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ANALYSIS OF IN-FLIGHT ACOUSTIC DATA FOR A TWIN-ENGINED TURBOPROP AIRPLANE

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1. INTRODUCTION

During recent years there has been considerable research activity in the field of noise control in propeller-driven aircraft [1]. This interest has been generated to a large extent by the advent of high speed propellers designed for cruise at flight Mach numbers of about 0.8. Since the propellers generate high sound pressure levels under these operating conditions, there is a need to evaluate means for reducing the interior sound pressure levels. Other areas of interest in propeller noise are related to general aviation aircraft, again due to the desire for improved noise control and a reassessment of simplified prediction methods for propeller near-field noise.

There are several approaches to the design and evaluation of noise control treatments for propeller aircraft interiors. Analytical studies can be performed on candidate treatments, laboratory tests can be conducted using either noise transmission suites or actual aircraft fuselages, or flight test measurements can be undertaken. While the flight test approach has the advantage that it is the most representative of actual operational conditions, the measurement of interior noise in propeller-driven aircraft poses a number of problems in terms of data accuracy and variability. For example, it is often found that flight test evaluations of noise control treatments suffer from data variability, with the consequence that confusing or misleading information can be obtained regarding the acoustic performance of the treatment. This is particularly critical for treatments that provide only small changes in the interior noise levels, as is often the case at low frequencies. The problems arise because propeller noise is dominated by a series of discrete frequency components. Thus, interior sound pressures can be influenced strongly by changes in cabin acoustic modes, uncertainties in propeller synchrophasing and beats between different propellers.

Some of the problems associated with the evaluation of interior noise control treatments in propeller-driven aircraft were evident in flight tests measurements made in a general aviation turboprop airplane [2,3]. The problems were associated, at least in part, with data variability from flight to flight, with the result that the acoustic performance of the treatment could not be evaluated accurately for low order harmonics of the propeller blade passage frequency. As a consequence, a second series of flight tests was conducted with the objective of improving the understanding of the problems and exploring methods of alleviating them. Results from these flight tests are described in this report, data from the tests having been documented in an earlier report [4]. The flight test program consisted of four flights, the first three of which were performed with an untreated cabin and had the objective of determining data repeatability. Prior to the fourth flight, a limited amount of acoustic treatment was installed in the cabin so that problems associated with the evaluation of noise control materials could be assessed.

The discussion in this report considers exterior and interior sound pressure levels separately, both discrete frequency and broadband components being included. Statistical parameters in the form of standard deviation and confidence limits are calculated for the data in order to obtain quantitative assessments of the data variability. In the case of the exterior sound pressure levels, the harmonic and broadband levels are compared with simplified prediction methods for propeller noise and turbulent boundary layer pressure fluctuations, respectively. Interior sound pressure levels are analyzed in terms of contributions from port and starboard propellers, including the influence of relative phase between the two propellers. Finally, the insertion loss provided by the treatment is discussed in terms of the data variability. Average values of insertion loss are compared with measurements from laboratory tests and predictions based on acoustic absorption only.

2. TEST DESCRIPTION

2.1 Test Airplane

The airplane used for the tests was a Gulfstream Aerospace Commander 695A. The Commander is a high-wing business aircraft with a maximum take-off weight of 5079 kg (11,200 lb); it has a pressurized cabin and retractable landing gear. During the test program, the fuselage interior did not contain standard sidewall treatment or cabin furnishings. Except for the fourth flight, the interior was bare.

The Commander 695A is powered by two AiResearch TPE331-10-501K single-shaft, turboprop engines which have a nominal rating of 610 kW (820 SHP). The engines drive Dowty Rotol three-bladed propellers with super-critical airfoil sections. The propellers have a diameter of 2.69 m (106 inches) and the minimum clearance between the fuselage and the propeller tip is 0.36 m (14 inches) or 0.13D, where D denotes the propeller diameter. The maximum rotational speed of the TPE331-10-510K engine is 41,800 rpm. There is a two-stage reduction gear box, with overall gear reduction ratio of 26.3:1, connecting the engine to the propeller. The maximum rotational speed of the propeller is 1591 rpm and the direction of rotation is counter-clockwise when viewed from the rear. Engine exhausts are located on the outboard side of each nacelle. A three-view diagram of the Commander airplane is given in Figure 1.

The fuselage structure of the Commander 695A is of conventional skin-stringer-frame construction. The thickness of the fuselage sidewall skin panels is typically 1.6 mm (0.063 inch) and the longitudinal stiffeners consist mainly of longerons at three vertical stations.

2.2 Test Conditions

Four flights were performed with the intention of repeating the same test conditions on each flight. Typical test conditions are given in Table 1; test conditions for all four flights are given in Reference 4. Unfortunately, the propeller synchrophaser was not operable during the fourth flight, with the consequence that several of the test conditions could not be achieved. The

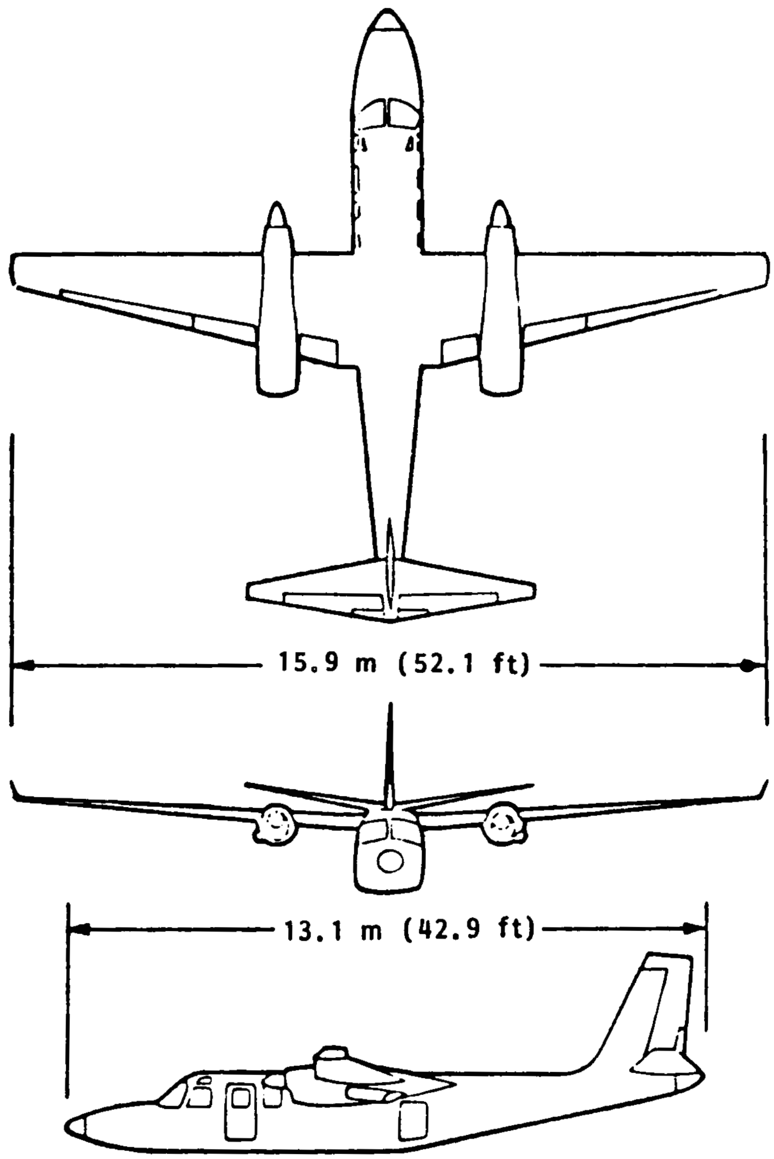


FIGURE 1. THREE-VIEW DIAGRAM OF TEST AIRPLANE

TABLE 1
NOMINAL FLIGHT TEST CONDITIONS

CONDT IDENT.	REMARKS	FLIGHT PRESSURE ALTITUDE m/ft	CABIN ALTITUDE m/ft	CABIN PRESSURE DIFFER. kNm^{-2}/psi	IAS kts	OUTSIDE AIR TEMP °F	PROPELLER OPERATING CONDITION PORT RPM	PORT TORQUE (1)	PORT POWER kW/SHP	STARBOARD RPM	STARBOARD TORQUE (1)	STARBOARD POWER kW/SHP	RELATIVE PHASE SETTING (2)
1	Zero Pressure Diff.	3.0k/10k	3.0k/10k	0	Not Specified	Not Specified	1591	80%	Not Specified	1527	80%	Not Specified	———
2	Zero Pressure Diff.	3.0k/10k	3.0k/10k	0			1527	80%		1591	80%		———
3	Cabin Pressurized	3.0k/10k	Normal	Normal			1527	80%		1591	80%		———
4	Cabin Pressurized	3.0k/10k	Normal	Normal			1591	80%		1527	80%		———
5	Normal Cruise	4.6k/15k	0.7k/2.3k	36/5.2			1527	80%		1527	80%		9 o'clock
6	Normal Cruise	4.6k/15k	0.7k/2.3k	36/5.2			1527	80%		1527	80%		11 o'clock
7	Normal Cruise	4.6k/15k	0.7k/2.3k	36/5.2			1527	80%		1527	80%		1 o'clock
8	Normal Cruise	4.6k/15k	0.7k/2.3k	36/5.2			1527	80%		1527	80%		3 o'clock
9	Engines Diff.RPM	4.6k/15k	0.7k/2.3k	36/5.2			1591	80%		1527	80%		———
10	Engines Diff.RPM	4.6k/15k	0.7k/2.3k	36/5.2			1527	80%		1591	80%		———
11	Starboard Engine	4.6k/15k	0.7k/2.3k	36/5.2			0	0		1527	80%		———
12	Port Engine	4.6k/15k	0.7k/2.3k	36/5.2			1527	80%		0	0		———
13	Normal Cruise	9.1k/30k	2.6k/8.6k	43/6.3			1527	52%		1527	52%		9 o'clock
14	Normal Cruise	9.1k/30k	2.6k/8.6k	43/6.3			1527	52%		1527	52%		11 o'clock
15	Normal Cruise	9.1k/30k	2.6k/8.6k	43/6.3			1527	52%		1527	52%		1 o'clock
16	Normal Cruise	9.1k/30k	2.6k/8.6k	43/6.3			1527	52%		1527	52%		3 o'clock
17	Engines Diff.RPM	9.1k/30k	2.6k/8.6k	43/6.3			1591	52%		1527	52%		———
18	Engines Diff.RPM	9.1k/30k	2.6k/8.6k	43/6.3			1527	52%		1591	52%		———

(1) Torque measured as percentage of maximum

(2) Relative phase setting measured arbitrarily in terms of position of cockpit control knob

first three flights were performed with the cabin untreated. No changes were made to the cabin contents between these flights and the transducers were not moved. Following the third flight, the acoustic instrumentation was removed so that the fiberglass batts could be installed. The instrumentation was re-installed prior to the fourth flight. The flights were typically 90 minutes in duration and were conducted at different times of day between 0730 hrs and 1600 hrs.

Three nominal flight altitudes were selected for the tests, 3,000 m (10,000 ft), 4,600 m (15,000 ft) and 9,100 m (30,000 ft). The 3,000 m altitude was chosen as suitable for tests at zero cabin pressure differential, the 4,600 m altitude was suitable for various tests including single-engine operation, and the 9,100 m altitude was a typical cruise altitude. The actual value of flight altitude for any given test depended upon aircraft traffic control constraints at the time of the test, but was usually within 500 m of the goal. Propeller torque settings were selected to be typical cruise conditions -- they were also similar to conditions associated with an earlier test program. Propeller rotational speeds were restricted to the range (96% to 100%) permitted for the TPE331 engines. Actual values for the torque were read from cockpit instruments as a percentage of maximum; propeller rpm values were deduced from measured blade passage frequencies in the acoustic spectra.

