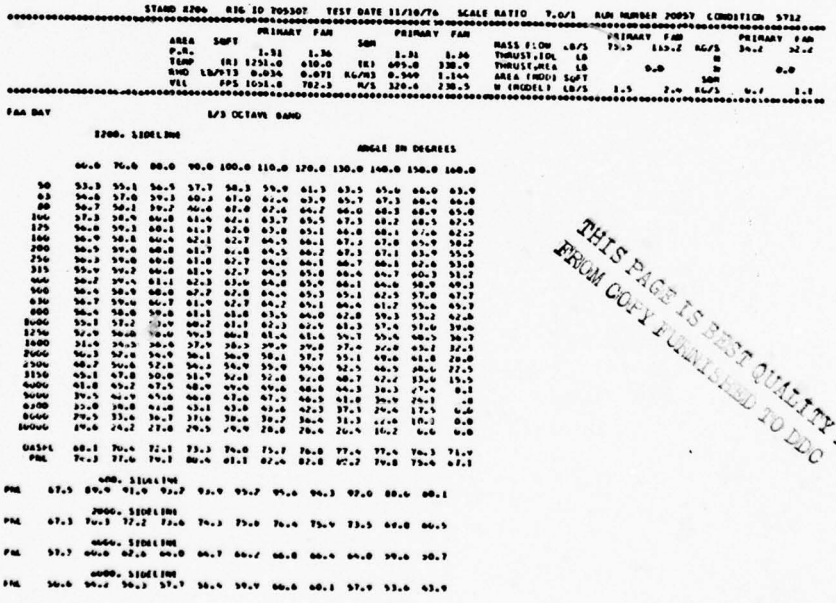
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Shallow Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 3A; Condition 5712

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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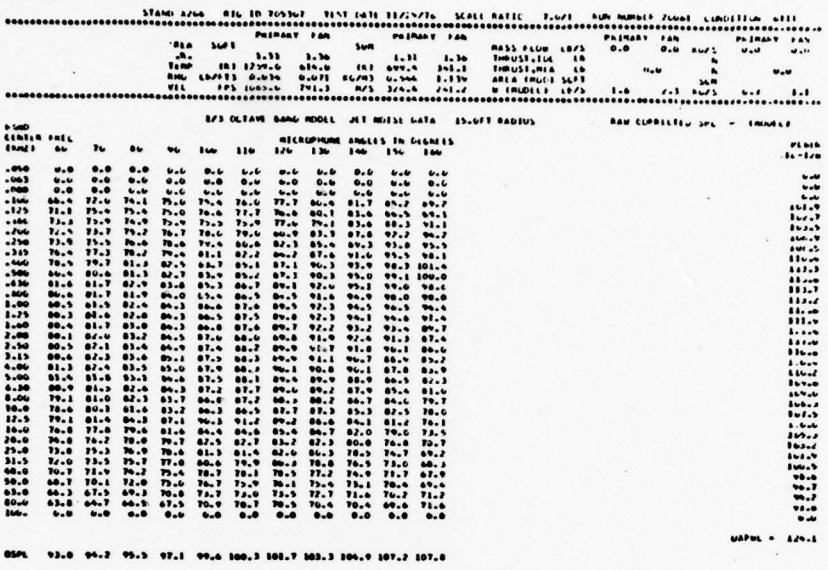
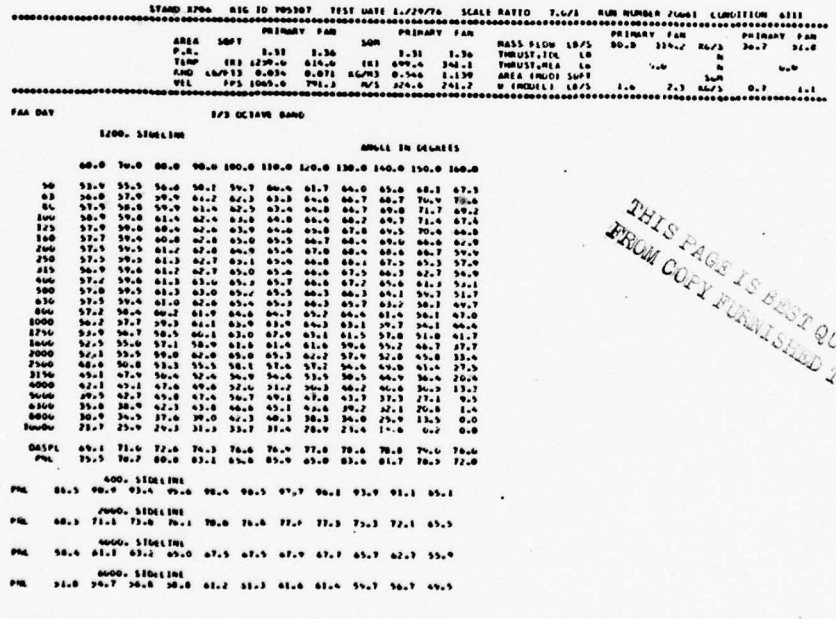
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 4A; Condition 6111

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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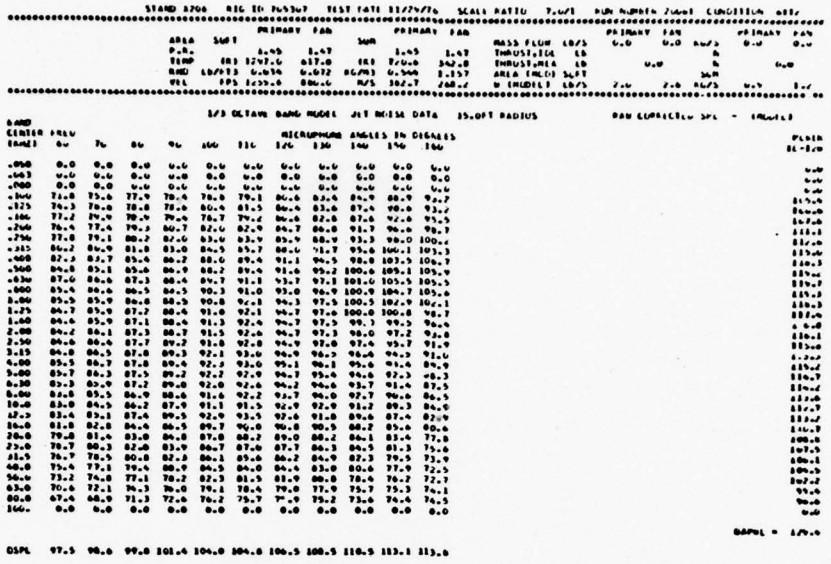
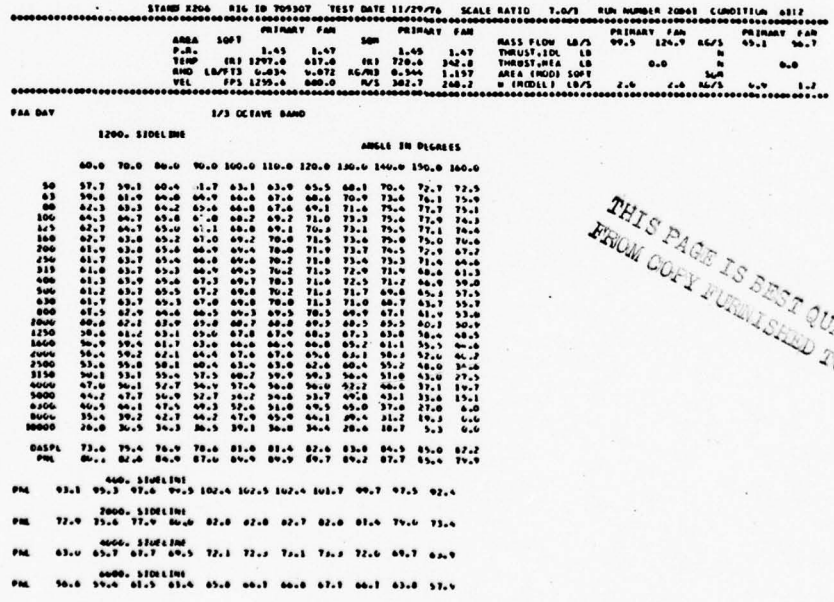
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 4A; Condition 6112

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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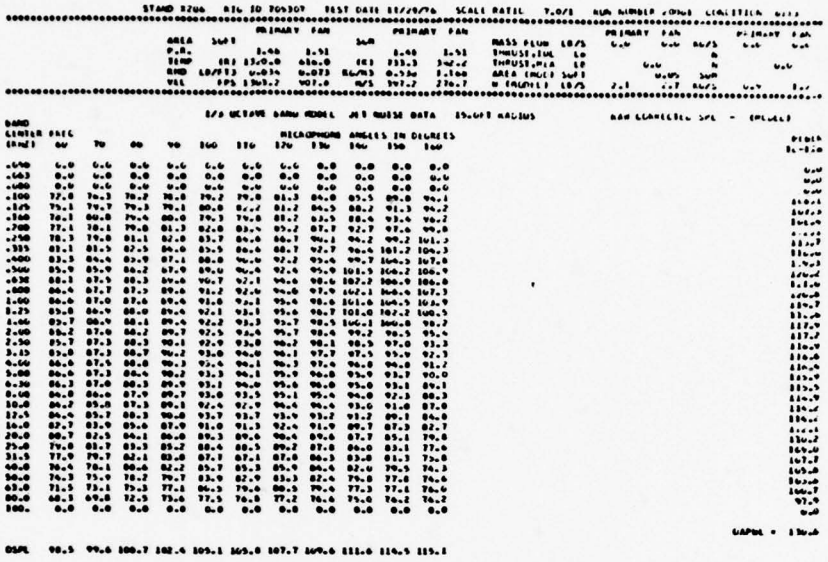
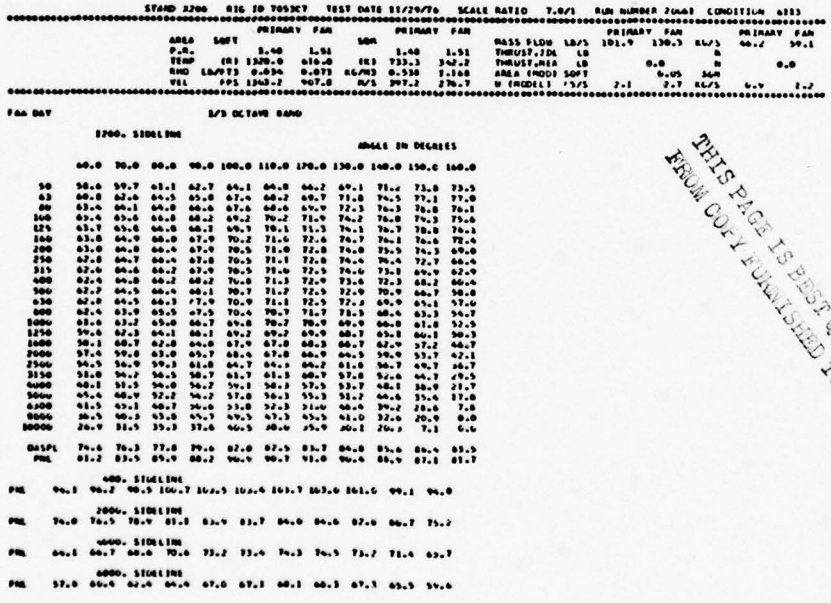
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 4A; Condition 6113

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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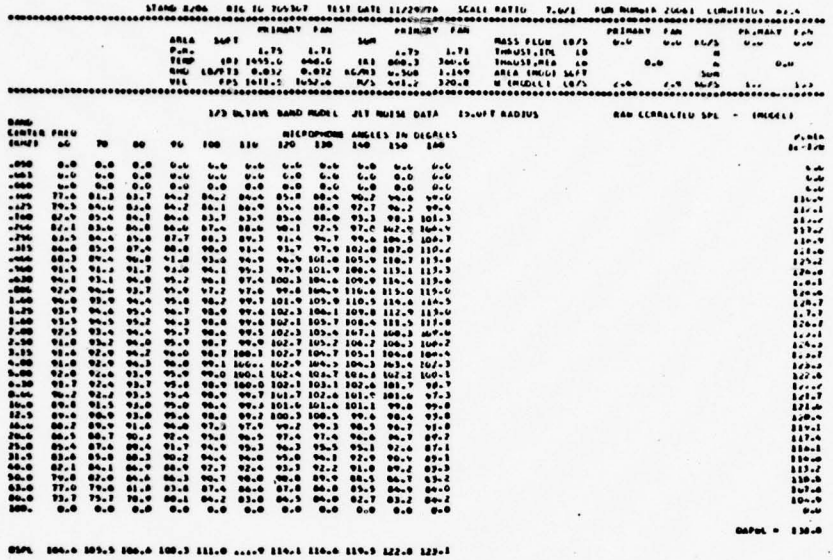
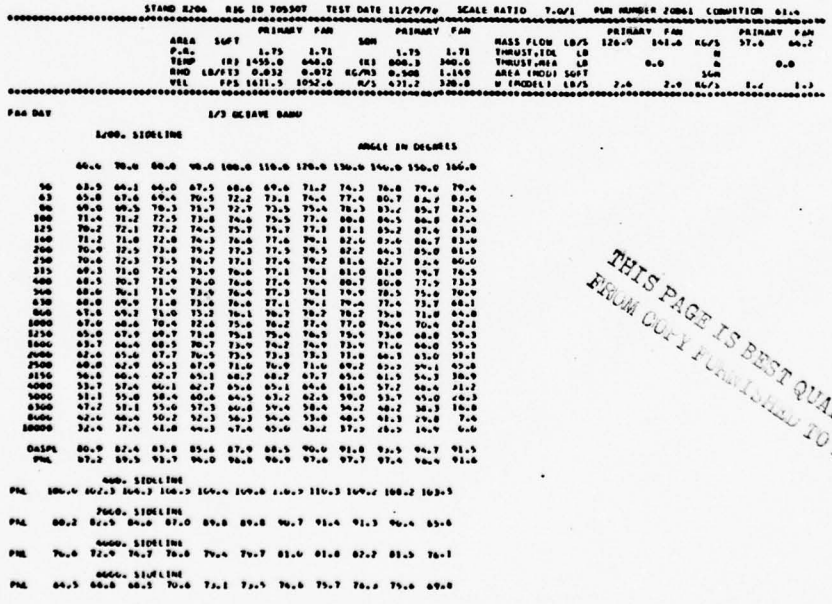
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 4A; Condition 6114

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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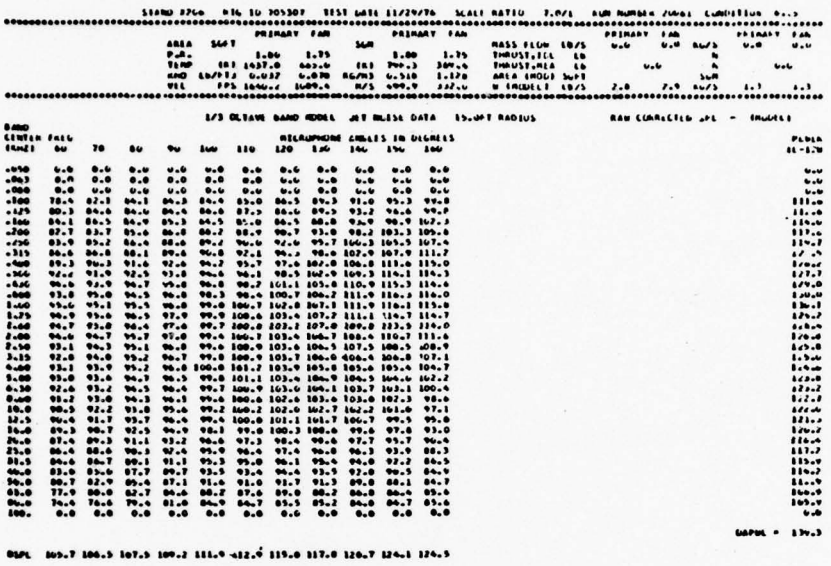
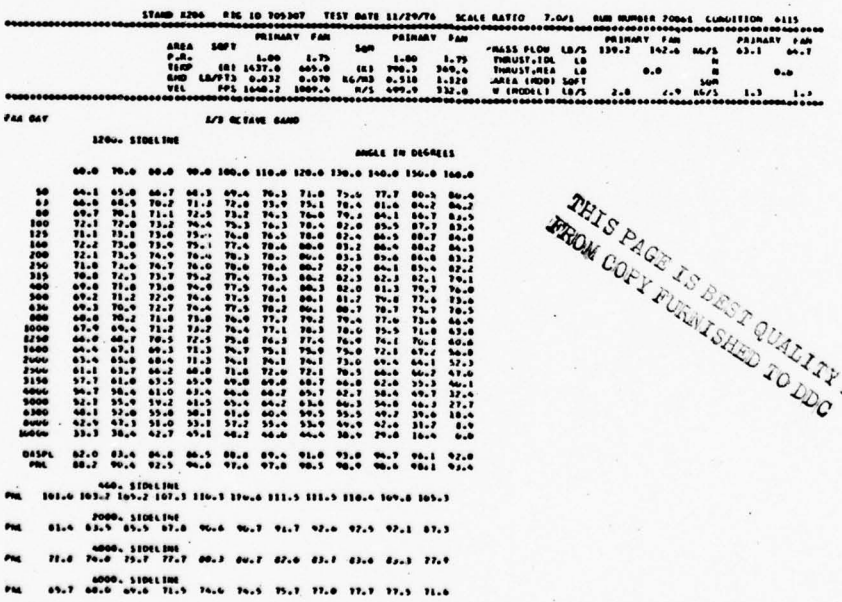
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 4A; Condition 6115

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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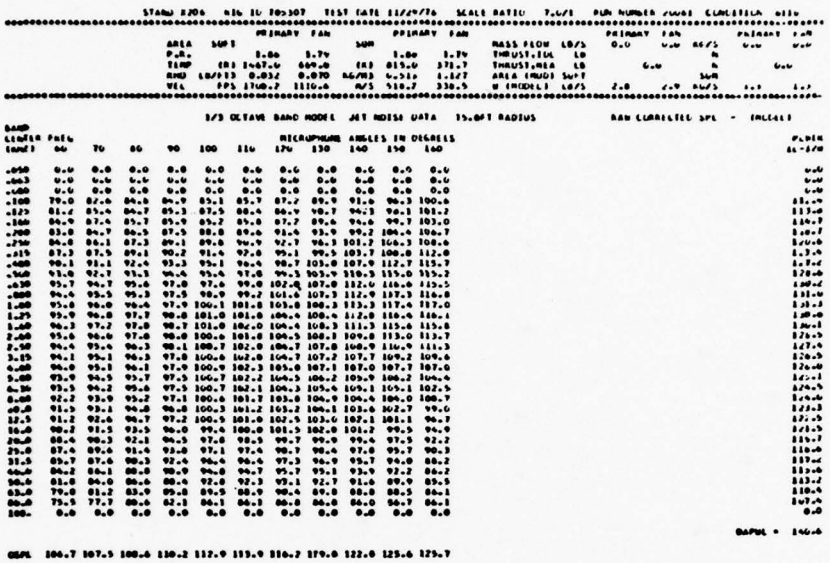
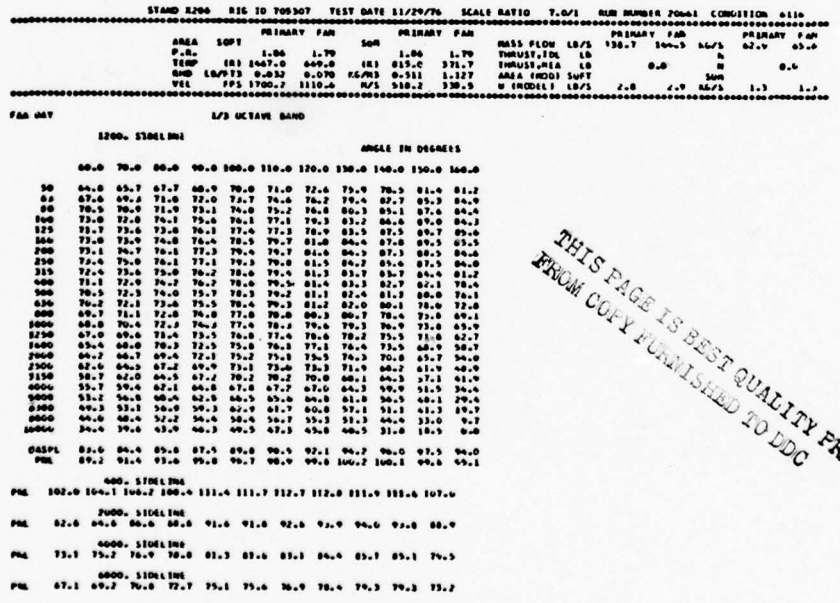
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 4A; Condition 6116

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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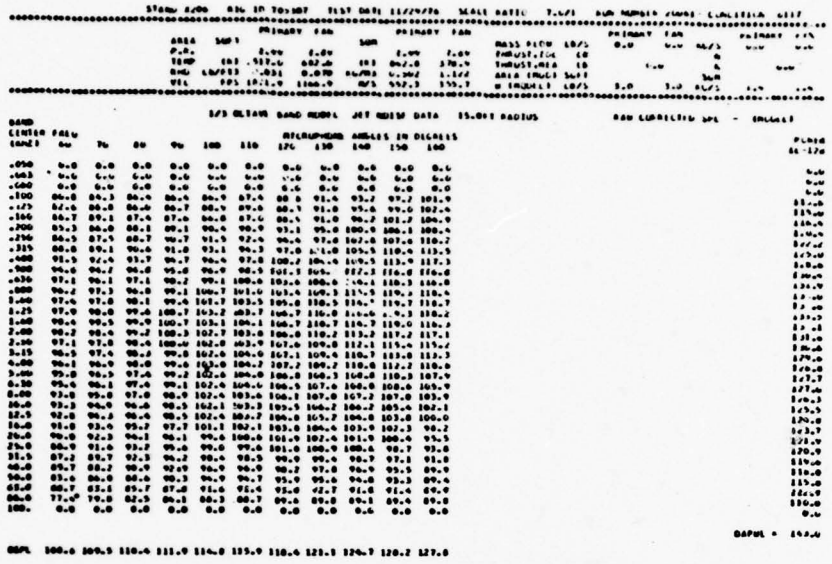
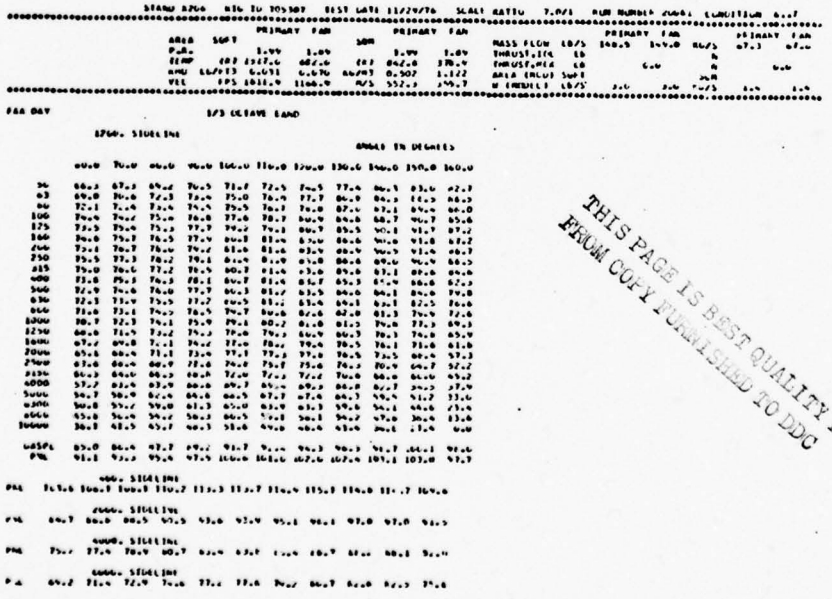
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 4A; Condition 6117

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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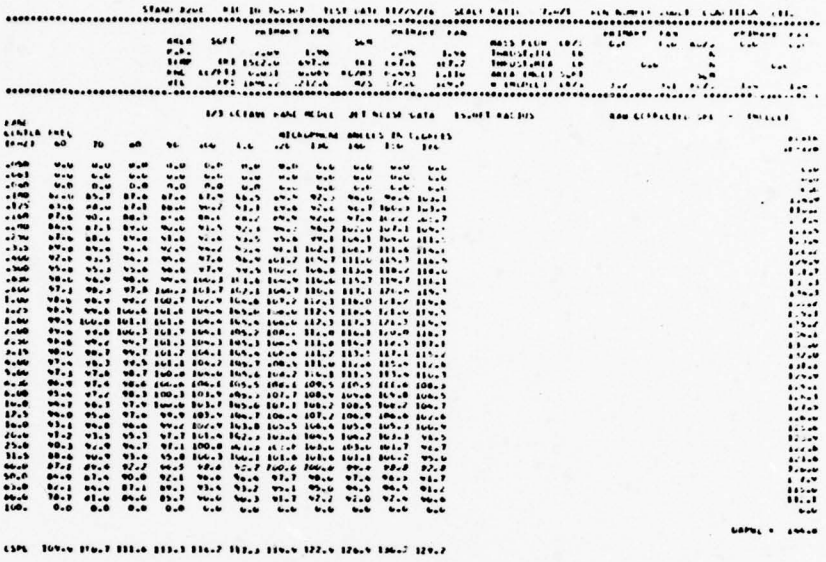
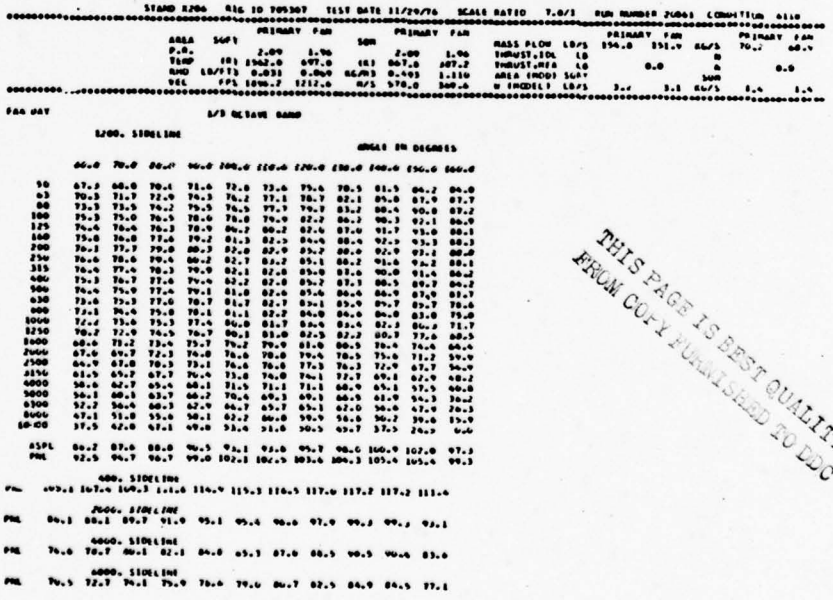
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 4A; Condition 6118

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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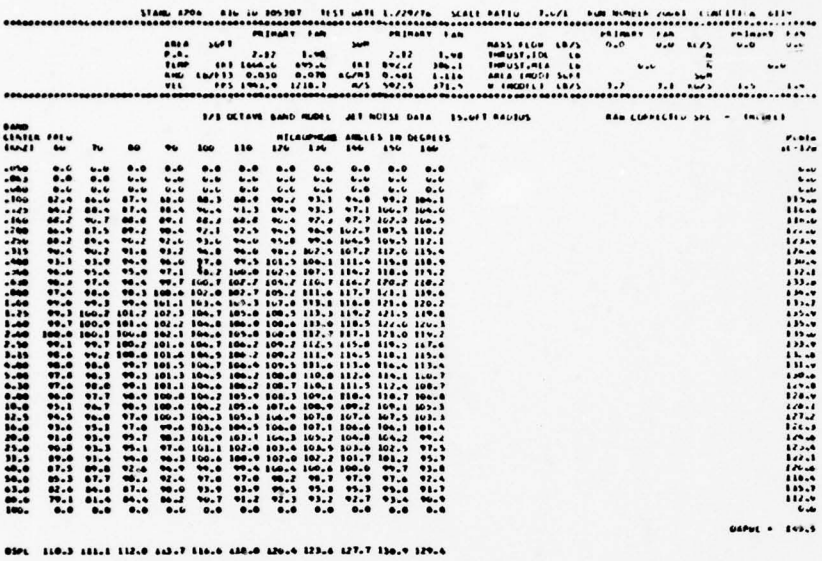
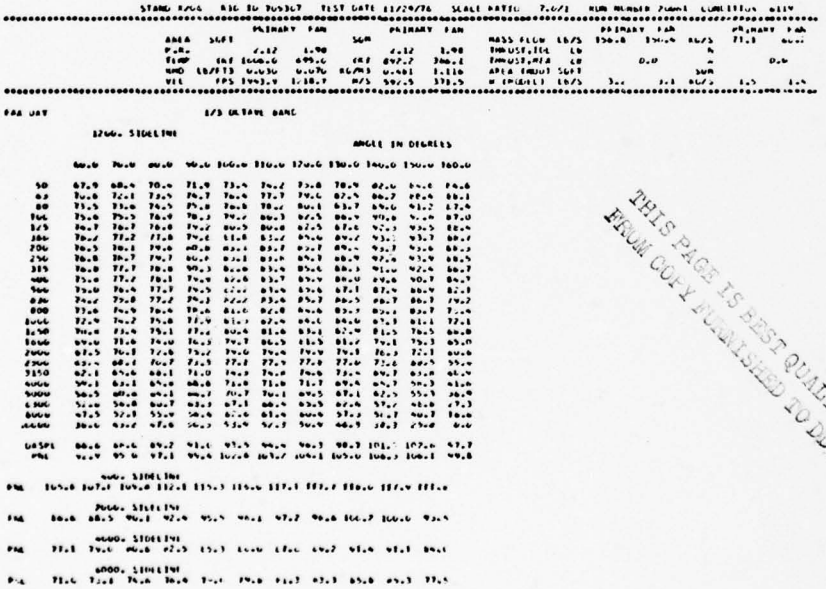
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 4A; Condition 6119

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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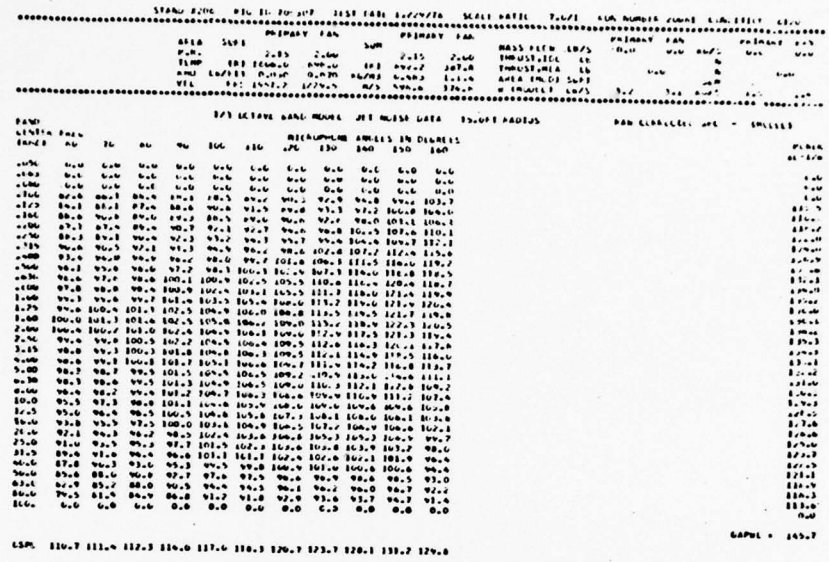
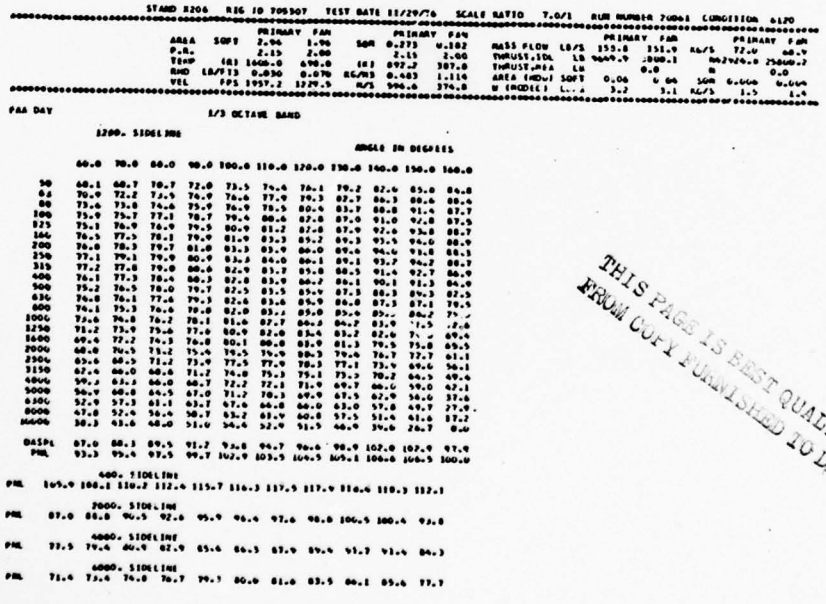
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 4A; Condition 6120

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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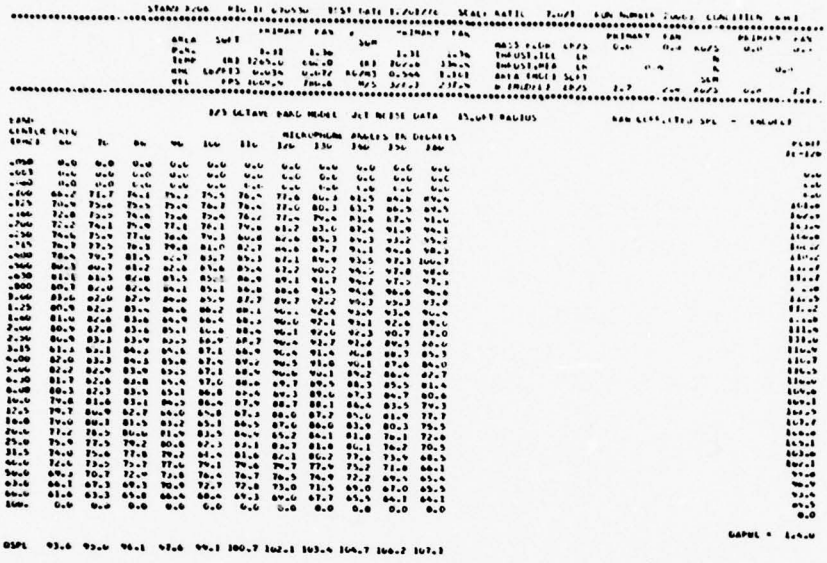
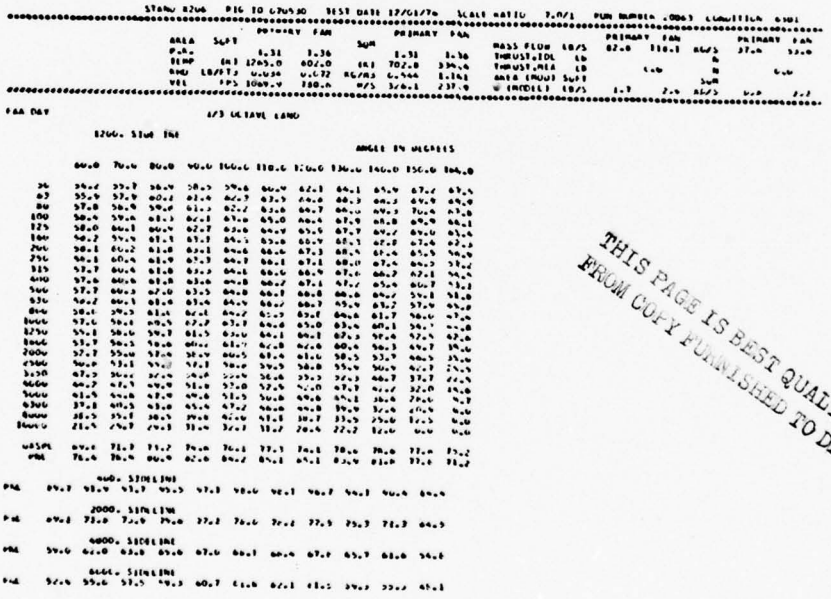
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

...Flow Simulation; Configuration 6A; Condition 6301

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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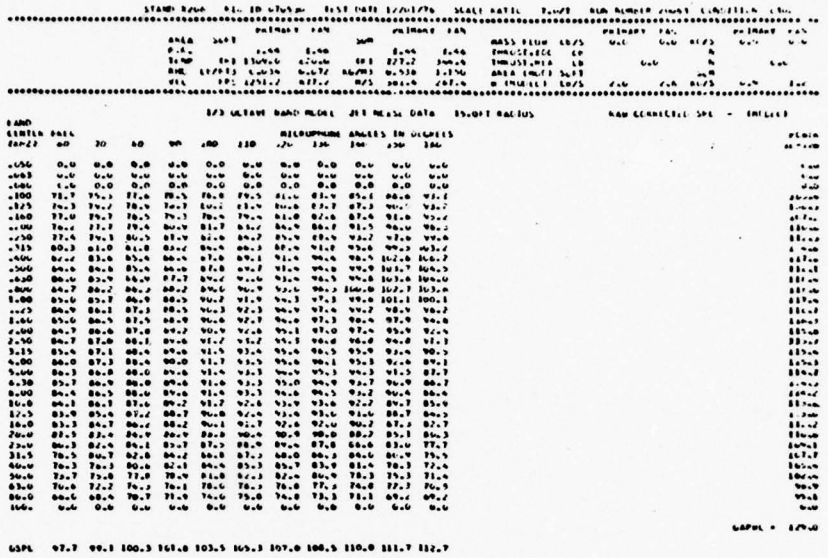
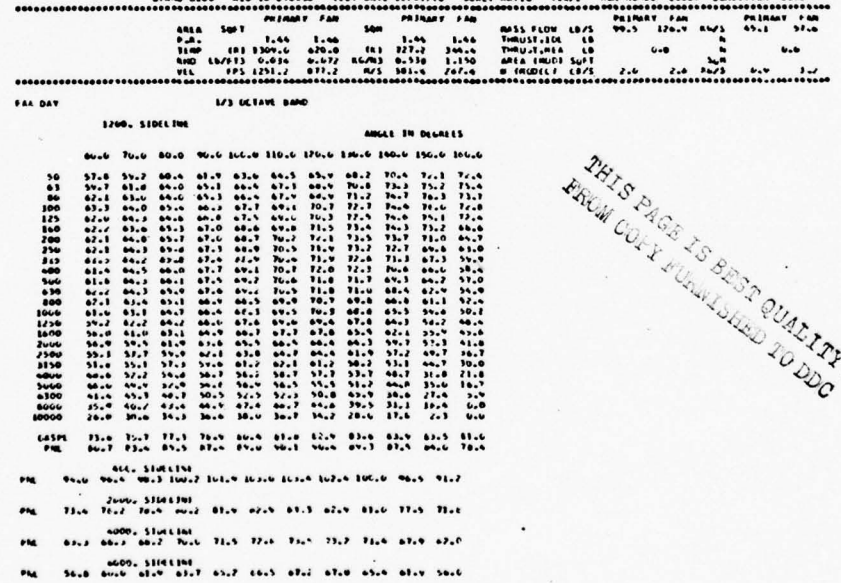
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Non-Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 6A; Condition 6302

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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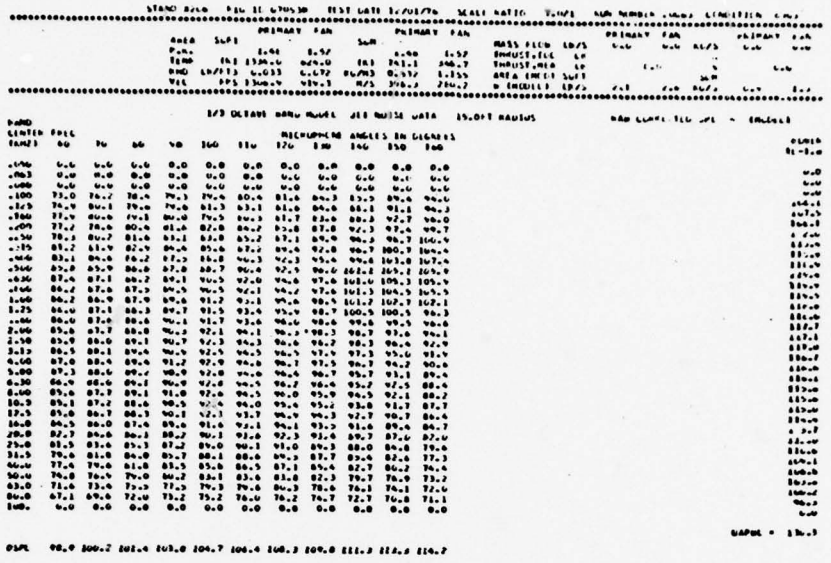
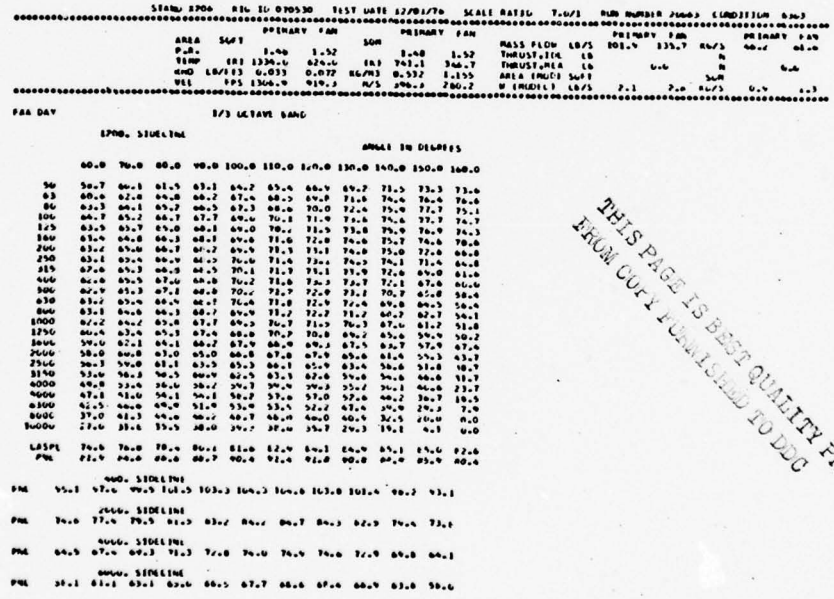
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Non-Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 6A; Condition 6303

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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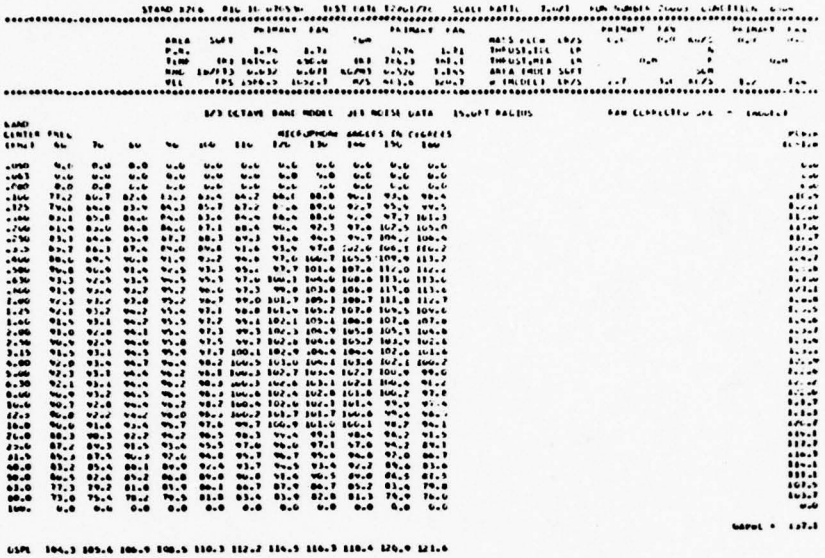
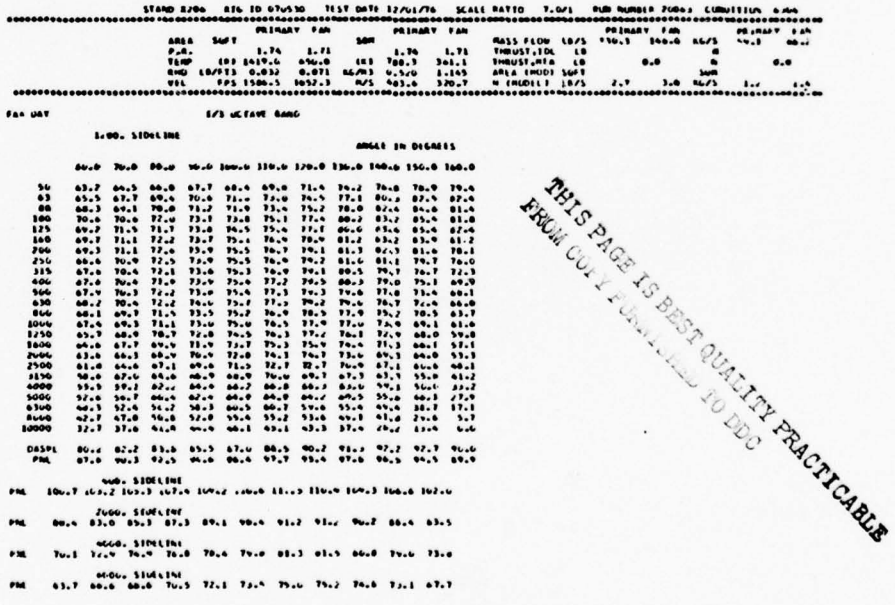
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Non-Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 6A; Condition 6304

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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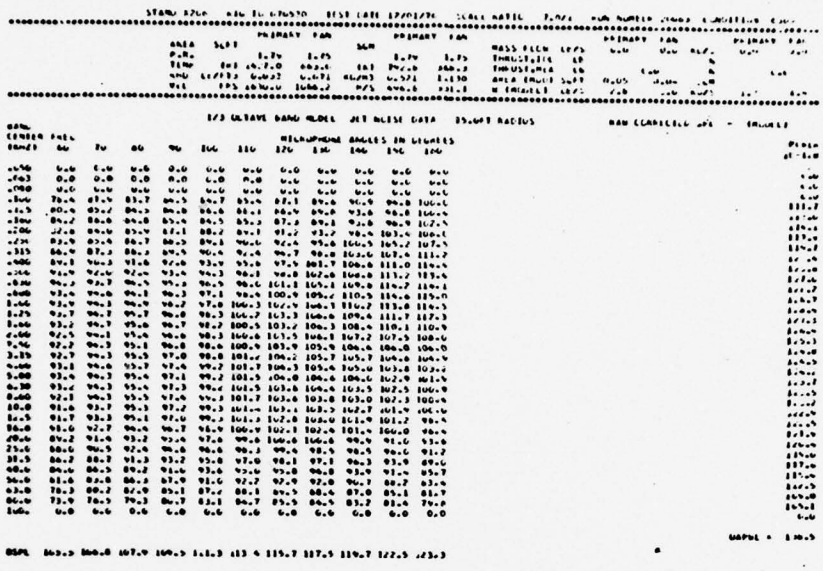
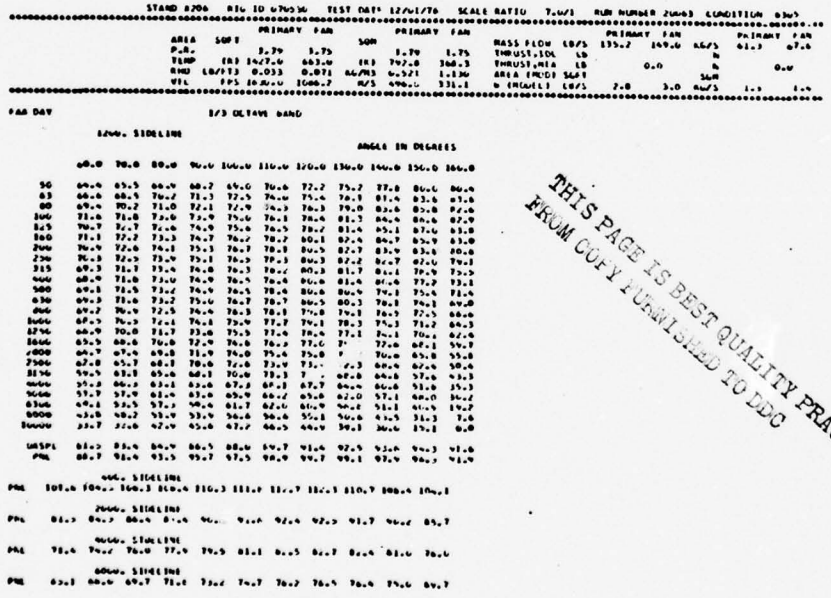
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Non-Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 6A; Condition 6305

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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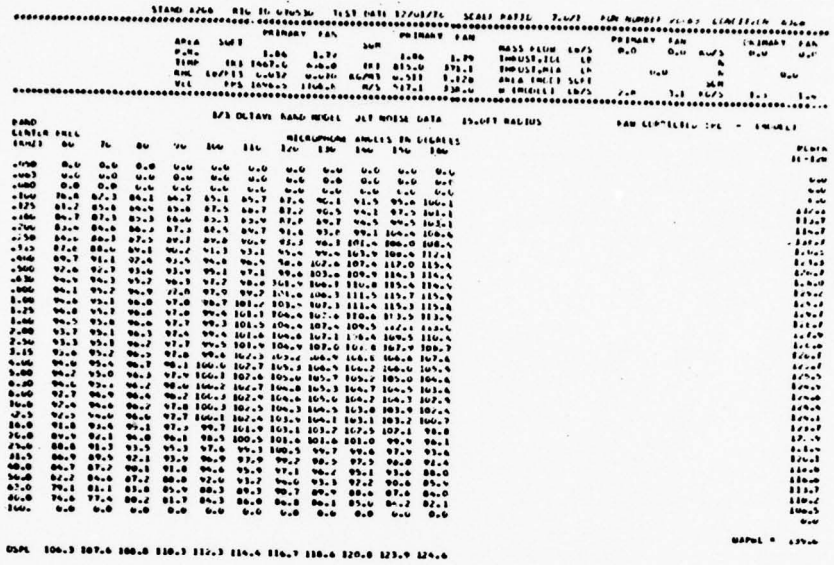
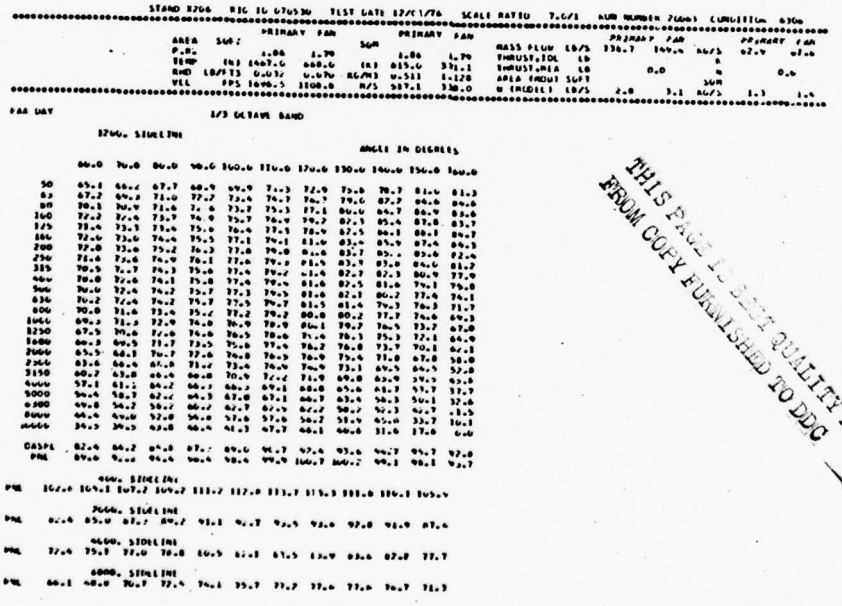
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Non-Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 6A; Condition 6306

