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ABSTRACT

As part of a joint NASA Lewis, Langley and Ames Research Center Program to study flight effects on the exhaust noise of a full-scale JT15D engine, static half-scale model jet noise experiments were conducted. Acoustic data were recorded for microphone angles of 45° to 155° with jet conditions for the model-scale nozzle corresponding closely to those at 55, 73, and 97 percent of corrected rated speed for the full-scale engine. These data are useful for determining the relative importance of jet and core noise in the static full-scale engine test data and will in turn allow for a proper evaluation of flight effects on the exhaust noise results. The model-scale data are also compared with the current NASA Lewis coaxial jet noise prediction. Above 1000 Hz, the prediction is nominally 0 to 3 dB higher than the data. The arithmetic mean of the differences between the experimental OASPL and the predicted OASPL for all angles for each run ranged from 0 to -3.2 dB. The standard deviation of all the OASPL differences is 2.2. The discrepancies are greatest at low primary jet velocities and appear to be due to inadequacy in the variable jet density exponent incorporated in the prediction procedure.

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INTRODUCTION

In order to determine the environmental impact of new aircraft engine jet noise on communities surrounding airports, an accurate prediction of jet noise is required. The current NASA Lewis coaxial jet noise prediction is described in reference 1 and is based on substantial static model scale experimental data, mainly from references 2 and 3. As a means of confirming and/or improving the current prediction, a joint program was initiated by the NASA Lewis and Langley Research Centers to evaluate engine exhaust noise, including core noise and jet mixing noise, statically and in flight. Three sets of data will evolve from the program; static full size engine noise, in-flight full size engine noise, and static 1/2-scale jet mixing noise. The 1/2-scale data (without core noise) may be scaled and used for comparison with the full size engine data, when it becomes available, to show the degree of similarity and to show where core noise dominates over jet mixing noise, particularly at low power settings. All three sets of data can then be compared with the results of the prediction of reference 1 to indicate the amount of agreement, or disagreement, in order to point out areas where the prediction might be improved. The 1/2-scale tests, conducted at Lewis, incorporated a model scale replica of the nozzle of the JT15D engine.

The purpose of this paper is to present the 1/2-scale nozzle noise data and to show how it agrees with the predicted results of reference 1. Acoustic data were taken at temperature and pressure conditions simulating a range of full size engine speeds. The jet noise was recorded at microphone angles from 45° to 155°, referenced to the nozzle inlet. The comparisons include overall sound pressure level (OASPL) as a function of directivity angle, and spectral

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comparisons at selected directivity angles. All measured and predicted data are tabulated.

APPARATUS AND PROCEDURE

Facility

A photograph of the dual-stream heated jet facility is shown in figure 1. Both streams could be heated to 1100 K and operated to nozzle pressure ratios of 3.0. Flow rate, total pressure and total temperature were measured for both streams. Mufflers in each line attenuated flow control valve noise and internal combustion noise. A detailed description of the flow facility is given in reference 3.

In order to produce a single free-field (no reflections) spectrum at each microphone angle, two microphone arrays were used as shown in figure 2. Nine 0.635-cm condenser microphones at the nozzle centerline elevation were mounted on poles. The protective metal grid caps were removed to improve the microphone performance at high frequencies. Nine 1.27-cm condenser microphones, mounted on metal plates, were placed on the ground at the same angle and acoustic ray distance as the corresponding centerline microphone. The microphones up to and including 135° were at a sideline distance of 50 core nozzle diameters (6.67 m). The microphones at 145°, 150°, and 155° were at the same radial distance as the 135° microphone because of space and acoustic level considerations. The angle θ is referenced to the centerline of the nozzle exit plane. The angle θ^* is referenced to assumed distributed noise sources in the jet as discussed in reference 4 and are within one degree of the angles determined by the assumptions of reference 1. The ground plane of the acoustic area was asphalt interspersed with patches of concrete.

Test Nozzle

A schematic of the 1/2-scale JT15D nozzle is shown in figure 3. The primary and secondary nozzles are circular convergent with the inside diameter of the primary equal to 13.34 cm. The nozzle is noncoplanar and has a secondary to primary exit area ratio of 1.56 (unheated).

Procedure

All tests were conducted at steady-state flow conditions for given nozzle total pressures and temperatures. Upstream plenum chamber total pressures and total temperatures were used to calculate nozzle exhaust velocities assuming isentropic expansion to atmospheric conditions. Nozzle exit static temperatures were calculated from the measured total temperatures after correcting the total temperature for thermocouple radiation heat loss. In order to simulate the JT15D engine flows only the primary (core) nozzle flow was heated.

An on-line analysis of the noise signal from each microphone in succession was performed. One-third octave band sound pressure level spectra were digitally recorded. Atmospheric attenuation and ground reflection corrections were applied to the spectral data to give free-field lossless data for each microphone at each angle. A single spectrum for each measurement angle was obtained by combining the centerline and ground microphone spectra. The ground microphone spectrum was used over the frequency range of 100 to 1000 Hz; the centerline microphone spectrum was used over the frequency range from 5000 to 80 000

Hz. For the intermediate frequency range of 1250 to 4000 Hz the data from both microphones were arithmetically averaged.

RESULTS

The JT15D 1/2-scale nozzle noise test conditions are given in table I. Runs 3, 5 and 6 simulate the JT15D engine operating line, while runs 1, 2, and 4 extend the data range.

A tabulation of the measured combined lossless free-field spectra for all nine directivity angles used in the tests is given in table II. At the higher frequencies, there was a reversal of the slope of the sound pressure level (SPL) with frequency. This reversal of slope came about because the magnitude of the input signal at the higher frequencies was lower than the internal noise floor of the spectrum analyzer; therefore, all the listings have been deleted beyond the frequency where the slope reversal began.

The predicted spectra using the prediction of reference 1 are listed in table III for comparison with the measured spectra given in table II. A statistical comparison of the differences between the experimental and calculated (ref. 1) OASPL for each run is given in table IV.

The measured and predicted spectra at microphone angles, θ^*, of 45°, 90°, 125°, and 145°, are compared in figures 4 to 7, respectively. In general, the noise for the four higher velocities are fairly well predicted with an exception at $\theta^* = 145°$ where the data peaks at a lower frequency and drops off more rapidly than the prediction. The noise for the two lower jet velocities are overpredicted except for $\theta^* = 145°$ where the data are in better agreement with the prediction than at the other angles.

An OASPL directivity comparison between the experimental data and predicted results is shown in figure 8. The four higher velocity runs are well predicted except for the highest velocity run for θ^* greater than 135°. This would be expected for this run because in figure 7 ($\theta^* = 145°$) it was shown that the measured spectra were as much as 13 dB below the predicted level (at 10 kHz). The OASPL levels are overpredicted for the two lower velocity runs but follow the data trends very well.

DISCUSSION

It is believed that the overprediction of the noise at low jet velocities is due to the manner in which temperature (or jet density effects) are incorporated in the prediction. In reference 1, as in most coaxial jet prediction procedures, it is assumed that the noise varies in proportion to 10 log $(\rho p/\rho a)^{\omega}$ where ω varies with the nondimensionalized primary jet velocity as shown by the curves in figure 9, which are based on single-stream data (ref. 5). Also shown are the values of ω (data points) which would minimize the difference between the experimental and calculated OASPL for each of the experimental runs of this study. It can be seen that the value of ω should be increased at low primary jet velocity to improve the agreement. Previous validations of this prediction procedure were limited to higher primary jet velocities. At higher primary jet velocities, the present data show reasonable agreement with prediction ($\log V_p/c_a \geq 0$), as shown in figures 4 to 8. In table IV for the four higher velocities the average standard deviation is 1.5 dB in OASPL which is better than the 1.8 dB standard deviation reported in reference 1. The overprediction of jet noise at low primary velocities is not currently of practical importance since other noise sources generally dominate at these conditions, but future developments in quieting core and fan noise may make it necessary to improve the prediction procedure and validate any changes.

SUMMARY OF RESULTS

The jet noise of a 1/2-scale JT15D nozzle was measured for directivity angles of 45° to 155°. The conditions included those corresponding to 55, 73 and 97 percent of full-scale corrected rated engine speed. All of the experimental results are compared to the NASA-Lewis coaxial jet noise prediction. In general, for the higher velocity and temperature conditions, the spectra are well predicted up to 1000 Hz and slightly overpredicted above 1000 Hz for microphone angles up to 125°. Closer to the jet axis centerline (higher angles) the differences can become appreciable.