The instruments in the cockpit of the test airplane did not permit selection of specific relative phase angles between the two propellers when the propellers were operated at the same rotational speed. Adjustment of the relative phase was provided simply by means of a knob without a scale. Consequently, four arbitrary settings were chosen whereby the knob positions were identified as 9 o'clock, 11 o'clock, 1 o'clock and 3 o'clock, respectively. The full range of adjustment for the knob was from 8 o'clock to 4 o'clock. Subsequent analysis of the acoustic test data was used to provide an indication of the associated relative phase angles [4].

When the two propellers were operated at different rotational speeds, but at the same torque, the acoustic contributions from the two propellers were separated in frequency so that contributions from each propeller could be identified. The propeller speeds were selected to be 100% and 96% of maximum, the maximum separation permitted by the engines. Propeller torque was used as the controlling parameter, rather than engine power, because only torque is indicated in the cockpit. As a consequence, the engines were at slightly different power settings, because of the differences in rpm.

All acoustic data were recorded during straight-and-level flight. Flight through clouds was avoided and the flight conditions were essentially "smooth" during the four flight tests. Four crew members were present during each flight -- pilot, flight engineer (in copilot's seat) and two acoustic test engineers (in seats close to microphone locations 2 and 3).

2.3 Instrumentation

During the flight test program, measurements were made of the sound pressure levels inside the cabin and the fluctuating pressures on the exterior of the fuselage. Six fixed microphone locations were selected inside the cabin; these locations are identified in Figure 2 and listed in Table 2. Four of the locations were on the starboard side of the cabin and two on the port side; all six microphones were positioned vertically at the approximate ear height of a seated occupant. The microphones were not moved until the end of the third flight, when they were removed to allow for installation of the fiberglass treatment. The microphones were re-installed for the fourth flight.

Exterior fluctuating pressures were measured simultaneously on the port and starboard sides of the fuselage using two condenser microphones mounted without protective grids and with diaphragms flush with the exterior surface of the skin panels. The locations are shown in Figure 2 and listed in Table 3. Based on available drawings, it is estimated that the flush-mounted microphones were about 5 cm (2 inches) below the centers of the propeller spinners.

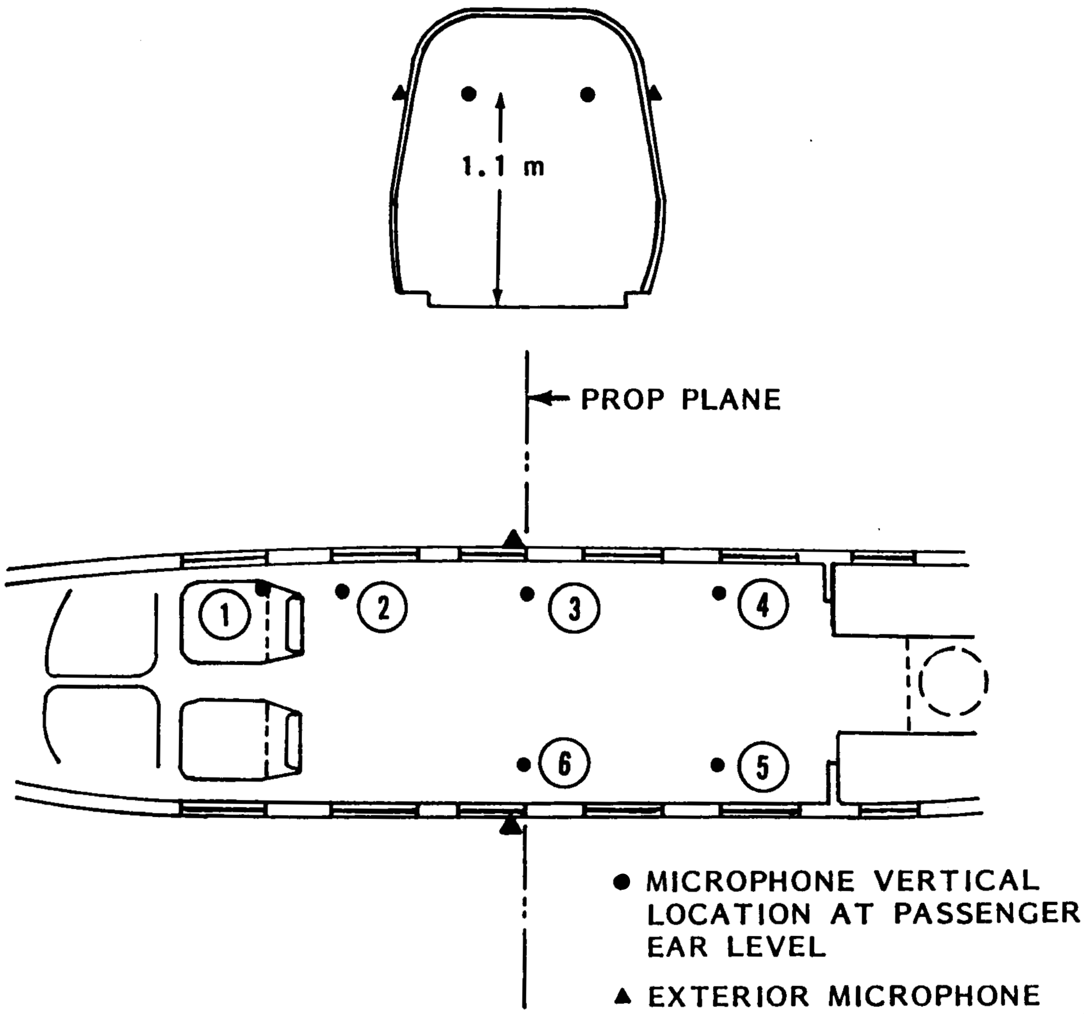


FIGURE 2. LOCATIONS OF MICROPHONES INSIDE CABIN AND ON EXTERIOR OF FUSELAGE.

TABLE 2

LOCATIONS OF CABIN MICROPHONES

Transducer	Location	Station (Inches)
1	Copilot Seat	60
2	Forward Passenger Seat, Starboard	78
3	Propeller Plane, Starboard	117
4	Aft Passenger Seat, Starboard	155
5	Aft Passenger Seat, Port	155
6	Propeller Plane, Port	117

TABLE 3

LOCATIONS OF TRANSDUCERS ON FUSELAGE EXTERIOR

Transducer	Location
Port	7.5 cm (3 in.) forward of propeller plane 5 cm (2 in.) below propeller center Station (Inches) 114.5
Starboard	7.5 cm (3 in.) forward of propeller plane 5 cm (2 in.) below propeller center Station (Inches) 114.5

The microphones used inside the cabin were Bruel and Kjaer Type 4155 0.5-inch prepolarized condenser microphones with windscreens. The exterior flush-mounted microphones were B & K Type 4135 (port side) and Type 4136 (starboard side) 0.25-inch condenser microphones, installed by means of B & K Type UA 0122 Flexible Adaptors with flush mountings. All the data were recorded simultaneously on a 14-track Honeywell Model 5600C tape recorder at a tape speed of 30 ips using FM record/reproduce and IRIG Intermediate band (10 kHz bandwidth).

Data reduction was performed in terms of narrowband spectra using a Spectral Dynamics Model 360 Digital Signal Processor and in terms of one-third octave band spectra using a GenRad Type 1921 one-third octave band analyzer. In order to provide adequate resolution for the low-order harmonics of the blade passage frequency, the narrowband data reduction was performed first for the frequency range 0-500 Hz (with a frequency resolution or spectrum line spacing of 0.5 Hz) and then repeated for the range 0-1000 Hz (with a frequency resolution of 1.0 Hz and an effective filter bandwidth of 1.7 Hz for broadband signals). Only harmonic levels were obtained for the lower frequency range; complete spectra (harmonic and broadband components) were plotted only for the higher range. Where necessary, harmonic levels were adjusted to remove the estimated broadband contribution at the harmonic frequencies.

2.4 Interior Configuration

The first three flight tests were conducted with a "bare" or untreated interior. All noise control and thermal treatments (fiberglass batts, interior trim, carpets, bulkhead covering, dynamic absorbers, etc.) were removed from the interior, aft of the pilot and copilot seats. Four seats were present in the interior for all four flights. Three of the seats were close to microphone locations, as is indicated in Figure 2.

Prior to the fourth flight, fiberglass batts were installed throughout the cabin aft of the pilot and copilot seats. The batts were formed from Mansville "Insul-Shield" Type 3, had a thickness of 5 cm (2 inches) on the sidewalls and 7.5 cm (3 inches) on the cabin aft bulkhead, a density of 48 kg/cu.m (3 pcf) and were unfaced. Narrow regions that surrounded cabin windows were not amenable to treatment with Insul-Shield; AA fiberglass with a thickness of 5 cm (2 inches) was used at these locations. There was no sound-absorbing material on the cabin floor.

In addition, an acoustic barrier was installed between the cockpit and the cabin. This barrier consisted of a sheet of lead-impregnated vinyl which was 0.25 cm (0.1 inch) thick, a layer of foam which was 0.64 cm (0.25 inch) thick and an outer sheet of open-cell foam, 2.5 cm (1 inch) thick. The surface density of the lead-impregnated vinyl was 4.94 kg/sq.m (1.01 psf). The barrier was attached by cable ties to a horizontal crossbar which was installed just aft of the flight crew seats. The top edge of the barrier was attached by ties to a fuselage frame. The fit between the barrier and the fuselage structure was not tight because of the presence of ducts, cables, etc., and small gaps were observed during flight. The barrier was cut vertically at the mid-point to allow access to the cockpit; an adequate overlap of material at this cut minimized the acoustic leak. The barrier was installed such that the 2.5 cm foam sheet was on the cabin side. The acoustic leaks were probably insignificant, since the acoustic treatment in the cabin did not provide a high transmission loss through the fuselage sidewall. Furthermore, time constraints did not permit improvements to the installation.

2.5 Statistical Analysis

The measured exterior and interior harmonic and broadband sound pressure levels have been analyzed in terms of means and standard deviations. The averaging was performed on an energy basis and the means and standard deviations were converted to decibel values. In the case of the standard deviation, this was accomplished in the following manner:

$$\text{Standard deviation (dB)} = 10\log(\text{Energy mean} \pm \text{Energy standard deviation}) - 10\log(\text{Energy mean})$$

In this format, the standard deviation has different positive and negative decibel values. The negative value is much more sensitive to variability in the data than is the positive value. For example, a positive standard deviation of +2.83 dB is associated with a negative value of -10.79 dB.

It is apparent from this definition that, in cases where the energy standard deviation is greater than the mean, the conversion to decibel values will fail since it will involve the logarithm of a negative number. No lower values for the standard deviation are quoted in such a case -- as will be seen in the tabulated data when the positive standard deviation exceeds 3 dB.

In some cases, 90% confidence limits are also calculated for the data. Since lower limits can be estimated only when there is a sufficiently large number of data samples, the confidence limits are not calculated for most of the interior sound pressure level measurements.

3. EXTERIOR HARMONIC PRESSURE LEVELS

3.1 Narrowband Spectra

The spectral characteristics of the exterior pressure field on the test airplane are typical of many general aviation turboprop aircraft. The pressure spectrum, as shown, for example, in Figure 3, is composed of a series of discrete frequency components superimposed on a broadband background. The contributions of the discrete frequency components will depend on the operation of the propellers. For example, Figure 3 shows two families of discrete frequency components, one associated with the starboard propeller, which was operating at 1520 rpm (blade passage frequency of 76.0 Hz), and the other with the port propeller operating at 1570 rpm (blade passage frequency of 78.5 Hz). In this case, the test was designed specifically to separate the contributions from the two propellers. Since the measurements were made on the starboard side of the fuselage, the sound pressure levels associated with the starboard propeller are much higher than those associated with the port propeller, the difference in levels being 15 to 20 dB. The spectra contain some minor contributions at discrete frequencies associated with multiples of the propeller shaft rotational frequency. These contributions may be associated with slight differences between different blades of the propeller but, since they are very low level and of little significance, they will not be considered further.

The primary intent of this analysis is to evaluate the variability of the measured exterior pressure levels from test to test and from flight to flight. To do this, the discrete frequency (harmonic) and broadband contributions will be considered separately. Harmonic components will be discussed in this section and broadband components in Section 4.

