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A COMPILATION OF TURBOJET NOISE DATA

BY

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FOREWORD

This report was prepared by the firm of Bolt Beranek and Newman Inc., under Contract No. AF 33(616)-2151, Call 3, for the Wright Air Development Center, under Authority of Project No. 7210 entitled "Acoustic Energy Control". Technical supervision of the preparation of this report was the responsibility of Dr. Henning von Gierke, Aero Medical Laboratory, Directorate of Research, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

The authors acknowledge the assistance of Dr. Ira Dyer and Dr. Francis M. Wiener of Bolt Beranek and Newman Inc. who were particularly helpful in the preparation of this report.

ABSTRACT

Turbojet noise data have been compiled from measurements in engine test facilities and under static open field conditions. All of the measurements were made on conventional engines which have no jet stream modifiers such as teeth or corrugations. About one hundred measurements on 20 types and models of turbojets are included, of which 4 types are English and 16 American.

For both open field and test facility measurements, total acoustic power and the distribution of power in octave bands of frequency have been calculated and tabulated. In the case of open field data, directivity information is presented in plots of sound pressure level as a function of angle. Each acoustic measurement is accompanied by the engine operating conditions that existed at the time of the acoustic measurements. A concise history of each test is given which includes the source of the data, the type of acoustic measurements that were made, and the particular method used to calculate acoustic power.

No critical evaluation has been made of the data herein, however, the far field measurements give more accurate source acoustic power than do the test cell measurements.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

JACK BOLLERUD
Colonel, USAF (MC)
Chief, Aero Medical Laboratory
Directorate of Research

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SECTION I

INTRODUCTION

This report contains a compilation of the bulk of information available prior to 1955 on the acoustical characteristics of turbojet engines. Turbojet noise data have been compiled from measurements in engine test cells and under open field conditions. For both types of measurements total acoustic power and the distribution of power in octave bands of frequency have been calculated and tabulated. In the case of open field data directivity information is presented as plots of sound pressure level as a function of angle. Each acoustic measurement is accompanied by engine operating conditions that existed at the time of the acoustic measurements.

Readers are cautioned that no attempt to evaluate the data presented in this report is given. Obvious discrepancies exist, especially between some free field and test cell measurements on the same engine. In light of later data, (ref. 7, 8, and 9) the free field data represents the most accurate measure of the source acoustical power level as radiated to open space.

SECTION II

DETERMINATION OF ACOUSTIC POWER FROM SOUND PRESSURE MEASUREMENTS

1. General

Since instruments for measuring acoustic intensity and, hence, the radiated acoustic power, have not as yet progressed beyond the laboratory stage, acoustic power must be computed from sound pressure measurements. This can be done, strictly speaking, only in two limiting cases of acoustic environment, namely a) in a free-field, and b) in a diffuse field. In a free sound field in air, the intensity level (IL)* is very nearly equal 1/ to the sound pressure level (SPL)** provided the measurements are carried out in the far radiation field of the source. In a diffuse field in air, the intensity level is very nearly 6 db less 2/ than the sound pressure level.

In the free-field case, the sound intensity is integrated over a surface surrounding the radiator to obtain the radiated power. In the diffuse field case, the radiated power is obtained by multiplying the sound intensity (watts/meter^2) by the number of absorption units (meters^2) present in the room.

In measuring the acoustic output of turbojet engines, neither of the above ideal environmental conditions is practicable. Engines of this type are either mounted on a runway or concrete apron of sizable extent, or measurements are performed in a test cell. Nonetheless, it is generally possible to obtain a useful measure of the radiated power in either of these environments.

The following sections contain a discussion of the three methods used in this report to obtain acoustic power. The problems involved, and the assumptions

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* in decibels re 10^{-12} watts/meter^2

** in decibels re 0.0002 ubar

underlying these methods, are discussed. Wherever possible empirical justification for the methods is also given.

2. Measurements in an Open Field Environment

In the open field environment, the turbojet engine is usually located 2-5 ft above a hard and reasonably smooth surface which extends continuously around the engine and several wavelengths beyond the farthest measuring position. Thus, the sound power is radiated into a semi-infinite space. The total power radiated may be found by integrating sound intensity over a surface which encloses the source if appropriate precautions are taken. In the initial description of the method it is assumed that (1) the atmosphere is calm, dissipationless, and of uniform temperature, (2) the ground plane is infinitely hard, (3) the turbojet may be represented by a small source located at the exhaust orifice of the engine (or of the aircraft if the engine is mounted in an aircraft), and (4) the acoustic radiation pattern is symmetrical about the longitudinal axis of the jet engine which is parallel to the ground plane.

Consideration is given later to the actual conditions under which acoustic power computations are reasonably valid in a real open field environment. In the following, acoustic power shall be specified as power level (PWL) in decibels 1/ where:

$$PWL = 10 \log_{10} W + 130 \text{ db}$$

where W is the acoustic power in watts.

The acoustic power flowing through an area S_j (square feet) may be expressed as

$$PWL_j = SPL_j + 10 \log_{10} S_j$$

if S_j is normal to the direction of the freely progressing wave, and if SPL_j is nearly constant over S_j. If SPL varies with position, then the total power may be found by taking small S_j's such that SPL_j is nearly constant over each area. A good practical rule is to keep the variation of SPL within a given $\Delta \theta_j$ to less than about 5 db. The total power level is found by summing the contribution from each area, S_j,

$$PWL = 10 \log_{10} \sum_{j}^{n} \text{antilog} \frac{PWL_j}{10}$$

where PWL = total power radiated through the total area involved

PWL_j = power level associated with the j^{th} area element.

The requirement that S_j be everywhere normal to the direction of propagation suggests that the surface be a hemisphere centered at the source (assumed to be at the exhaust orifice) since this tends to satisfy the normality condition. The assumed symmetry of the noise field about the longitudinal axis implies that a convenient selection of areas be circular segments subtended by an angle $\Delta \theta_j$, at a mean angle θ_j from the axis of symmetry. The direction of propagation S_j may be assumed normal to such an area and the SPL approximately constant over the area if the radius of the hemisphere is suitably chosen (see below). Thus it is only necessary to measure the SPL_j at a number of angles θ_j at the engine axis height above the ground over a semi-circle which terminates at the axis of symmetry. Then

$$S_j = \pi r^2 \sin \theta_j \, \Delta \theta_j$$

where r = radius of the hemisphere in feet

θ_j = the angle associated with the area element S_j

$\Delta \theta_j$ = the incremental angle extending from a point half-way between θ_j and θ_{j-1} to half-way between θ_j and θ_{j+1}.

The total PWL may be found by appropriately summing the PWL_j's.

It has been shown that if measurements are made near the ground plane in the field of a point source above that plane, a region of maxima and minima is traversed as the radius is increased. Beyond a distance of about $4\ h^2/\lambda$ where h is the height of the source and the receiver above the ground plane, and λ is the wavelength at the mid-frequency of the octave band in question, the sound pressure decreases inversely with distance. For the highest octave band (4.8 - 10 kc) the region of maxima and minima extends to about 300 ft for source and receiver about 3.5 ft off the ground.

Thus, it is seen that even under the idealized assumptions outlined at the beginning of this section, a large r is required for accurate measurements of PWL.

Now, consideration must be given to the fact that the actual source under consideration is of finite size. This has two effects on our results. First, to be in the far radiation field of a finite source (which is essential to measure radiated power) in free space requires that the measuring point be $2\ a^2/\lambda$ or 2a, whichever is greater, away from the source (a is a characteristic dimension of the source). If the source is located above a plane, the measuring points must be even farther away because of interference from the image source. This restriction is difficult to evaluate since the value of a cannot be well defined for a jet.

Similarly, the location of the source is not accurately determinable for a jet engine. Depending on the frequency of interest, the "location" is probably from 5 - 20 diameters downstream from the exhaust orifice. If r_1 is the distance downstream to the source, then in practice $r/r_1 > 2$ to avoid a significant error due to the fact that the waves are not normal to the surface of the hemisphere. Hence, if r_1 is 20 d, then r should be $>$ 40 d.

Finally, consideration must be given to the condition of the atmosphere in which propagation occurs. In general, the atmosphere is neither calm nor of uniform temperature. However, propagation studies indicate that 3,4/ for average wind velocities of less than 10 miles/hour and for a normal range of temperature gradients, the effects of refraction should be negligible within 200' of a source. Effects of ground and air absorption are also negligible out to 200 ft.

In summary, the following restrictions on open field measurements on jet aircraft have been outlined:

1. Due to interference of the image source the measuring point should be 4 h^2/λ ft from the source.

2. Due to the finite size of the source a) the measuring point should be 2 a^2/λ or 2a away from the source, b) the radius of the hemisphere should be greater than 40 d.

3. Due to refraction and dissipation in the atmosphere, appropriate corrections should be applied to data taken at radii greater than 200 ft.

Although the above restrictions serve to delineate the restrictions on the measurement distance, it is often impossible to fulfill all conditions simultaneously. The magnitude of the attendant errors that might be involved by violation of such restrictions is not indicated. An empirical indication of the errors involved is given by measurements on jet engines performed at 50, 100 and 200 ft which have shown that computed PWL's in octave bands at each of these distances agree within about 2 to 3 db.

3. Measurements in Test Cells

Two methods are used in this report to calculate acoustic power during jet operation in test cells. These methods are referred to in this report as the "noise reduction" method and the "reverberant field" method. The method employed depends upon the geometry of the test facility. Of particular importance is the location of the engine relative to an eductor tube or to the exhaust chamber. If the engine is closely coupled to an eductor tube or a separate exhaust chamber, then only a small fraction of the acoustic power is radiated to the test section, and the noise reduction method becomes most applicable. In certain test facilities, usually those that were converted from propeller test cells; the exhaust chamber is usually integral with the test section and readily accessible for acoustic measurements. In these facilities, the reverberant field method is applicable.

A. "Reverberant Field" Method. If the geometry of a test cell is such that the exhaust region is not separated from the test cell proper, the sound field inside the test cell contains substantially the total sound power output. (Sometimes a lightweight barrier divides the cell to prevent recirculation, but usually such a barrier is ineffective in dividing the cell acoustically.) The sound pressure level in such an enclosure is neither completely independent of position, as in a diffuse sound field, or entirely dependent on position, as in the far free-radiation field. It is generally assumed that the direct and reverberant sound field in the enclosure add on an intensity basis. The sound power level radiated by the source is given by

$$PWL = SPL - 10 \log_{10} \left(\frac{Q}{4 \pi r^2} + \frac{4}{R} \right)$$

where PWL is the sound power level in db re 10^{-13} watt

SPL is the sound pressure level measured at $\underline{r}$ feet from the source, in db re 0.0002 μbar

Q is the directivity factor in the direction and at the distance which the sound pressure level is measured

$R = \frac{\alpha A}{1-\alpha}$, the room constant of the enclosure in square feet

A is the total surface area of the room, in square feet

α is the average statistical absorption coefficient of the surface of the room.

While the room constant R can be estimated readily from published tables of the absorption coefficients, a greater uncertainty is involved in estimating Q. The situation is somewhat circuitous since determination of Q requires the knowledge of the PWL and determination of PWL depends on Q.

Estimation of $\underline{r}$ is likewise difficult, since the acoustic center of the source is unknown. In practice the attempt is made to be far enough from the source so that the second term in the above equation is at least of the same order of magnitude or smaller than the first term for a reasonable range of values of Q and $\underline{r}$. However, at low frequencies the measuring point must be about λ/2 (or about 12 ft in the first octave band) from a wall to prevent interference effects from image sources.

Moreover, it is tacitly assumed that the engine will radiate the same acoustic power into the test cell, as it would radiate, similarly mounted, in an open field. In order for this to be even approximately true, the test cell walls should be one wavelength or more distant from the engine at the center of the lowest frequency band considered. To keep the spatial distribution of the sound pressure within the test cell from becoming too non-uniform at low frequencies, the test cell volume should be at least 20,000 cu ft which is greater than the volume of many of the older test cells. Thus, in most instances, the measured SPL's in test cells may be suspect in the first octave band.

Despite these limitations, useful determination of the total radiated power, and the power in all other octave bands, can be obtained using this method. It should be clear, however, that this method is less accurate than the open field method; moreover, a reliable measure of directivity can be made only in the open field.

B. "Noise Reduction" Method. The noise reduction method has already been reported 5/ and will only be described briefly here. As mentioned previously, it is applicable in cells where most of the acoustic power is radiated directly to the exhaust treatment.

In this method, measurements are made to determine the power flux from the exhaust opening during engine operation and independent measurements are made to determine the loss of power or noise reduction of the exhaust acoustical treatment. The acoustic power of the engine is then taken to be the sum of the power radiated through the exhaust opening of the cell and the loss or noise reduction of the exhaust treatment. A calculation of the power flowing into the intake treatment is also made, but in general the intake power level is 10 db below the exhaust power level and may be neglected.

The particulars of the "noise reduction" method are as follows. With the engine operating, SPL measurements are made outside the cell near the exhaust opening. By applying appropriate area and directivity corrections, the SPL at the exhaust plane can be determined.

The noise reduction of the exhaust acoustical treatment is found by taking the difference of SPL's measured at both ends of the acoustical treatment during detonation of an explosive noise source 6/. The noise reduction so determined must be corrected for the increase in temperature during engine operation. The corrected noise reduction is added to the SPL at the exhaust plane to obtain the SPL at the entrance to the exhaust acoustical treatment during engine operation. The acoustic power flowing into the exhaust acoustical treatment is then expressed as 1/

$$PWL = SPL + 10 \log A$$

where A is the area in square feet of the entrance to the exhaust acoustical treatment.

Since the noise reduction of the treatment measured with the explosive noise source expresses the difference in SPL across the total length of treatment, the location of the noise source with respect to the treatment is important. As mentioned earlier, the noise source of a jet engine is probably distributed over a distance of 5 to 20 diameters downstream of the jet. Hence, it is important that the engine be at least this distance from the treatment. If the engine is near the acoustical treatment, then all or part of the noise source may be located within the treatment. Thus the noise will not propagate through the entire length of treatment. Obviously, under these conditions, an error will arise through use of the noise reduction obtained for the entire length. Fortunately, this problem does not arise often since most cells are designed with the engine 20-80 ft from the acoustical treatment.

Although the "noise reduction" method of determining the PWL of a turbojet engine from test cell measurements also involved some uncertainties, it is believed to be more reliable than the "reverberant field" method. Also, it is more generally applicable in present-day test cells where microphone access to the exhaust section of a test cell during engine operation is impractical.

SECTION III

COMMENTS ON ENGINE OPERATING VARIABLES

The following symbols are used in the presentation of the engine operating variables:

n - compressor revolution rate in revolution per minute

F - thrust in lbs

f - fuel weight flow in lbs/hr

d - diameter of the exhaust orifice in inches. When the engine is mounted in an aircraft, the diameter of the exhaust orifice may not be identical to the diameter of the exhaust of the engine.

T_e - measured temperature of the jet stream in degrees Rankine (absolute Fahrenheit). The value of T_e generally lies between the static temperature of the jet stream and the total temperature of the jet stream depending upon the recovery factor of the thermocouple used to measure T_e.

T_i - compressor inlet static temperature in degrees Fahrenheit

m - total weight flow of gases through the jet exhaust in lbs/sec

M_j - external Mach number of the jet. It is dimensionless and is defined by the equation

$M_j = \frac{v_j}{c_o}$ where v_j is the velocity of the jet and

c_o is the speed of sound in the gas surrounding the jet.

Inasmuch as engine operating conditions vary with atmospheric conditions, it is common practice for engine manufacturers to present data that are "corrected" to pressures and temperatures of 59°F and 29.92" Hg (the NACA Standard Atmosphere at sea level). No data in this report have been corrected to the NACA Standard Atmosphere at sea level.

There are three main sources of information from which the engine operating variables were obtained. The sources described below offer data of varying degrees of reliability, confidence, or accuracy.

When the acoustic measurements are made in fully instrumented test cells, the engine operating variables may be obtained from engine log sheets which are written when the measurements are made. In general, these log sheets provide the most reliable information on the engine operating variables.

When the engine is mounted in an aircraft on an open field, usually only n and T_e are available from the cockpit instruments. However, performance curves may be available from engine manufacturers which give mass flow, turbine outlet temperature, specific fuel consumption and thrust as a function of compressor revolution rate. These data are less reliable than the engine log sheet data for three reasons. First, these curves describe the average characteristics of a given type of engine, but a particular engine of a type may vary from the average. Second, when an engine is mounted in an airframe its performance characteristics may change. For example, in some aircraft a thrust loss of 10% is common. The performance characteristics, however, describe the behavior of the unmounted engine. In some cases the performance curves for an engine mounted in a given aircraft are available, but this is the exception rather than the rule. Third, the performance curves may be applicable only at the NACA Standard Sea Level Atmosphere.

The third and probably least reliable source of information is nominal specifications which are published in technical books or literature. These data are usually published for one compressor revolution rate (usually maximum). Nominal values of fuel consumption, thrust, total weight flow and turbine outlet temperature can usually be found this way.

SECTION IV

PRESENTATION OF DATA

The data are presented in "test groups" which list the available data on a particular engine of a given type and model. If measurements were made on two or more engines of the same type and model, the test group is divided into Sections a, b, and c, etc. In the interest of simplicity, continuity and easy reference, each individual measurement (i.e., each different operating condition for which acoustical measurements were made) is given a separate test number.

In addition to listing the total acoustic power radiated, the overall PWL, and the PWL in octave bands of frequency for each test, the acoustical measurement technique and the method of computing PWL from measured SPL's are explained. In the case of open field measurements, plots of the angular distribution of SPL are presented immediately following the test group. For $0^\circ < \theta < 90^\circ$ the abscissa in these plots is proportional to the sine of the angle θ, measured from the intake of the engine. From 90° to 180° the abscissa is the mirror image of that from 0° to 90°. When the directivity pattern is plotted in this fashion, equal increments in the abscissa represent equal areas on the hypothetical hemisphere surrounding the source. This method of plotting weights the SPL at all angles in a manner that facilitates a comparison between various directivity curves on a power basis.

All available engine operating variables are listed for each test and the source of these variables is given. For each test group the source of the data, the date and location of the test, and the placement of the engine are given.

SECTION V

INDEX TO DATA

Engine	Test Group	Measurement Location	Test Numbers
I40	1	Open Field	01
J33-A-10	2	Open Field	02
J33-A-33	3	Test Cell	03 - 07
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Rolls Royce Conway	21	Open Field	95
Rolls Royce Derwent	22	Open Field	96 - 98
Rolls Royce Nene	23	Open Field	99

I40

Test Group I

History and Description of Tests

Source of Data: W. Wathen-Dunn "Audible P-80 Jet Aircraft Noise," Naval Research Laboratory Report S-3266, 26 March 1948

Date of Tests: 17-31 June 1947

Location of Tests: NATC Patuxent River, Maryland

Placement of Engine: In P-80 aircraft on an open field.

Engine Operating Variables

The NRL report states only that the engine was at "full throttle." The engine operating conditions were estimated from nominal specification data.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
01	11,500	4000	4760	19	1660	80	-	-

I40

TEST GROUP 1

Acoustic Measurement Techniques and

Method of Obtaining PWL

The microphone was located 58" above ground. Measurements were taken at angular separations of 22-1/2° and 45° at distances ranging from 15-150' from the exhaust.

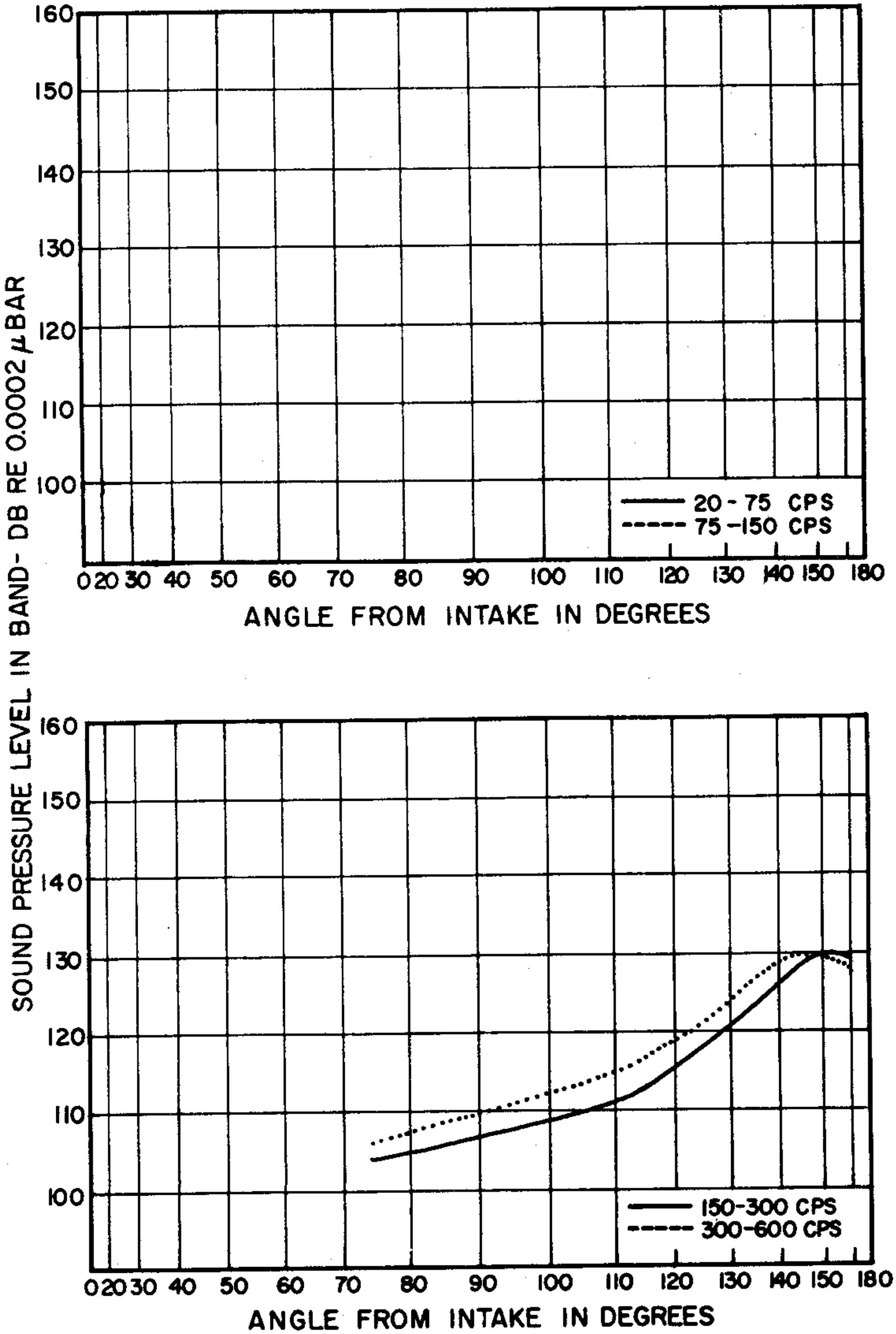
The SPL data at various distances were normalized to a distance of 50' but insufficient data and uncertainties in the normalization procedure limit the reliability of these SPL's.

Data were not taken below 100 cps. Reported narrow (50 cps) band data have been converted to octave bands.

Wind speed ranged from 0-15 miles per hour. Relative directions of wind unknown. The P-80 aircraft was located on a concrete runway.

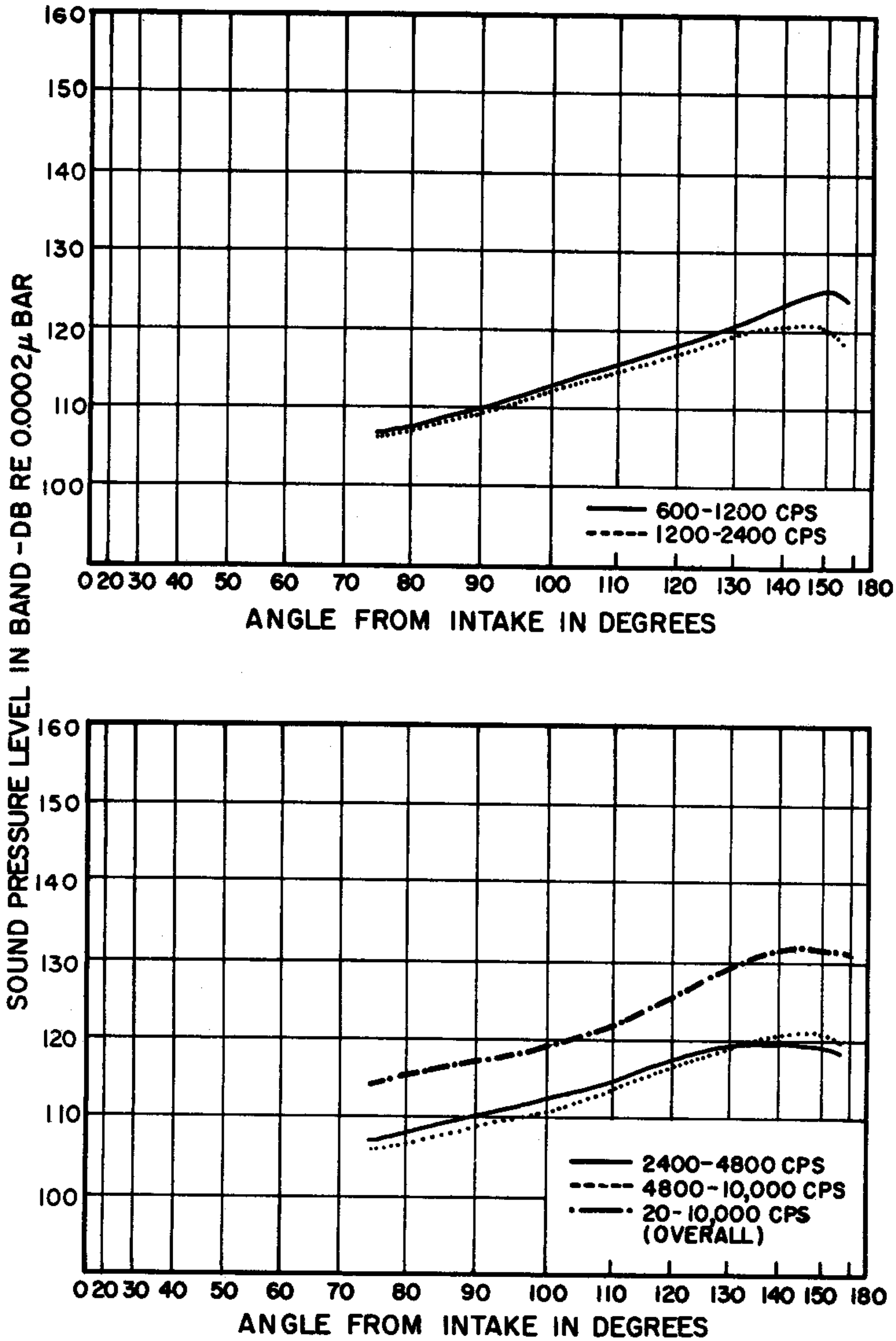
Power Levels and Total Acoustic Power

Test No.	Total Power	PWL in db re 10^{-13} watt								
	watts	overall	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
01	8000	169	-	-	163	164	160	157	156	158



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
01	I-40	50′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
01	I-40	50′

J33-A-10

TEST GROUP 2

History and Description of Tests

Source of Data: BBN Report No. 282, "Free-Field Measurements on Carrier Based Jet Aircraft" (Contract No. NObs 61592)

Date of Tests: 20-21 May 1953

Location of Tests: NATC Patuxent River, Maryland

Placement of Engine: In AJ-2 aircraft on an open field

Engine Operating Variables

At the time of the acoustic measurements n and T_e were obtained from the cockpit instruments. Other data were obtained from the manufacturer's engine specifications combined with the practical knowledge of NATC personnel. NATC personnel indicated the values of quantities which would obtain in this aircraft.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_1	m	M_j
02	11,750	4600	3650	19	1750	70	87	-

J33-A-10

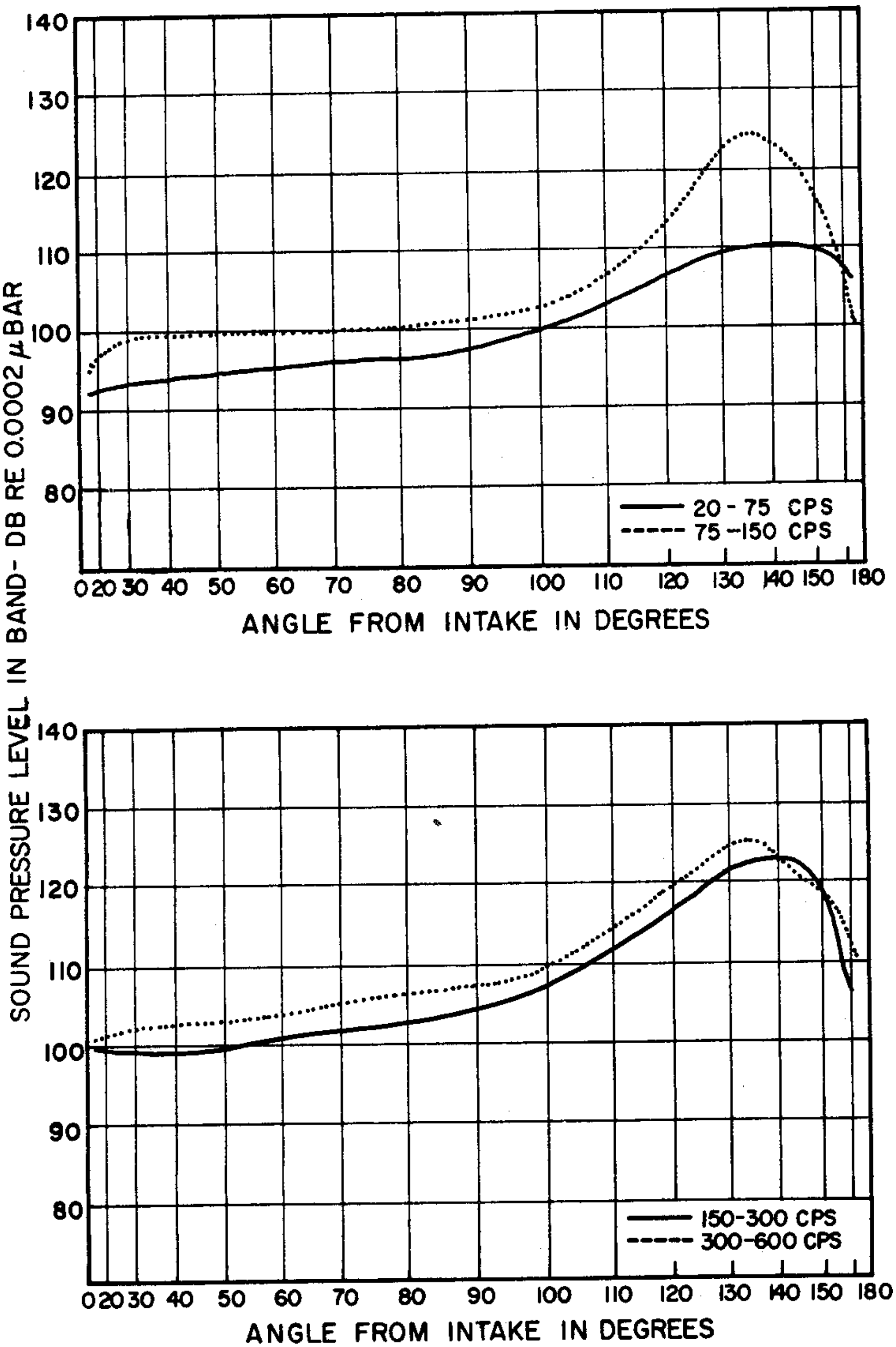
TEST GROUP 2

Acoustic Measurement Techniques and Method of Obtaining PWL

A continuous traverse with the microphone was made on a semi-circle of 100' radius centered at the exhaust orifice of the airplane. Data were recorded on magnetic tape and reduced in octave bands. Windscreens were used. The microphone was approximately 5' above ground.