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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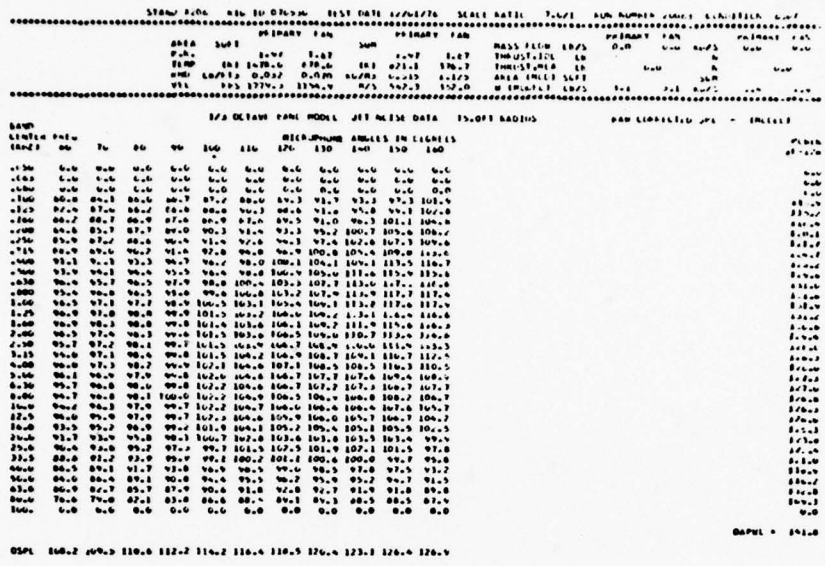
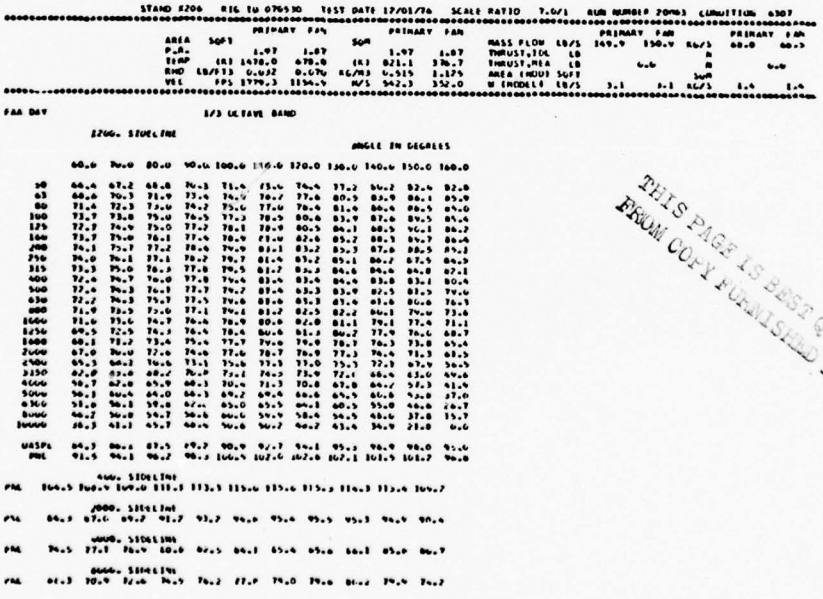
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Non-Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 6A; Condition 6307

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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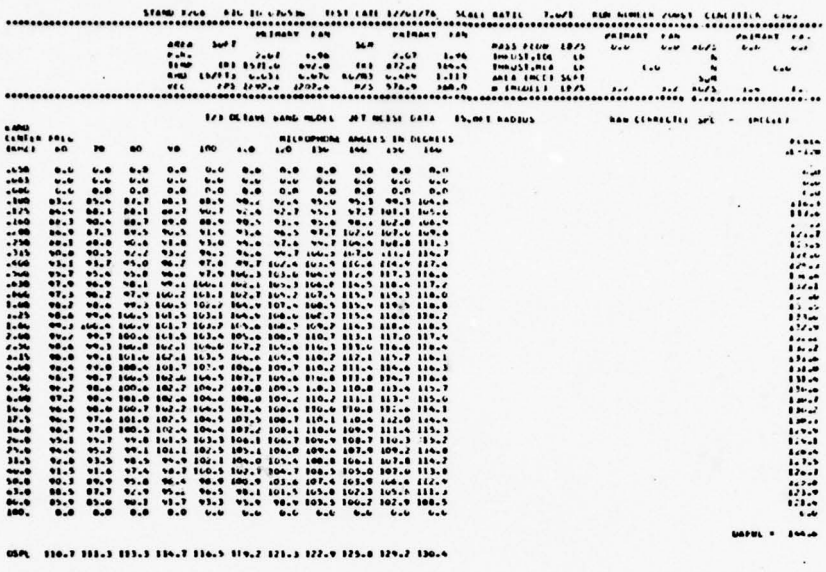
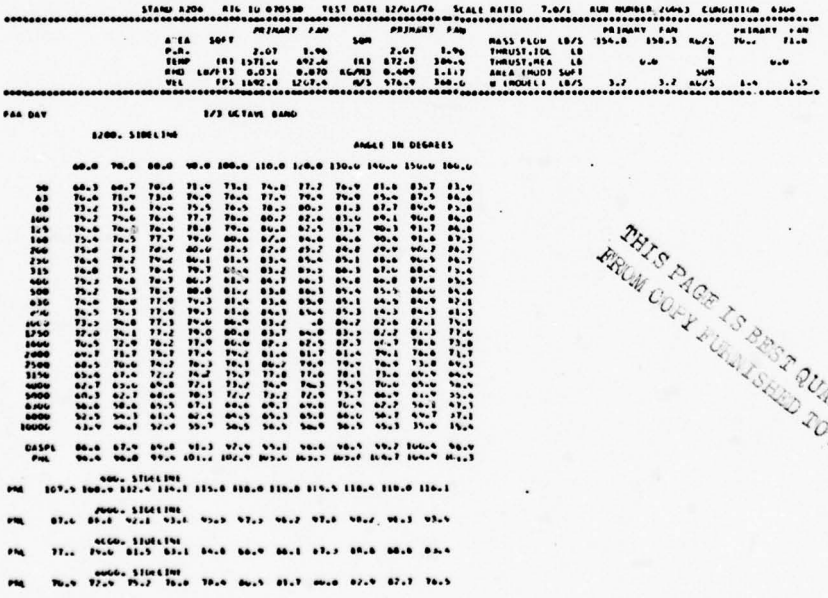
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Non-Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 6A; Condition 6308

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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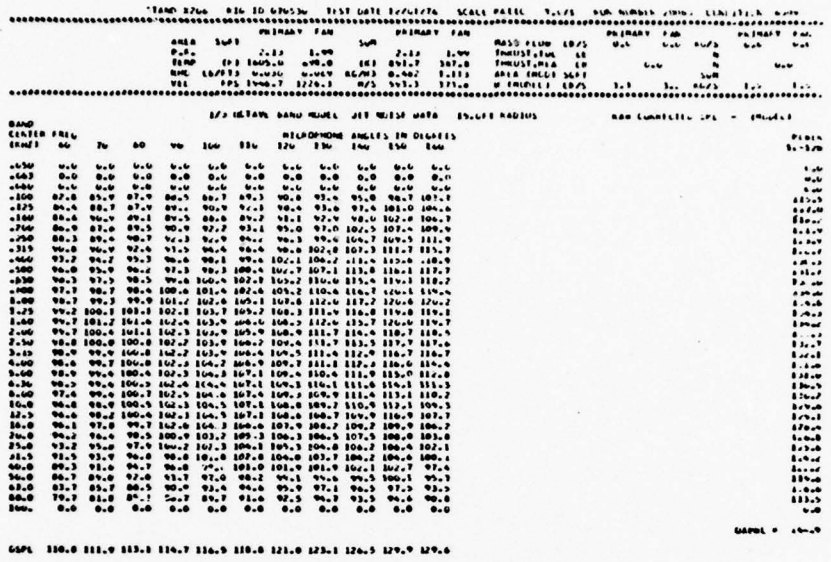
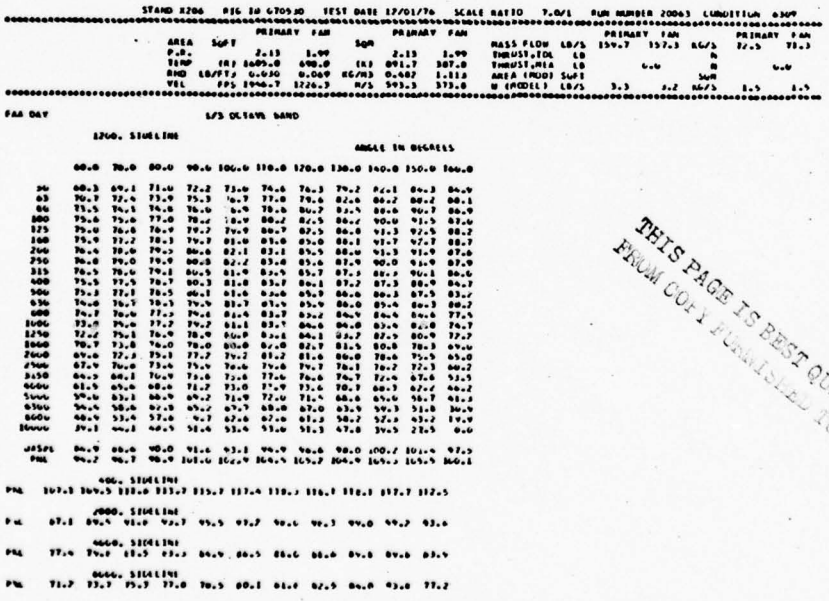
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Non-Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 6A; Condition 6309

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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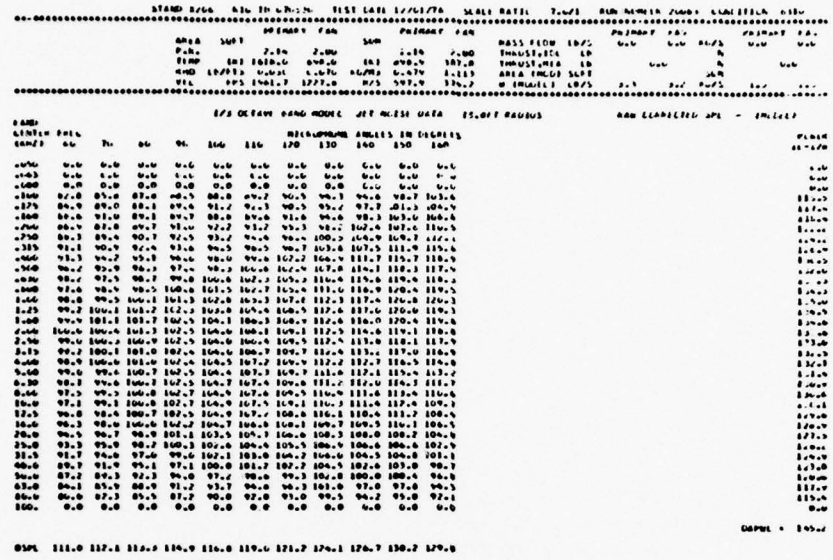
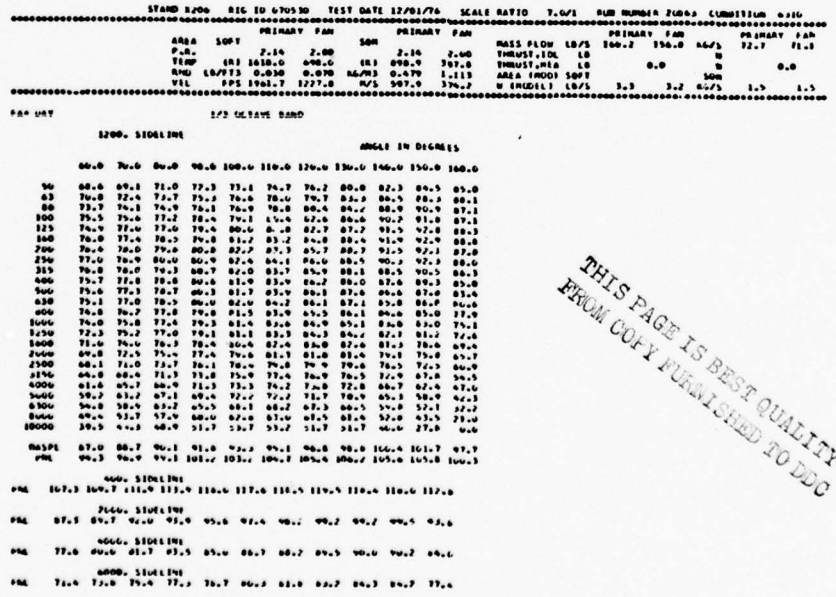
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Non-Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 6A; Condition 6310

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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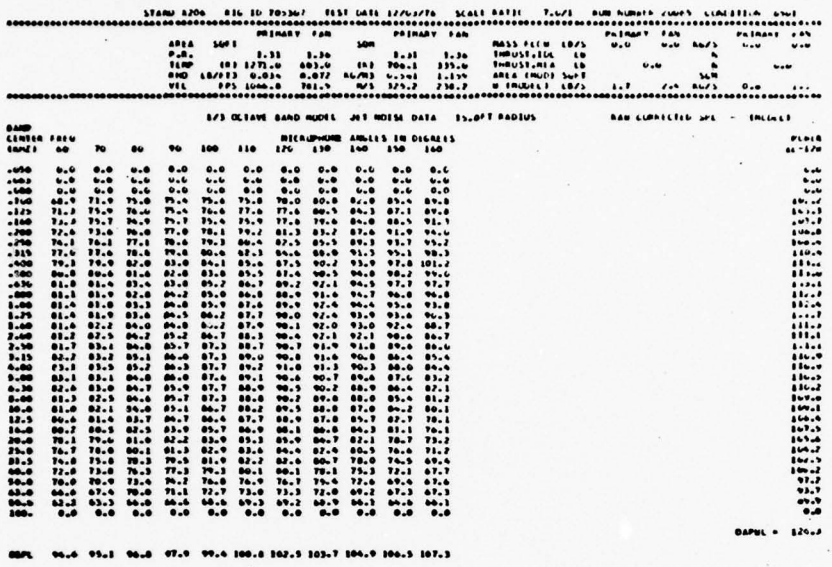
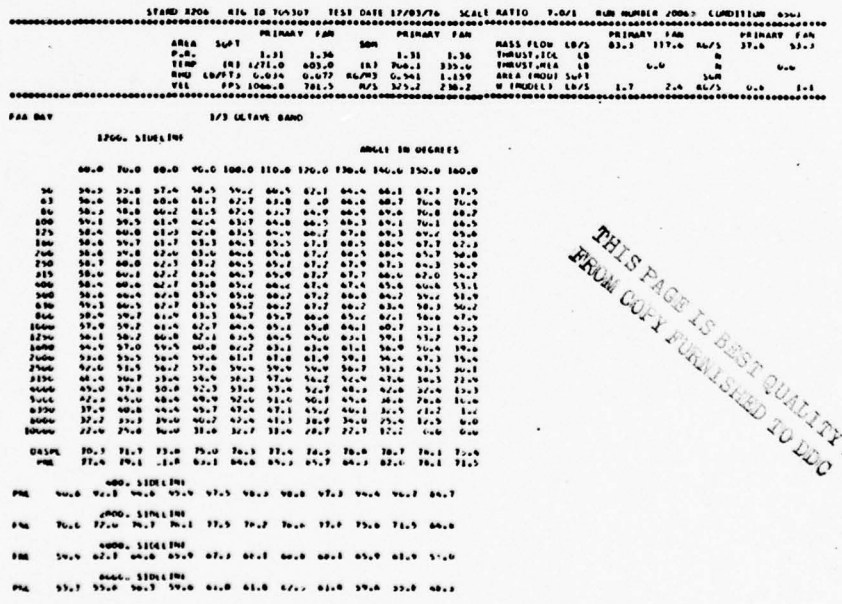
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 5A; Condition 6501

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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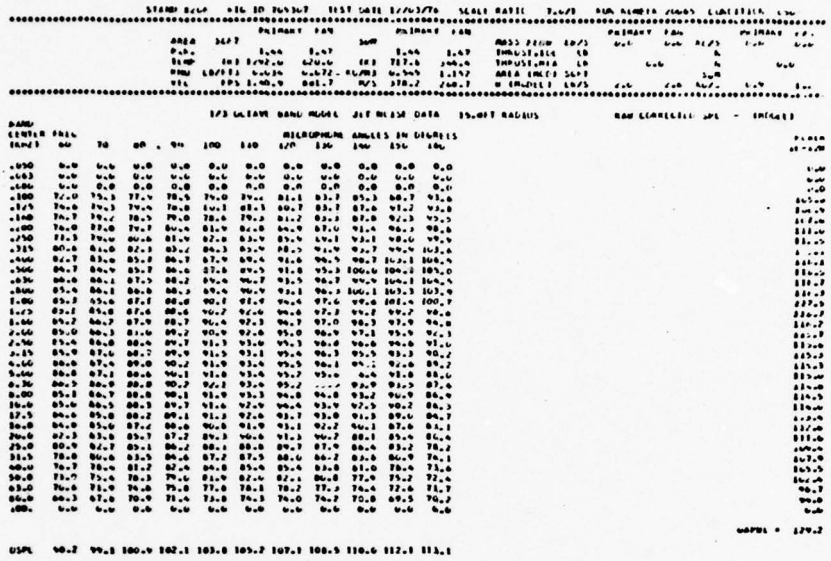
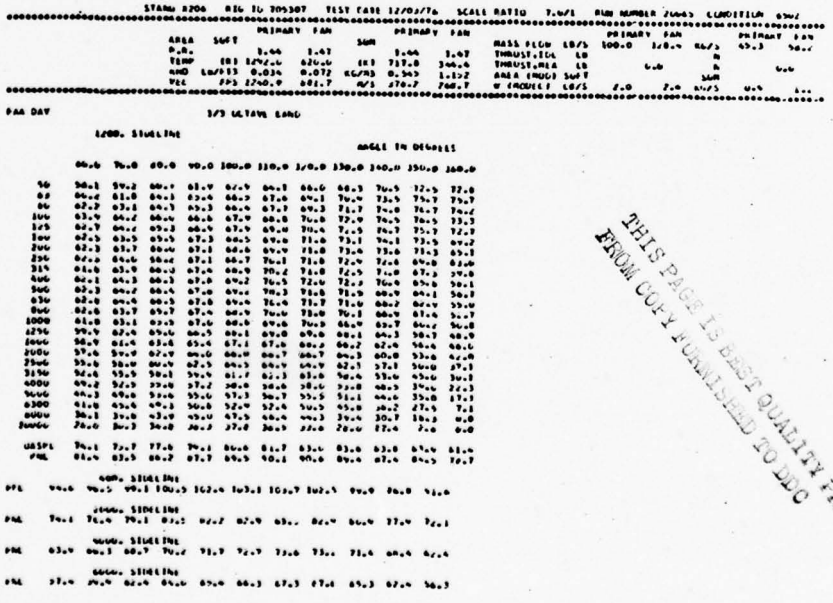
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 5A; Condition 6502

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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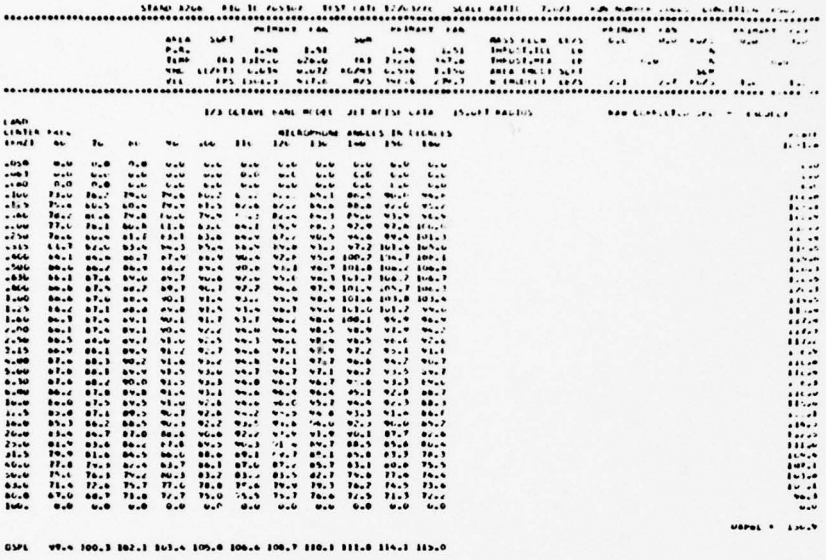
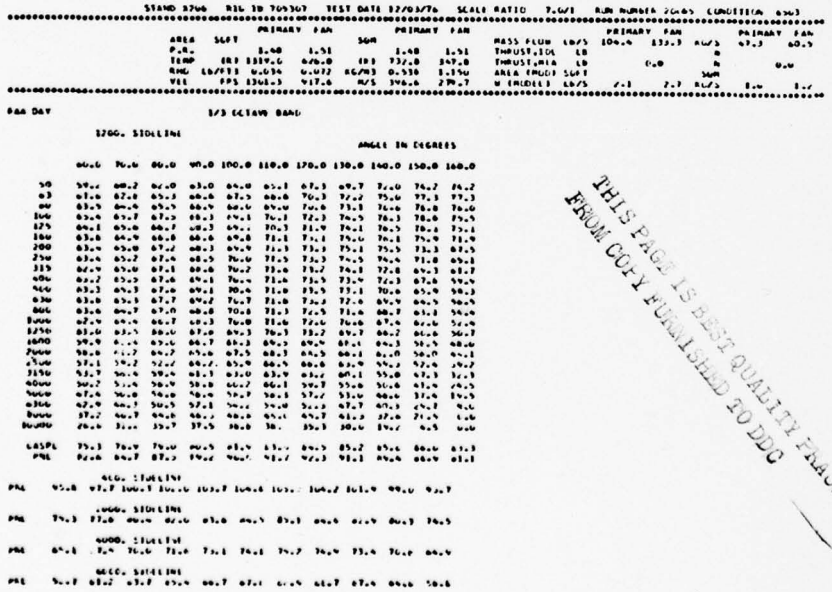
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 5A; Condition 6503

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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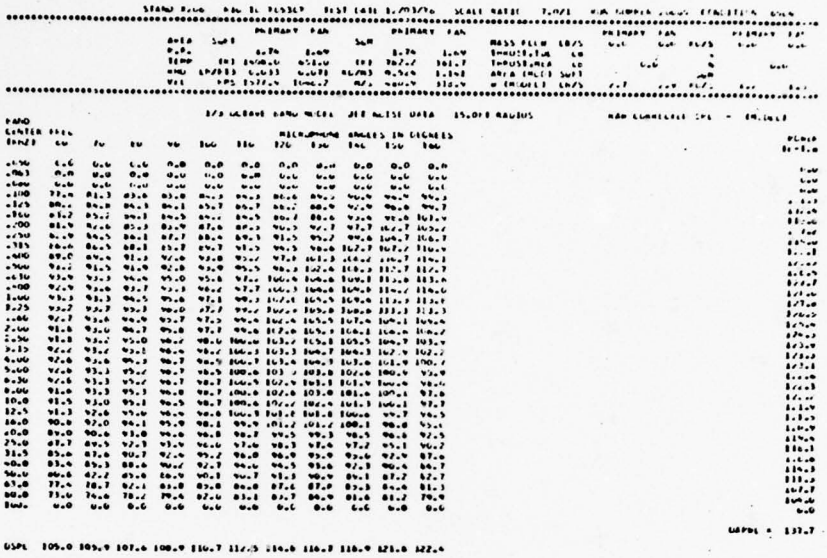
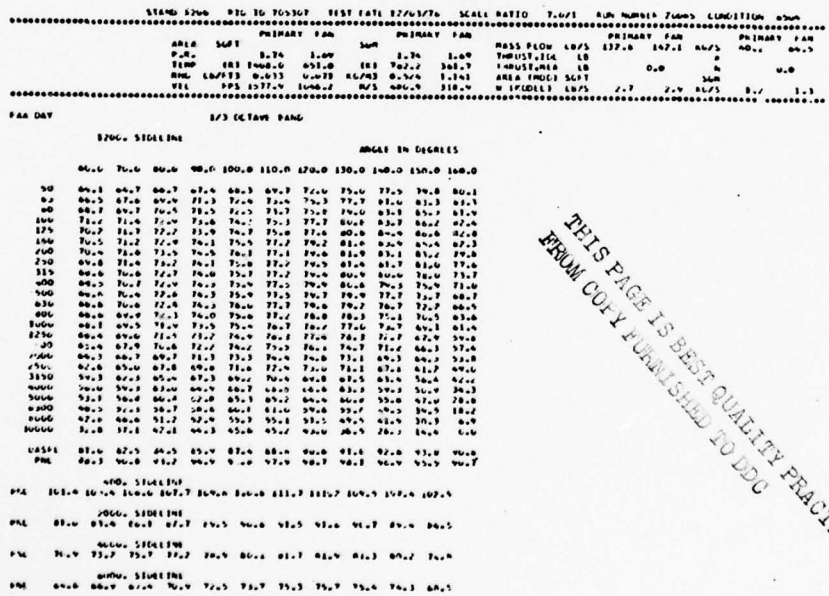
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 5A; Condition 6504

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT9D Engine Jet Noise At 1200 Ft. Linear Distance



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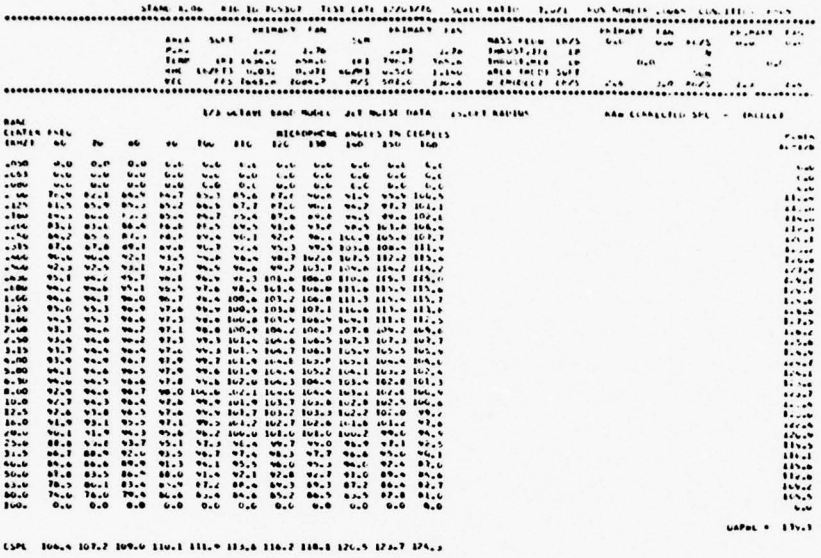
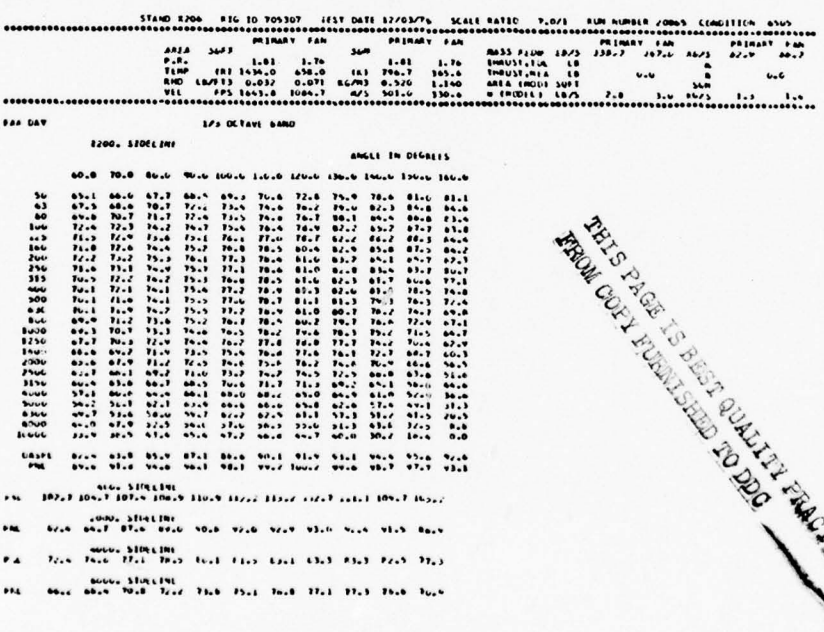
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Flow Simulation; Configuration 5A; Condition 6505

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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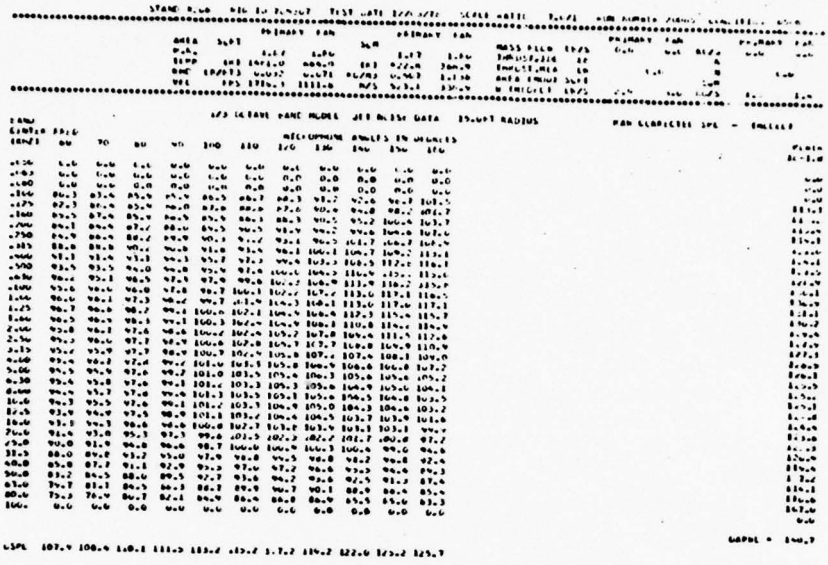
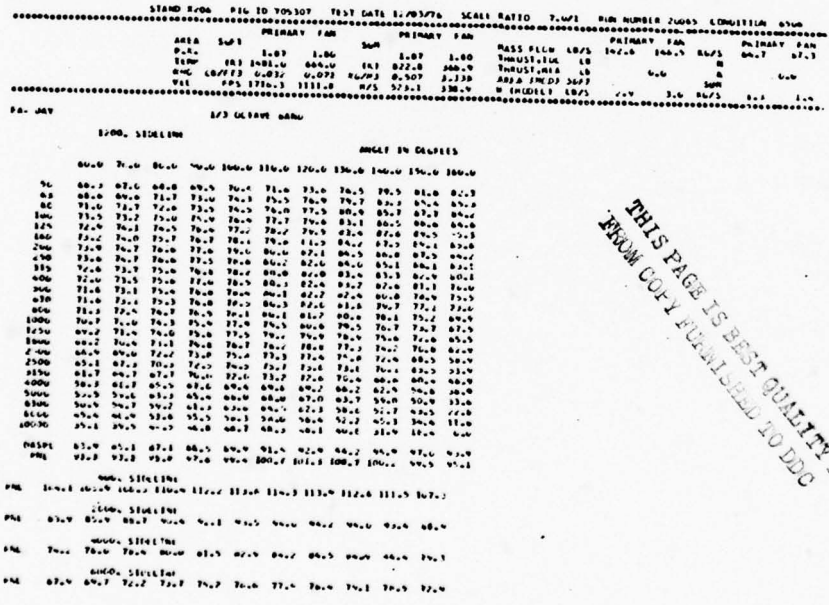
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 5A; Condition 6506

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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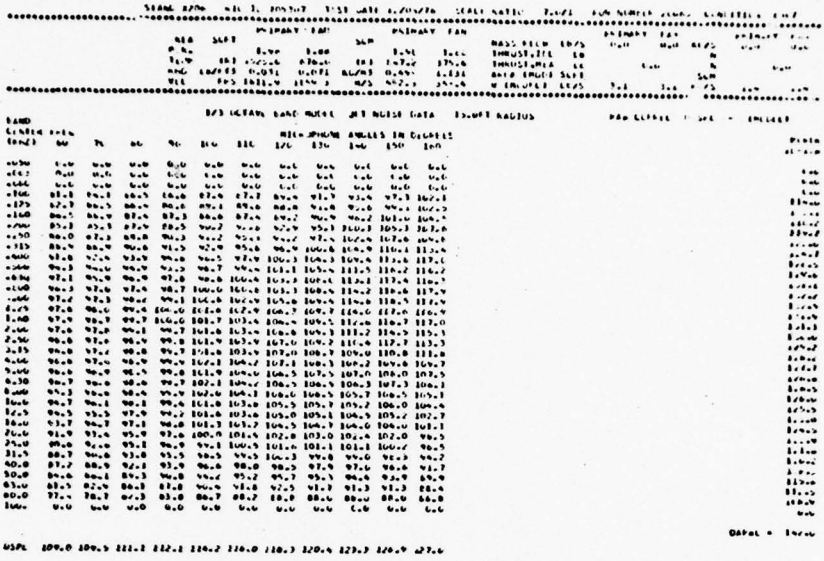
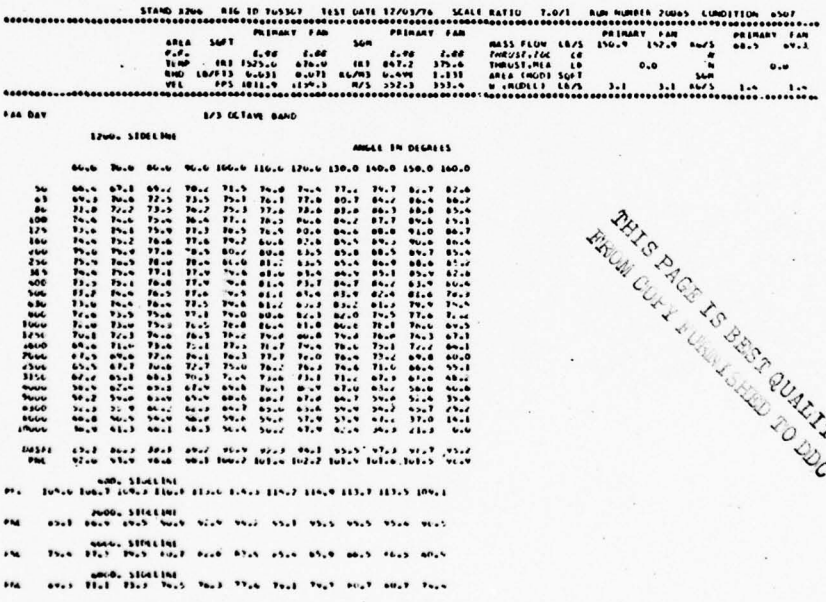
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 5A; Condition 6507

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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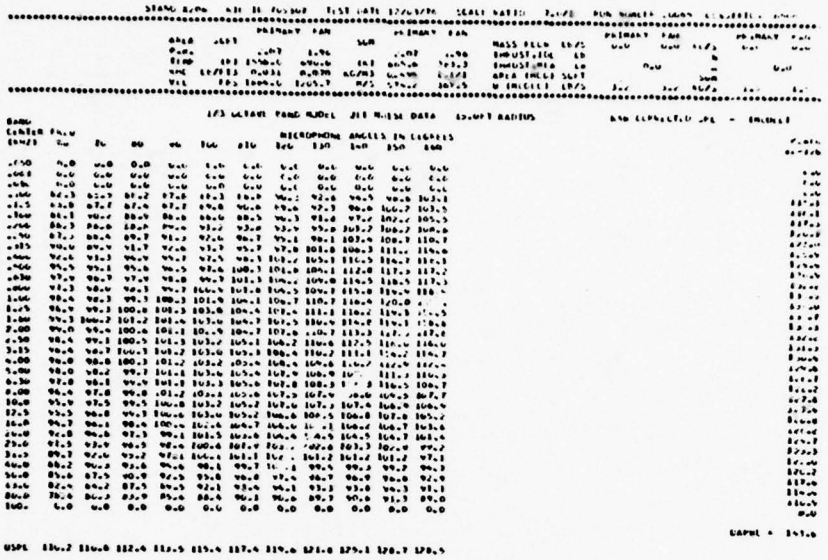
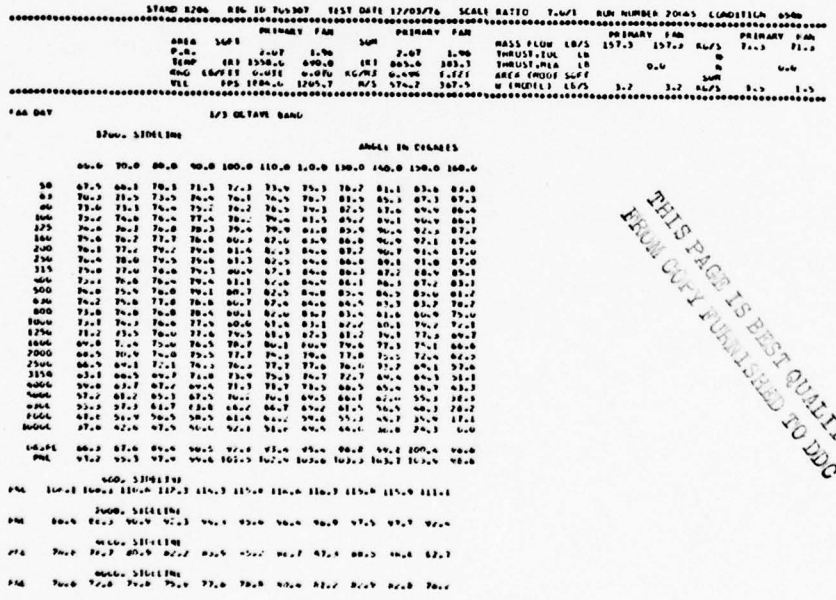
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 5A; Condition 6508

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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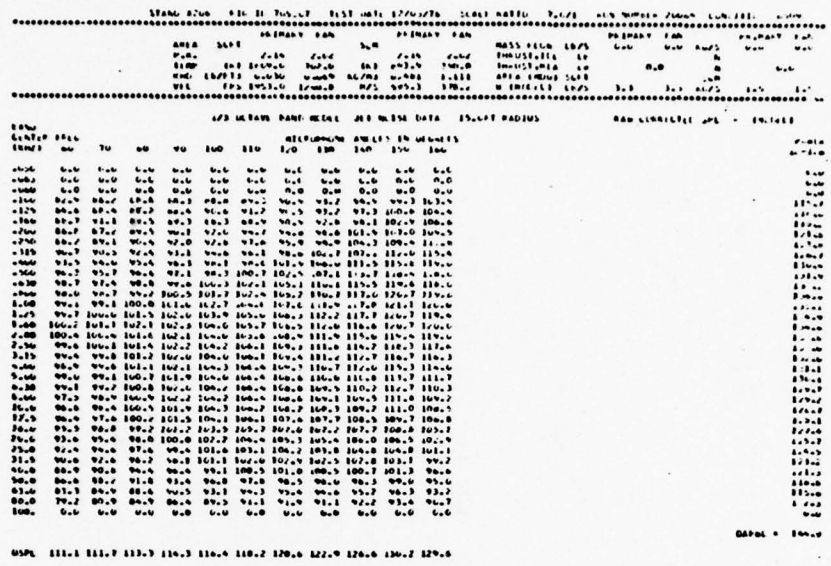
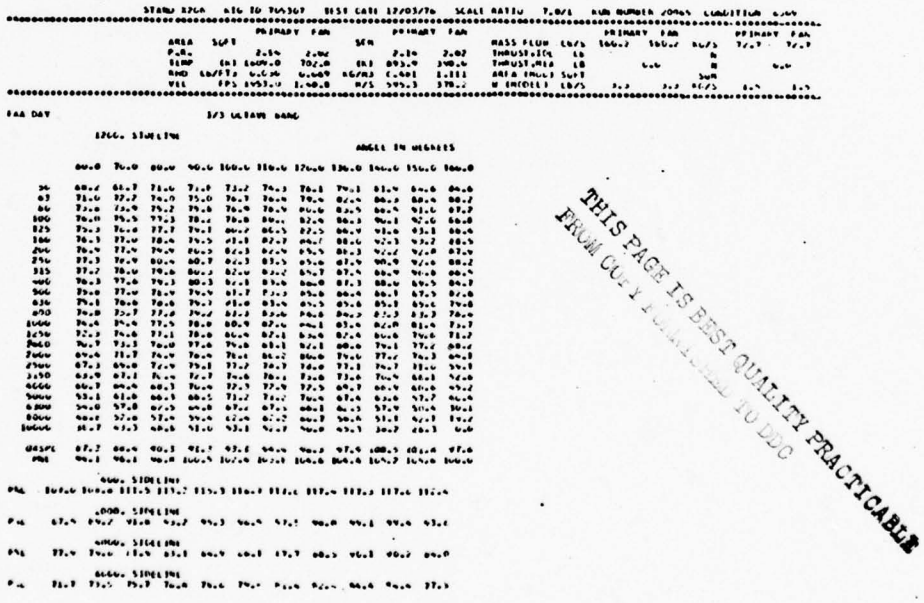
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 5A; Condition 6509

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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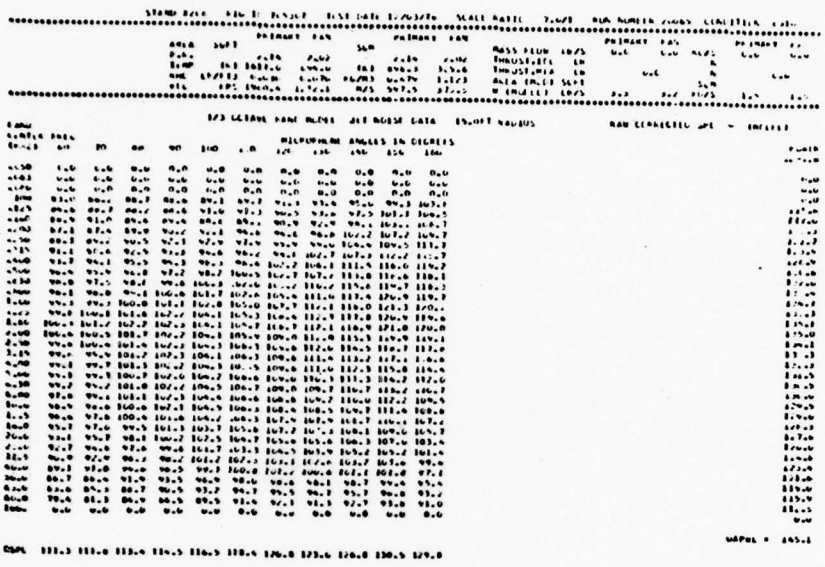
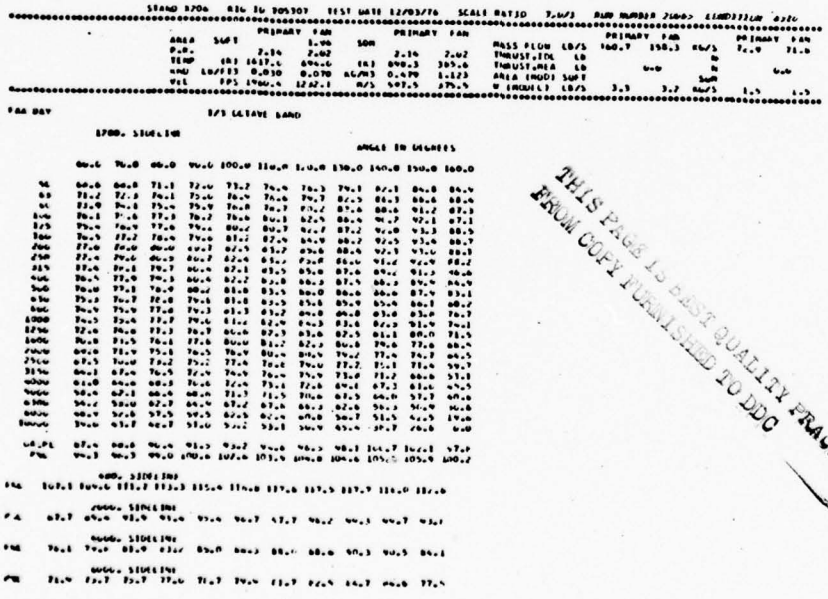
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Long Flowpath Mixer Without Engine Secondary Flow Simulation; Configuration 5A; Condition 6510

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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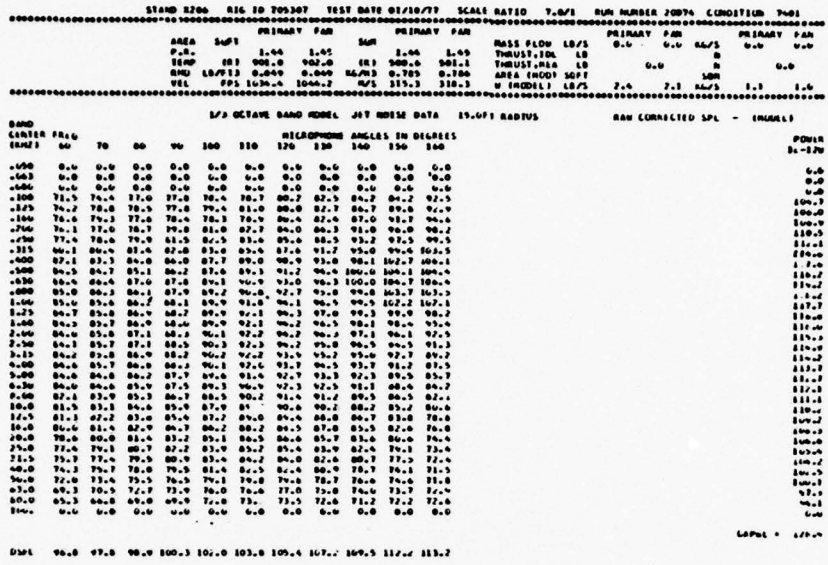
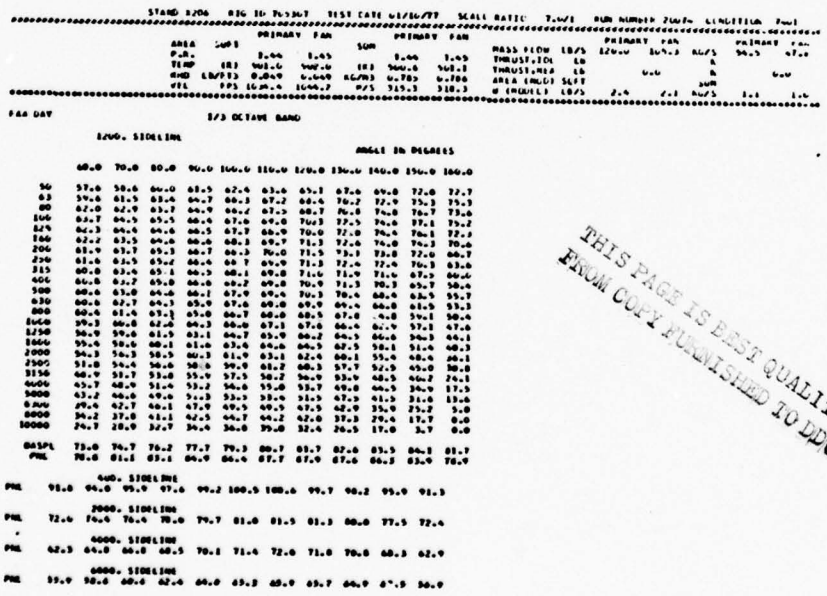
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Tested at Ideally Mixed Conditions Without Engine Secondary Flow Simulation; Configuration 2Am; Condition 7401

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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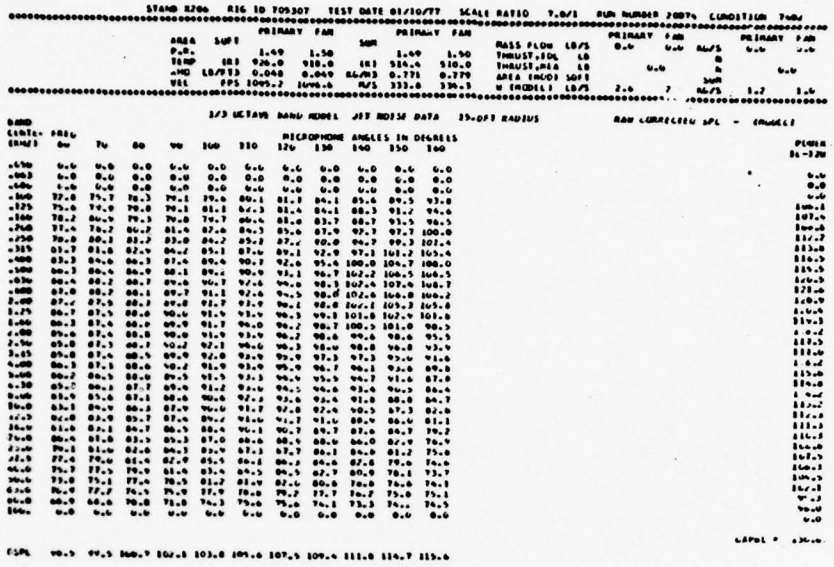
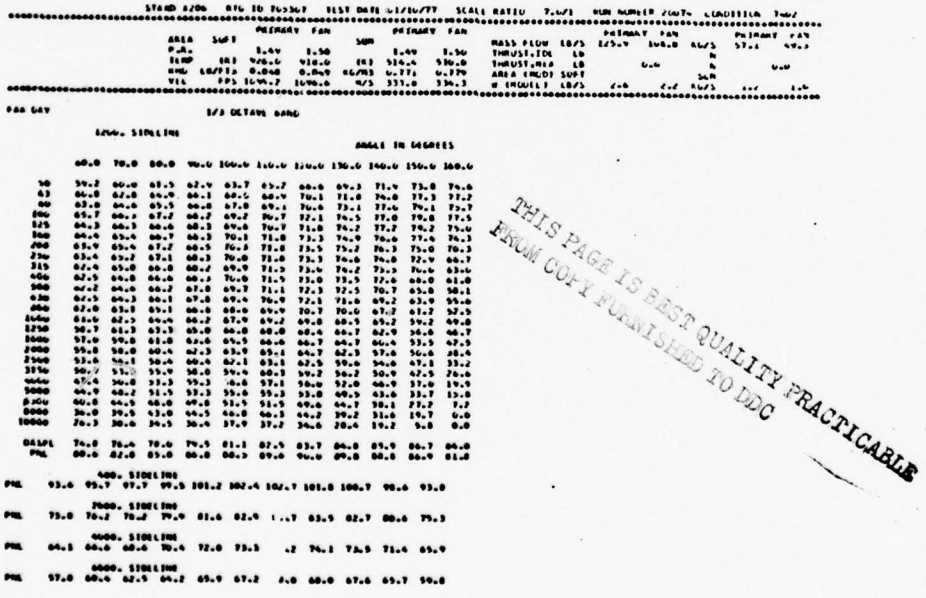
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Tested at Ideally Mixed Conditions Without Engine Secondary Flow Simulation; Configuration 2Am; Condition 7402