3.2 Data Variability

A comprehensive documentation of the discrete frequency components is contained in Reference 4 and it will not be repeated here. In this section, the data will be analyzed statistically to determine standard deviations and confidence limits. The data for each propeller can be divided into six groups

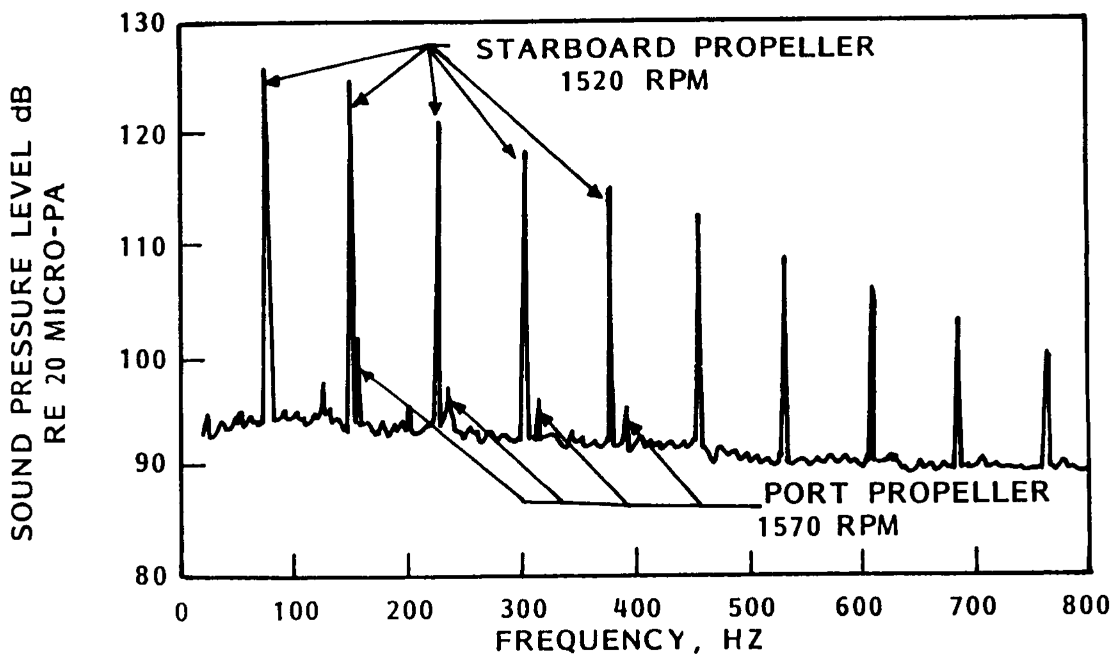


FIGURE 3. TYPICAL NARROWBAND SPECTRA OF EXTERNAL FLUCTUATING PRESSURE FIELD.

corresponding to the six test conditions when the test airplane was operating both engines. These six data groups are associated with three flight altitudes (3,000 m, 4,600 m and 9,100 m) and two propeller speeds (100% and 96% of maximum rpm, referred to as "high" and "low" rpm in this discussion). Measurements were also performed during single-engine operation at an altitude of 4,600 m, but these data are considered separately because the associated aircraft speed and engine power are significantly different from the corresponding two-engine case.

Twin-engine operation was performed with the port and starboard propellers either at the same rotational speed or at different speeds. When the propellers were at different rotational speeds, it was possible to distinguish between the two contributions. This was not possible when both propellers were at the same speed. However, since it was observed, when the speeds were different, that the contribution from a propeller on the opposite side of the fuselage was 15 to 20 dB lower than the contribution from the propeller on the same side as the microphone, measured sound levels could be attributed to the adjacent propeller in all cases. This allows the number of data points that can be considered for a given flight condition to be maximized. Taking into account some loss of data due to instrument malfunction, the four flights provided 6 to 8 data points for each of the rpm conditions at 3,000 m altitude, 14 to 16 data points for the low rpm condition at each of the two highest altitudes (4,600 m and 9,100 m) and 4 data points for the high rpm conditions at the two highest altitudes.

A statistical summary of the test data is presented in tabular form in Appendix A of this report. The standard deviations and 90% confidence limits were computed as indicated in Section 2.5. Mean levels and confidence limits, taken from the tables, are plotted in Figures A.1 through A.6. Inspection of the figures shows that the variability was greater for the port propeller than for the starboard propeller. Also, the variability was greater for the higher rpm data than for the lower, partly due to the fewer data points for the data at altitudes of 4,600 m and 9,100 m. Finally, the variability seems to increase slightly as harmonic order increases.

An indication of the variability in the data can be obtained from the width of the 90% confidence interval. On the average, the width for the low rpm data is 1.3 dB for the starboard propeller and 2.6 dB for the port propeller. The corresponding values for the high rpm are 2.5 and 5.9 dB, respectively.

Having determined the variability of the data, the results can now be considered in terms of the mean sound pressure levels.

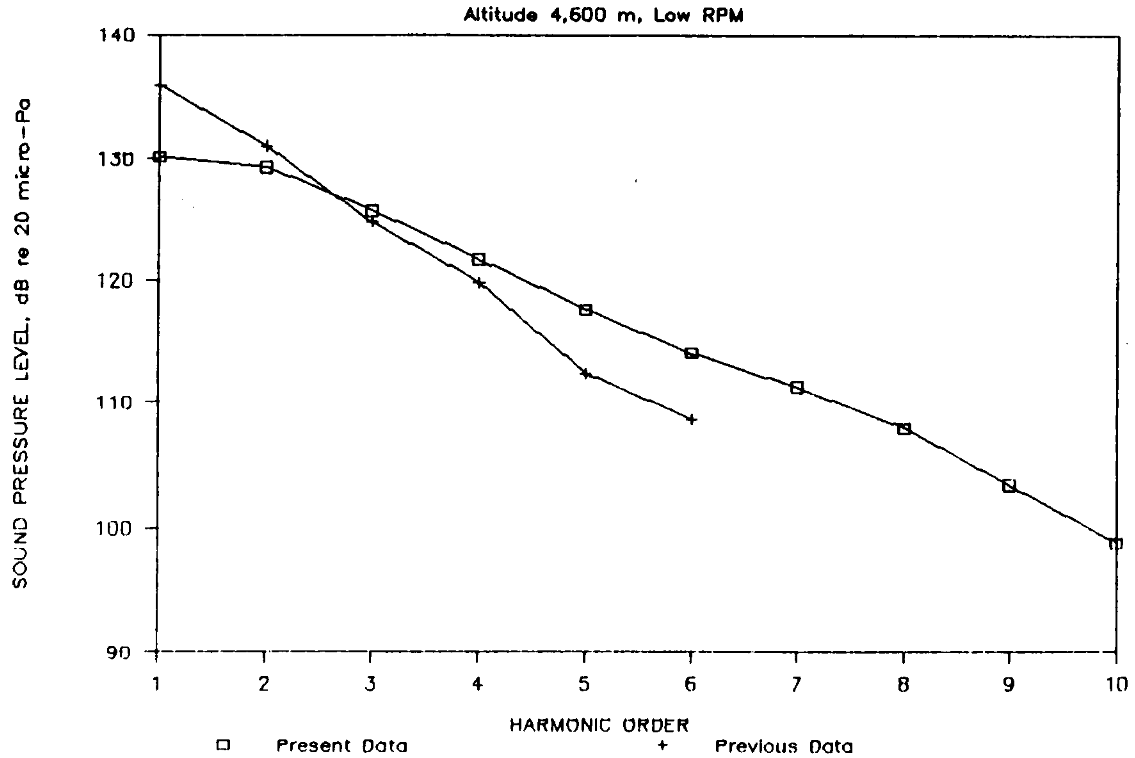
3.3 Comparison with Earlier Test

In the earlier test on the same airplane, a small number of measurements were made of the exterior pressure field using two piezoelectric pressure sensors which were attached to the exterior of the fuselage skin, one on each side of the fuselage. Two data samples were obtained in the plane of rotation of the propeller on each side of the fuselage, one measurement being made at an altitude of 4600 m and the other at 9100 m. In each case the propeller rpm was 96% of maximum. Since the pressure sensors were in the boundary layer flow, the broadband pressure levels were higher than in the present case with flush-mounted microphones. Consequently it was not possible to measure levels for harmonics greater than 7 on the port side and 6 on the starboard side of the fuselage. A comparison of the mean harmonic levels from the present test and the corresponding single data point from the earlier test is contained in Figures 4 and 5. It is seen that sound pressure levels are approximately the same but the slope of the curves are different for the two tests. Overall sound pressure levels, obtained by energy sums over all harmonics, show that the levels for the earlier tests are 3 to 4 dB higher than the corresponding levels for the present test, primarily due to the differences in the fundamental (blade passage frequency) component.

3.4 Comparison of Port and Starboard Levels

A comparison of the harmonic pressure levels measured on the exterior of the fuselage during two-engine operation shows that the levels are similar on the port and starboard sides for the test conditions at an altitude of 9100 m but not at lower altitudes. In the latter case the harmonic pressure levels are higher on the port side than on the starboard side. Typical comparisons are shown in Figure 6, which contains mean harmonic levels for the 96% rpm

(a) Exterior Harmonic Levels – Port Side, 4600 m.



(b) Exterior Harmonic Levels – Port Side, 9100 m.

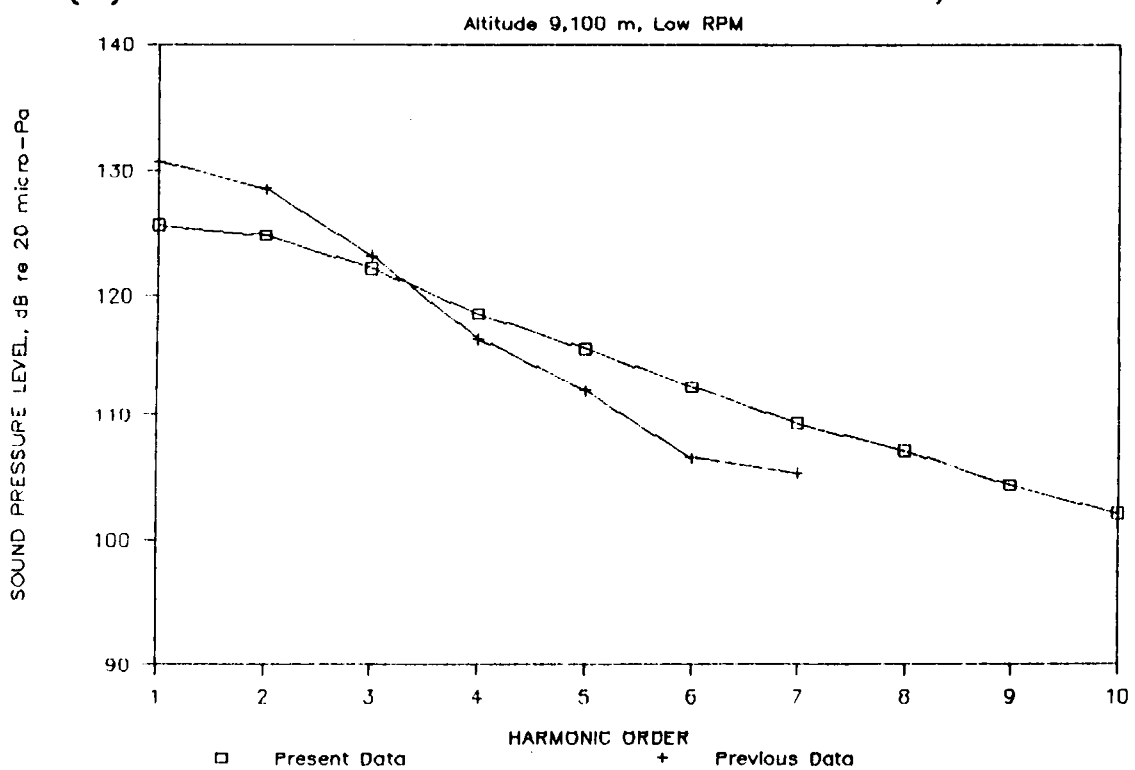
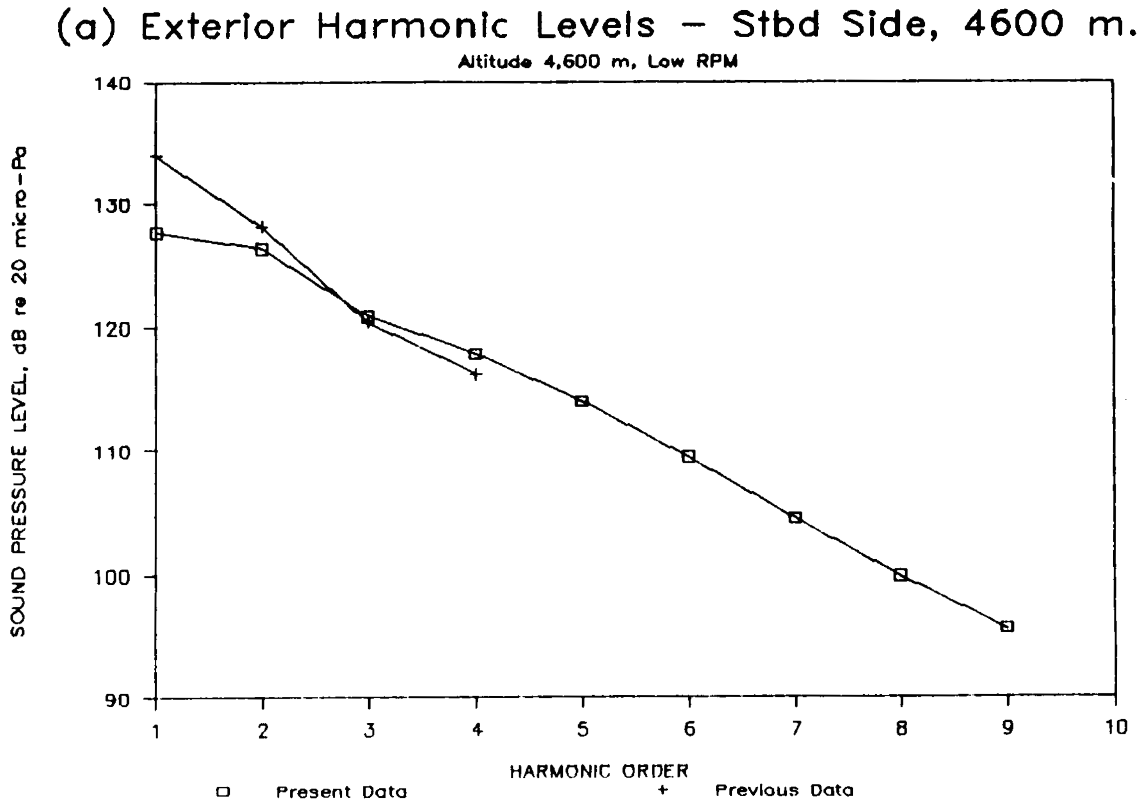