A statistical mean of the difference between the experimental OASPL and the predicted OASPL for all angles for each run ranged from 0 dB to -3.2 dB with the standard deviation of all the OASPL differences equal to 2.2 dB. The discrepancies are greatest at low primary jet velocities and appear to be due to the inadequacy of the variable jet density exponent approach incorporated in the prediction procedure.

SYMBOLS

(All dimensions are in SI units unless noted)

A	area
c	speed of sound
D	diameter
f	1/3-octave band center frequency
M	Mach number
N	full-scale engine corrected speed or number of data points
OASPL	overall sound pressure level, dB RE 20 $\mu N/m^2$
P	total pressure
p	static pressure
R	nozzle-to-microphone distance
R*	nozzle-to-microphone distance for distributed noise sources (ref. 1)
SPL	1/3-octave band sound pressure level, dB RE 20 $\mu N/m^2$
STD DEV	standard deviation
T	total temperature
t	static temperature
V	velocity
γ	ratio of specific heats
θ	directivity angle from inlet axis (Fig. 3), deg, relative to nozzle exit
θ^*	directivity angle from inlet axis (Fig. 3), deg, for distributed noise sources (ref. 1)

ρ density

Δ $OASPL_{exp} - OASPL_{calc}$

ω density exponent (ref. 1) $= \dfrac{3(V_p/c_a)^{3.5}}{0.6 + (V_p/c_a)^{3.5}} - 1$

Subscripts:

a	ambient
calc	calculated
eq	equivalent
exp	experimental
p	primary
s	secondary
total	total

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TABLE I. - JT15D 1/2-SCALE NOZZLE CONDITIONS

Run	Primary				Secondary				Percent maximum corrected engine speed, N
	Pressure ratio, $\frac{P_p}{p_a}$	Exit total temperature, T_p, K (°R)	Exit Mach no., M_p	Mass flow rate, kg/sec (lb_Msec)	Pressure ratio, $\frac{P_s}{p_a}$	Exit total temperature, T_s, K (°R)	Exit Mach no., M_s	Mass flow rate, kg/sec (lb_Msec)	
1	1.70	1122 (2019)	0.93	2.64 (5.82)	1.60	293 (527)	0.85	7.56 (16.66)	-
2	1.51	1031 (1855)	.81	2.28 (5.03)	1.61	292 (525)	.85	7.63 (16.82)	-
3	1.30	894 (1610)	.64	1.77 (3.91)	1.61	291 (523)	.85	7.75 (17.09)	97
4	1.37	746 (1343)	.70	2.21 (4.88)	1.61	289 (521)	.85	7.70 (16.98)	-
5	1.14	702 (1264)	.44	1.34 (2.95)	1.26	289 (521)	.59	5.15 (11.36)	73
6	1.07	674 (1214)	.31	0.86 (1.89)	1.14	289 (521)	.43	2.63 (5.79)	55

TABLE II. - 1/2-SCALE JT15D JET MIXING NOISE DATA
LOSSLESS, FREE-FIELD

Sound Pressure Level, SPL, dB   Run 1

f kHz	θ* 45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	79.3	82.8	86.8	86.6	93.3	97.2	95.6	101.2	103.8
.125	81.3	85.0	88.5	90.7	95.8	97.4	100.5	103.2	106.4
.16	81.7	86.4	88.8	90.5	96.2	102.2	105.3	106.2	106.8
.2	81.2	89.0	91.9	93.8	102.1	106.5	106.9	110.2	109.3
.25	84.7	89.2	93.9	96.9	103.0	109.1	109.9	112.2	111.6
.315	85.2	89.8	94.9	99.2	104.7	109.0	113.8	113.1	111.7
.4	88.4	91.6	96.5	100.7	108.0	111.1	113.8	113.2	111.5
.5	88.6	94.0	97.6	101.6	110.5	114.1	114.5	113.6	110.6
.63	91.3	94.3	99.2	105.1	112.5	117.2	116.0	114.1	111.3
.8	91.5	95.0	100.2	104.9	112.6	116.3	114.4	112.6	110.0
1	92.9	95.8	101.1	105.7	113.8	115.7	114.4	111.5	109.7
1.25	91.6	96.3	100.1	106.1	113.7	112.9	111.5	109.8	110.9
1.6	92.6	95.9	100.6	106.6	110.6	113.4	112.6	111.1	111.4
2	92.4	95.7	100.6	106.3	110.9	111.6	109.5	107.3	107.7
2.5	91.2	95.0	100.8	105.7	109.7	108.5	106.2	104.3	104.9
3.15	88.9	93.8	98.6	106.2	107.2	105.7	102.3	99.7	99.4
4	90.2	93.8	99.9	104.8	105.3	105.1	101.7	97.0	96.8
5	89.7	94.0	99.3	102.7	104.3	102.6	96.0	92.8	96.8
6.3	86.9	91.9	97.7	102.1	100.6	98.9	95.5	91.9	95.3
8	85.6	91.0	97.3	102.7	100.4	100.5	92.9	89.9	91.1
10	83.9	90.8	96.8	100.5	97.8	97.5	90.2	88.3	88.0
12.5	83.6	88.6	95.3	99.0	97.5	97.3	89.7	87.4	86.0
16	91.7	87.4	94.2	96.7	95.8	95.8	88.5	87.9	85.8
20	80.9	87.1	92.2	95.0	94.4	95.4	87.1	86.7	85.5
25	79.5	86.0	90.3	93.4	92.5	93.4	–	–	–
31.5	79.0	84.8	90.2	92.8	–	–	–	–	–
40	79.0	84.3	89.6	91.1	–	–	–	–	–
50	–	83.3	–	–	–	–	–	–	–
63	–	–	–	–	–	–	–	–	–
80	–	–	–	–	–	–	–	–	–
OASPL	102.6	106.7	111.7	116.7	122.0	124.3	123.8	122.8	121.7

TABLE II. - Continued

Sound Pressure Level, SPL, dB Run 2

f kHz	θ* 45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	76.8	84.0	82.8	86.3	90.9	94.6	96.5	98.7	98.5
.125	79.4	83.6	84.1	87.2	92.6	96.4	98.8	100.5	102.4
.16	80.0	85.2	87.1	92.0	95.8	99.5	100.4	102.3	104.5
.2	82.7	86.5	90.4	93.8	98.7	102.5	104.2	107.1	106.7
.25	84.0	87.4	94.5	97.3	104.2	107.2	110.1	110.6	108.8
.315	86.4	87.1	92.7	96.2	103.1	107.1	109.1	109.7	109.6
.4	86.8	90.6	94.5	99.5	105.1	109.0	112.9	110.4	109.4
.5	87.3	91.6	96.4	99.8	107.7	110.5	112.6	111.0	110.9
.63	88.7	93.3	96.5	101.2	109.1	111.5	114.7	111.9	109.7
.8	90.4	93.3	97.7	101.5	108.9	111.6	111.8	110.3	109.2
1	90.9	92.9	98.6	103.8	108.3	111.3	110.1	108.5	107.2
1.25	89.8	93.2	97.8	102.4	108.2	107.0	107.5	104.7	106.7
1.6	89.8	92.3	97.7	102.2	105.4	107.6	106.8	104.9	106.5
2	90.0	91.9	97.6	102.1	105.3	104.6	102.8	101.0	102.4
2.5	88.4	91.3	97.4	101.3	103.7	101.6	99.6	97.3	99.2
3.15	87.0	89.4	94.6	100.2	102.1	98.6	95.1	94.0	96.1
4	87.3	91.0	94.7	100.1	100.7	97.6	93.6	90.7	92.7
5	87.0	89.9	95.5	97.5	98.8	94.9	90.4	90.1	90.9
6.3	84.4	88.7	95.6	97.6	97.7	93.5	90.0	89.2	89.1
8	83.2	88.5	92.9	97.1	95.7	94.0	86.7	85.7	86.8
10	82.7	86.3	93.0	95.2	91.5	93.0	85.6	83.7	84.8
12.5	80.6	86.4	91.9	92.9	91.5	92.6	85.6	83.4	84.5
16	79.6	86.3	89.9	91.2	90.5	90.4	84.0	81.7	83.3
20	78.2	84.3	88.1	89.7	87.2	89.6	83.1	81.4	-
25	76.3	82.8	86.0	87.5	86.3	87.3	82.8	81.0	-
31.5	76.4	82.0	85.8	87.5	86.2	85.3	-	-	-
40	75.6	81.0	84.6	-	-	-	-	-	-
50	75.6	81.3	83.7	-	-	-	-	-	-
63	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
OASPL	100.6	103.9	108.8	112.8	117.7	119.7	121.2	119.8	119.2