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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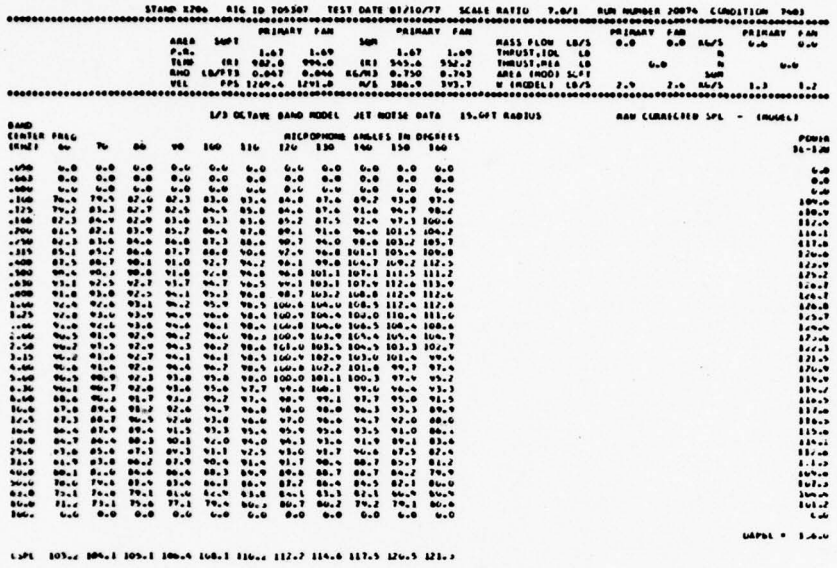
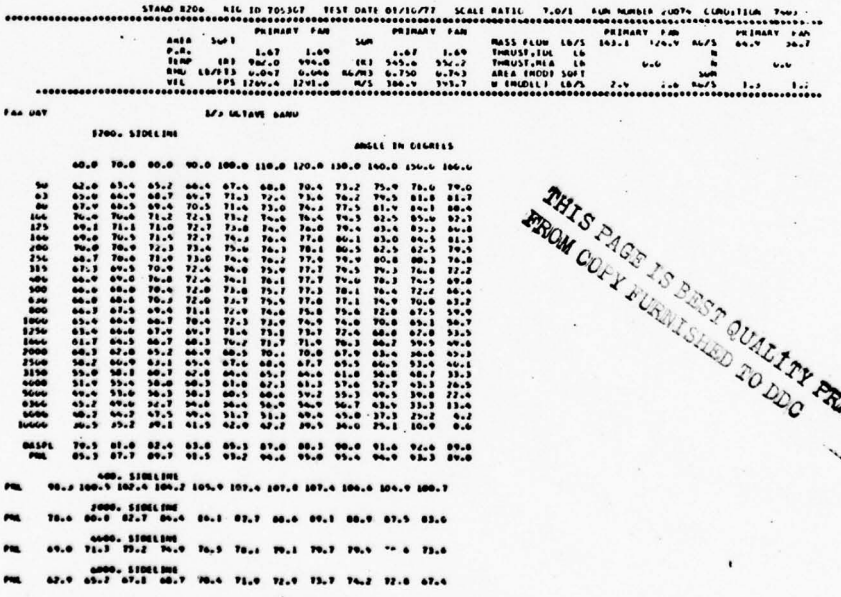
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Tested at Ideally Mixed Conditions Without Engine Secondary Flow Simulation; Configuration 2Am; Condition 7403

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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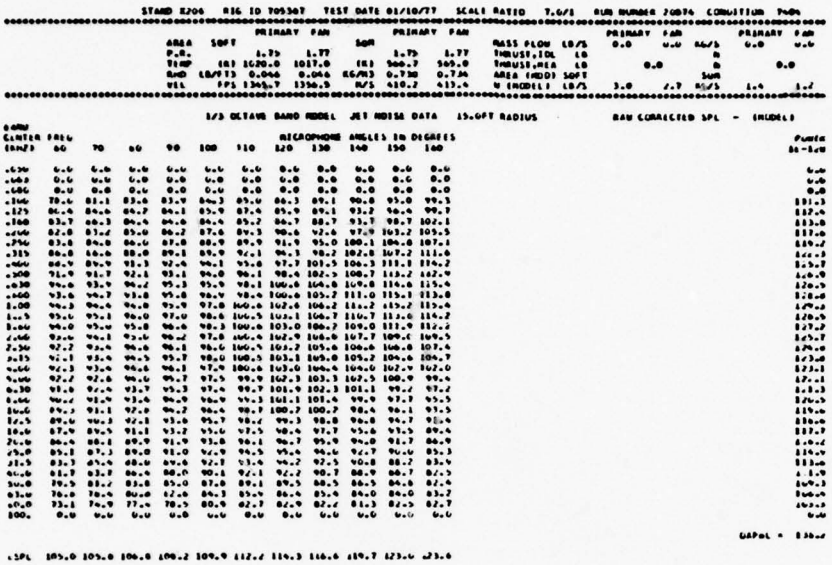
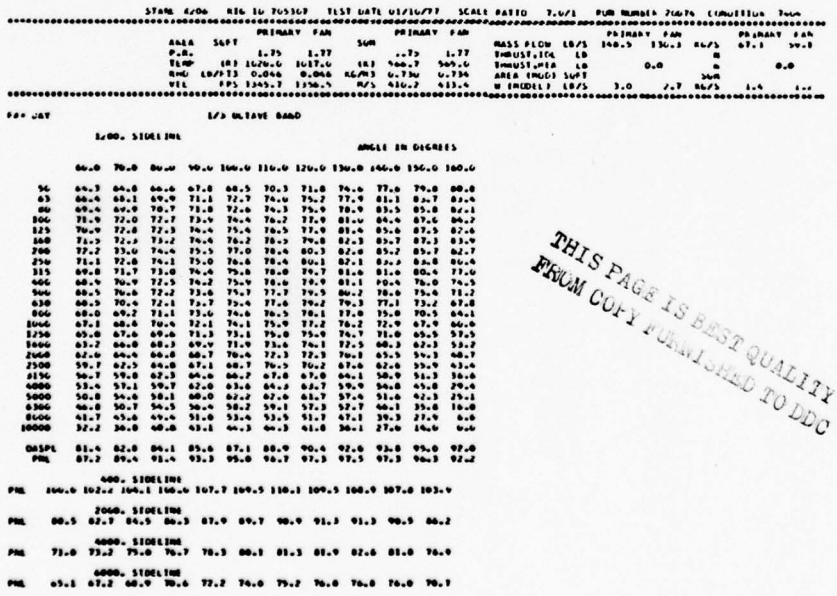
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Tested at Ideally Mixed Conditions Without Engine Secondary Flow Simulation; Configuration 2Am; Condition 7404

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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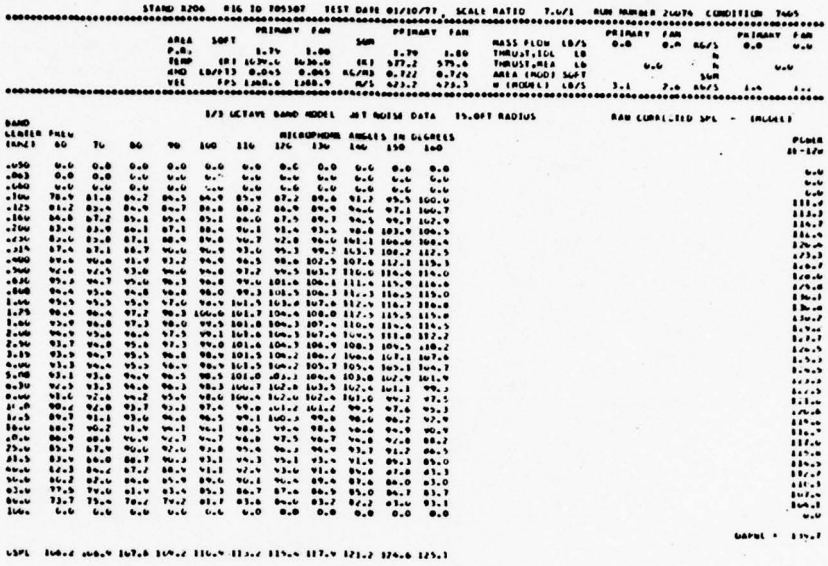
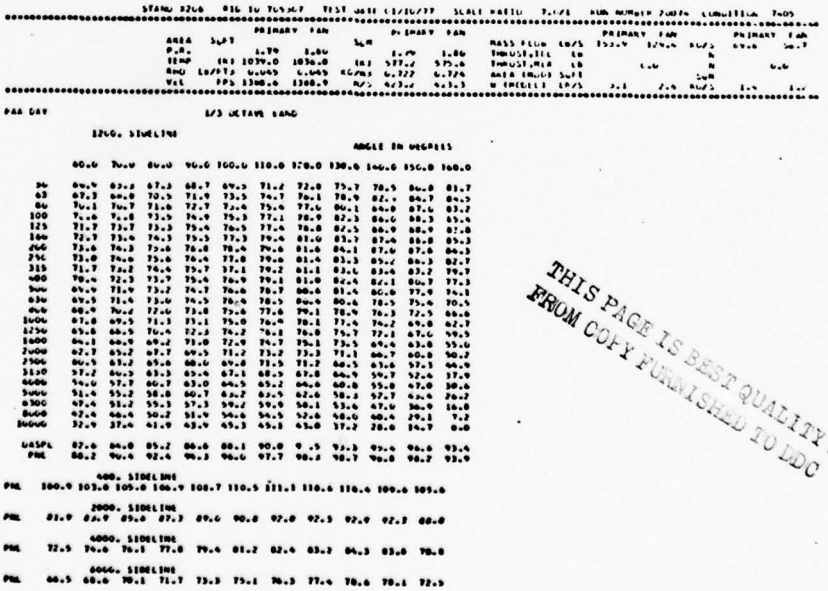
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Tested at Ideally Mixed Conditions Without Engine Secondary Flow Simulation; Configuration 2Am; Condition 7405

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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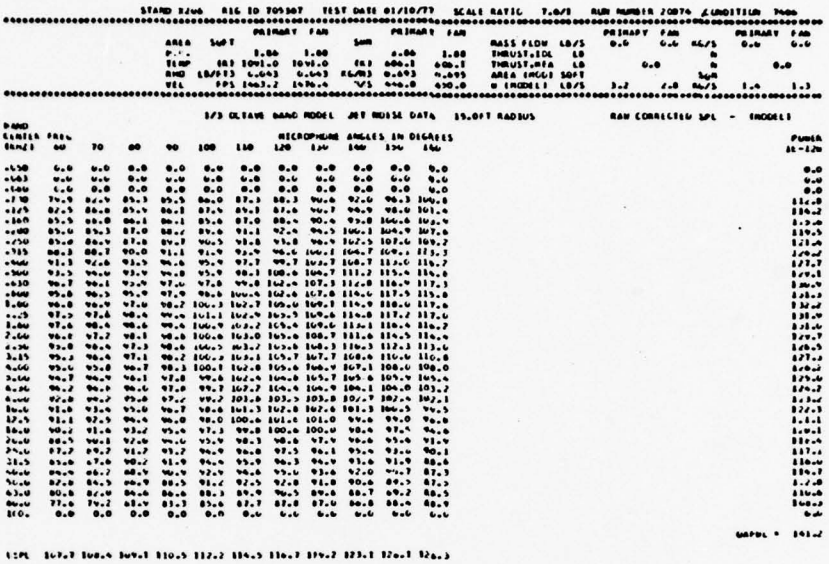
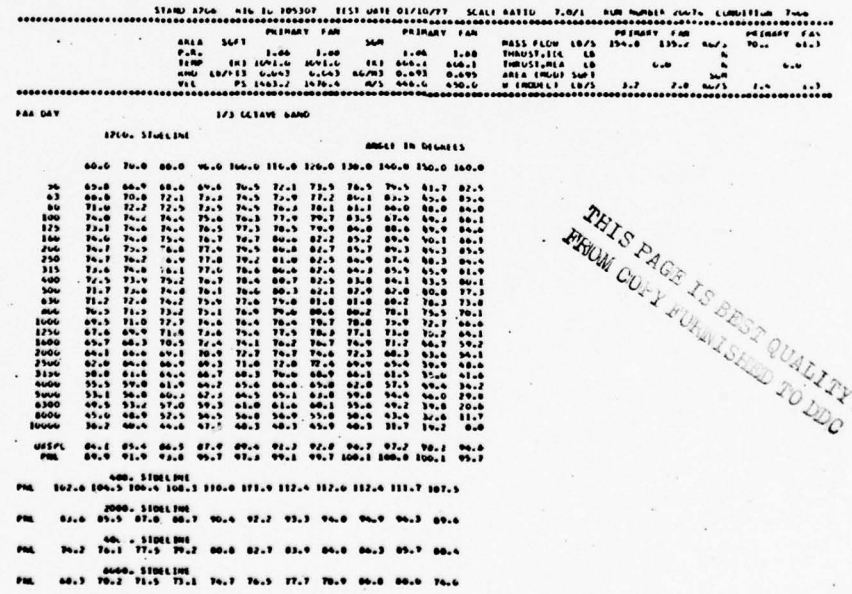
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Tested at Ideally Mixed Conditions Without Engine Secondary Flow Simulation; Configuration 2Am; Condition 7406

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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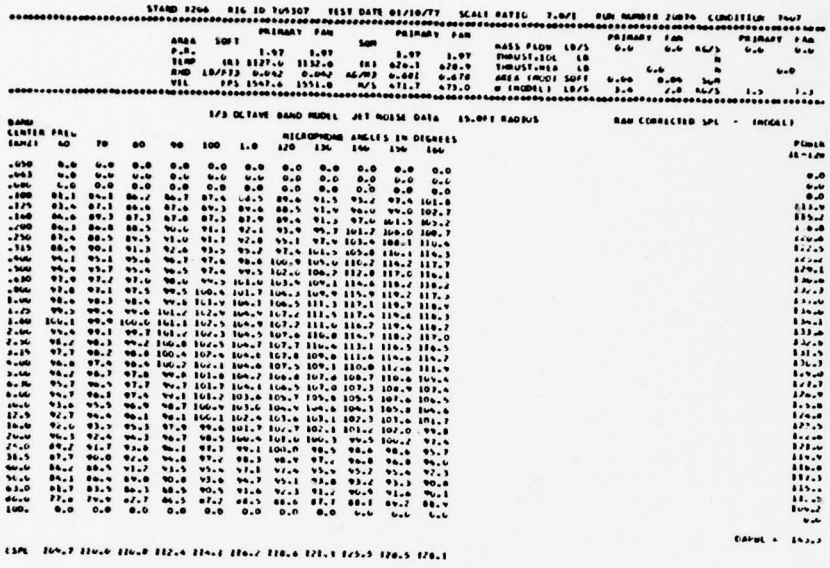
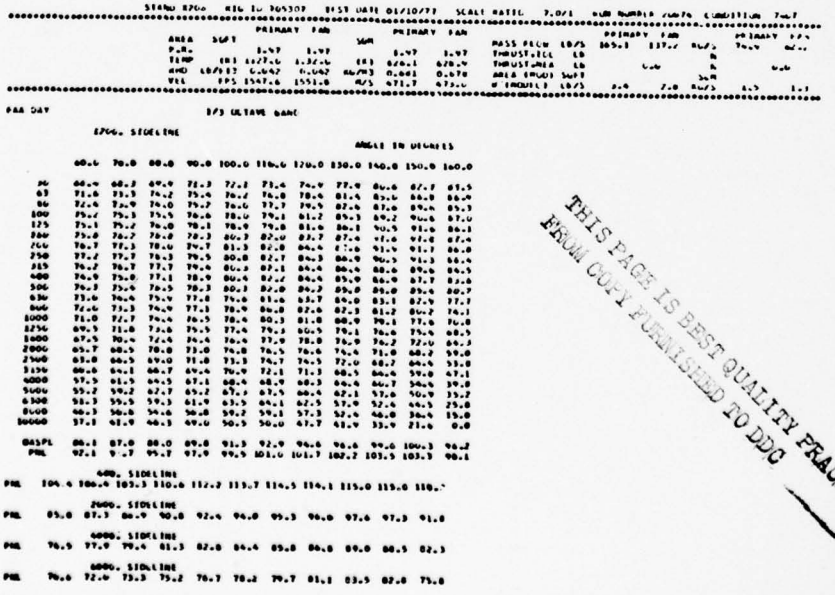
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Tested at Ideally Mixed Conditions Without Engine Secondary Flow Simulation; Configuration 2Am; Condition 7407

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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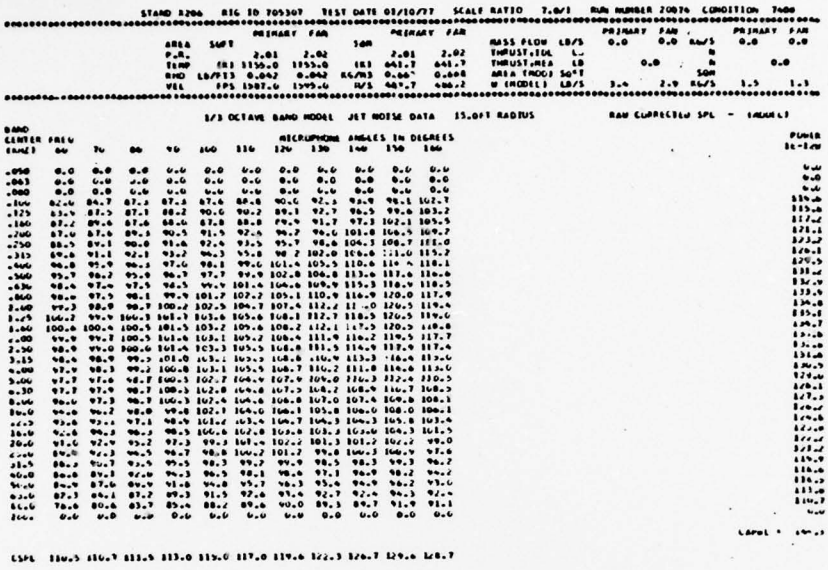
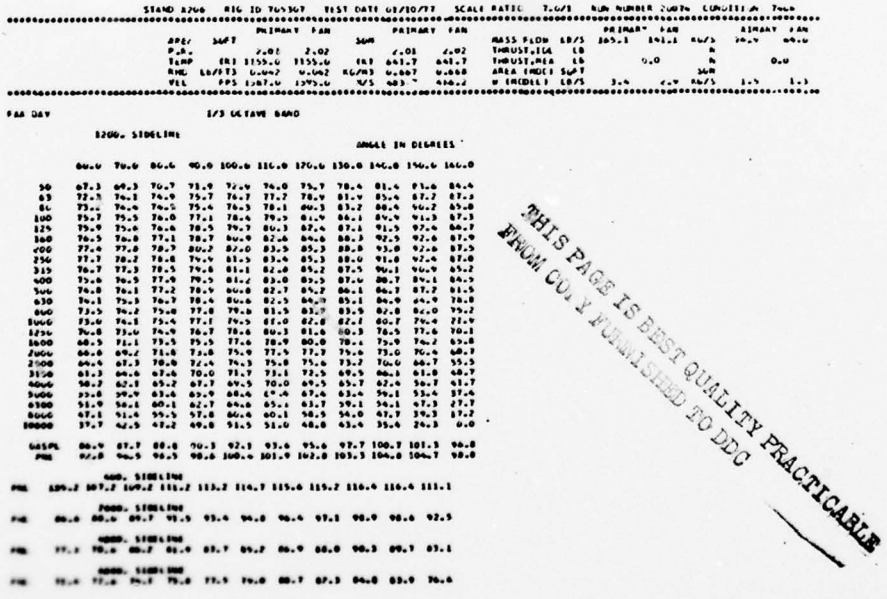
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Tested at Ideally Mixed Conditions Without Engine Secondary Flow Simulation; Configuration 2A.m; Condition 7408

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



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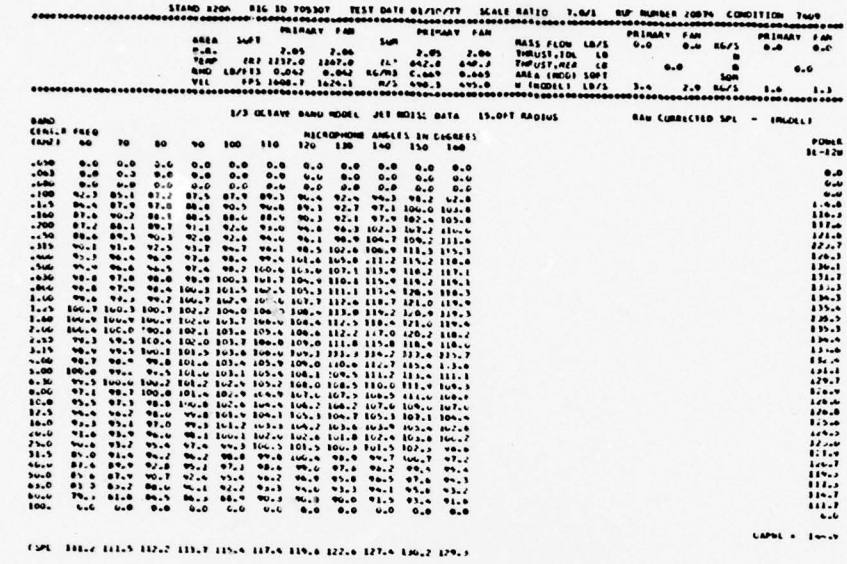
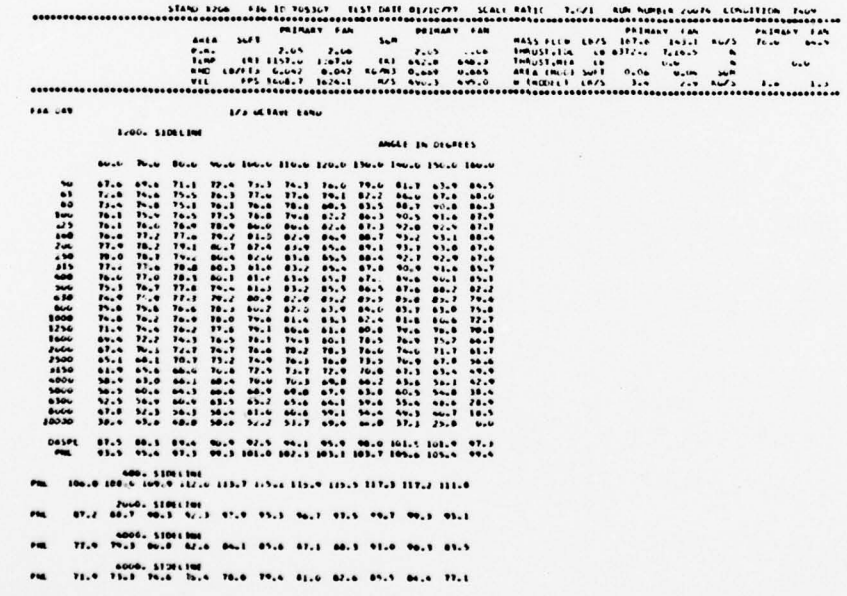
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Reference Exhaust System Tested at Ideally Mixed Conditions Without Engine Secondary Flow Simulation; Configuration 2Am; Condition 7409

a.) Model Data Measured At 15 Ft. Radius



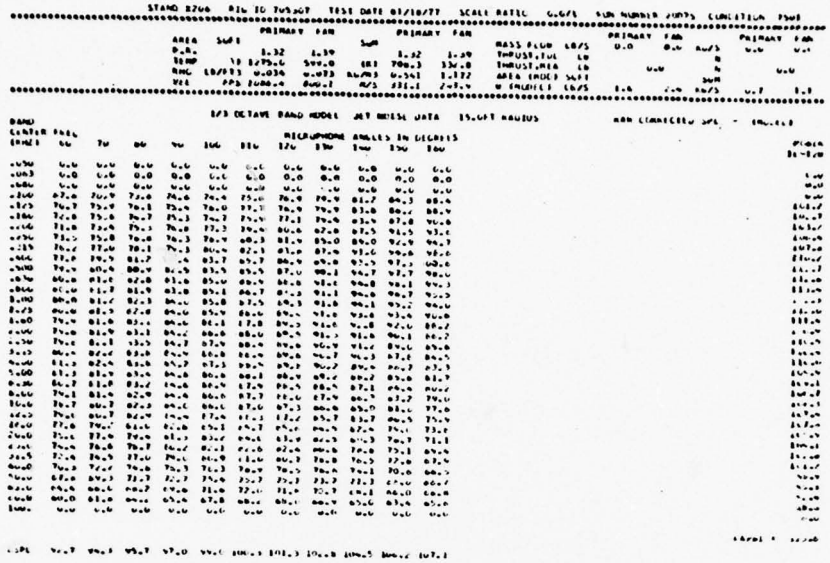
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



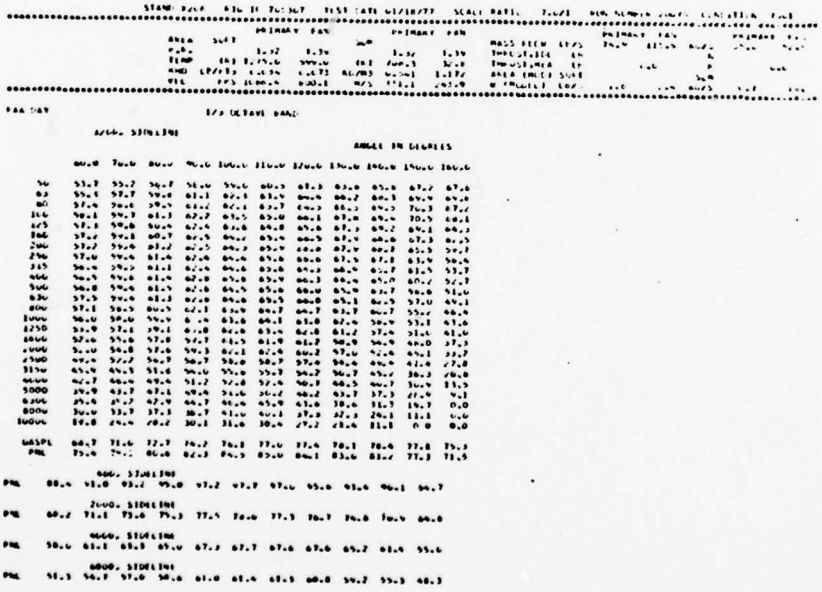
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 7A; Condition 7501

a.) Model Data Measured At 15 Ft. Radius



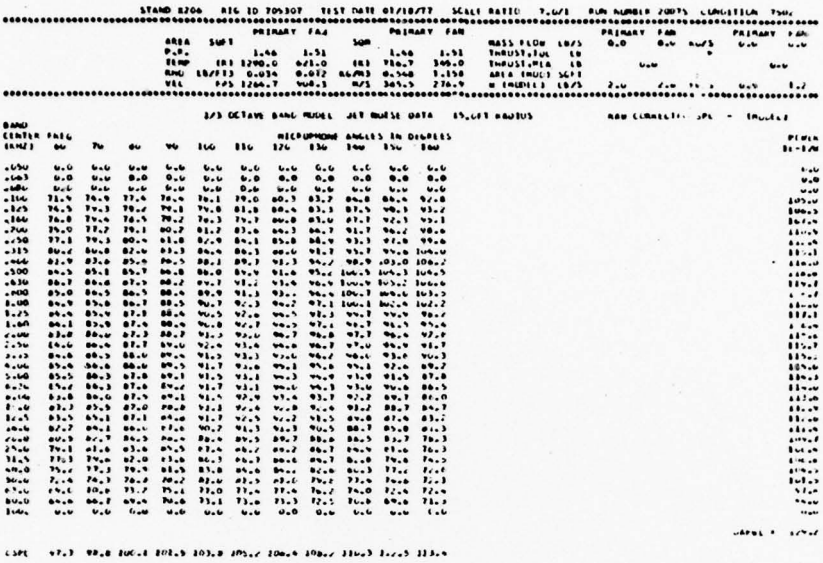
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



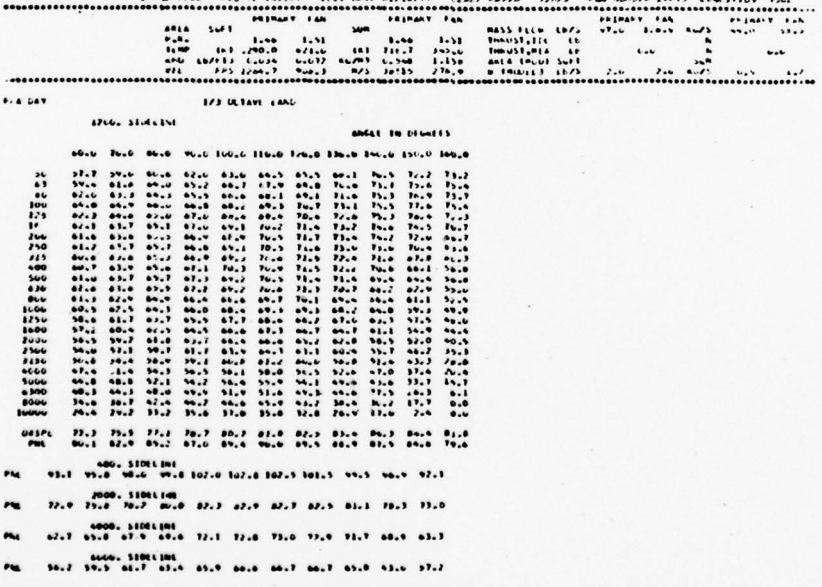
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 7A; Condition 7502

a.) Model Data Measured At 15 Ft. Radius



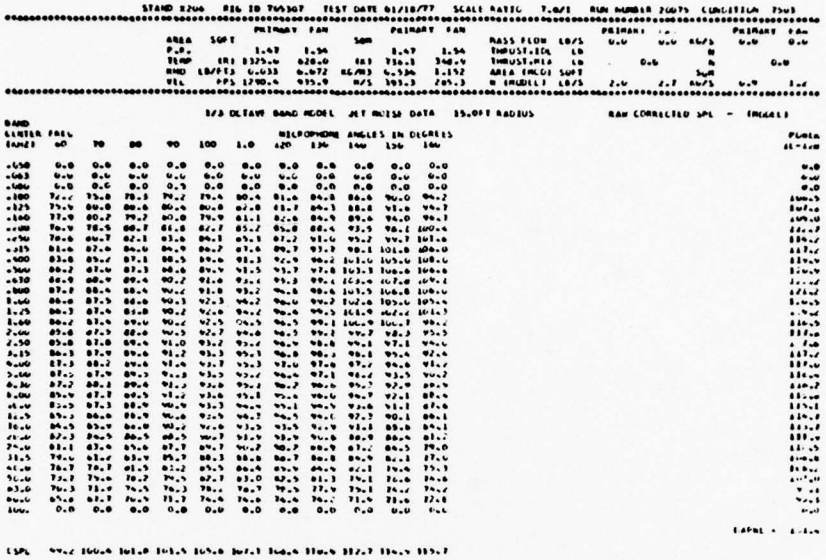
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



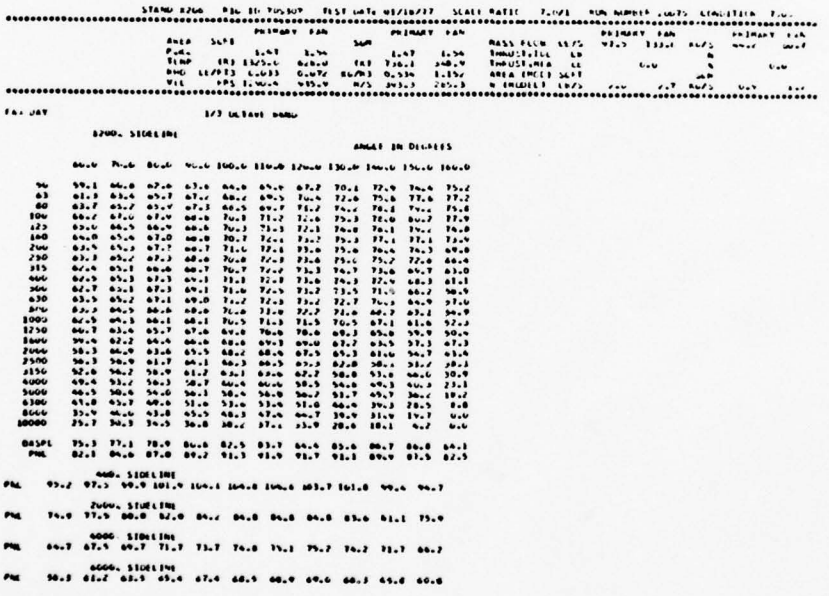
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 7A; Condition 7503

a.) Model Data Measured At 15 Ft. Radius



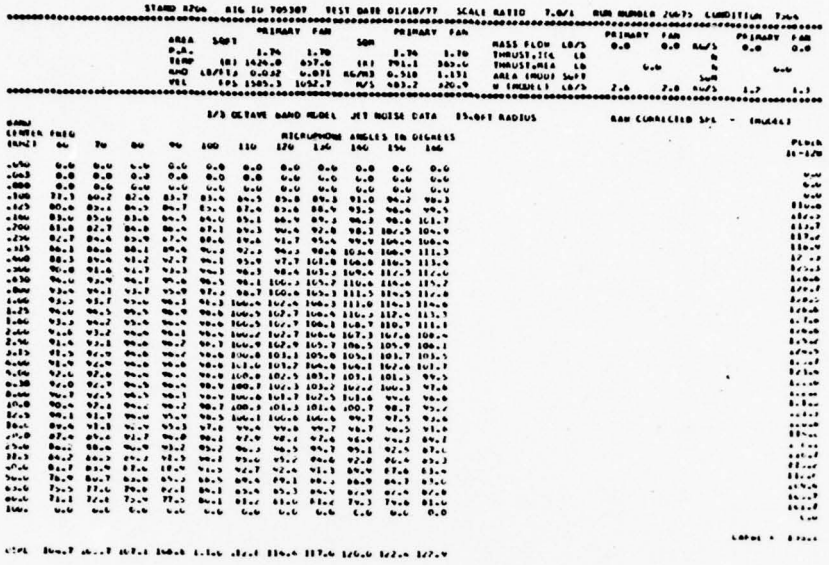
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



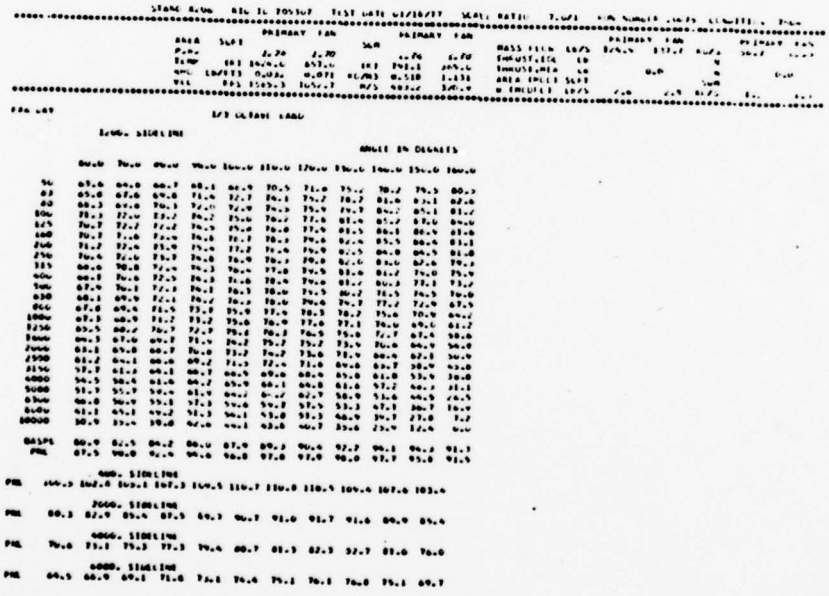
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 7A; Condition 7504

a.) Model Data Measured At 15 Ft. Radius



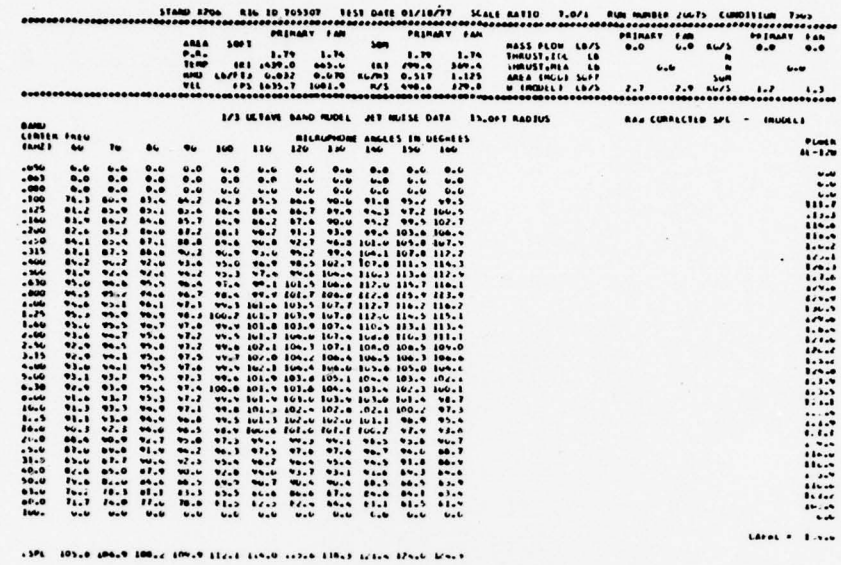
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



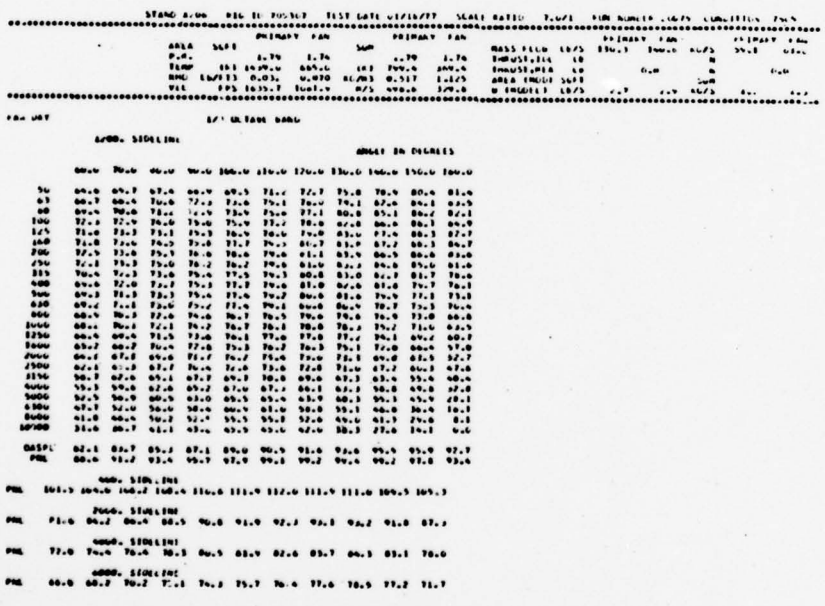
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 7A; Condition 7505

a.) Model Data Measured At 15 Ft. Radius



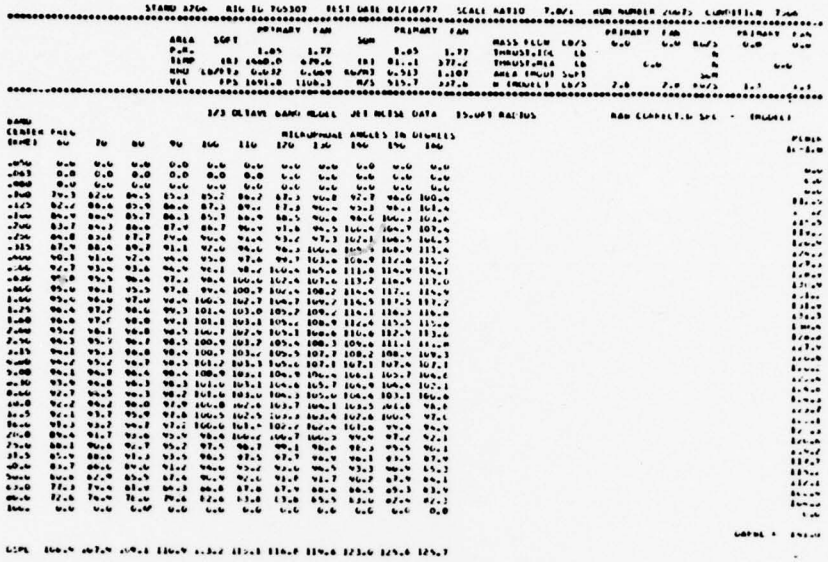
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



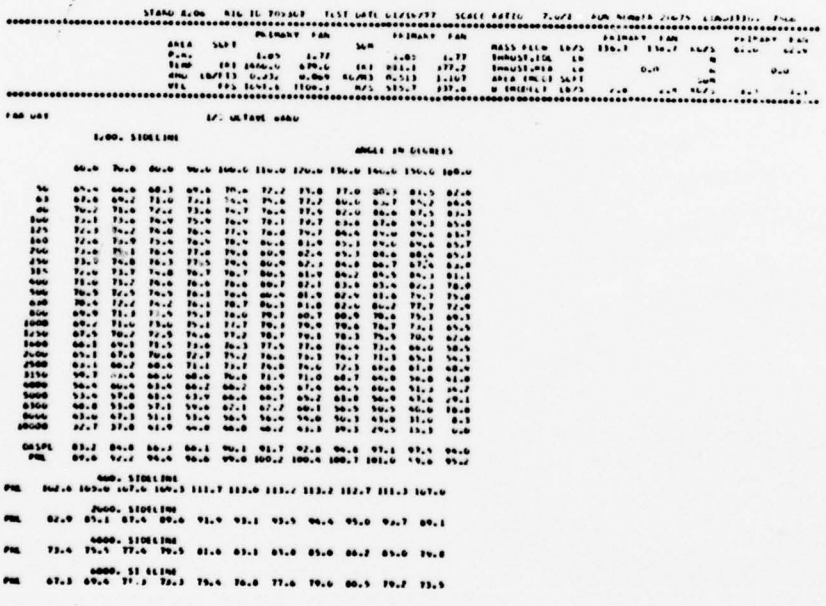
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 7A; Condition 7506

a.) Model Data Measured At 15 Ft. Radius



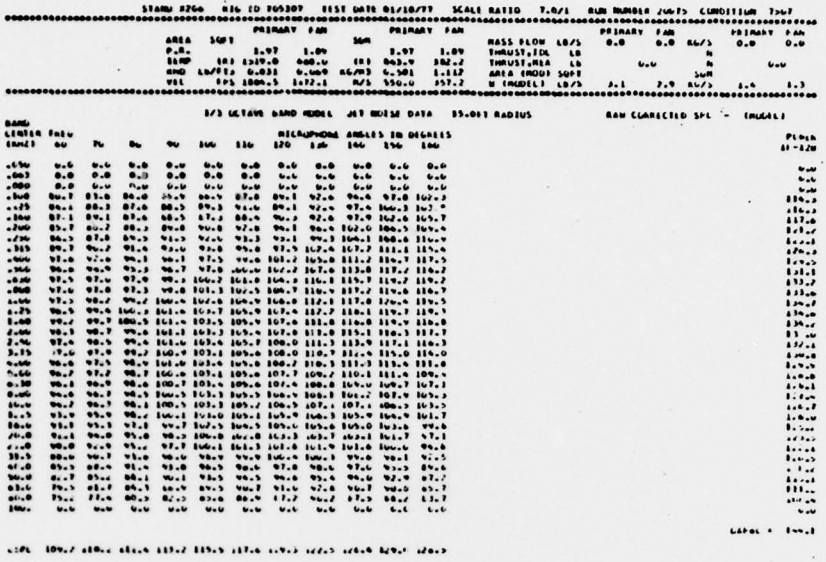
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



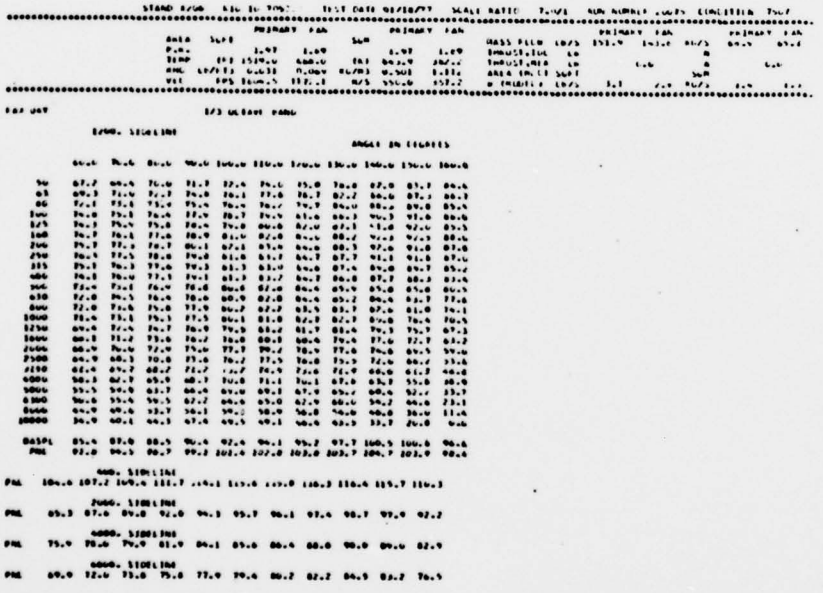
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 7A; Condition 7507

a.) Model Data Measured At 15 Ft. Radius



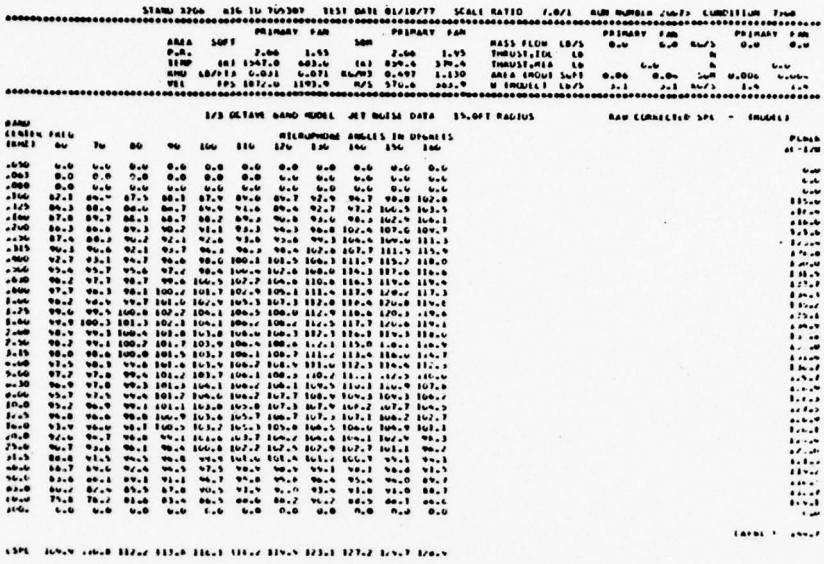
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



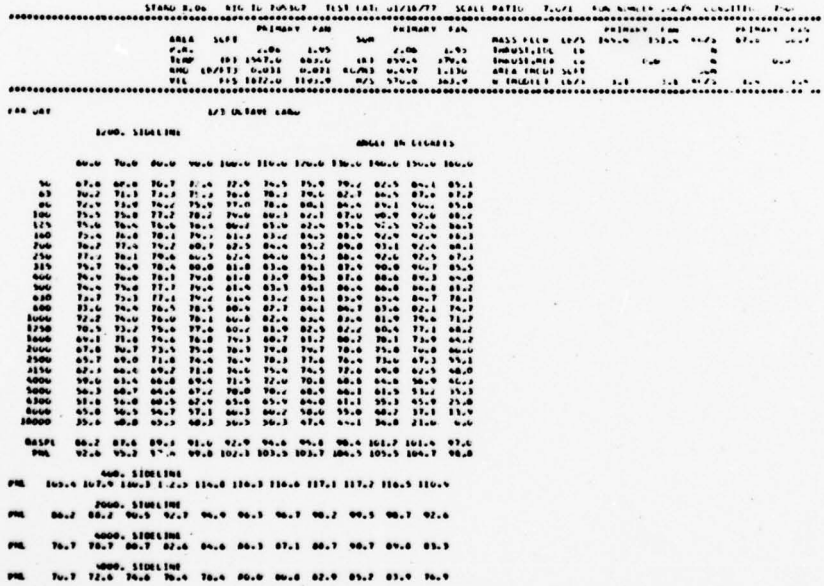
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 7A; Condition 7508

a.) Model Data Measured At 15 Ft. Radius



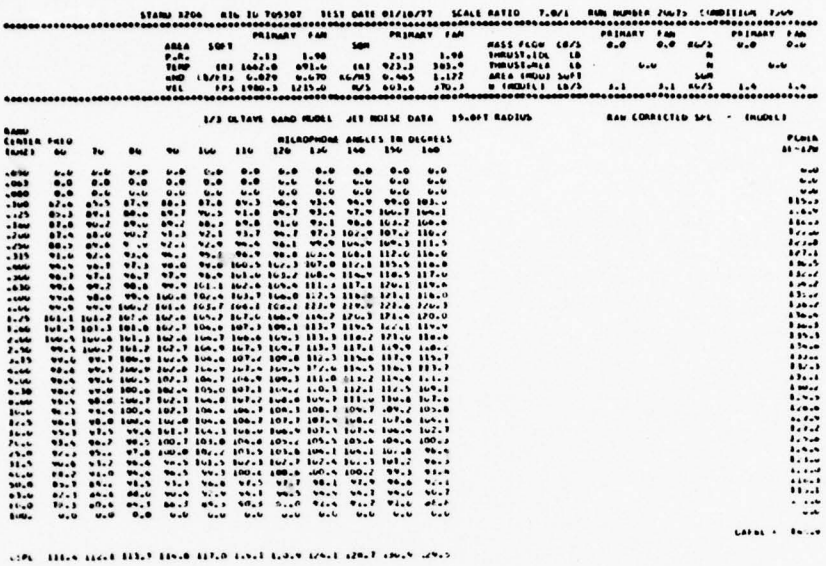
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