FIGURE 4. COMPARISON OF EXTERIOR PROPELLER HARMONIC SOUND PRESSURE LEVELS WITH DATA FROM EARLIER TEST; PORT PROPELLER.



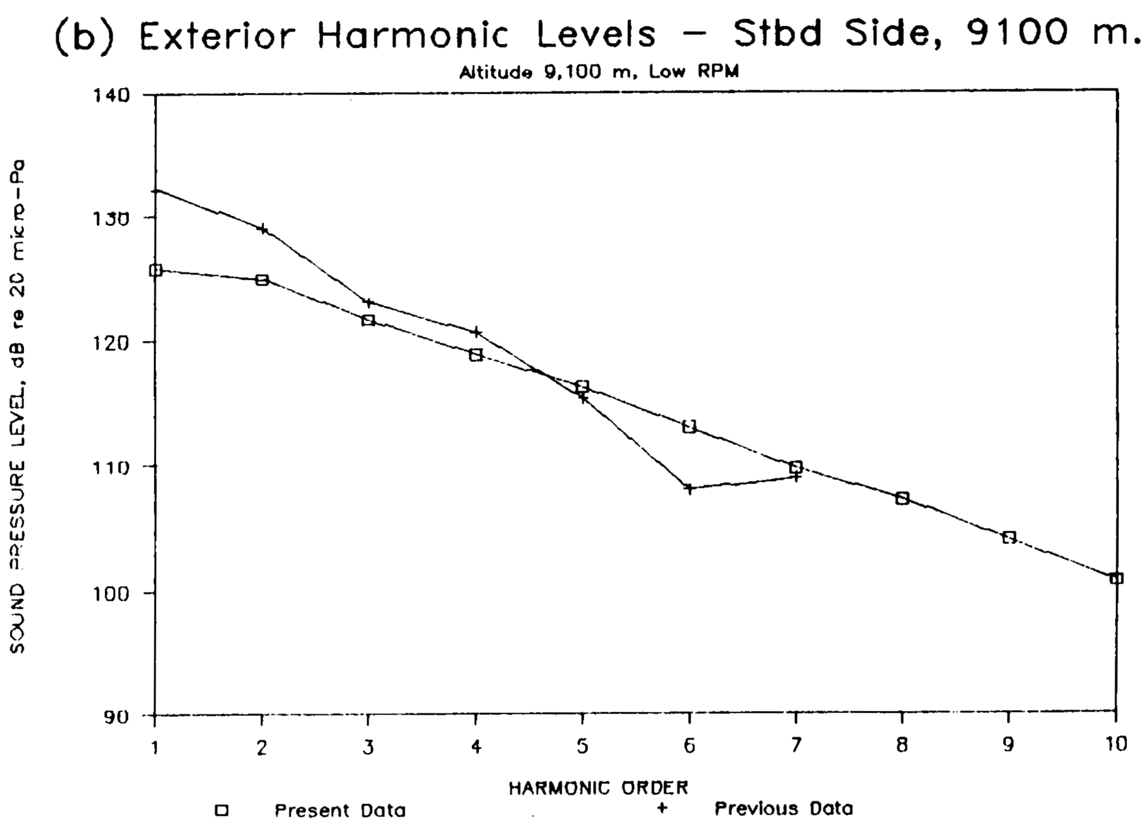


FIGURE 5, COMPARISON OF EXTERIOR PROPELLER HARMONIC SOUND PRESSURE LEVELS WITH DATA FROM EARLIER TEST: STARBOARD PROPELLER.

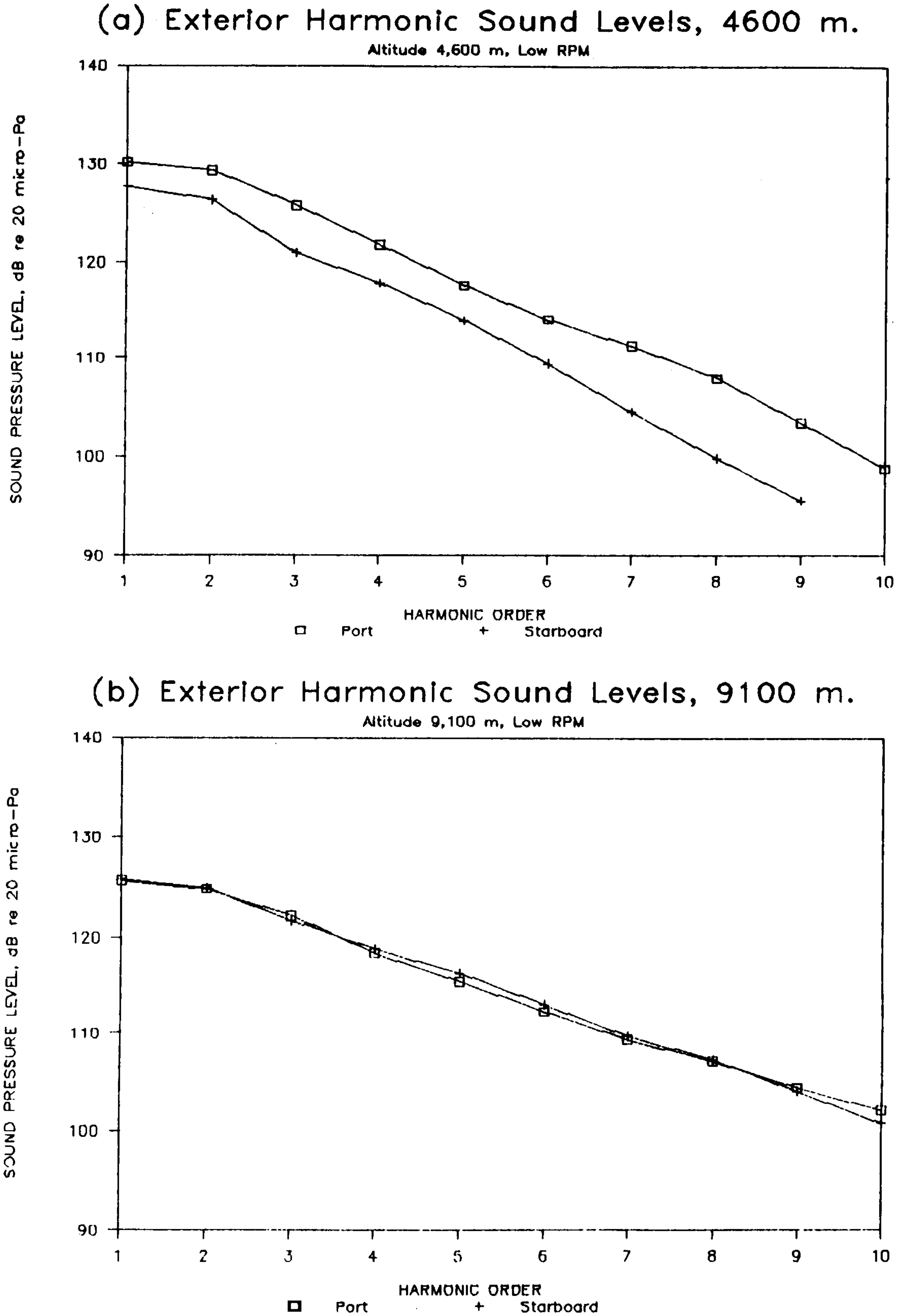


FIGURE 6. COMPARISON OF EXTERIOR PROPELLER HARMONIC SOUND PRESSURE LEVELS FOR PORT AND STARBOARD PROPELLERS.

condition at altitudes of 4600 m and 9100 m. It is seen in Figure 6(a) that, at the 4600 m altitude, the harmonic levels are consistently higher on the port side, with the difference increasing with harmonic order. At an altitude of 9100 m, the harmonic levels are essentially identical at all harmonic orders (Figure 6(b)).

A similar comparison can be made for the overall sound pressure levels obtained from an energy sum over the ten lowest-order harmonics; the results are shown in Table 4. The largest difference between port and starboard sound pressure levels occurs at an altitude of 3000 m and the smallest difference at 9600 m. Table 4 also contains unpublished data from the earlier tests on the same airplane but with different pressure transducers. The trend of the data is the same for the two tests, with the differences between port and starboard being almost the same in the two cases.

TABLE 4

COMPARISON OF PROPELLER SOUND PRESSURES ON PORT AND STARBOARD SIDES

Altitude (m)	3000	3000	4600	4600	9100	9100
Nominal rpm (%)	100	96	100	96	100	96
(Port)-(Stbd) (dB)	4.5	3.8	3.5	3.1	0.4	-0.1
(Port)-(Stbd)* (dB)				2.5		-1.2
(Port)-(Stbd) [5] (dB)	0-3.8					

(Port)-(Stbd) refers to the difference in overall sound pressure level between port and starboard sides of the fuselage,
(Port)-(Stbd)* refers to unpublished data from earlier test,
(Port)-(Stbd) [5], aircraft speed 219 - 324 ft/sec,
power 196-376 kW, 1900 rpm.