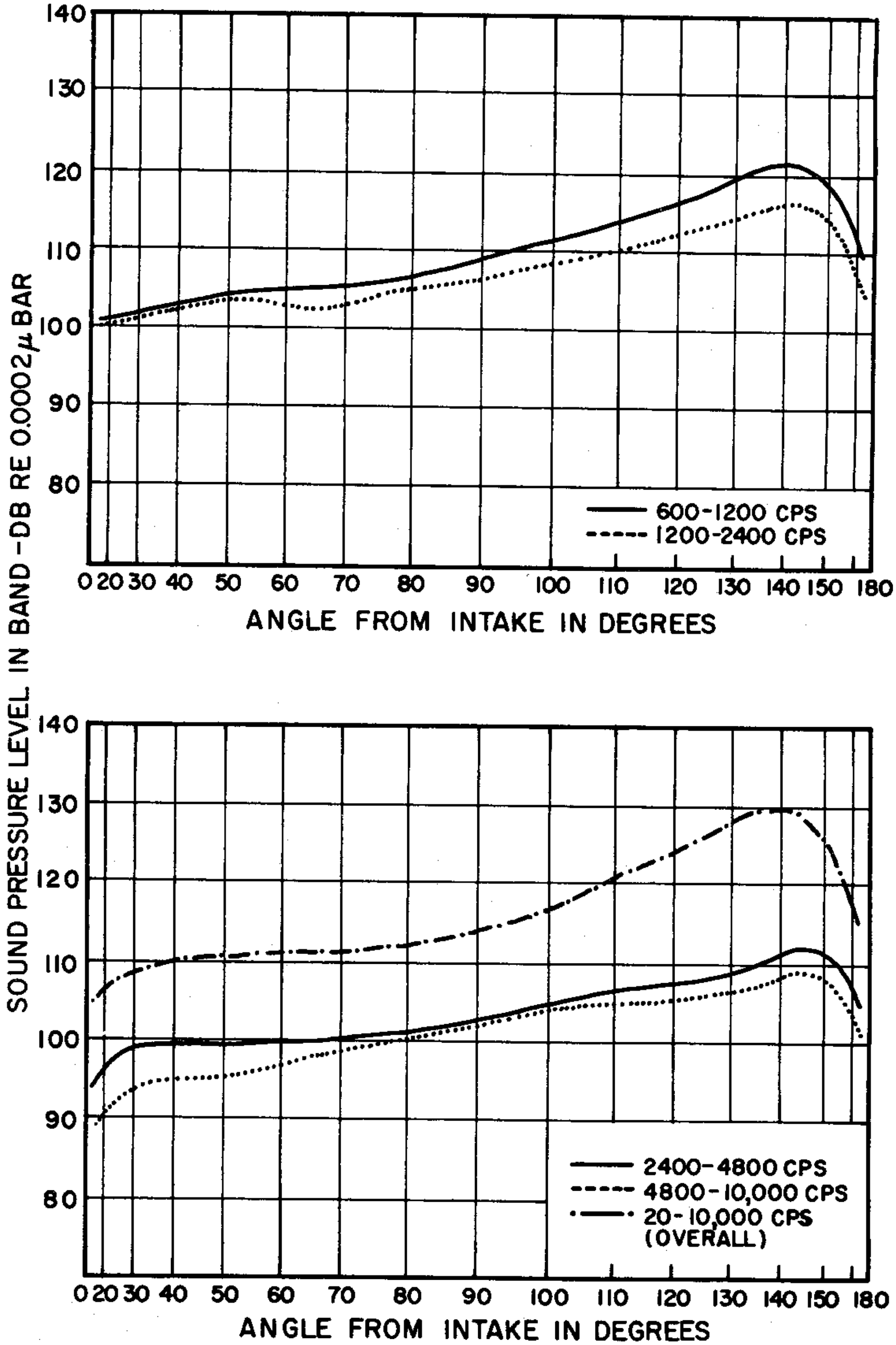
Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt overall	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
02	10,000	170	152	163	164	165	162	158	154	151



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
02	J-33-A-10	100′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
02	J-33-A-10	100′

J33-A-33

TEST GROUP 3

History and Description of Tests

Source of Data: Measurements by BBN under USAF Contract No. AF 33(038)-20572

Date of Tests: 31 May-4 June 1951

Location of Tests: Tinker AFB, Oklahoma City, Oklahoma

Placement of Engine: Mounted on thrust stand in Test Cell 2-214

Engine Operating Variables

All engine data were obtained from log sheets written at the time of the acoustic measurements. The spread in T_e represents the range of values at 7 temperature measuring positions. Thrust values were obtained by subtracting the tare of 180 lbs from the measured value.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
03	3750	235	865	19.1	1440 ± 40	82	-	-
04	7500	1100	1730	19.1	1310 ± 40	82	-	-
05	10,124	2640	2970	19.1	1410 ± 10	82	-	-
06	11,249	3800	4170	19.1	1590 ± 10	82	-	-
07	11,757	4420	4910	19.1	1710 ± 20	82	-	-

J33-A-33

TEST GROUP 3

Acoustic Measurement Techniques and Method of Obtaining PWL

Several microphones were distributed through the test section of the cell. Octave band analysis from 20-10,000 cps was made at the time of the measurements. Power level was calculated by the "reverberant field" method.

Power Levels and Total Acoustic Power

Test No.	Total Power	PWL in db re 10^{-13} watt								
	watts	overall	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
03	16	142	135	129	132	132	136	131	129	121
04	250	154	140	149	141	144	145	143	140	143
05	800	159	147	152	150	152	152	149	147	148
06	2500	164	151	157	155	159	156	153	150	150
07	6300	168	153	158	162	163	159	156	152	152

J33-A-35

TEST GROUP 4

History and Description of Tests

Source of Data: Measurements by BBN under USAF Contract No. AF 33(038)-20572

Date of Tests: 18-22 July 1951

Location of Tests: Olmstead AFB, Middletown, Pa.

Placement of Engine: Test Cell 24

Engine Operating Variables

All data were obtained from engine log sheets at the time of the measurements. Since tare of 210 lbs was subtracted from the gross thrust, the net thrust for low operating conditions may be unreliable. Tests 08-17 were made at a different time of day than measurements in Tests 18-27. However, both sets of measurements were made with the same engine in the same test cell and hence, the comparison of the two sets of data affords a measure of the reproducibility of the data.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
08	3,000	140	500	19.1	1520	75	-	-
09	4,000	240	1000	19.1	1480	75	-	-
10	5,000	400	1230	19.1	1430	75	-	-
11	6,000	600	1480	19.1	1400	75	-	-
12	7,000	870	1750	19.1	1380	75	-	-
13	8,000	1260	2030	19.1	1330	75	-	-
14	9,000	1740	2430	19.1	1350	75	-	-
15	10,000	2420	2980	19.1	1390	75	-	-
16	11,000	3330	3850	19.1	1490	75	-	-

J33-A-35

TEST GROUP 4

Acoustic Measurement Techniques and

Method of Obtaining PWL

Several microphones were distributed through the test section of the cell. Octave band analysis from 20-10,000 cps was made at the time of the measurements. Power level was obtained by the "reverberant Field" method. Certain irregularities and inconsistencies in the measurements limit the 5th band in test 09 to ± 5 db.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
08	3.2	135	128	122	127	125	130	123	124	114
09	10	140	129	129	130	129	136	129	127	132
10	20	143	134	137	132	133	134	136	133	127
11	40	146	134	139	134	137	138	137	136	133
12	63	148	135	141	137	139	140	139	138	137
13	130	151	136	143	139	141	144	141	141	143
14	200	153	137	144	143	144	147	143	144	146
15	400	156	139	146	146	147	149	146	145	148
16	1600	162	142	149	156	156	152	149	148	151

J33-A-35

TEST GROUP 4 (Continued)

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_1	m	M_j
17	11,756	4220	4880	19.1	1640	75	-	-
18	3,000	150	500	19.1	1500	70	-	-
19	4,000	270	.975	19.1	1470	70	-	-
20	5,000	430	1240	19.1	1410	70	-	-
21	6,000	640	1500	19.1	1380	70	-	-
22	7,000	900	1750	19.1	1360	70	-	-
23	8,000	1300	2010	19.1	1310	70	-	-
24	9,000	1820	2450	19.1	1330	70	-	-
25	10,000	2510	3030	19.1	1370	70	-	-
26	11,000	3440	3950	19.1	1480	70	-	-
27	11,756	4410	5080	19.1	1550	70	-	-

J33-A-35

TEST GROUP 4 (Continued)

POWER LEVELS AND TOTAL ACOUSTIC POWER

Test No.	Total Power watts	PWL in db re 10^{-13} watt over-all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
17	3200	165	143	150	158	162	155	151	150	152
18	2.5	134	127	128	127	123	124	122	119	113
19	6.3	138	130	132	129	127	128	128	125	119
20	13	141	133	136	133	132	133	135	131	126
21	50	147	133	139	134	136	137	143	134	132
22	63	148	135	142	136	139	140	142	137	136
23	130	151	135	143	139	142	143	141	139	143
24	200	153	138	145	143	145	146	143	143	145
25	400	156	140	146	147	148	148	146	144	147
26	1300	161	143	149	157	156	151	149	147	149
27	6300	168	144	150	160	166	155	152	149	151

J33-A-35

TEST GROUP 4a

History and Description of Tests

Source of Data: Measurements by BBN under USAF Contract No. AF 33(038)-20572

Date of Tests: 31 May - 4 June 1951

Location of Tests: Tinker AFB, Oklahoma City, Oklahoma

Placement of Engine: Mounted on thrust stand in Test Cell 3-215

Engine Operating Variables

All data were obtained from engine log sheets at the time of the measurements. Tare was unknown but was estimated to be 200 ± 100 lbs and was subtracted from the observed thrust. The spread in tailpipe temperature is represented in the range of values at seven measuring positions.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
28	3750	150 ± 100	890	19.1	1460 ± 40	66	-	-
29	7500	950 ± 100	1750	19.1	1330 ± 40	66	-	-
30	10124	2570 ± 100	3000	19.1	1390 ± 20	66	-	-
31	11249	3690 ± 100	4150	19.1	1520 ± 60	66	-	-
32	11757	4340 ± 100	5000	19.1	1690 ± 30	66	-	-

J33-A-35

TEST GROUP 4a

Acoustic Measurement Techniques and Method of Obtaining PWL

Several microphones were distributed through the test section of the cell. Octave band analysis from 20-10,000 cps was made at the time of the measurements. Power level was obtained by the "reverberant field" method.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over-all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
28	5	137	133	127	128	128	128	121	117	108
29	80	149	137	146	142	140	140	135	132	129
30	400	156	137	145	151	150	148	143	140	137
31	800	159	138	144	154	153	151	147	143	140
32	1000	160	138	145	154	156	153	149	145	142

J34-WE-24C

TEST GROUP 5

History and Description of Tests

Source of Data: BBN Report No. 56, "Revised Analysis of Noise Problem, Propulsion Sciences Laboratory," 7 April 1951

Date of Tests: February 1951

Location of Tests: Propulsion Sciences Laboratory, NACA, Cleveland, Ohio

Placement of Engine: In altitude tunnel facility SW-23

Engine Operating Variables

Engine data were obtained from NACA at time of measurements. Measurements were made in an altitude tunnel test facility. Ambient pressures were 8.92" Hg., 5.6" Hg, and 3.85" Hg in Tests Nos. 33, 34, and 35, respectively. The speed of the air past the engine was Mach 0.3 for all three measurements.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
33	-	-	652	14.8	1200	-	15.0	-
34	-	-	446	14.8	1190	-	10.5	-
35	-	-	362	14.8	1500	-	5.0	-

J34-WE-24C

TEST GROUP 5

Acoustic Measurement Techniques and Method of Obtaining PWL

Several probe microphones were distributed through the test section of the cell. Octave band analysis from 20-10,000 cps was made at the time of the measurements. Power levels were calculated by the "reverberant field" method. Measurements were not obtained in the last octave band. This should not affect the overall power level. In this case there is an uncertainty associated with the reduction of measured sound pressure levels to power levels because of some unknown geometrical-acoustical factors. The resulting total uncertainty is estimated to be ± 5 db.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
33	50	147	118	134	144	141	135	134	128	-
34	63	148	116	133	143	145	136	134	127	-
35	80	149	117	133	145	146	136	134	122	-

J34-WE-34

TEST GROUP 6

History and Description of Tests

Source of Data: BBN Report 282, "Free-Field Measurements on Carrier Based Jet Aircraft" (Contract No. NObs 61592)

Date of Tests: 20-21 May 1953

Location of Tests: NATC Patuxent River, Maryland

Placement of Engine: In F2H-3 on an open field

Engine Operating Variables

At the time of the acoustic measurements n and T_e were obtained from the cockpit instruments. Other data were obtained from the manufacturer's engine specifications combined with the practical knowledge of NATC personnel. NATC personnel indicated the values of quantities which would obtain this aircraft. A single engine was operating during these tests.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
36	12,500	3250	3450	14.8	1680	70	59	-

J34-WE-34

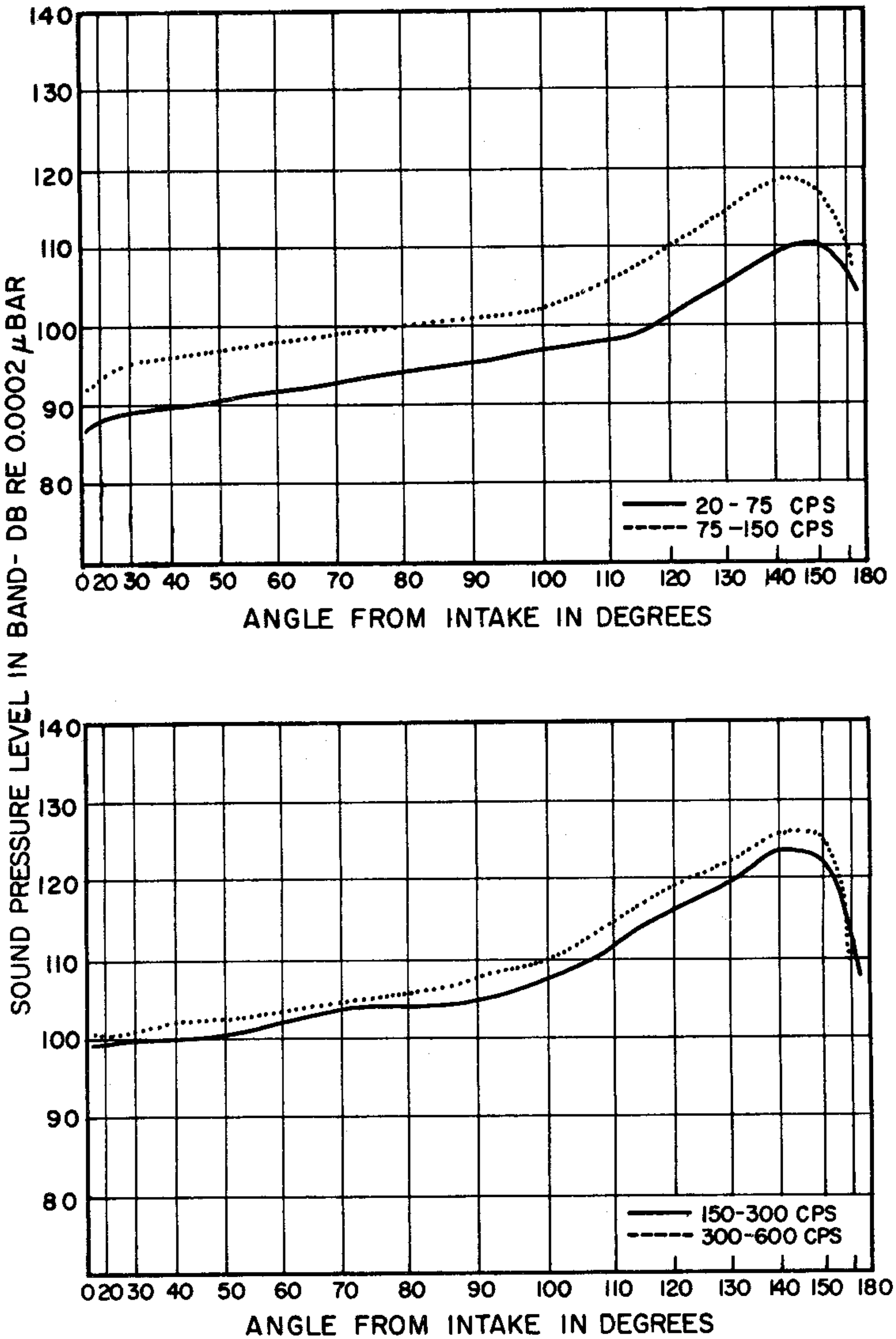
TEST GROUP 6

Acoustic Measurement Techniques and Method of Obtaining PWL

A continuous traverse with the microphone was made on a semicircle of 100' radius centered at the exhaust orifice of the airplane. Data were recorded on magnetic tape and reduced in octave bands. Windscreens were used. The microphone was approximately 5' above ground.

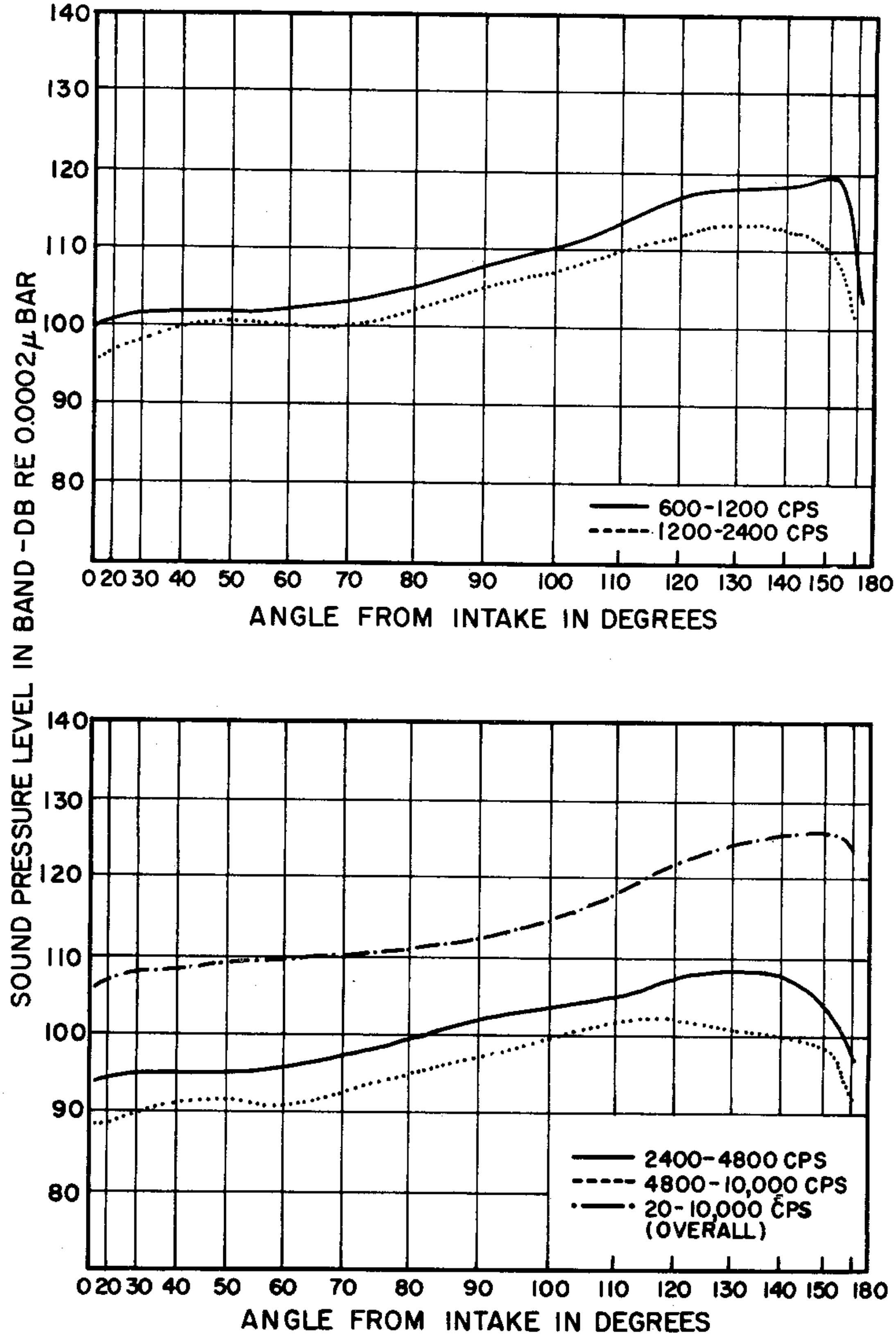
Power Levels and Total Acoustic Power

Test No.	Total Power	PWL in db re 10^{-13} watt								
	watts	over-all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
36	8000	168	149	158	162	165	160	155	151	146



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
36	J-34-WE-34	100′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
36	J-34-WE-34	100′

J34-WE-42

TEST GROUP 7

History and Description of Tests

Source of Data: BBN Report No. 282, "Free-Field Measurements on Carrier Based Jet Aircraft" (Contract No. NObs 61592)

Date of Tests: 20-21 May 1953

Location of Tests: NATC Patuxent River, Maryland

Placement of Engine: In F7U-1 aircraft on an open field

Engine Operating Variables

At the time of the acoustics measurements n and T_e were obtained from the cockpit instruments. Other data were obtained from the manufacturer's engine specifications combined with the practical knowledge of NATC personnel. NATC personnel indicated the values of quantities which would obtain in this aircraft. Only one engine in the aircraft was operated for this series of tests.

The afterburner was operating in Test 40; thrust is given to nearest 500 lbs.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
37	*	500	*	*	*	*	-	-
38	*	1000	*	*	*	*	-	-
39	*	3000	*	*	*	*	-	-
40	*	4500	*	*	*	*	-	-

* classified data

\- data not available

J34-WE-42

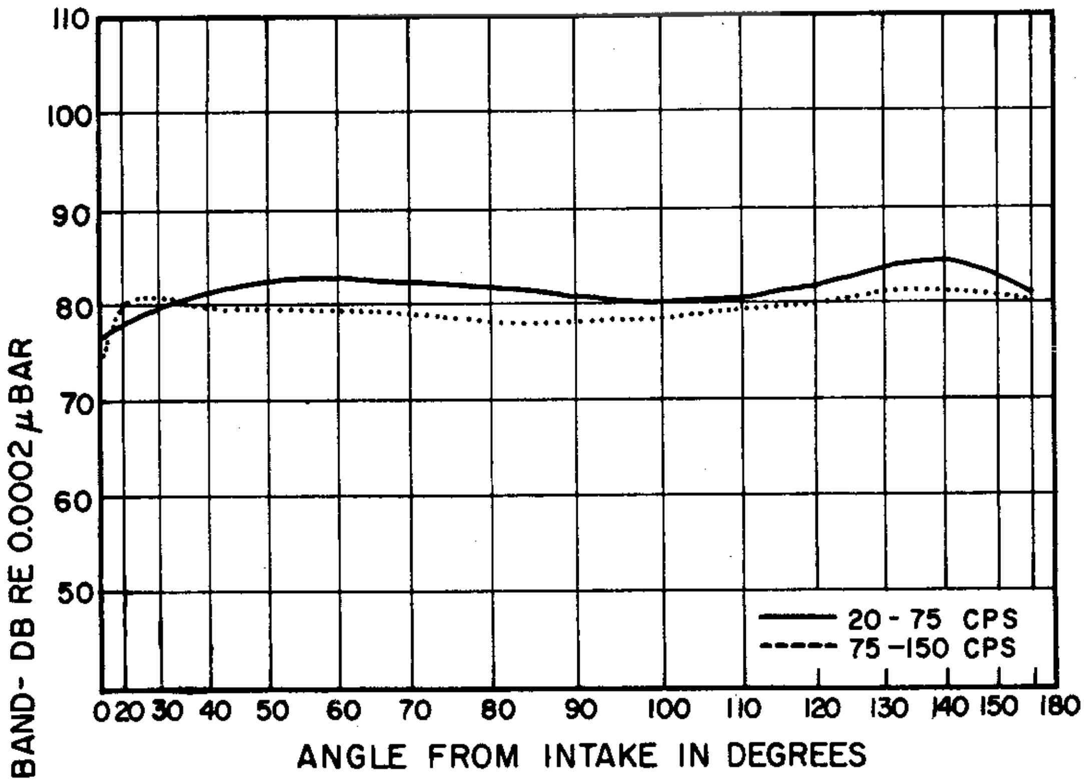
TEST GROUP 7

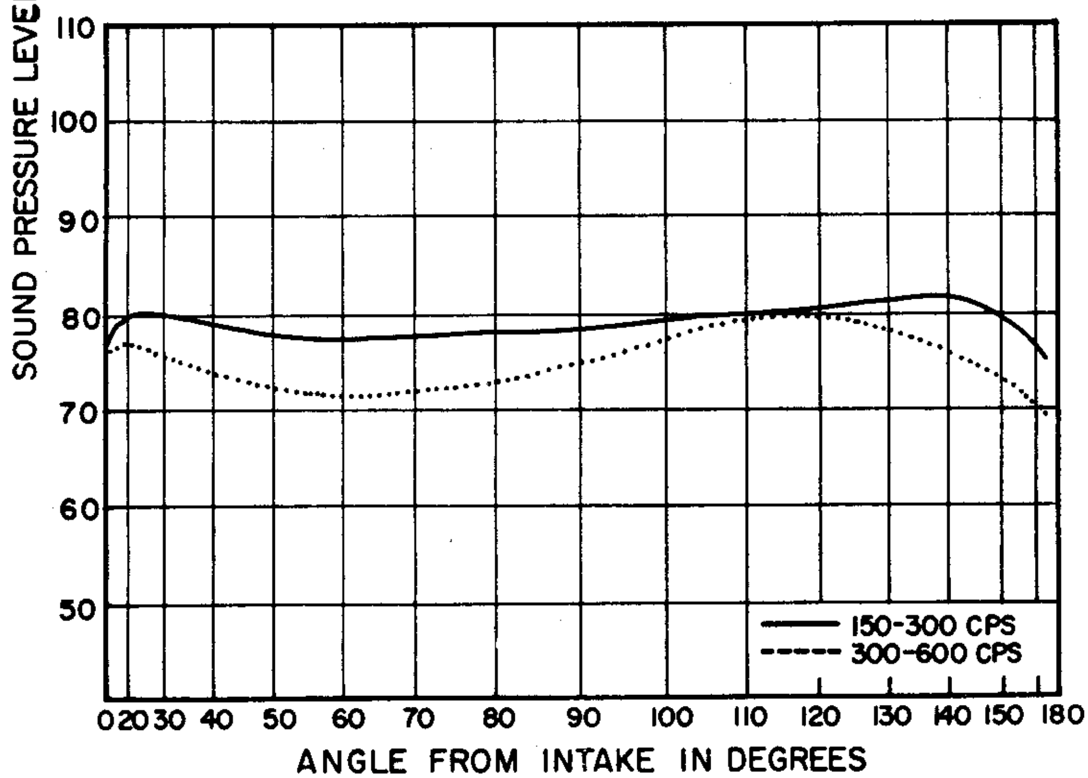
Acoustic Measurement Techniques and Method of Obtaining PWL

A continuous traverse with the microphone was made on a semi-circle of 100' radius centered at the exhaust orifice of the airplane. Data were recorded on magnetic tape and reduced in octave bands. Windscreens were used. The microphone was approximately 5' above ground.

Power Levels and Total Acoustic Power

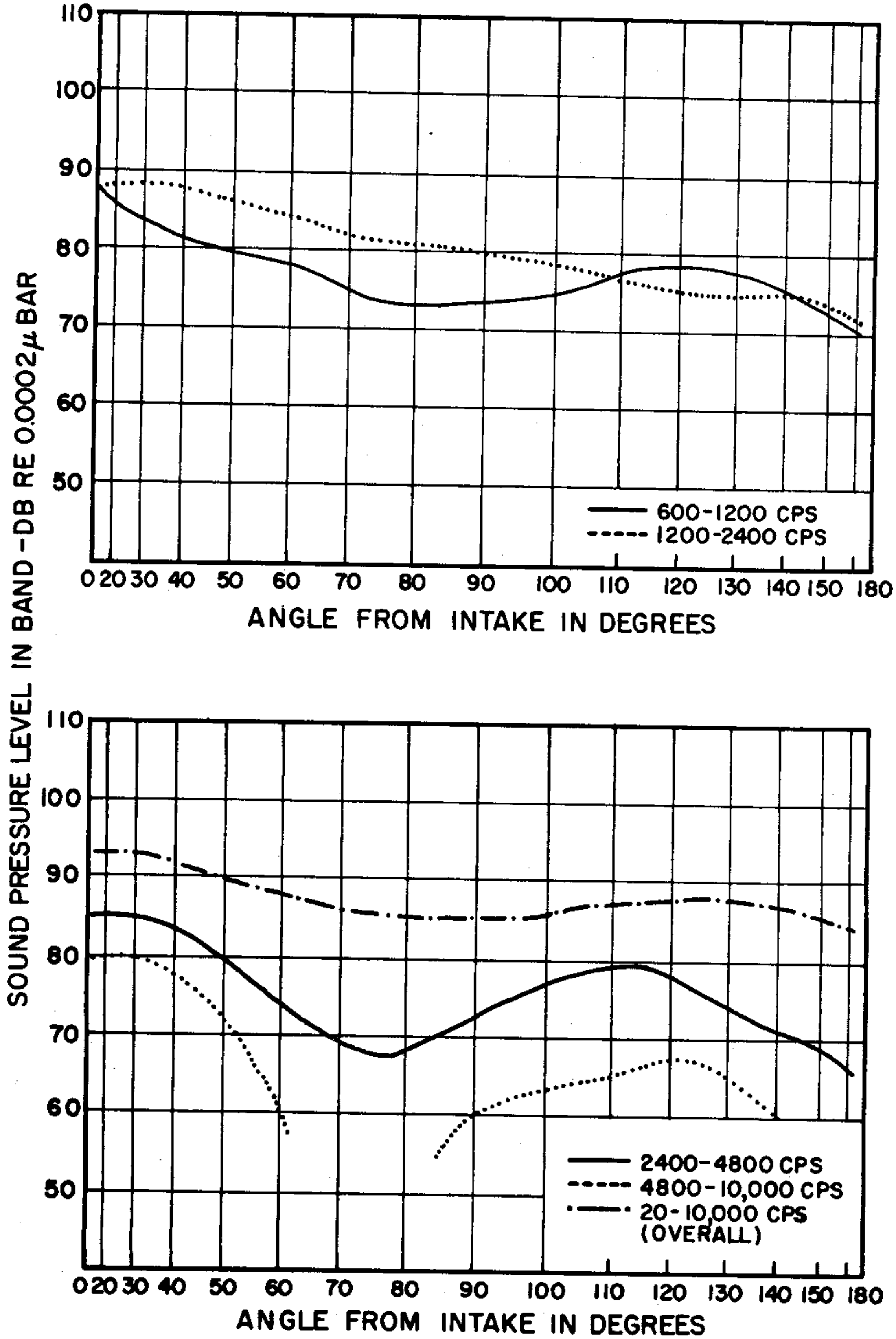
Test No.	Total Power watts	PWL in db re 10^{-13} watt over-all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
37	5	137	128	120	132	124	126	131	126	-
38	160	152	138	146	146	146	145	139	139	136
39	1600	162	142	148	154	155	156	154	147	140
40	5000	167	151	157	161	161	158	157	150	146





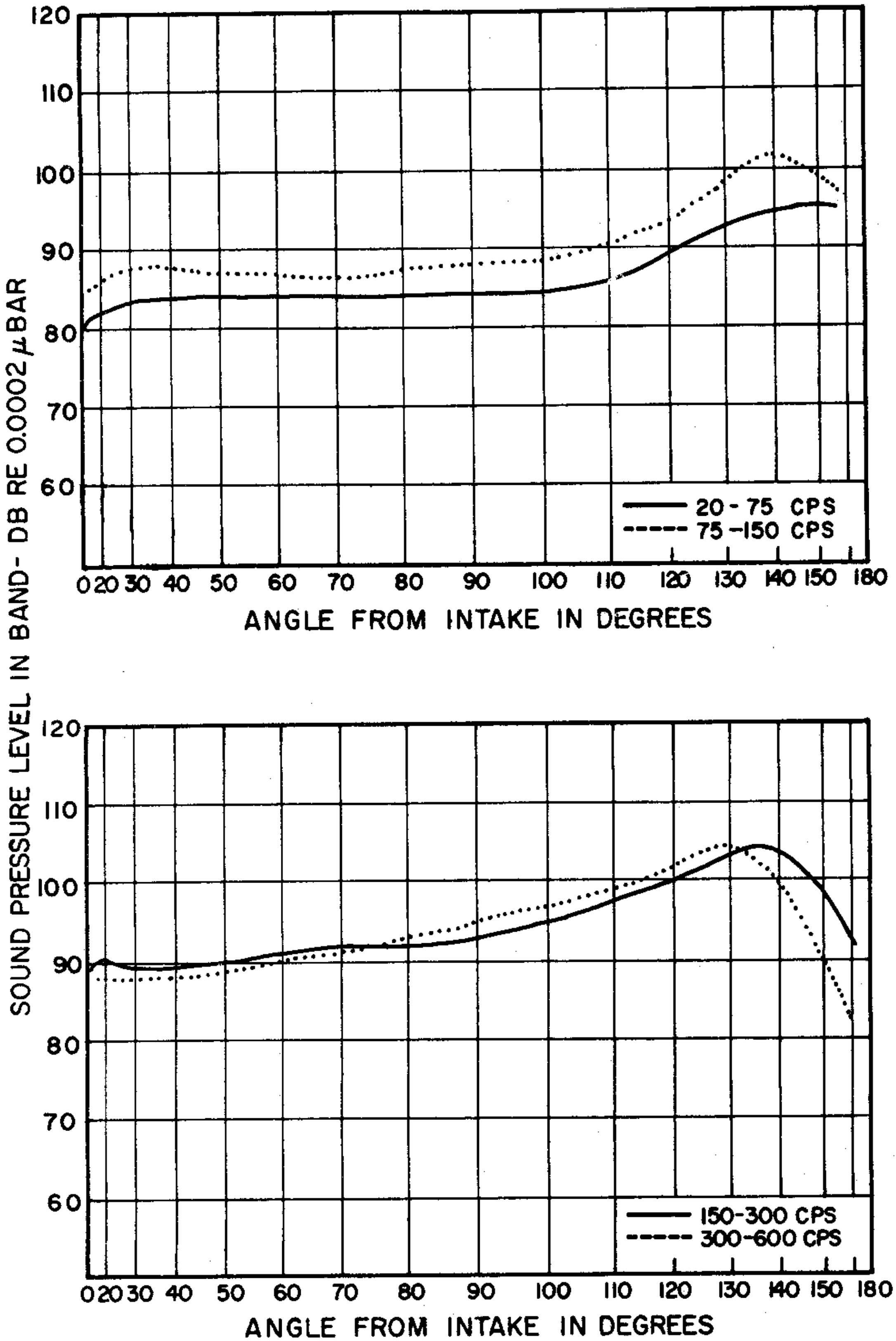
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
37	J-34-WE-42	100′