TABLE II. - Continued

Sound Pressure Level, SPL, dB Run 3

f kHz	θ* 45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	76.8	80.6	81.6	83.9	86.2	90.2	88.1	93.4	96.8
.125	77.4	82.4	83.6	84.5	89.4	92.5	95.4	95.3	97.0
.16	78.7	82.8	85.7	87.9	89.8	94.8	96.4	98.5	100.8
.2	79.5	84.7	88.9	89.3	95.5	97.1	99.9	101.1	101.5
.25	81.6	84.6	92.5	93.6	99.7	101.3	105.4	106.0	105.0
.315	81.6	85.7	89.5	93.2	97.6	101.1	106.0	105.8	106.1
.4	84.3	85.3	91.1	93.0	100.0	102.9	106.3	106.1	103.5
.5	84.5	87.4	92.6	95.3	100.4	102.7	105.0	103.7	103.9
.63	84.6	89.6	94.1	97.5	100.2	102.3	103.6	102.4	100.6
.8	85.0	89.0	93.3	95.9	100.2	101.9	101.8	100.2	98.1
1	86.2	88.9	92.4	96.9	99.7	100.5	99.5	97.0	94.9
1.25	85.1	89.2	92.1	96.6	100.2	97.1	95.8	94.1	95.1
1.6	85.6	88.7	92.6	96.0	96.7	97.5	95.7	93.5	94.0
2	85.7	87.9	91.6	95.4	97.0	95.4	92.4	90.1	90.4
2.5	84.3	87.0	91.4	94.0	95.8	92.7	89.4	88.3	88.8
3.15	84.2	86.3	88.9	93.8	94.1	90.3	87.6	86.2	86.0
4	83.0	86.2	88.7	92.0	92.4	90.3	87.1	84.3	85.2
5	81.2	86.5	88.3	91.7	88.9	89.3	85.5	83.8	86.9
6.3	81.1	87.1	86.8	90.3	89.9	85.6	84.2	83.4	84.1
8	79.6	85.4	87.9	90.7	90.5	86.8	82.8	82.3	82.2
10	78.5	84.0	86.2	88.2	88.1	87.7	81.7	81.4	81.1
12.5	77.5	83.7	84.8	87.5	86.3	87.3	80.7	79.8	79.1
16	76.4	82.0	85.5	86.0	85.4	87.6	80.8	79.8	78.2
20	74.2	80.2	84.2	85.2	84.3	86.9	79.8	-	76.7
25	73.2	80.5	83.1	84.2	82.7	84.2	-	-	-
31.5	-	79.6	82.9	83.8	82.7	83.4	-	-	-
40	-	79.2	81.6	82.9	82.4	-	-	-	-
50	-	-	-	-	-	-	-	-	-
63	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
OASPL	96.5	100.3	104.0	107.1	110.3	111.5	113.6	113.1	112.7

TABLE II. - Continued

Sound Pressure Level, SPL, dB Run 4

f kHz	θ* 45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	76.9	78.8	84.3	84.4	86.0	90.2	88.2	93.6	96.9
.125	79.3	81.5	83.4	85.0	89.9	91.7	93.5	96.6	98.5
.16	78.1	79.5	86.5	88.4	92.0	92.5	96.6	100.1	98.3
.2	79.9	85.5	89.5	91.1	95.7	98.4	100.4	102.3	102.1
.25	80.0	85.4	90.1	91.4	96.0	100.0	104.0	105.0	104.5
.315	82.3	86.7	89.8	93.5	96.6	101.2	104.9	106.1	105.3
.4	83.9	87.7	92.0	94.9	99.9	102.8	106.6	106.3	106.8
.5	84.1	88.9	93.0	95.4	100.5	102.9	106.8	106.8	105.1
.63	84.9	88.3	93.9	96.8	101.8	103.0	105.5	105.0	102.3
.8	85.8	89.2	92.5	96.2	100.8	101.8	102.2	101.9	99.4
1	86.5	88.7	93.9	97.4	100.7	100.8	100.0	98.0	96.7
1.25	84.7	88.7	92.6	96.6	100.0	97.7	97.1	94.1	94.8
1.6	85.5	88.8	92.2	96.1	97.5	97.6	96.1	93.7	94.6
2	85.2	88.5	91.8	95.4	97.1	95.9	93.1	90.8	91.0
2.5	84.4	87.4	91.1	94.1	96.1	93.0	90.1	88.0	88.9
3.15	83.4	85.2	88.9	93.1	95.3	89.8	88.4	85.7	85.6
4	82.7	86.8	89.8	92.4	93.9	89.6	87.3	84.0	84.4
5	81.0	85.5	89.2	90.7	91.8	90.0	85.3	84.7	87.4
6.3	80.7	84.7	88.7	90.9	89.0	89.5	84.3	83.7	85.5
8	80.1	84.6	89.4	89.4	89.7	89.6	83.6	82.3	82.7
10	77.3	84.0	87.2	89.2	87.9	87.4	82.6	81.6	81.1
12.5	76.4	82.8	85.6	87.9	86.5	88.5	82.2	80.8	79.7
16	75.4	83.2	86.1	85.9	86.0	87.7	81.6	80.8	78.0
20	74.7	81.9	83.9	86.0	83.2	86.9	79.9	79.7	76.2
25	73.3	81.0	82.7	84.4	83.8	84.8	80.4	79.5	-
31.5	73.7	81.1	82.7	83.7	83.5	83.5	-	-	-
40	72.9	79.5	81.6	83.0	82.3	-	-	-	-
50	-	-	81.3	82.7	82.8	-	-	-	-
63	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
OASPL	96.4	100.3	104.3	107.1	110.5	111.6	114.0	114.1	113.4

TABLE II. - Continued

Sound Pressure Level, SPL, dB Run 5

f kHz	θ* 45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	72.7	75.6	77.1	77.1	78.1	77.5	78.8	84.4	84.6
.125	75.0	77.9	78.4	79.6	81.2	81.7	83.2	84.9	84.2
.16	70.0	76.1	75.9	79.5	80.2	83.7	84.5	86.1	88.9
.2	71.6	77.0	78.4	81.3	83.4	82.3	87.8	89.7	88.6
.25	72.1	75.7	79.1	82.6	83.5	83.4	89.3	90.1	88.6
.315	72.5	77.5	79.1	82.8	83.4	85.9	88.2	87.5	89.4
.4	72.8	77.5	81.2	83.5	85.1	85.2	88.0	87.0	88.4
.5	74.6	79.5	80.5	82.5	85.0	85.4	87.7	85.0	84.7
.63	73.8	78.4	82.2	83.4	86.2	85.8	87.4	84.7	83.6
.8	74.2	78.2	80.6	82.7	84.5	84.6	84.3	82.1	80.1
1	75.3	76.8	80.7	83.5	84.2	83.0	83.0	79.0	77.2
1.25	74.6	77.7	80.1	82.4	84.1	80.9	80.2	78.2	78.7
1.6	75.0	77.2	79.3	81.7	80.8	81.2	80.5	77.9	78.5
2	74.5	76.7	79.1	80.6	80.1	79.5	78.2	75.8	76.4
2.5	73.0	75.4	78.7	79.1	79.6	77.2	76.1	74.1	75.3
3.15	71.6	73.7	76.3	78.9	77.6	75.1	73.5	72.5	72.0
4	69.8	73.1	75.9	78.6	76.5	75.7	72.2	71.7	71.3
5	70.3	72.8	76.5	75.6	76.1	73.6	70.4	71.2	73.4
6.3	68.5	72.9	74.5	75.8	74.1	72.7	70.4	70.5	71.5
8	68.1	71.7	74.9	76.5	75.4	72.8	69.6	70.4	71.9
10	65.9	72.4	74.0	76.0	74.8	73.4	68.4	67.3	69.8
12.5	65.2	69.9	73.5	75.2	73.7	74.2	66.1	–	–
16	64.9	68.6	72.5	73.2	73.4	73.4	66.7	–	–
20	63.7	68.8	71.2	72.8	70.6	73.2	64.7	–	–
25	63.7	68.6	69.5	71.5	69.6	71.3	–	–	–
31.5	63.7	67.8	69.7	71.0	69.8	68.0	–	–	–
40	–	67.9	69.3	71.0	69.6	67.3	–	–	–
50	–	–	–	–	–	–	–	–	–
63	–	–	–	–	–	–	–	–	–
80	–	–	–	–	–	–	–	–	–
OASPL	86.2	89.9	92.2	94.3	95.4	95.4	97.3	97.1	97.3