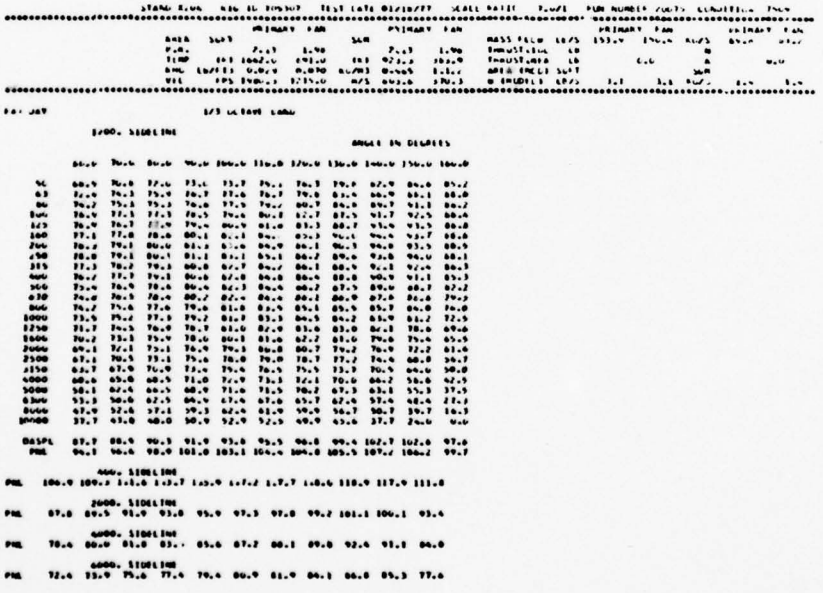
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 7A; Condition 7509

a.) Model Data Measured At 15 Ft. Radius



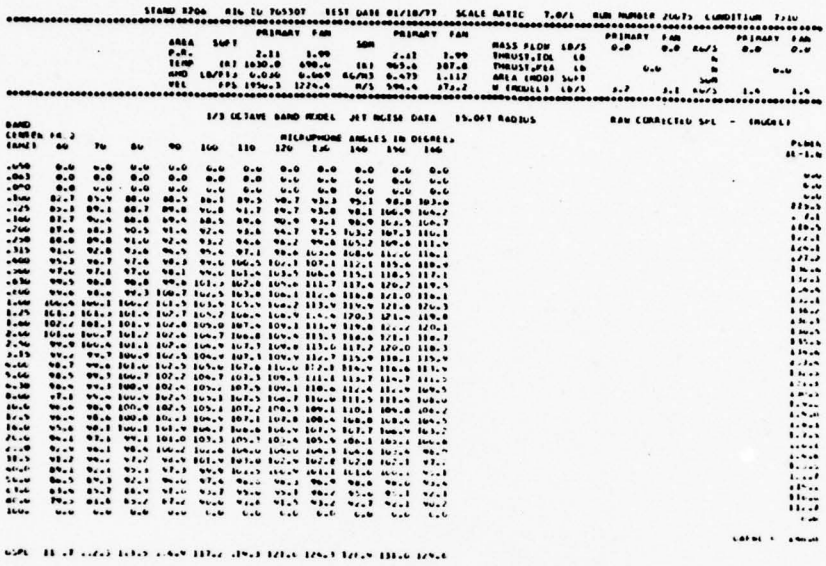
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



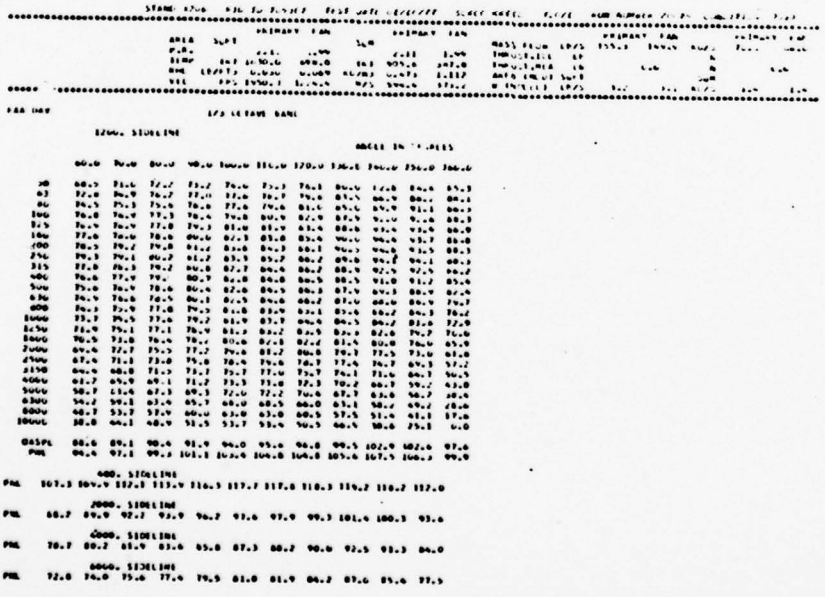
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Scalloped Long Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 7A; Condition 7510

a.) Model Data Measured At 15 Ft. Radius



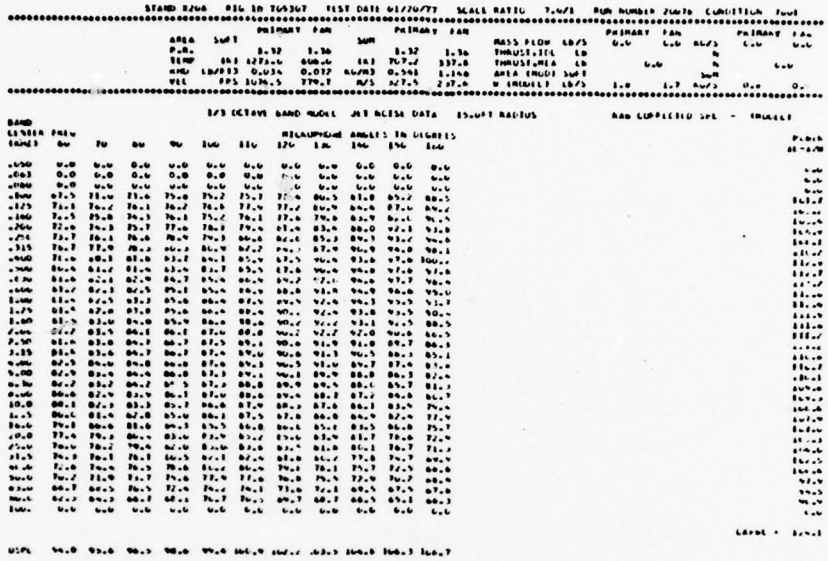
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



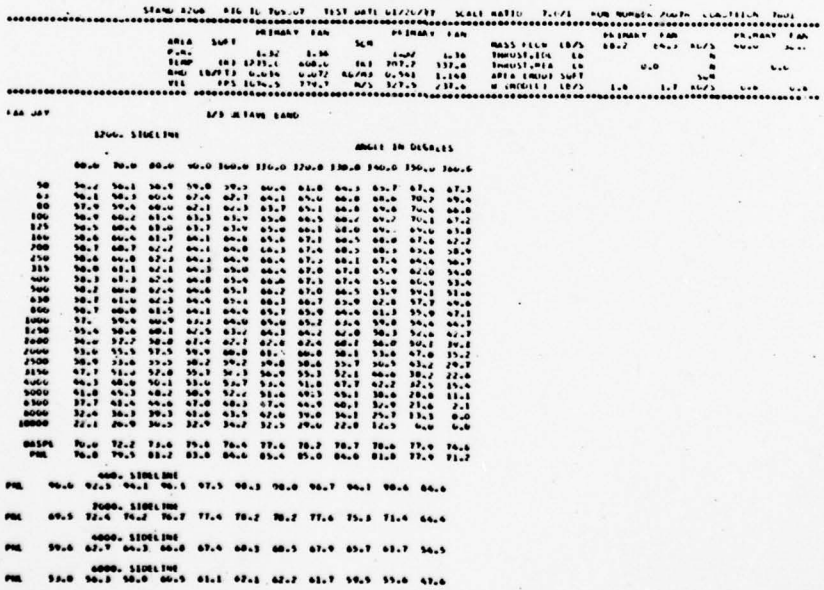
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Mixer Modified to Fit Within 7.6 Inch Engine Extension Without Engine Secondary Flow Simulation; Configuration 8A; Condition 7601

a.) Model Data Measured At 15 Ft. Radius



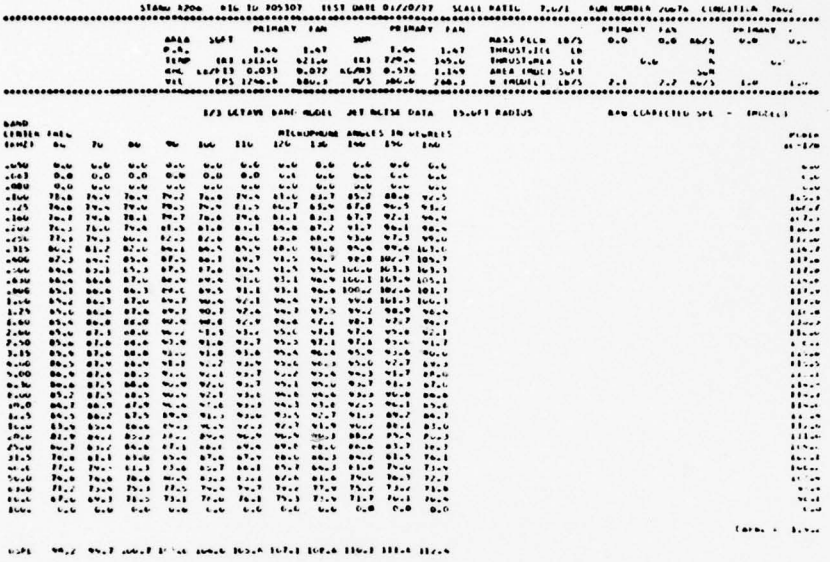
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



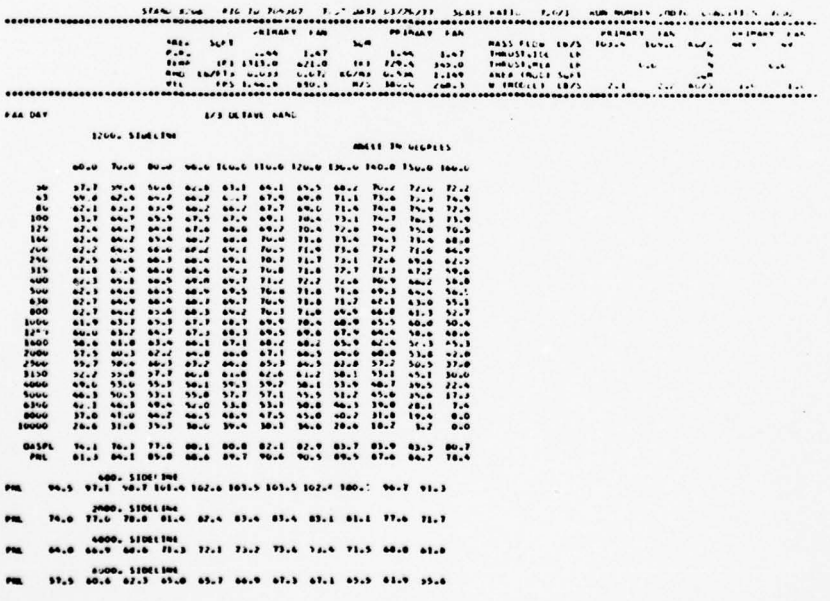
Measured model and scaled data are referenced and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Mixer Modified to Fit Within 7.6 Inch Engine Extension Without Engine Secondary Flow Simulation; Configuration 8A; Condition 7602

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (. .°F, 70% RH)

AD-A057 310 PRATT AND WHITNEY AIRCRAFT GROUP EAST HARTFORD CONN F/G 20/1
INTERNAL MIXER INVESTIGATION FOR JT8D ENGINE JET NOISE REDUCTIO--ETC(U)
DEC 77 A B PACKMAN, D C EILER DOT-FA76WA-3809
UNCLASSIFIED PWA-5582-VOL-2 FAA-RD-77-132-2 NL

2 OF 2
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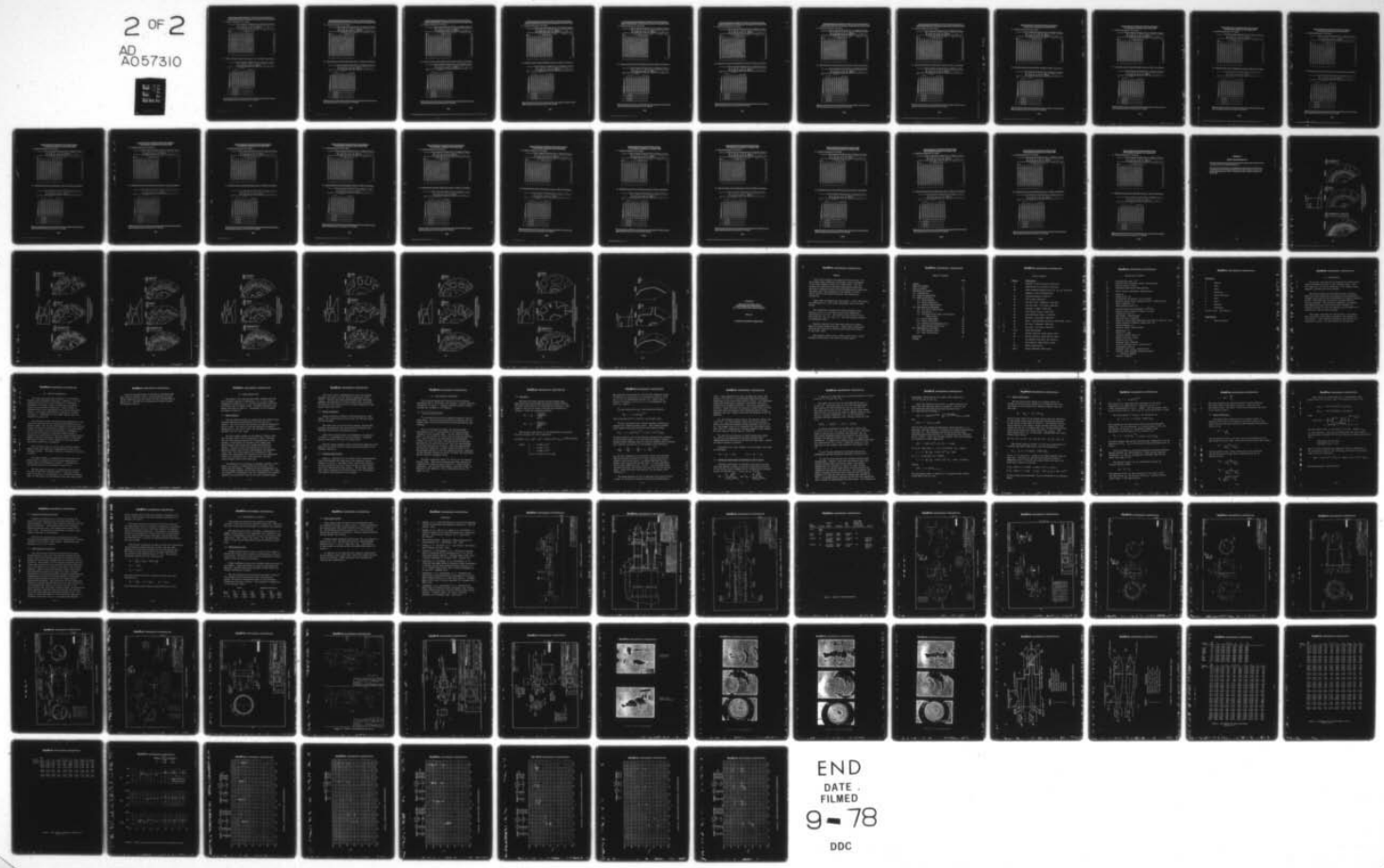

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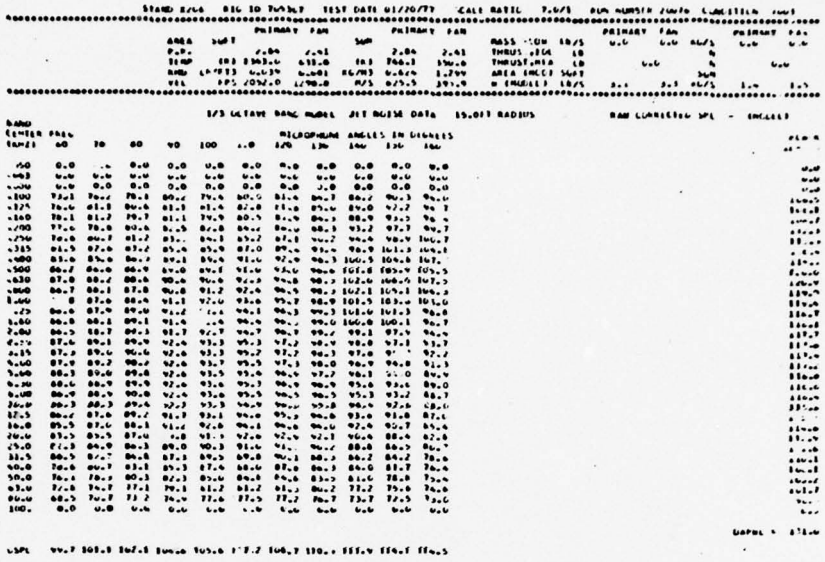
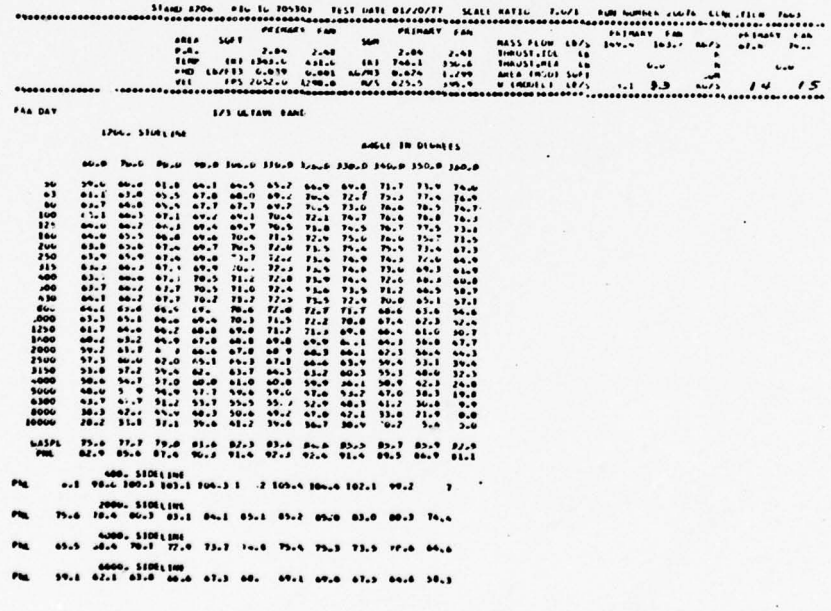
Cutback Scalloped Mixer Modified to Fit Within 7.6 Inch Engine Extension Without Engine Secondary Flow Simulation; Configuration 8A; Condition 7603

a.) Model Data Measured At 15 Ft. Radius



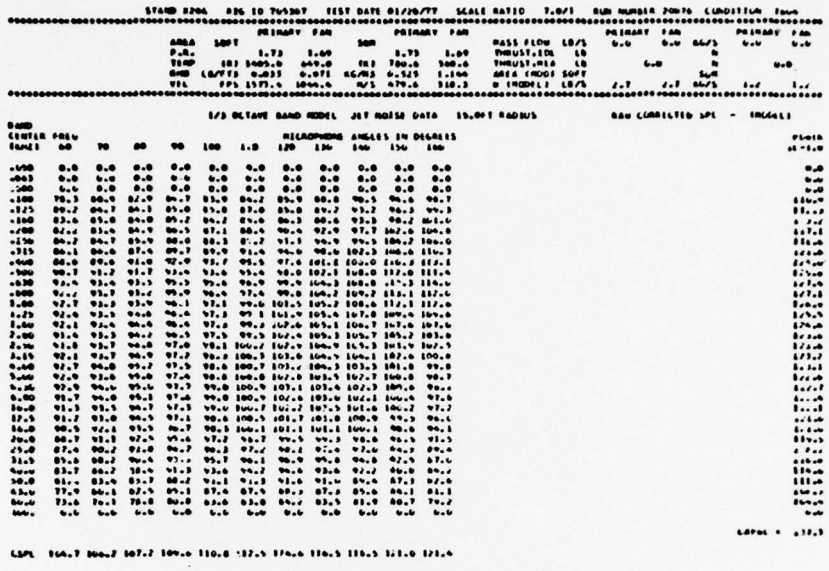
b.) Model Data Scaled to Predict F13D Engine Jet Noise At 1200 Ft. Linear Distance



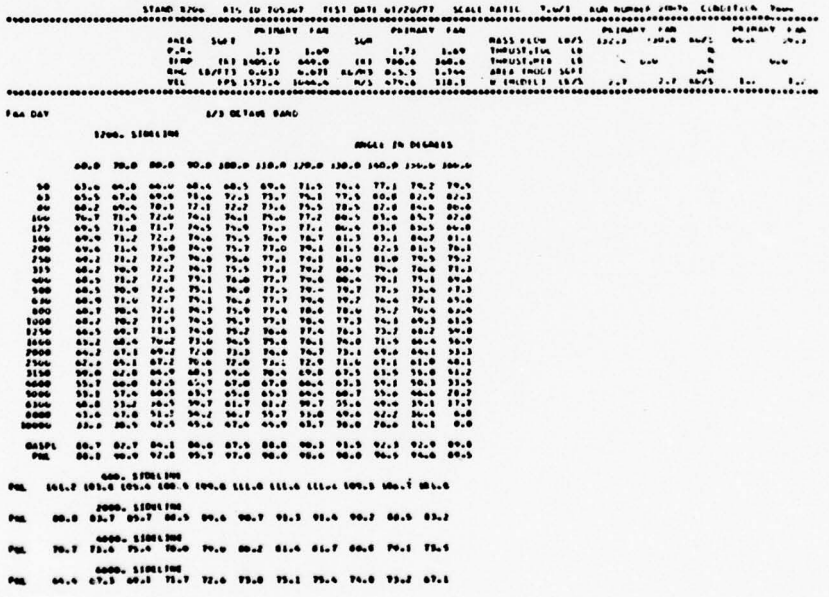
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Mixer Modified to Fit Within 7.6 Inch Engine Extension Without Engine Secondary Flow Simulation; Configuration 8A; Condition 7604

a.) Model Data Measured At 15 Ft. Radius



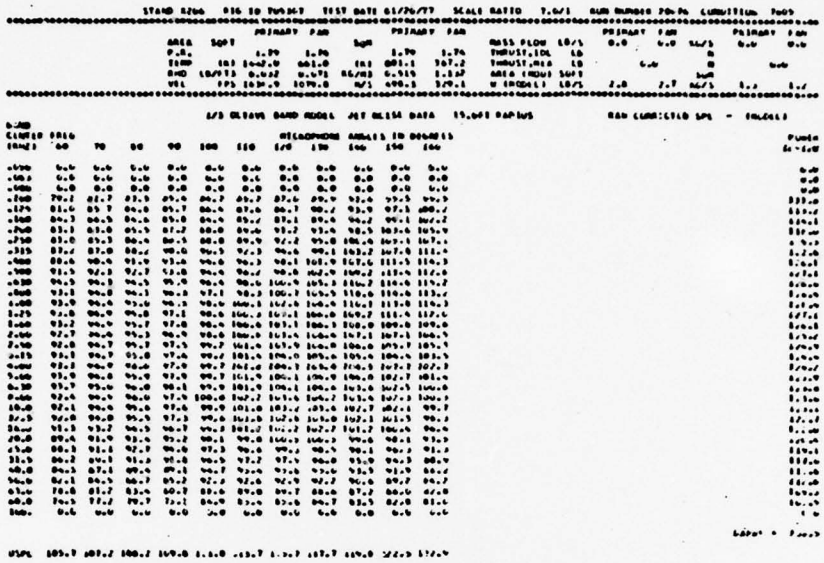
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



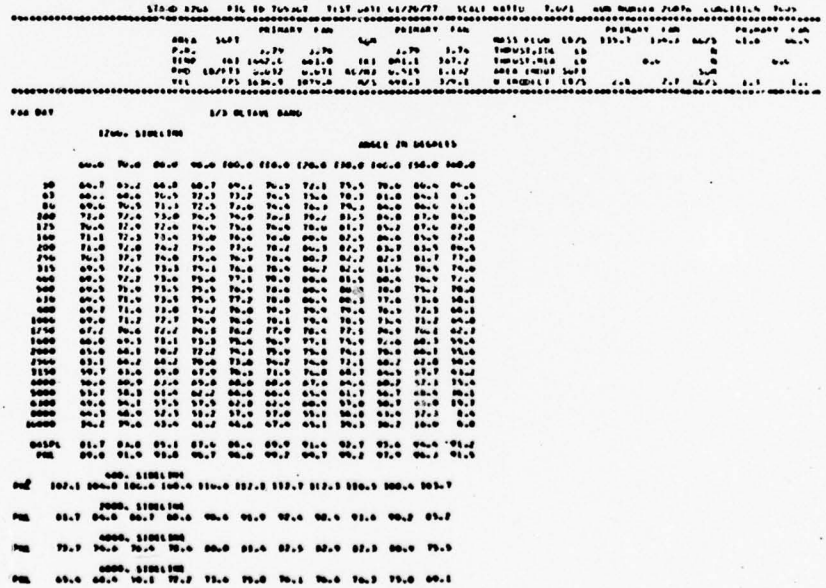
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Mixer Modified to Fit Within 7.6 Inch Engine Extension Without Engine Secondary Flow Simulation; Configuration 8A; Condition 7605

a.) Model Data Measured At 15 Ft. Radius



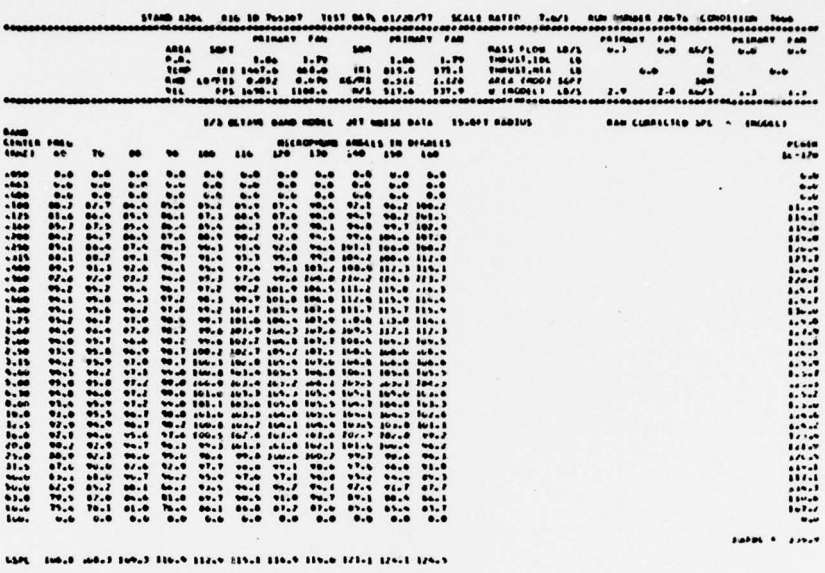
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



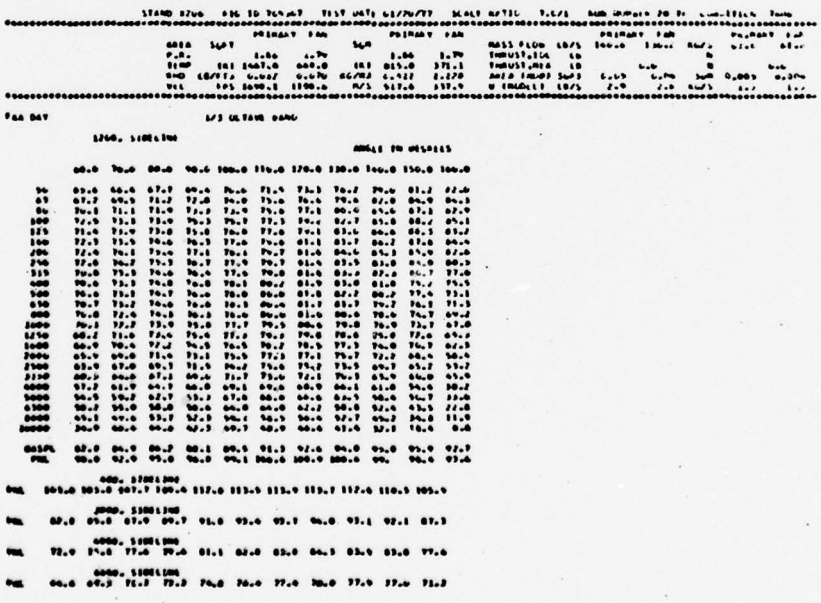
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Mixer Modified to Fit Within 7.6 Inch Engine Extension Without Engine Secondary Flow Simulation; Configuration 8A; Condition 7606

a.) Model Data Measured At 15 Ft. Radius



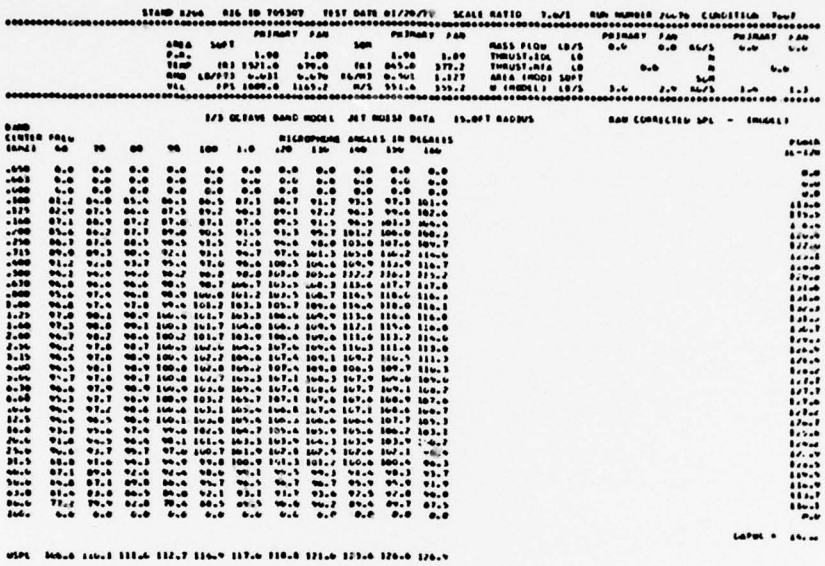
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



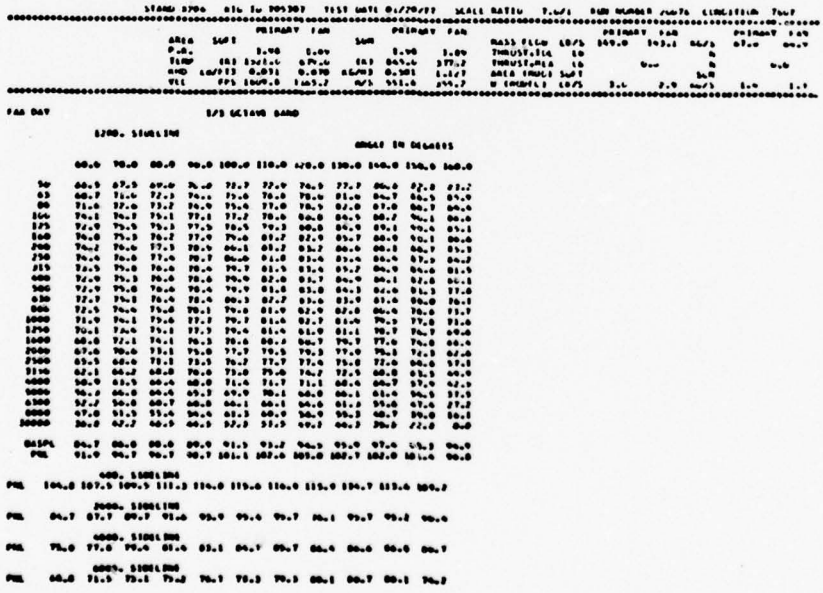
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Mixer Modified to Fit Within 7.6 Inch Engine Extension Without Engine Secondary Flow Simulation; Configuration 8A; Condition 7607

a.) Model Data Measured At 15 Ft. Radius



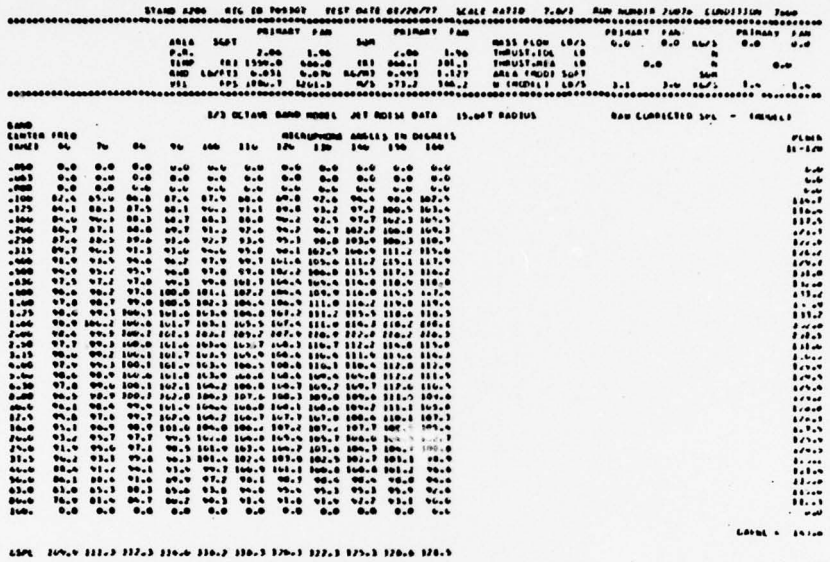
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



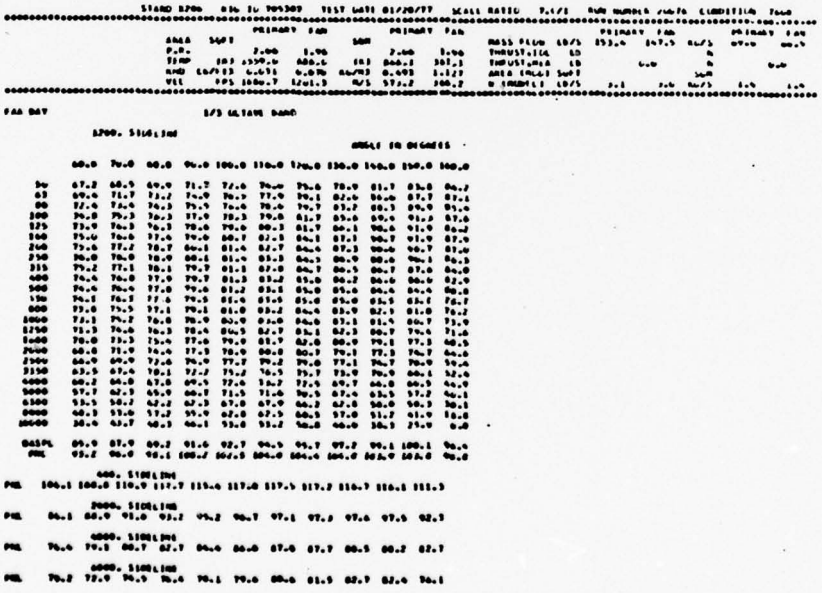
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Mixer Modified to Fit Within 7.6 Inch Engine Extension Without Engine Secondary Flow Simulation; Configurstion 8A; Condition 7608

a.) Model Data Measured At 15 Ft. Radius



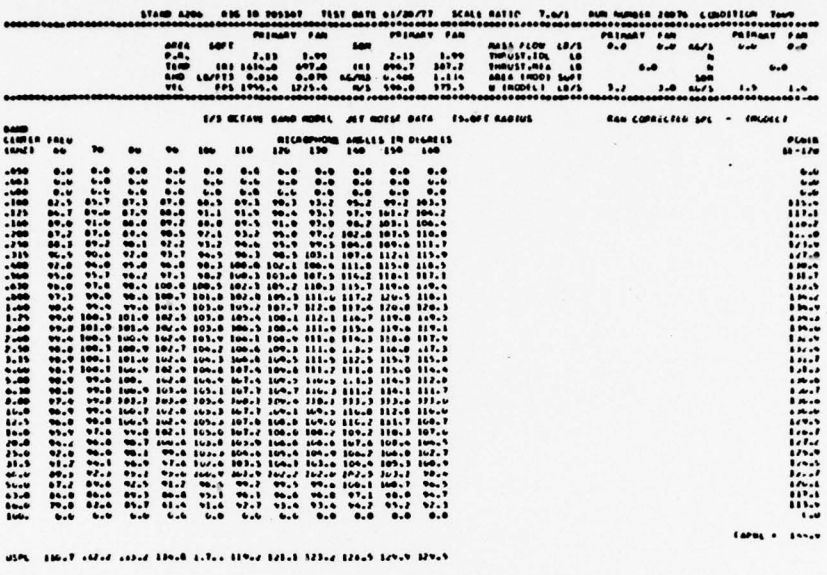
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



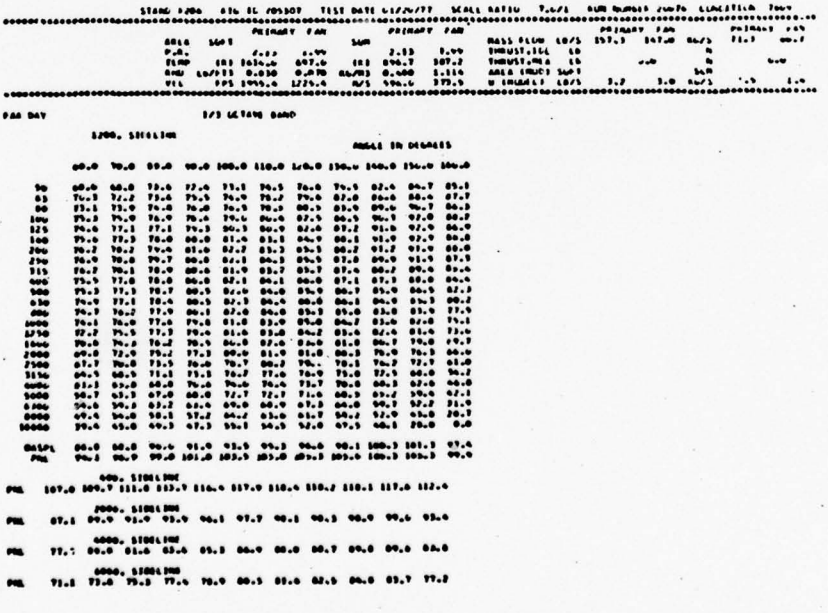
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Mixer Modified to Fit Within 7.6 Inch Engine Extension Without Engine Secondary Flow Simulation; Configuration 8A; Condition 7609

a.) Model Data Measured At 15 Ft. Radius



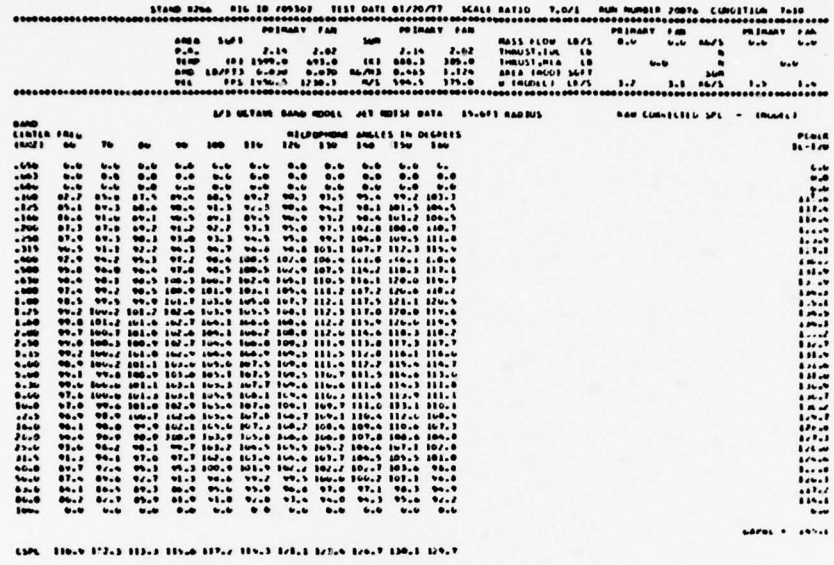
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



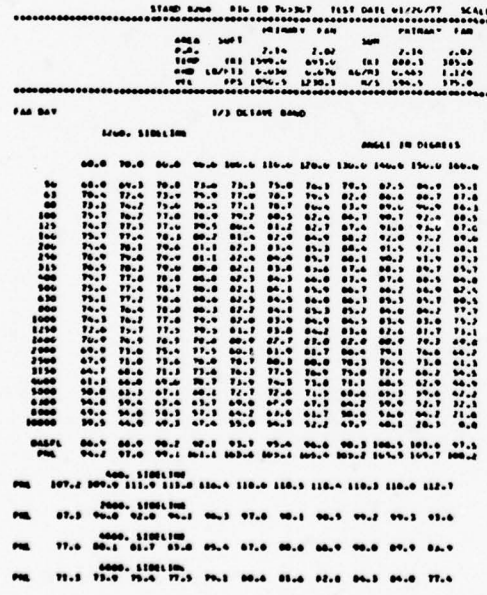
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Cutback Scalloped Mixer Modified to Fit Within 7.6 Inch Engine Extension Without Engine Secondary Flow Simulation; Configuration 8A; Condition 7610

a.) Model Data Measured At 15 Ft. Radius



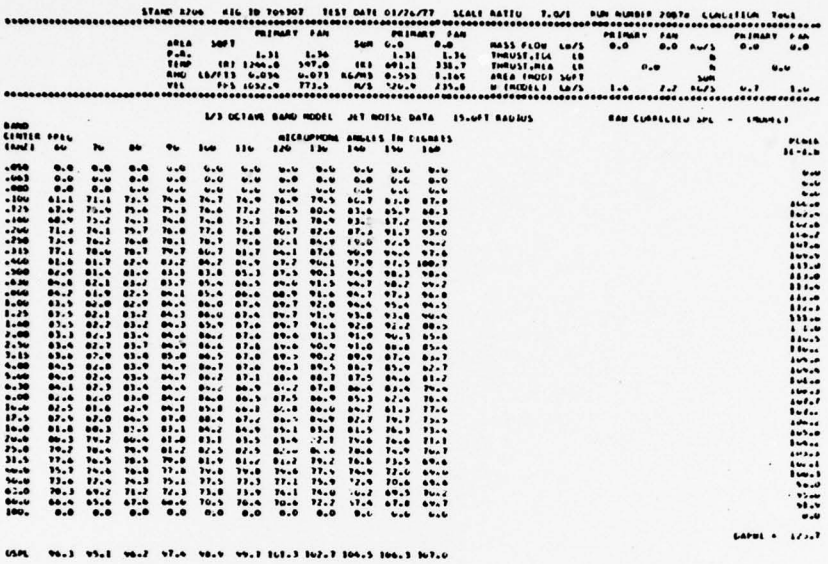
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



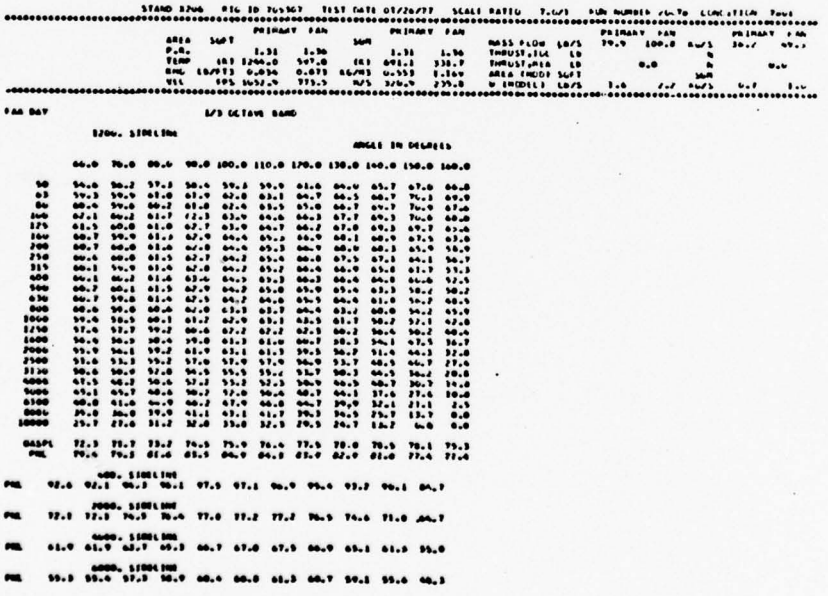
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 10A; Condition 7801

a.) Model Data Measured At 15 Ft. Radius



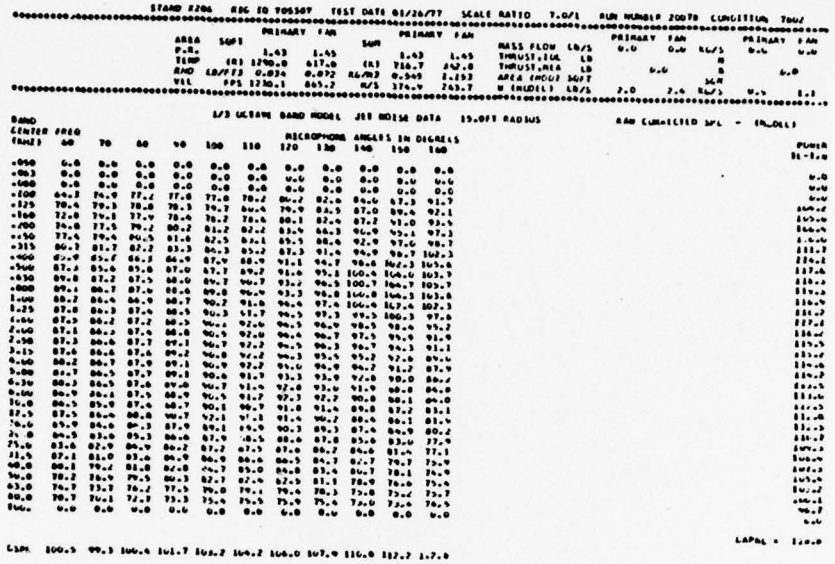
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



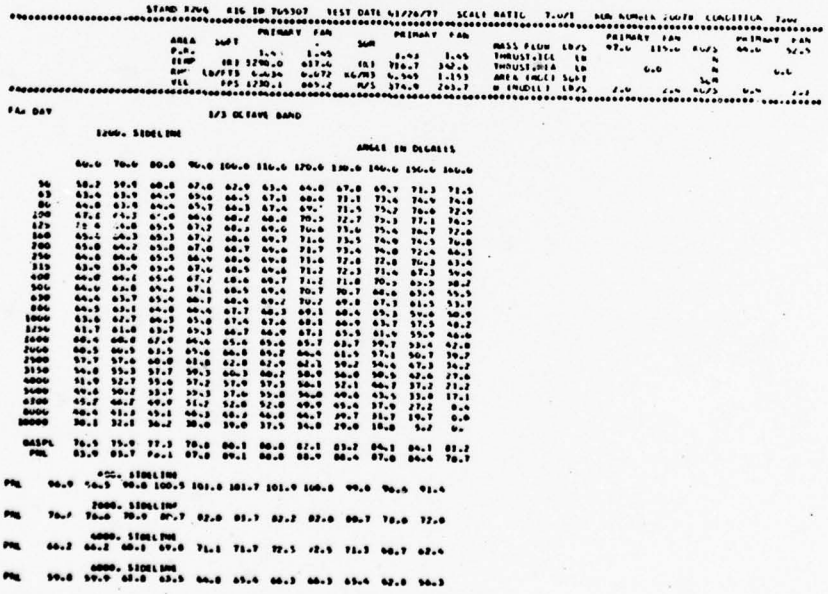
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 10A; Condition 7802

a.) Model Data Measured At 15 Ft. Radius



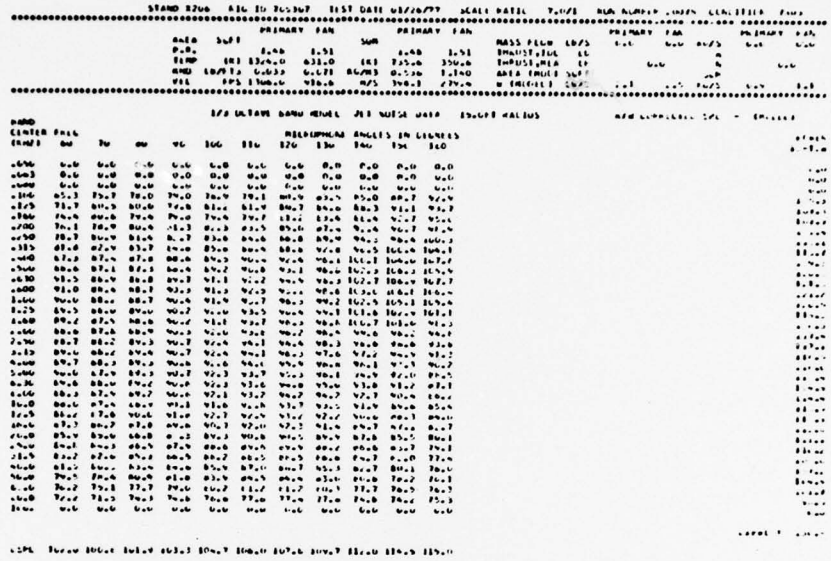
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



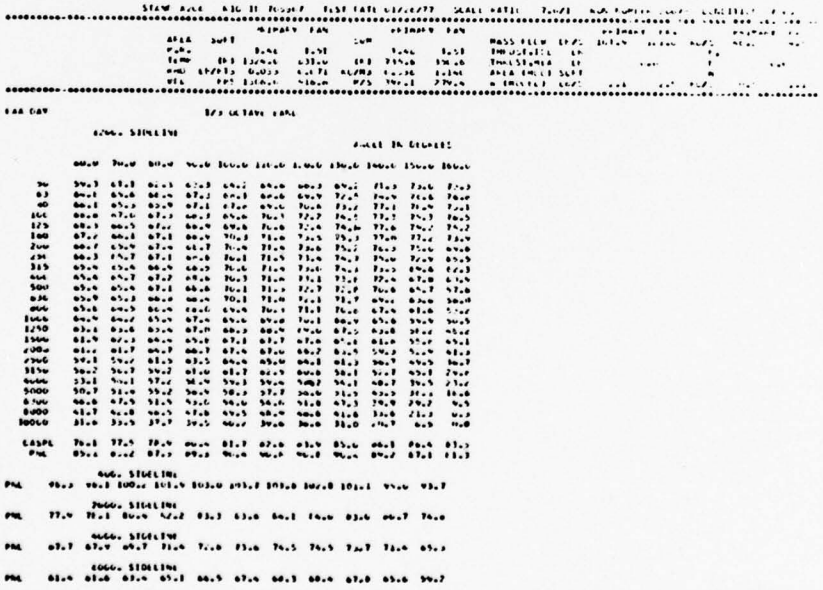
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 10A; Condition 7803

a.) Model Data Measured At 15 Ft. Radius



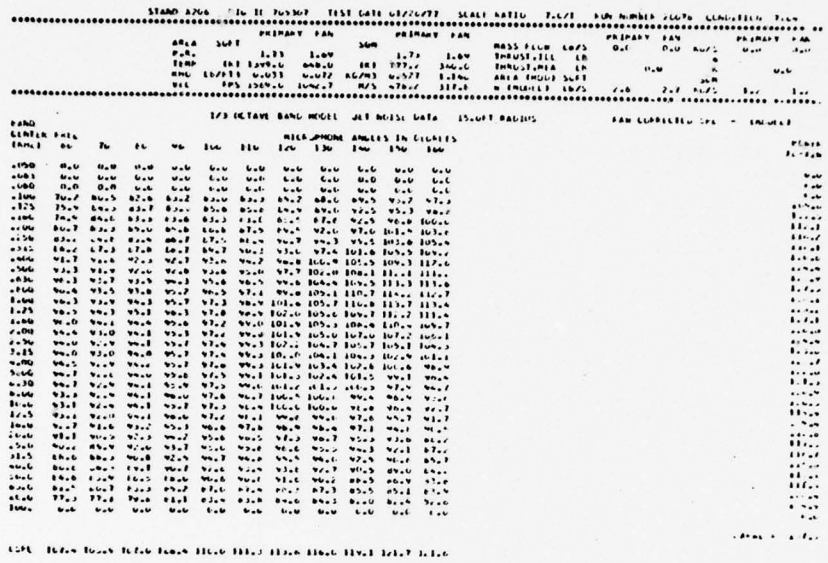
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