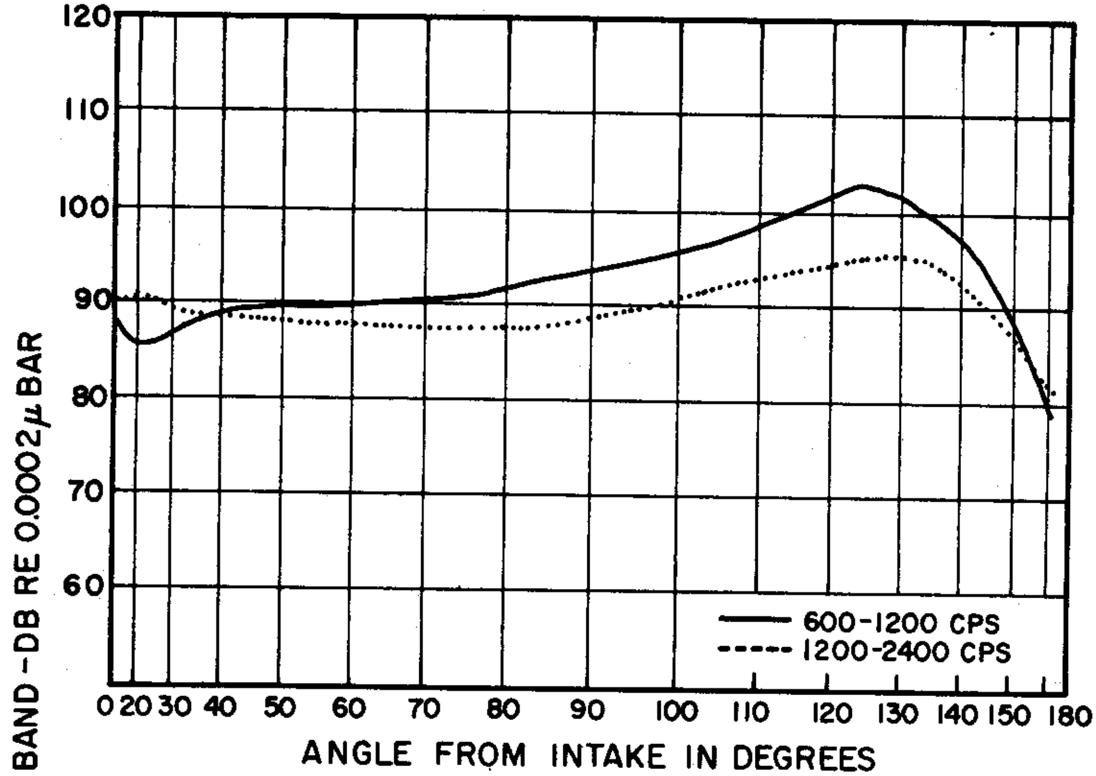
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

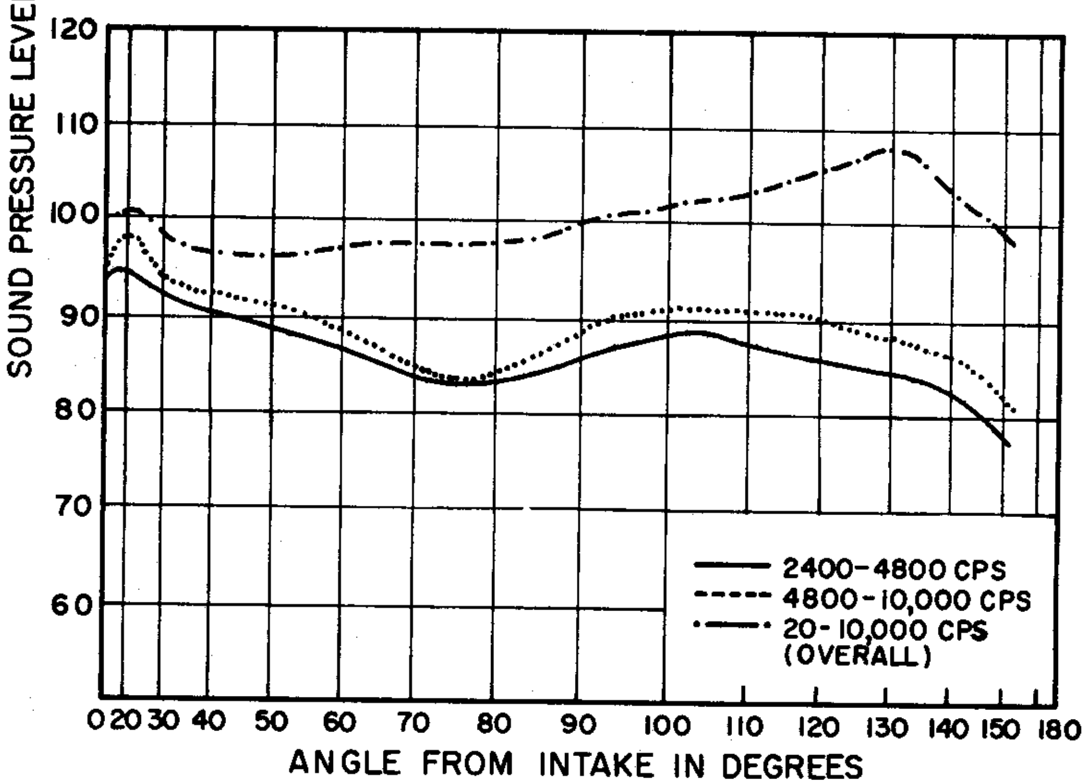
TEST NO.	ENGINE	DISTANCE
37	J-34-WE-42	100′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

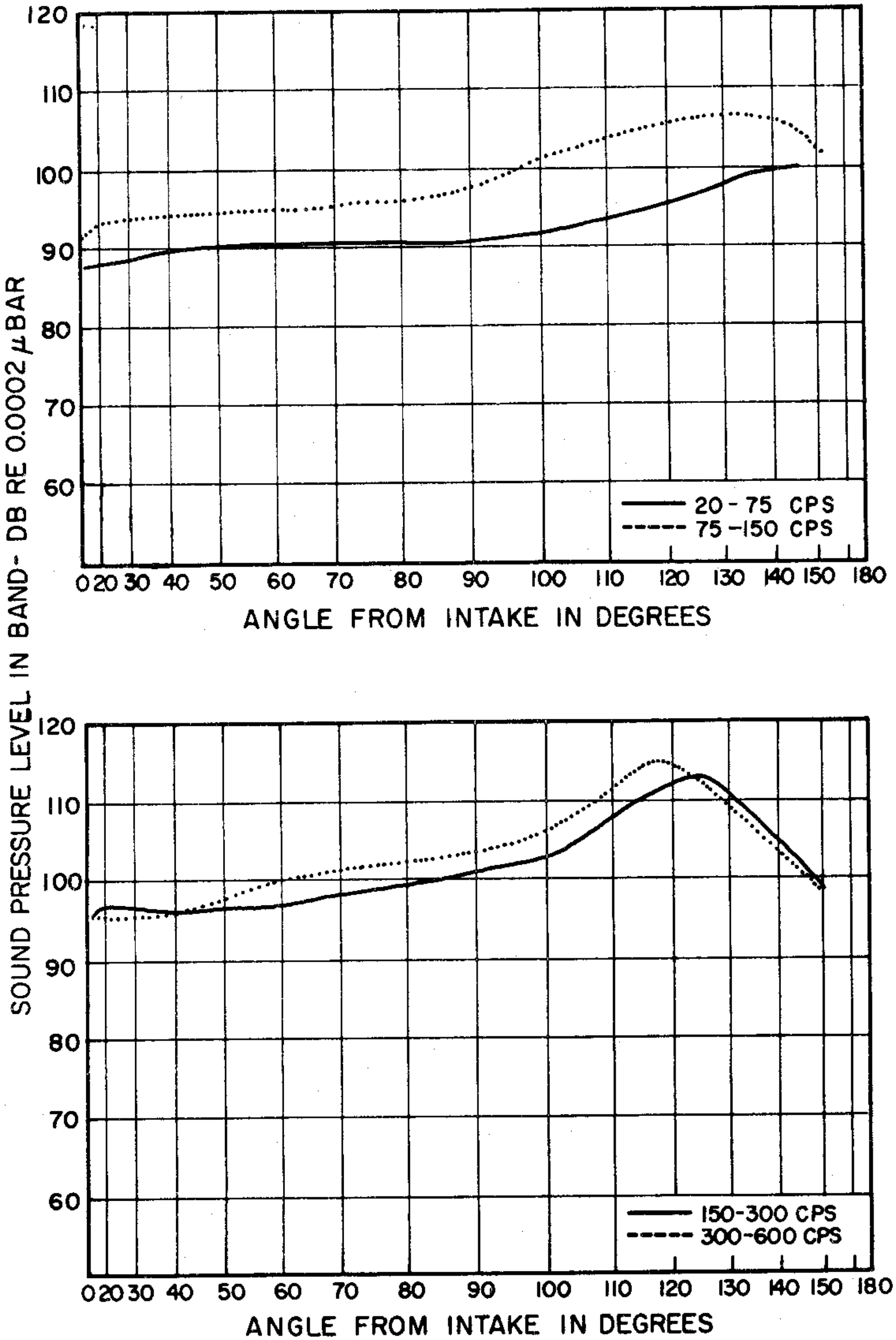
TEST NO.	ENGINE	DISTANCE
38	J-34-WE-42	100'





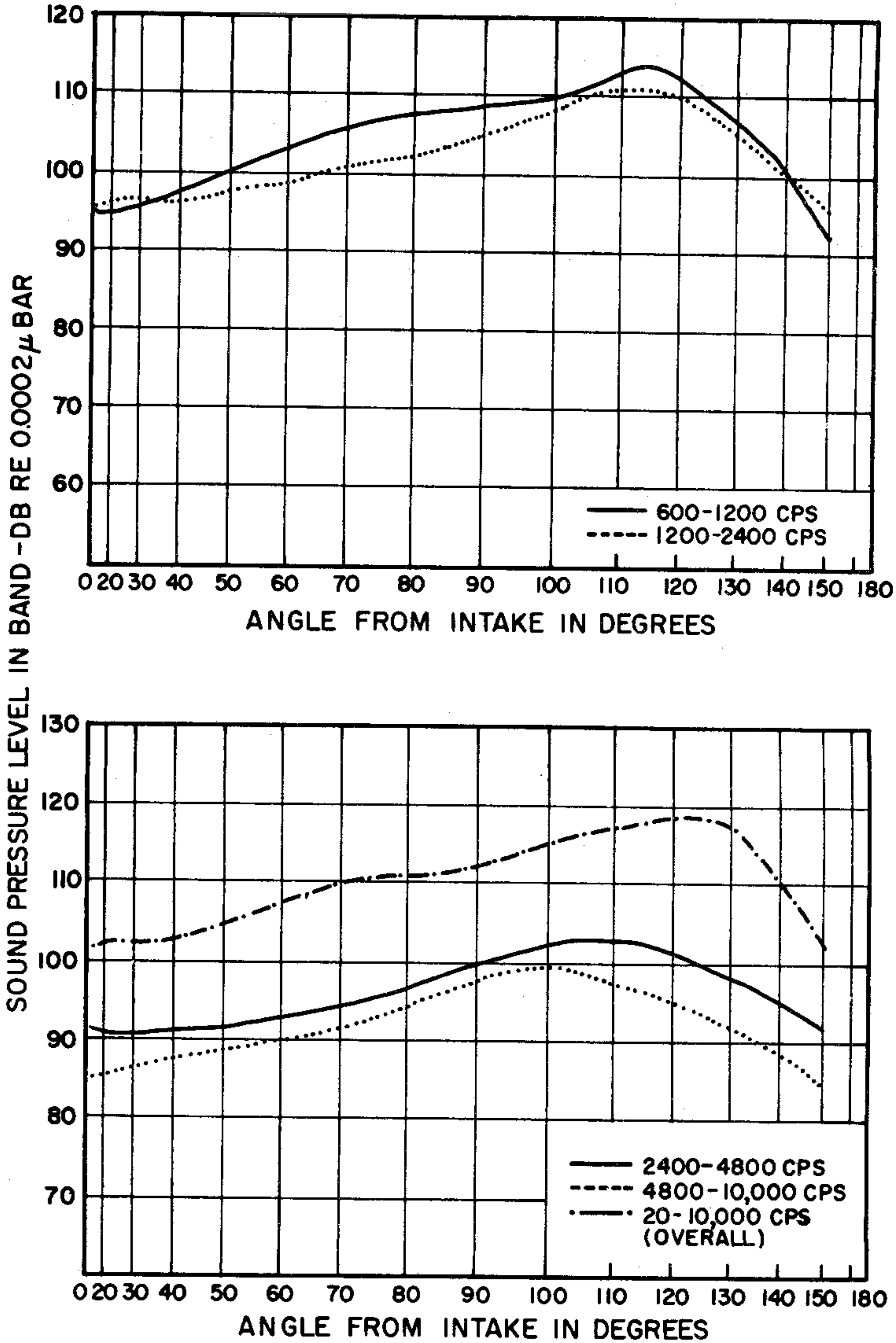
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
38	J-34-WE-42	100′



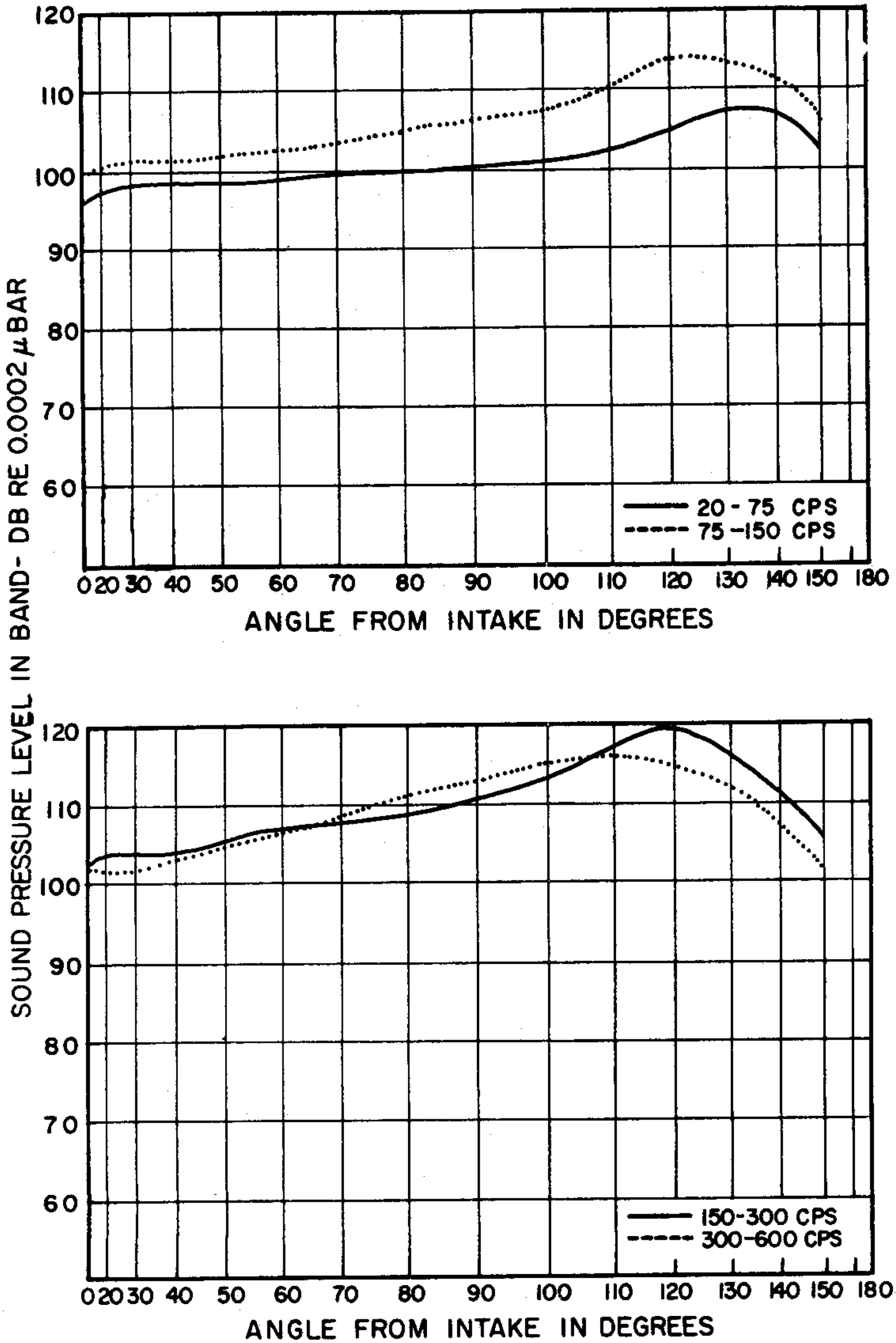
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
39	J-34-WE-42	100′



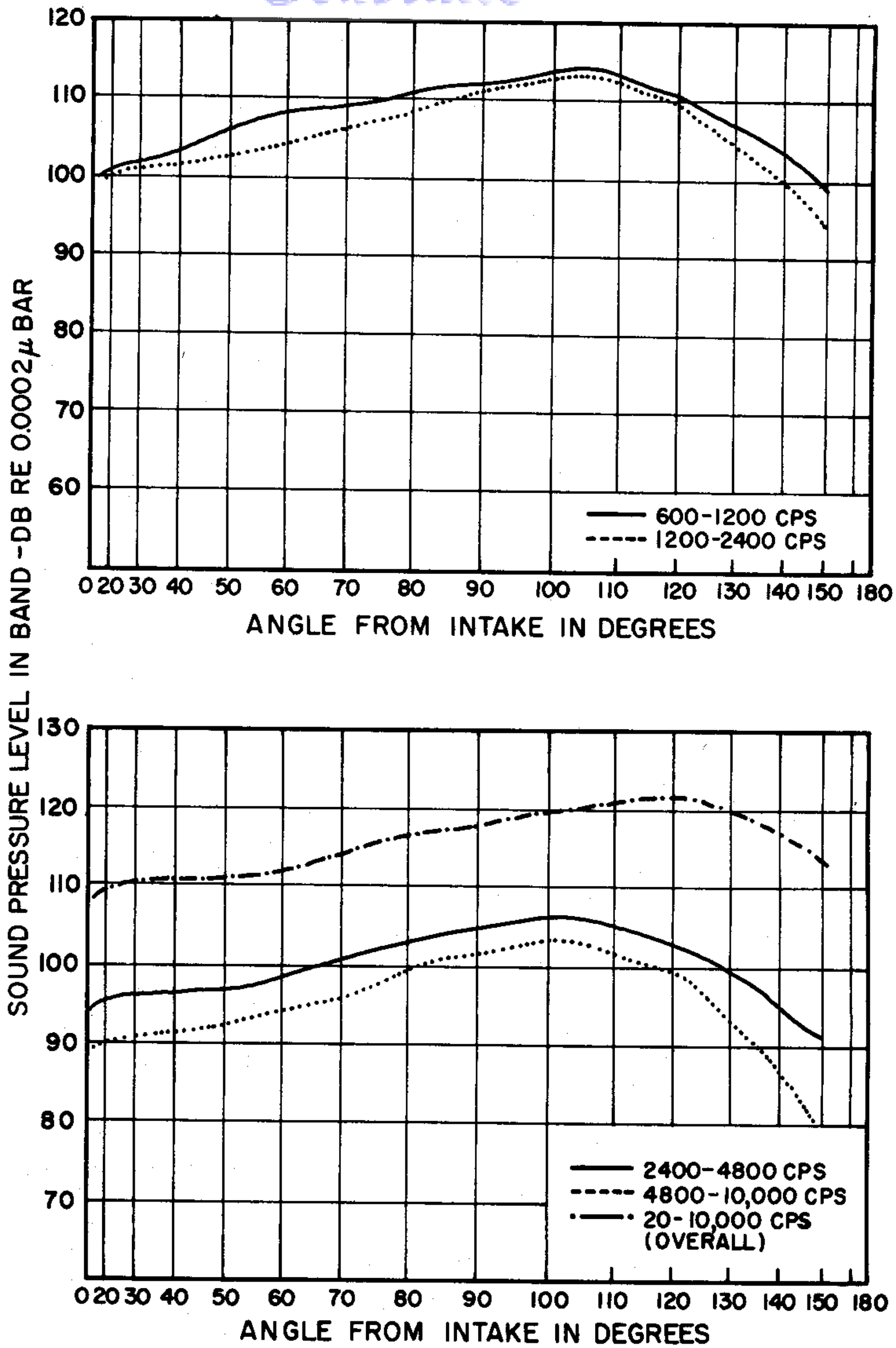
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
39	J-34-WE-42	100′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
40	J-34-WE-42	100′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
40	J-34-WE-42	100′

J34-WE-42

TEST GROUP 7a

History and Description of Tests

Source of Data: Unreported measurements by Bolt Beranek and Newman Inc.

Date of Tests: August 1953

Location of Tests: NATC Patuxent River, Maryland

Placement of Engine: In F7U-1 aircraft on an open field

Engine Operating Variables

At the time of the acoustic measurements n was obtained from the cockpit instruments. Other data were obtained from the manufacturer's engine specifications. T_e is static temperature. Both engines in the aircraft were operating. Thrust is given to nearest 500 lb.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
41	*	500	-	*	*	*	*	-
42	*	1000	-	*	*	*	*	-
43	*	1000	-	*	*	*	*	-
44	*	1500	-	*	*	*	*	-
45	*	2000	-	*	*	*	*	-
46	*	3000	-	*	*	*	*	-
47	*	3000	-	*	*	*	*	-

* classified data

\- data not available

J34-WE-42

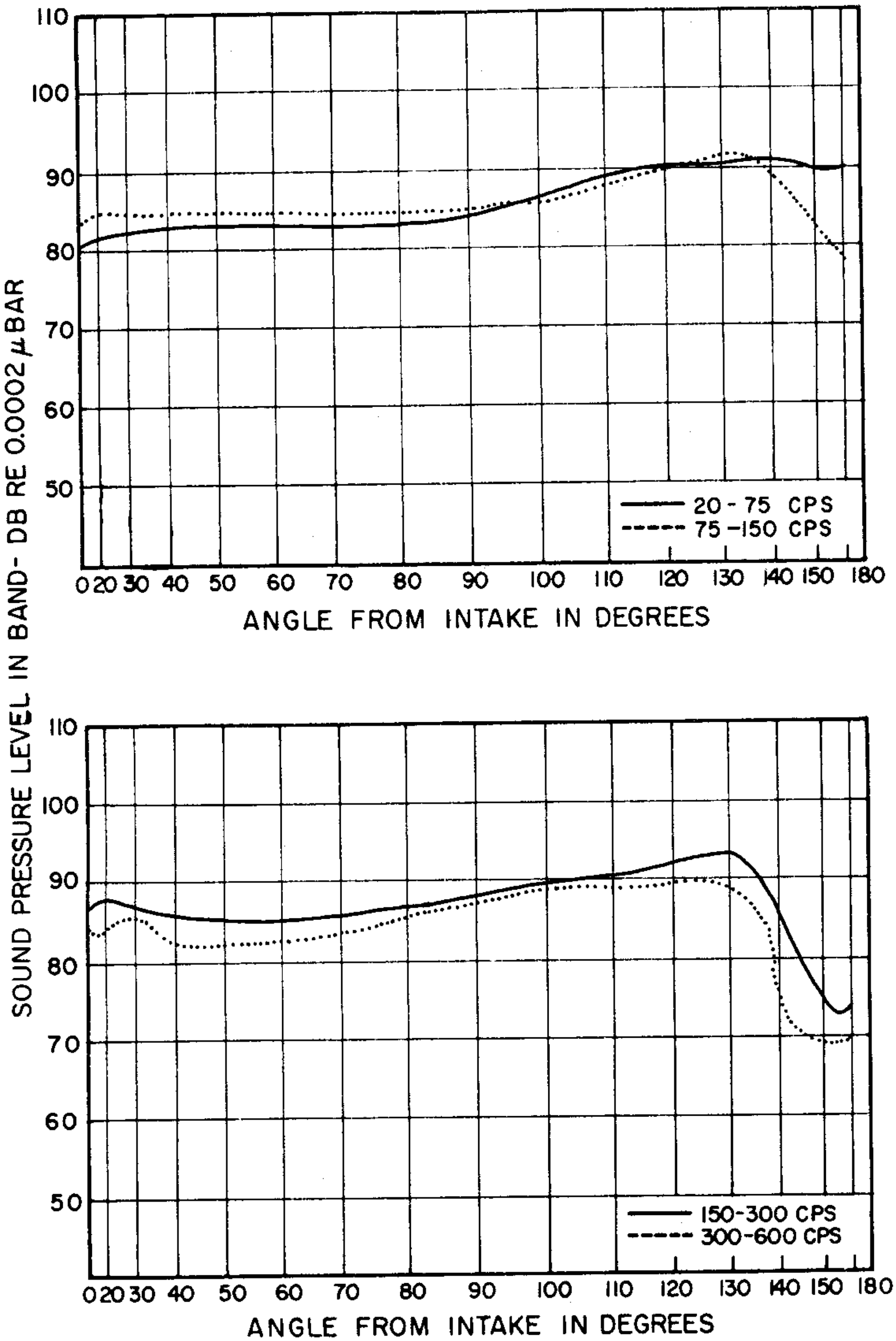
TEST GROUP 7a

Acoustic Measurement Techniques and Method of Obtaining PWL

All measurements except Test Nos. 47 were made by a continuous traverse on a semicircle of 100' radius. Data were recorded on magnetic tape and reduced in octave bands. Windscreens were used. The microphone location was approximately 5' above ground. Test No. 47 was made on a semi-circle of 50' radius.

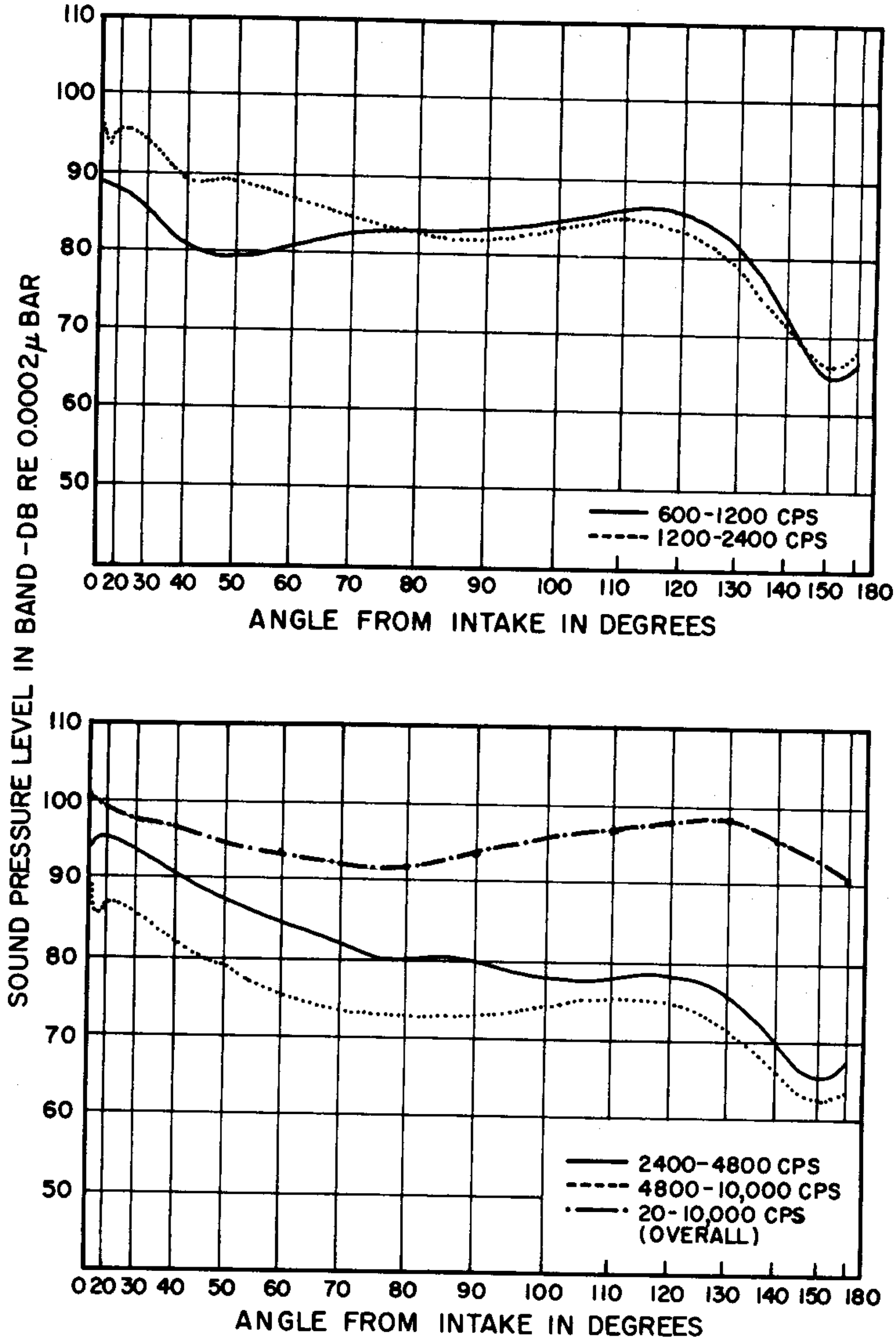
Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
41	-	143	135	135	136	134	131	135	135	127
42	-	146	136	138	141	138	136	135	134	130
43	-	148	137	140	143	141	138	137	136	131
44	-	152	134	141	150	146	143	139	137	132
45	-	153	138	144	148	148	145	143	138	131
46	-	158	138	146	153	153	151	148	144	139
47	-	161	140	147	156	157	153	151	147	141



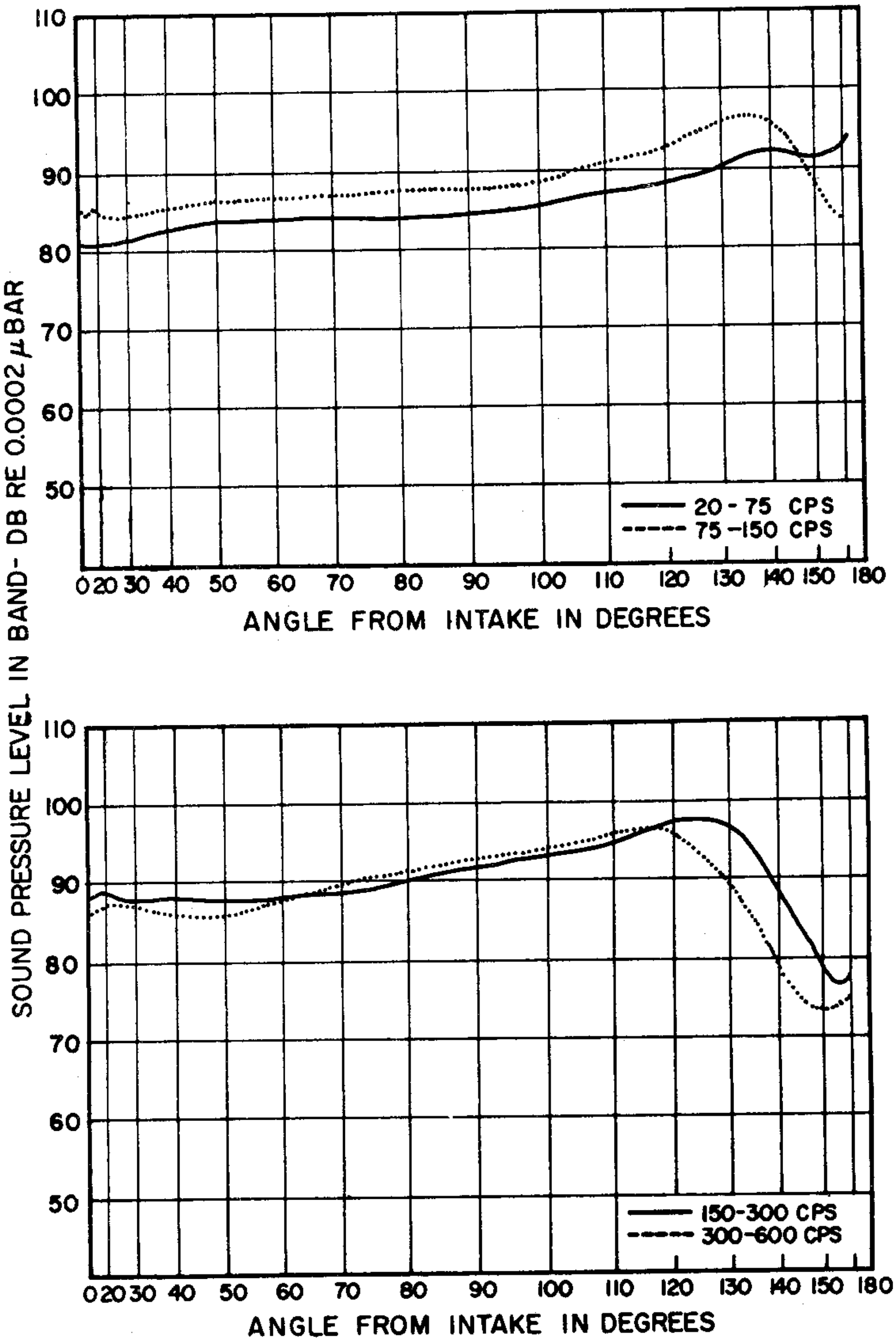
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
41	TWO J-34-WE-42	100'



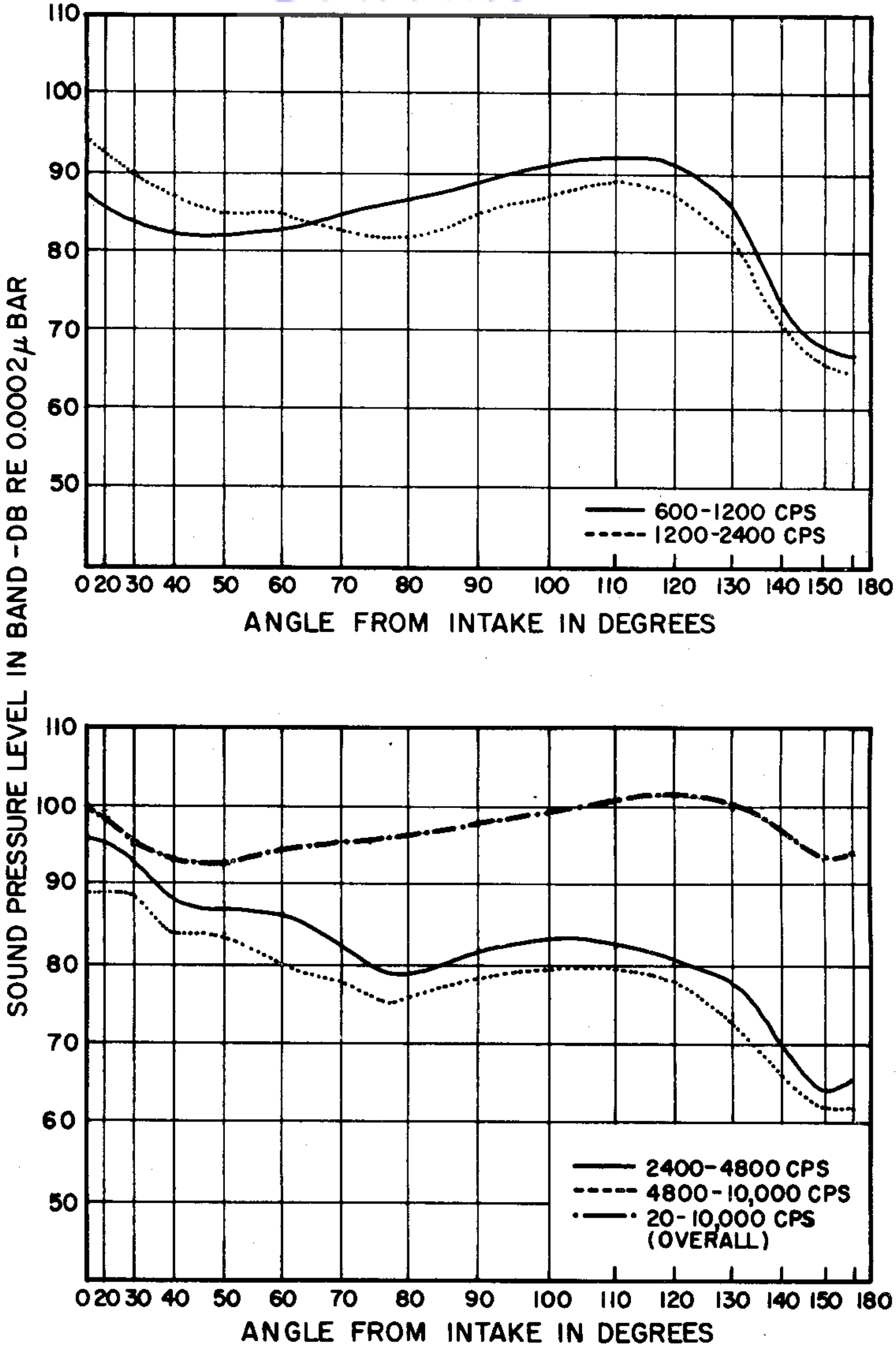
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
41	TWO J-34-WE-42	100′