Measurements by Sulc et al. [5] on a different high-wing, turboprop airplane also show higher harmonic levels on the port side of the fuselage than on the starboard side. In that case measurements were made at only one altitude

(3000 m) and the difference varied from 3.8 dB to 0 dB as propeller power increased. Confusing the issue, however, is the fact that in the case of Reference 5 the propeller rotation was in the opposite direction (clockwise when viewed from the rear) to that of the present test airplane. Also, the fuselage sidewall was much more curved than in the Commander fuselage and the propeller tip rotational Mach number was about 13% higher (0.76 instead of 0.67). Wind tunnel tests on a model of a third high-wing turboprop airplane [6] show differences between port and starboard harmonic pressure levels that are related to fuselage angle of attack, a parameter that was not measured or controlled in the Commander tests. In the case of the wind tunnel model, the propeller direction of rotation was clockwise when viewed from the rear and the harmonic levels were generally higher on the port side, with the difference increasing with angle of attack. At an angle of attack of -3 degrees, the wind tunnel data show that harmonic levels on the port side are about 1 dB lower than on the starboard side, but at +3 degrees the harmonic levels on the port side are 3 to 6 dB higher than on the starboard side. These differences between port and starboard propeller sound pressures are typical of those measured in the present flight tests.

One argument used in the past to explain differences between harmonic levels on the two sides of the fuselage has been based on test data that showed pressure levels to be higher when the blade was advancing than when it was retreating [7]. This argument has been used [8] to suggest possible approaches to reducing cabin sound pressure levels. However, in all the test configurations referred to in the preceding discussion, the pressure transducers were in the region of the closest separation between the propeller and the fuselage skin. Thus, the differentiation between advancing and retreating blade does not really apply.

3.5 Comparison with Predictions

Several simplified procedures are available for predicting propeller harmonic sound pressure levels on the exterior of a general aviation airplane fuselage. A method in common use for general aviation aircraft is the SAE procedure [9]; a similar approach is given in Reference 10. Alternative methods are based on the early work of Gutin [11] or empirical results of Hubbard and Regier [12]. The procedures require fairly rudimentary information for the propeller and need significantly less detailed information than do the analytical models developed recently for general aviation and high speed propellers. The methods have been used by various investigators with limited success; some of the methods will be used here to compare with the mean sound pressure levels measured during the present flight tests.

The comparisons can be performed in terms of the overall sound pressure level (energy sum over all harmonics) or the individual harmonic levels. Prediction of the overall and harmonic levels requires knowledge of the propeller tip rotational Mach number, propeller power, diameter and number of blades, and the location of the obseration point. These input data values are available except for the power. This has been estimated using the simple relationship between power, rpm and torque, and the assumption that 100% torque was associated with 820 shp at maximum rpm.

Consider first the overall levels. The measured values are significantly lower than levels predicted by either Reference 9 or 10, Reference 9 consistently giving the highest overall levels. The comparison is given in Table 5. The two prediction methods do not distinguish between port and starboard propellers, or direction of rotation. Thus, the measured levels for the port propeller are usually closer in value to the predictions than are the measured levels for the starboard propeller.

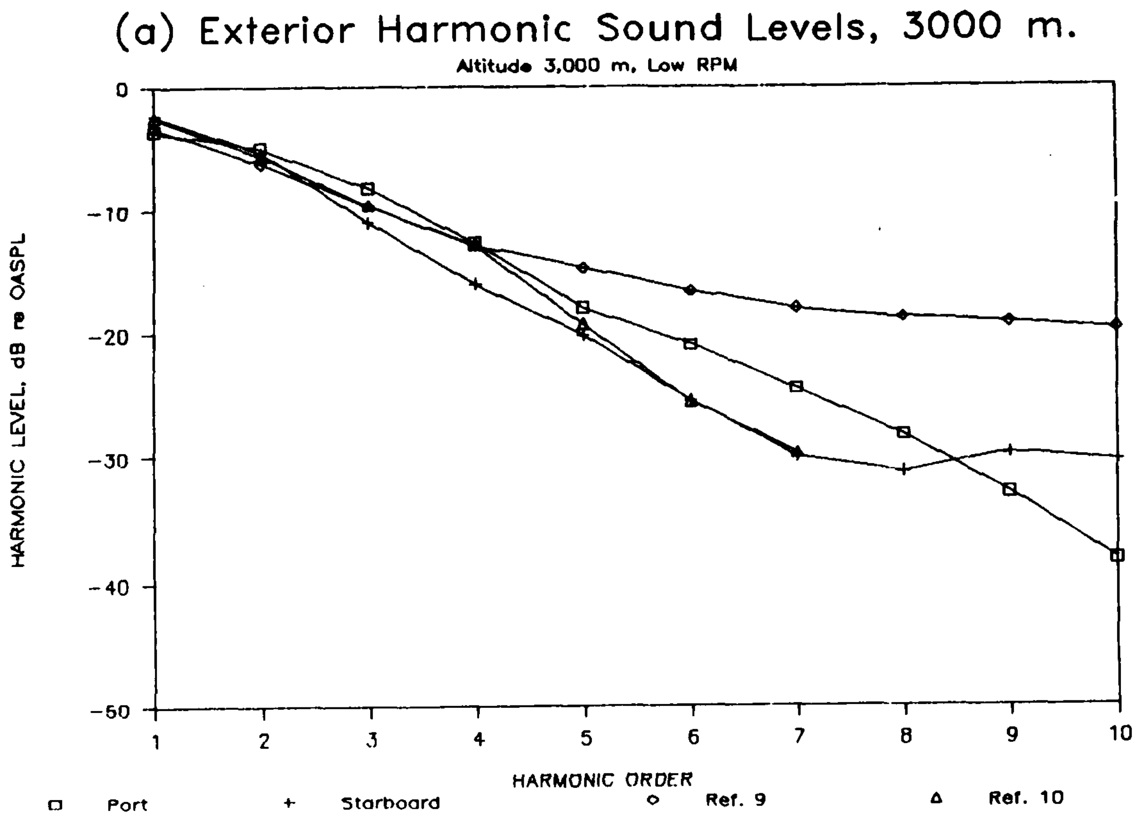
Measurements from the earlier Commander tests also show the same trend, as is indicated in the table. Measurements by Sulc et al. [5] show overall levels lower than predicted by Reference 9 but higher than predicted by Reference 10.

TABLE 5

COMPARISON OF MEASURED AND PREDICTED OVERALL LEVELS FOR HARMONICS

Test Condition	Overall Sound Pressure Level (dB) Measured Port	Stbd	Predicted [9]	Predicted [10]
Commander (Present Test)				
Altitude 3000 m, 96% rpm	135.7	131.9	144.1	139.5
100% rpm	136.2	131.7	144.4	140.0
4600 m, 96% rpm	134.0	130.9	144.3	139.9
100% rpm	134.9	131.4	144.4	140.4
9100 m 96% rpm	129.9	130.6	141.9	137.5
100% rpm	131.0	130.0	142.2	138.0
Commander (Earlier Test)				
Altitude 4600 m, 96% rpm	137.6	135.1	144.5	139.5
9100 m, 96% rpm	133.4	134.6	142.5	137.5
Sulc et al. [5]				
Altitude 3000 m, 96% rpm	142.5	141.5	145.7	138.0

A comparison of measured and predicted harmonic levels can be accomplished most readily by expressing the levels relative to the overall, summation levels. In that manner, the differences in actual level associated with the differences in overall level discussed above can be excluded. Figures 7 and 8 compare measured results for the port and starboard propellers with predictions based on References 9 and 10. Since the prediction methods do not distinguish betweeen port and starboard propellers, only one curve is presented for each prediction procedure. The figures show that the measured values generally lie between the two predicted curves. Ground tests on an early Commander airplane with reciprocating engines [13,14] have shown that



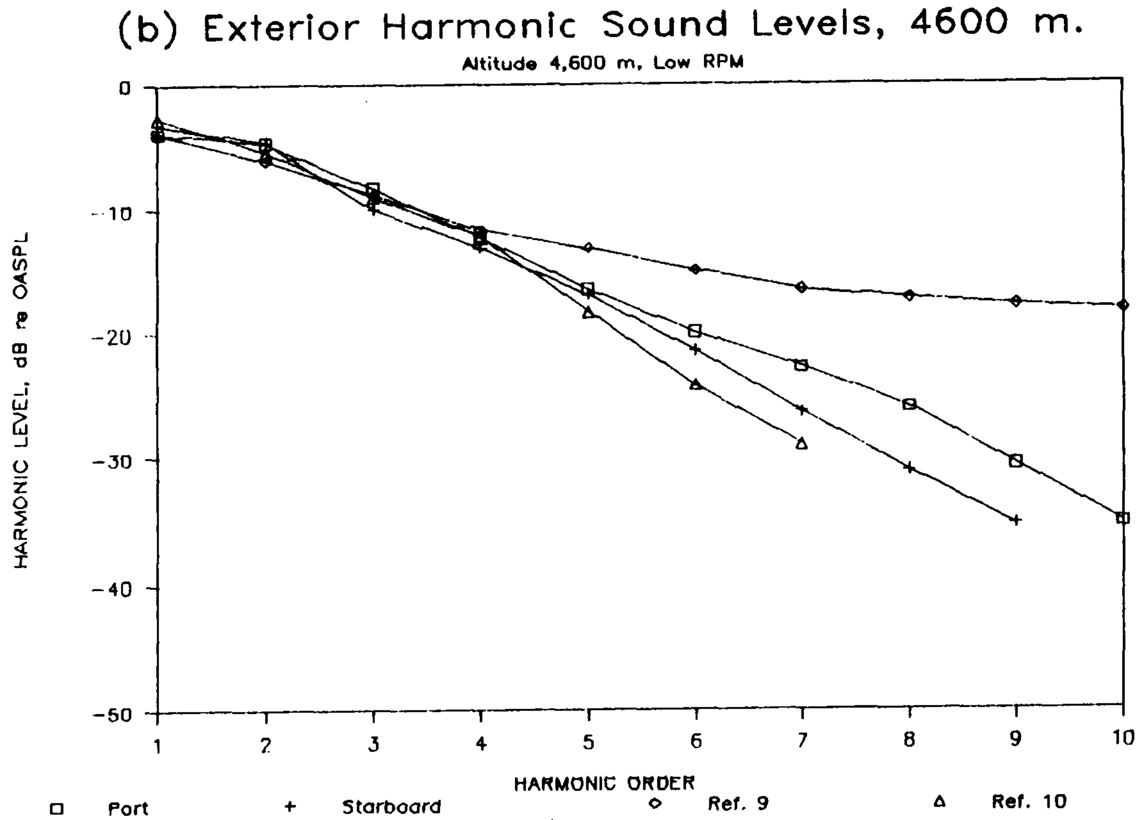


FIGURE 7. COMPARISON OF MEASURED AND PREDICTED PROPELLER HARMONIC SOUND PRESSURE LEVELS: 96% RPM.

(c) Exterior Harmonic Sound Levels, 9100 m.