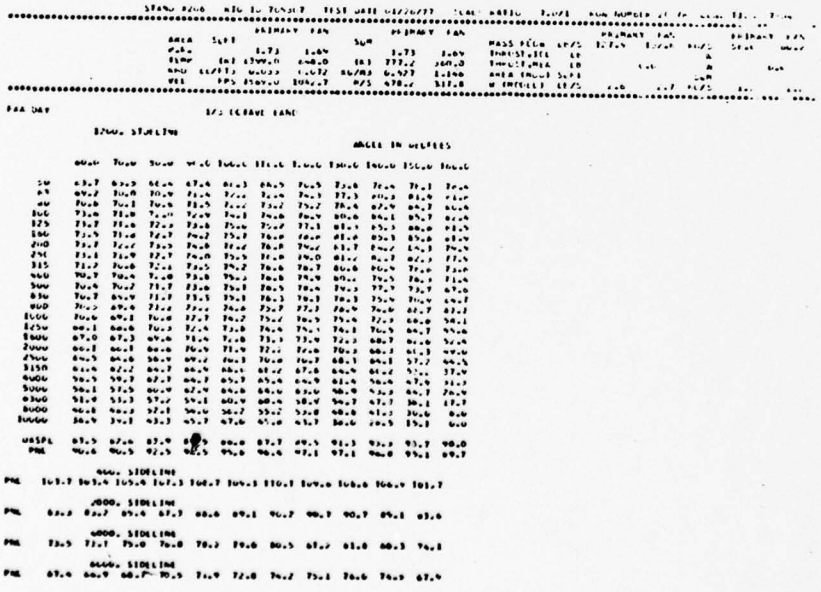
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 10A; Condition 7804

a.) Model Data Measured At 15 Ft. Radius



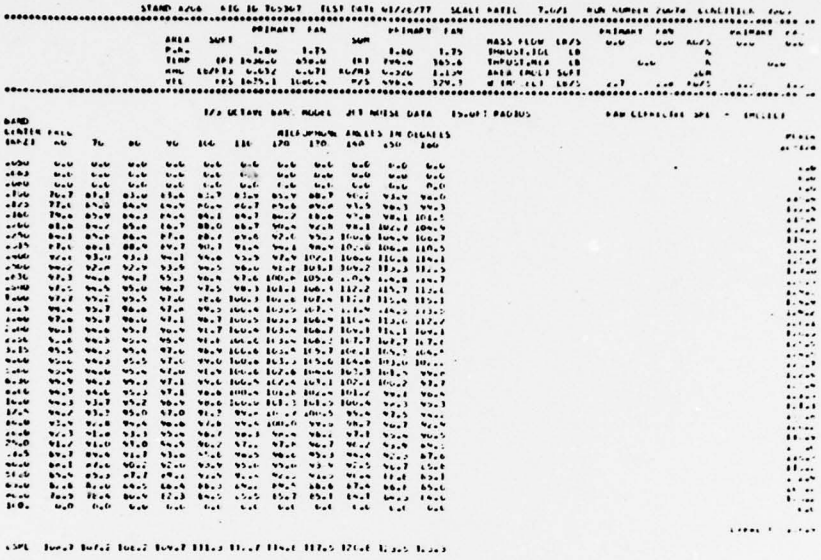
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



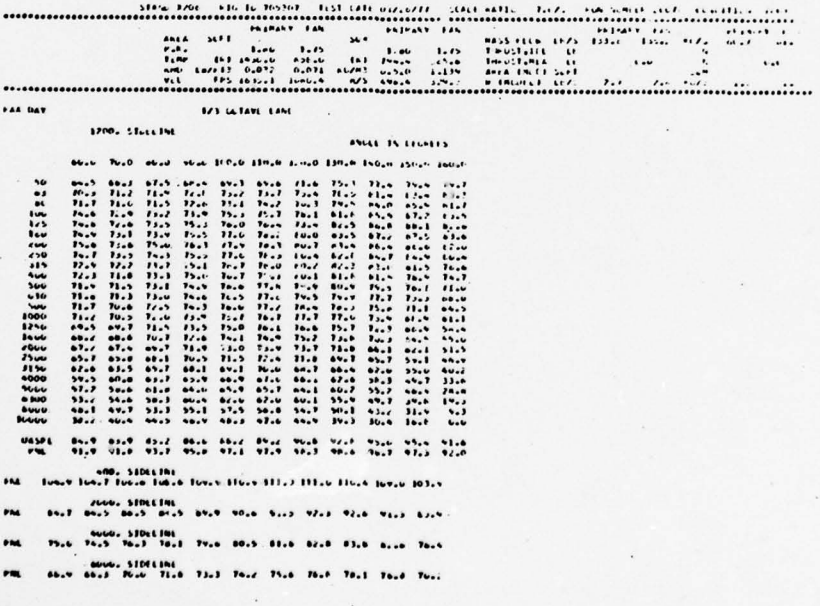
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 10A; Condition 7805

a.) Model Data Measured At 15 Ft. Radius



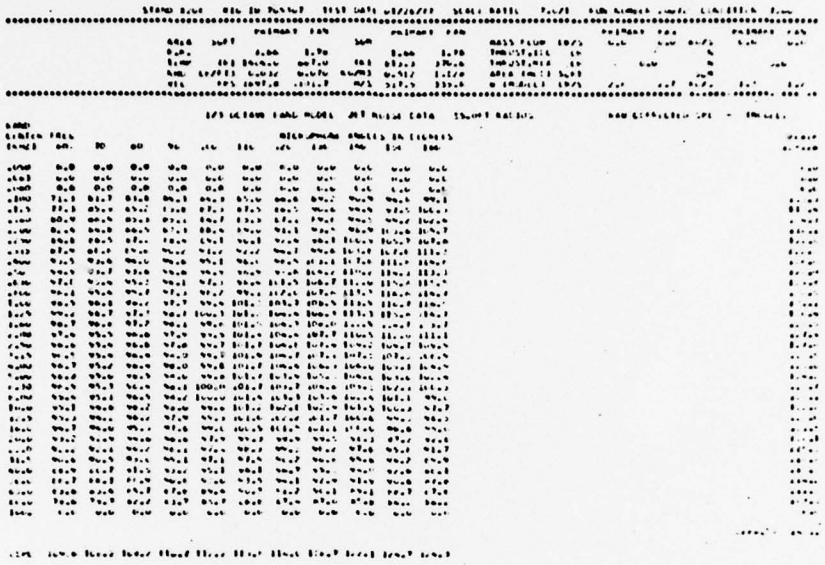
b.) Model Data Scaled to *Predict* JT8D Engine Jet Noise At 1200 Ft. Linear Distance



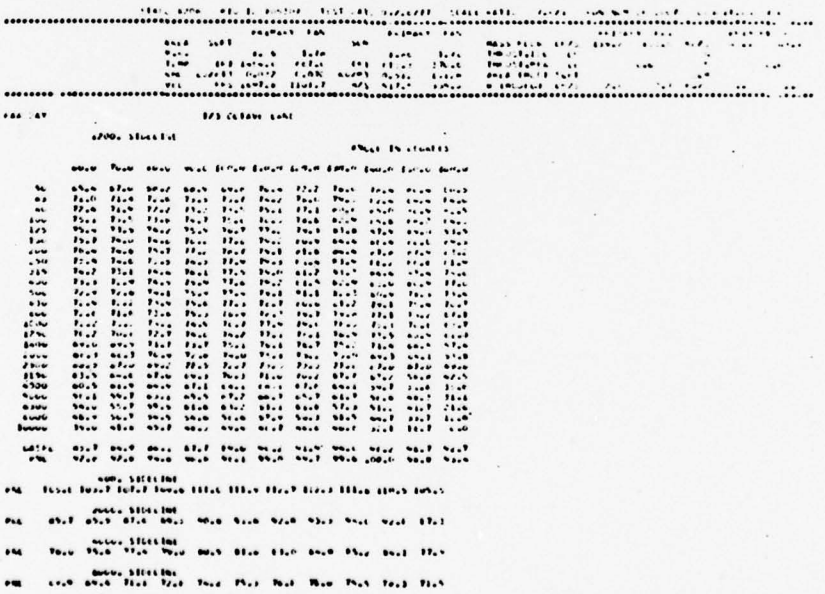
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 10A; Condition 7806

a.) Model Data Measured At 15 Ft. Radius



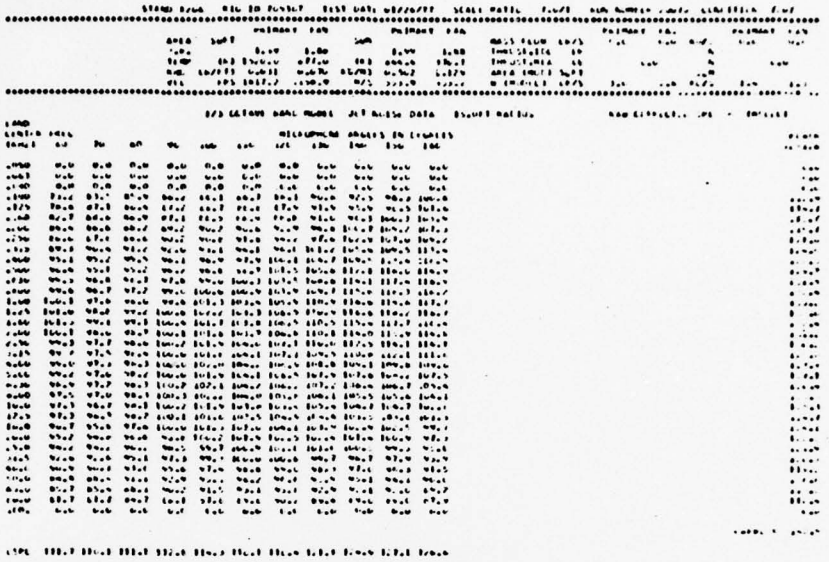
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



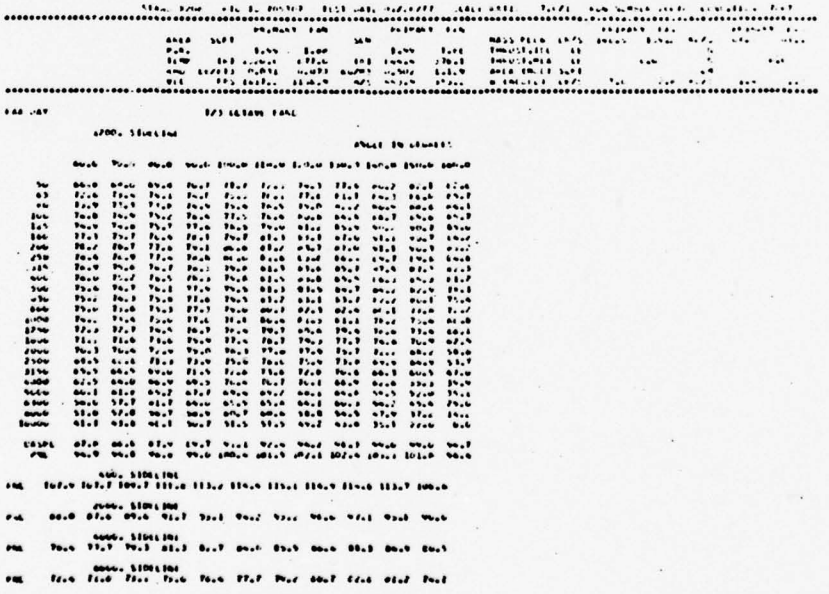
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 10A; Condition 7807

a.) Model Data Measured At 15 Ft. Radius



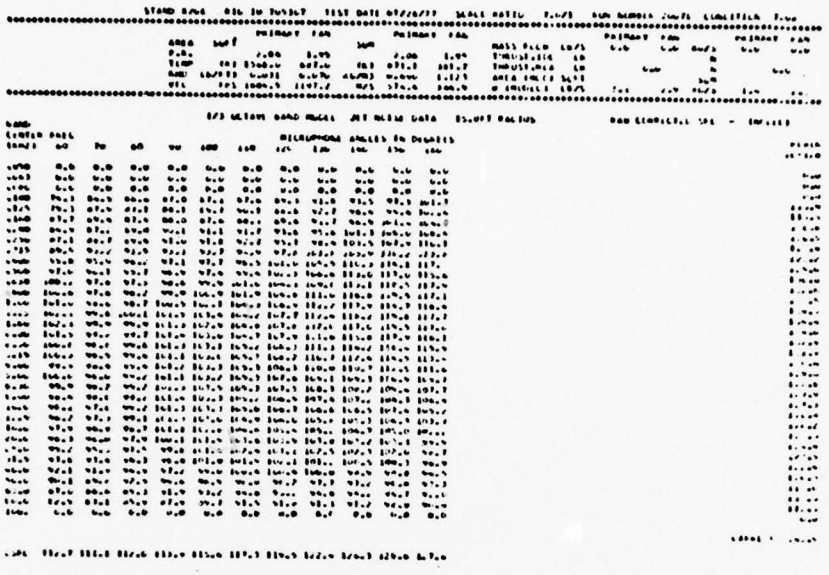
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



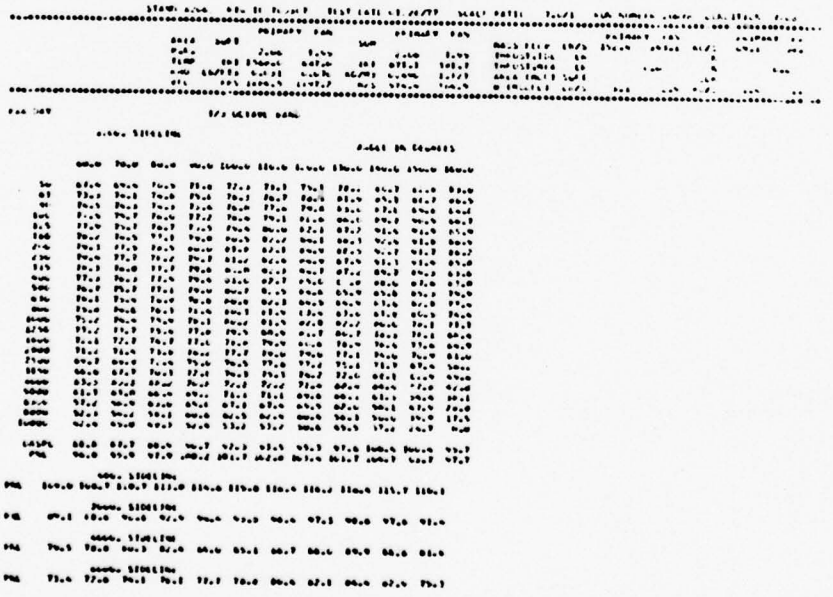
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 10A; Condition 7808

a.) Model Data Measured At 15 Ft. Radius



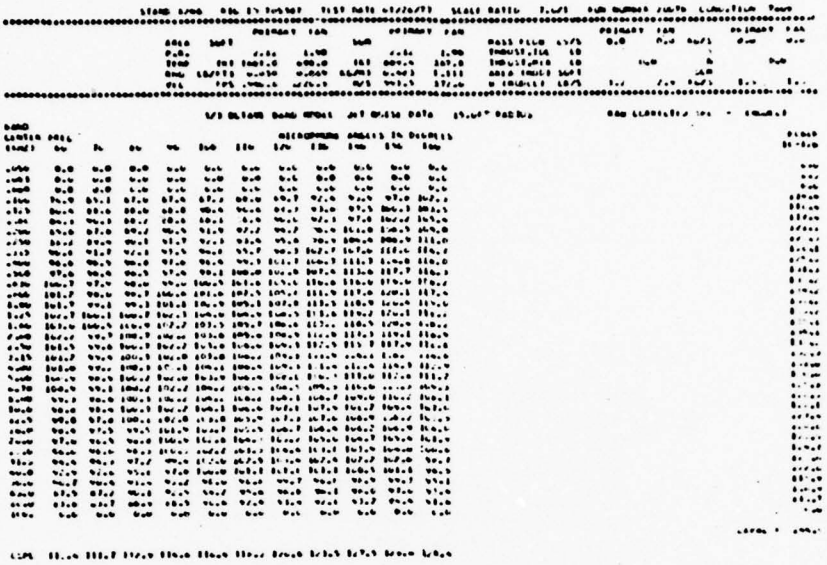
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



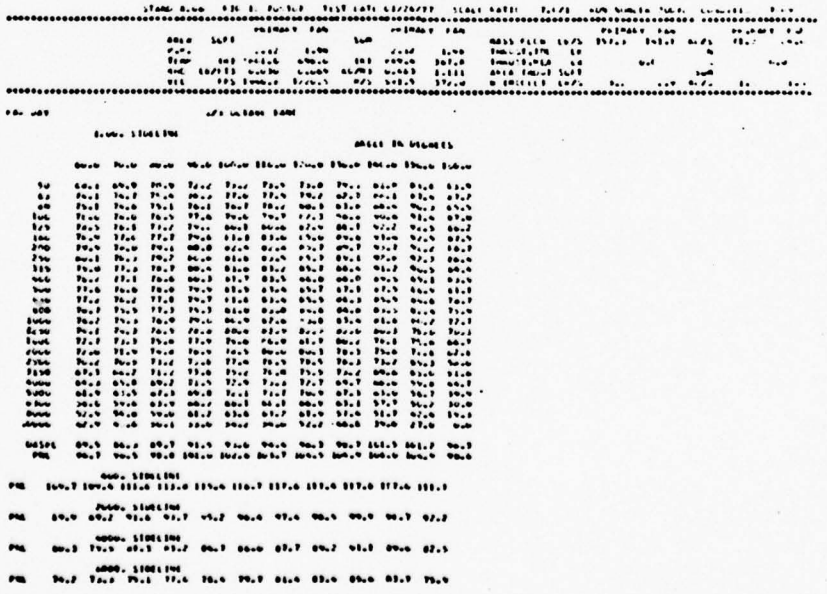
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 10A; Condition 7809

a.) Model Data Measured At 15 Ft. Radius



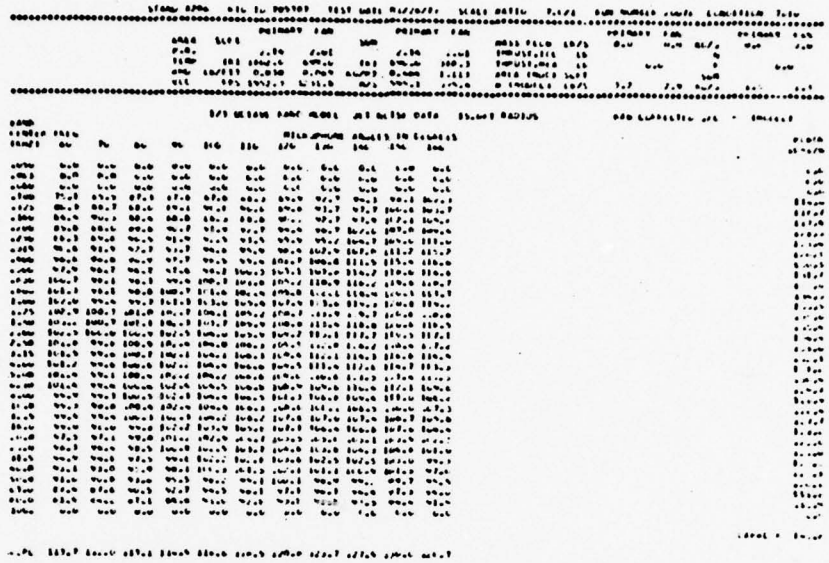
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



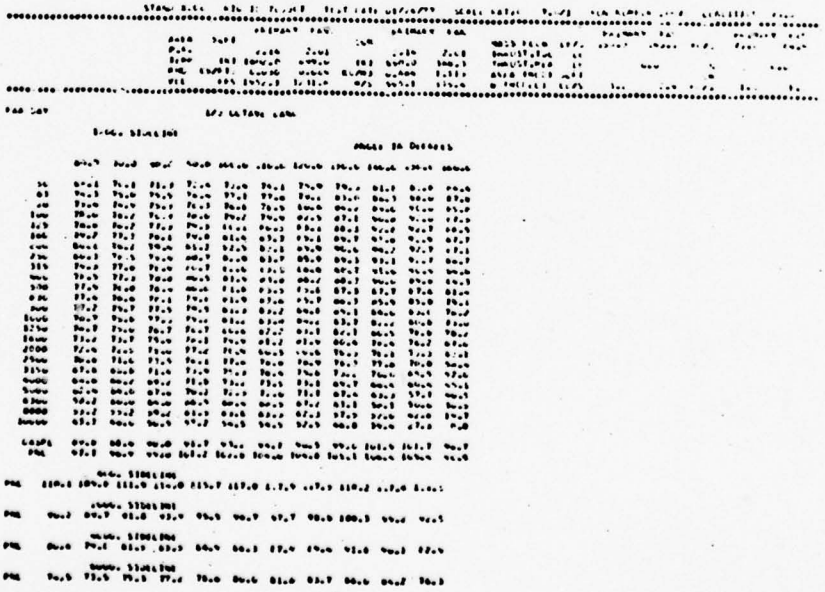
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer With Engine Secondary Flow Simulation; Configuration 10A; Condition 7810

a.) Model Data Measured At 15 Ft. Radius



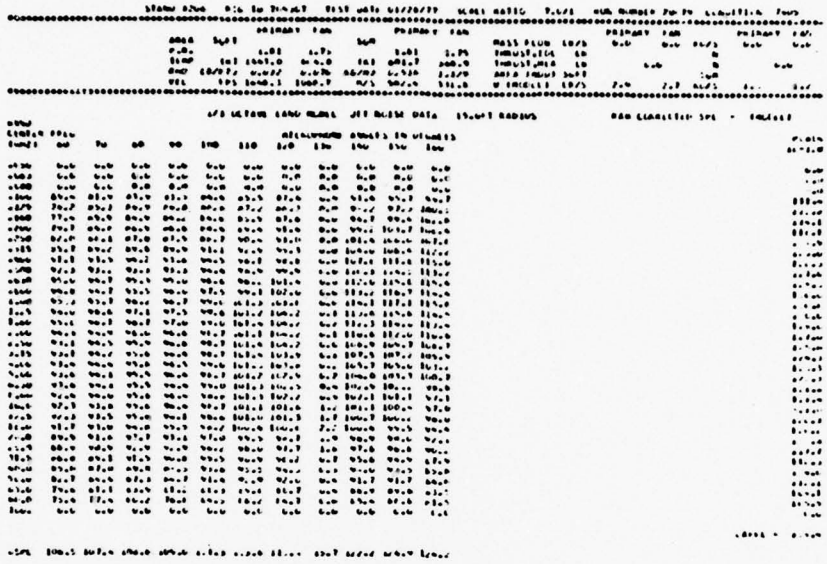
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



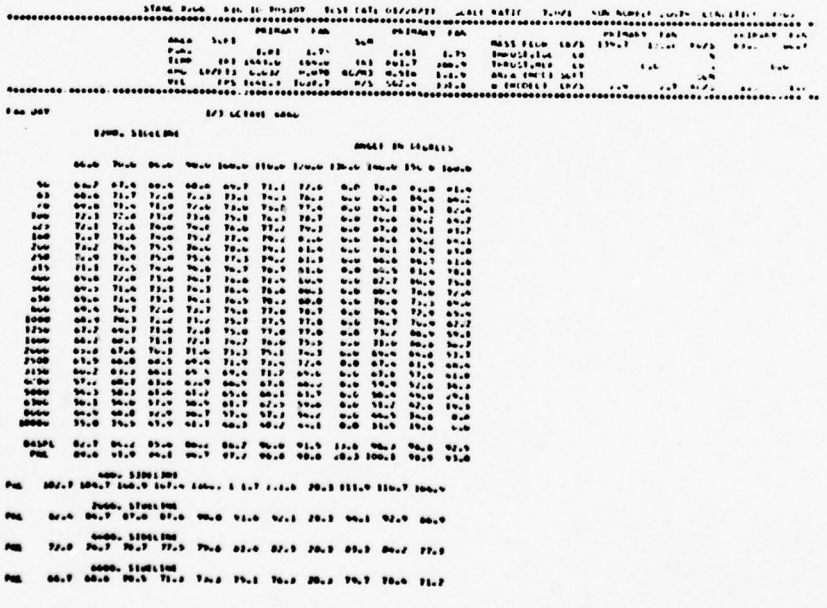
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer Without Engine Flow Simulation; Configuration 11A; Condition 7905

a.) Model Data Measured At 15 Ft. Radius



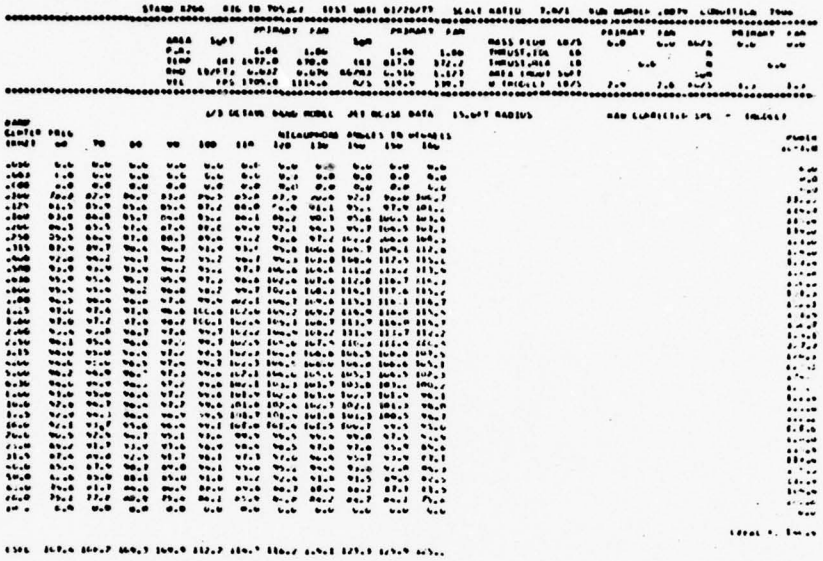
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



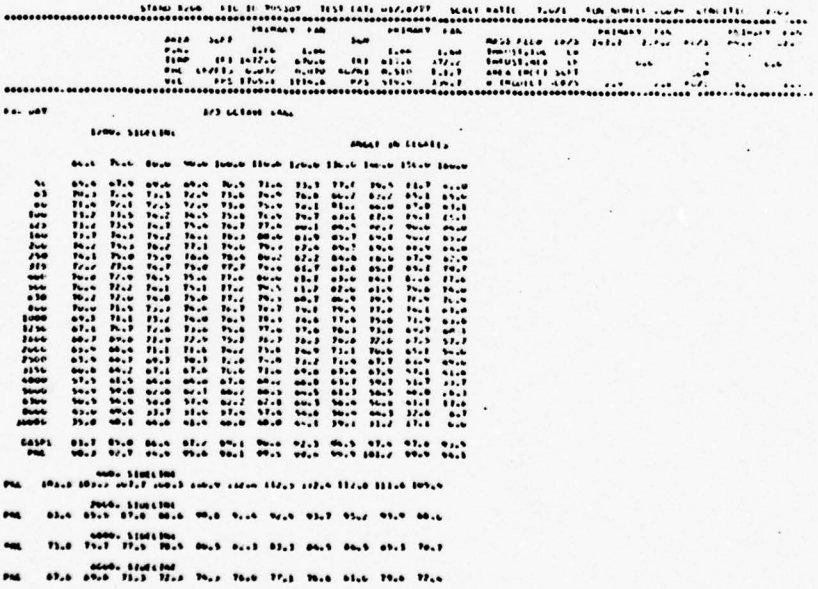
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer Without Engine Flow Simulation; Configuration 11A; Condition 7906

a.) Model Data Measured At 15 Ft. Radius



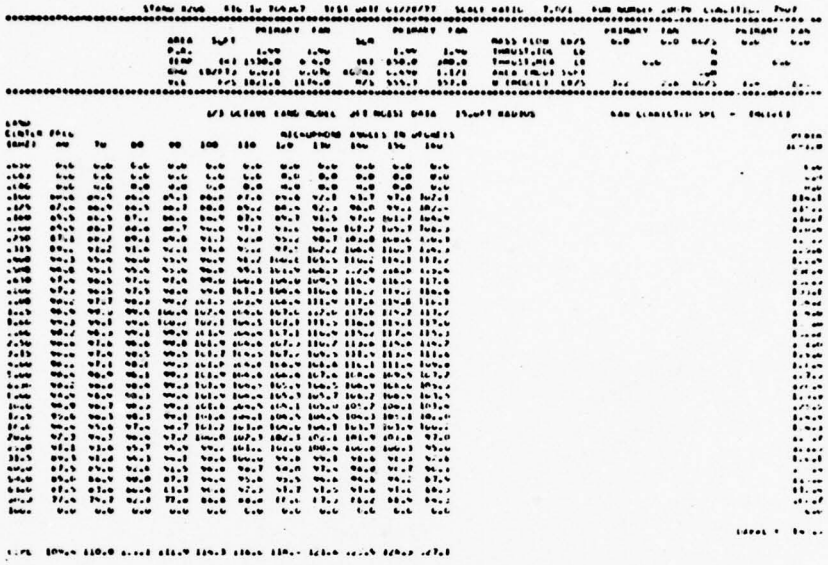
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



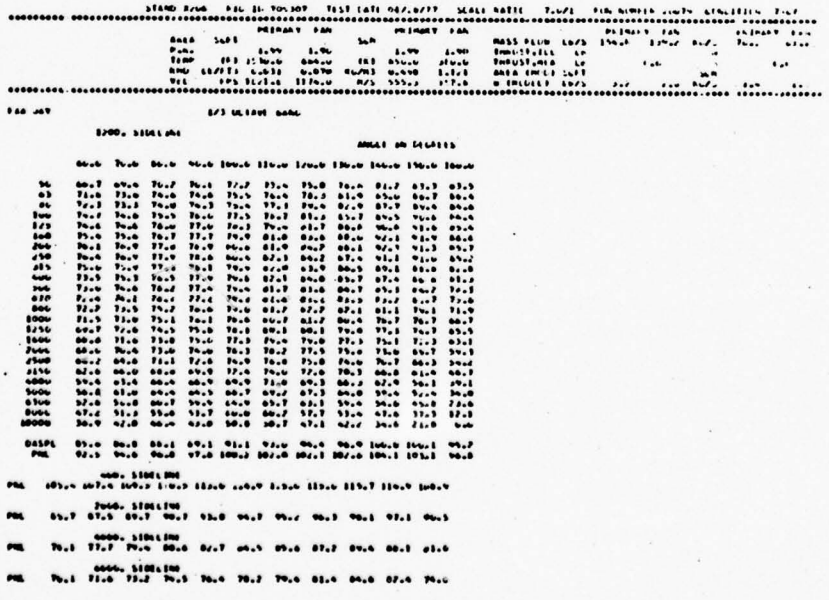
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer Without Engine Flow Simulation; Configuration 11A; Condition 7907

a.) Model Data Measured At 15 Ft. Radius



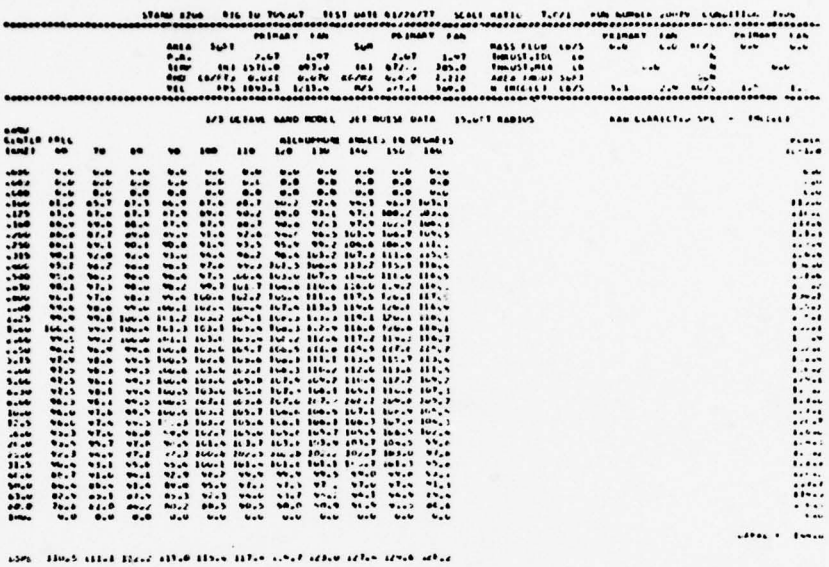
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



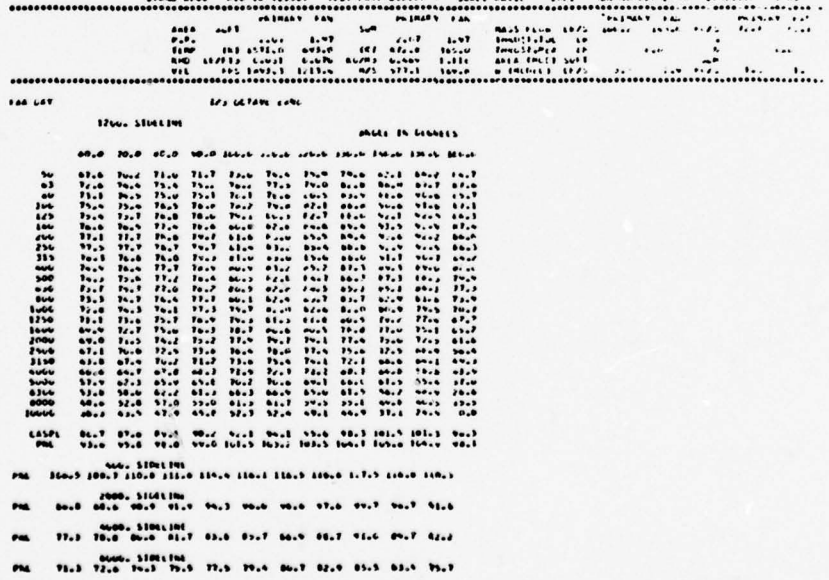
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer Without Engine Flow Simulation; Configuration 11A; Condition 7908

a.) Model Data Measured At 15 Ft. Radius



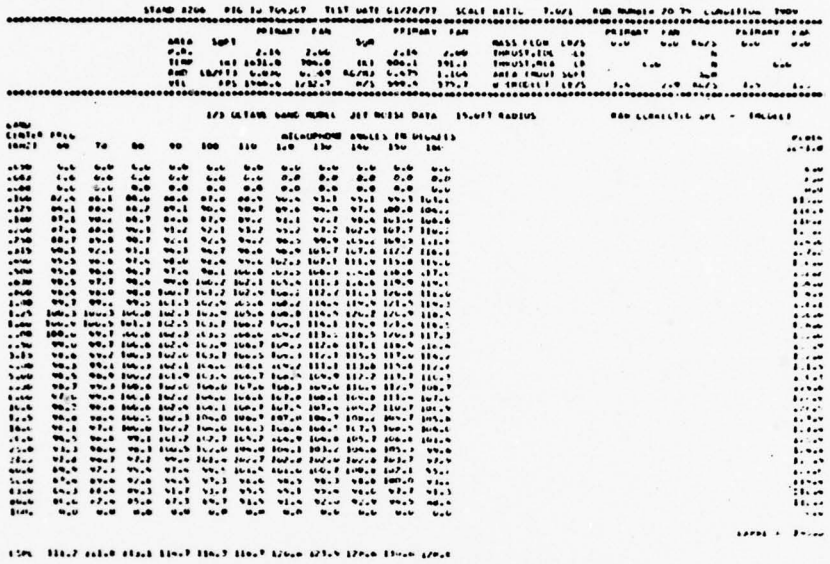
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



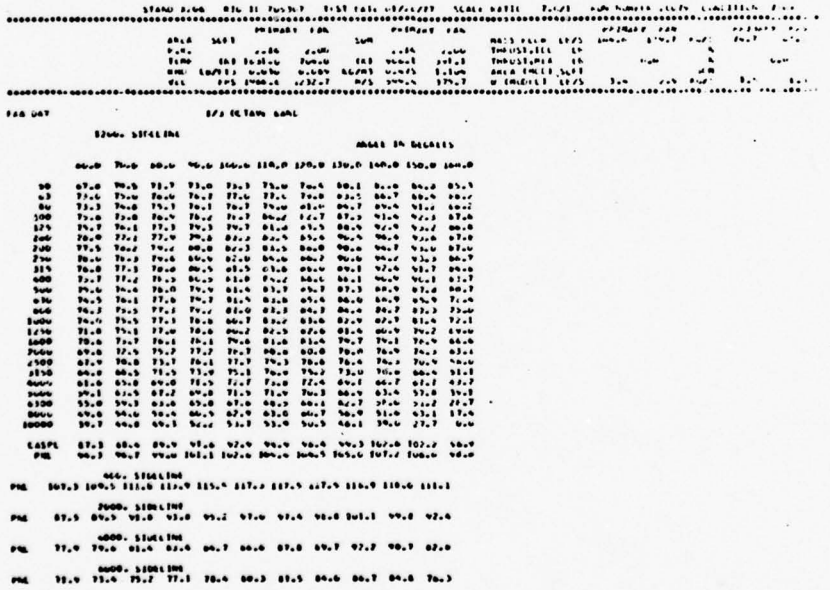
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer Without Engine Flow Simulation; Configuration 11A; Condition 7909

a.) Model Data Measured At 15 Ft. Radius



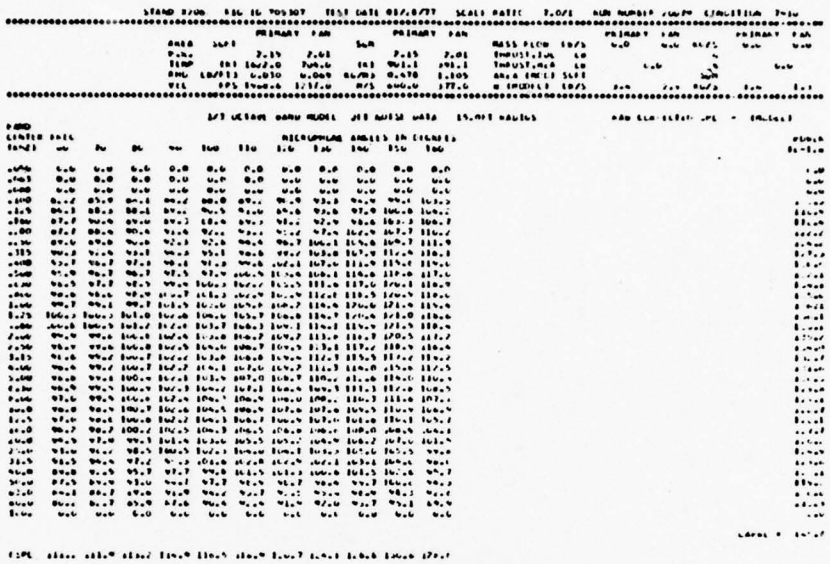
b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



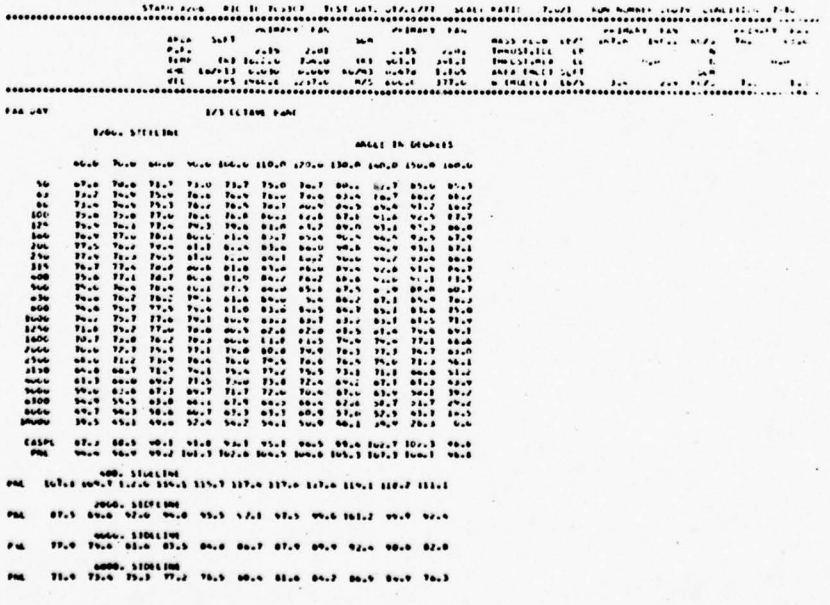
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

Severe Cutback Short Flowpath Mixer Without Engine Flow Simulation; Configuration 11A; Condition 7910

a.) Model Data Measured At 15 Ft. Radius



b.) Model Data Scaled to Predict JT8D Engine Jet Noise At 1200 Ft. Linear Distance



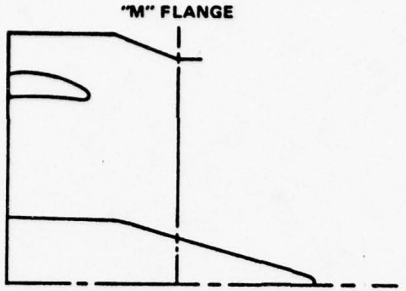
Measured model and scaled data are freefield and have been adjusted to reflect the atmospheric absorption present on an FAA day (77°F, 70% RH)

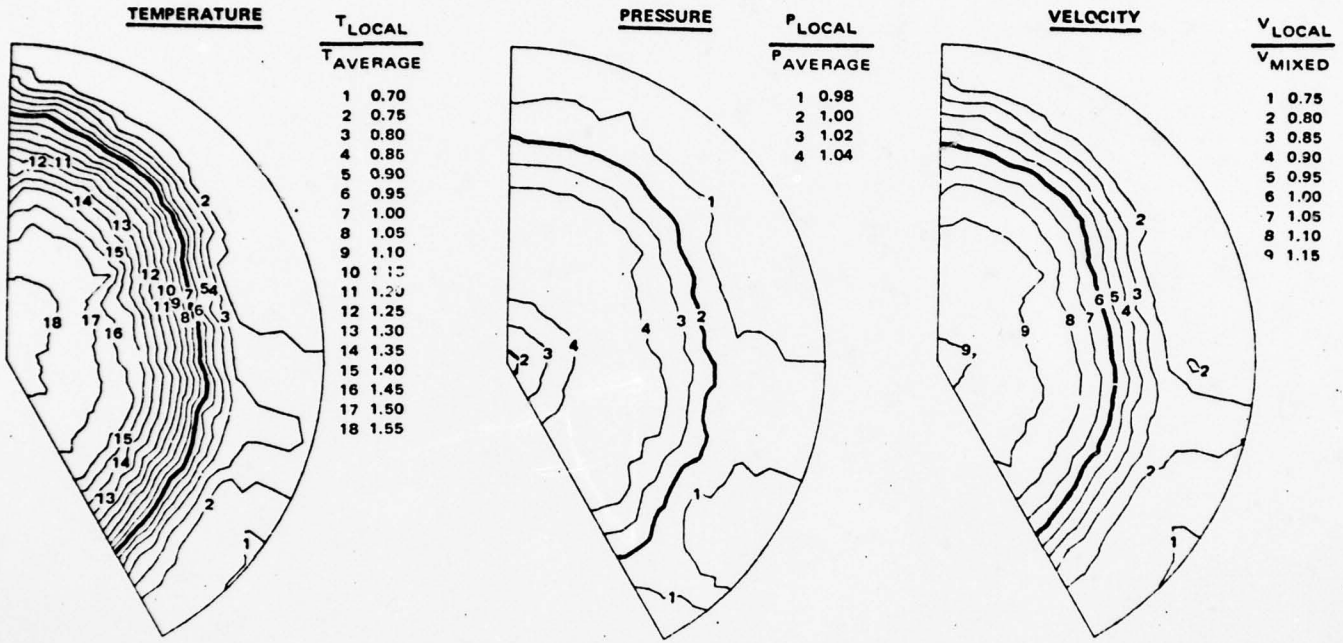
APPENDIX C

NOZZLE TRAVERSE RESULTS

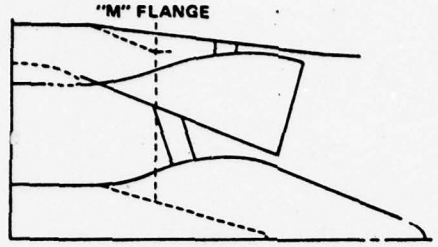
The figures contained in this section present the results of nozzle traverse testing conducted under the FAA contract as described in Section 3.

Contour plots of total temperature, total pressure and calculated fully expanded velocity are presented with contour line values normalized to average temperature or pressure and the calculated ideally mixed velocity. Test results are based on testing at takeoff nozzle pressure ratio.