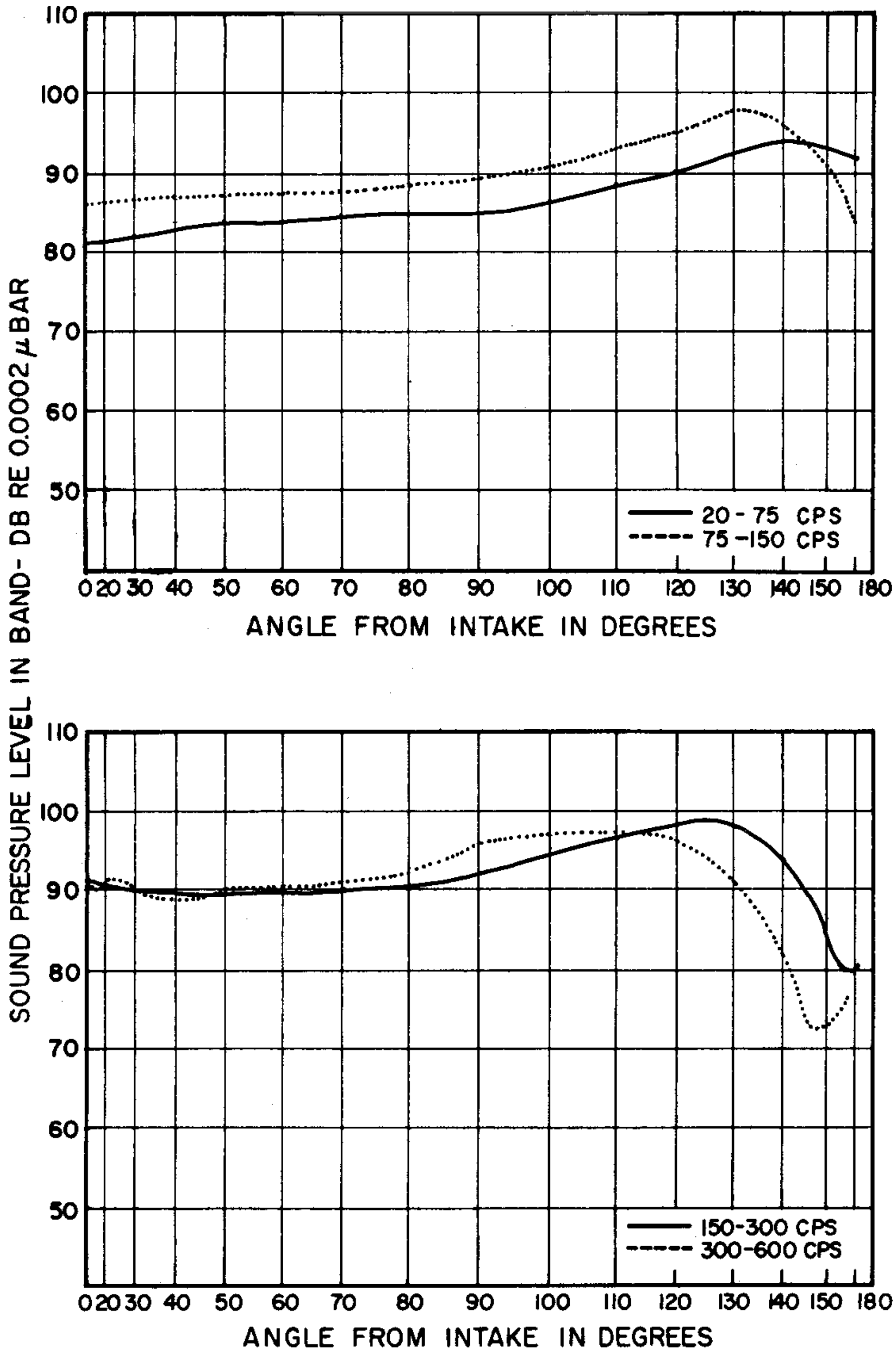
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
42	TWO J-34-WE-42	100′



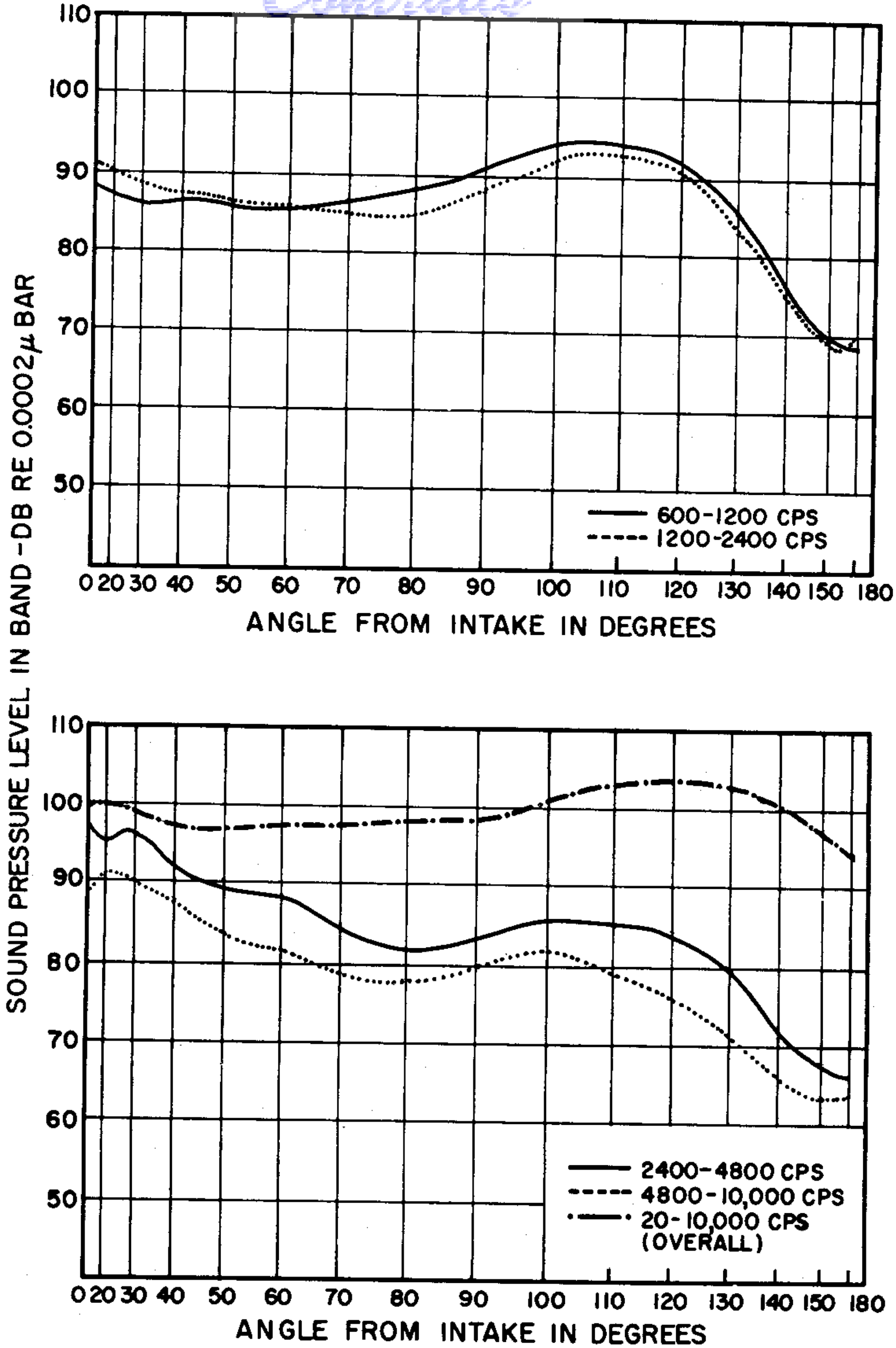
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
42	TWO J-34-WE-42	100′



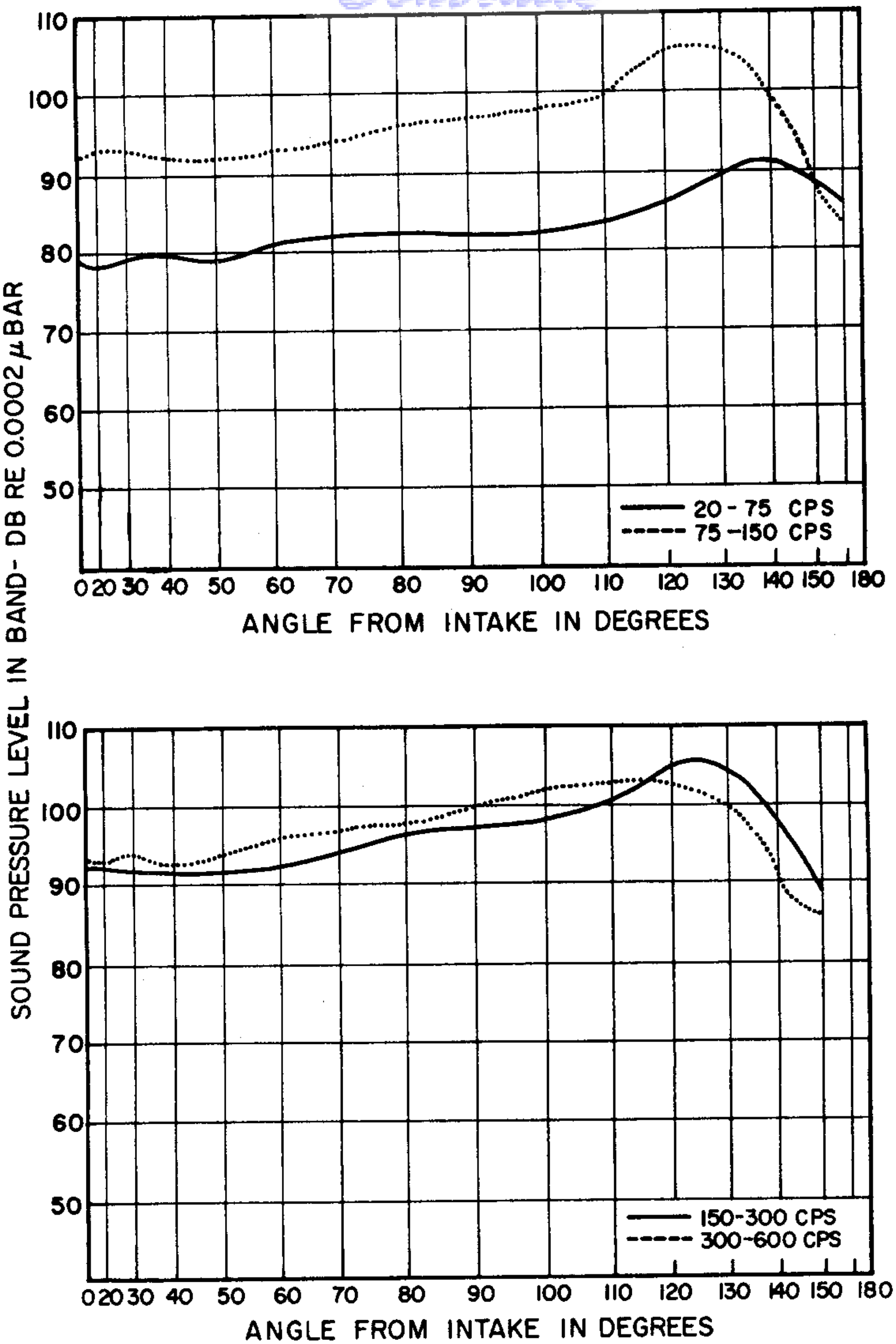
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
43	TWO J-34-WE-42	100′



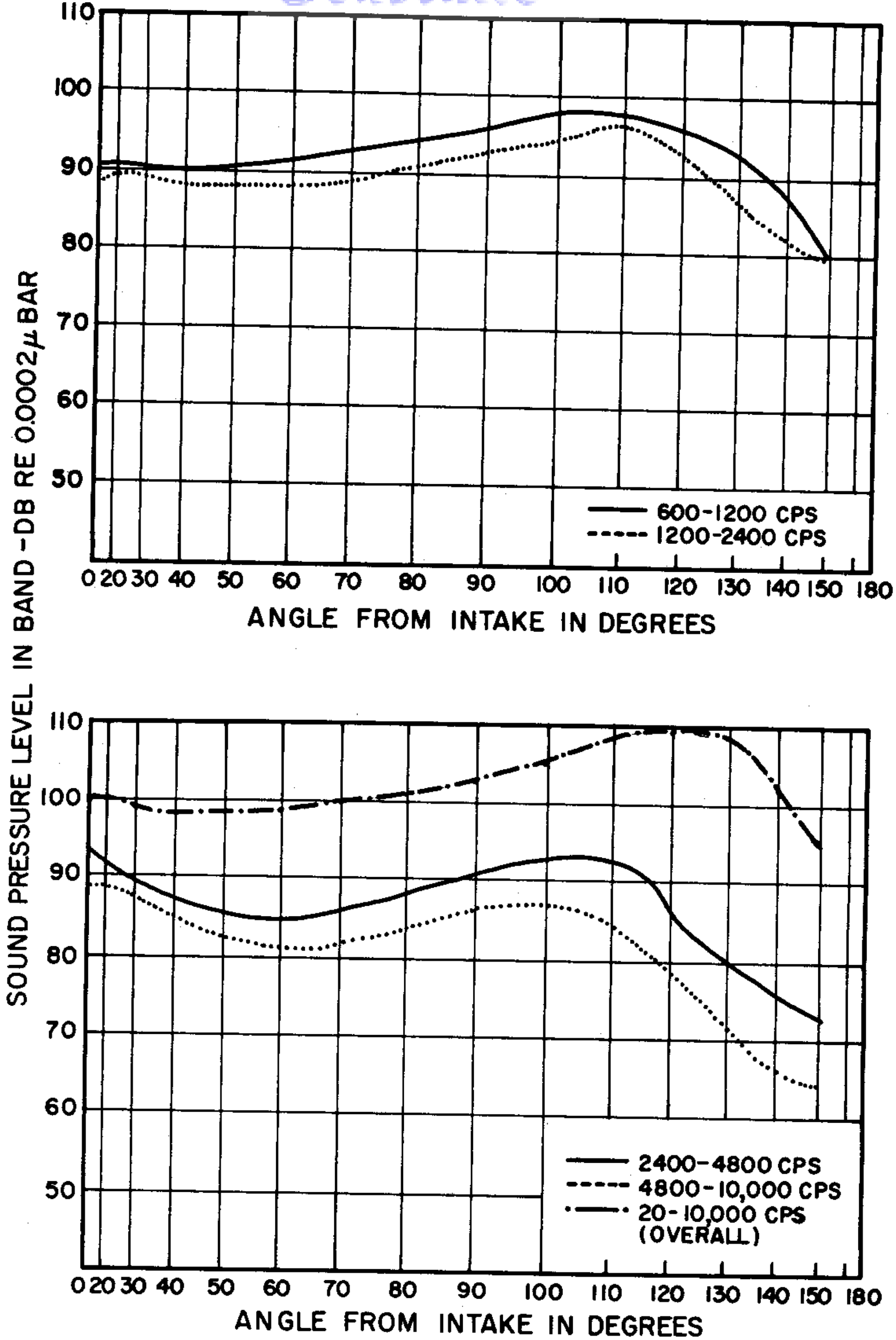
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
43	TWO J-34-WE-42	100'



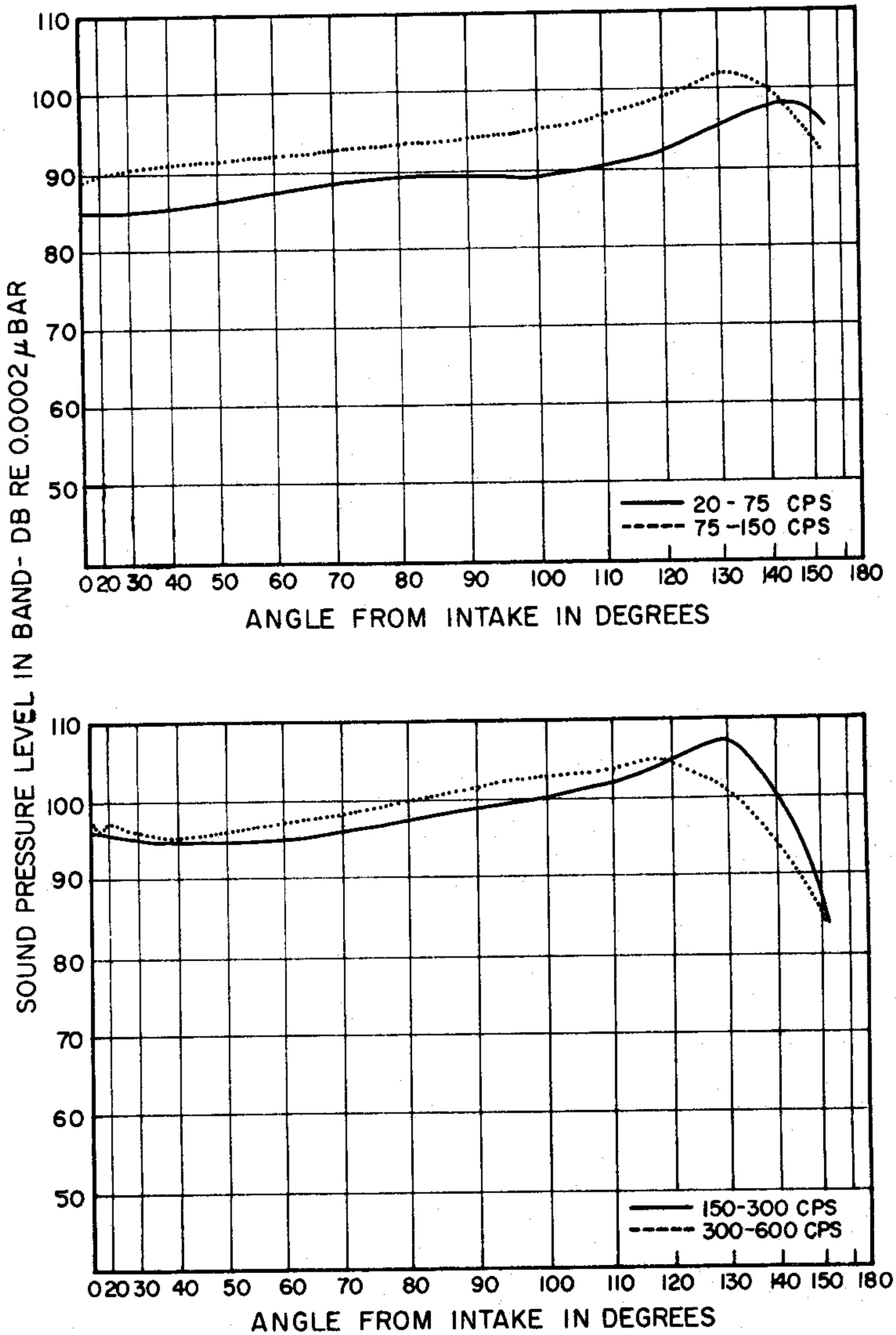
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
44	TWO J-34-WE-42	100′



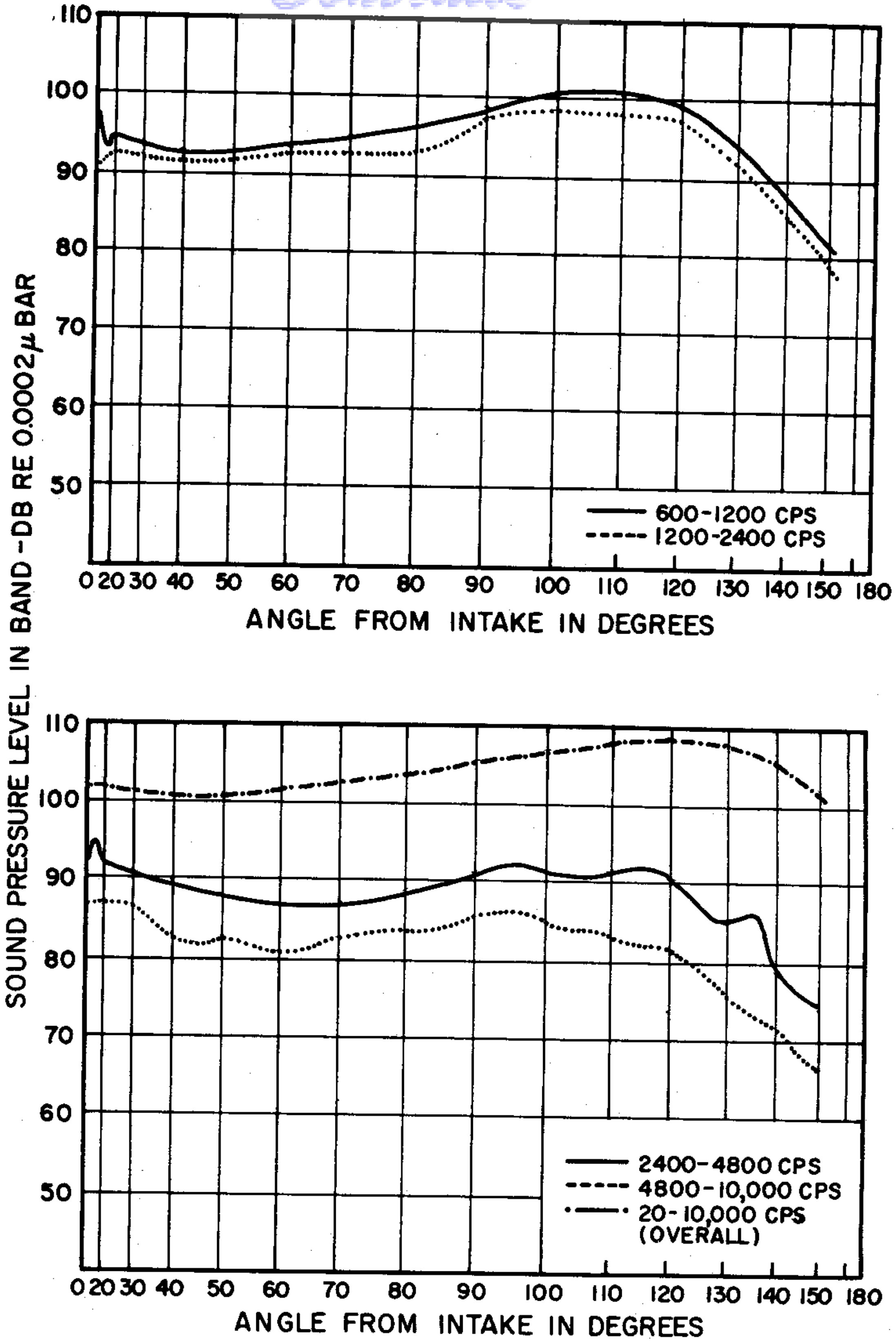
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
44	TWO J-34-WE-42	100′



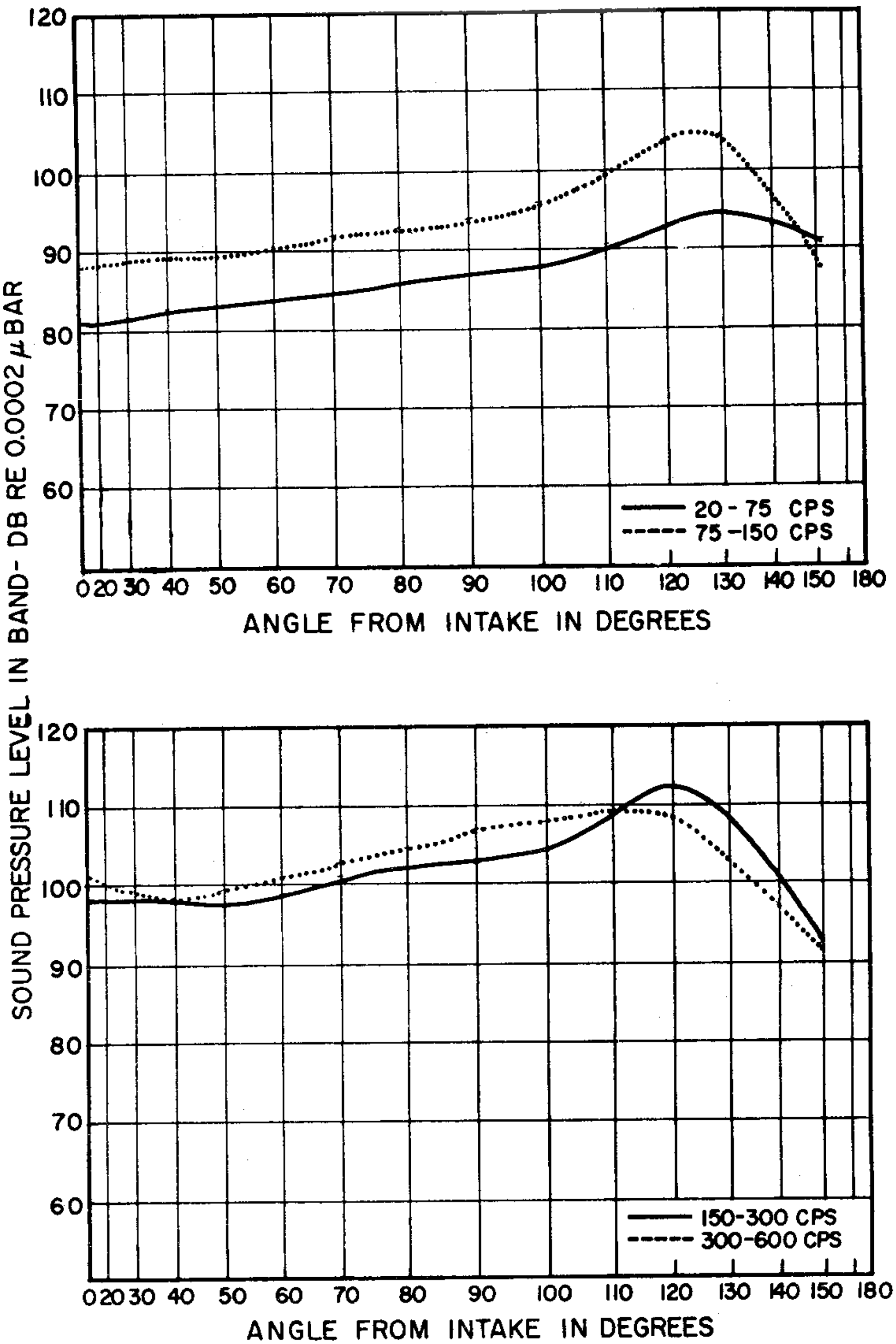
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
45	TWO J-34-WE-42	100′



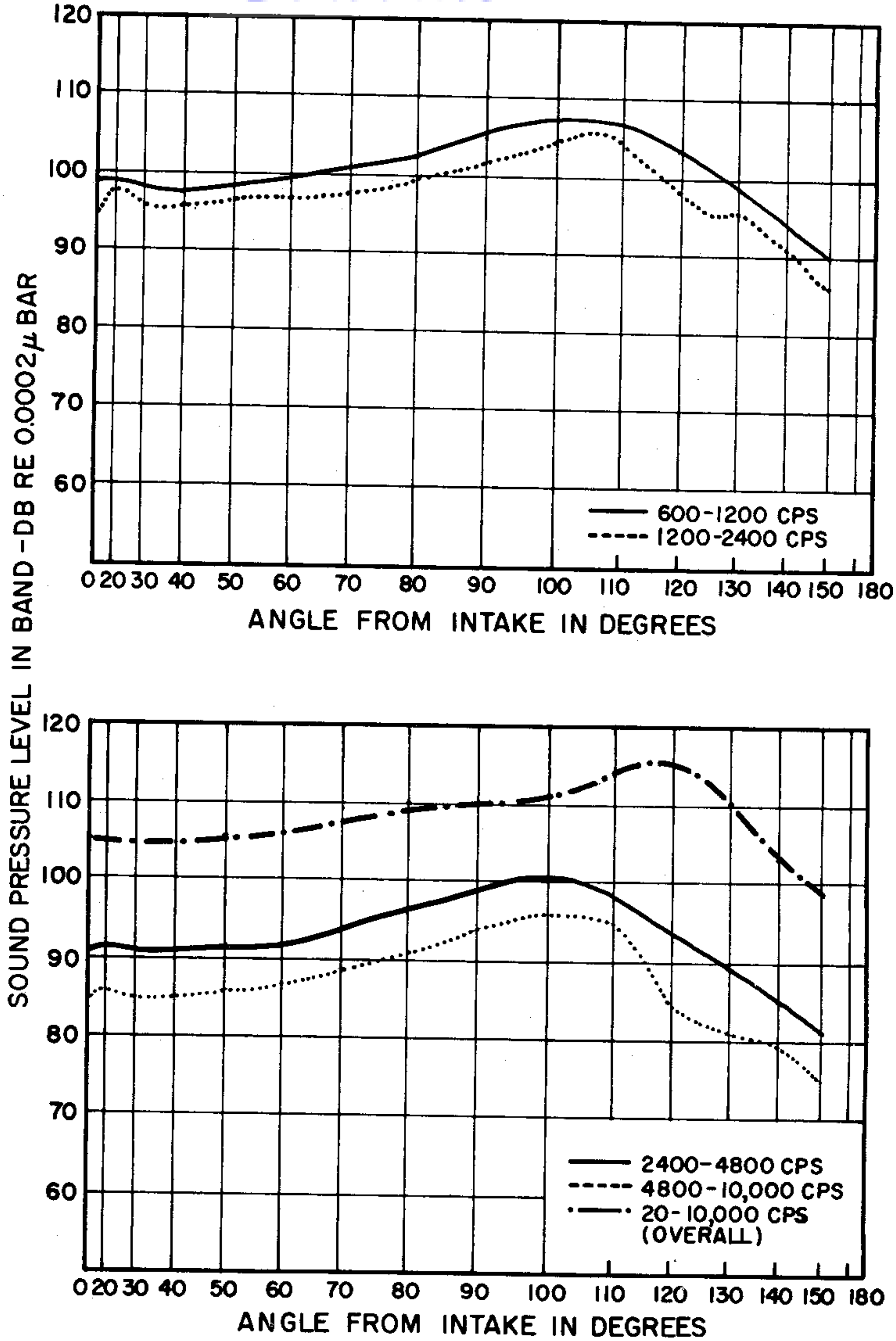
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
45	TWO J-34-WE-42	100′



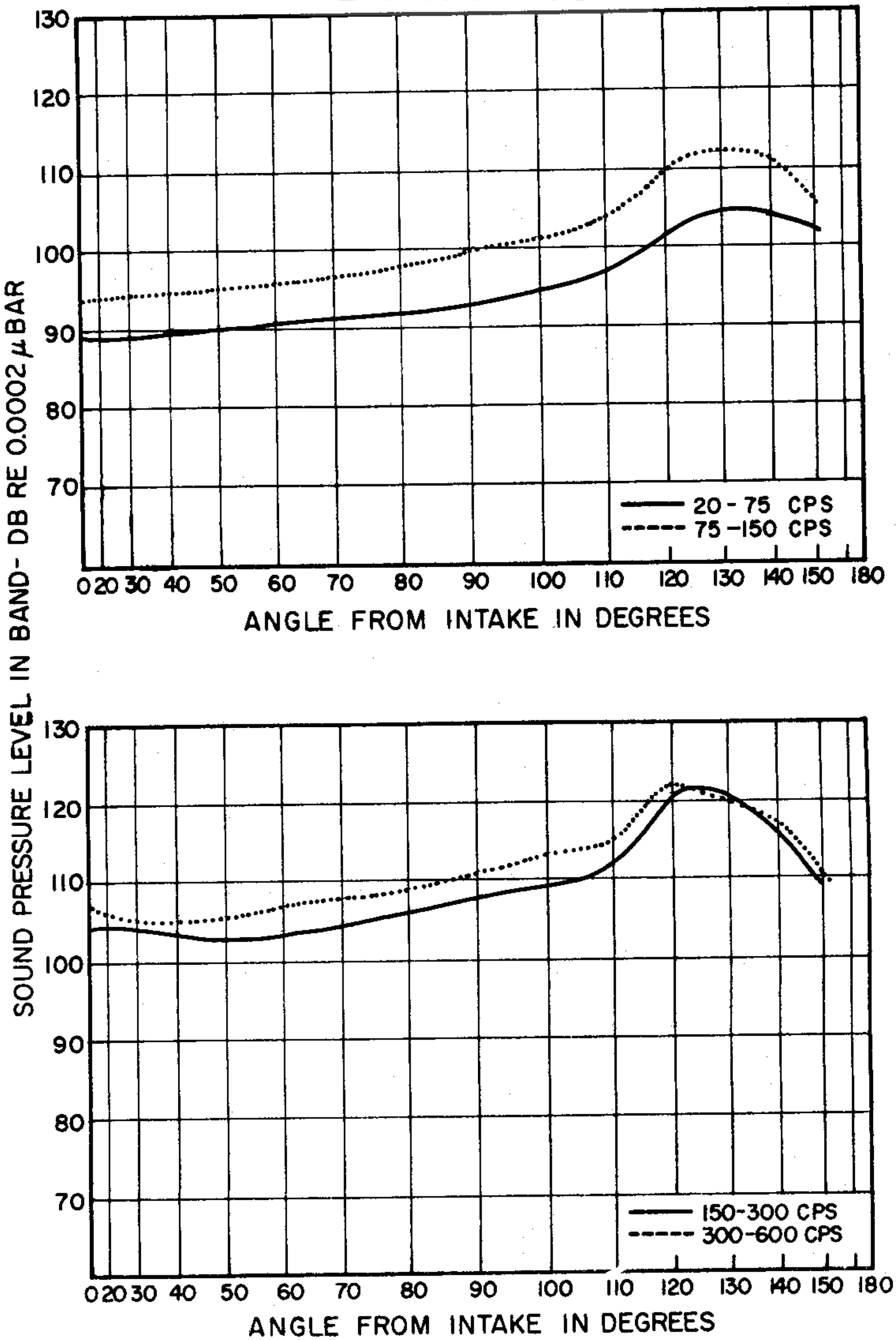
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
46	TWO J-34-WE-42	100′