TABLE II. - Concluded

Sound Pressure Level, SPL, dB Run 6

f kHz	θ* 45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	-	-	-	70.6	72.7	71.3	72.6	76.2	75.6
.125	-	-	-	72.3	74.5	72.6	74.2	77.8	77.1
.16	69.5	70.0	73.9	71.5	73.2	72.9	73.2	78.6	76.3
.2	71.2	72.0	72.9	74.3	75.2	75.1	73.6	77.5	76.0
.25	67.3	69.4	72.7	73.2	74.3	72.4	73.3	76.8	75.8
.315	67.3	69.2	73.1	74.2	74.9	73.9	73.2	75.5	75.2
.4	69.3	69.0	72.6	73.5	74.1	74.1	75.0	74.0	74.3
.5	67.7	68.4	73.4	73.3	73.4	71.5	75.1	74.5	71.2
.63	65.9	69.3	73.0	74.6	73.4	72.9	73.6	72.6	70.3
.8	66.1	69.6	71.5	72.2	73.3	71.9	71.8	70.8	67.9
1	67.2	68.3	71.2	71.9	72.5	71.2	69.8	67.9	66.0
1.25	68.4	70.8	69.8	71.3	72.3	68.7	70.5	70.2	68.6
1.6	68.3	69.6	70.2	70.9	69.0	69.2	70.7	70.3	68.1
2	67.2	68.4	69.1	69.6	68.6	67.9	68.6	68.6	66.9
2.5	65.8	67.0	68.0	68.0	67.6	66.2	66.6	66.5	64.8
3.15	64.4	63.6	67.2	67.6	65.6	65.3	63.1	65.6	62.3
4	62.5	63.7	66.3	67.2	65.7	64.0	64.0	63.4	58.8
5	59.9	63.1	64.4	64.1	64.5	65.0	63.3	63.9	-
6.3	59.3	61.2	63.4	63.9	63.0	62.4	62.9	63.7	-
8	57.7	61.2	64.1	64.0	62.5	63.3	60.6	62.8	-
10	57.9	60.7	62.0	63.2	61.4	64.8	58.9	61.4	-
12.5	57.9	60.1	63.4	63.6	61.3	64.1	58.0	-	-
16	56.5	59.7	63.0	62.9	61.2	62.6	-	-	-
20	56.8	59.1	62.4	61.8	59.6	62.4	-	-	-
25	-	-	60.9	61.1	59.7	62.0	-	-	-
31.5	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-
63	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
OASPL	79.4	80.7	83.6	84.6	85.1	84.2	84.6	86.5	85.1

TABLE III. - 1/2-SCALE JT15D PREDICTED JET MIXING
LOSSLESS FREE-FIELD SPECTRA

Sound Pressure Level, SPL, dB Run 1

f	θ*								
kHz	45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	78.5	81.3	84.2	87.1	91.8	94.4	97.4	98.9	100.8
.125	80.7	83.5	86.6	89.4	94.6	97.8	101.1	102.8	104.3
.16	82.8	85.7	88.9	91.8	97.1	101.1	104.3	106.0	106.8
.2	85.0	88.0	91.1	94.0	100.5	104.6	107.8	109.5	109.0
.25	86.9	90.1	93.3	96.2	103.5	107.6	110.7	111.7	111.8
.315	88.4	91.8	95.4	98.5	106.3	110.4	112.8	113.6	113.8
.4	89.6	93.2	97.3	101.7	108.3	112.4	114.4	115.1	115.5
.5	90.5	94.3	98.6	102.5	110.0	113.9	116.1	116.5	116.7
.63	91.8	95.2	99.7	103.9	111.4	115.1	117.3	117.7	117.5
.8	92.0	96.0	100.6	105.3	112.5	116.1	118.5	118.7	118.0
1.0	92.4	96.7	101.4	106.5	113.2	116.8	118.8	119.0	118.0
1.25	92.7	97.0	102.0	107.3	113.3	116.6	118.5	118.5	117.0
1.6	92.8	97.2	102.4	107.8	113.0	115.7	117.3	117.1	115.2
2	92.7	97.1	102.6	107.9	112.5	114.5	115.7	115.3	113.4
2.5	92.1	97.0	102.6	107.8	111.3	113.0	114.0	113.4	111.3
3.15	92.0	96.9	102.5	107.4	110.1	111.4	112.2	111.5	109.4
4	91.4	96.4	102.2	107.0	108.8	109.8	110.7	109.6	107.3
5	90.7	95.6	101.7	106.4	107.5	108.1	108.3	107.8	105.5
6.3	89.9	95.0	101.0	105.6	106.0	106.5	106.6	105.9	103.5
8	89.0	94.2	100.3	104.7	104.8	104.9	104.8	104.0	101.5
10	87.7	93.2	99.5	103.8	103.5	103.3	102.9	102.1	99.5
12.5	86.8	92.1	98.6	102.8	102.0	101.6	101.2	100.3	97.5
16	85.7	91.0	97.5	101.8	100.9	100.0	99.3	98.4	95.7
20	84.6	89.9	96.4	100.6	99.4	98.3	97.4	96.5	93.5
25	83.4	88.6	95.3	99.5	98.0	96.8	-	-	-
31.5	82.2	87.5	94.1	98.3	-	95.2	-	-	-
40	81.1	86.3	92.9	97.1	-	-	-	-	-
50	-	85.0	-	-	-	-	-	-	-
63	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
OASPL	103.8	108.3	113.7	118.4	122.7	125.6	127.3	127.5	126.6

TABLE III. - Continued

Sound Pressure Level, SPL, dB Run 2

f kHz	θ* 45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	76.8	79.7	82.3	84.4	88.3	90.7	93.8	95.0	96.5
.125	79.0	81.7	84.6	86.8	91.1	94.0	97.3	98.5	100.0
.16	81.3	84.1	86.8	89.0	93.8	97.3	100.4	101.6	102.5
.2	83.3	86.2	89.0	91.2	96.4	100.3	103.4	104.4	105.0
.25	84.9	88.2	91.2	93.5	99.3	103.4	105.9	106.5	107.1
.315	86.1	89.7	93.1	95.6	101.6	105.5	107.7	108.1	108.7
.4	87.1	90.6	94.5	97.5	103.3	107.0	109.2	109.7	110.1
.5	88.1	91.6	95.7	99.0	104.8	108.2	110.7	111.1	111.1
.63	88.8	92.4	96.6	100.2	106.0	109.4	111.6	112.2	112.0
.8	89.2	93.0	97.4	101.4	107.0	110.0	112.3	112.7	112.1
1	89.5	93.6	98.0	102.2	107.4	109.9	112.0	112.4	111.5
1.25	89.7	93.9	98.5	102.7	107.2	109.3	111.0	111.2	109.9
1.6	89.7	94.0	98.7	102.9	106.9	108.3	109.5	109.4	108.0
2	89.5	93.9	98.8	102.9	105.8	106.9	107.7	107.6	106.0
2.5	89.1	93.7	98.7	102.7	104.8	105.3	106.0	105.7	104.2
3.15	88.5	93.2	98.4	102.4	103.7	103.8	104.2	103.9	102.3
4	87.8	92.5	98.0	101.9	102.4	102.2	102.5	102.0	100.3
5	87.0	91.8	97.3	101.2	101.3	100.6	100.8	100.2	98.4
6.3	86.2	91.0	96.6	100.4	99.8	99.1	98.8	98.3	96.5
8	85.2	90.0	95.8	99.6	98.5	97.5	97.0	96.4	94.5
10	84.1	89.1	94.9	98.7	97.4	95.9	95.3	94.6	92.6
12.5	83.0	88.0	93.8	97.7	96.0	94.4	93.5	92.7	90.5
16	81.9	87.0	92.7	96.5	94.6	92.8	91.8	90.9	88.5
20	80.7	85.7	91.6	95.4	93.4	91.2	90.0	89.0	-
25	79.5	84.5	90.5	94.3	92.0	89.7	88.1	87.2	-
31.5	78.4	83.3	89.3	93.1	90.6	88.1	-	-	-
40	77.2	82.2	88.1	-	-	-	-	-	-
50	76.0	-	87.0	-	-	-	-	-	-
63	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
OASPL	100.8	105.0	109.8	113.6	116.9	119.0	121.0	121.1	120.6