EXHAUST NOZZLE TRAVERSE RESULTS
REFERENCE EXHAUST SYSTEM
CONFIGURATION 2Au



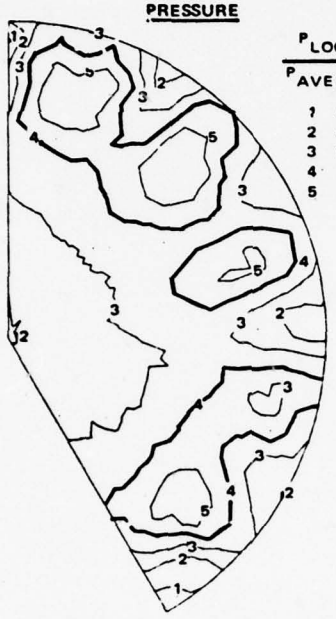
BASIC LONG FLOWPATH MIXER

REFERENCE EXHAUST SYSTEM

TEMPERATURE

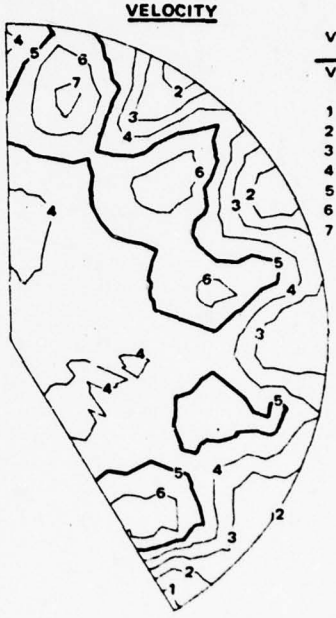
$T_{LOCAL}/T_{AVERAGE}$	
1	0.75
2	0.80
3	0.85
4	0.90
5	0.95
6	1.00
7	1.05
8	1.10
9	1.15
10	1.20
11	1.25

PRESSURE



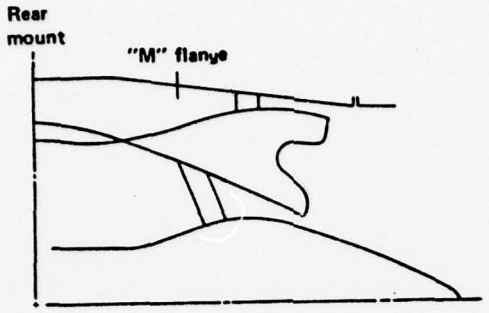
$P_{LOCAL}/P_{AVERAGE}$	
1	0.95
2	0.97
3	0.99
4	1.01
5	1.03

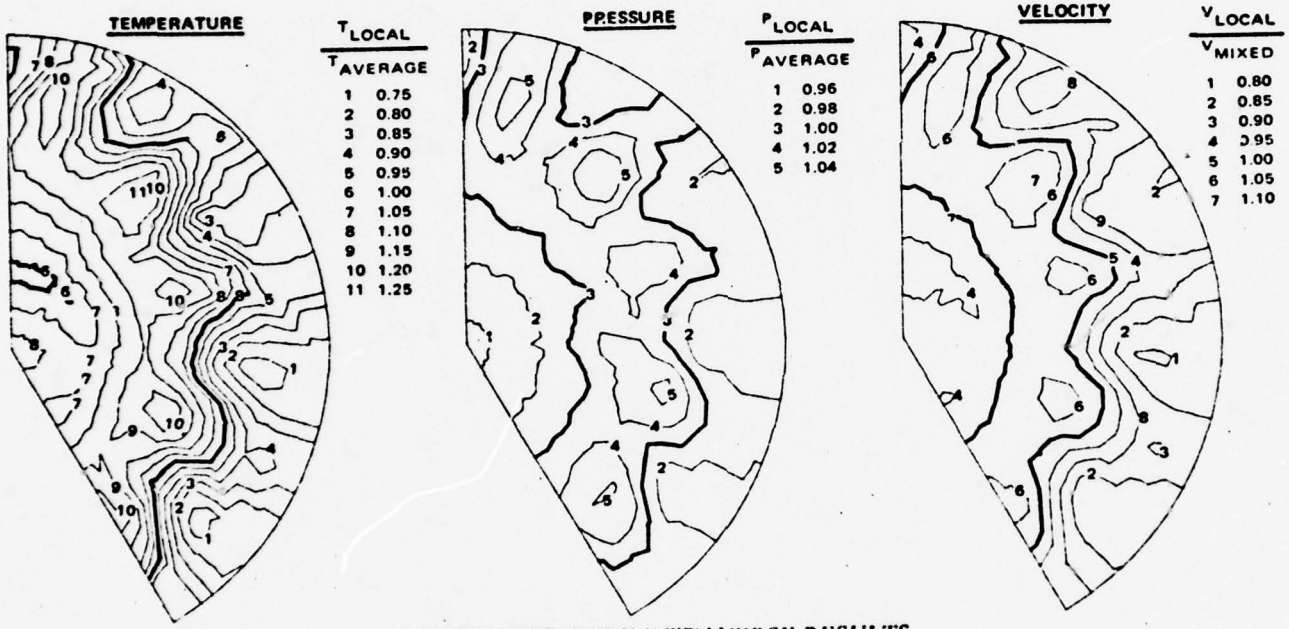
VELOCITY



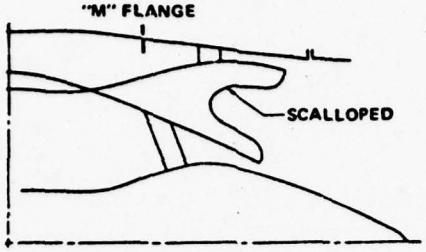
V_{LOCAL}/V_{MIXED}	
1	0.80
2	0.85
3	0.90
4	0.95
5	1.00
6	1.05
7	1.10

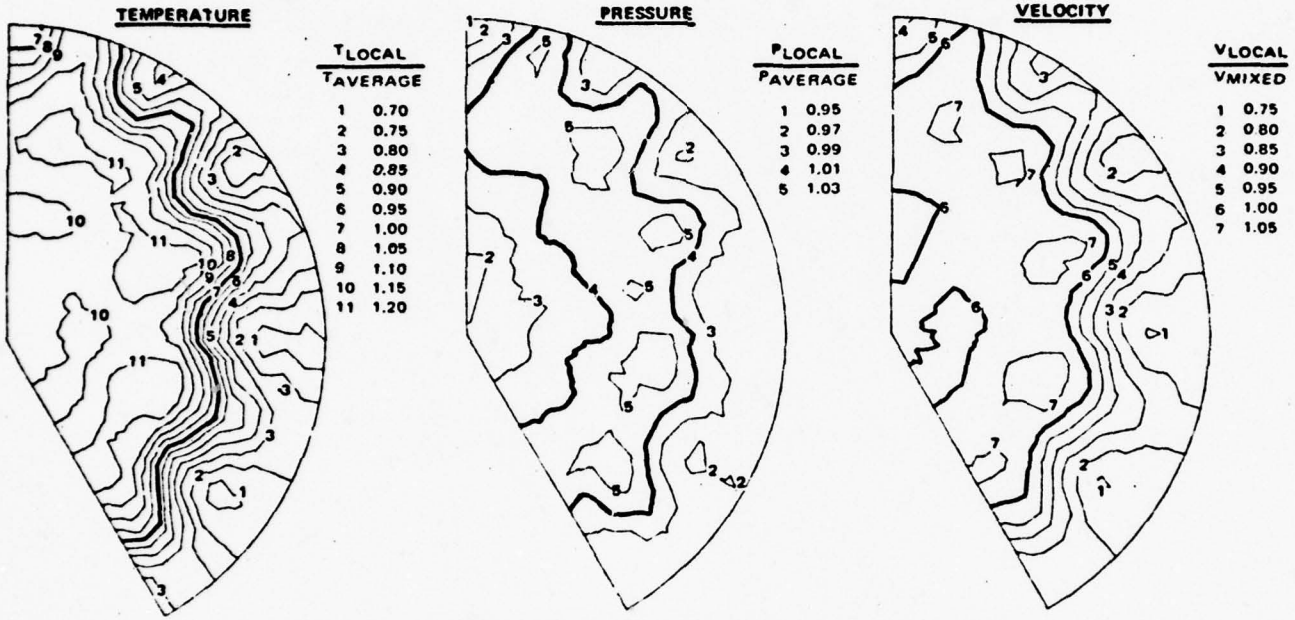
EXHAUST NOZZLE TRAVERSE RESULTS
BASIC LONG FLOWPATH MIXER
CONFIGURATION 1A



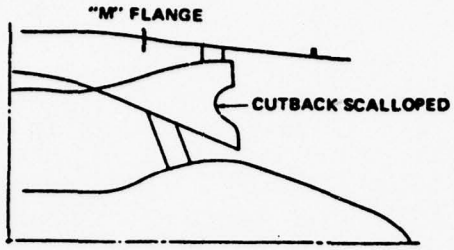


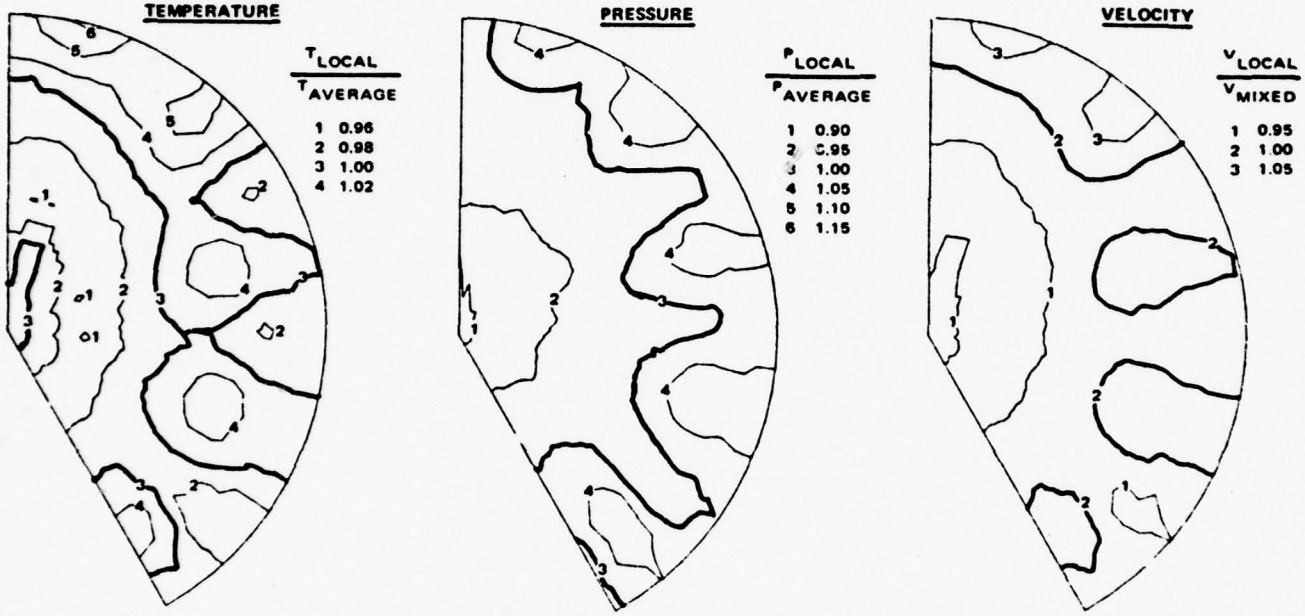
EXHAUST NOZZLE TRAVERSE RESULTS
SHALLOWED SCALLOPED LONG FLOWPATH MIXER
CONFIGURATION 3A



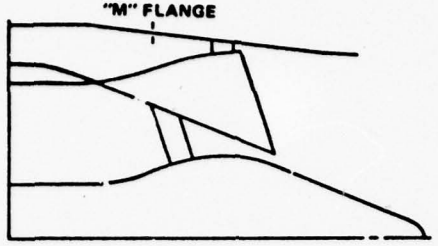


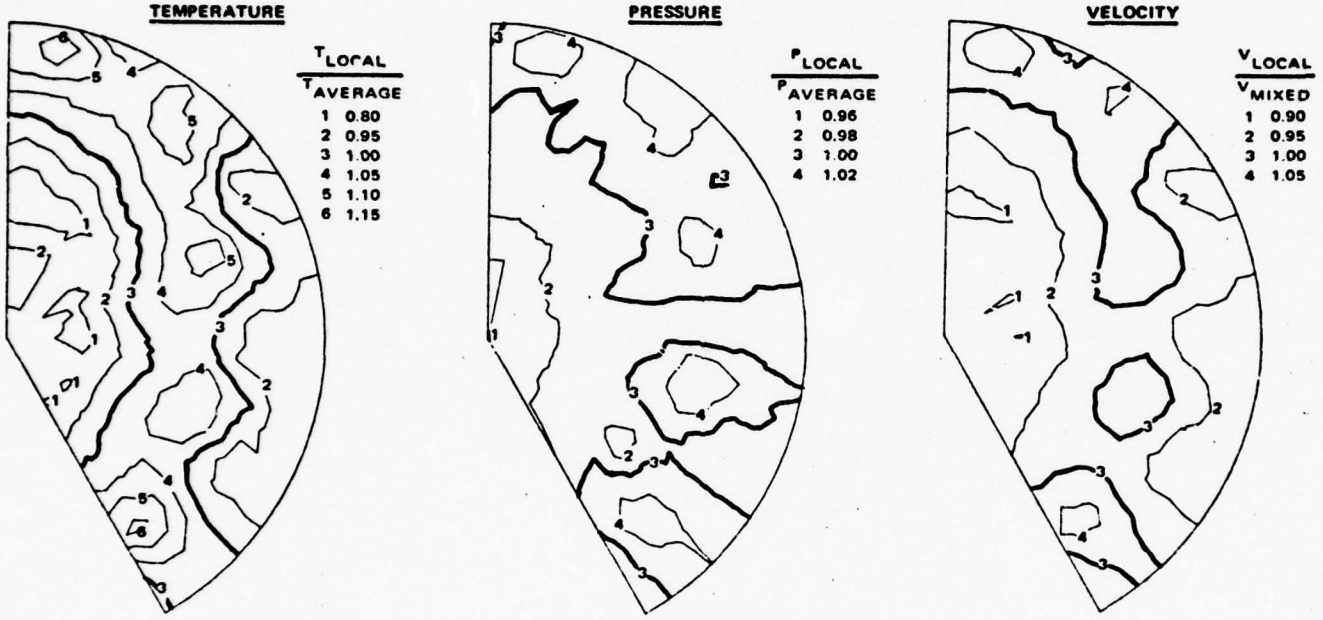
EXHAUST NOZZLE TRAVERSE RESULTS
SCALLOPED LONG FLOWPATH MIXER
CONFIGURATION 4A



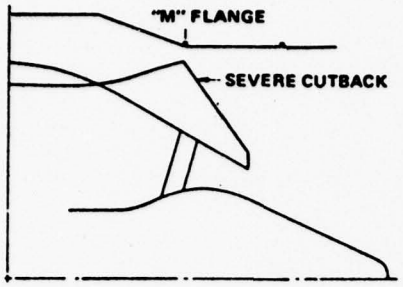


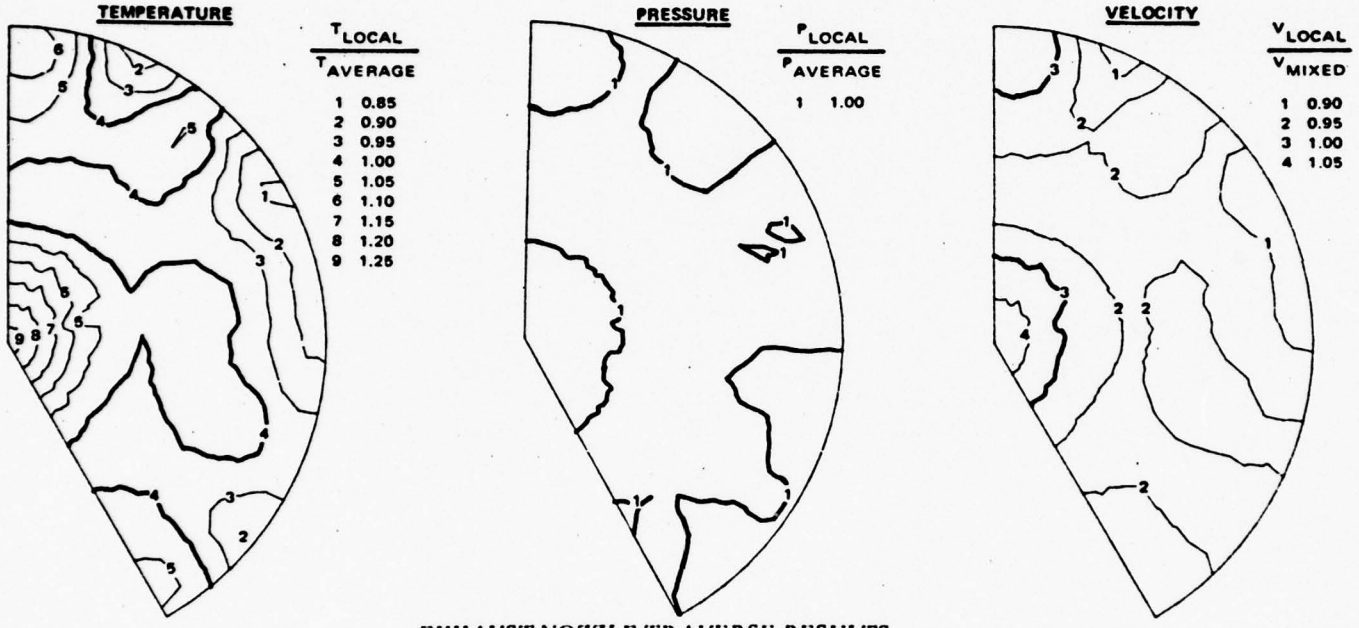
EXHAUST NOZZLE TRAVERSE RESULTS
CUTBACK SCALLOPED LONG FLOWPATH MIXER
CONFIGURATION 5A



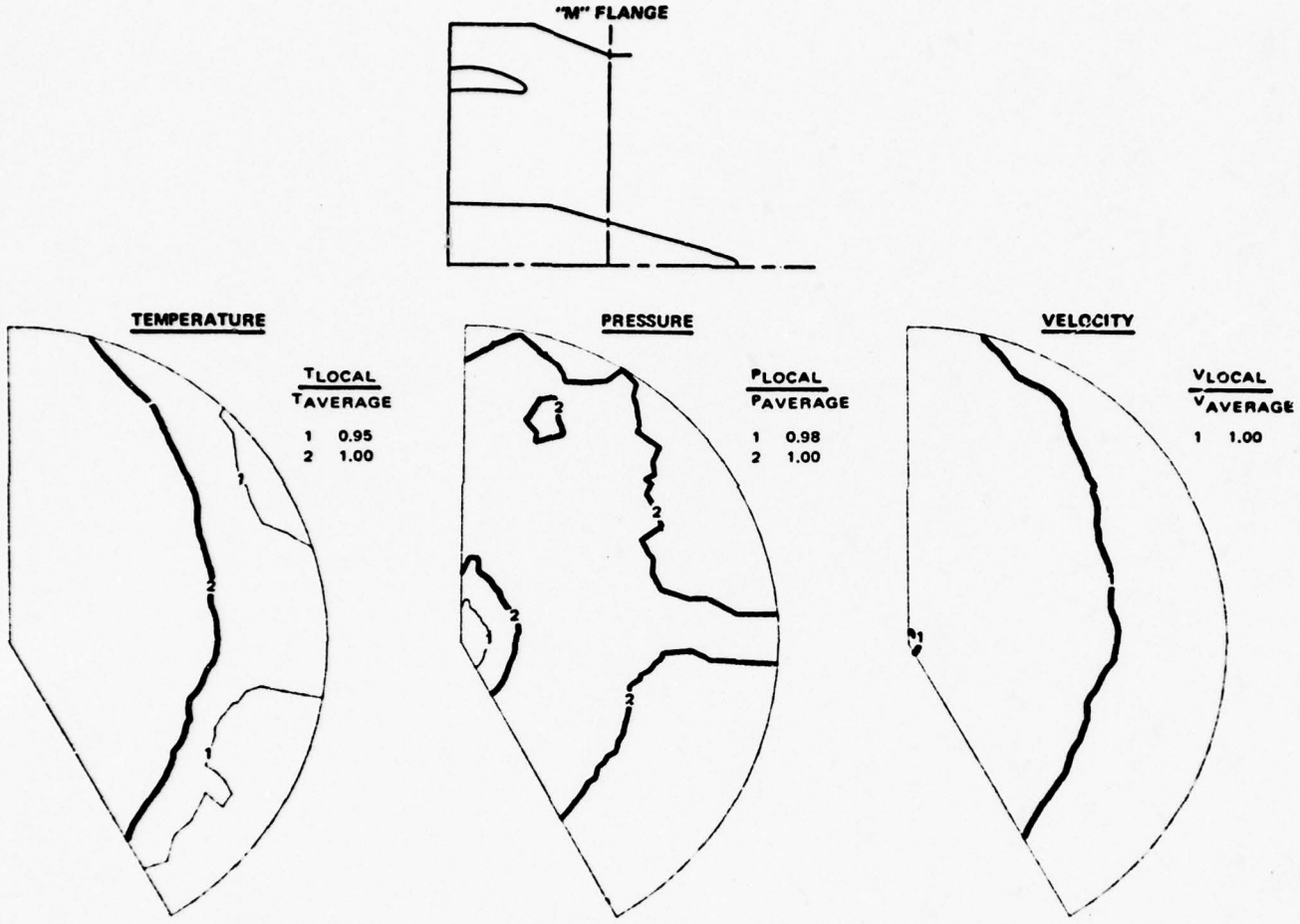


EXHAUST NOZZLE TRAVERSE RESULTS
SEVERE CUTBACK LONG FLOWPATH MIXER
CONFIGURATION 6A





EXHAUST NOZZLE TRAVERSE RESULTS
SEVERE CUTBACK SHORT FLOWPATH MIXER WITH SECONDARY FLOW SIMULATION
CONFIGURATION 10A



EXHAUST NOZZLE TRAVERSE RESULTS REFERENCE EXHAUST NOZZLE SYSTEM TESTED AT IDEALLY MIXED CONDITIONS CONFIGURATION 2Am

APPENDIX D

HOT/COLD FLOW MODEL TESTS TO DETERMINE STATIC PERFORMANCE OF 1/7-SCALE JT8D MIXER EXHAUST NOZZLES

Prepared by

FLUIDYNE ENGINEERING CORPORATION

SUMMARY

This report presents the results of hot/cold flow, 1/7-scale model tests conducted to determine static performance of two mixer exhaust nozzles for a JT8D engine. The test program was conducted by FluiDyne Engineering Corporation for Pratt & Whitney Division of United Technologies Corporation. The model tests were performed in the Channel 11 static thrust stand at the FluiDyne Medicine Lake Aerodynamic Laboratory.

Three model configurations were tested. Static performance was determined for a free mixer (Reference) and two 12-lobe mixers.

Test conditions included core nozzle pressure ratios from λ_8 = 1.6 to 3.2, and core-to-fan total temperature ratios from 1.0 to 2.41. Fan-to-core total pressure ratios were nominally .88, .93, and 1.00. The test program included 69 performance tests.

Facility checkout tests were made using two standard ASME long-radius metering nozzles. These tests demonstrated facility data accuracy at hot/cold flow conditions similar to the mixer tests.

Test results include static thrust coefficients, nozzle discharge coefficients, and effective throat areas.

TABLE OF CONTENTS

	Page
SUMMARY	i
TABLE OF CONTENTS	ii
LIST OF FIGURES	iii
DEFINITION OF SYMBOLS	iv
1.0 INTRODUCTION	1
2.0 FACILITY DESCRIPTION	2
3.0 MODEL DESCRIPTION	4
3.1 Model Adapters	4
3.2 Nozzle Components	5
3.3 Standard ASME Nozzles	5
4.0 DATA ANALYSIS PROCEDURES	6
4.1 P_{t_7} and P_{t_8} Definitions	6
4.2 Flow Rates	7
4.3 Discharge Coefficients and Effective Throat Areas	9
4.4 Thrust Measurement	12
4.5 Thrust Coefficient	14
4.6 Pressure and Temperature Data	16
4.7 Force Balance Calibration	16
5.0 PRESENTATION OF RESULTS	18
5.1 ASME Checkout Tests	18
5.2 Mixer Nozzle Tests	19
REFERENCES	20
FIGURES	

LIST OF FIGURES

Figure	Description
1	Channel 11 Facility Layout (6040-021)
2a	ASME Nozzle Test Assembly (6074-019)
2b	Model Assembly-Configurations 2A, 4A, 5A (1090-006)
3	Summary of Test Configurations
4a	Tailpipe Adapater (1090-403)
4b	Fan P_t Rake (1090-616)
4c	Fan Duct Case - Reference (1090-001)
4d	Fan Duct Case - 16" Mixer (1090-003)
4e	Tailpipe - Common (1090-401)
4f	Core Shroud Adapter (1034-401D)
4g	Splitter/Mixer Adapter (1090-404)
4h	Splitter - Reference (1090-603)
4i	Mixer - Configuration 4A and 5A (SKN 62264, 64437)
4j	Aft Plug - Reference (1090-801)
4k	Aft Plug - 16" Mixer (1090-608)
5a-d	Model Photographs
6a	Station Notation, Mixer Nozzle Tests
6b	Station Notation, ASME Checkout Tests
7	Run Schedule and Major Test Results
8	Test Results, ASME Checkout Tests
9a-c	Thrust coefficients
10a-c	Nozzle Discharge Coefficients

DEFINITION OF SYMBOLS

A	Cross-section area, $in.^2$
c	Real-gas A/A* correction factor, dimensionless
C	Balance readout, counts
C_D	Discharge coefficient, dimensionless
C_T	Static thrust coefficient, dimensionless
D	Diameter
F	Steam thrust, lb
g	Acceleration of gravity, 32.174 ft/sec^2
G	Real-fas stream thrust correction factor, dimensionless
H	Thrust component, lb
H_2	Axial balance force, lb
K	Critical weight flow parameter, $°R^{1/2}/sec$
K	Balance force calibration factor, lb/count
L	Calibration load, lb
M	Mach number, dimensionless
m	Mass flow rate, slugs/sec
P	Pressure, static unless otherwise specified by subscript, psia
ΔP	Static pressure difference across seal, psi
r	Radial distance, in
R_N	Reynolds number, dimensionless
T	Temperature, °R
v	Velocity, ft/sec
V	Vertical balance force, lb
W	Weight flow rate, lb/sec
y	Distance from wall
δ	Boundary layer thickness
γ	Ratio of specific heats, dimensionless
Δ	Incremental quantity
λ	Pressure ratio, P_t/P_a, dimensionless
θ	Meridian angle measured clockwise looking upstream, degrees
ρ	Density, $slugs/ft^3$

Subscripts

a	Ambient
e	Exit
i	Ideal
r	Resultant
t	Total conditions
w	Wall
x	Axial
y	Vertical
∞	Freestream
1,2,4,5,7,8,9	See Figure 6

Superscripts

*	Sonic condition

1.0 INTRODUCTION

The present test program was conducted to provide mixer nozzle performance data for a JT8D turbofan engine. The test model was a 1/7-scale simulation of the exhaust system flowpath, including two mixer nozzles.

The mixer nozzles were furnished by Pratt & Whitney. Additional model components were designed and fabricated by FluiDyne using contours and instrumentation locations specified by P&W. The models were attached to existing model-to-facility adapters. The tests were conducted in FluiDyne's two-temperature-flow static thrust stand (Channel 11). Technical liaison for Pratt and Whitney was performed by Mr. Jerrold Blatt and Mr. Maurice Bridge.

This report describes the test facility, test models, data acquisition and analysis procedures, and presents the test results. Test conditions and major test results are tabulated in Figure 7 and are plotted in Figures 8-10.

2.0 FACILITY DESCRIPTION

The tests were performed in Channel 11 at FluiDyne's Medicine Lake Aerodynamic Laboratory. Channel 11 is a two-temperature-flow static thrust stand used to determine performance of exhaust nozzles in which the two exhaust flows are at different temperatures. Nozzle thrust is determined from force measurement with a strain gage force balance. The general arrangement of Channel 11 is shown in Figure 1. Photographs of test model installations are presented in Figure 5a.

The airflows for both the cold and hot passages of a test nozzle are obtained from the facility high-pressure dry air storage system. Air for the cold passage is throttled, metered through a long-radius ASME nozzle, ducted to the cold passage of the test nozzle, and finally exhausted to atmosphere. Air for the hot passage is throttled, passed through a regenerative storage heater, mixed with unheated bypass flow to achieve a desired temperature, metered through a long-radius ASME nozzle, ducted to the hot passage of the test nozzle, and finally exhausted to atmosphere.

The air heater used for the hot flow contains alumina pebbles which are preheated to approximately 1250°F with a combustion heater. The heater capacity is nominally 40 lbs/sec at 1200°F.

The model assembly is supported by a strain gage force balance and is isolated from the facility piping by two elastic seals; see schematic in Figure 6. Calibration of the balance and seals is described in Section 4.7.

The ASME meter at Station 1 is water-cooled to protect the elastic seal from thermal effects. Since the cooling water is confined to the upstream (i.e., non-metric) hardware only, no tare forces are introduced by the water supply lines.

Facility instrumentation is provided to calculate mass flow rates at Stations 1 and 4, and to calculate the exit thrust produced by the test nozzle; details are described in Section 4.0. The data were recorded with Polaroid cameras and digital printers.

3.0 MODEL DESCRIPTION

The present tests used existing model adapters from the test programs reported in References 5, 6, 7, and 8, model components provided by P & W, and model components fabricated by FluiDyne for the present tests. Assembly drawings of the models are shown in Figure 2. Photographs of test hardware are shown in Figure 5.

3.1 Model Adapters

The test models attached to common adapting hardware which supplied separately-metered flows to the fan and core nozzles. The fan air flow was nominally at ambient temperature for all tests. The core air flow was nominally at ambient temperature for the "cold" tests, but was heated to approximately 600-800°F for the "hot" tests.

The main support member for the adapters (Spider, 0937-902) had been rebuilt for the Reference 7 tests. Adapters for the core passage consisted of an insulated duct, a jet breaker, a choke plate, two screens, and a common core shroud adapter which supported a common splitter/mixer adapter. Charging station instrumentation in the core passage included three 10-tube area-weighted total pressure ($^{P}t_{8}$) rakes, five area-weighted total temperature ($^{T}t_{8}$) probes, one thermocouple for controlling the flow temperature, three static pressure taps on the inner wall, and four static pressure taps on the outer wall.

The adapters for the annular fan passage included a choke plate, two screens, a common bellmouth contraction, and a common fan cowl adapter. Charging station instrumentation in the fan passage included four 12-tube, area-weighted, $^{P}t_{7}$ rakes; one 4-probe $^{T}t_{7}$ thermocouple rake, one thermocouple for control purposes; and four static taps on the inner and outer walls.

The single control thermocouples at the two charging stations were used to set the desired temperature ratio, T_{t_8}/T_{t_7}. Outputs from these thermocouples were amplified, divided, and displayed on a digital panel meter to provide the facility valve operators with a visual indication of the actual temperature ratio.

3.2 Nozzle Components

Nozzle components included a reference splitter (free mixer), two 12-lobed mixers, three plugs, two fan duct cases, and one tailpipe.

The mixers were of the same basic design; one had deep scallops (Configuration 4A) and another had scallops and shortened mixing lobes (Configuration 5A).

Three test configurations were assembled, as summarized in Figure 3. Photographs of the test hardware, including partial assemblies, are shown in Figures 5a-d.

The only static pressure taps on the nozzle components were added for the thrust reverser tests; details are shown in the drawings (Figure 4).

3.3 Standard ASME Nozzles

Facility demonstration and checkout tests were performed using two standard ASME long-radius flow metering nozzles (Figures 2a and 5a). The upper nozzle (cold flow) simulated the fan passage of the mixer nozzle, while the lower nozzle (hot flow) simulated the core passage. The two ASME nozzles were tested separately and simultaneously (only simultaneous test results are presented in this report).

4.0 DATA ANALYSIS PROCEDURES

The following subsections describe the data analysis procedures used in the present test program. Station notations are defined in Figure 6 Computer programs written in BASIC language are included in the Appendix.

4.1 P_{t_7} and P_{t_8} Definitions

P_{t_7} was defined as the area-weighted average of four 12-probe rakes. The area-weighting method was adequate for the present tests since only non-distorted pressure profiles were involved.

For all configurations except the reference model (Configuration 2A), P_{t_8} was defined as the area-weighted average of three 10-probe rakes. For the reference model tests, P_{t_8} was defined as 1.0075 times the mass-flow-derived P_{t_8}. This correlation was used because of disagreement between the three P_{t_8} rakes. The correlation was obtained by comparing the mass-flow-derived P_{t_8} to the area-weighted P_{t_8} on the configuration 2A tests. After the configuration 2A tests were completed, a second screen was added to the core passage upstream of the core charging station, resulting in good agreement between the three P_{t_8} rakes; the correlation was not used for subsequent tests.

The above paragraphs define P_{t_7} and P_{t_8} at the charging station rakes. These total pressures were then adjusted to a hypothetical charging station located 1.2 inches further downstream. The calculation procedure, specified by P&W, is detailed in the Appendix. The P_t corrections were on the order of 0.1%.

4.2 Flow Rates

The mass flow rates through the test nozzles were determined using choked ASME long-radius metering nozzles. The core nozzle flow rate was calculated at Station 1, (see Figure 6) and the fan nozzle flow rate was calculated at Station 4, using the following equations.

$$W_1 = W_8 = \frac{K_1 C_{D_1} A_1 P_{t_1}}{\sqrt{T_{t_1}}}$$

$$W_4 = W_7 = \frac{K_4 C_{D_4} A_4 P_{t_4}}{\sqrt{T_{t_4}}}$$

The critical flow factor, K, was calculated as a function of total pressure and total temperature.

$$K = 0.52820 + aT_t + bT_t^2 + cT_t^3 + 0.186 \times 10^{-4} \times P_t \times e^{-.0067(T_t - 5000)}$$

where: $a = 0.1654 \times 10^{-4}$

$b = -0.2119 \times 10^{-7}$

$c = 0.6008 \times 10^{-11}$

T_t is in °R and P_t is in psia.

This equation was obtained by curve-fitting tabulated values in Reference 1; the curve-fit is accurate to within ± 0.03% for $0 < P_t < 30$ atmospheres and $460 < T_t < 700°R$, and is accurate to within ± 0.1% for $0 < P_t < 40$ atmospheres and $460 < T_t < 1800°R$.

C_{D_4} was calculated using a semi-empirical equation

$$C_{D_4} = 1 - 0.184\ R_{N_4}^{-0.2}$$

and varied from 0.991 to 0.993 for the present tests.

C_{D_1} was calculated from a similar equation, modified to account for a thermal boundary layer. This thermal boundary layer results from water-cooling of the Station 1 meter.

$$C_{D_1} = 1 - (0.184\ R_{N_1}^{-0.2})\ (1.574 - 0.574\ T_{t_1}/T_w)$$

The above equation was derived assuming constant static pressure in the boundary layer, a 1/7 power velocity profile, thermal boundary layer thickness equal to velocity boundary layer thickness, and a density distribution in the boundary layer defined by

$$\frac{\rho}{\rho_\infty} = \frac{T_\infty}{T_w} - \left(\frac{T_\infty}{T_w} - 1\right)\left(\frac{y}{\delta}\right)^{1/7}$$

T_w, the wall temperature at the nozzle throat, was estimated from heat-balance calculations of heat transfer from the air stream to the cooling water. T_w values calculated for the present tests varied from 105° to 165°F. R_{N_1} was calculated using a mean temperature $(T_w + T_{t_1})/2$. C_{D_1}, calculated using the above equation, varied from 0.991 to 0.997 for the present tests. Given sufficient wall-cooling, C_{D_1} may exceed unity (Reference 2).

The above equation for C_{D_1} is believed to be correct within ± 0.002, on the basis of results from facility demonstration

tests. These demonstration tests included test series with either a 2.5-inch or a 4-inch diameter ASME nozzle located downstream of the water-cooled Station 1 meter. The downstream nozzle was essentially at adiabatic conditions (thin-wall construction, backside insulated). Flow rates calculated at Station 1 (using the above C_{D_1} equation) agreed within $\pm$ 0.25% with flow rates calculated at the downstream nozzle (using adiabatic wall C_D), thereby indicating the adequacy of the C_{D_1} equation.

A_4, the geometric throat area of the Station 4 meter, was 2.5475 in^2. A_1, the geometric throat area of the Station 1 meter, was calculated assuming thermal expansion from 70°F to T_w. The largest value of A_1 calculated for the present tests was 1.3490 in^2, representing a thermal expansion (area change) of 0.16% from the nominal area of 1.3468 in^2.

P_{t_1} and P_{t_4} were measured on Heise bourdon-tube gages. T_{t_1} and T_{t_4} were measured with shiedled chromel/alumel thermocouples and recorded on the facility Vidar system (analog to digital converter, printer).

Calculated flow rates (lbm/sec) for the present tests were in the ranges

$$2.6 < W_1 < 10.2 \qquad 2.2 < W_4 < 9.1$$

4.3 Discharge Coefficients and Effective Throat Areas

Discharge coefficient is defined as the ratio of actual flow rate through a nozzle to the ideal isentropic flow rate at the overall nozzle pressure ratio. Overall nozzle pressure ratios are defined as $\lambda_7 = P_{t_7}/P_a$ and $\lambda_8 = P_{t_8}/P_a$.

$$C_{D_7} = \frac{W_4 \sqrt{T_{t_7}}}{K_7 A_7 P_{t_7} (A^*/A)_7} \quad \text{and} \quad C_{D_8} = \frac{W_1 \sqrt{T_{t_8}}}{K_8 A_8 P_{t_8} (A^*/A)_8}$$

K_7 and K_8 were evaluated using a previous equation, as functions of $^{P}t_7$, $^{T}t_7$ and $^{P}t_8$, $^{T}t_8$.

The throat area of the 3.75-inch ASME nozzle was A_7 = 11.0447 in^2. The throat area of the 4.00-inch ASME nozzle, when measured at room temperature, was A_8 = 12.5664 in^2. The actual throat area of the 4.00-inch nozzle, when tested with hot flow, was calculated assuming thermal expansion from 70°F to a recovery temperature, T_w. T_w was calculated assuming isentropic expansion and a recovery factor of 0.89, i.e.,

$$T_w/^{T}t_8 = (T_8/^{T}t_8) + 0.89\ (1 - T_8/^{T}t_8)$$

A_8 values calculated for the ASME tests ranged from 12.710 to 12.714 in^2. For the mixer nozzle tests, reference areas A_7 and A_8 were not defined, and therefore, fan and core nozzle discharge coefficients could not be calculated. However, the effective throat areas ($^{C}D_7A_7 + {}^{C}D_8A_8$) were calculated. In addition, an overall nozzle discharge coefficient was calculated as $^{C}D_9 = (^{C}D_7A_7 + {}^{C}D_8A_8)/A_9$ where A_9 is the exit area of the tailpipe (see Figure 6a) and equals 14.21 in^2.

$^{P}t_7$ and $^{P}t_8$ were measured on multiple-tube mercury manometers, and were defined as described in Section 4.1.

$^{T}t_7$ and $^{T}t_8$ were measured with shielded chromel/alumel thermocouples. However, since the thermocouple rakes were further upstream than the pressure rakes, the measured temperatures were adjusted to account for heat transfer (between the air and the model walls) occurring between the temperature and pressure rake stations. This adjustment was based on analytic estimates which indicated that $^{T}t_8$ should decrease 5.7° when the core and fan temperatures differed by 760°F. An energy balance required that the fan flow temperature would increase by approximately the same amount. The temperature

adjustments calculated for the present tests ranged up to -6° for T_{t_8} and +6° for T_{t_7}.

A*/A, the isentropic area ratio, is used to correct the ideal flow rate when the nozzle is unchoked. A*/A for the fan nozzle was calculated using equations valid for γ = 1.4, obtained from Reference 3.

$$A^*/A = 3.86393\lambda^{-0.71429} \sqrt{1 - \lambda^{-0.28571}} \quad \text{for } \lambda \leq 1.8929$$

and

$$A^*/A = 1 \quad \text{for } \lambda \geq 1.8929$$

A*/A for the core nozzle was obtained by correcting the γ = 1.4 value for "real gas effects," to account for γ_8 being significantly less than 1.4. The correction was derived by curve-fitting tabulated values from Reference 4; no corrections were indicated for $T_t < 900°R$. First, the critical pressure ratio was expressed as a function of total temperature:

$$1/\lambda^* = 9.667 \times 10^{-6} \times T_t \ (°R) + 0.5196$$

If $\lambda \geq \lambda^*$, then A*/A = 1. If $\lambda < \lambda^*$ and $900 < T_t < 1260°R$,

$$c = 1 + \left(\frac{1}{\lambda} - \frac{1}{\lambda^*}\right) 5.728 \times 10^{-5} (T_t - 900)$$

If $\lambda < \lambda^*$ and $1260 < T_t < 1800°R$,

$$c = 1 + \left(\frac{1}{\lambda} - \frac{1}{\lambda^*}\right) [2.615 \times 10^{-5} (T_t - 1260) + 0.020621]$$

Finally,

$$A^*/A = c \times (A^*/A)_{\gamma = 1.4}$$

For the present tests, c (denoted c* on computer output sheets) varied from 1.000 to 1.002.

4.4 Thrust Measurement

The net static axial thrust of an exhaust nozzle is defined as the axial exit momentum of the exhaust flow, plus the excess of exit pressure over ambient pressure times the exit area.

$$H_x = mv_{e_x} + (P_e - P_a) A_{e_x}.$$

The net static thrust of an exhaust nozzle model was determined in the present test program by applying the momentum equation to the control volume shown in Figure 6. The analysis of axial forces applied to the control volume includes entering stream thrusts (F_1 and F_4), a balance force (H_2), various pressure-area terms and the axial exit stream thrust, ($H_x + p_a A_{e_x}$). The axial balance force, H_2, as used here, included seal tare forces. Summing axial forces,

$$H_x = F_1 + F_4 + p_2 (A_2 - A_1) + p_5 (A_5 - A_4) - p_a (A_2 + A_5) - H_2$$

The stream thrust at Station 4 is the exit stream thrust of a choked long-radius ASME nozzle, and was calculated as:

$$F_4 = G_4 (1 + 1.4 \, C_{D_4} C_{T_4}) \, .52828 \, P_{t_4} A_4$$

Use of $\gamma = 1.4$ and $P^*/P_t = .52828$ in the above equation imply an ideal gas. The factor G, derived from tabulated values in References 1 and 4, corrects the stream thrust from that of an ideal gas to that of a real gas.

If $T_t < 560°R$, $G = 1.00012 + 6.8338 \times 10^{-6} \times P_t$ (psia)

If $T_t > 560°R$, $G = 1.0044 - (4.196 - .0059 \, P_t) (T_t + 460) \times 10^{-6}$

C_{D_4} has already been discussed; C_{T_4} was calculated in an analogous manner,

$$C_{T_4} = 1 - 0.109\ R_{N_4}^{-0.2}$$

This equation is a semi-empirical expression of the thrust coefficient of an ASME nozzle at a pressure ratio of λ = 1.8929 (corresponding to P^*/P_t = .52828). For the present tests, G_4 varied from 1.000 to 1.0013, and C_{T_4} varied from 0.995 to 0.997.

The stream thrust at Station 1 was calculated as:

$$F_1 = G_1\ (1 + 1.4\ C_{D_1} C_{T_1})\ .52828\ P_{t_1} A_1$$

Each variable in this equation has been previously described, except C_{T_1}. C_{T_1} was calculated in a similar manner as C_{T_4}, but was modified to account for the thermal boundary layer described in the discussion of C_{D_1} in Section 4.1:

$$C_{T_1} = 1 - (0.109\ R_{N_1}^{-0.2})\ (0.828 + 0.172\ T_{t_1} T_w)$$

The above equation was derived using the same assumptions as in the derivation of C_{D_1}. C_{T_1} for the present tests varied from 0.992 to 0.996.

Static pressures p_2 and p_5 were measured on mercury manometer. Ambient pressure (p_a) was measured on a Haas mercury manometer (barometer). A_5 and A_2, the geometric reference areas for the seals, were both 3.5 in^2.

The vertical thrust, H_y, was calculated from the two vertical balance forces:

$$H_y = V_1 + V_3$$

The resultant thrust, H_r was calculated as the vector sum of the axial thrust H_x, and vertical thrust H_y. Resultant thrust vector angle, α, was determined as:

$$\alpha = \tan^{-1} \frac{H_y}{H_x}$$

The sign convention for positive values of thrust components and vector angle is defined in Figure 6a. Note that for the present tests, the nozzle is mounted horizontally and there is no vertical thrust.

4.5 Thrust Coefficient

The static thrust coefficient of an exhaust nozzle is defined as the ratio of the measured nozzle net thrust to the ideal thrust of the actual mass flow when expanded isentropically from P_t to P_a.

$$C_T = \frac{H}{m\, v_i}$$

For the dual-flow tests, the ideal thrust was calculated as the sum of the fan nozzle ideal thrust and the core nozzle ideal thrust:

$$C_T = \frac{H}{m_7 v_{i_7} + m_8 v_{i_8}}$$

For the present tests, thrust coefficients were calculated for the axial and vertical thrust components and for the resultant vector.

$$C_{T_x} = \frac{H_x}{m_7 v_i + m_8 v_{i_8}}$$

$$C_{T_y} = \frac{H_y}{m_7 v_{i_7} + m_8 v_{i_8}}$$

$$C_{T_r} = \sqrt{C_{T_x}^2 + C_{T_y}^2}$$

Ideal thrust was calculated using a dimensionless ideal thrust function, $m_i v_i / P_t A^*$, which is a function of both λ and γ.

$$m_i v_{i_7} = (A^*/A)_7 \; C_{D_7} A_7 P_{t_7} \; (m_i v_i / P_t A^*)_7$$

$$m_i v_{i_8} = (A^*/A)_8 \; C_{D_8} A_8 P_{t_8} \; (m_i v_i ; P_t A^*)_8$$

where

$$(m_i v_i / P_t A^*) = \gamma \left[\frac{2}{\gamma + 1}\right]^{\frac{\gamma}{\gamma - 1}} \sqrt{\frac{\gamma + 1}{\gamma - 1}} \sqrt{1 - \gamma^{\frac{1 - \gamma}{\gamma}}}$$

$$= 1.81162 \sqrt{1 - \lambda^{-0.28571}}, \text{ for } \gamma = 1.4.$$

For the present tests, γ_7 was taken to be 1.400. However, $\gamma_8 \neq 1.4$ and, therefore, $(m_i v_i / P_t A^*)_8$ obtained from the above equation was corrected to account for "real gas effects" by multiplying by the ratio

$$\frac{(m_i v_i / P_t A^*) \text{ for real gas}}{(m_i v_i / P_t A^*) \text{ for } \gamma = 1.4}$$

This ratio was calculated from tabulated values in Reference 4; for the present range of test conditions this factor was obtained from a curve-fit expression

$$.9957 - 5.81 \times 10^{-5} \times ({}^{T}t_8, {}^{\circ}R - 1000) + 1.25 \times 10^{-3} \times (\lambda_8 - 1)$$

and varied between .9950 and .9972.

4.6 Pressure and Temperature Data

Pressure instrumentation for facility pressures and charging station pressures were described previously. All other pressures in the model were measured using multiple-tube mercury manometers. Model pressure data were reduced to absolute pressures (psia) and dimensionless ratios (P/P_{t_7}, P/P_{t_8}, P/P_a). The results are tabulated on computer output sheets, contained in the Appendix.

Facility and charging station temperature data were obtained using shielded chromel/alumel thermocouples, and were recorded on the facility Vidar system. Temperatures were expressed in °F or °R, or both.

4.7 Force Balance Calibration

The force balance calibration determines the output characteristics of both the force balance flexures and the elastic seals which provide pressure-tight expansion joints between the metric model assembly and the non-metric facility structure. The outputs of the strain-gage flexures are very linear with applied load, but the seals provide an additional axial force which is a function of both axial load and seal pressure. Most of this force carryover results from radial seal deflections required to support the static pressure differentials across the seals when the ducts are pressurized. Consequently, the seal and balance assembly is calibrated under simulated operating conditions of loads and seal differential pressures. The calibration for this mixed flow facility is further complicated by the fact that the location of the applied load during a test is a function of the hot/cold flow split and nozzle pressure ratios; the calibration must, therefore, duplicate both the magnitude and location of the net force which was experienced during a test. As a result of these requirements, it has been found expedient to calibrate "on-point," that is, to determine the balance

output characteristics while simultaneously reproducing the forces, force location, and seal pressures experienced at a specific test point.

The forces and force location for each test point are not known exactly until the on-point calibration is completed. The initial test data are, therefore, reduced (by computer) using a preliminary calibration. The computer is programmed so that, as it reduces the initial test data, it also prints out the required calibration information (calibration load and load location), such that an accurate on-point calibration can then be made.

The on-point calibration is made with the seals pressurized to the pressures measured during the test, and the loads applied at the locations obtained from the preliminary data. The loads are then varied slightly to obtain approximately the balance output measured during the test. The on-point calibration factors are then calculated as:

$$K_2 = \left[(L_x + \Delta P_2 A_2 + \Delta P_5 A_5)/C_2\right]$$

$$K_1 = V_1/C_1$$

$$K_3 = V_3/C_3$$

The final balance forces for reducing test data were then calculated as

$$H_2 = K_2 C_2, \quad V_1 = K_1 C_1, \quad V_3 = K_3 C_3,$$

using the actual balance outputs measured during the test.

5.0 PRESENTATION OF RESULTS

Test conditions and major test results are tabulated in Figure 7 and are plotted in Figures 8 through 10. Detailed data and calculations are contained in a separate Data Appendix.

The tabulation in Figure 7 includes: configuration, run number, actual values of the independent test variables (λ_7, λ_8, T_{t_8}/T_{t_7}), the pressure ratio split (λ_7/λ_8), and the major test results (C_T, $C_{D_7}A_7$, $C_{D_8}A_8$, C_{D_9}, W_7/W_8). For the ASME nozzle tests, C_{D_7} and C_{D_8} are tabulated in place of effective throat areas.

5.1 ASME Checkout Tests

Standard ASME nozzles (Figures 2a and 5a) were tested to demonstrate facility data accuracy in determining C_D and C_T of test nozzles. Results of these tests are tabulated in Figure 7 (sheet 1) and are plotted in Figure 8.

Target performance curves for the ASME nozzles are shown in the figures. These predictions are based on semi-empirical equations, and were obtained by analysis of ASME nozzle exit surveys conducted by FluiDyne.

The test results were statistically analyzed in terms of bias (average difference between actual and predicted values) and scatter (standard deviation of the individual differences from their average). This analysis is summarized in the following table:

	Bias:			Standard Deviation:		
Runs	C_{D_7}	C_{D_8}	C_T	C_{D_7}	C_{D_8}	C_T
1 - 5	.0002	-.0010	-.0006	.0009	.0012	.0006
6 - 10	.0003	-.0008	.0004	.0014	.0018	.0017

5.2 Mixer Nozzle Tests

Major results from the mixer nozzle performance tests are tabulated in Figure 7, Sheets 2 and 3. Thrust Coefficients are plotted versus core nozzle pressure ratio in Figures 9a - 9c. Justification of high C_T values ($C_T > 1.00$) for mixer nozzles was discussed in Reference 5; similar reasoning applies for the present test results.

Overall nozzle discharge coefficients, C_{D_9}, are plotted in Figures 10a - 10c. The abscissa is the mass-flow-weighted pressure ratio, $\lambda = (W_7\lambda_7 + W_8\lambda_8)/(W_7 + W_8)$. The ordering of the figures is the same as for the thrust coefficients in Figure 9.

In addition to the specified test program, Configuration 2A was tested at three other times (twice near middle and near the end of program). These additional tests demonstrated facility data repeatability.

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2. Massier, P. F., Back, L. H., Noel, M. B., and Saheli, F., "Viscous Effects on the Flow Coefficient for a Supersonic Nozzle." AIAA Journal, Volume 8, No. 3, March 1970, pp. 605-607.

3. Ames Research Staff, "Equations, Tables and Charts for Compressible Flow." NACA Report 1135. 1953.

4. Jordan, D. P., and Mintz, M. D., "Air Tables." McGraw-Hill Book Company, New York. 1965.

5. Kovacevic, N., and Brasket, R. G., "Hot/Cold Flow Model Tests to Determine Static Performance of 0, 12, and 18-Lobe Mixer Exhaust Nozzles." FluiDyne Report 0937, Pratt & Whitney Agreement of 18 August 1972. January 1973.

6. Kovacevic, N., Kirschbaum, R. A., and Brasket, R. G., "Hot/Cold Flow Model Tests to Determine Static Performance of Several 18-Lobe Mixer Exhaust Nozzles (Engines A, B, C)." FluiDyne Report 0967, Pratt & Whitney Agreement of 10 May 1973. November 1973.

7. Kirschbaum, R. A., and Brasket, R. G., "Hot/Cold Flow Model Tests to Determine Static Performance of 1/7-Scale Mixer Exhaust Nozzles for a JT8D Refan Engine." FluiDyne Report 1034, Pratt & Whitney Agreement of 5 December 1974. March 1975.

8. Kirschbaum, R. A., and Brasket, R. G., "Hot/Cold Flow Model TEsts to Determine Static Performance and Jet-Wing Surface Temperatures for 1/7-Scale JT8D-217 Mixer Exhaust Nozzles." FluiDyne Report 1067, Pratt & Whitney Agreement of 30 December 1975. March 1976.