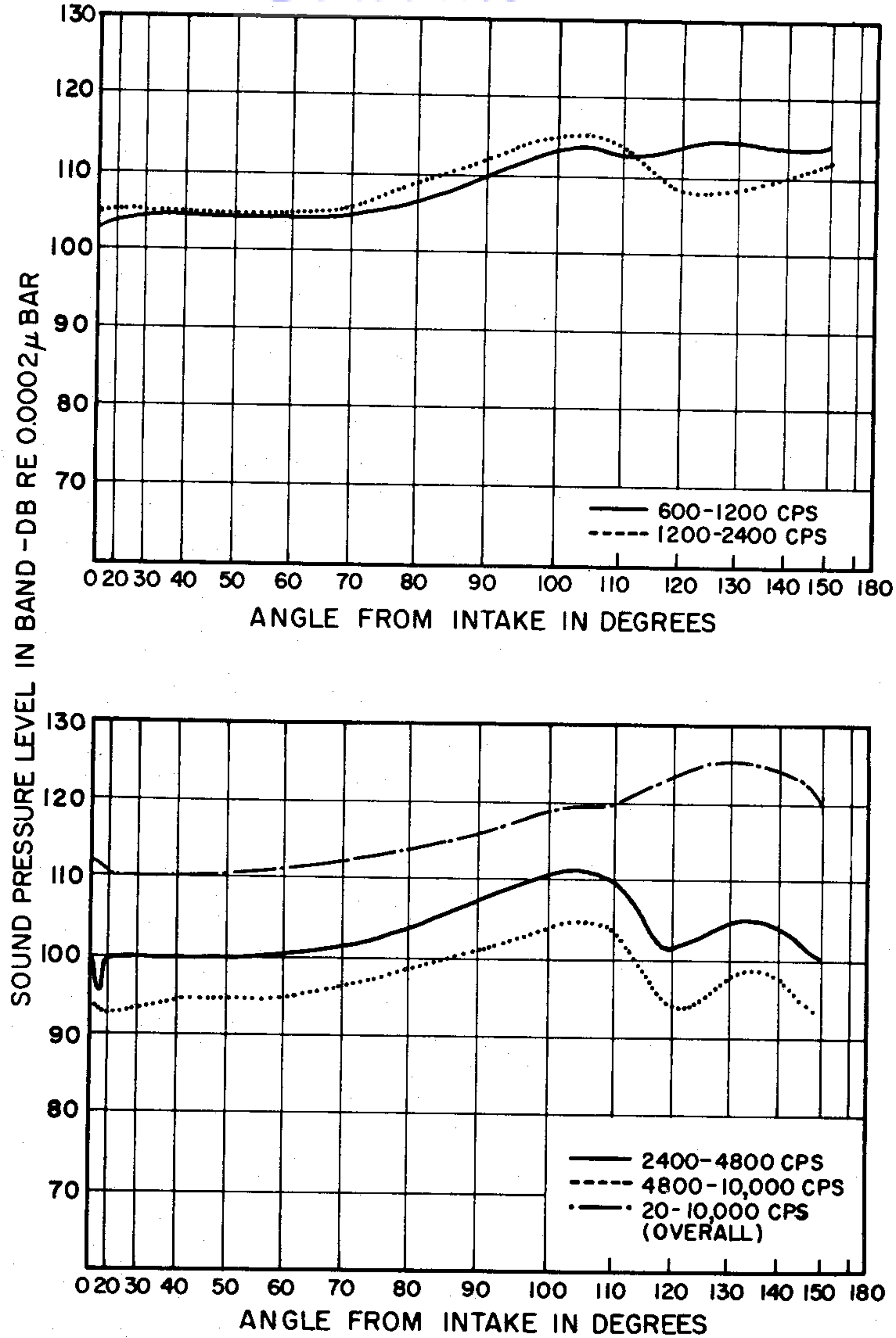
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
46	TWO J-34-WE-42	100′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
47	TWO J-34-WE-42	50′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
47	TWO J-34-WE-42	50'

J35-A-13D

TEST GROUP 8

History and Description of Tests

Source of Data:	Measurements by BBN under USAF Contract No. AF 33(038)-20572
Date of Tests:	31 May - 4 June 1951
Location of Tests:	Tinker AFB, Oklahoma City, Oklahoma
Placement of Engine:	Mounted on thrust stand in Test Cell 4-215

Engine Operating Variables

All engine data were obtained from engine log sheets at the time of the acoustic measurements. Jet nozzle diameter was not recorded but was estimated to be about 19". Spread in tailpipe temperature represents the range of values at seven temperature measuring positions; where no spread is indicated, the temperature at only one measurement position was recorded. Thrust data were obtained by subtracting the tare of 110 lbs from the observed values.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
48	2200	130	715	19	1580	82-86	-	-
49	3700	430	1200	19	1540 $\pm$ 60	82-86	-	-
50	6212	1820	2150	19	1360 $\pm$ 20	82-86	-	-
51	6813	2500	2750	19	1450 $\pm$ 20	82-86	-	-
52	7625	3480	3760	19	1570	82-86	-	-
53	7665	3570	3850	19	1590	82-86	-	-

J35-A-13D

TEST GROUP 8

Acoustic Measurement Techniques and Method of Obtaining PWL

Several microphones were distributed through the test section of the cell. Octave band analysis from 20-10,000 cps was made at the time of the measurements. Power level was calculated by the "reverberant field" method.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over-all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
48	3.2	135	125	131	130	124	121	122	113	109
49	40	146	131	138	143	135	133	130	129	125
50	200	153	131	140	148	145	145	142	140	140
51	320	155	133	140	149	149	148	145	143	142
52	1300	161	133	143	153	155	155	152	150	149
53	1000	160	134	142	152	154	154	152	149	149

J35-A-13D

TEST GROUP 8a

History and Description of Tests

Source of Data:	Measurements by BBN under USAF Contract No. AF 33(038)-20572
Date of Tests:	31 May - 4 June 1951
Location of Tests:	Tinker AFB, Oklahoma City, Oklahoma
Placement of Engine:	Mounted on thrust stand in Test Cell 2-214

Engine Operating Variables

All engine data were obtained from engine log sheets at the time of the acoustic measurements. Jet nozzle diameter was not recorded but was estimated to be about 19". Spread in tailpipe temperature represents the range of values at seven temperature measuring positions. Thrust data were obtained by subtracting the tare of 190 lbs from the observed values.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_J
54	3700	440	1150	19	1480 ± 40	-	-	-
55	6212	1830	2140	19	1350 ± 30	-	-	-
56	6813	2470	2660	19	1410 ± 20	-	-	-
57	7665	3550	3775	19	1590 ± 20	-	-	-

J35-A-13D

TEST GROUP 8a

Acoustic Measurement Techniques and Method of Obtaining PWL

Several microphones were distributed through the test section of the cell. Octave band analysis from 20-10,000 cps was made at the time of the measurements. Power level was obtained by the "reverberation field" method.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	over-all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
54	63	148	139	140	143	139	138	137	134	129
55	400	156	144	148	147	149	149	149	144	142
56	1300	161	147	152	153	154	153	153	148	146
57	3200	165	150	155	156	160	158	157	153	151

J35-A-17

TEST GROUP 9

History and Description of Tests

Source of Data:	BBN Report No. 56, "Revised Analysis of Noise Problem, Propulsion Sciences Laboratory," April 1951
Date of Tests:	February 1951
Location of Tests:	Propulsion Sciences Laboratory, NACA, Cleveland, Ohio
Placement of Engine:	In altitude tunnel facility SW-24

Engine Operating Variables

Engine data were obtained from the NACA at the time of the acoustic measurements. In the tunnel facility, there was air flow past the engine at low ambient pressure. The Mach number of the air flow and the ambient pressures for the tests were: Test 59, Mach number 0.624, 13.81" Hg; Test 60, Mach number 0.96, 8.92" Hg; Test 61, Mach number 0.624, 3.45" Hg; Test 62, Mach number 0.91, 3.45" Hg. Ambient temperature was not recorded.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_1	m	M_j
58	7500	-	2135	19	1100	-	55.6	-
59	7914	-	2045	19	1400	-	37.5	-
60	6750	-	427	19	1100	-	12.5	-
61	7914	-	916	19	1500	-	15.3	-

J 35-A-17

TEST GROUP 9

Acoustic Measurement Techniques and

Method of Obtaining PWL

Several probe microphones were distributed through the test section of the cell. Octave band analysis from 20-10,000 cps was made at the time of the measurements. Power levels were obtained by the "reverberant field" method.

Power Levels and Total Acoustic Power

Test No.	Total Power	PWL in db re 10^{-13} watt								
	watts	over-all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
58	300	155	137	136	146	150	149	147	141	142
59	300	155	140	138	146	150	147	148	142	144
60	40	146	131	128	136	140	140	138	135	134
61	160	152	137	134	143	145	143	142	139	146

J47-GE-1

TEST GROUP 10

History and Description of Tests

Source of Data:	Journal of the Acoustical Society of America, 24, 169 (1952) and Journal of the Acoustical Society of America 25, 369 (1953)
Date of the Tests:	1952
Location of Tests:	Wright-Patterson AFB, Dayton, Ohio
Placement of Engine:	On test stand in open field

Engine Operating Variables

The engine data, which were obtained from average engine test data, were supplied in a private communication.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
62	4000	690	1360	19.3	1180	-	-	-
63	7200	3900	4100	19.3	1440	-	-	-
64	7850	4500	5100	19.3	1630	-	-	-

J47-GE-1

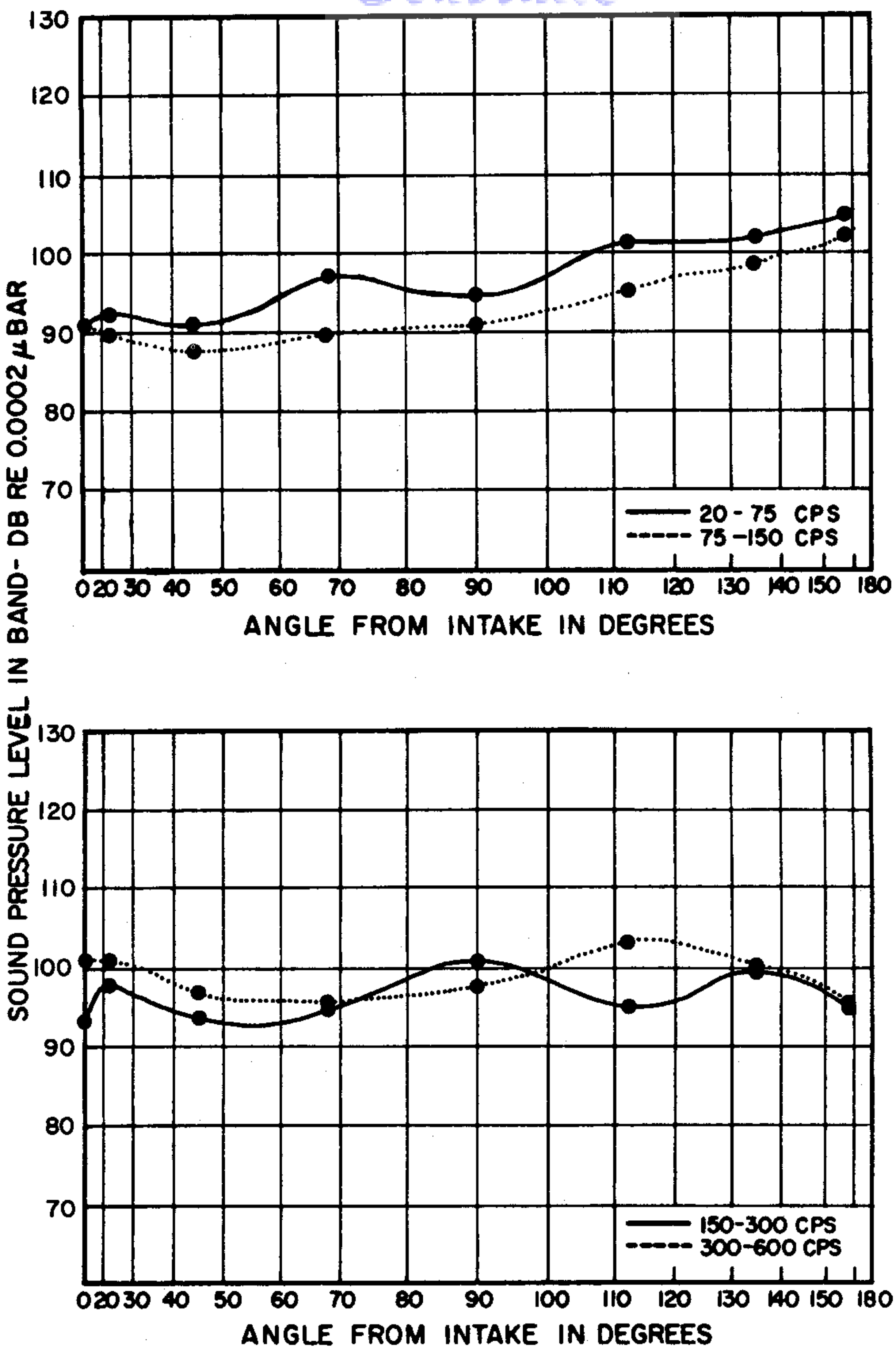
TEST GROUP 10

Acoustic Measurement Techniques and Method of Obtaining PWL

Measurements were made in a free field on a circle of radius 50' at discrete intervals 22-1/2° apart.

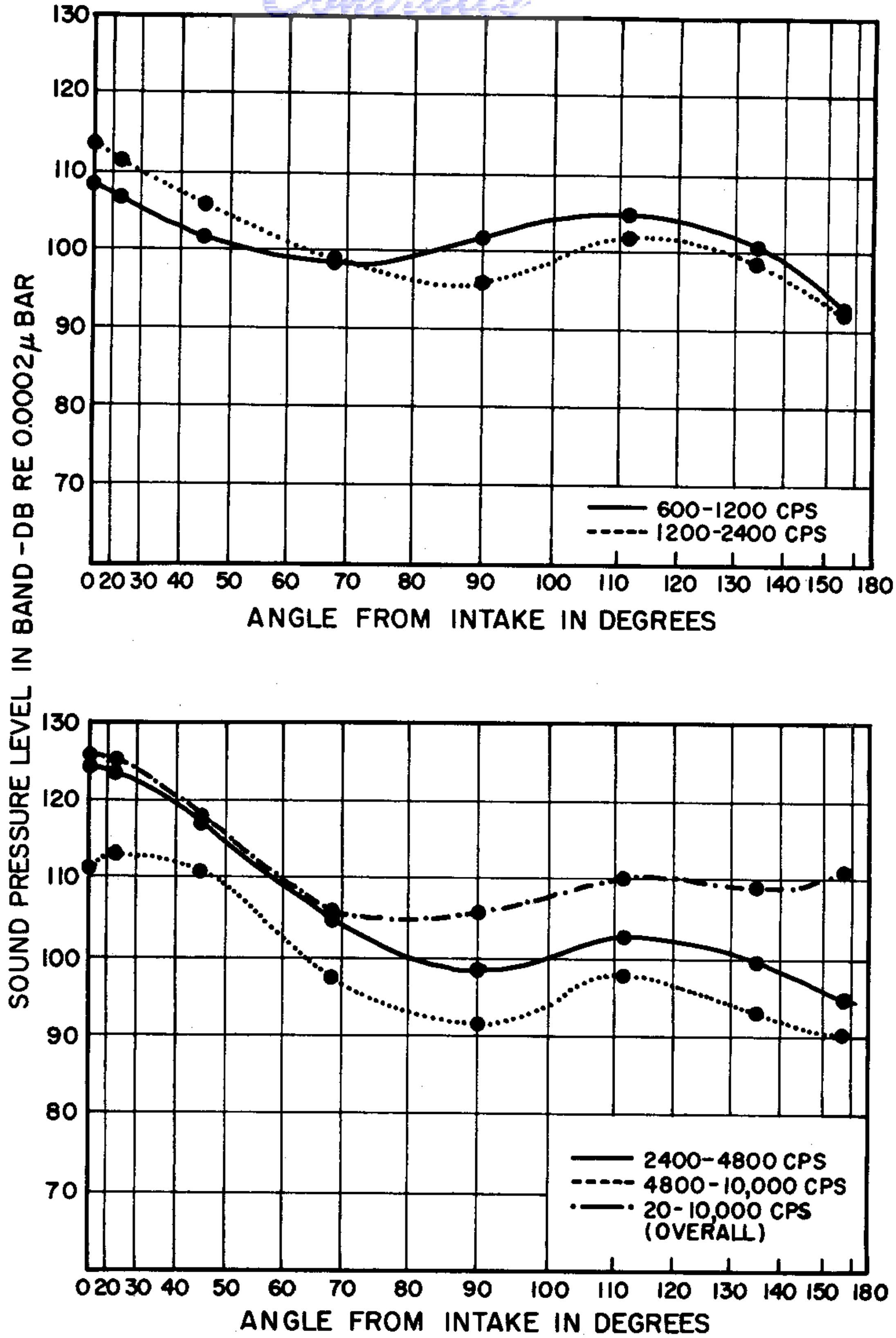
Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
62	63	158	141	136	140	141	144	147	157	147
63	12,000	171	160	166	162	164	163	160	158	152
64	40,000	176	165	170	167	170	169	164	163	156



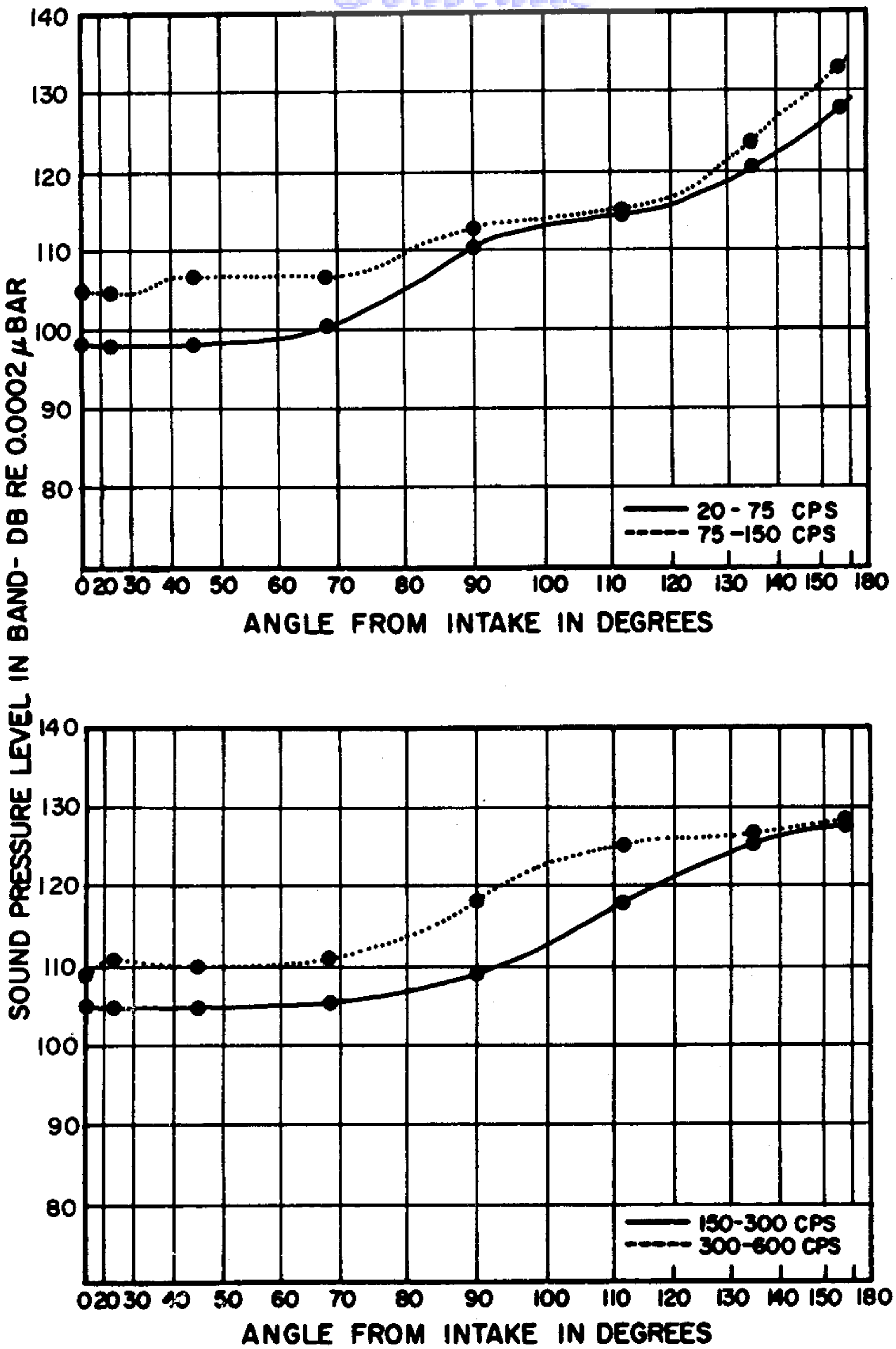
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
62	J47-GE-I	50′



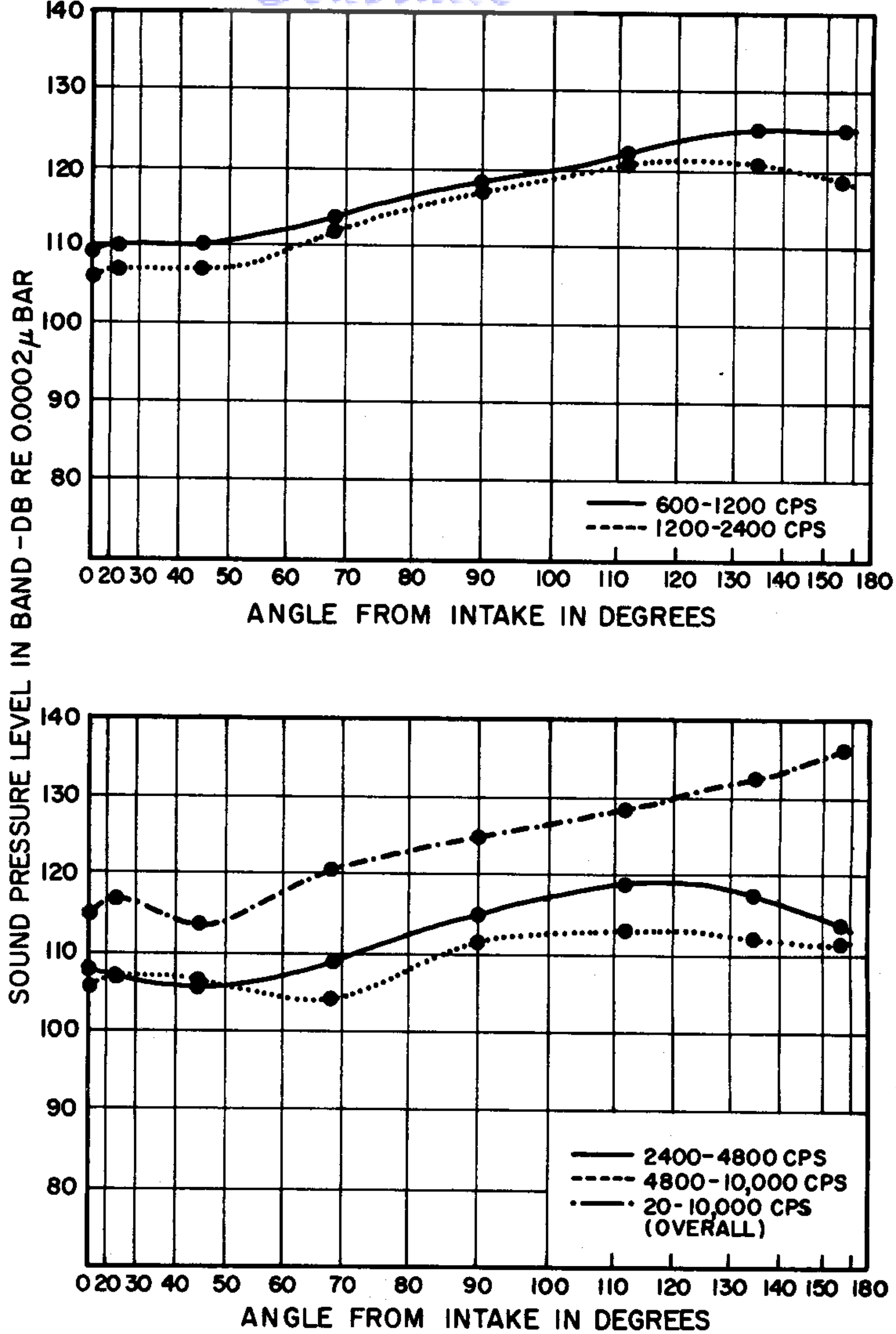
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
62	J47-GE-1	50′



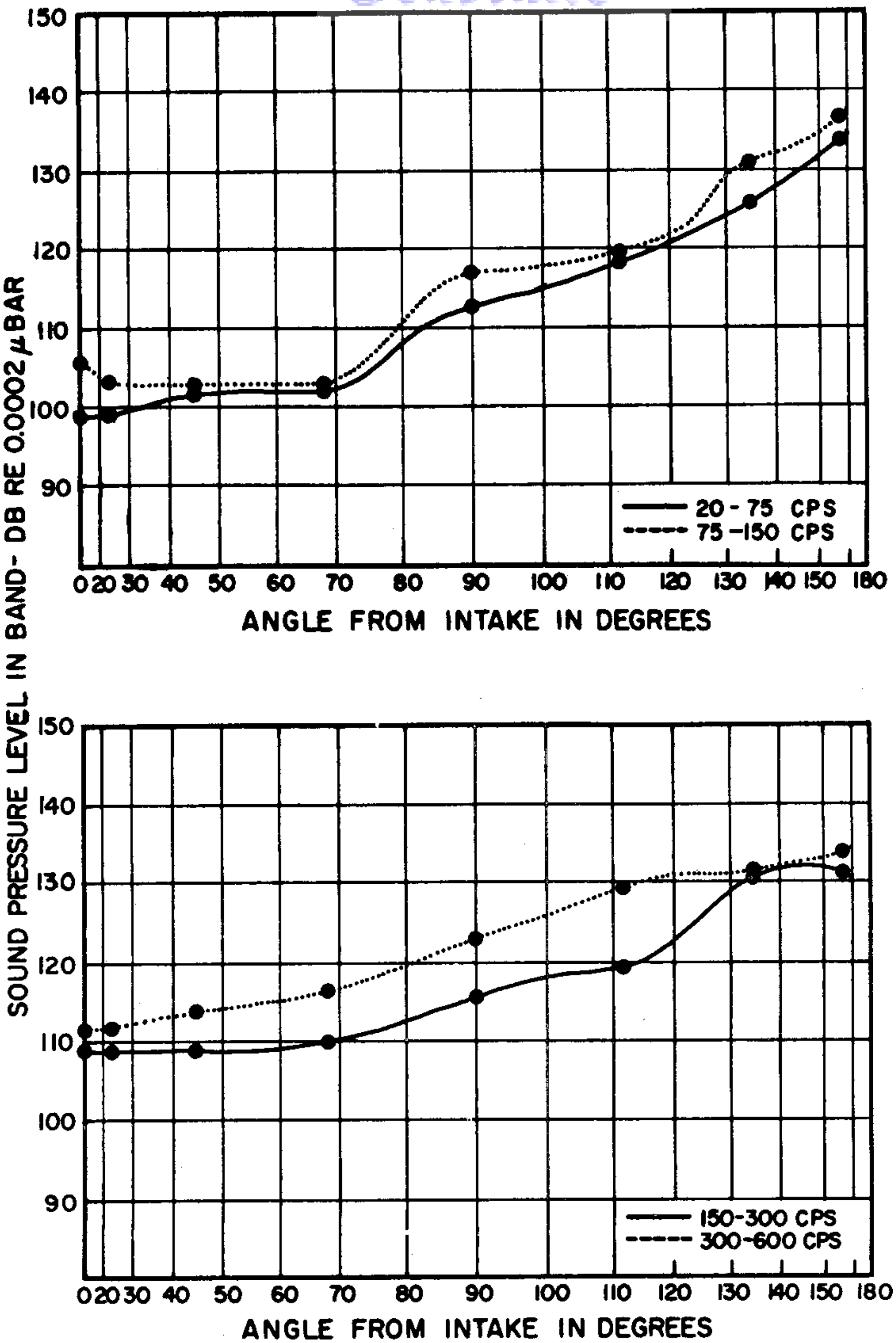
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
63	J47-GE-1	50′



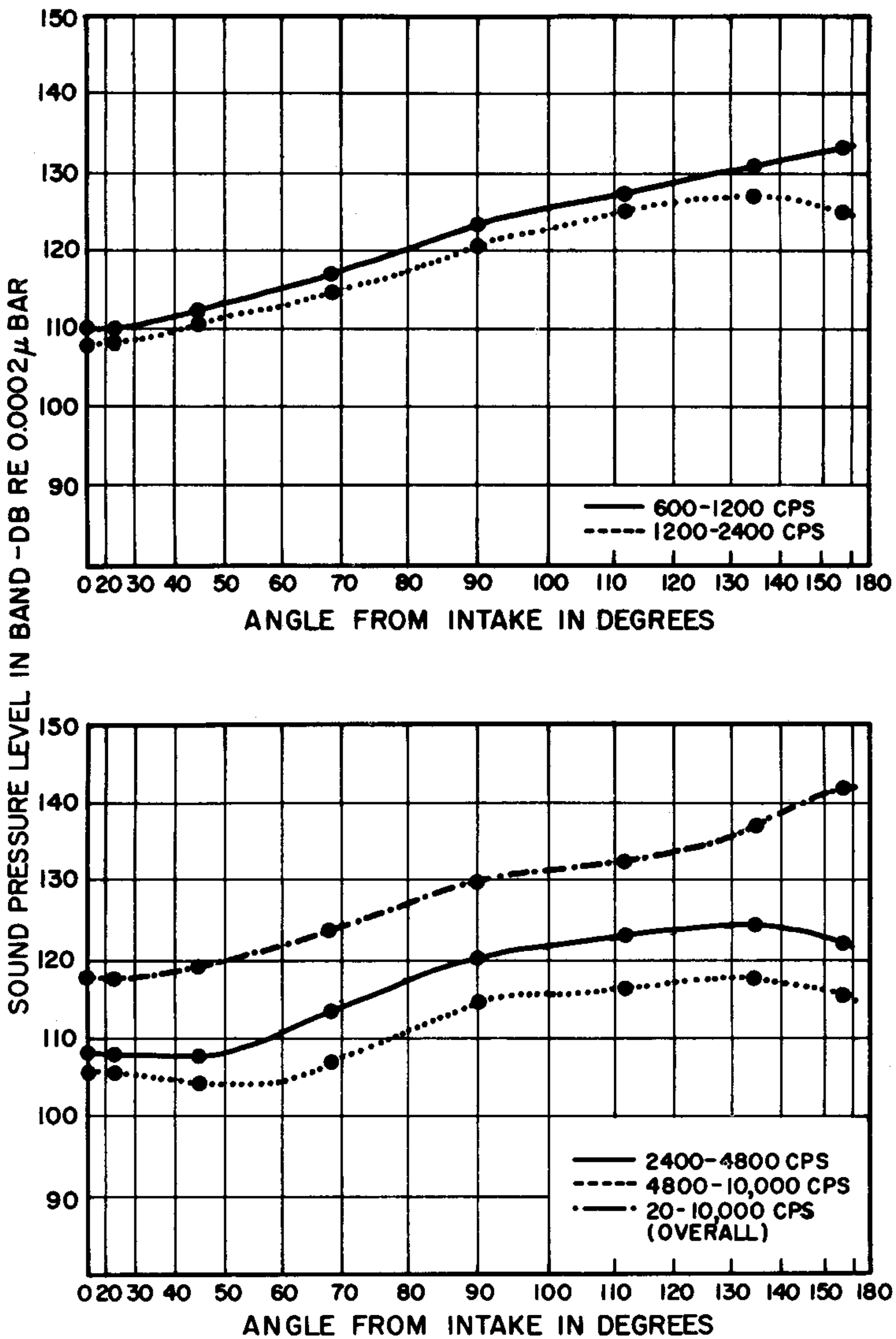
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
63	J47-GE-1	50′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
64	J47-GE-1	50′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
64	J47-GE-1	50′

J47-GE-7A

TEST GROUP 11

History and Description of Tests

Source of Data: Measurements by BBN under USAF Contract No. AF 33(038)-20572

Date of Tests: 31 May - 4 June 1951

Location of Tests: Tinker AFB, Oklahoma City, Oklahoma

Placement of Engine: Test Cell 2-214

Engine Operating Variables

All engine data was obtained from log sheets at the time of the acoustic measurements. The spread in tailpipe temperature represents the range of values at five temperature measuring positions.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
65	2199	370	775	19.3	1400 ± 40	60	-	-
66	6157	2640	2600	19.3	1250 ± 10	60	-	-
67	7343	4430	4440	19.3	1490 ± 20	60	-	-
68	7953	5130	5530	19.3	1690 ± 30	60	-	-

J47-GE-7A

TEST GROUP 11

Acoustic Measurement Techniques and Method of Obtaining PWL

Several microphones were distributed through the test section of the cell. Octave band analysis from 20-10,000 cps was made at the time of the measurements. Power level was obtained by the "reverberant field" method.