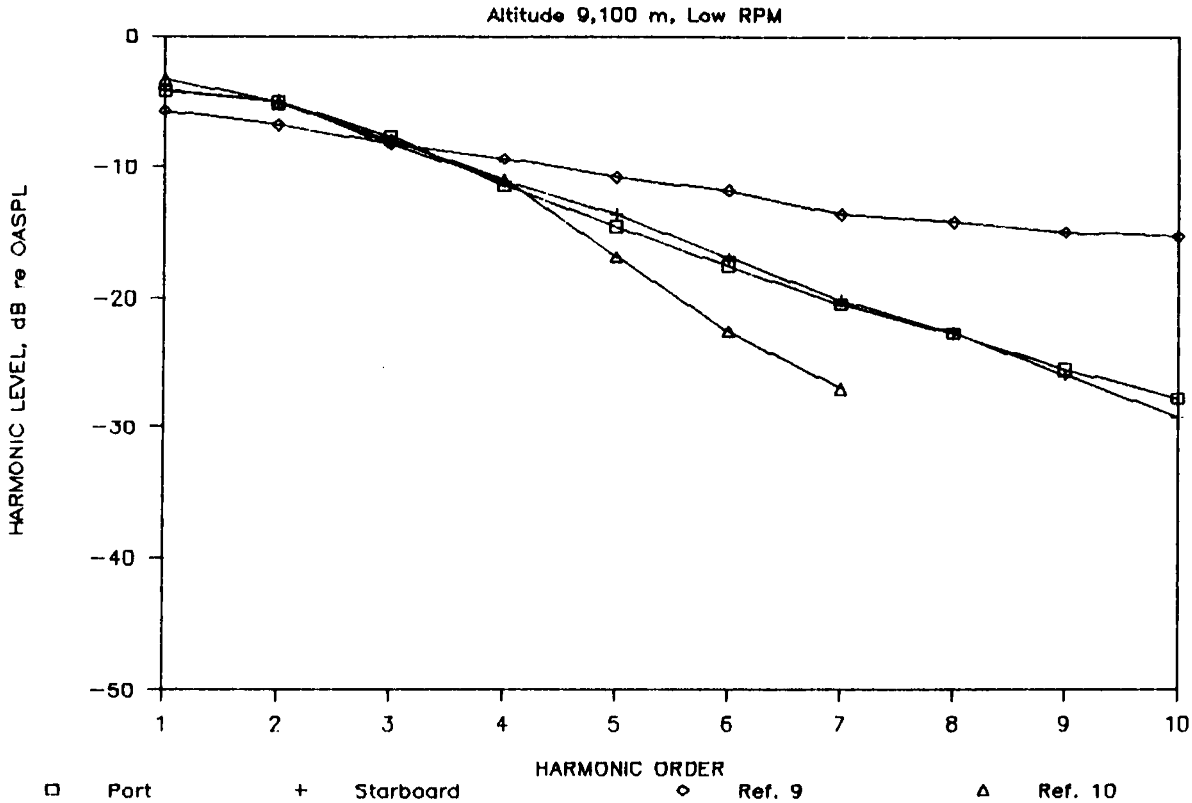


FIGURE 7. CONTINUED.

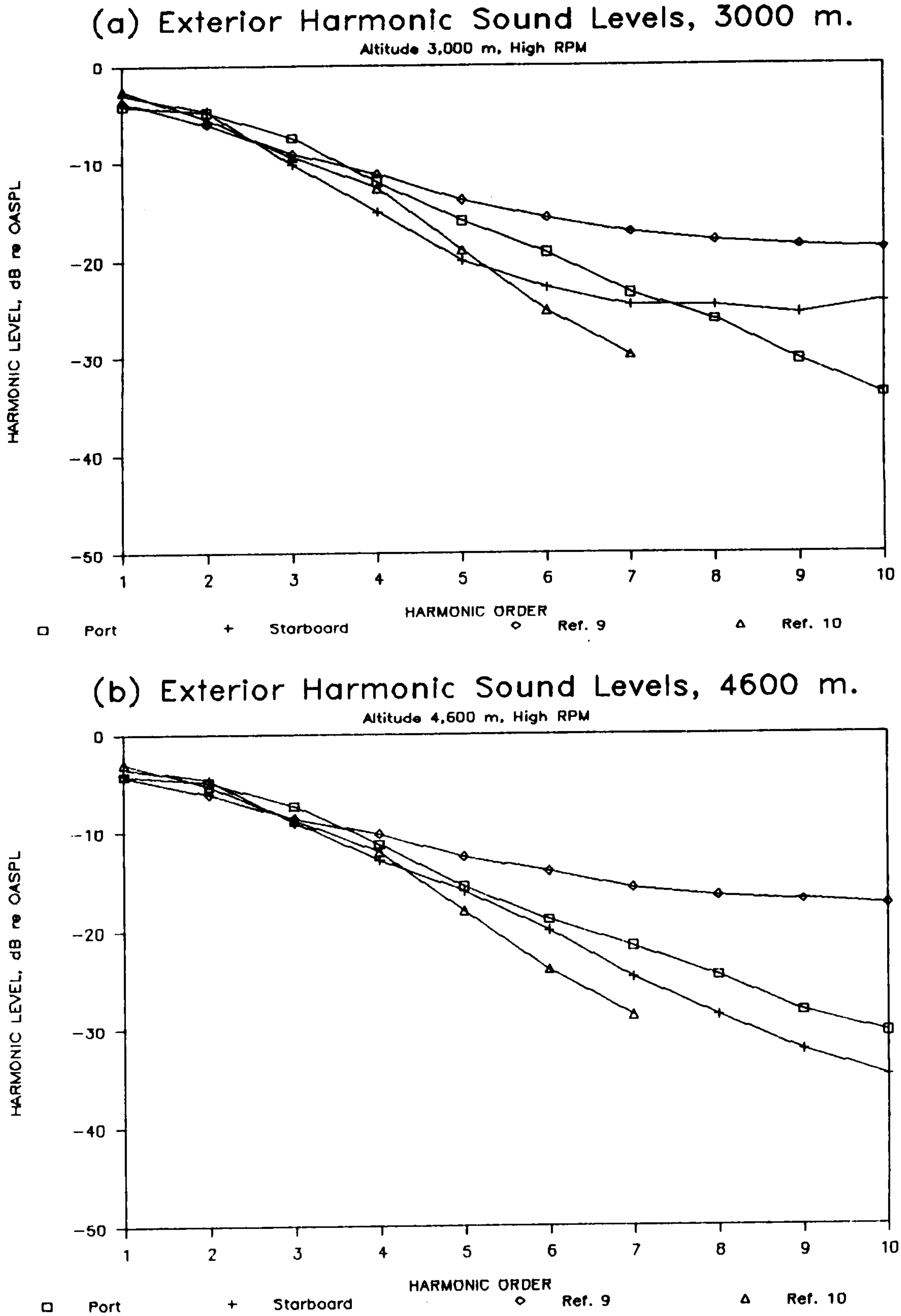


FIGURE 8. COMPARISON OF MEASURED AND PREDICTED PROPELLER HARMONIC SOUND PRESSURE LEVELS: 100% RPM.

(c) Exterior Harmonic Sound Levels, 9100 m.

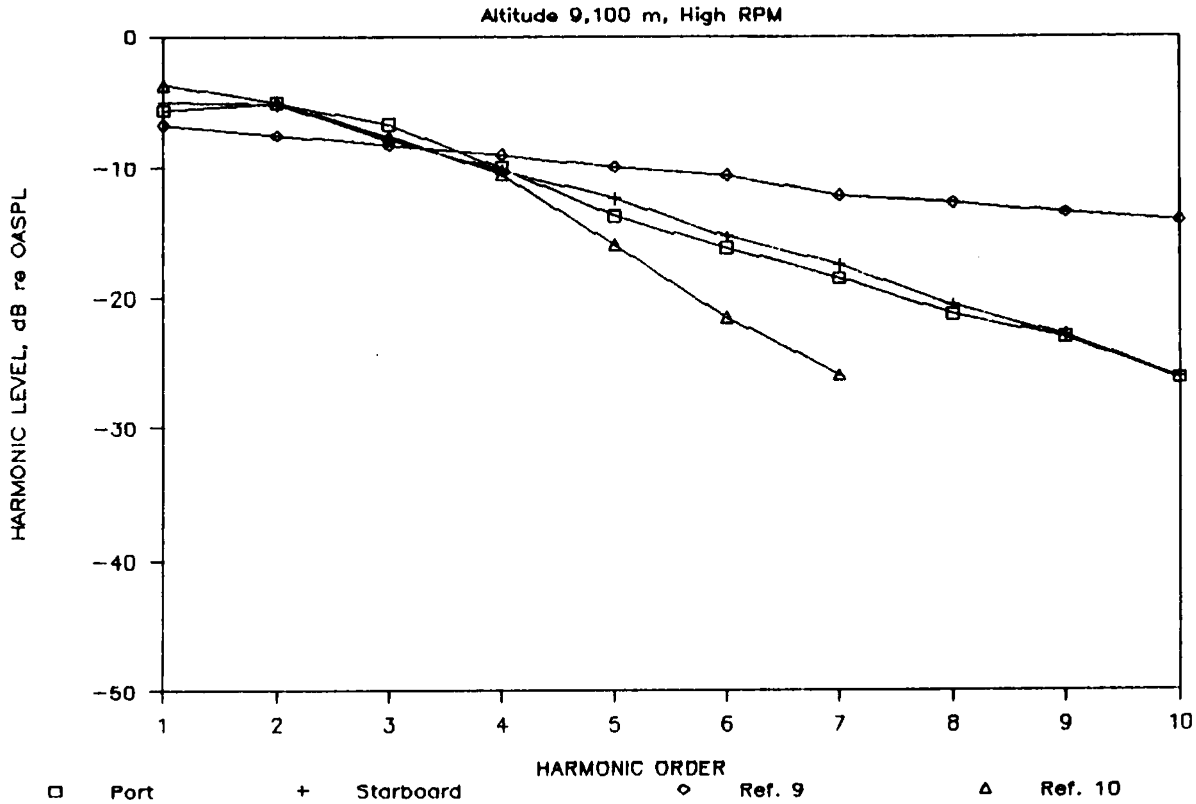


FIGURE 8. CONTINUED.

Reference 9 provides a reasonably accurate prediction of harmonic levels when the aircraft is stationary, but overpredicts the levels of the higher order harmonics when there is forward motion of the airplane, even at the low speeds associated with taxiing. Data from the earlier tests on the present turboprop Commander and published data of Sulc et al. [5] show similar trends, with the harmonic levels being even closer to the values predicted by Reference 10.

4. EXTERIOR BROADBAND PRESSURE LEVELS

4.1 Measured Spectra

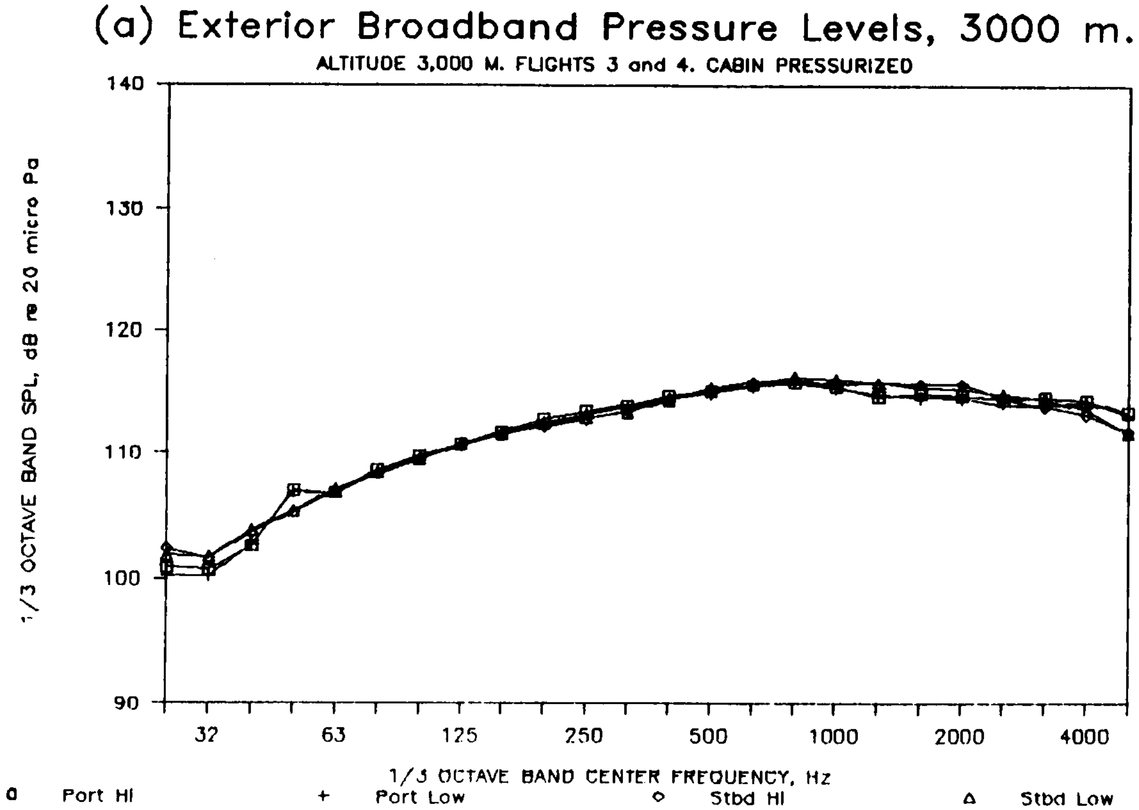
The broadband components in the exterior pressure spectrum have been analyzed in terms of the relationship with propeller and flight conditions. The broadband components were determined from both narrowband and one-third octave band spectra. The narrowband spectra were used at mid-frequencies were the spectra are dominated by the harmonic components, and one-third octave band data were used at very low frequencies (below the blade passage frequency) and at high frequencies (above the tenth harmonic). In the mid-frequency range, adjustment of one-third octave band data to remove the harmonic components was found to be too inaccurate because of the dominance of the harmonics. In this frequency range, average levels were determined for the narrowband spectra and the values were adjusted for bandwidth to obtain estimates of the equivalent one-third octave band levels. The results were then combined to given one-third octave band levels for the broadband pressures in the frequency range from 25 Hz to 5000 Hz. In some cases, it was found that the mid-frequency information was adequate, so that the full frequency range need not be used.