TABLE III. - Continued

Sound Pressure Level, SPL, dB   Run 3

f kHz	θ* 45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	75.8	78.4	80.7	81.9	84.1	86.8	89.2	89.9	90.5
.125	78.1	80.6	82.9	84.1	86.6	89.8	92.8	93.4	93.6
.16	80.1	82.7	85.1	86.3	89.1	92.9	95.9	96.0	96.0
.2	81.6	84.3	87.2	88.6	91.8	95.8	98.1	98.2	98.0
.25	82.9	86.0	89.0	90.6	93.8	97.8	99.8	99.6	99.5
.315	83.9	87.2	90.3	92.2	95.6	99.0	101.3	101.6	101.0
.4	84.8	88.0	91.4	93.5	97.3	100.3	102.4	103.2	102.3
.5	85.4	88.8	92.3	94.5	98.5	101.3	103.4	104.3	103.1
.63	85.9	89.5	93.1	95.4	99.5	101.7	103.8	104.7	103.4
.8	86.2	89.8	93.6	96.1	99.9	102.5	103.3	104.1	102.8
1	86.4	90.1	94.0	96.6	100.0	100.9	102.1	102.6	101.0
1.25	86.3	90.2	94.2	96.9	99.4	100.0	100.8	100.7	99.0
1.6	86.2	90.1	94.2	97.0	98.7	98.6	99.1	98.9	97.2
2	85.8	89.8	94.1	96.9	97.8	97.1	97.5	97.1	95.3
2.5	85.2	89.4	93.8	96.8	96.7	95.7	95.6	95.3	93.5
3.15	84.5	88.6	93.3	96.3	95.6	94.2	94.0	93.5	91.6
4	83.8	87.9	92.6	95.7	94.4	92.7	92.2	91.7	89.8
5	82.9	87.2	91.9	95.0	93.4	91.3	90.6	89.9	87.9
6.3	81.8	86.2	91.0	94.2	92.1	89.8	88.8	88.1	86.1
8	80.7	85.2	90.1	93.3	91.0	88.4	87.1	86.3	84.2
10	79.6	84.0	89.0	92.3	89.7	86.9	85.5	84.5	82.3
12.5	78.5	83.0	87.9	91.2	88.4	85.4	83.6	82.7	80.3
16	77.3	81.8	86.8	90.1	87.2	83.8	82.0	80.9	78.5
20	76.1	80.7	85.6	89.0	85.8	82.5	80.3	–	76.7
25	75.0	79.5	84.4	87.8	84.5	81.0	–	–	–
31.5	–	78.4	83.3	86.6	83.3	79.5	–	–	–
40	–	77.2	82.1	85.5	82.0	–	–	–	–
50	–	–	–	–	–	–	–	–	–
63	–	–	–	–	–	–	–	–	–
80	–	–	–	–	–	–	–	–	–
OASPL	97.4	101.2	105.3	108.0	109.6	111.0	112.4	112.9	111.7

TABLE III. - Continued

Sound Pressure Level, SPL, dB — Run 4

f kHz	θ* 45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	75.3	78.2	80.7	82.2	84.5	87.2	89.8	90.5	91.2
.125	77.6	80.5	82.9	84.4	86.8	89.3	93.3	93.9	94.2
.16	79.8	82.6	85.1	86.6	89.2	93.4	96.3	96.5	96.6
.2	81.4	82.0	87.3	88.9	92.0	96.3	98.7	98.6	98.4
.25	82.8	86.1	89.1	90.9	94.3	98.1	100.2	100.1	99.1
.315	83.9	87.3	90.5	92.5	95.8	99.4	101.5	102.1	101.3
.4	84.8	88.1	91.6	93.8	97.3	100.6	102.8	103.6	102.7
.5	85.6	89.2	92.5	94.8	99.0	101.6	103.8	104.6	103.5
.63	86.1	89.7	93.3	95.7	99.7	101.9	104.1	104.9	103.5
.8	86.5	90.2	93.9	96.4	100.1	101.7	103.6	104.2	102.8
1	86.7	90.4	94.3	96.9	100.3	101.2	102.4	102.6	101.0
1.25	86.7	90.6	94.5	97.2	99.7	100.1	100.8	100.8	99.2
1.6	86.6	90.5	94.6	97.3	98.8	98.8	99.2	99.0	97.2
2	86.3	90.3	94.5	97.2	98.0	97.3	97.5	97.2	95.1
2.5	85.8	89.8	94.2	97.1	96.8	95.9	95.8	95.4	93.5
3.15	85.1	89.2	93.7	96.7	95.8	94.3	94.1	93.6	91.7
4	84.4	88.5	93.0	96.0	94.7	92.8	92.3	91.7	89.8
5	83.6	87.8	92.3	95.3	93.6	91.4	90.6	89.9	87.9
6.3	82.6	86.8	91.5	94.6	92.3	90.0	88.8	88.1	86.0
8	81.5	85.8	90.5	93.7	91.2	88.5	87.2	86.3	84.0
10	80.4	84.8	89.5	92.7	90.0	87.0	85.4	84.5	82.3
12.5	79.3	83.7	88.4	91.6	88.7	85.6	83.8	82.7	80.5
16	78.2	82.6	87.3	90.5	87.3	84.1	82.1	80.9	78.5
20	77.0	81.8	86.1	89.4	86.0	82.6	80.4	79.1	76.8
25	75.8	80.2	84.9	88.2	84.8	81.2	-	-	-
31.5	74.7	79.2	83.8	87.0	83.5	79.7	-	-	-
40	73.5	77.8	82.6	85.9	82.3	-	-	-	-
50	-	-	81.4	84.7	-	-	-	-	-
63	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
OASPL	97.8	101.6	105.7	108.4	109.9	111.1	112.7	113.1	111.9

TABLE III. - Continued

Sound Pressure Level, SPL, dB Run 5

f kHz	θ* 45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	71.8	74.5	76.0	76.3	76.8	78.6	81.8	83.3	83.1
.125	73.6	76.3	78.1	78.5	79.0	81.4	84.3	85.8	85.3
.16	74.9	77.7	79.9	80.5	81.2	83.4	86.5	87.4	86.9
.2	76.1	79.0	81.2	82.0	83.0	84.0	87.8	88.7	88.3
.25	77.0	80.0	82.3	83.2	84.5	86.4	88.8	89.7	89.3
.315	77.8	80.9	83.2	84.2	85.8	87.5	89.8	90.5	90.2
.4	78.4	81.5	84.0	85.1	86.9	88.2	90.1	90.8	90.3
.5	78.7	81.9	84.6	85.8	87.5	88.4	89.8	90.2	89.6
.63	79.0	82.1	85.0	86.2	87.8	88.2	89.0	89.3	88.6
.8	79.0	82.4	85.2	86.5	87.5	87.4	87.9	87.9	86.5
1	78.9	82.3	85.2	86.7	87.1	86.3	86.4	86.3	85.1
1.25	78.6	82.0	85.1	86.6	86.5	85.2	84.8	84.6	83.5
1.6	78.0	81.5	84.8	86.4	86.0	84.0	83.3	82.9	81.3
2	77.4	81.1	84.3	86.0	85.0	82.8	81.6	81.2	79.8
2.5	76.7	80.2	83.6	85.4	84.2	81.6	80.1	79.6	78.2
3.15	75.9	79.5	82.9	84.7	83.2	80.3	78.7	77.9	76.5
4	74.9	78.7	82.1	83.9	82.2	79.0	77.1	76.2	74.5
5	73.9	77.7	81.1	83.0	81.0	77.7	75.6	74.5	72.9
6.3	72.8	76.5	80.1	82.0	79.9	76.4	74.0	72.9	71.2
8	71.7	75.3	79.0	80.9	78.6	75.1	72.4	71.2	69.3
10	70.5	74.2	77.9	79.8	77.5	73.7	71.0	69.5	67.5
12.5	69.3	73.2	76.7	78.7	76.3	72.4	69.3	-	-
16	68.2	71.9	75.5	77.5	75.2	71.0	67.8	-	-
20	67.0	70.8	74.4	76.3	73.8	69.7	66.1	-	-
25	65.8	69.6	73.2	75.2	72.8	68.4	-	-	-
31.5	64.6	68.4	72.0	74.0	71.5	67.0	-	-	-
40	-	67.2	70.8	72.8	70.4	65.7	-	-	-
50	-	-	-	-	-	-	-	-	-
63	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-
OASPL	90.0	93.4	96.3	97.7	97.9	97.8	99.0	99.5	99.0