Power Levels and Total Acoustic Power

Test No.	Total Power	PWL in db re 10^{-13} watt								
	watts	over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
65	4	136	126	125	130	128	128	130	122	117
66	500	157	146	150	148	150	151	148	143	144
67	3200	165	152	157	157	160	157	155	149	148
68	10000	170	155	159	162	165	162	158	152	148

J47-GE-25

TEST GROUP 12

History and Description of Tests

Source of Data: BBN Report No. 327, "Acoustical Survey and Evaluation of J-47 and J-73 Turbojet Engine Test Facilities, Aircraft Gas Turbine Division, General Electric Company"

Date of Tests: 13-16 September 1954

Location of Tests: General Electric Company, Aircraft Gas Turbine Division, Evandale, Ohio

Placement of Engine: Mounted on thrust stand in Test Cell No. 3

Engine Operating Variables

All data were obtained from log sheets at the time of the acoustical measurements. Test 84 was made with water-alcohol injection.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_1	m	M_j
69	7953	5510	6058	20	1730	86	-	-

J47-GE-25

TEST GROUP 12

Acoustic Measurement Techniques and Method of Obtaining PWL

The PWL's reported here were calculated indirectly from measurements of SPL in the test section of the cell. The SPL's in the test section were compared with the equivalent SPL's caused by a J47-PM-25 (See Test Group 13) in a cell of similar geometry and acoustical treatment. It was assumed that the SPL's in each case were proportional to the respective PWL's.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt								
		over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
69	50000	177	157	167	168	173	171	161	162	-

J47-PM-25

TEST GROUP 13

History and Description of Tests

Source of Data:	BBN Report No. 325, "Acoustical Survey and Evaluation of Turbojet Test Cells, Packard Motor Car Company, Utica, Michigan"
Date of Tests:	10-14 May 1954
Location of Tests:	Packard Motor Car Company, Utica Michigan
Placement of Engine:	Mounted on thrust stand in Test Cell 2

Engine Operating Variables

All engine data were obtained from log sheets which were written at the time of the acoustical measurements.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_1	m	M_j
70	3070	350	-	20	-	70	-	-
71	5300	1500	2000	20	1274	70	-	-
72	6400	3000	3225	20	1374	70	65-71	-
73	7250	4500	4750	20	1564	70	95	-
74	7953	5550	6000	20	1709	70	105	-

J47-PM-25

TEST GROUP 13

Acoustic Measurement Techniques and Method of Obtaining PWL

The "noise reduction" method was used to obtain PWL. Both the exhaust and intake acoustic powers are considered.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt								
		over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
70	32	145	127	123	127	133	138	138	141	-
71	120	151	139	140	140	142	145	143	144	-
72	630	158	145	149	150	152	151	148	148	-
73	3200	165	150	154	158	161	157	154	151	-
74	6300	168	153	158	157	163	159	156	155	-

J48-P-5

TEST GROUP 14

History and Description of Tests

Source of Data:	BBN Report No. 295, "Acoustical Evaluation of Maxim Silencer Installation, Wright-Patterson Air Force Base," 16 May 1955
Date of Tests:	March 1955
Location of Tests:	Wright-Patterson AFB, Dayton, Ohio
Placement of Engine:	In Test Cell No. 6

Engine Operating Variables

The mass flow of air was supplied by WADC engineers. The other data was taken from manufacturer's specification data on this type engine.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
75	11,000	6250	-	21	-	-	124	-

J48-P-5

TEST GROUP 14

Acoustic Measurement Techniques and

Method of Obtaining PWL

The "noise reduction" method was used to obtain PWL. Only the power going through the exhaust section was calculated. Neglecting the power radiated forward should cause no significant change in the PWL values.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
75	10000	170	161	160	162	165	165	160	158	154

J48-P-8

TEST GROUP 15

History and Description of Tests

Source of Data:	BBN Report 282, "Free-Field Measurements on Carrier Based Jet Aircraft" (Contract No. NObs 61592)
Date of Tests:	20-21 May 1953
Location of Tests:	NATC Patuxent River, Maryland
Placement of Engine:	In F9F-6 on runway

Engine Operating Variables

At the time of the acoustic measurements n and T_e were obtained from the cockpit instruments. Other data were obtained from the manufacturer's engine specifications combined with the practical knowledge of NATC personnel. NATC personnel indicated the values of quantities which would obtain in this aircraft.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_1	m	M_J
76	11,000	7250	8250	21	1790	70	122	-
77	11,000	7250	8250	21	1790	70	122	-
78	11,000	7250	8250	21	1790	70	122	-

J48-P-8

TEST GROUP 15

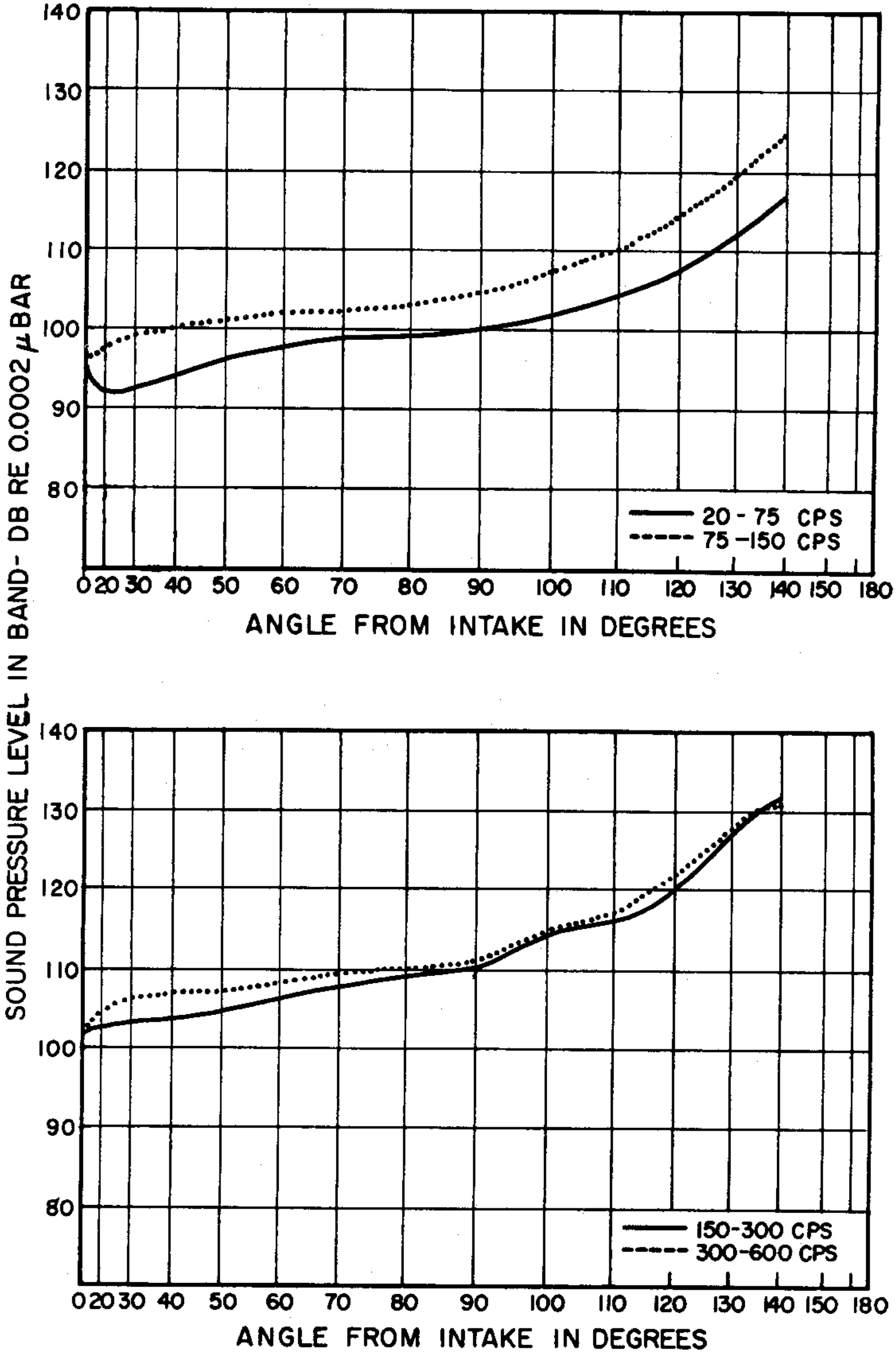
Acoustic Measurement Techniques and

Method of Obtaining PWL

A continuous traverse was made on a circle of 50', 100' and 200' radii in Tests 93, 94 and 95, respectively. Data were recorded on magnetic tape and reduced in octave bands. Windscreens were used. The microphone was approximately 5' above ground.

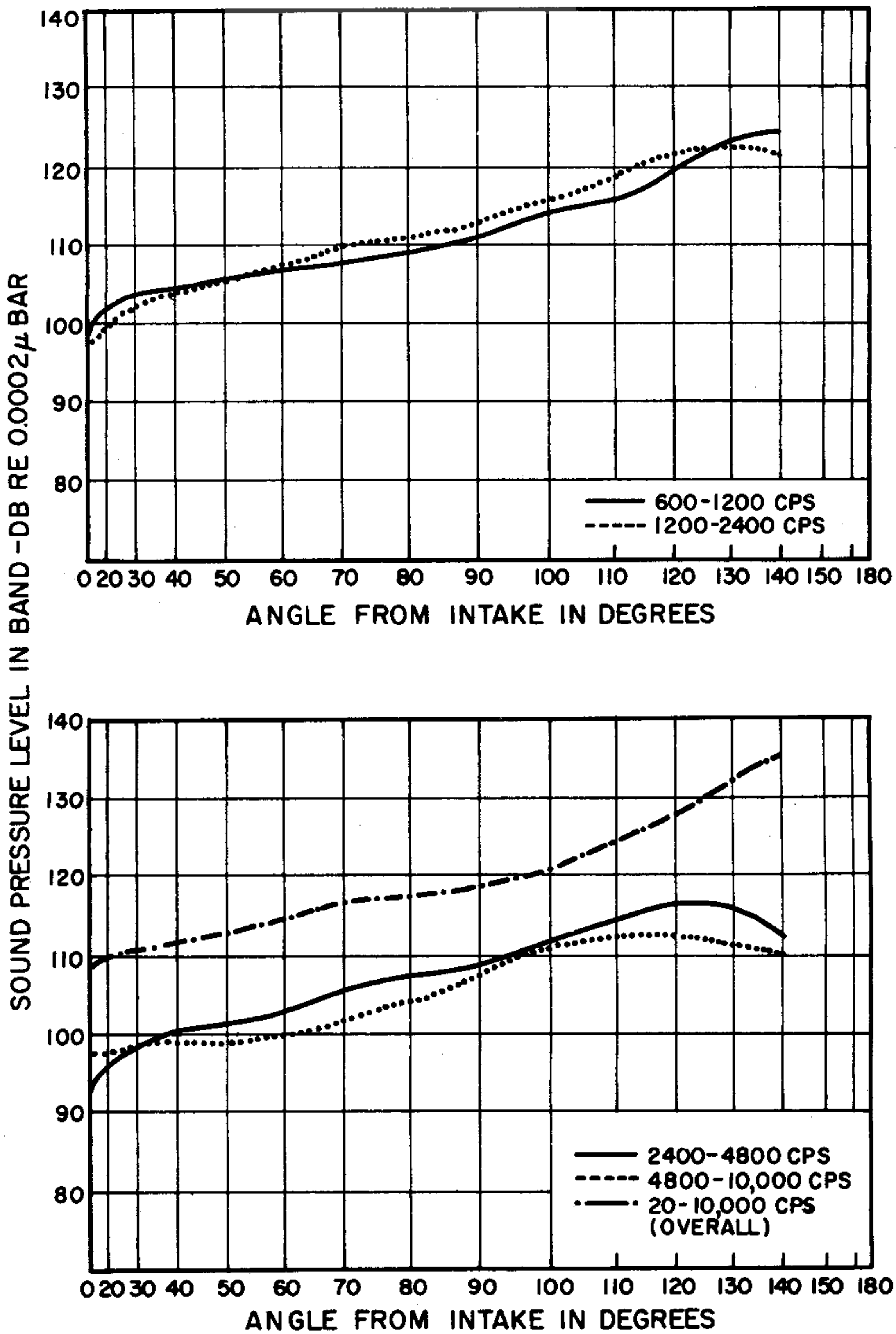
Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt								
		over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
76	10000	170	152	161	166	166	163	158	154	150
77	10000	170	155	161	166	165	163	159	157	152
78	12000	171	154	161	167	166	160	159	153	150



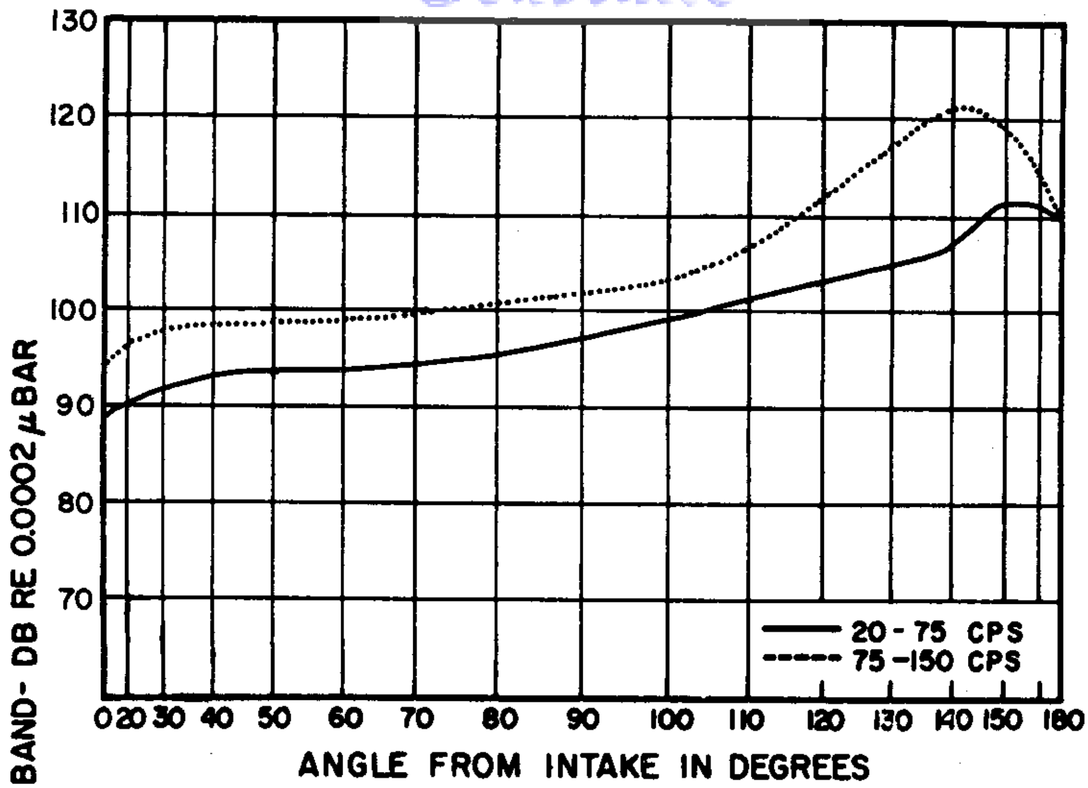
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

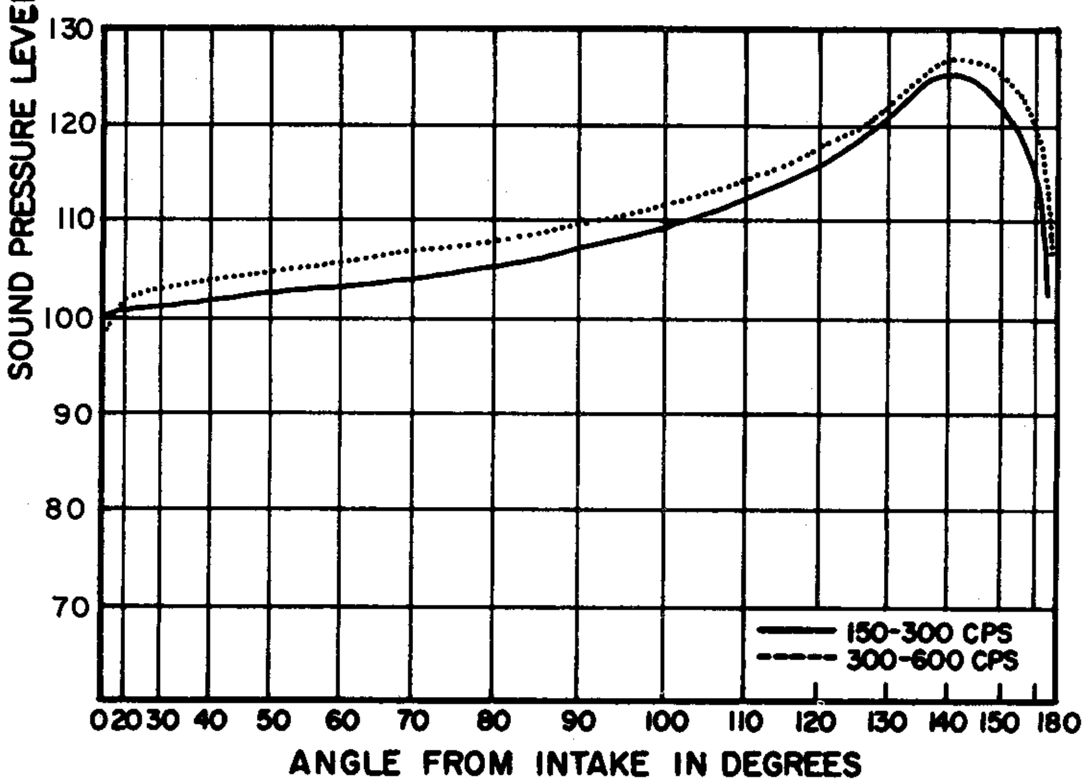
TEST NO.	ENGINE	DISTANCE
75	J48-P-8	50'



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

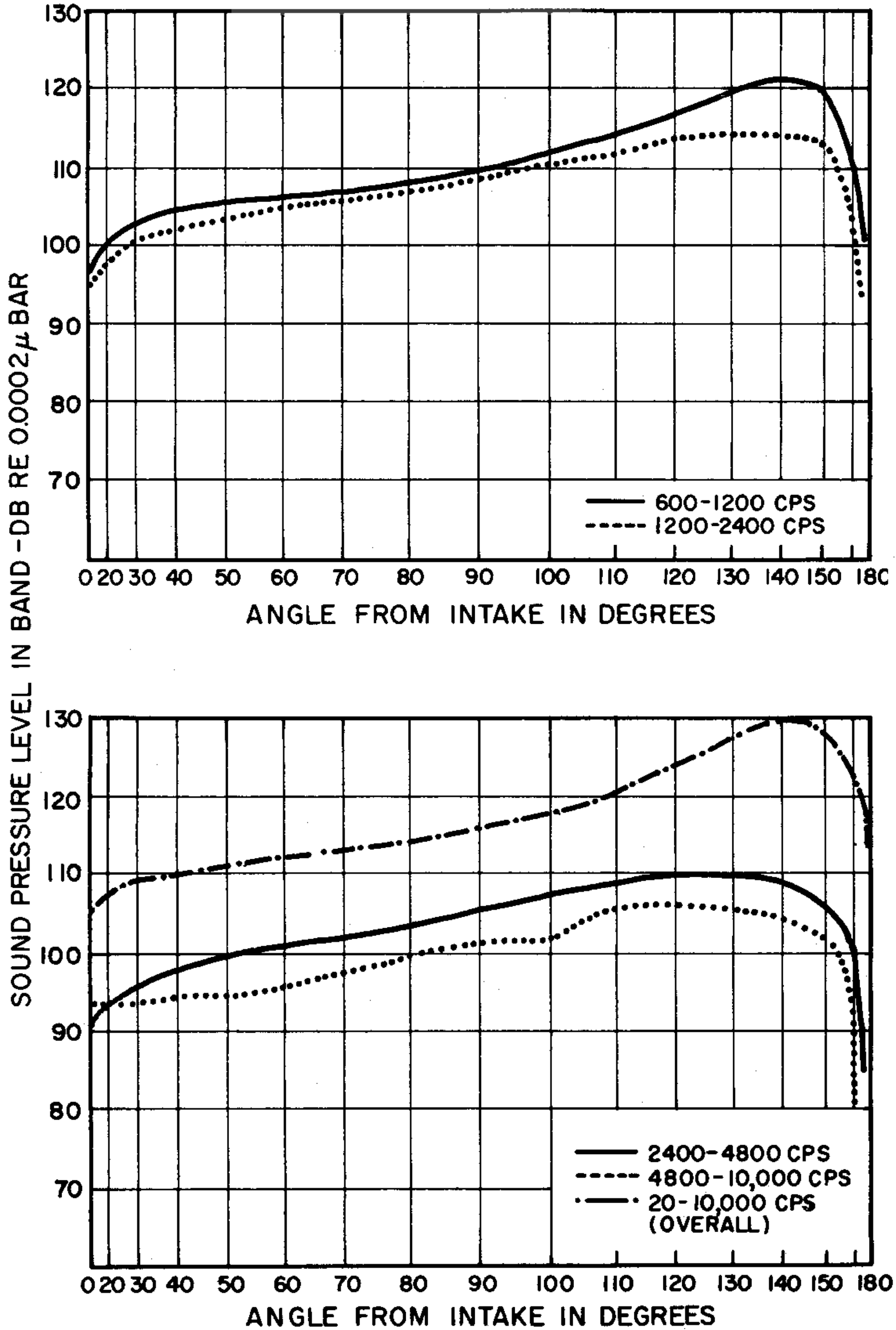
TEST NO.	ENGINE	DISTANCE
75	J48-P-8	50'





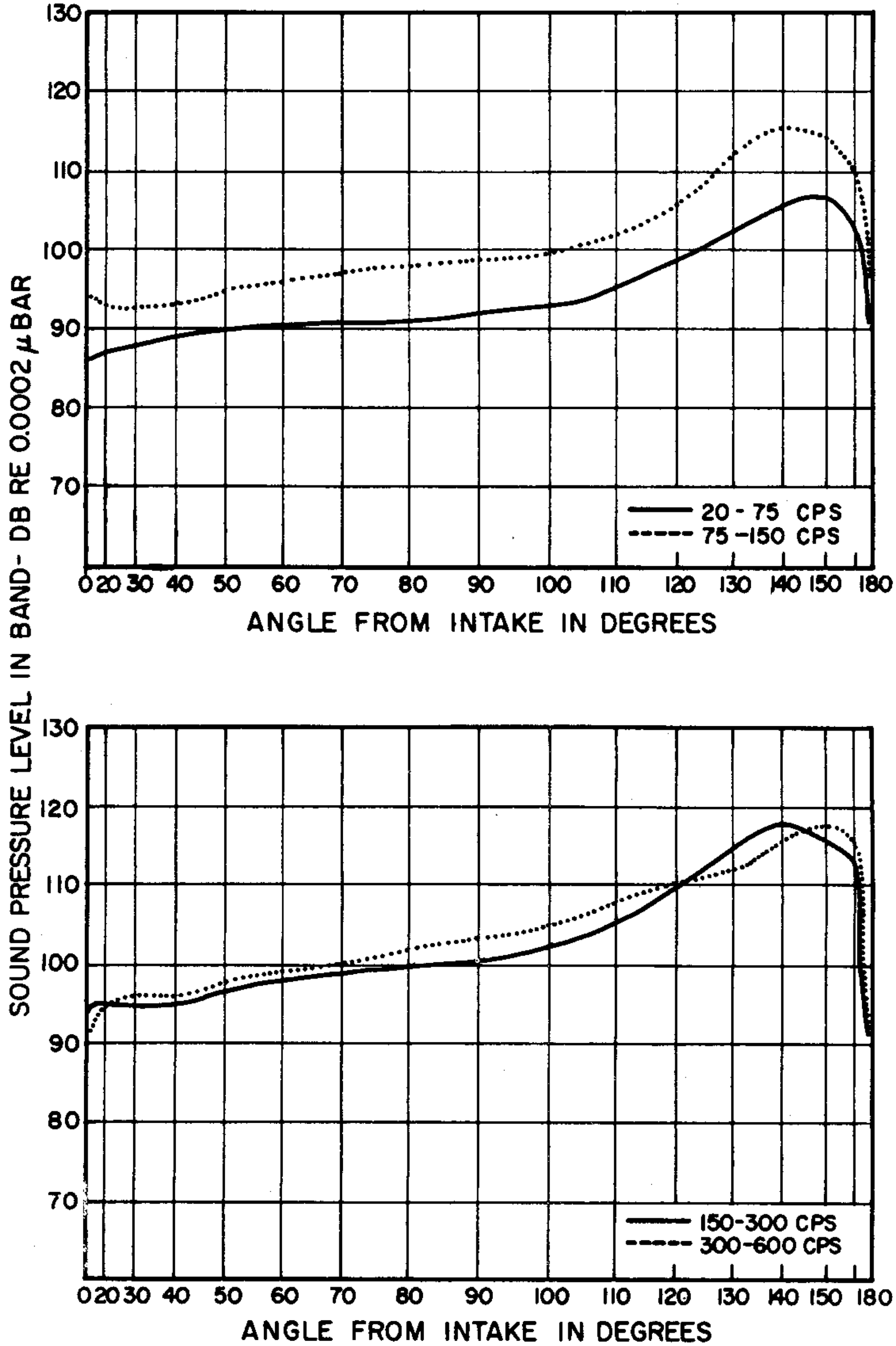
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
76	J48-P-8	100′



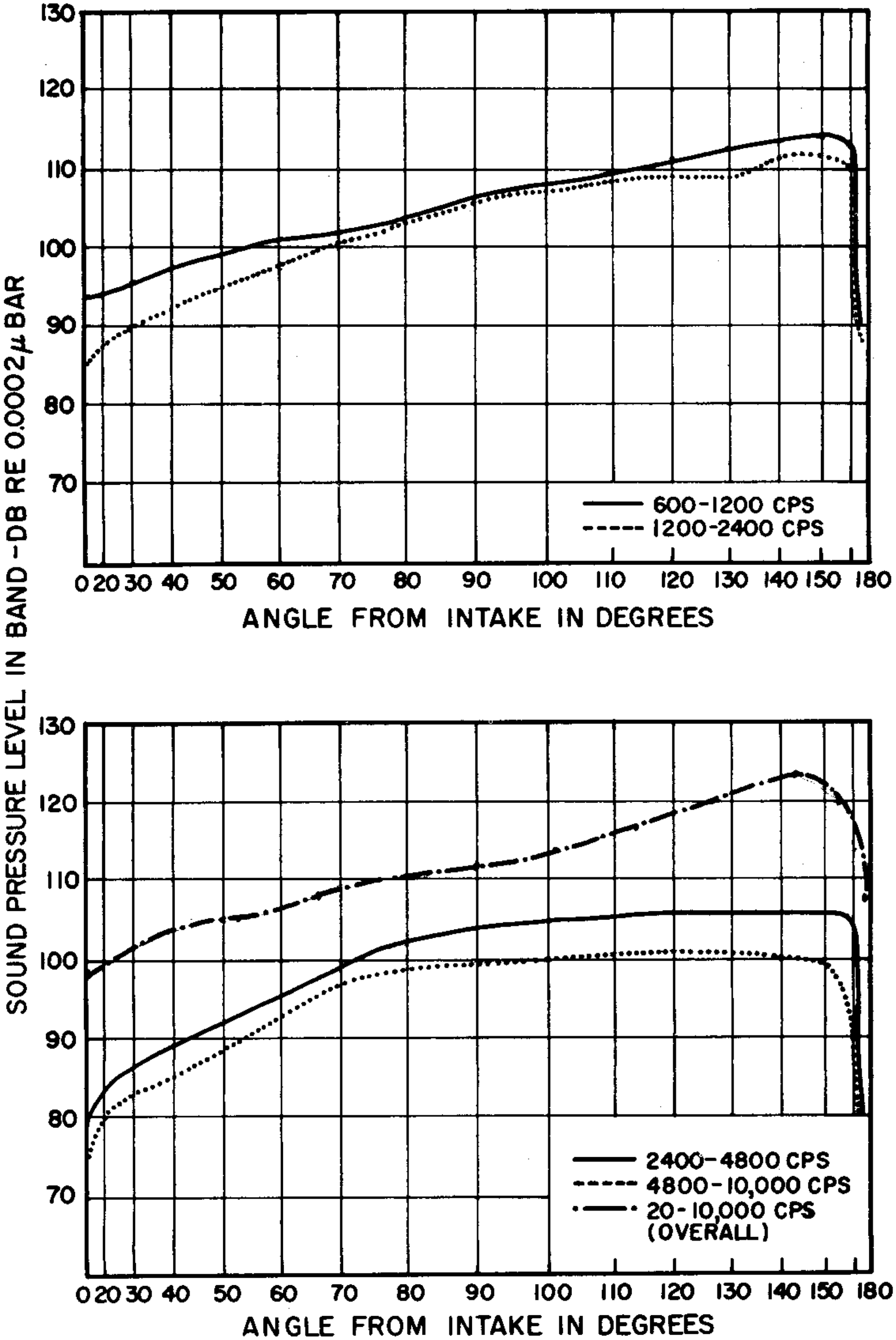
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
76	J48-P-8	100′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
77	J48-P-8	200′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
77	J48-P-8	200′

J57-P-1

TEST GROUP 16

History and Description of Tests

Source of Data: BBN Report No. 352, "Acoustic Survey and Evaluation of J57 Turbojet Engine Test Facility, Aircraft Engine Division, Ford Motor Company, Chicago, Illinois

Date of Tests: 20-23 September 1954

Location of Tests: Ford Motor Company, Aircraft Engine Division, Chicago, Illinois

Placement of Engine: In Test Cell E2

Engine Operating Variables

All engine data were taken from log sheets at the time of the acoustical measurements. T_e is turbine outlet temperature.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_1	m	M_j
79	*	9500	*	-	*	64	*	-
80	*	9500	*	-	*	63	*	-
81	*	8000	*	-	*	63	*	-
82	*	7000	*	-	*	63	*	-
83	*	5500	*	-	*	63	*	-
84	*	3000	*	-	*	63	*	-
85	*	2000	*	-	*	64	*	-

* classified data

\- data not available

J57-P-1

TEST GROUP 16

Acoustic Measurement Techniques and Method of Obtaining PWL

The "noise reduction" method was used to obtain PWL. Both the exhaust and intake acoustic powers are considered.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt								
		over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
79	50,000	177	163	165	170	172	170	164	160	-
80	50,000	177	161	164	171	172	169	165	160	-
81	20,000	173	160	163	168	168	165	161	157	-
82	10,000	170	157	159	165	164	163	157	153	-
83	3,000	165	151	156	161	158	153	151	152	-
84	830	159	146	148	151	149	148	155	146	-
85	400	156	144	148	149	145	148	152	145	-

J57-P-7

TEST GROUP 17

History and Description of Tests

Source of Data:	Memorandum from Wright Air Development Center 2 December 1954
Date of Tests:	23-27 October 1954
Location of Tests:	Nellis AFB, Nevada
Placement of Engine:	In F-100A aircraft in open field

Engine Operating Variables

The engine data was obtained from a private communication from Wright Air Development Center. The values given were obtained from the aircraft manufacturer and are representative of the values of the engine variables which are obtained with the J57 mounted in an F100 aircraft. The thrust is given to the nearest 500 lb.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
86	-	8000	*	*	*	*	*	-

* classified data

\- data not available

J57-P-7

TEST GROUP 17

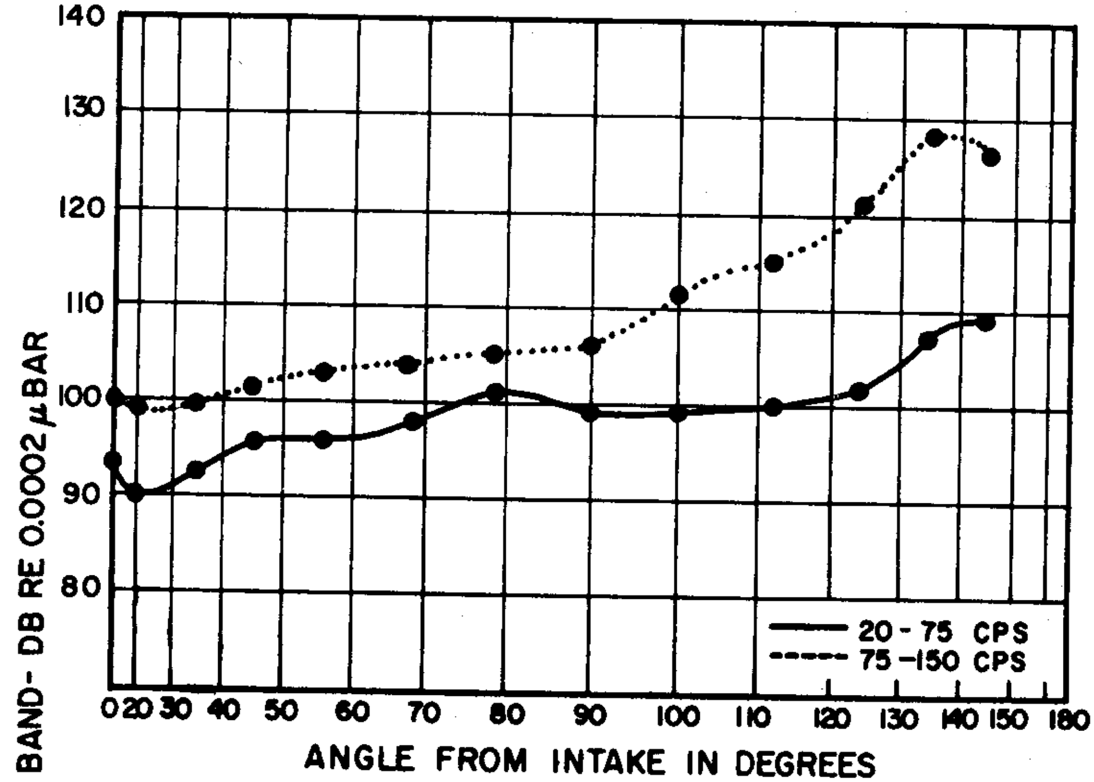
Acoustic Measurement Techniques and

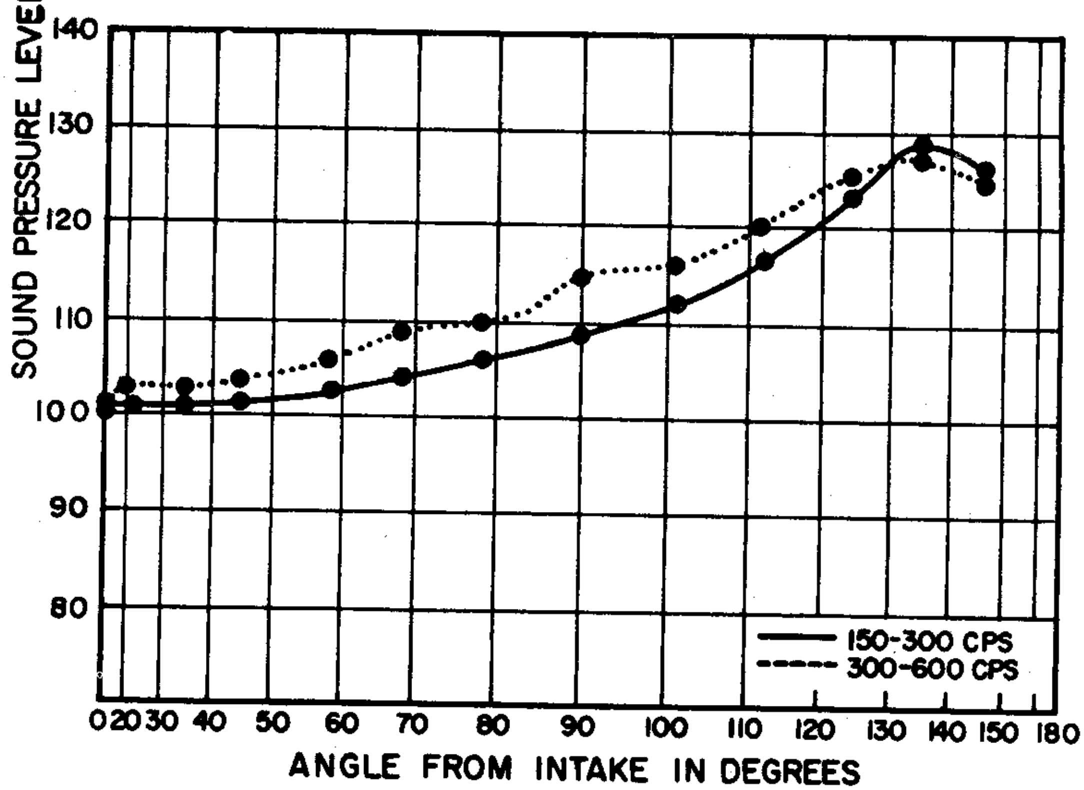
Method of Obtaining PWL

Data was obtained on a semicircle of 100' radius. Measurements were made at discrete points 11-1/4° apart. The microphone was about 6' off the ground.