Mean and standard deviations for the broadband components, averaged over flights 3 and 4, are contained in Table 6. Data for the port and starboard sides of the fuselage, and for low and high propeller rpm, have been combined to obtain these averages. This combining of the data was justified because the variations between port and starboard, and between low and high rpm were small. This can be seen in Figure 9 which compares average broadband spectra for the two sides of the fuselage and the two propeller speeds, at each of the three altitudes. The comparison indicates that the broadband levels are essentially independent of propeller speed and are the same on each side of the fuselage. This conclusion is reinforced by spectra in Figure 10 which were obtained by averaging narrowband data, in the frequency range 50-800 Hz, for all four flights. In this figure, it is seen that during single-engine operation, the broadband levels on a given side of the fuselage are essentially the same whether or not the adjacent propeller is operating. The broadband levels are higher during two-engine operation, but so is the flight

TABLE 6

ONE-THIRD OCTAVE BAND SOUND PRESSURE LEVELS, ESTIMATED BROADBAND LEVELS
EXTERIOR MICROPHONE, PORT & STARBOARD SIDES. FLIGHTS #3 AND #4

Band Center Frequency	One-Third Octave Band Sound Pressure Level, dB re 20 micro Pa								
	Altitude 3,000 m.			Altitude 4,600 m.			Altitude 9,100 m.		
Hz	Mean	SD	SD	Mean	SD	SD	Mean	SD	SD
25	101.4	1.34	-1.95	99.8	1.60	-2.56	94.8	1.18	-1.63
32	101.2	1.14	-1.56	100.2	1.49	-2.29	95.3	1.45	-2.20
40	103.3	1.04	-1.37	101.9	1.23	-1.71	97.0	1.36	-1.98
50	106.3	1.52	-2.36	104.5	1.19	-1.64	99.7	1.09	-1.46
63	107.0	1.20	-1.66	105.3	1.26	-1.78	100.1	1.42	-2.13
80	108.5	1.34	-1.95	106.6	1.22	-1.70	101.4	1.45	-2.19
100	109.7	1.30	-1.87	107.9	1.27	-1.80	102.5	1.44	-2.18
125	110.7	1.22	-1.70	109.0	1.20	-1.66	103.4	1.37	-2.01
160	111.6	1.21	-1.68	109.9	1.11	-1.49	104.2	1.33	-1.92
200	112.4	1.18	-1.63	110.7	1.06	-1.41	104.8	1.30	-1.87
250	113.0	1.24	-1.74	111.2	1.19	-1.65	105.4	1.30	-1.86
315	113.6	1.29	-1.85	111.8	1.19	-1.65	105.9	1.35	-1.96
400	114.5	1.25	-1.76	112.7	1.22	-1.70	106.5	1.22	-1.70
500	115.1	1.21	-1.69	113.4	1.19	-1.65	107.0	1.24	-1.75
630	115.6	1.24	-1.75	113.7	1.29	-1.84	107.4	1.36	-1.99
800	116.0	1.28	-1.82	113.9	1.36	-1.99	107.8	1.48	-2.26
1000	115.6	1.12	-1.51	113.9	0.99	-1.28	108.8	1.03	-1.35
1250	115.2	1.08	-1.43	113.6	0.96	-1.23	108.3	1.25	-1.76
1600	115.1	1.02	-1.34	113.4	1.02	-1.33	108.2	1.16	-1.58
2000	115.1	1.01	-1.32	113.2	0.98	-1.27	108.1	1.20	-1.66
2500	114.5	1.10	-1.48	112.6	1.02	-1.33	107.8	1.29	-1.85
3150	114.2	1.12	-1.51	112.5	0.98	-1.27	107.7	1.31	-1.88
4000	113.9	1.25	-1.76	112.1	1.04	-1.38	107.5	1.48	-2.27
5000	112.5	1.30	-1.86	111.2	1.09	-1.46	106.7	1.50	-2.31
OASPL	126.9	1.14	-1.55	125.1	1.08	-1.43	119.6	1.11	-1.49
No of Samples	8			16			18		



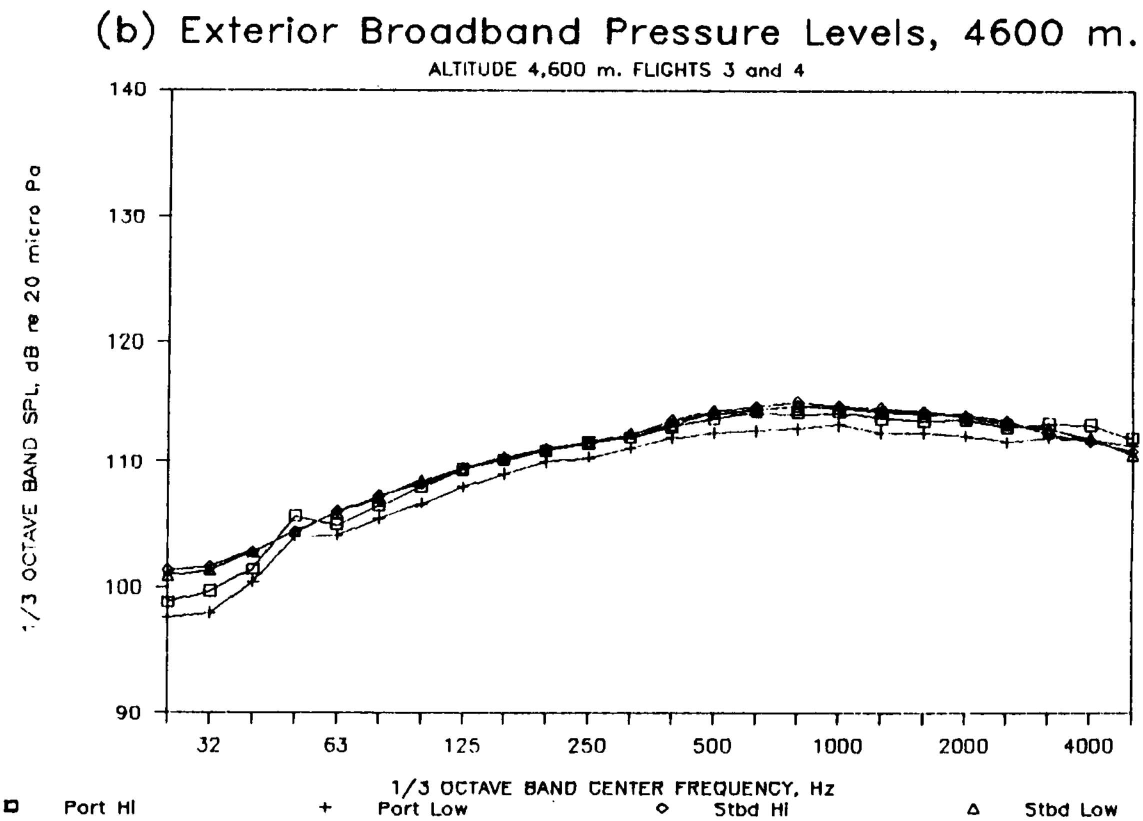


FIGURE 9. BROADBAND PRESSURE SPECTRA MEASURED ON FUSELAGE EXTERIOR.

(c) Exterior Broadband Pressure Levels, 9100 m.

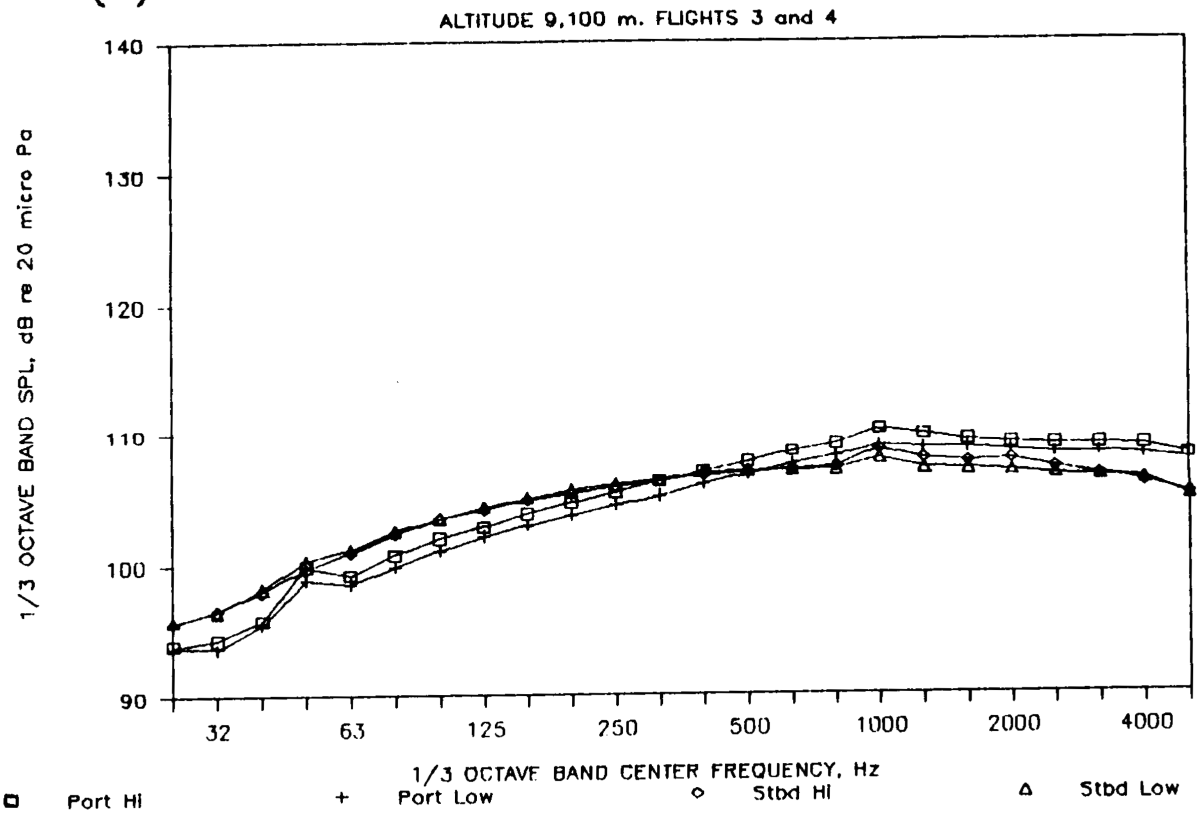
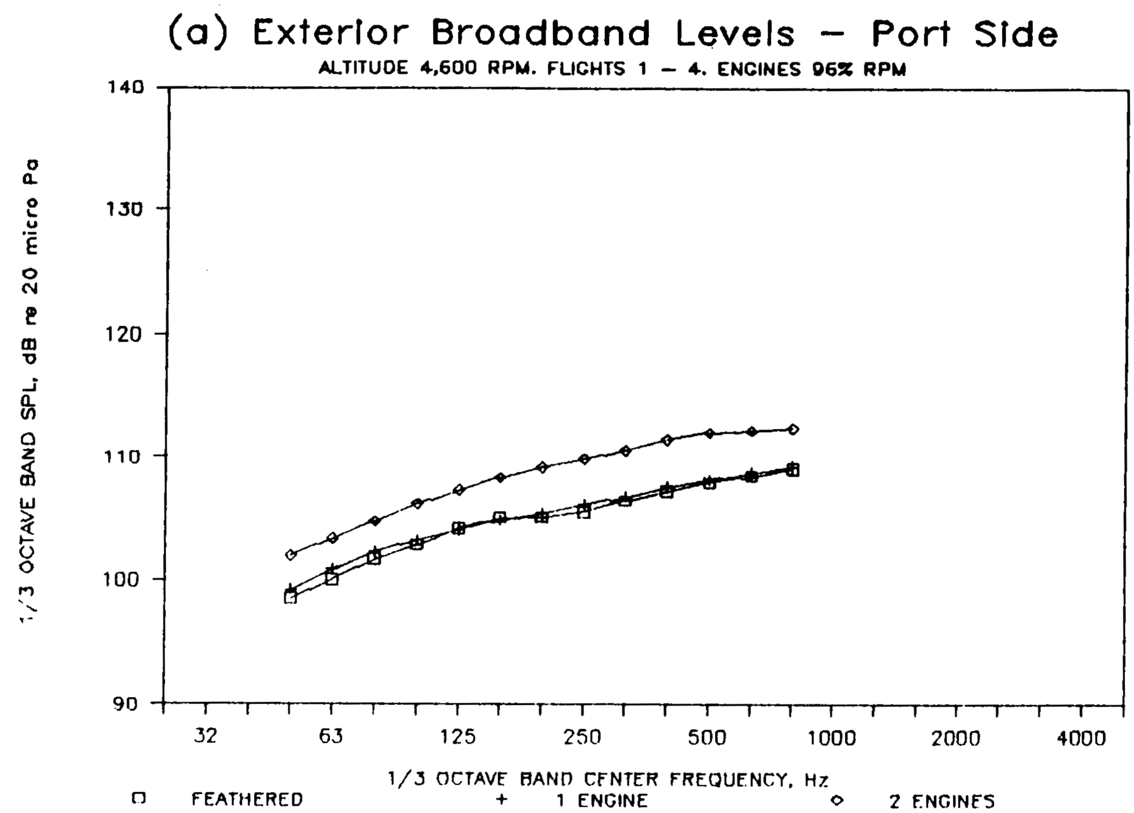