TABLE III. - Concluded

Sound Pressure Level, SPL, dB   Run 6

f kHz	θ*								
	45°	65°	90°	110°	125°	135°	145°	150°	155°
0.1	–	–	–	70.2	69.5	70.6	74.4	76.3	75.9
.125	–	–	–	72.0	71.3	72.6	76.3	77.5	77.4
.16	68.3	71.0	73.0	73.3	73.0	74.0	77.4	78.3	78.5
.2	69.3	72.0	74.0	74.3	74.1	75.6	78.5	79.1	79.5
.25	70.0	72.7	74.8	75.3	75.6	77.0	79.2	79.9	80.2
.315	70.5	73.3	75.5	76.0	76.5	77.5	79.2	79.7	80.0
.4	71.0	73.8	76.0	76.6	77.0	77.6	78.8	79.2	80.1
.5	71.1	74.0	76.3	76.9	77.4	77.4	78.2	78.4	78.0
.63	71.0	74.0	76.4	77.2	77.3	76.8	76.9	77.0	76.0
.8	70.8	73.9	76.3	77.2	77.2	75.8	75.5	75.4	74.8
1	70.3	73.6	76.1	77.1	76.8	75.0	74.1	73.9	73.2
1.25	69.9	73.1	75.7	76.7	76.2	74.0	72.9	72.3	71.5
1.6	69.1	72.3	75.1	76.2	75.5	72.8	71.3	70.8	69.8
2	68.4	71.7	74.4	75.5	74.7	71.7	69.8	69.2	68.0
2.5	67.5	70.8	73.6	74.8	73.7	70.6	68.3	67.6	66.5
3.15	66.5	69.9	72.7	74.0	72.9	69.3	67.0	66.1	64.8
4	65.3	69.0	71.7	73.0	71.8	68.3	65.8	64.5	63.2
5	64.4	67.6	70.6	71.9	70.6	66.8	64.3	63.0	–
6.3	63.1	66.5	69.5	70.8	69.5	65.8	62.9	61.4	–
8	62.0	65.4	68.4	69.7	68.0	64.5	61.3	59.8	–
10	61.0	64.1	67.2	68.5	67.0	63.1	60.0	58.3	–
12.5	59.6	63.1	66.0	67.3	66.0	62.0	58.4	–	–
16	58.5	61.8	64.9	66.2	64.8	60.7	–	–	–
20	57.3	60.5	63.7	65.0	63.5	59.5	–	–	–
25	–	–	62.5	63.8	62.3	58.3	–	–	–
31.5	–	–	–	–	–	–	–	–	–
40	–	–	–	–	–	–	–	–	–
50	–	–	–	–	–	–	–	–	–
63	–	–	–	–	–	–	–	–	–
80	–	–	–	–	–	–	–	–	–
OASPL	81.6	84.7	87.1	88.2	87.9	87.3	88.4	88.8	88.8

TABLE IV. - STATISTICAL COMPARISON OF DATA
DIFFERENCE BETWEEN EXPERIMENTAL AND CALCULATED (REF. 1) OASPL

For all 54 points: Mean = -1.5 dB; Variance = 5.0 dB; Standard Deviation = 2.2 dB

Run	$(OASPL_{EXP} - OASPL_{CALC})$ dB = Δ									Overall		
	Angle from inlet axis, θ^*, degree									Mean	Variance	Standard deviation
	45°	65°	90°	110°	125°	135°	145°	150°	155°			
1	-1.2	-1.6	-2.0	-1.7	-0.7	-1.3	-3.5	-4.7	-4.9	-2.4	7.9	2.8
2	-0.2	1.1	-1.0	-0.8	0.8	0.7	0.2	-1.3	-1.4	-.2	0.9	0.9
3	-0.9	-0.9	-1.3	-0.9	0.7	0.5	1.2	0.2	1.0	0	0.8	0.9
4	-1.4	-1.3	-1.4	-1.3	0.6	0.5	1.3	1.0	1.5	-.1	1.4	1.2
5	-3.8	-3.5	-4.1	-3.4	-2.5	-2.4	-1.7	-2.4	-1.7	-2.8	8.7	3.0
6	-2.2	-4.0	-3.5	-3.6	-2.8	-3.1	-3.8	-2.3	-3.7	-3.2	10.8	3.3
Mean	-1.6	-1.7	-2.2	-2.0	-0.7	-0.9	-1.1	-1.6	-1.5	-	-	-
Variance	3.9	5.8	6.3	5.1	2.7	3.0	5.5	6.0	7.6	-	-	-
Standard Deviation	2.0	2.4	2.5	2.3	1.6	1.7	2.3	2.4	2.8	-	-	-

$\Delta = OASPL_{EXP} - OASPL_{CALC}$
Mean = Δ/N
Variance = Δ^2/N
Standard Deviation - Δ^2/N

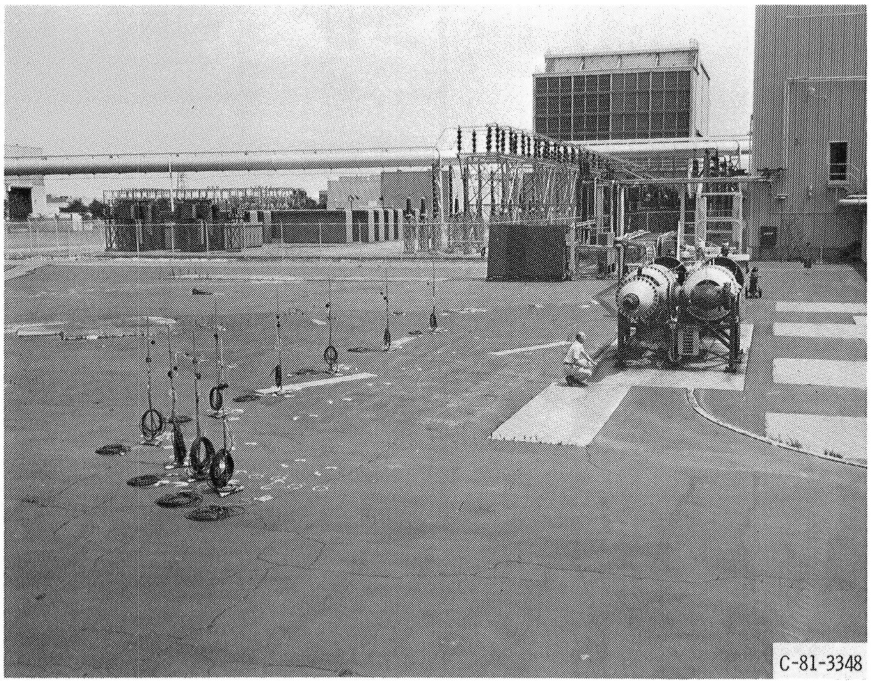
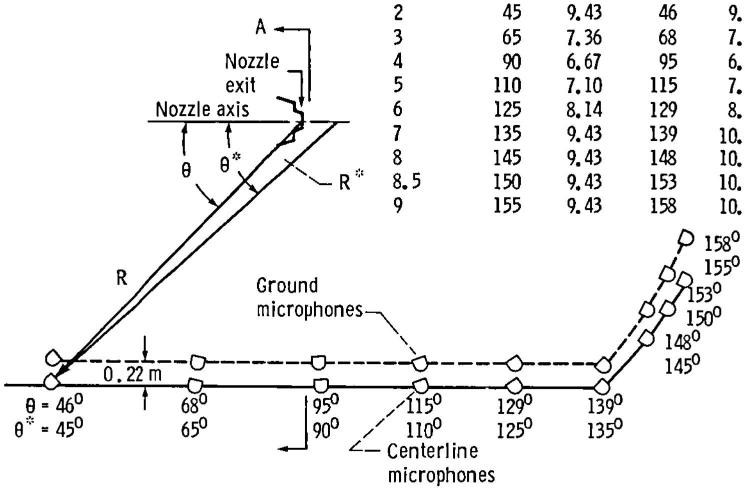
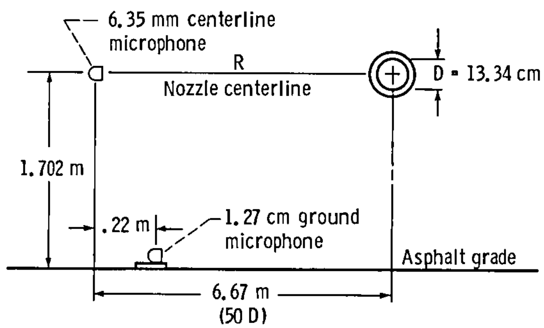


Figure 1. - NASA Lewis outdoor coaxial acoustic facility.