Power Levels and Total Acoustic Power

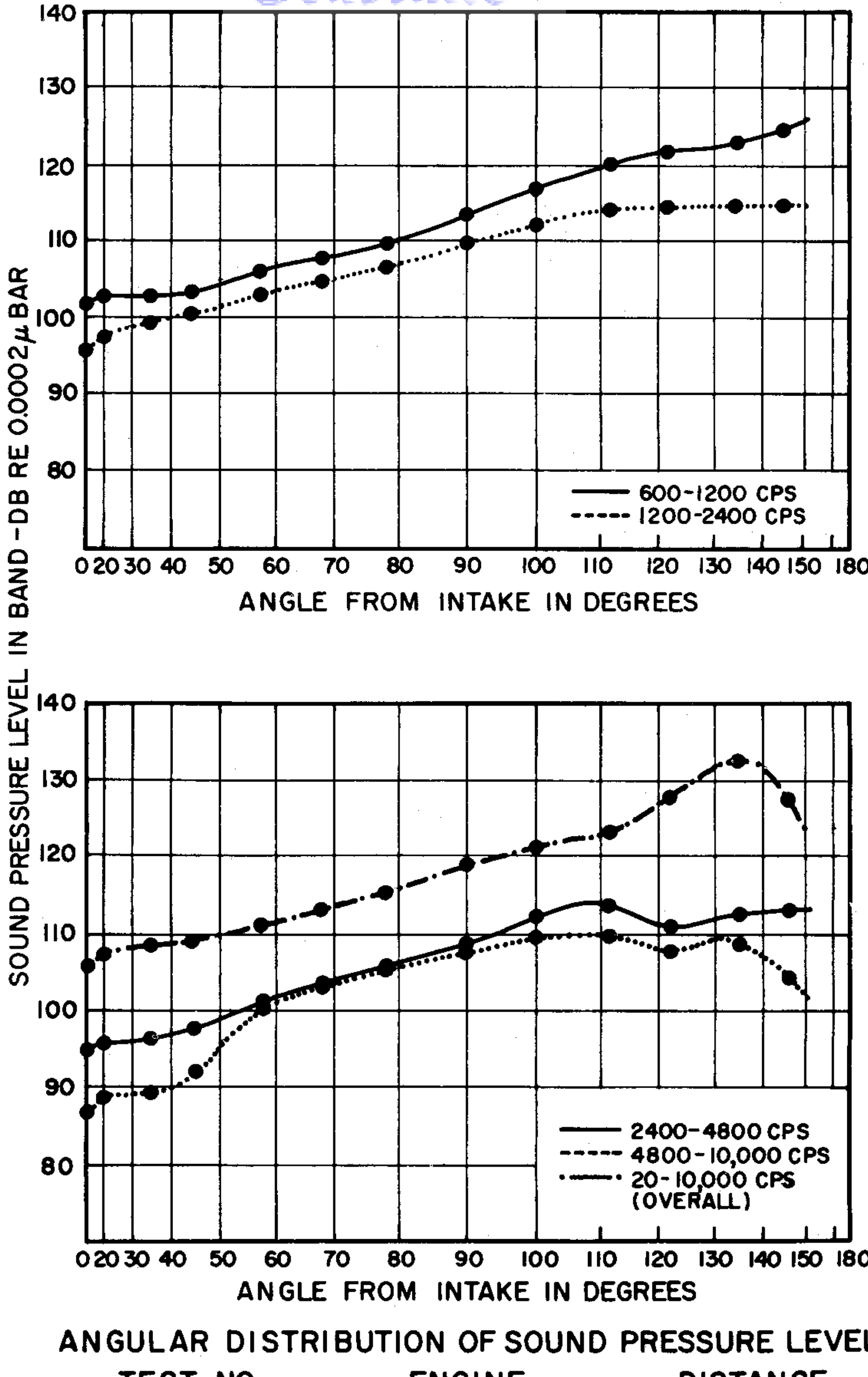
Test No.	Total Power watts	PWL in db re 10^{-13} watt								
		over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
86	16,000	172	159	167	168	168	165	158	157	154





ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
86	J-57-P-7	100′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
86	J-57-P-7	100′

J57-P-7

TEST GROUP 17a

History and Description of Tests

Source of Data:	BBN Report No. 318, "Noise Survey F102A and T29 Run-up Operations," 29 July 1955
Date of Tests:	16-17 June 1955
Location of Tests:	San Diego, California
Placement of Engine:	In F102A aircraft in open field

Engine Operating Variables

The data on the engine was obtained from Convair power plant engineers at the time of the acoustic measurement. Thrust is given to the nearest 500 lbs.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
87	-	8000	-	*	*	*	*	-

* classified data

\- data not available

J57-P-7

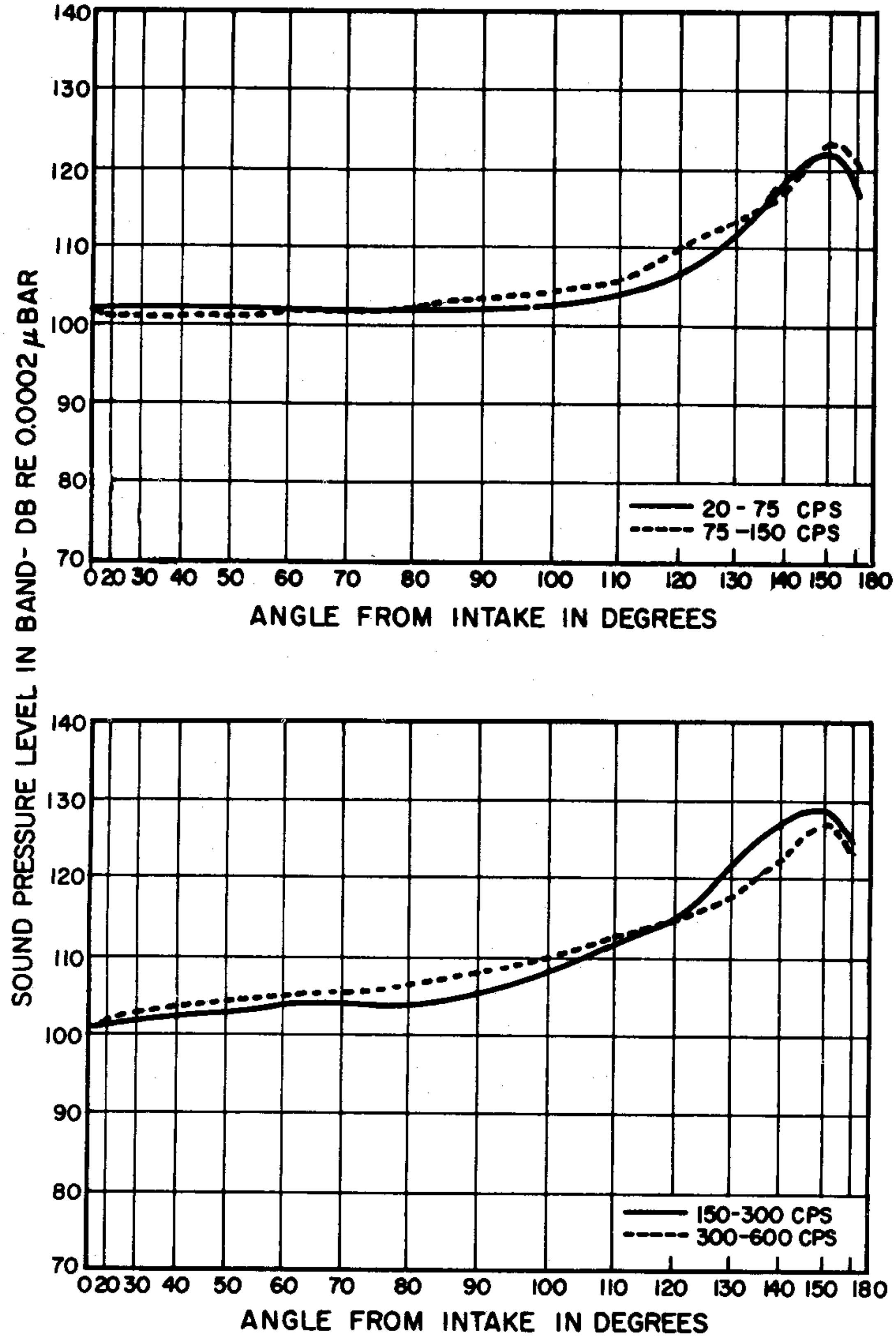
TEST GROUP 17a

Acoustic Measurement Techniques and Method of Obtaining PWL

A continuous traverse with the microphone was made on a semicircle of 100' radius centered at the exhaust orifice of the airplane. Data were recorded on magnetic tape and reduced in octave bands. Windscreens were used. The microphone was approximately 5' above ground.

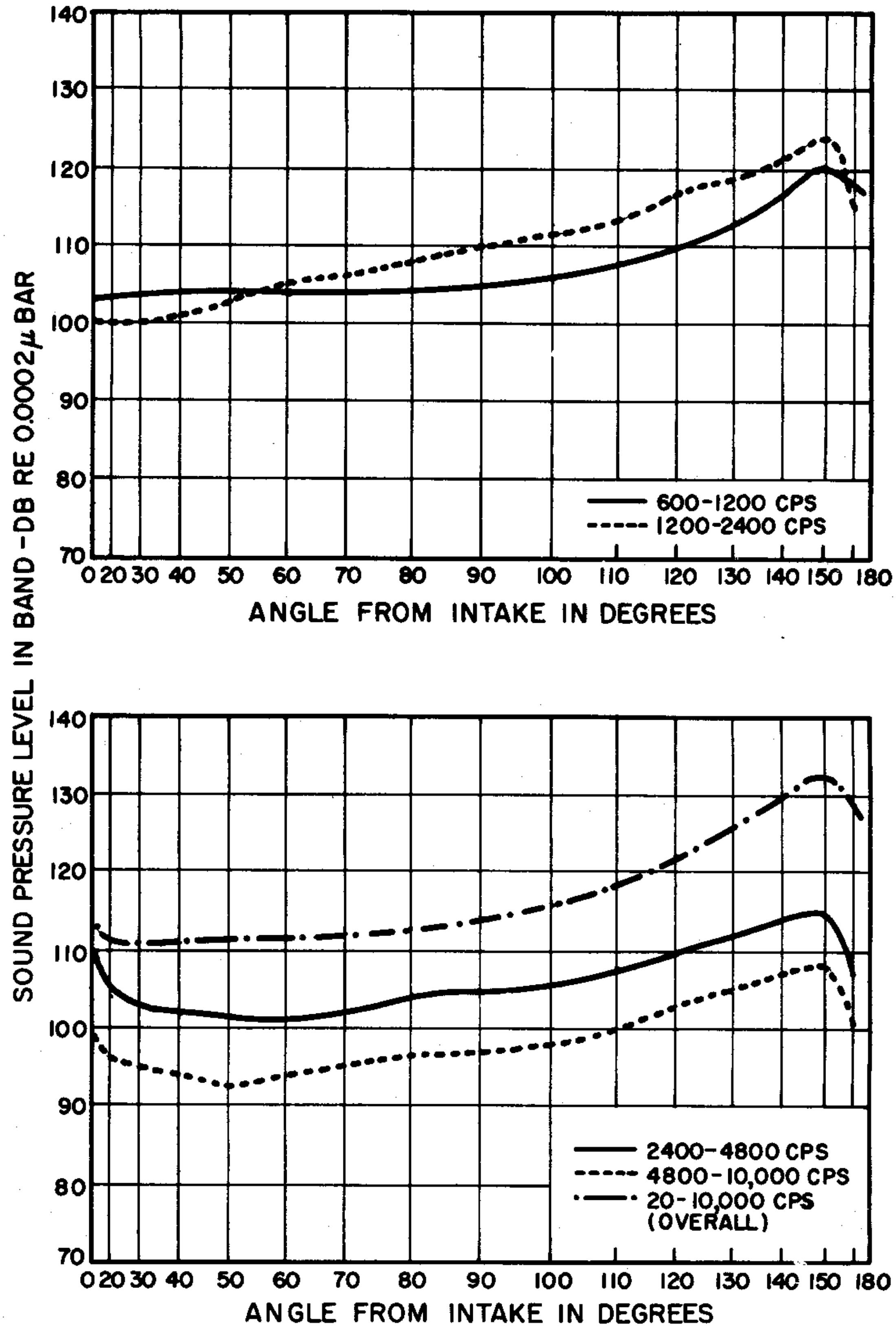
Power Levels and Total Acoustic Power

Test No.	Total Power	PWL in db re 10^{-13} watt								
	watts	over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
87	16,000	172	161	163	168	166	165	160	158	149



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
87	J-57-P-7	100'



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
87	J-57-P-7	100'

J65-B-3

TEST GROUP 18

History and Description of Tests

Source of Data: BBN Report No. 326, "Acoustical Survey and Evaluation of Buick Motor Division, GMC, Turbojet Engine Test Facility, Willow Springs, Illinois

Date of Tests: 12-16 July 1954

Location of Tests: Turbojet Engine Test Facility, Buick Motor Division, GMC, Willow Springs, Illinois

Placement of Engine: In Test Cell 107

Engine Operating Variables

All engine data were obtained from engine log sheets at the time of the acoustic measurements. A calibrated bell mouth was used to obtain the mass flow of the engine.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
88	3100	225	960	-	1495	78	20.5	-
89	5000	865	1540	-	1265	77	42	-
90	6600	2665	3550	-	1175	77	76.5	-
91	7400	4390	3850	-	1315	78	94	-
92	8300	6875	6175	-	1580	78	110	-

J65-B-3

TEST GROUP 18

Acoustic Measurement Techniques and Method of Obtaining PWL

The "noise reduction" method was used to obtain PWL. Both the exhaust and intake acoustic powers are considered.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
88	1,600	162	132	139	161	155	150	146	145	-
89	1,000	160	141	148	149	156	157	150	150	-
90	5,000	167	148	152	156	162	163	156	148	-
91	12,000	171	150	155	159	166	167	159	152	-
92	40,000	176	156	160	164	171	172	164	156	-

J71-A-2

TEST GROUP 19

History and Description of Tests

Source of Data:	BBN Report No. 310, "Acoustical Evaluation of Helical Muffler, Burgess-Manning Muffler, Allison Plant No. 5, Indianapolis," 29 August 1955
Date of Tests:	15-17 April 1955
Location of Tests:	Allison Plant No. 5, Indianapolis
Placement of Engine:	Mounted on thrust stand in Test Cell 129

Engine Operating Variables

Engine data were supplied by Allison engineers at the time of the acoustic measurements.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
93	-	9000	-	22	1570	-	160	-

J71-A-2

TEST GROUP 19

Acoustic Measurement Techniques and

Method of Obtaining PWL

PWL's were obtained by the noise reduction method. Only power radiated through the exhaust treatment is included. This should not significantly affect the overall PWL.

Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
93	80,000	179	160	162	167	170	173	163	157	146

Rolls Royce Avon

TEST GROUP 20

History and Description of Tests

Source of Data:	F. B. Greatrex, "Jet Noise," Preprint No. 559, Institute of Aeronautical Sciences, New York (June 1955)
Date of Tests:	Unknown
Location of Tests:	Rolls Royce Ltd., Nottingham, England
Placement of Engine:	In test stand in open field

Engine Operating Variables

The engine operating variables were obtained partially from "Jet Noise" (see above) and partially from private communications.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
94	-	-	-	*	*	-	-	*

* classified data

\- data not available

Rolls Royce Avon

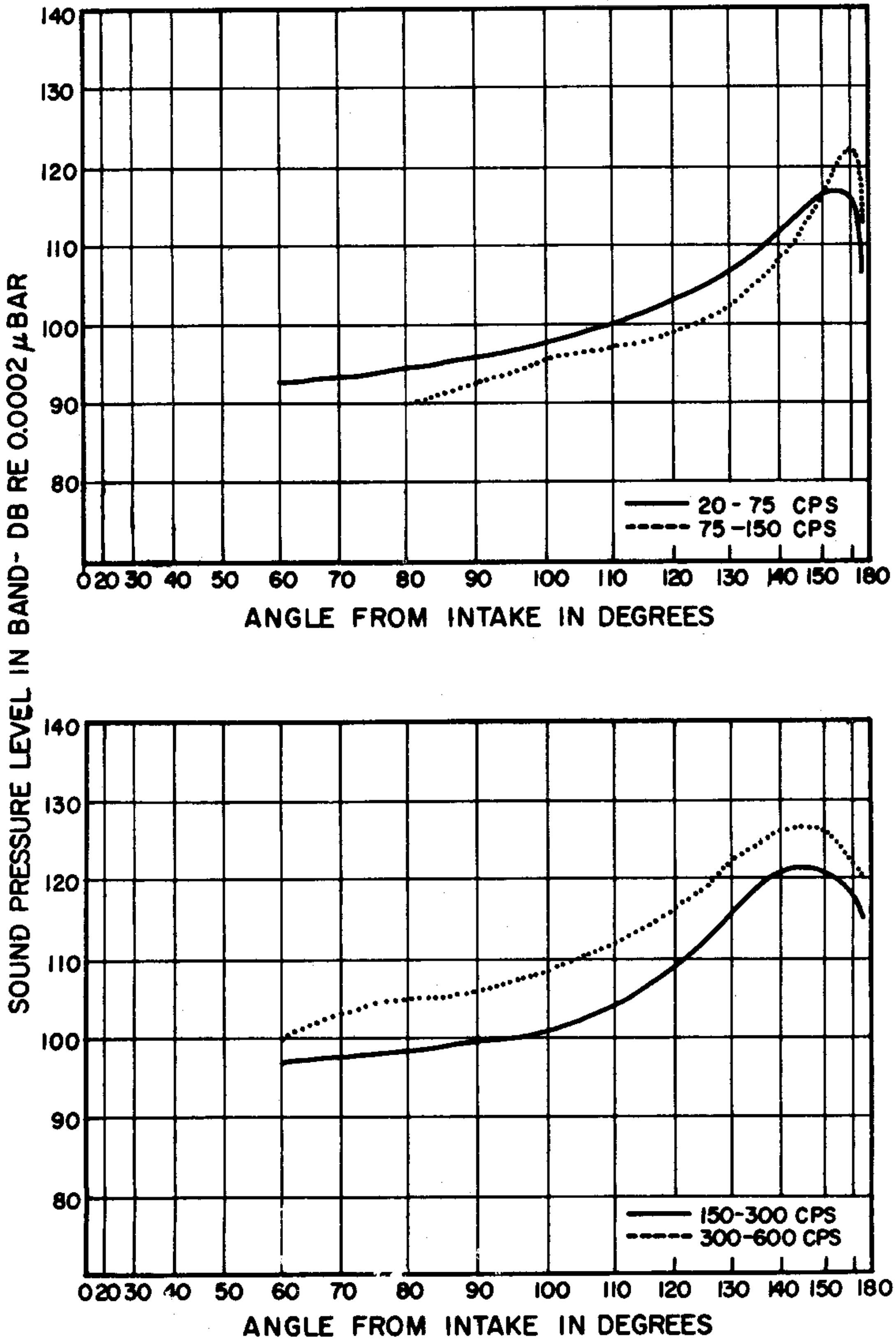
TEST GROUP 20

Acoustic Measurement Techniques and Method of Obtaining PWL

Measurements were made at radii of 10', 15', 25' 50' 75', 125', 200' at angles of 15°, 20°, 30°, 40°, 50°, 60°, 70°, 80°, 90°, 100°, 110°, and 120° from the axis of the jet (0° is the direction of jet velocity). The measurements were presented as equal SPL contours 5 db apart. The contours were in turn used to obtain the SPL on a semicircle of 100' radius. The acoustic measurements took several days to take. The acoustic stability of one engine over this period is not known.

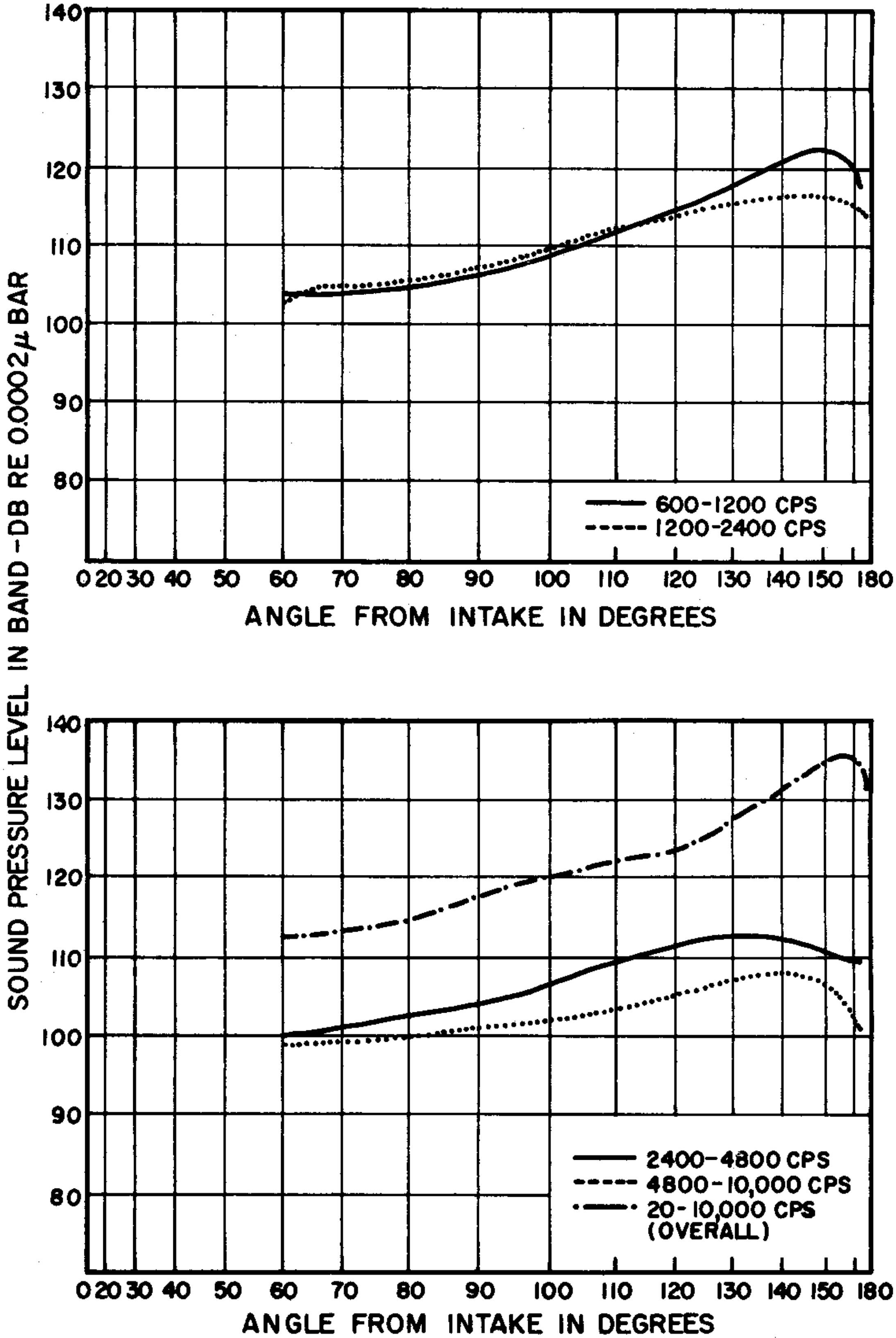
Power Levels and Total Acoustic Power

Test No.	Total Power	PWL in db re 10^{-13} watt								
	watts	over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
94	-	170	155	157	161	167	162	158	156	150



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
94	AVON	100'



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
94	AVON	100'

Rolls Royce Conway

TEST GROUP 21

History and Description of Tests

Source of Data: F. B. Greatrex, "Jet Noise," Preprint No. 559, Institute of Aeronautical Sciences, New York (June 1955)

Date of Tests: Unknown

Location of Tests: Rolls Royce Ltd., Nottingham, England

Placement of Engine: In test stand in open field

Engine Operating Variables

The engine operating variables were obtained partially from "Jet Noise" (see above) and partially from private communications.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
95	-	-	-	*	*	-	-	*

* classified data

\- data not available

Rolls Royce Conway

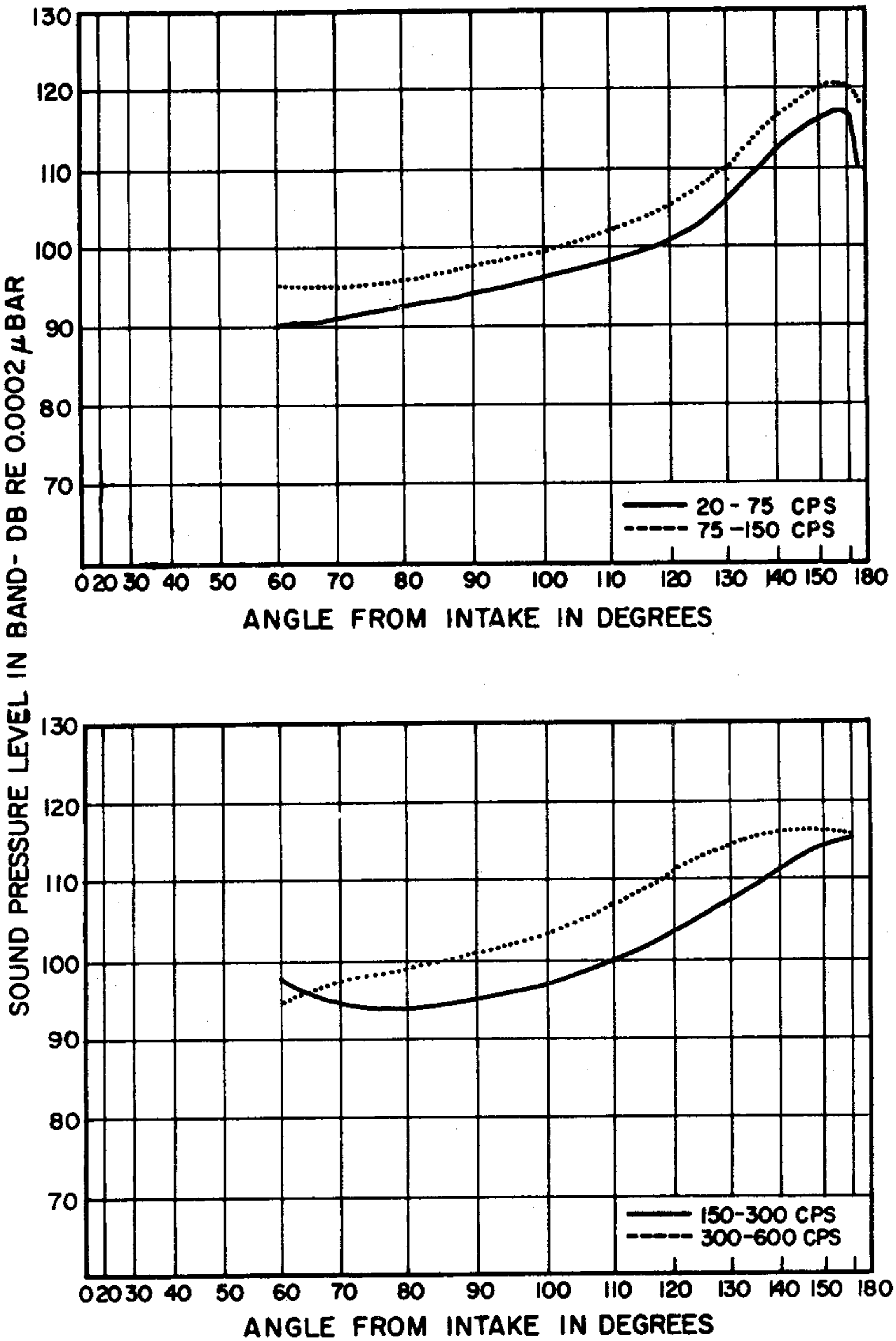
TEST GROUP 21

Acoustic Measurement Techniques and Method of Obtaining PWL

Measurements were made at radii of 10', 15', 25', 50', 75', 125', 200' at angles of 15°, 20°, 30°, 40°, 50°, 60°, 70°, 80°, 90°, 100°, 110°, and 120° from the axis of the jet (0° is the direction of jet velocity). The measurements were presented as equal SPL contours 5 db apart. The contours were in turn used to obtain the SPL on a semi-circle of 100' radius. The acoustic measurements took several days to take. The acoustic stability of the engine over this period is not known.