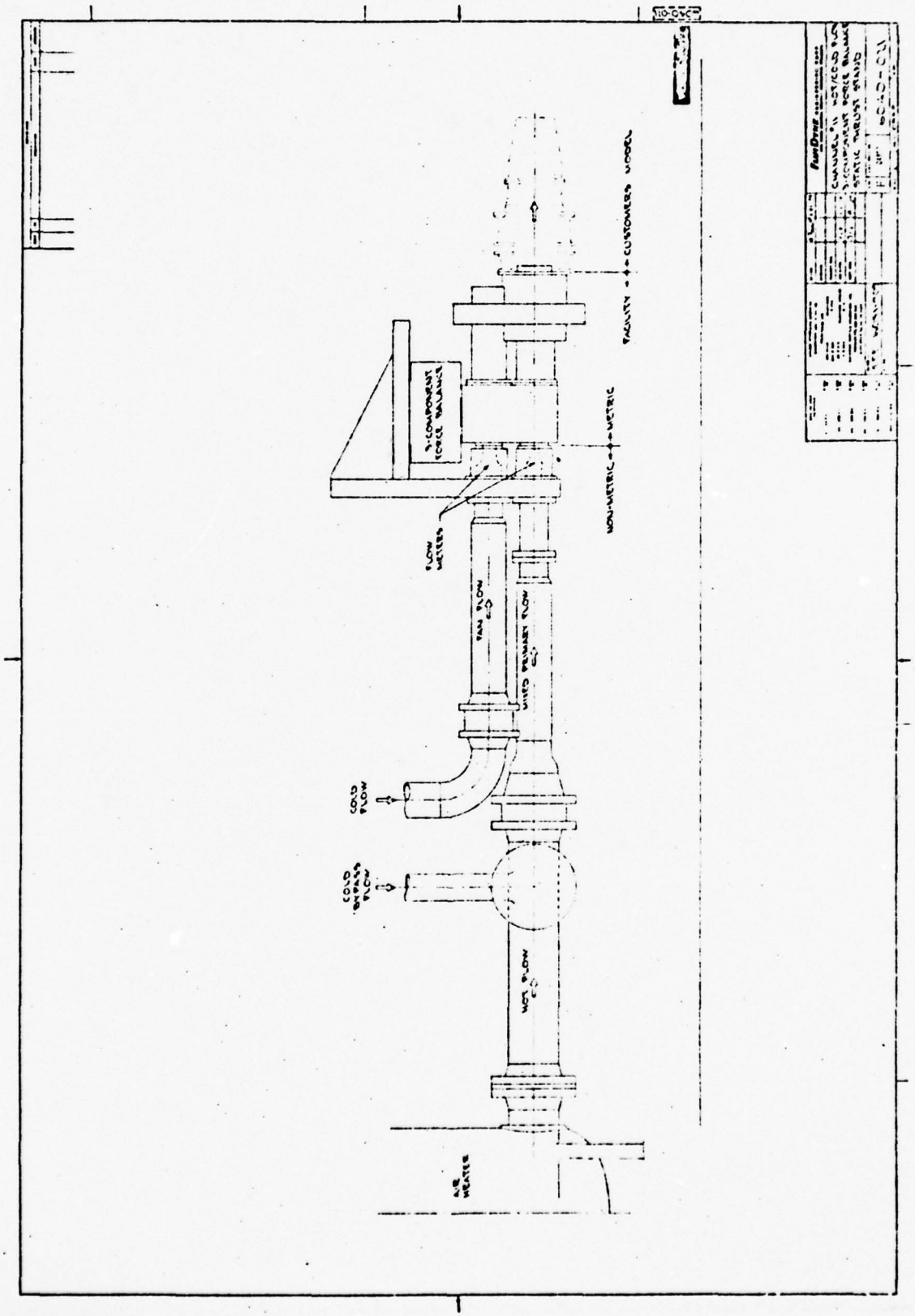


FIGURE 1. CHANNEL 11 FACILITY LAYOUT

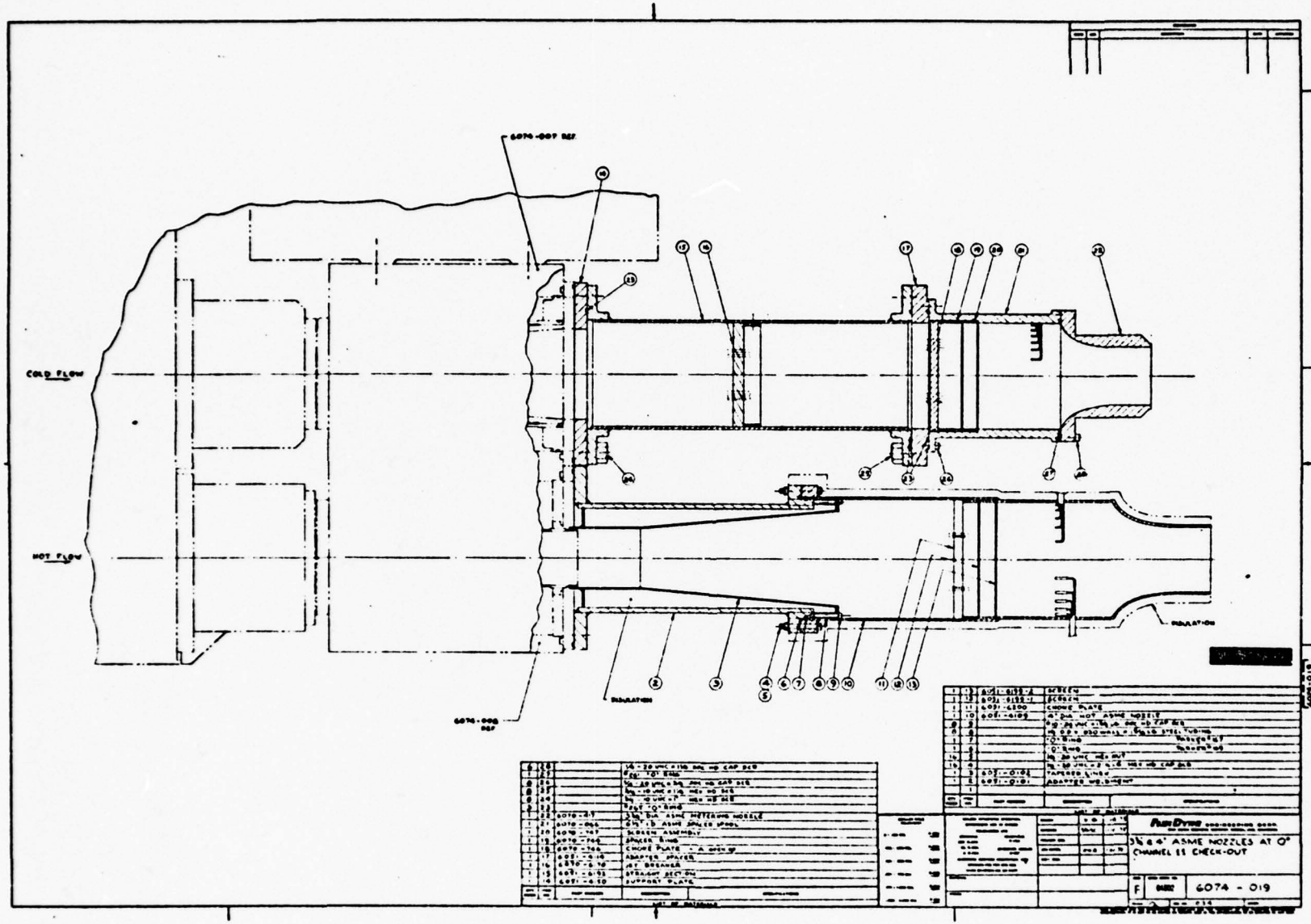


FIGURE 2a. ASME NOZZLE TEST ASSEMBLY DRAWING

FluiDyne ENGINEERING CORPORATION

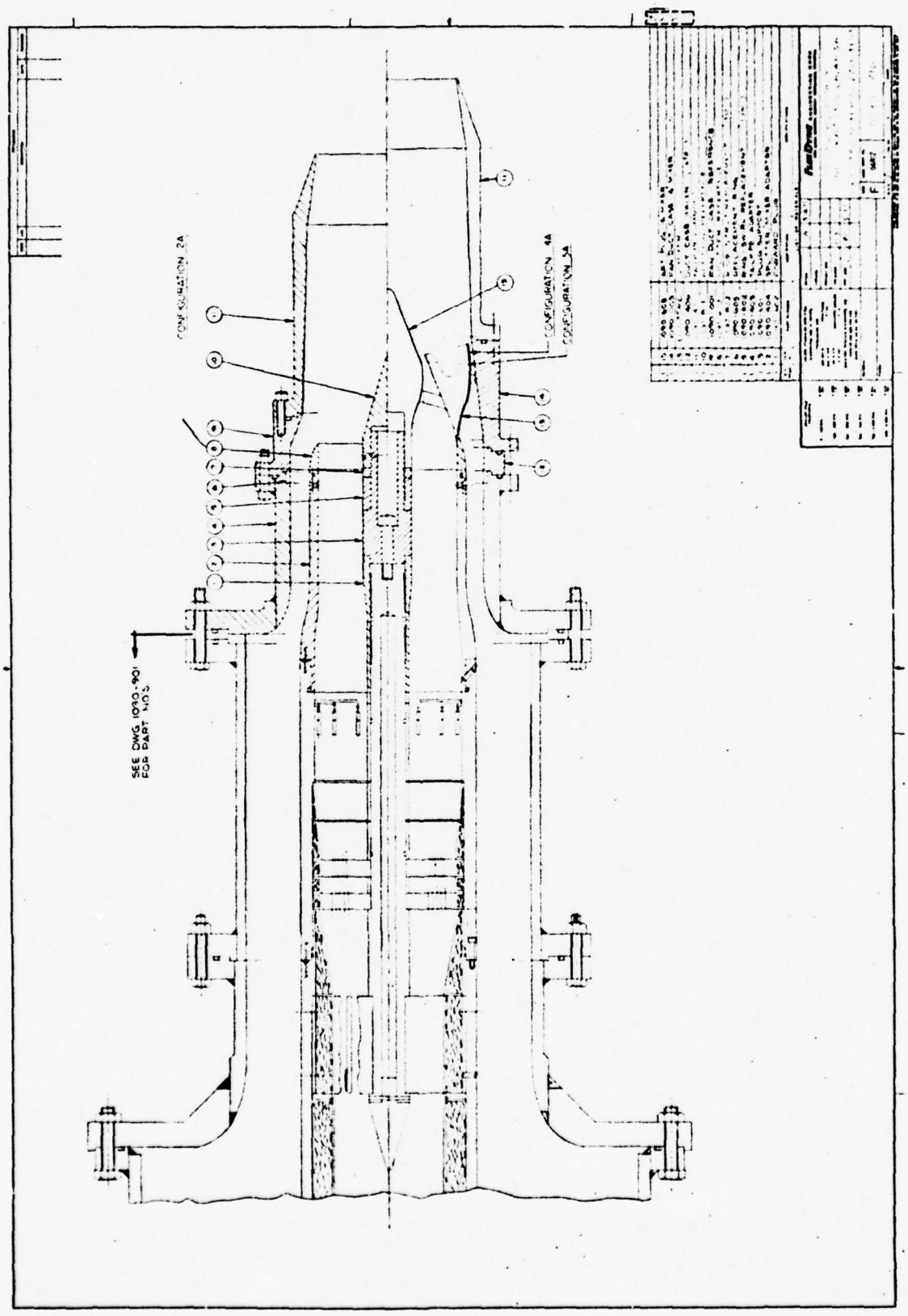


FIGURE 2b. MODEL ASSEMBLY - CONFIGURATIONS 2A, 4A, 5A

Run Numbers	Config.	Splitter or Mixer	Tailpipe	Fan Duct Case	Swirl, TEGV, Tangential Struts, Fan P_t Distortion	Other
1-10	Dual ASME					
11-38, 214	2A	Reference Splitter	Common (401)	Reference (001)	No	
114-123	5A	16" Mixer, Cutback, Scalloped	Common (401)	16" Mixer (003)	No	1090-406 duct case spacer
124-153	4A	16" Mixer, Scalloped	Common (401)	16" Mixer (003)	No	1090-406 duct case spacer

FIGURE 3. SUMMARY OF TEST CONFIGURATIONS

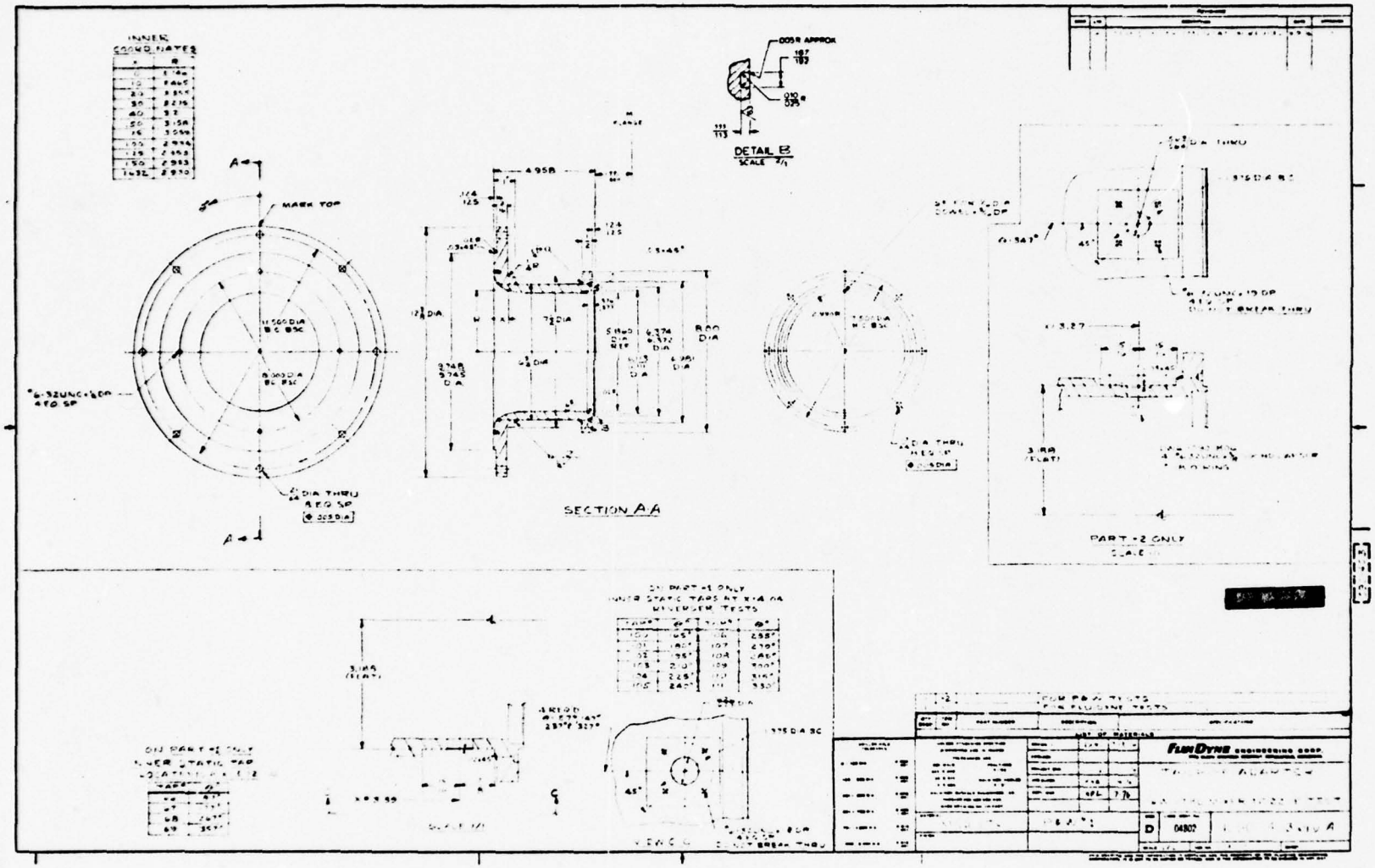


FIGURE 4a. TAILPIPE ADAPTER

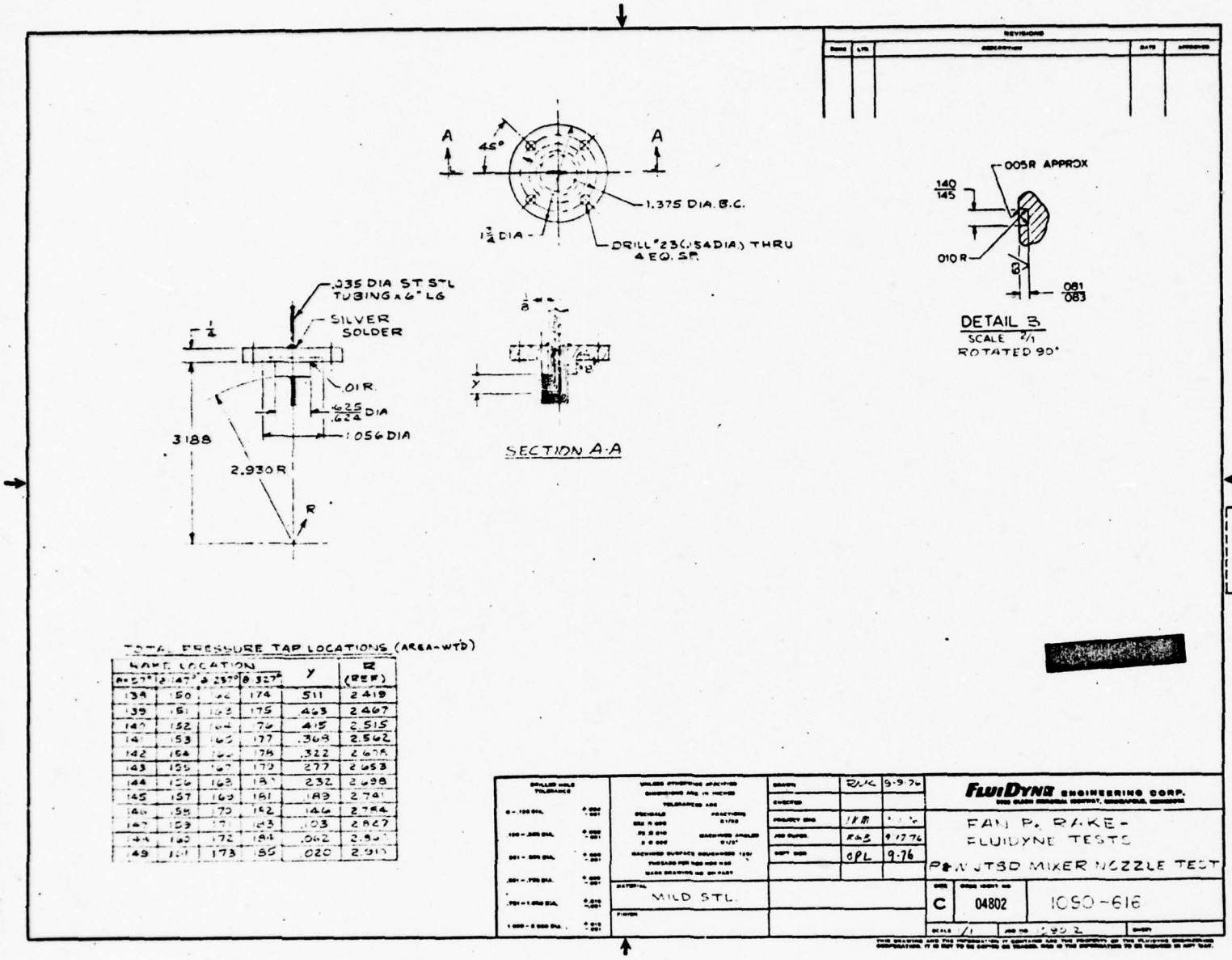


FIGURE 4b. FAN P_t RAKE

FLUIDYNE ENGINEERING CORPORATION

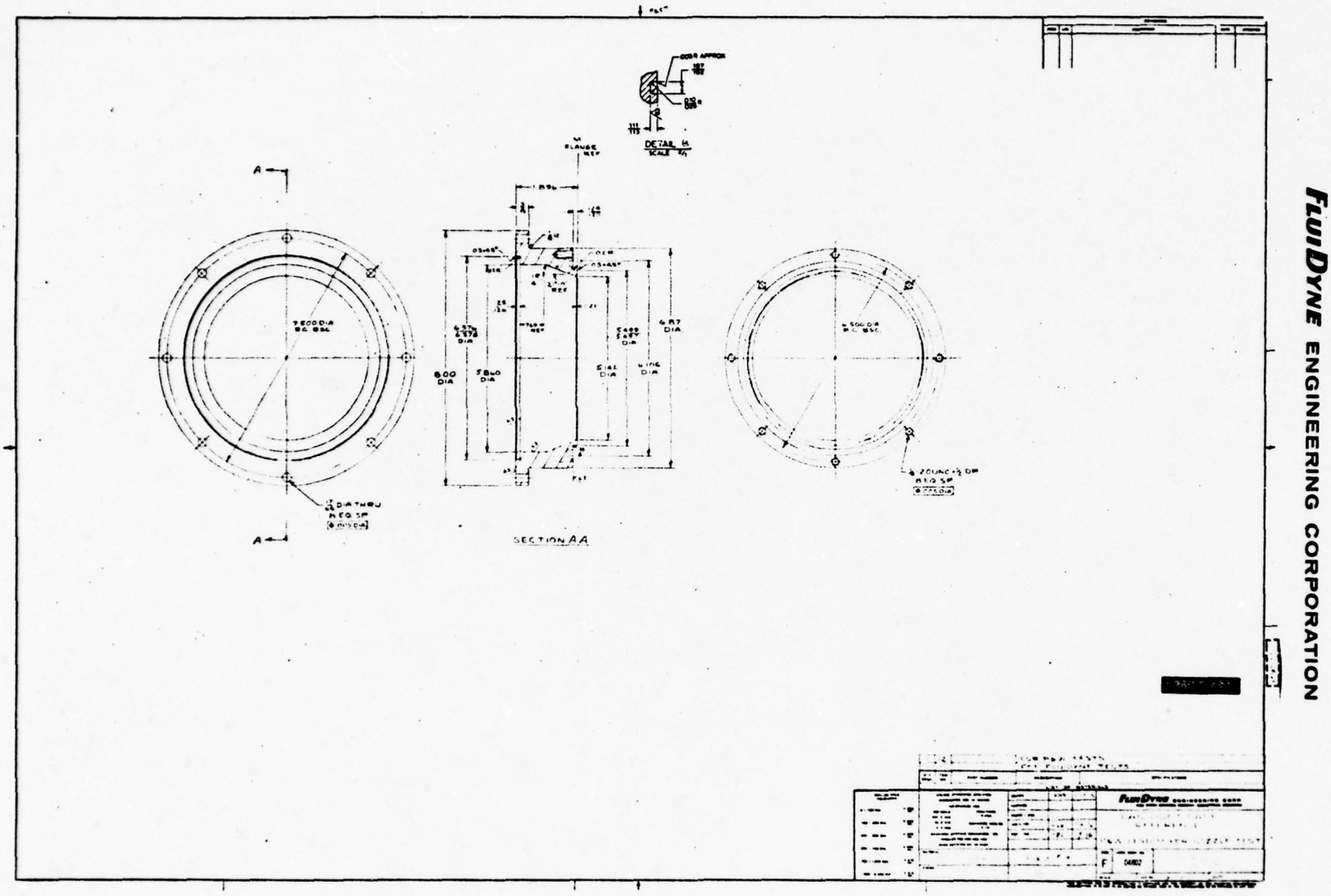


FIGURE 4c. FAN DUCT CASE-REFERENCE

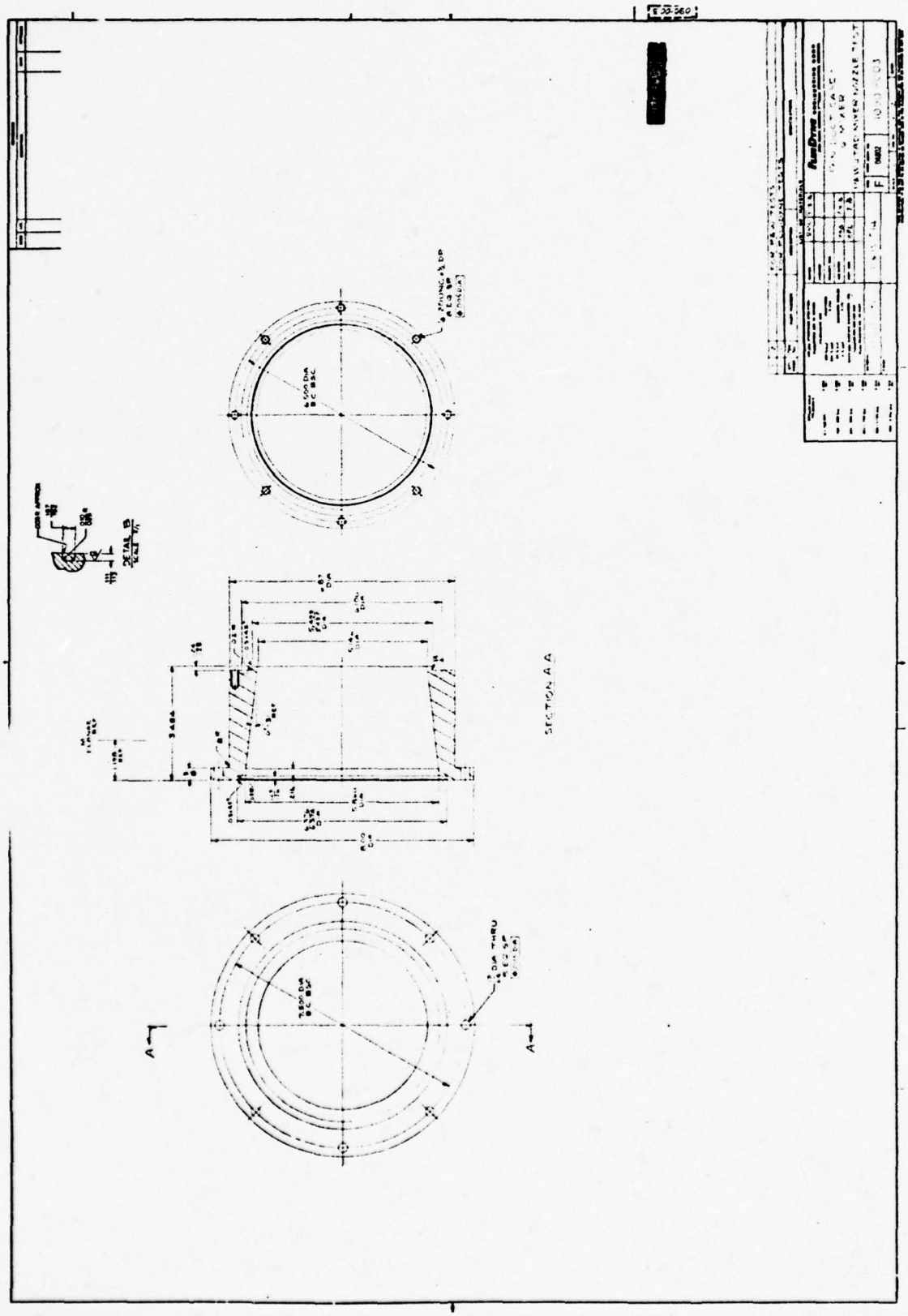


FIGURE 4d. FAN DUCT CASE - 16" MIXER

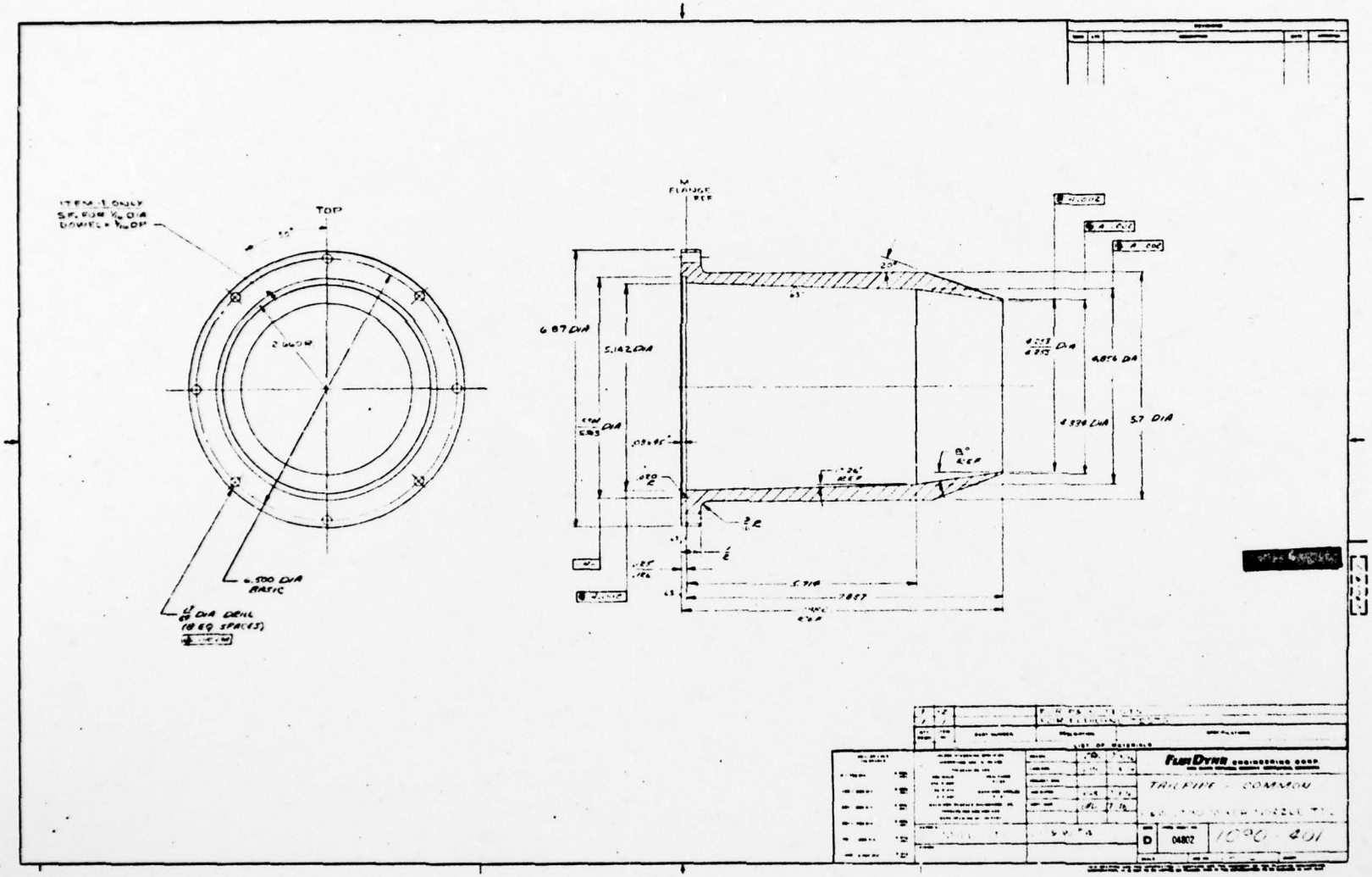


FIGURE 4e. TAILPIPE - COMMON

FLUIDYNE ENGINEERING CORPORATION

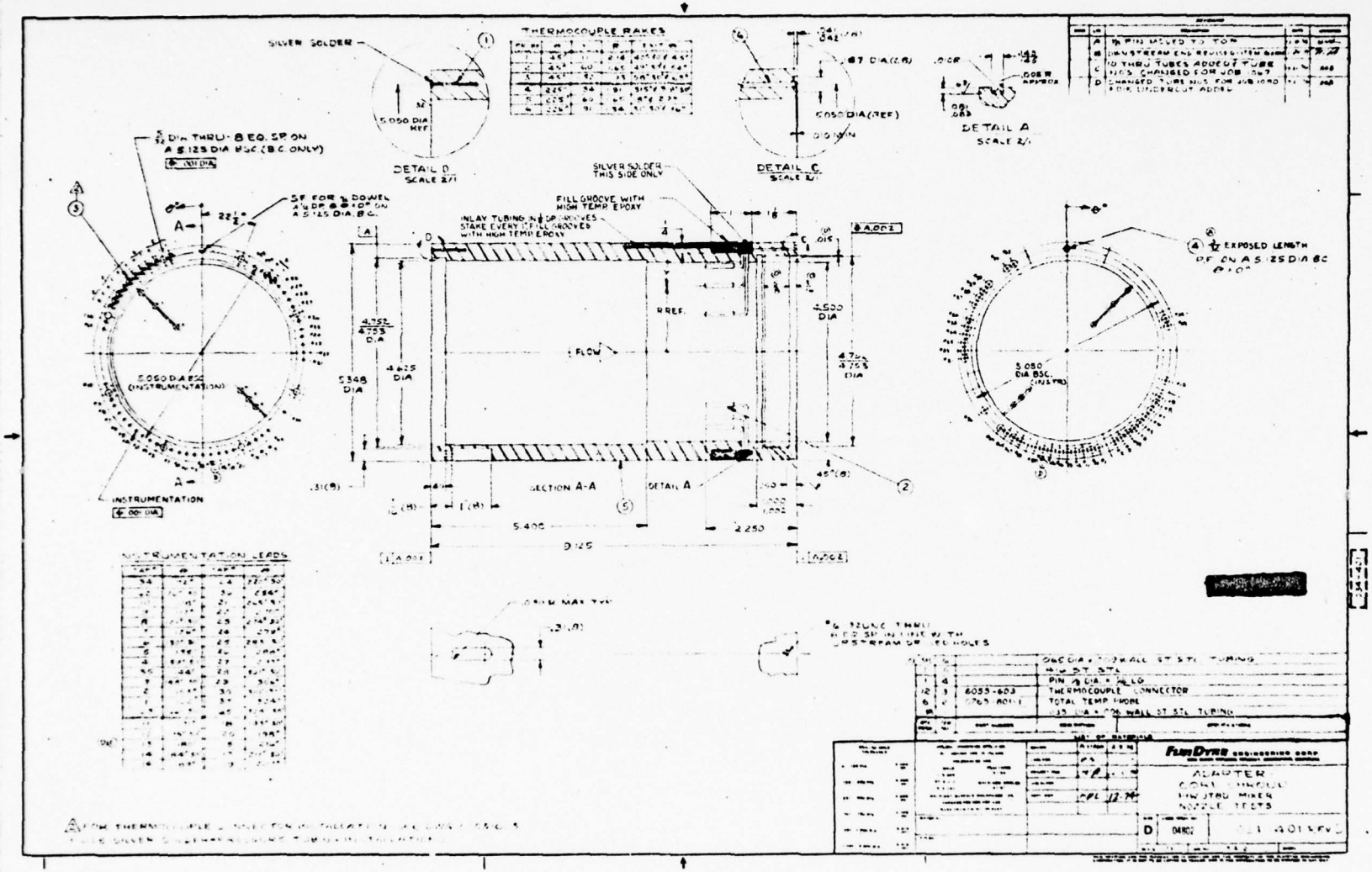


FIGURE 4f. CORE SHROUD ADAPTER

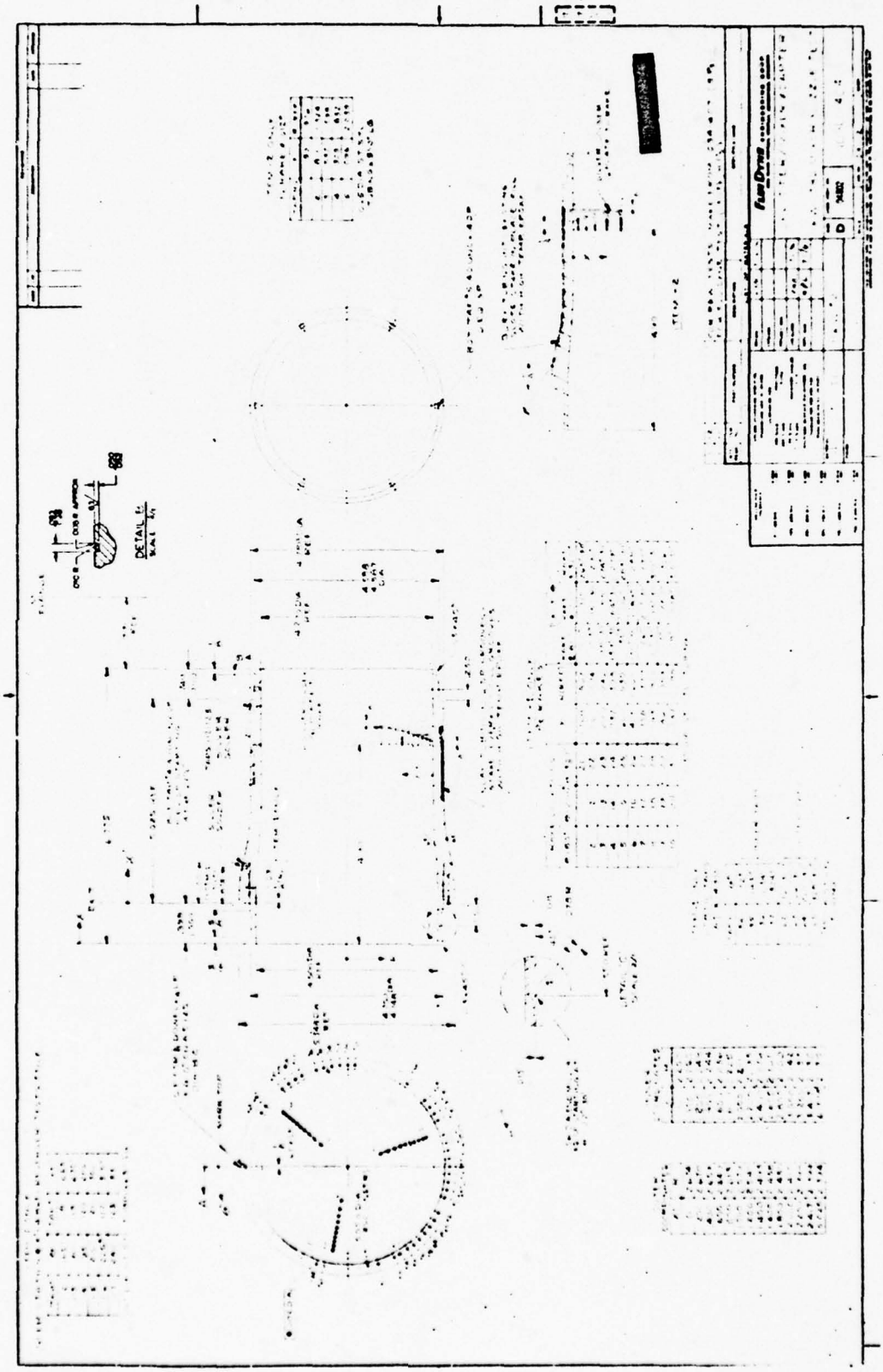


FIGURE 4g. SPLITTER/MIXER ADAPTER

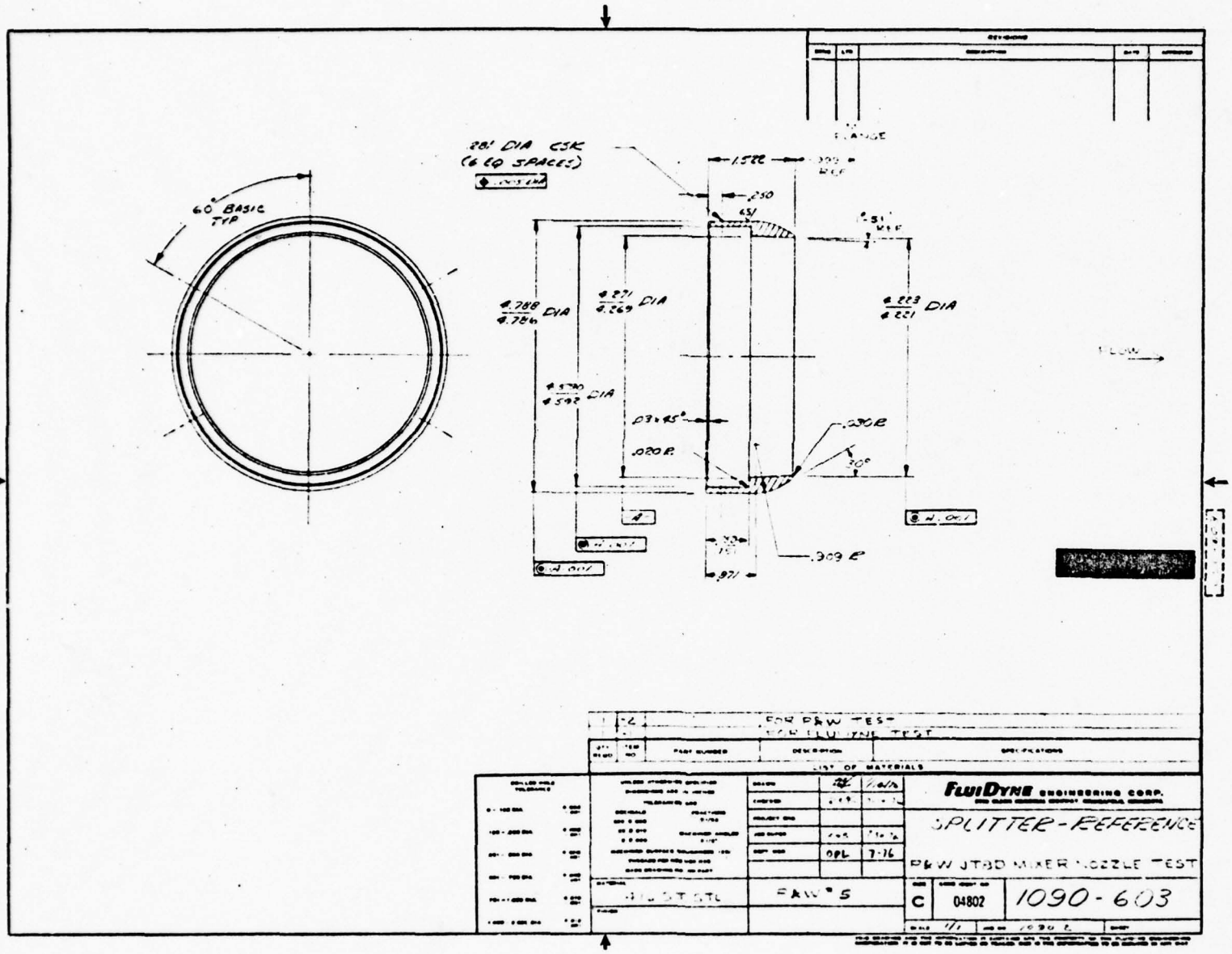


FIGURE 4h. SPLITTER - REFERENCE

FLUIDYNE ENGINEERING CORPORATION

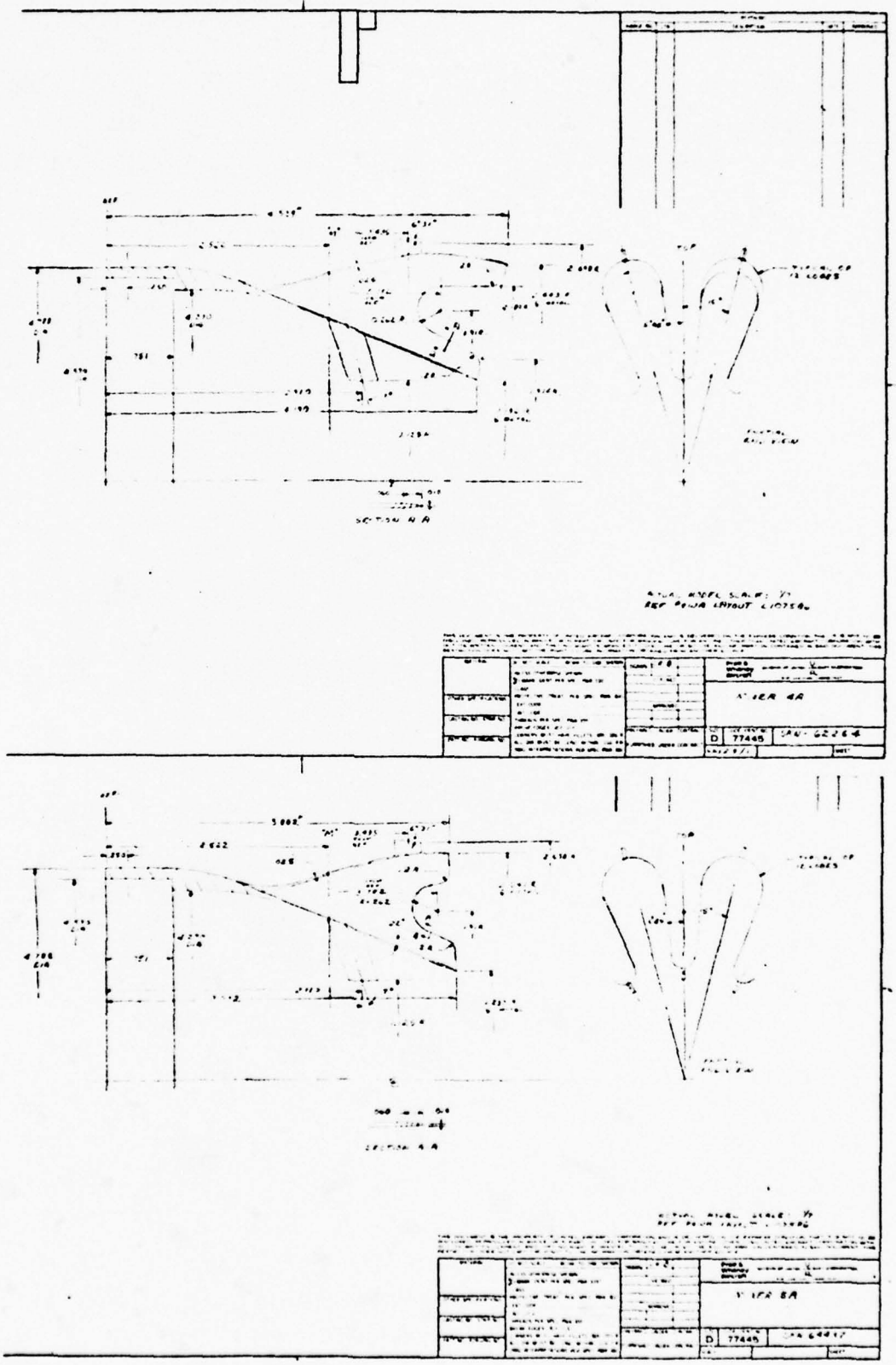
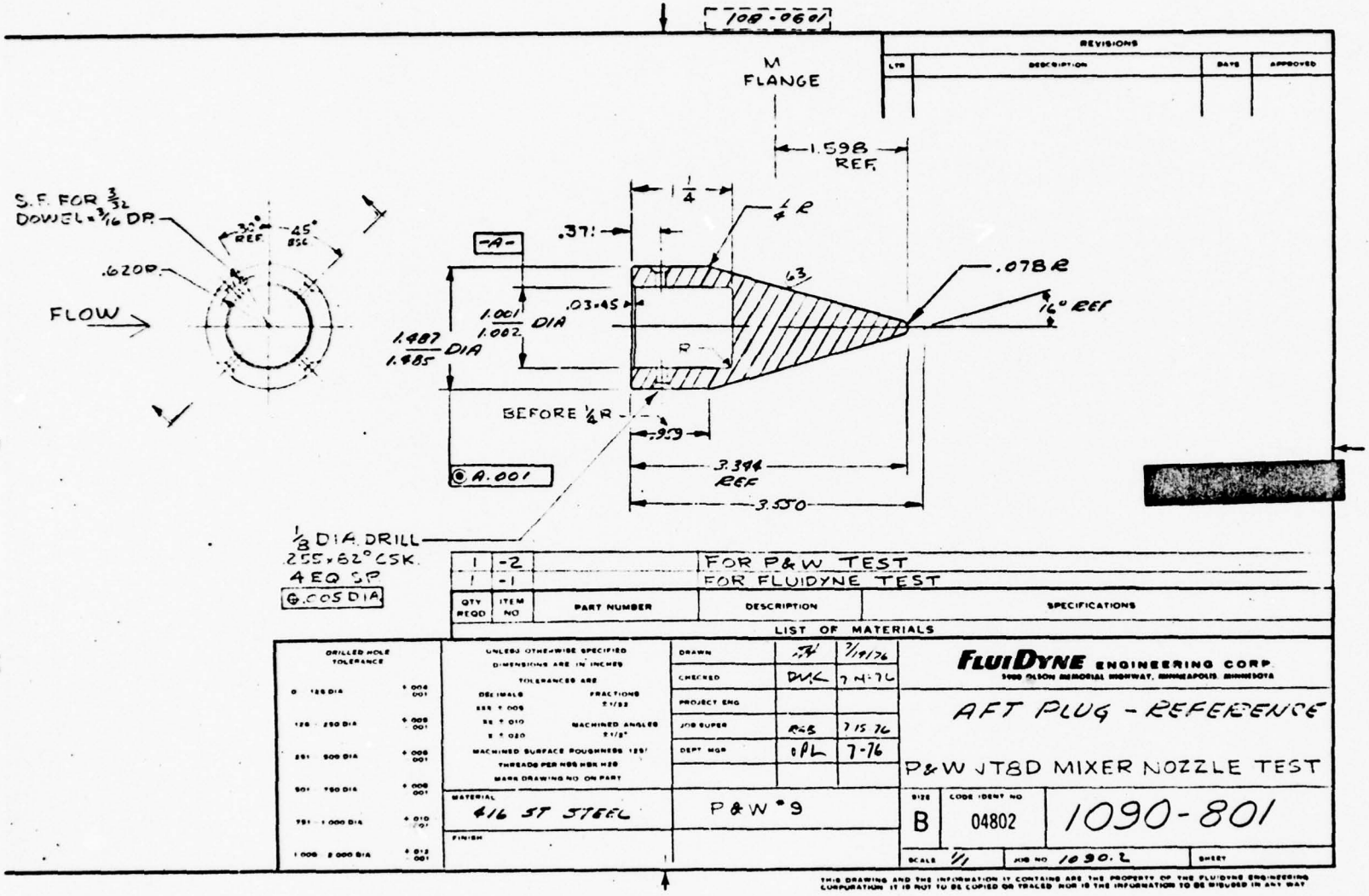


FIGURE 4i. MIXER - CONFIGURATION 4A and 5A



FLUIDYNE ENGINEERING CORPORATION

FIGURE 4j. AFT PLUG - REFERENCE

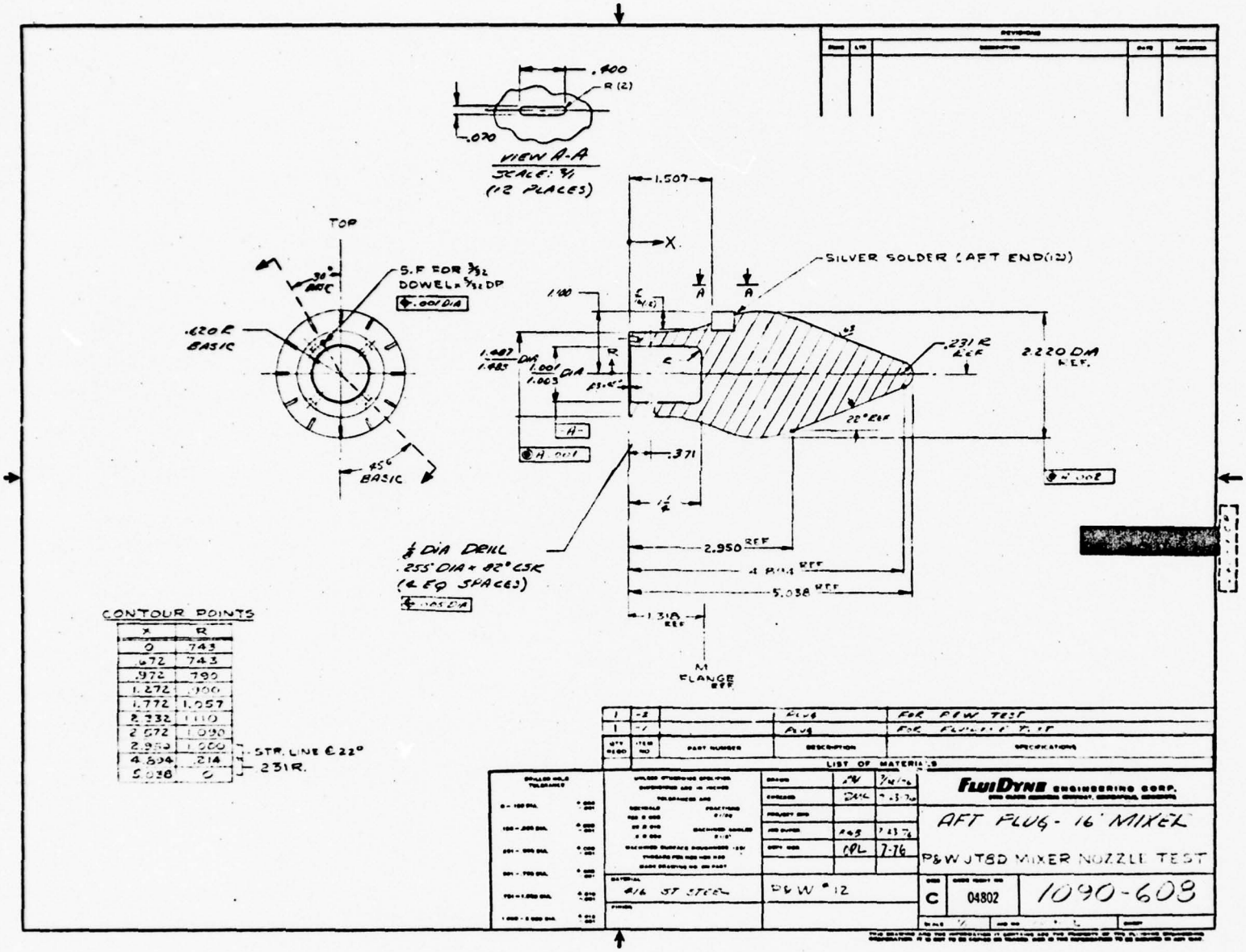
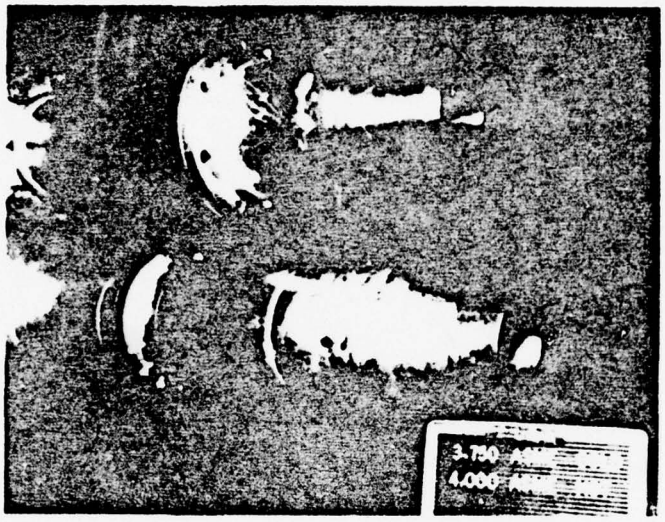
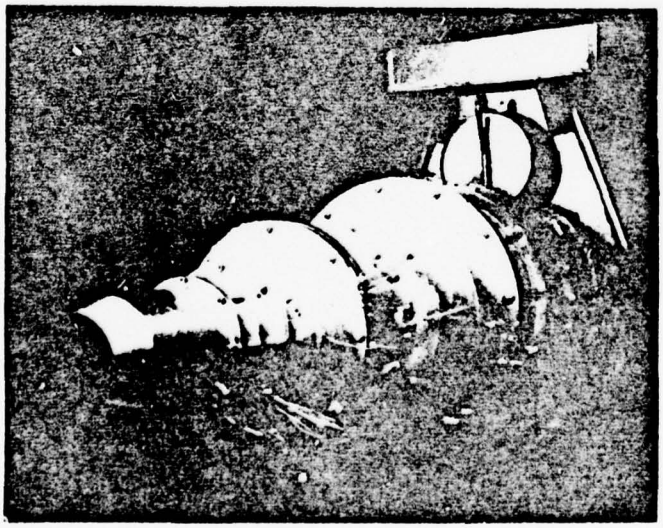