Down stream noise source location, nozzle diam	θ^*, deg	R^*, meters	θ, deg	R, meters
2	45	9.43	46	9.24
3	65	7.36	68	7.20
4	90	6.67	95	6.69
5	110	7.10	115	7.35
6	125	8.14	129	8.62
7	135	9.43	139	10.11
8	145	9.43	148	10.32
8.5	150	9.43	153	10.43
9	155	9.43	158	10.53

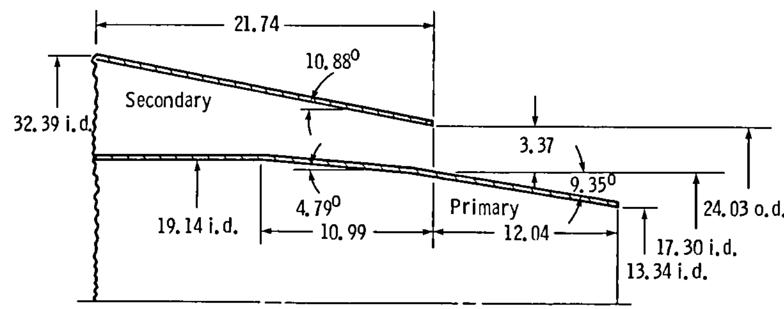


(a) Plan view.



(b) Elevation, view A-A.

Figure 2. - Schematic microphone layout.



Primary (core) diam, 13.34 : $A_p = 139.66\ cm^2$

Secondary (fan), 24.03 o.d. : $A_s = 218.47\ cm^2$

17.30 i.d.

$\frac{A_s}{A_p} = 1.56$

$A_{total} = 358.13\ cm^2$

$D_{eq} = 21.35$

Figure 3. - JT15D 1/2 -Scale nozzle schematic. All dimensions in centimeters.

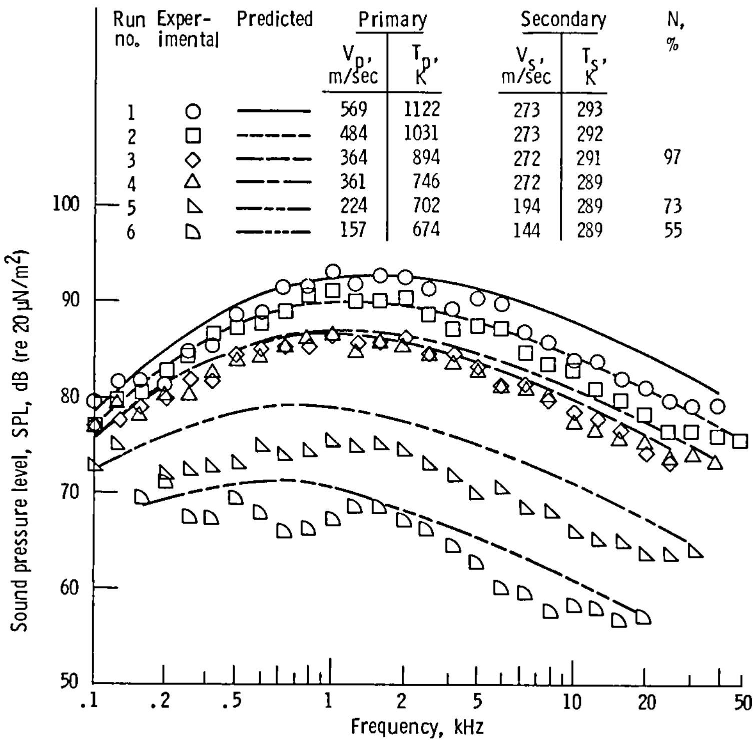


Figure 4. - Comparison of experimental and predicted spectral results at a directivity angle, θ*, of 45° for the JT15D 1/2-scale nozzle at various flow conditions.

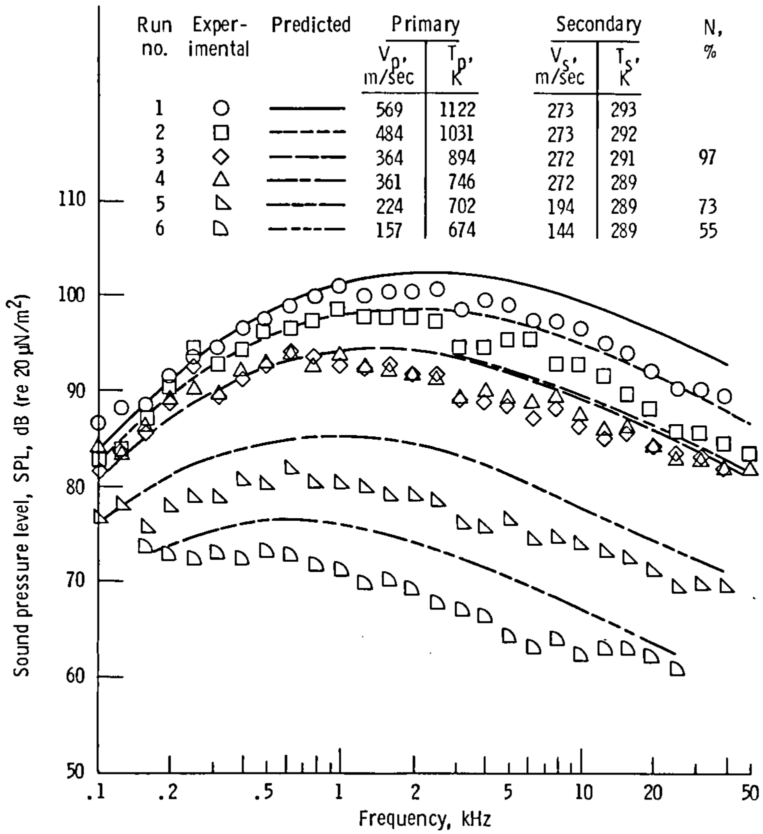


Figure 5. - Comparison of experimental and predicted spectral results at a directivity angle, θ*, of 90° for the JT15D 1/2-scale nozzle at various flow conditions.

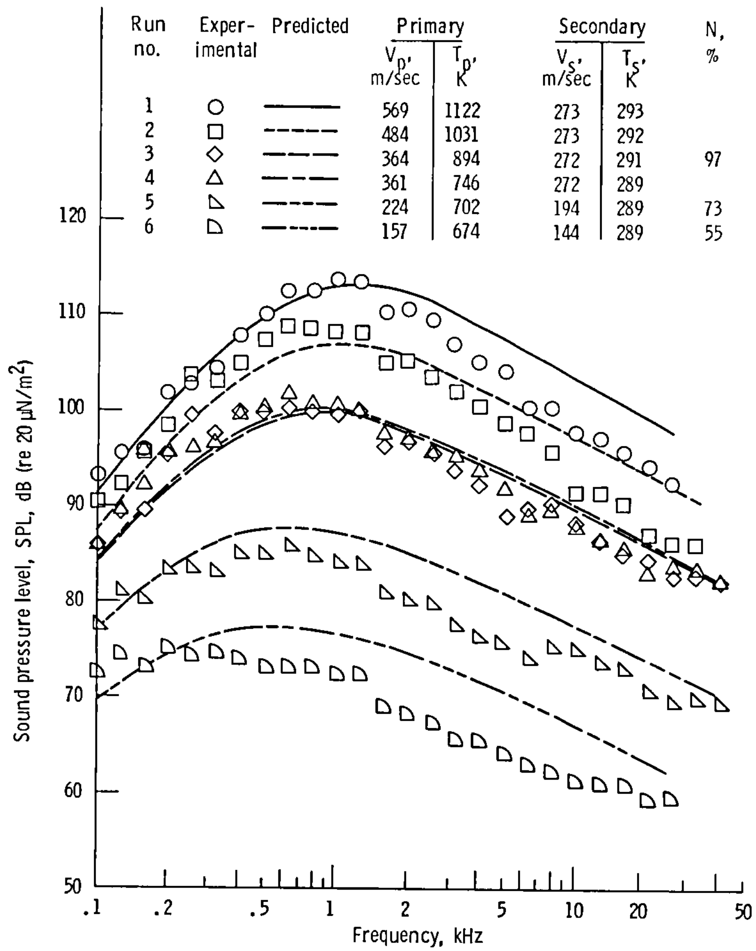


Figure 6. - Comparison of experimental and predicted spectral results at a directivity angle, θ^*, of 125° for the JT15D 1/2 - scale nozzle at various flow conditions.