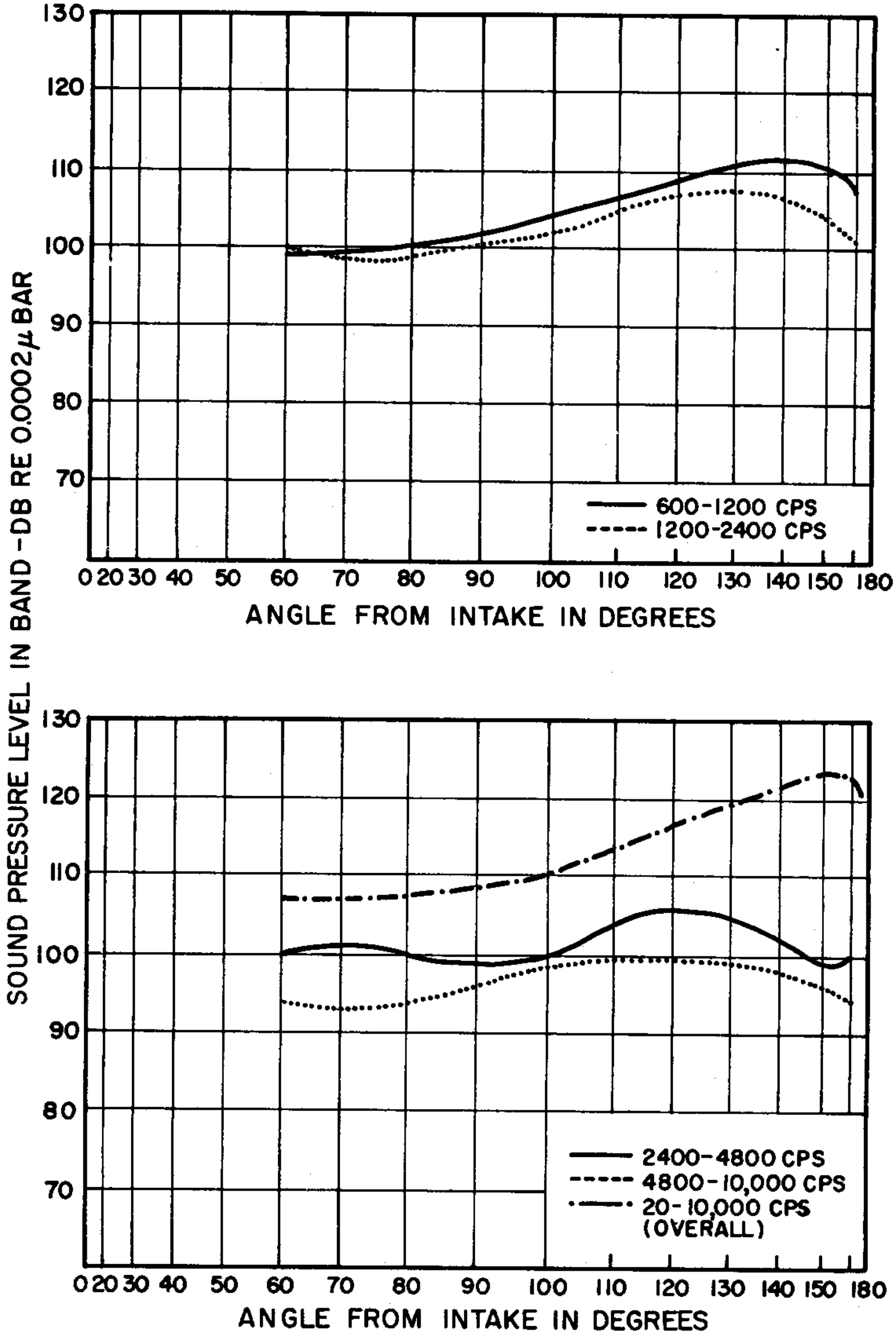
Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
95	-	164	154	159	153	157	154	150	146	144



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
95	CONWAY	100′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
95	CONWAY	100′

Rolls Royce Derwent

TEST GROUP 22

History and Description of Tests

Source of Data: F. B. Greatrex, "Jet Noise," Preprint No. 559, Institute of Aeronautical Sciences, New York (June 1955)

Date of Tests: Unknown

Location of Tests: Rolls Royce Ltd. Nottingham, England

Placement of Engine: In test stand in open field

Engine Operating Variables

The engine operating variables were obtained partially from "Jet Noise" (see above) and partially from private communications.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
96	*	1000	-	*	*	-	-	-
97	*	2500	-	*	*	-	-	*
98	*	3100	-	*	*	-	-	-

* Data classified

\- Data not available

Rolls Royce Derwent

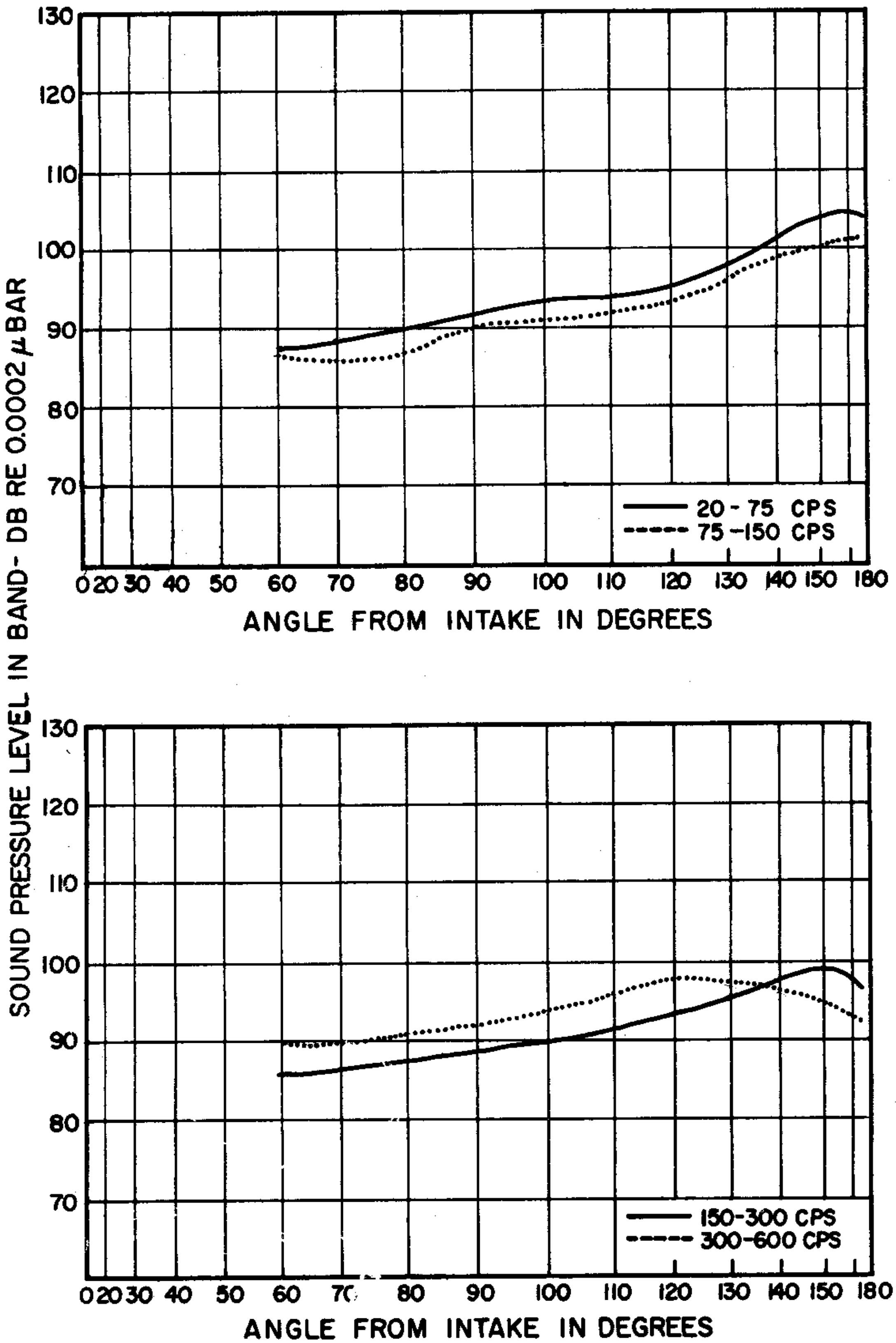
TEST GROUP 22

Acoustic Measurement Techniques and Method of Obtaining PWL

Measurements were made at radii of 10', 15', 25', 50', 75', 125', 200' at angles of 15°, 20°, 30°, 40°, 50°, 60°, 70°, 80°, 90°, 100°, 110°, and 120° from the axis of the jet (0° is the direction of jet velocity). The measurements were presented as equal SPL contours 5 db apart. The contours were in turn used to obtain the SPL on a semicircle of 100' radius. The acoustic measurements took several days to obtain. The acoustic stability of the engine over this period is not known.

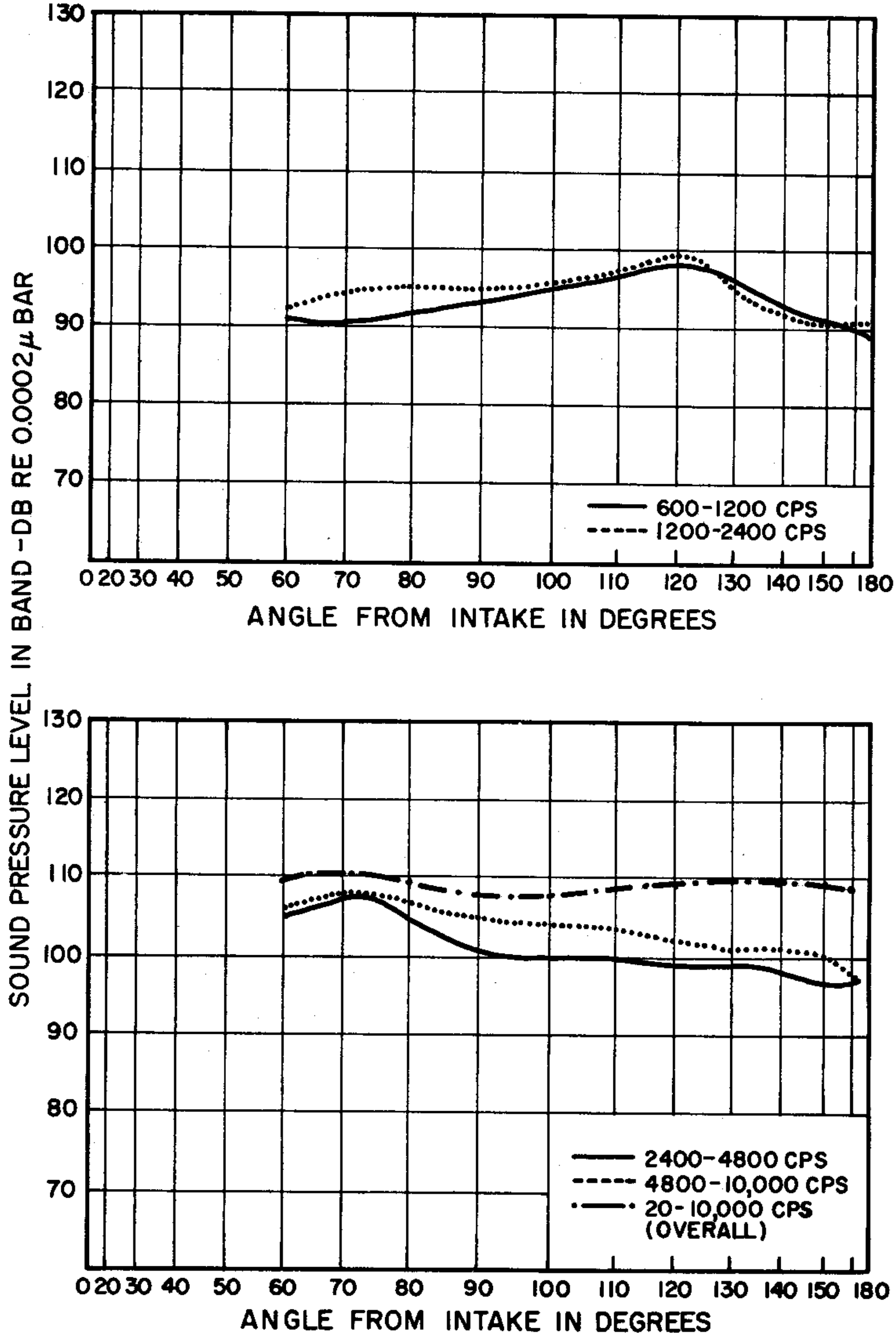
Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt								
		over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
96	80	149	138	135	134	135	135	136	142	146
97	1000	160	148	152	147	156	152	148	148	-
98	2500	164	148	149	158	156	157	154	150	152



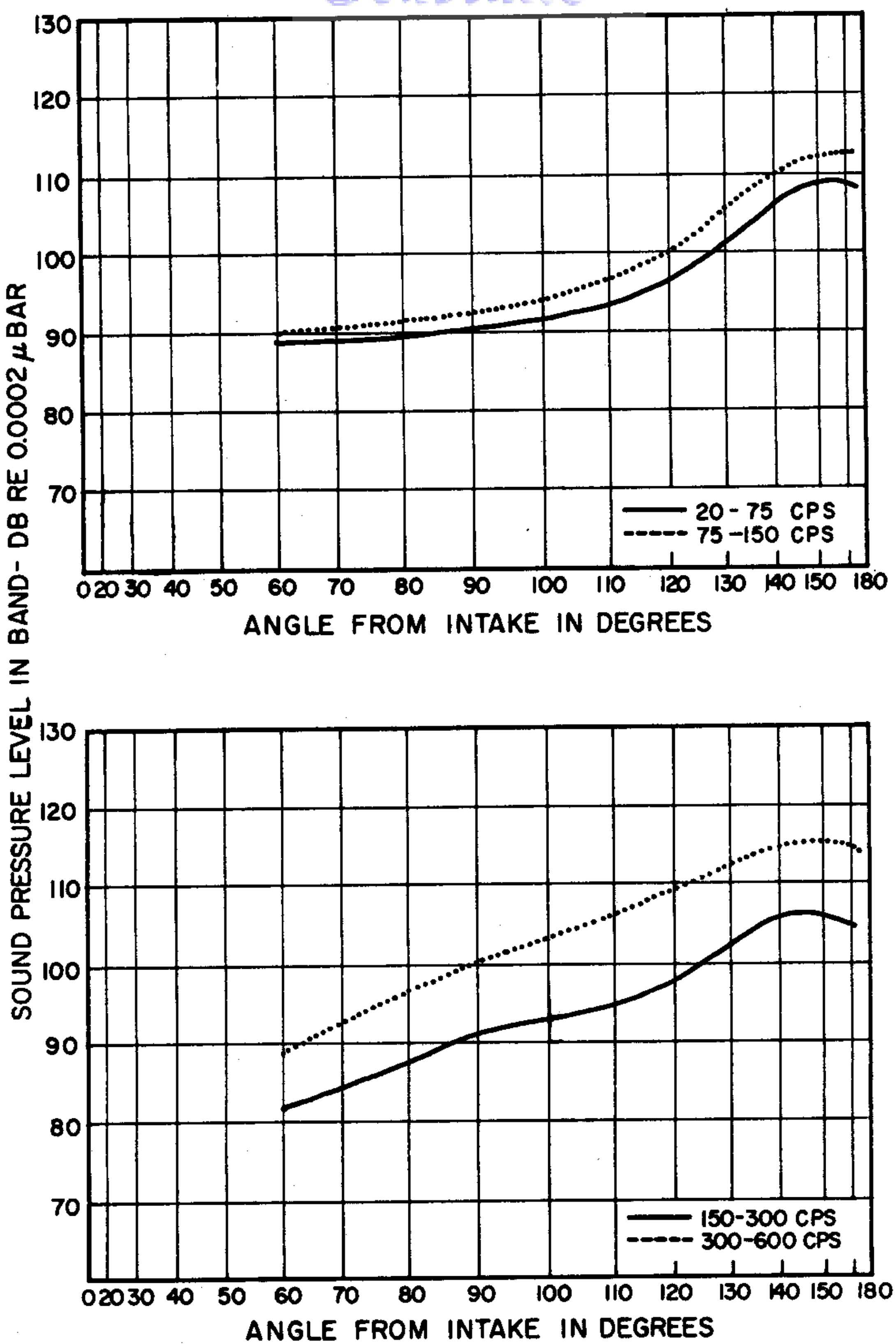
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
96	DERWENT	50′



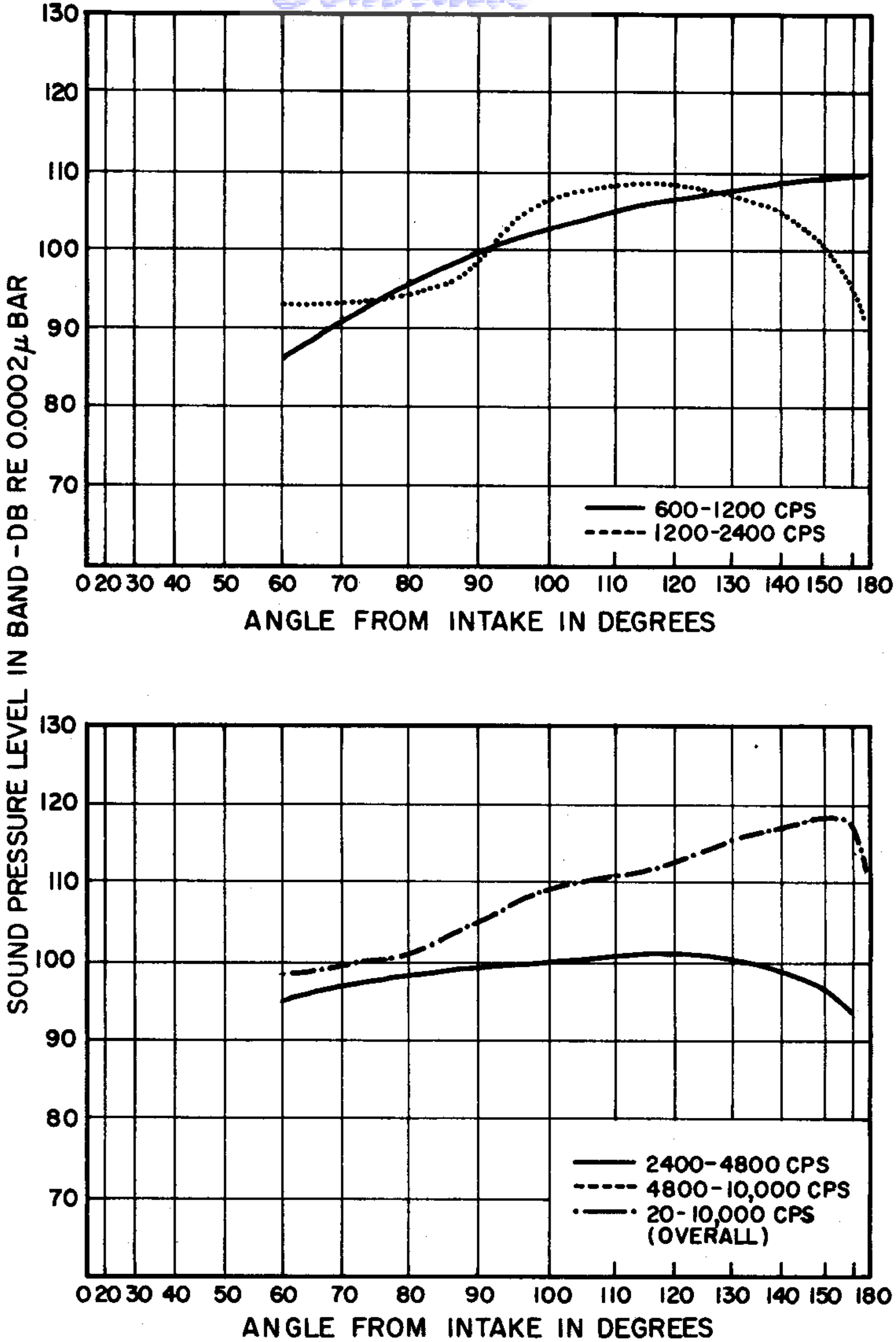
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
96	DERWENT	50′



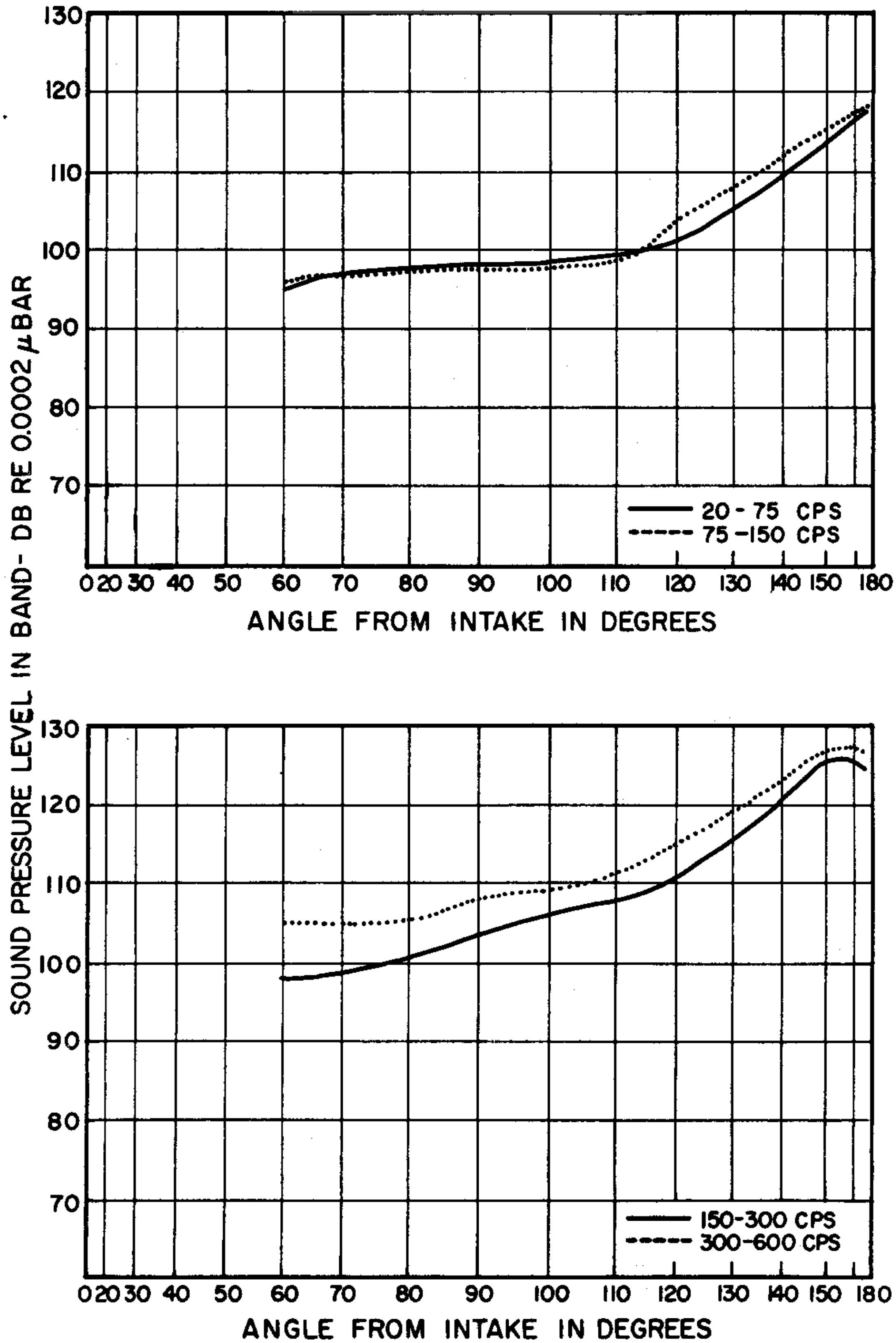
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
97	DERWENT	100'



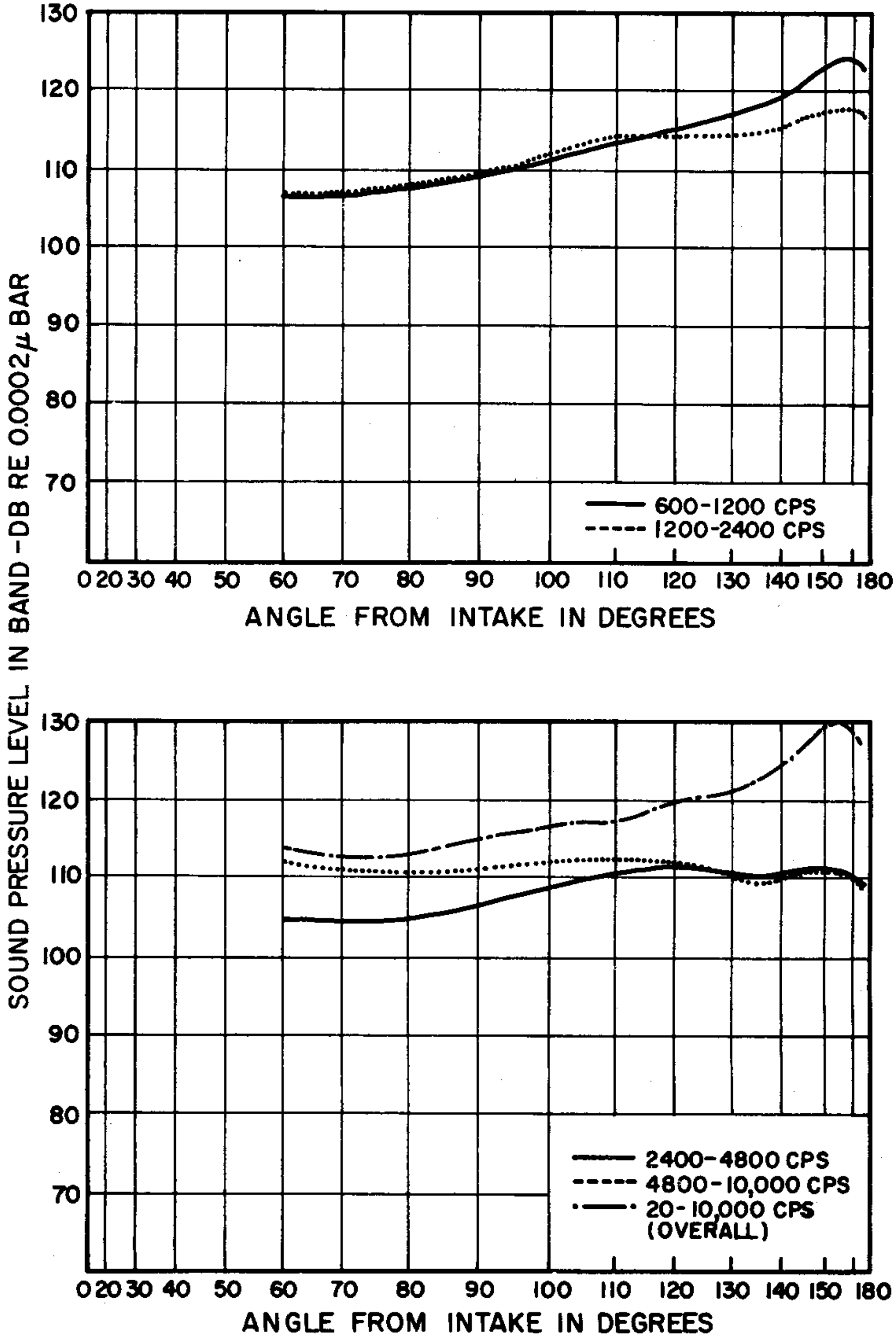
ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
97	DERWENT	100′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
98	DERWENT	50'



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
98	DERWENT	50′

Rolls Royce Nene

TEST GROUP 23

History and Description of Tests

Source of Data: This data was obtained from an appendix of a classified report. The appendix itself has been declassified, as is the data contained in this report. Reference to the source of this data is, however, not permitted.

Date of Tests:

Location of Tests:

Placement of Engine: In test stand in open field

Engine Operating Variables

The engine operating variables were obtained partially from "Jet Noise" (see above) and partially from private communications.

Values of Engine Operating Variables

Test No.	n	F	f	d	T_e	T_i	m	M_j
99	*	*	-	*	*	-	-	*

* classified data

\- data not available

Rolls Royce Nene

TEST GROUP 23

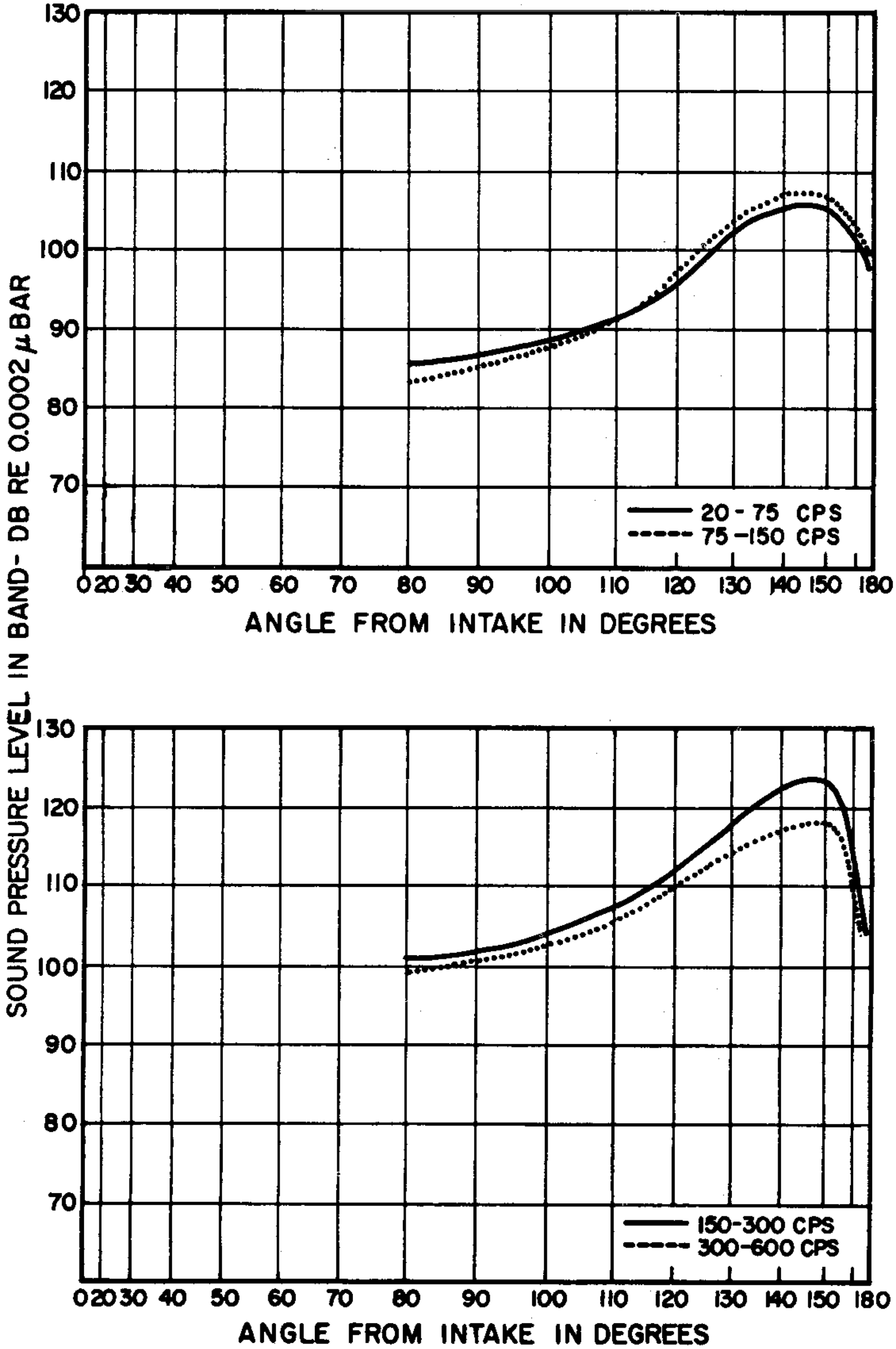
Acoustic Measurement Techniques and

Method of Obtaining PWL

Sound pressure measurements were made at 15° intervals, 150' from exhaust orifice.

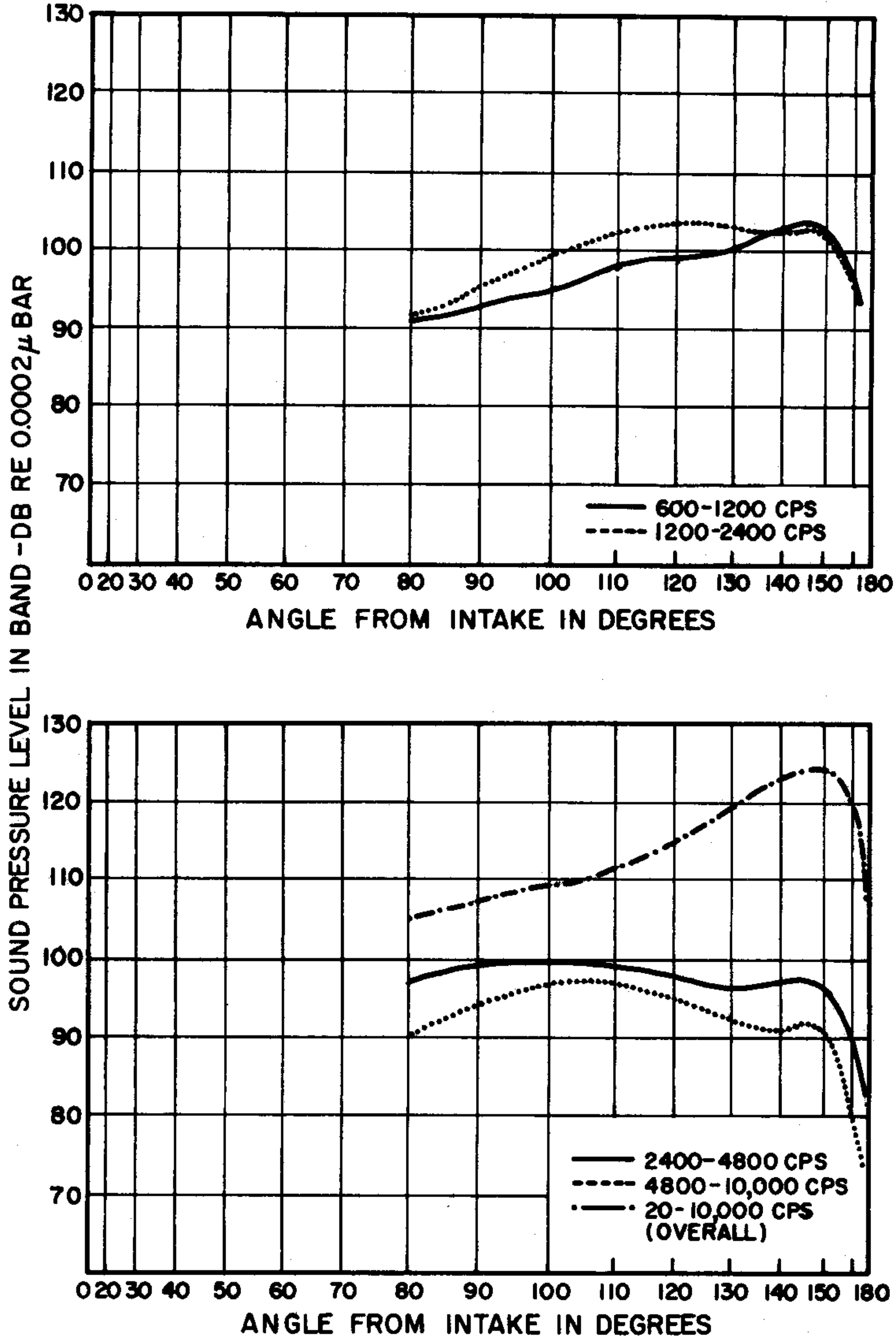
Power Levels and Total Acoustic Power

Test No.	Total Power watts	PWL in db re 10^{-13} watt over all	20 75	75 150	150 300	300 600	600 1200	1200 2400	2400 4800	4800 10000
99	6300	168	150	148	166	160	148	150	148	144



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
99	NENE	150′



ANGULAR DISTRIBUTION OF SOUND PRESSURE LEVEL

TEST NO.	ENGINE	DISTANCE
99	NENE	150′

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