FIGURE 4k. AFT PLUG - 16" MIXER

FLUIDYNE ENGINEERING CORPORATION

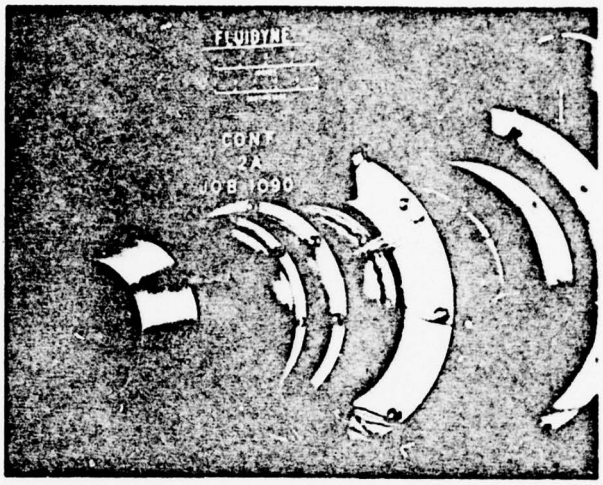


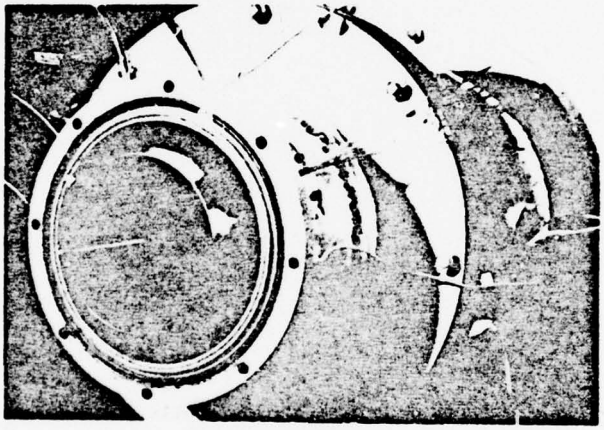
ASME nozzle
installation



typical mixer
nozzle installation

FIGURE 5a. MODEL PHOTOGRAPHS





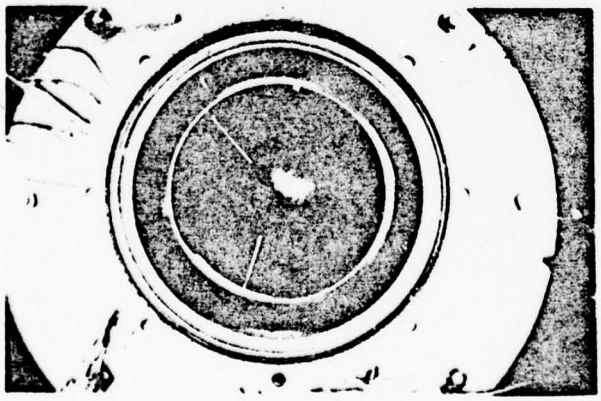
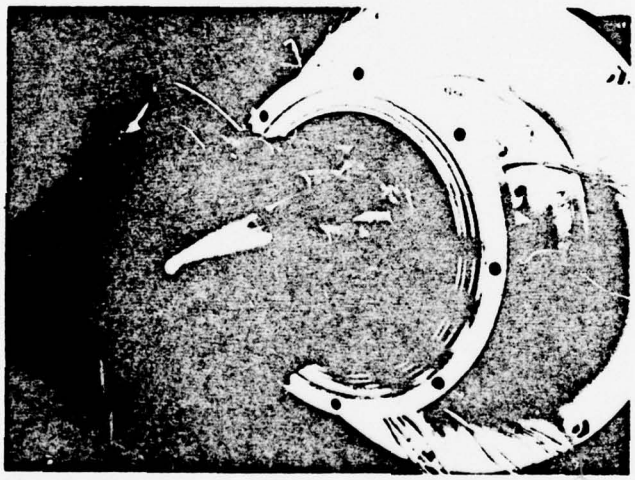


FIGURE 5b. MODEL PHOTOGRAPHS



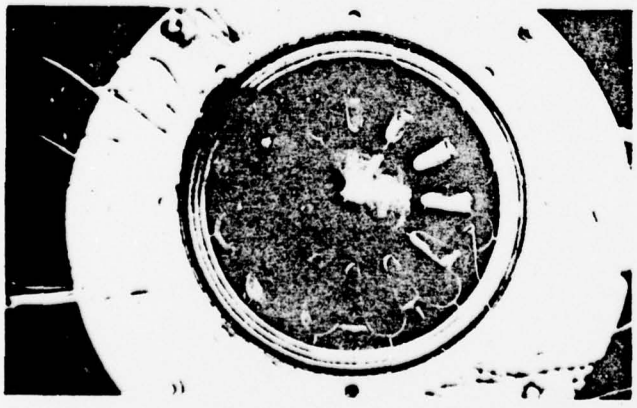
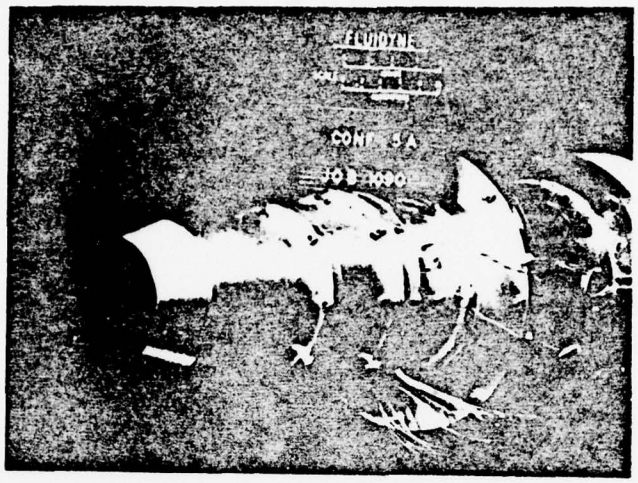
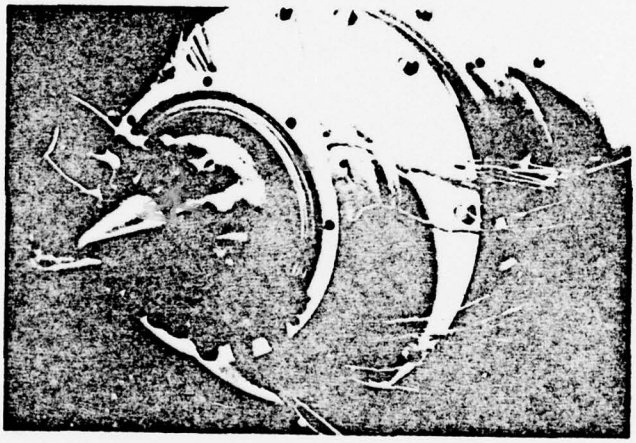


FIGURE 5c. MODEL PHOTOGRAPHS





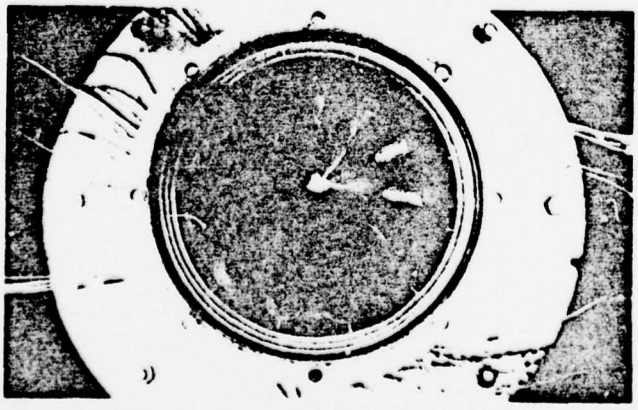
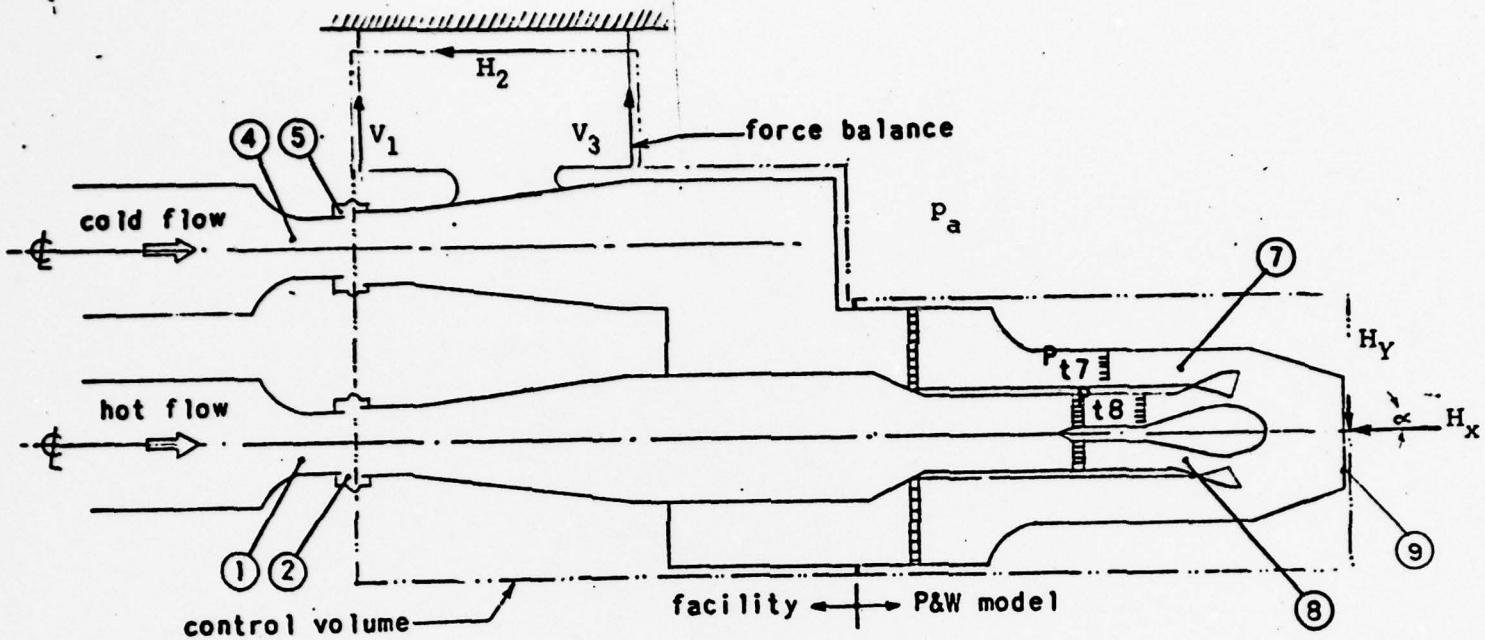


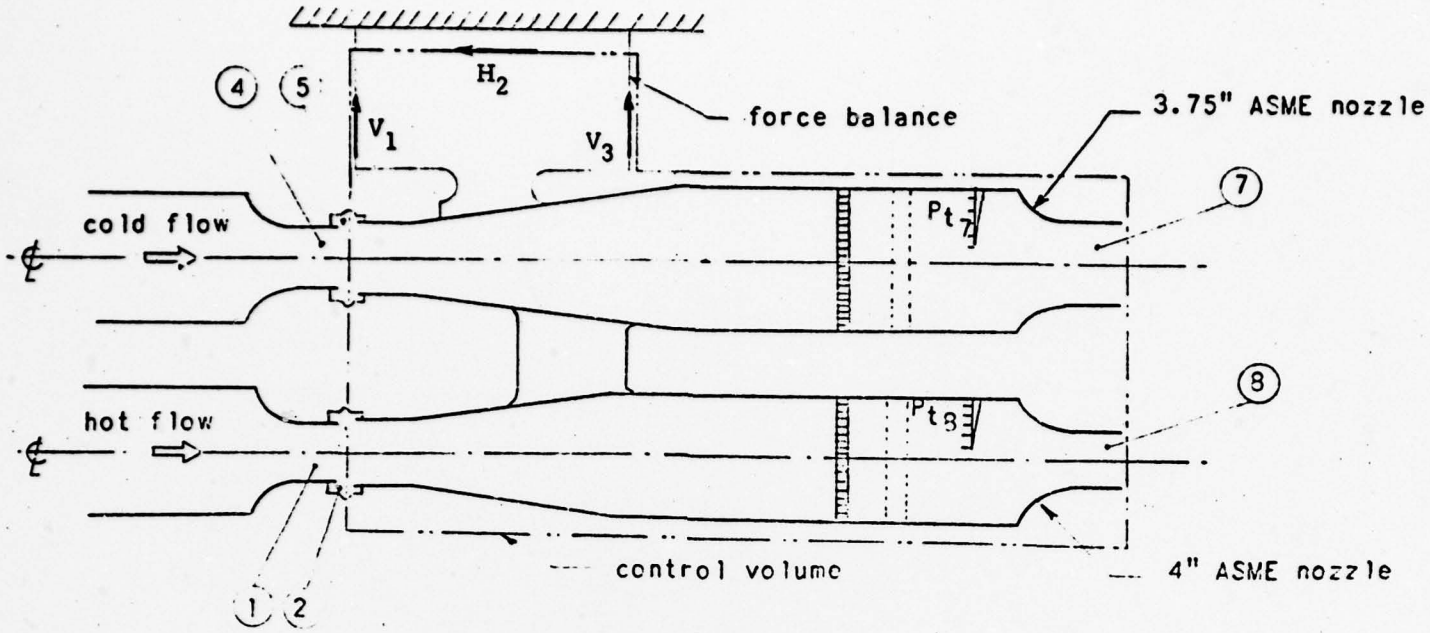
FIGURE 5d. MODEL PHOTOGRAPHS



Station	Description
1	ASME Meter Throat (core flow)
2	Flexible Seal (core flow)
4	ASME Meter Throat (fan flow)
5	Flexible Seal (fan flow)
7	Fan Nozzle
8	Core Nozzle
9	Nozzle Exit

FIGURE 6a. STATION NOTATION, MIXER MODEL TESTS

FLUIDYNE ENGINEERING CORPORATION



Station	Description
1	ASME Meter Throat (core flow)
2	Flexible Seal (core flow)
4	ASME Meter Throat (fan flow)
5	Flexible Seal (fan flow)
7	3.75" Cold ASME Nozzle Throat
8	4" Hot ASME Nozzle Throat

FIGURE 6b. STATION NOTATION, ASME CHECKOUT TESTS

FLUIDYNE ENGINEERING CORPORATION

Config.	Run No.	λ_7	λ_8	T_{t_8}/T_{t_7}	C_T	C_{D_7}	C_{D_8}
	1.0	1.506	1.489	1.008	.9919	.9894	.9882
3.75"	2.0	1.761	1.745	1.007	.9932	.9907	.9885
ASME	3.1	2.010	1.985	1.006	.9944	.9904	.9893
cold,	4.1	2.258	2.242	1.004	.9950	.9904	.9893
upper	5.0	2.510	2.490	1.003	.9954	.9927	.9921
&	6.2	1.504	1.529	2.489	.9916	.9883	.9908
4"	7.2	1.762	1.752	2.483	.9914	.9895	.9890
ASME	8.2	2.011	1.993	2.472	.9959	.9926	.9902
hot,	9.2	2.264	2.257	2.455	.9965	.9917	.9876
lower	10.2	2.518	2.485	2.446	.9966	.9919	.9879

Config.	Run No.	λ_7	λ_8	λ_7/λ_8	T_{t_8}/T_{t_7}	C_{T_r}	$C_{D_7}A_7$	$C_{D_8}A_8$	C_{D_9}	W_7/W_8
2A	11.4	1.495	1.609	.929	.998	.9884	4.993	8.525	.951	.530
	12.3	2.065	2.214	.932	.997	.9929	5.279	8.636	.979	.569
	13.2	2.533	2.717	.932	.997	.9929	5.286	8.665	.982	.568
	14.2	3.011	3.236	.930	.997	.9886	5.245	8.695	.981	.560
	15.0	1.601	1.609	.995	1.000	.9888	5.889	7.622	.951	.767
	16.0	2.210	2.221	.995	.999	.9933	6.047	7.825	.976	.768
	17.1	2.403	2.714	.885	.998	.9932	4.681	9.304	.984	.445
	18.1	2.833	3.223	.879	.996	.9894	4.563	9.376	.981	.427
	19.1	1.490	1.617	.921	2.117	.9923	4.759	8.646	.943	.721
	20.1	2.057	2.195	.937	2.125	.9973	5.149	8.670	.973	.817
	21.0	2.481	2.698	.919	2.119	.9974	4.952	8.887	.974	.751
	22.0	2.934	3.204	.916	2.117	.9931	4.927	8.950	.977	.739
	23.0	1.600	1.594	1.004	2.128	.9935	5.774	7.575	.940	1.124
	24.0	2.204	2.206	.999	2.130	.9967	5.885	7.891	.970	1.095
	25.1	2.402	2.712	.886	2.113	.9959	4.503	9.363	.976	.624
	26.1	2.832	3.209	.882	2.111	.9936	4.481	9.372	.975	.618
	27.1	1.493	1.620	.921	2.271	.9932	4.804	8.540	.939	.764
	28.2	2.051	2.209	.928	2.265	.9977	5.024	8.752	.969	.809
	29.0	2.529	2.713	.932	2.257	.9966	5.066	8.749	.972	.818
	30.3	2.983	3.215	.928	2.264	.9949	5.016	8.827	.974	.800
	31.0	1.604	1.605	1.000	2.275	.9939	5.748	7.614	.940	1.146
	32.0	2.212	2.208	1.001	2.272	.9976	5.924	7.815	.967	1.154
	33.0	2.404	2.717	.885	2.256	.9986	4.467	9.395	.976	.638
	34.0	2.843	3.224	.882	2.269	.9932	4.453	9.428	.977	.633
	35.1	1.489	1.612	.924	2.387	.9949	4.747	8.652	.943	.766
	36.0	2.062	2.208	.934	2.404	.9998	5.089	8.729	.973	.852
	37.0	2.533	2.719	.932	2.402	.9976	5.053	8.777	.973	.839
	38.0	3.002	3.210	.935	2.392	.9960	5.106	8.741	.975	.853
	214.0	1.668	1.823	.915	2.269	.9966	4.772	8.819	.954	.744

FIGURE 7. RUN SCHEDULE AND MAJOR TEST RESULTS
(Sheet 1 of 3)

Config.	Run No.	λ_7	λ_8	λ_7/λ_8	T_{t_8}/T_{t_7}	C_{T_r}	$C_{D_7A_7}$	$C_{D_8A_8}$	C_{D_9}	W_7/W_8
5A	114.0	1.492	1.606	.929	.992	.9767	5.535	7.713	.932	.646
	115.0	1.676	1.790	.932	.992	.9789	5.633	7.756	.942	.668
	116.0	2.056	2.199	.935	.993	.9851	5.788	7.851	.960	.687
	117.0	2.512	2.685	.936	.993	.9875	5.829	7.894	.966	.688
	118.0	2.982	3.185	.936	.989	.9871	5.824	7.890	.965	.687
	119.0	1.488	1.599	.931	2.286	.9819	5.252	7.625	.906	.950
	120.0	1.675	1.802	.930	2.280	.9881	5.339	7.693	.917	.973
	121.0	2.052	2.197	.934	2.272	.9964	5.508	7.825	.938	.999
	122.0	2.516	2.696	.933	2.275	1.0009	5.529	7.856	.942	.999
	123.0	2.988	3.192	.936	2.282	1.0016	5.551	7.832	.942	1.011
4A	124.0	1.496	1.607	.931	1.000	.9764	5.473	8.059	.947	.616
	125.0	2.043	2.194	.931	1.000	.9871	5.602	8.251	.969	.632
	126.0	2.517	2.687	.937	1.000	.9881	5.641	8.220	.970	.643
	127.0	2.990	3.181	.940	1.000	.9862	5.669	8.218	.971	.649
	128.0	1.603	1.605	.999	.998	.9753	5.869	7.650	.946	.765
	129.0	2.200	2.190	1.004	.997	.9864	6.010	7.793	.966	.773
	130.0	2.383	2.691	.885	.993	.9868	5.355	8.513	.970	.555
	131.0	2.818	3.181	.886	.993	.9846	5.385	8.537	.974	.557
	132.0	1.499	1.608	.933	2.159	.9798	5.290	7.900	.923	.900
	133.0	2.056	2.198	.935	2.160	.9926	5.481	8.087	.949	.938
	134.0	2.512	2.698	.931	2.134	.9972	5.458	8.137	.951	.919
	135.0	2.992	3.190	.938	2.135	.9968	5.482	8.053	.947	.940
	136.0	1.617	1.614	1.002	2.139	.9784	5.724	7.567	.930	1.115
	137.0	2.201	2.189	1.006	2.146	.9919	5.902	7.696	.951	1.138
	138.0	1.499	1.602	.935	2.325	.9792	5.300	7.838	.919	.948
	139.0	2.051	2.186	.938	2.285	.9940	5.494	8.039	.947	.977
	140.0	2.513	2.689	.935	2.288	1.0008	5.475	8.071	.948	.968
	141.0	2.988	3.177	.941	2.294	1.0004	5.492	8.097	.951	.975
	142.0	1.605	1.605	1.000	2.296	.9808	5.690	7.486	.922	1.159
	143.0	2.190	2.190	1.000	2.285	.9945	5.845	7.681	.946	1.160
	144.0	2.375	2.697	.881	2.281	1.0005	5.107	8.367	.943	.819
	145.0	2.820	3.178	.887	2.277	1.0010	5.154	8.398	.948	.829

FIGURE 7. RUN SCHEDULE AND MAJOR TEST RESULTS (Cont.)
(Sheet 2 of 3)

Config.	Run No.	λ_7	λ_8	λ_7/λ_8	T_{t_8}/T_{t_7}	C_{T_r}	$C_{D_7}A_7$	$C_{D_8}A_8$	C_{D_9}	W_7/W_8
4A(cont.)	146.0	1.485	1.597	.930	2.411	.9828	5.248	7.867	.917	.943
	147.1	2.052	2.211	.928	2.386	.9988	5.315	8.067	.940	.954
	148.1	2.509	2.714	.924	2.382	1.0024	5.332	8.117	.945	.946
	149.0	2.983	3.187	.936	2.400	1.0056	5.467	8.078	.948	.991
	150.0	2.380	2.692	.884	2.420	1.0003	5.105	8.351	.941	.849
	151.0	2.816	3.185	.884	2.422	1.0015	5.105	8.390	.944	.845
	152.0	2.695	2.698	.999	2.283	1.0006	5.847	7.705	.948	1.155
	153.0	2.695	2.686	1.003	2.145	.9963	5.880	7.700	.950	1.130

FIGURE 7. RUN SCHEDULE AND MAJOR TEST RESULTS (Cont.)
(Sheet 3 of 3)

FLUIDYNE ENGINEERING CORPORATION

Symbol	T_{t_8}/T_{t_7}	Run Nos.
○	1.000	1-5
◇	2.470	6-10

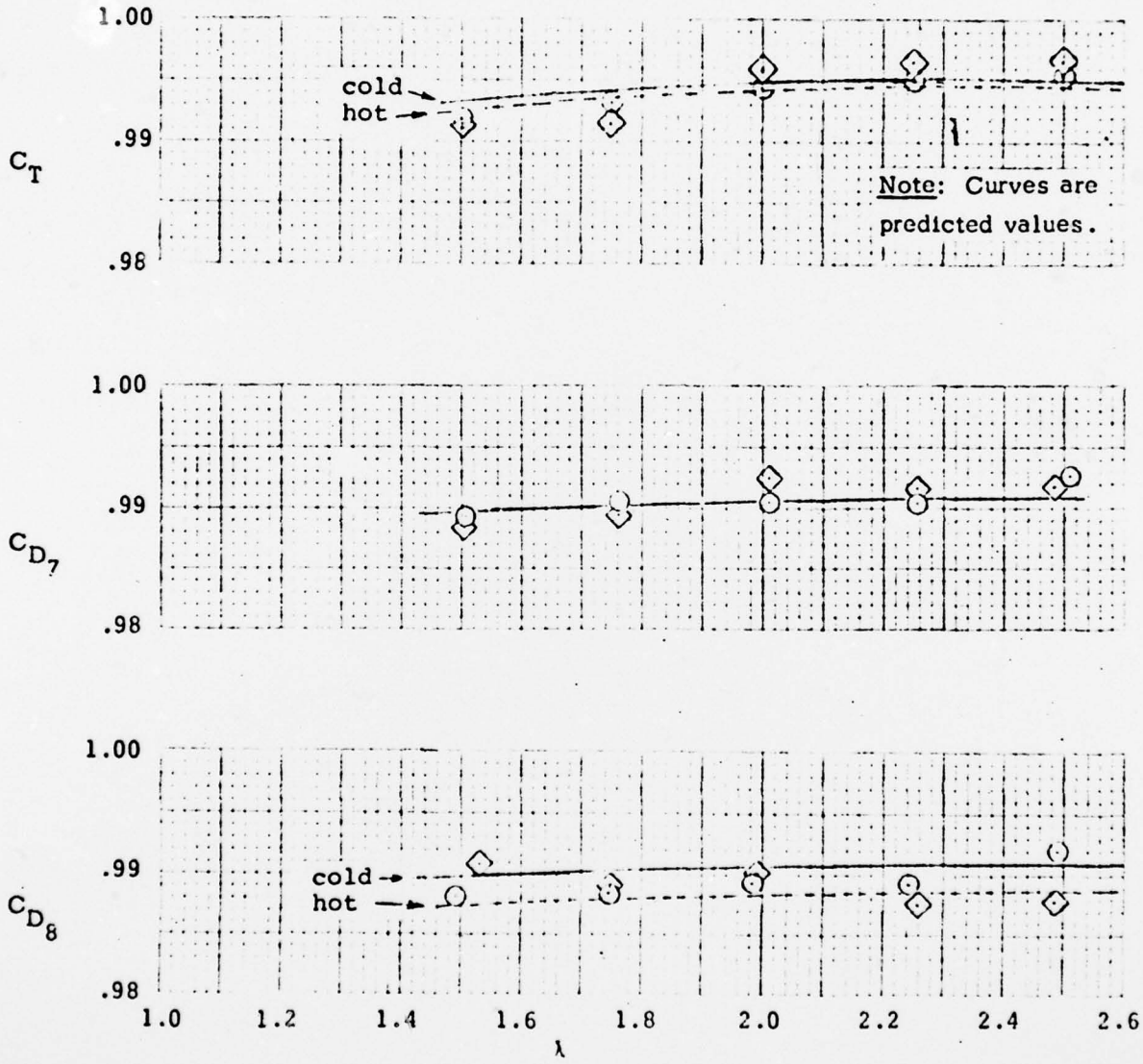


FIGURE 8. THRUST AND DISCHARGE COEFFICIENTS, ASME CHECKOUT TESTS

Symbol	λ_7/λ_8	T_{t_8}/T_{t_7}	Run Nos.
○	.93	1.00	11-14
○	1.00	↓	15-16
○	.88	↓	17-18
□	.93	2.128	19-22
□	1.00	↓	23-24
□	.88	↓	25-26

Symbol	λ_7/λ_8	T_{t_8}/T_{t_7}	Run Nos.
◇	.93	2.272	27-30,214
◇	1.00	↓	31-32
◇	.88	↓	33-34
△	.93	2.410	35-38

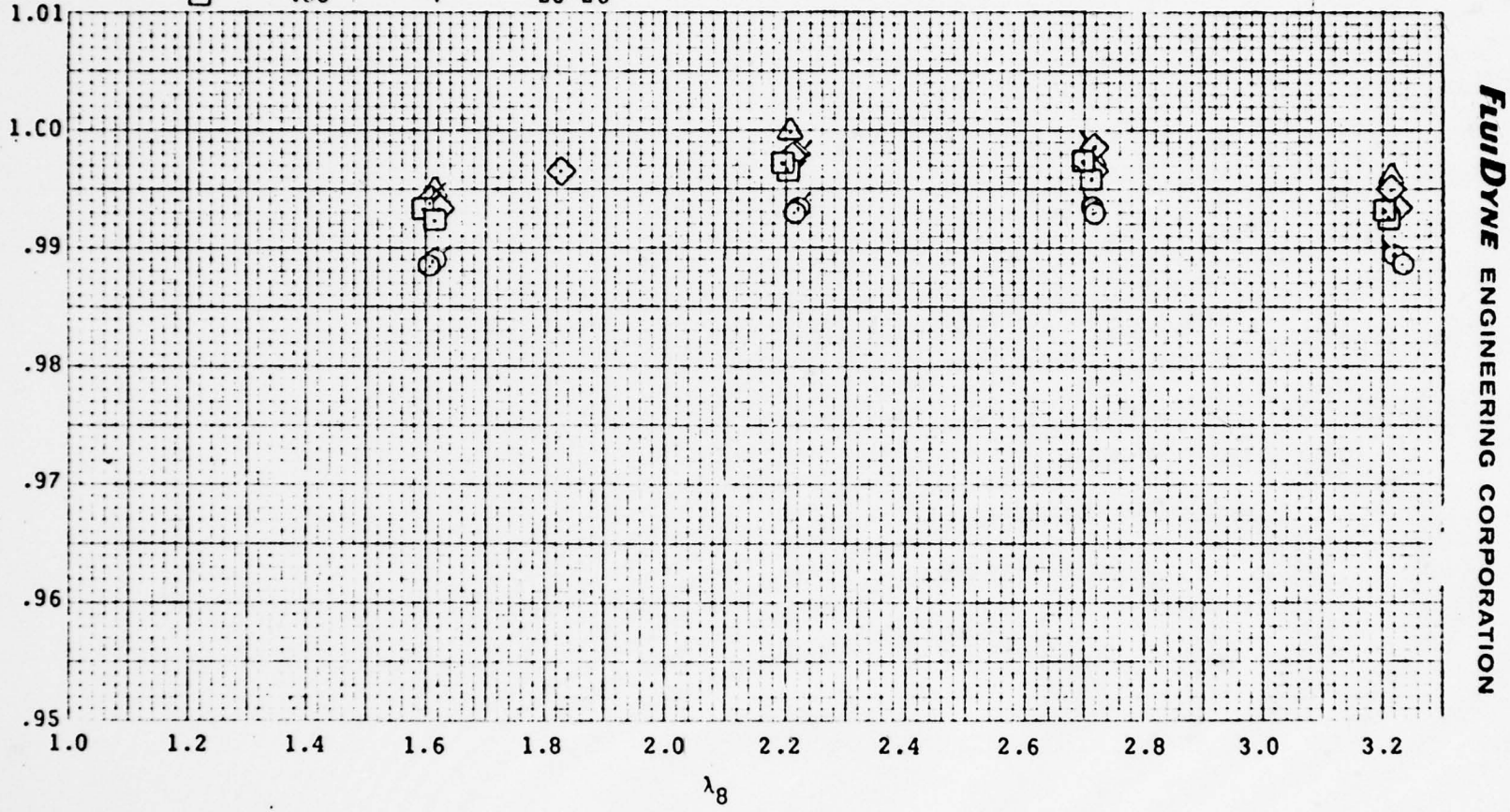


FIGURE 9a. THRUST COEFFICIENTS, CONFIGURATION 2A

FLUIDYNE ENGINEERING CORPORATION

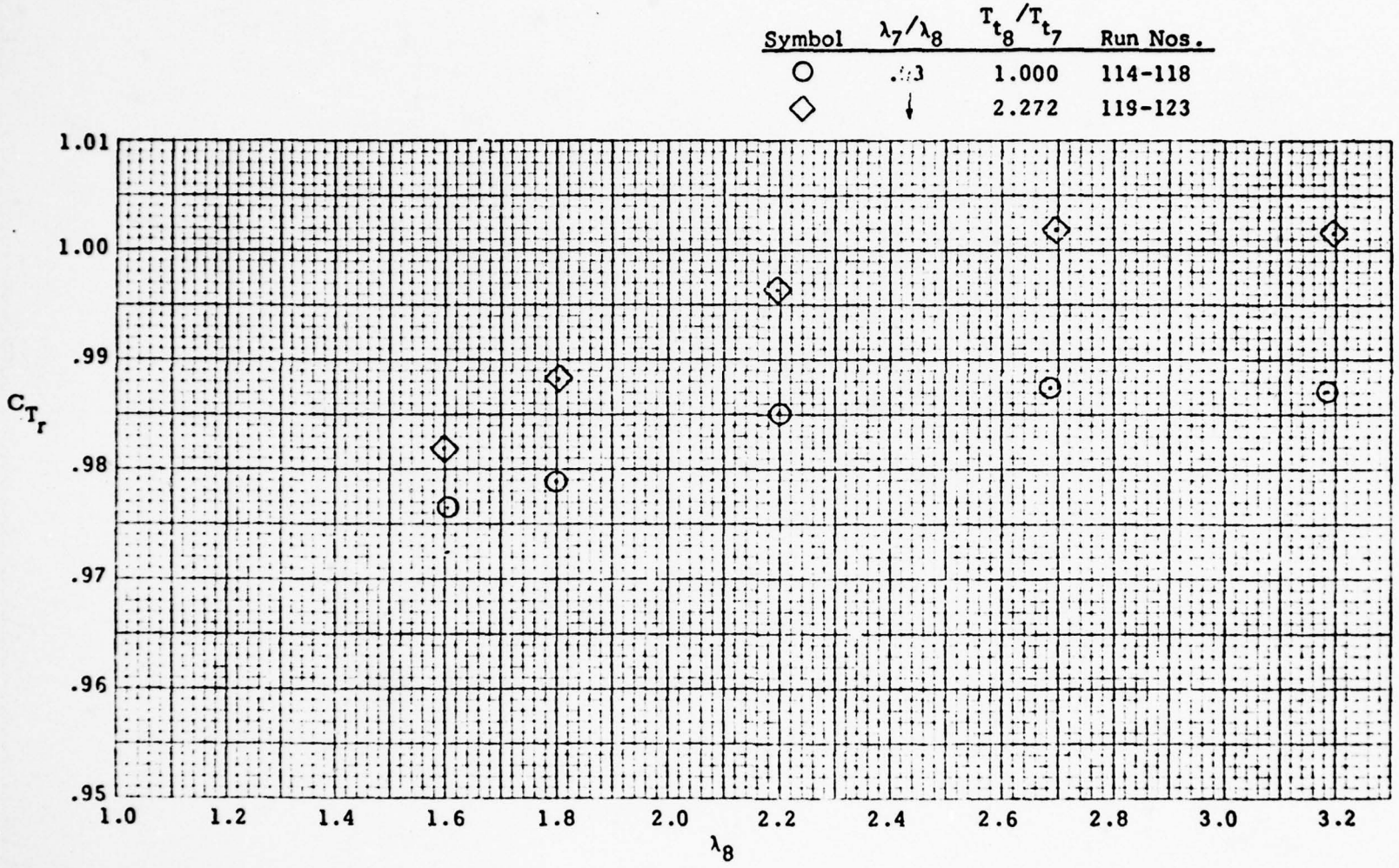


FIGURE 9b. THRUST COEFFICIENTS, CONFIGURATION 5A

FLUIDYNE ENGINEERING CORPORATION

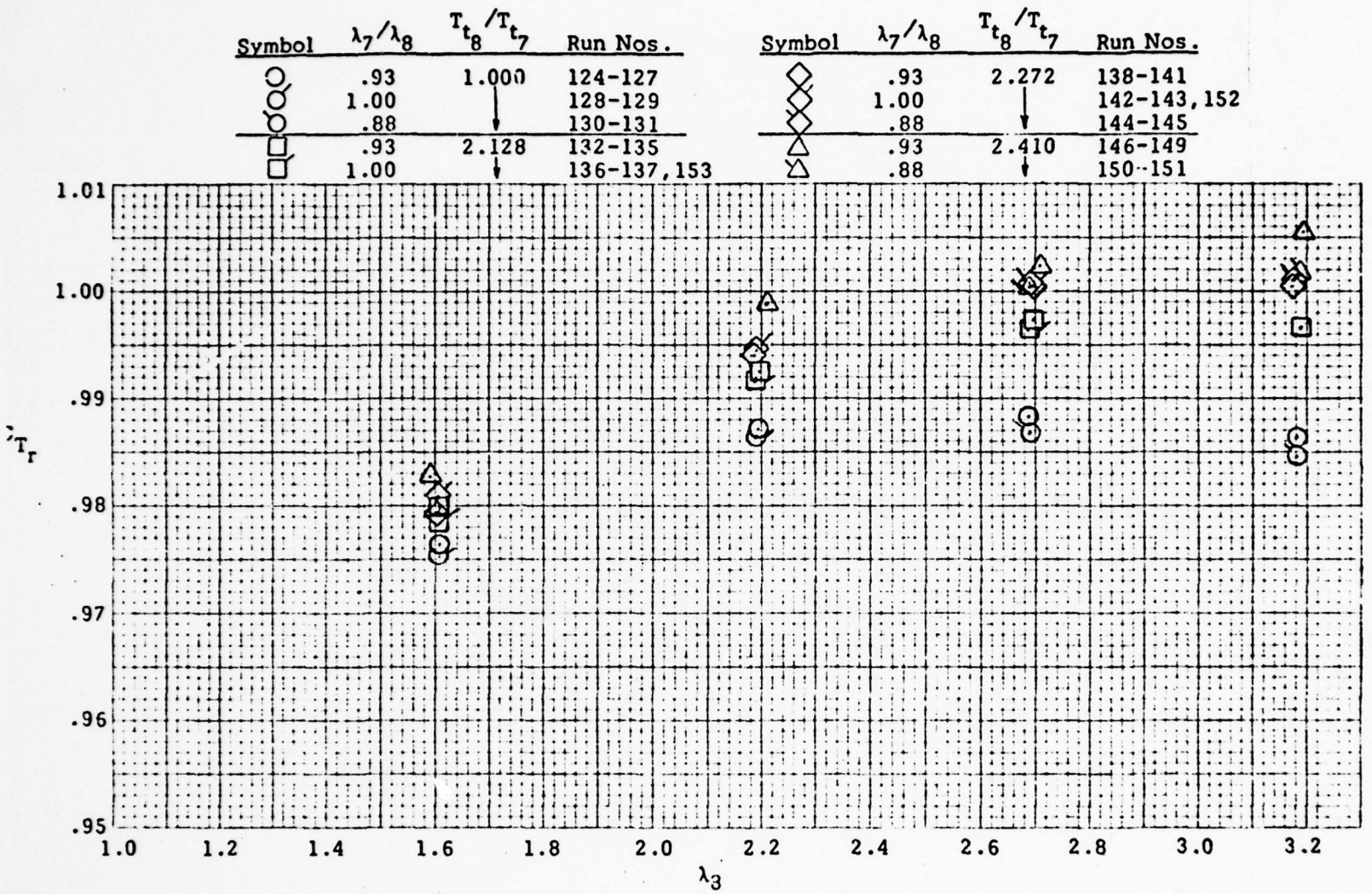


FIGURE 9c. THRUST COEFFICIENTS, CONFIGURATION 4A

FLUIDYNE ENGINEERING CORPORATION

Symbol	λ_7/λ_8	T_{t_8}/T_{t_7}	Run Nos.
○	.93	1.00	11-14
○	1.00	↓	15-16
○	.88	↓	17-18
□	.93	2.128	19-22
□	1.00	↓	23-24
□	.88	↓	25-26

Symbol	λ_7/λ_8	T_{t_8}/T_{t_7}	Run Nos.
◇	.93	2.272	27-30,214
◇	1.00	↓	31-32
◇	.88	↓	33-34
△	.93	2.410	35-38

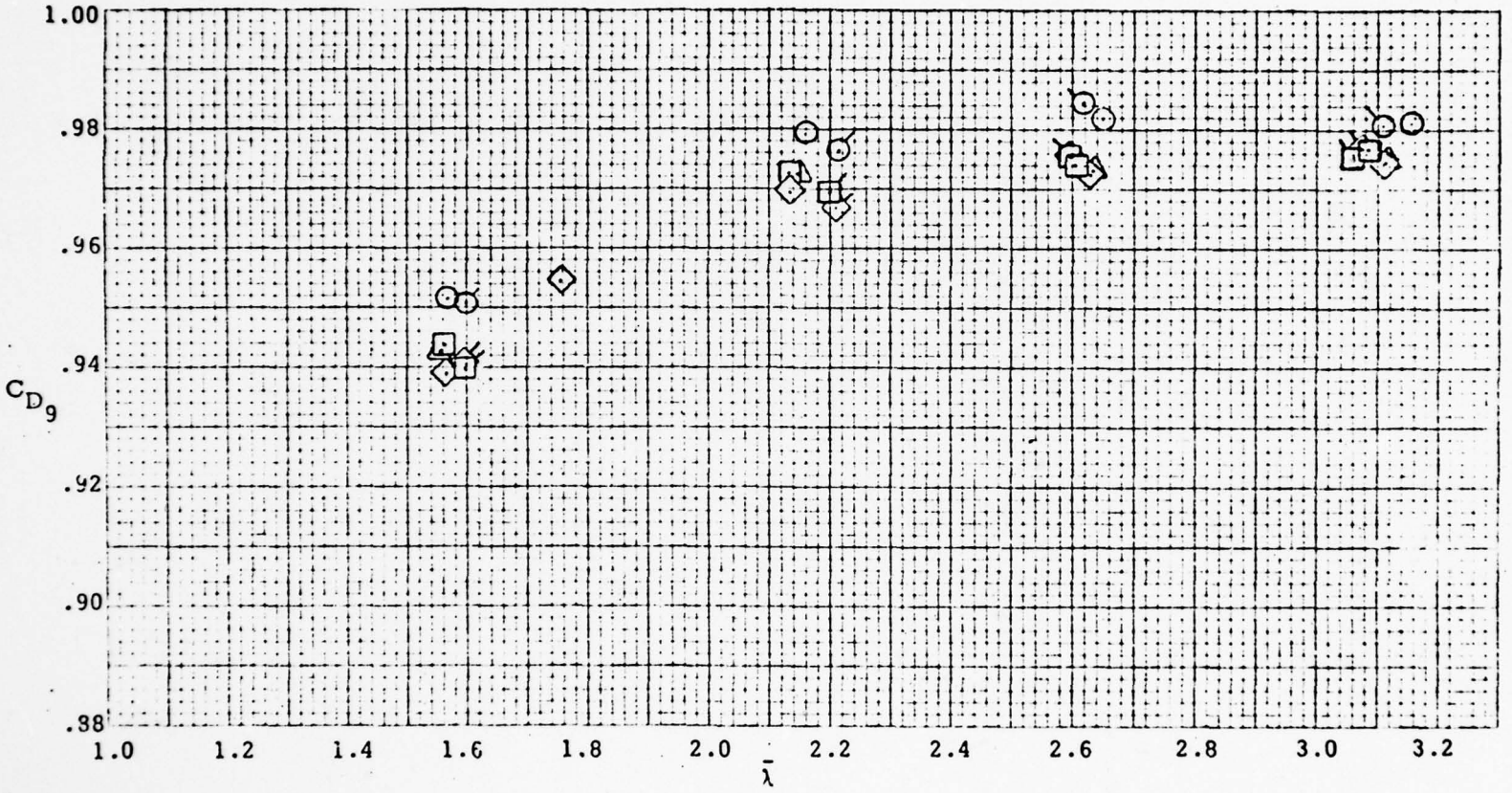


FIGURE 10a. NOZZLE DISCHARGE COEFFICIENTS, CONFIGURATION 2A

FLUIDYNE ENGINEERING CORPORATION

Symbol	λ_7/λ_8	T_{t_8}/T_{t_7}	Run Nos.
○	.93	1.000	114-118
◇	↓	2.272	119-123

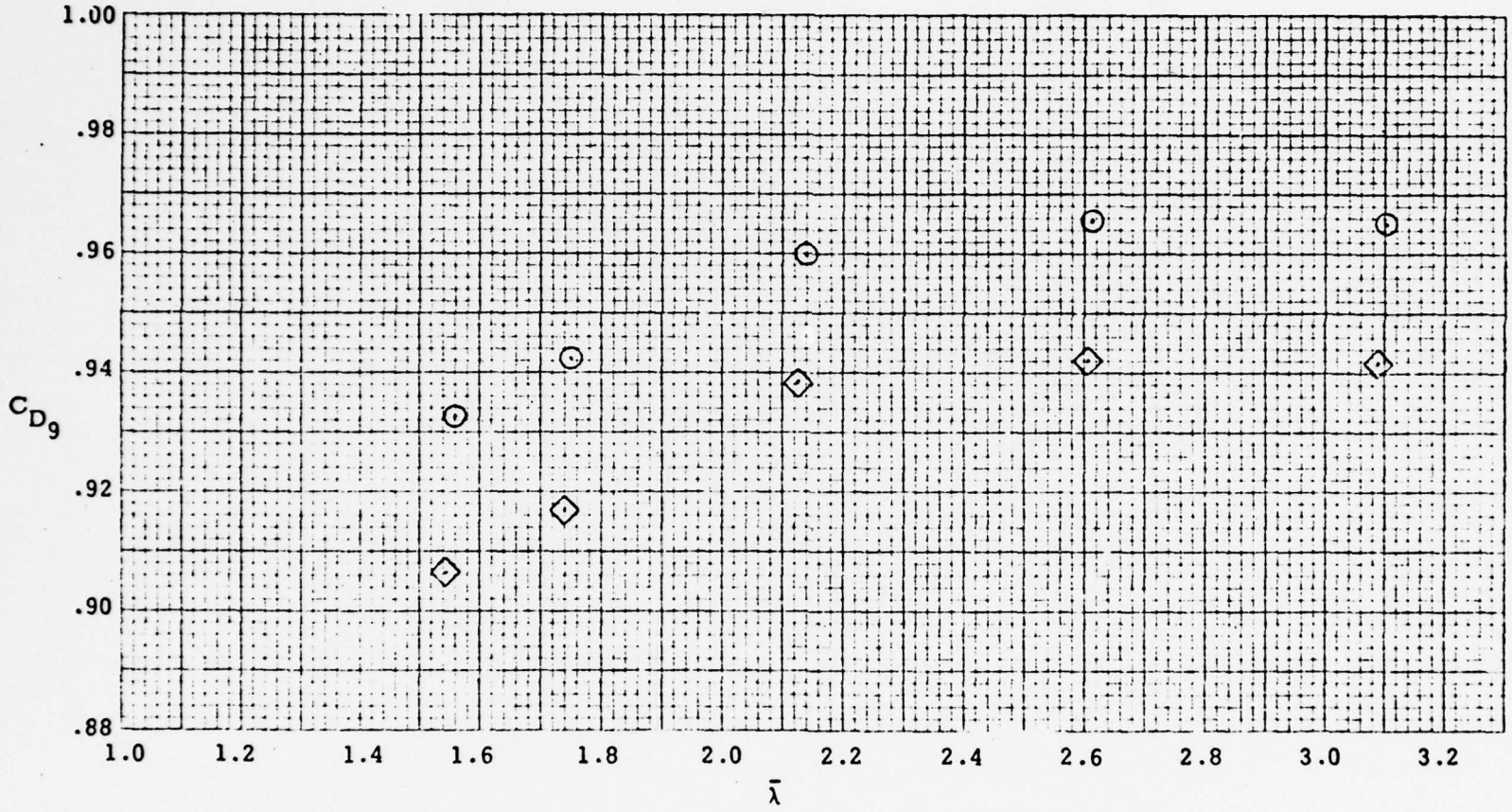


FIGURE 10b. NOZZLE DISCHARGE COEFFICIENTS, CONFIGURATION 5A

FLUIDYNE ENGINEERING CORPORATION

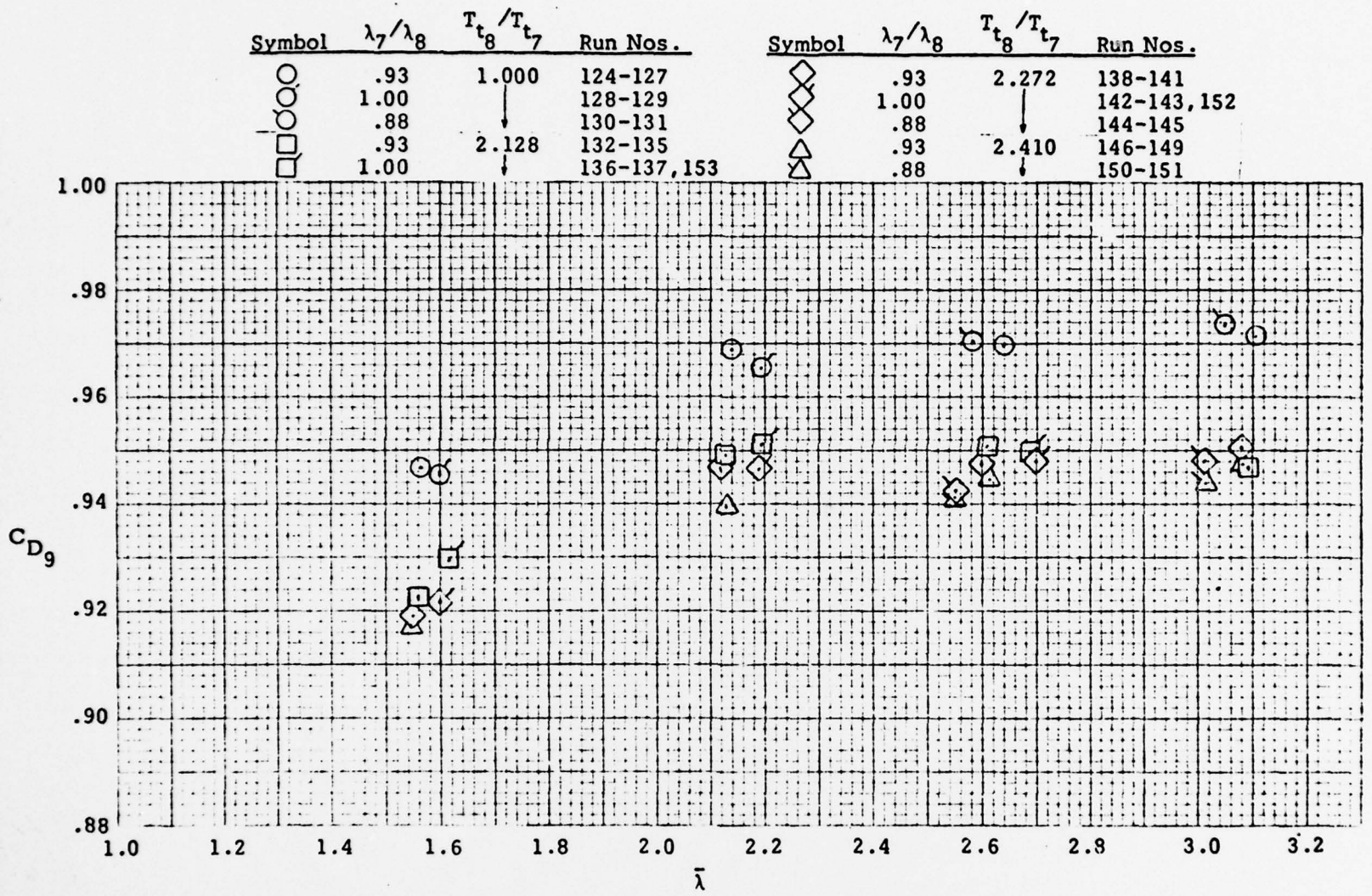


FIGURE 10c. NOZZLE DISCHARGE COEFFICIENTS, CONFIGURATION 4A

FLUIDYNE ENGINEERING CORPORATION