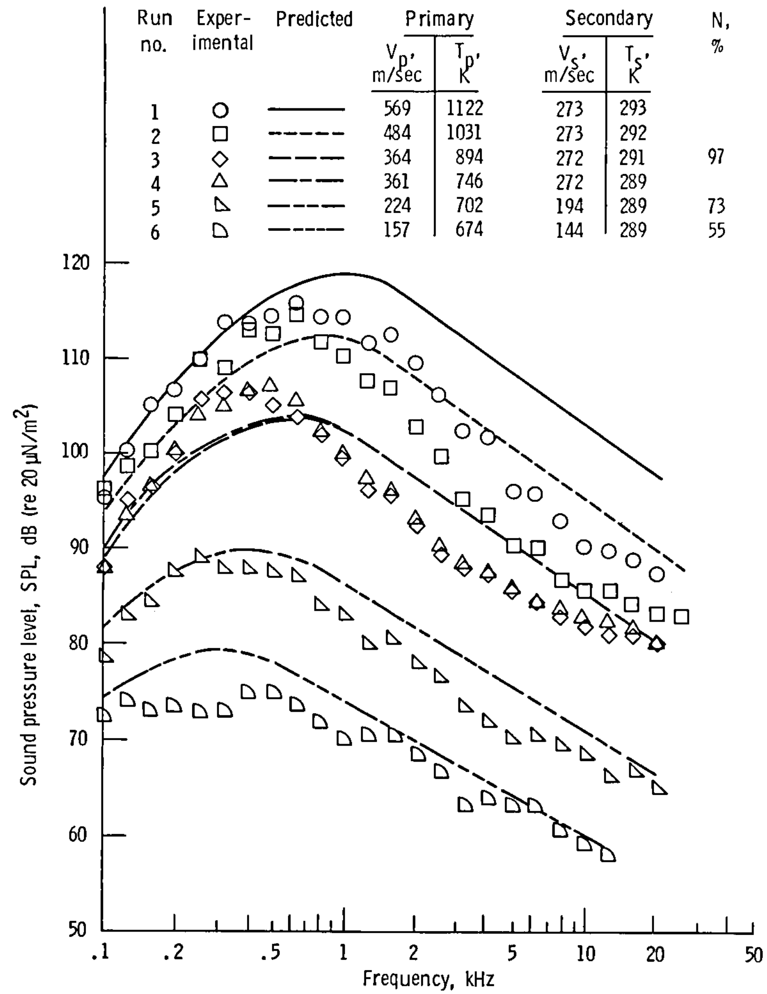
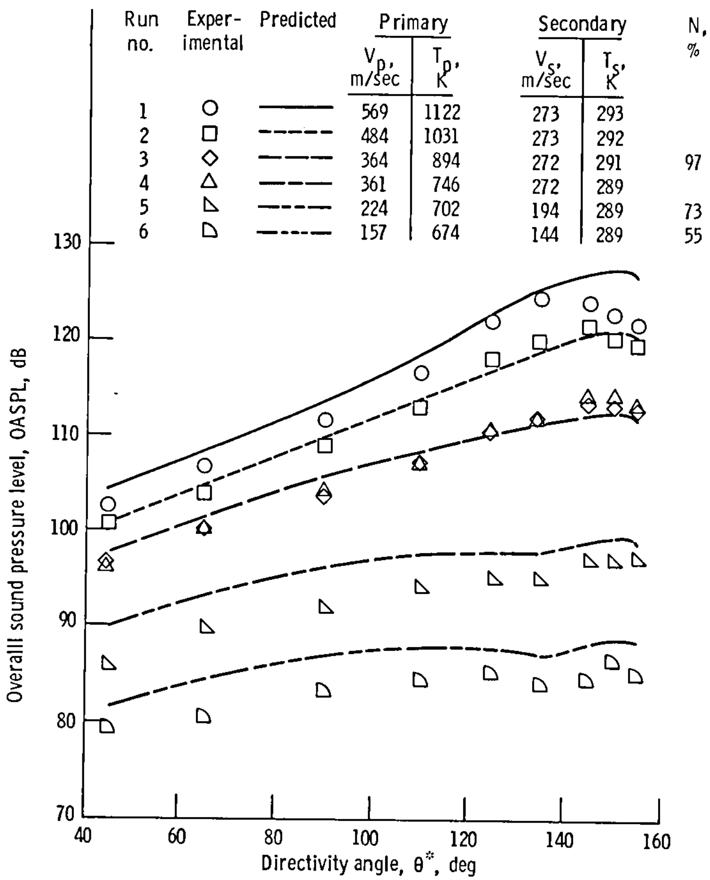


Figure 7. - Comparison of experimental and predicted spectral results at a directivity angle, θ^*, of 145° for the JT15D 1/2 - scale nozzle at various flow conditions.



Run no.	Exper-imental	Predicted	Primary V_p, m/sec	Primary T_p, K	Secondary V_s, m/sec	Secondary T_s, K	N, %
1	○	———	569	1122	273	293	
2	□	------	484	1031	273	292	
3	◇	— — —	364	894	272	291	97
4	△	— — —	361	746	272	289	
5	◺	-----	224	702	194	289	73
6	D	---·--	157	674	144	289	55

Figure 8. - Comparison of experimental and predicted lossless free-field OASPL directivity for the JT15D 1/2 -scale nozzle.

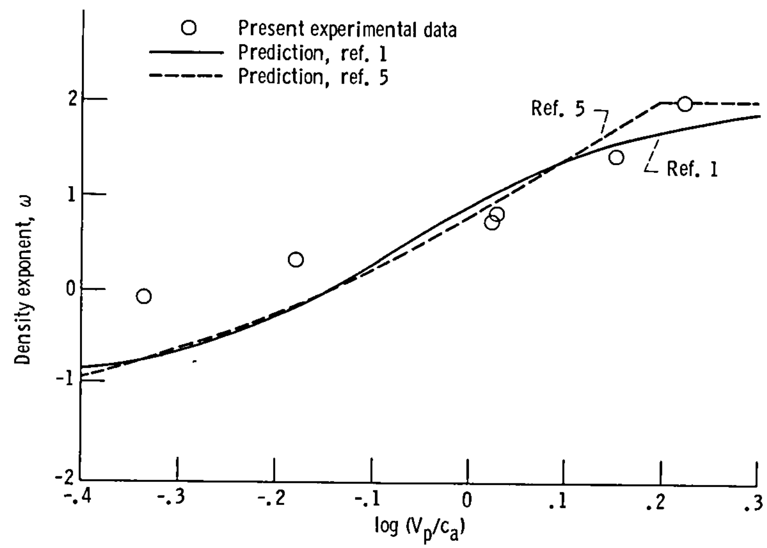


Figure 9. - Comparison of the experimental and predicted density exponent with the nondimensionalized primary jet velocity for the present data and references 1 and 5.

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15. Supplementary Notes

16. Abstract

As part of a joint NASA Lewis, Langley and Ames Research Center Program to study flight effects on the exhaust noise of a full-scale JT15D engine, static half-scale model jet noise experiments were conducted. Acoustic data were recorded for microphone angles of 45° to 155° with jet conditions for the model-scale nozzle corresponding closely to those at 55, 73 and 97 percent of corrected rated speed for the full-scale engine. These data are useful for determining the relative importance of jet and core noise in the static full-scale engine test data and will in turn allow for a proper evaluation of flight effects on the exhaust noise results. The model-scale data are also compared with the current NASA Lewis coaxial jet noise prediction. Above 1000 Hz, the prediction is nominally 0 to 3 dB higher than the data. The arithmetic mean of the differences between the experimental OASPL and the predicted OASPL for all angles for each run ranged from 0 dB to -3.2 dB. The standard deviation of all the OASPL differences is 2.2 dB. The discrepancies are greatest at low primary jet velocities and appear to be due to inadequacy in the variable jet density exponent incorporated in the prediction procedure.

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