FIGURE 9. CONTINUED.



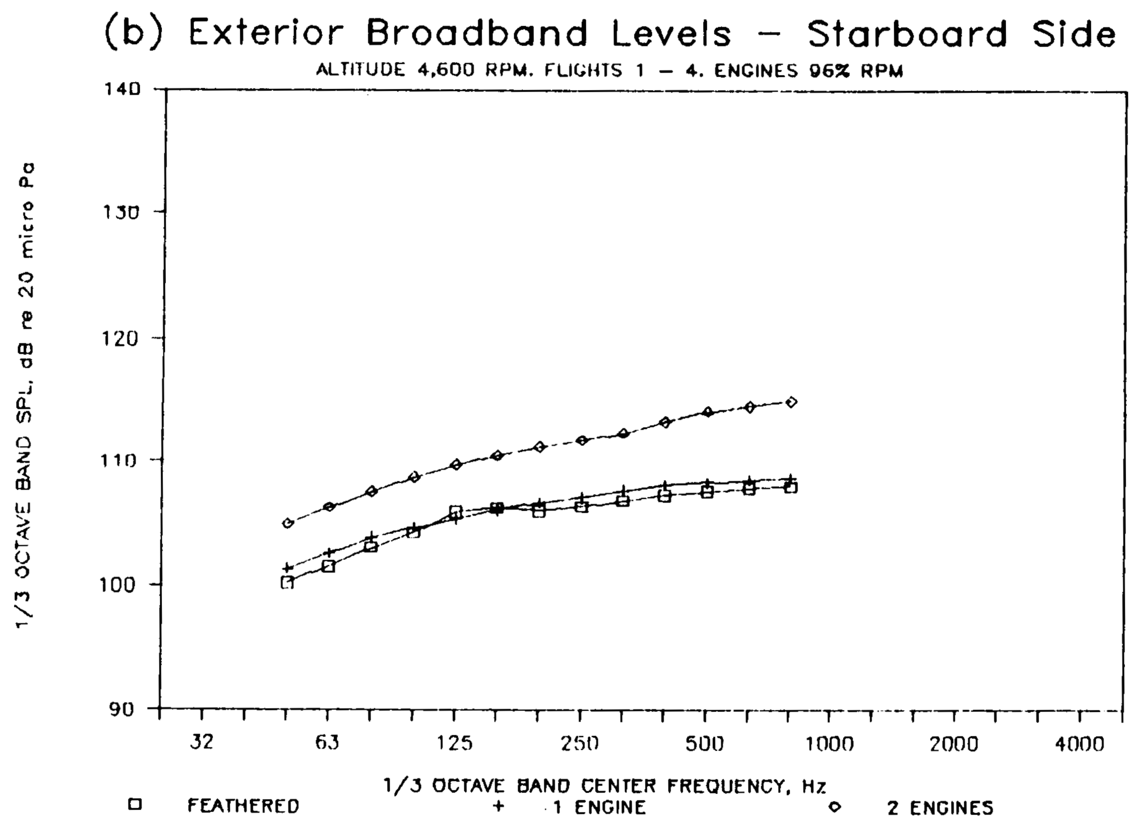


FIGURE 10. EXTERIOR BROADBAND PRESSURE LEVELS FOR DIFFERENT PROPELLER OPERATING CONDITIONS.

speed (by a factor of about 1.3).

A comparison of the average broadband levels for the three flight altitudes is shown in Figure 11, where it is seen that the levels decrease as altitude increases. The true airspeed is roughly the same at all three altitudes, but the free stream dynamic pressure decreases as altitude increases.

4.2 Turbulent Boundary Layer Pressure Fluctuations

The fluctuating pressure field beneath a turbulent boundary layer has been studied experimentally by several investigators, and various prediction procedures have been developed. Most of these procedures are based on wind tunnel data where the boundary layer was carefully controlled to be either attached or separated, but other procedures have been developed from measurements on jet aircraft. Little is known about the turbulent boundary layer on turboprop aircraft, except for data published by Sulc et al. [5].

The measured pressure power spectral density can be non-dimensionalized using various parameters associated with the flow over the fuselage. For the present test data, boundary layer thickness has been selected as a representative length, aircraft speed as a representative velocity and overall rms pressure or flight dynamic pressure as a typical pressure. All the parameters have been measured, or can be estimated, but in the case of the boundary layer thickness an assumption has to be made regarding the origin of the turbulent boundary layer. This origin was selected to be the lower edge of the windshield. Other origins, such as the nose of the airplane, could have been chosen, but the boundary layer thickness is not very sensitive to the actual choice, within the possible range from windshield to airplane nose.

Consider first the overall rms pressure obtained by integrating the pressure spectrum over the frequency range from 25 to 5000 Hz. Boeing 737 data [15] indicate that the ratio of rms pressure to flight dynamic pressure is approximately 0.0055 and the ratio of rms pressure to wall shear stress is approximately 3.4, although the range of published data for both ratios is quite large when all investigations are included. Data from the Commander tests show that, on the basis of the mean pressure levels at each altitude,

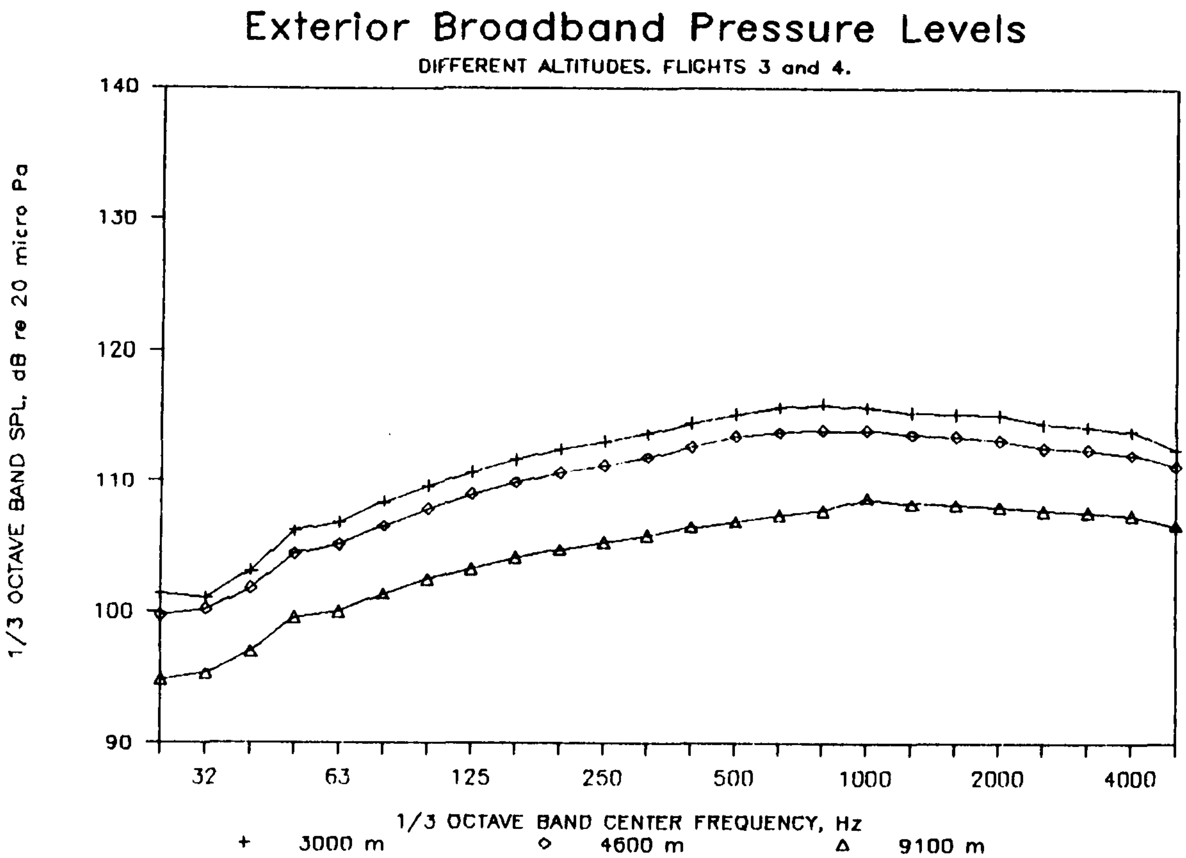


FIGURE 11. EXTERIOR BROADBAND PRESSURE SPECTRA FOR DIFFERENT TEST ALTITUDES.

the ratio of rms pressure to dynamic pressure has values in the range 0.0038 to 0.0049, and the ratio of rms pressure to wall shear stress has values in the range of 1.67 to 2.30. These values are generally consistent with other data.

Average broadband pressure spectra for two-engine operation at the three flight altitudes were non-dimensionalized first using overall rms pressure as the reference. The resulting spectra show a good collapse, as indicated in Figure 12. The data are compared to a non-dimensional spectrum developed from flight test data measured on the fuselage of a Boeing 737 airplane [15], where the boundary layer was known to be attached, although the measurements were made in a region of alternating adverse and favorable pressure gradients. It is seen that the non-dimensional power spectral density function for the Commander data is higher (by up to 6 dB) at low frequencies and lower at high frequencies. These characteristics suggest that there is disturbed flow over the Commander fuselage at the measurement location. A similar conclusion is reached when comparing the measurement locations and data with those of Sulc et al. [5].

When the Commander data are non-dimensionalized using flight dynamic pressure, instead of rms pressure, as the representative parameter, the data do not collapse completely; the data lie in a band which is about 3 dB wide, as shown in Figure 13. The lower values in the band are associated with the higher altitude and, conversely, the higher values refer to the lower altitudes. The values of the non-dimensional spectral density are typically 3 dB lower, at low frequencies, than the corresponding values measured by Sulc et al. [5] on their test airplane. In that reference, the non-dimensionalized data lie within a band that is about 10 dB wide.

In summary, it appears that the empirical procedures based on attached turbulent boundary layers give reasonably good estimates of the broadband pressure spectra measured on the Commander, provided some adjustments are made to the spectrum shape and level to account for disturbed flow aft of the windshield.

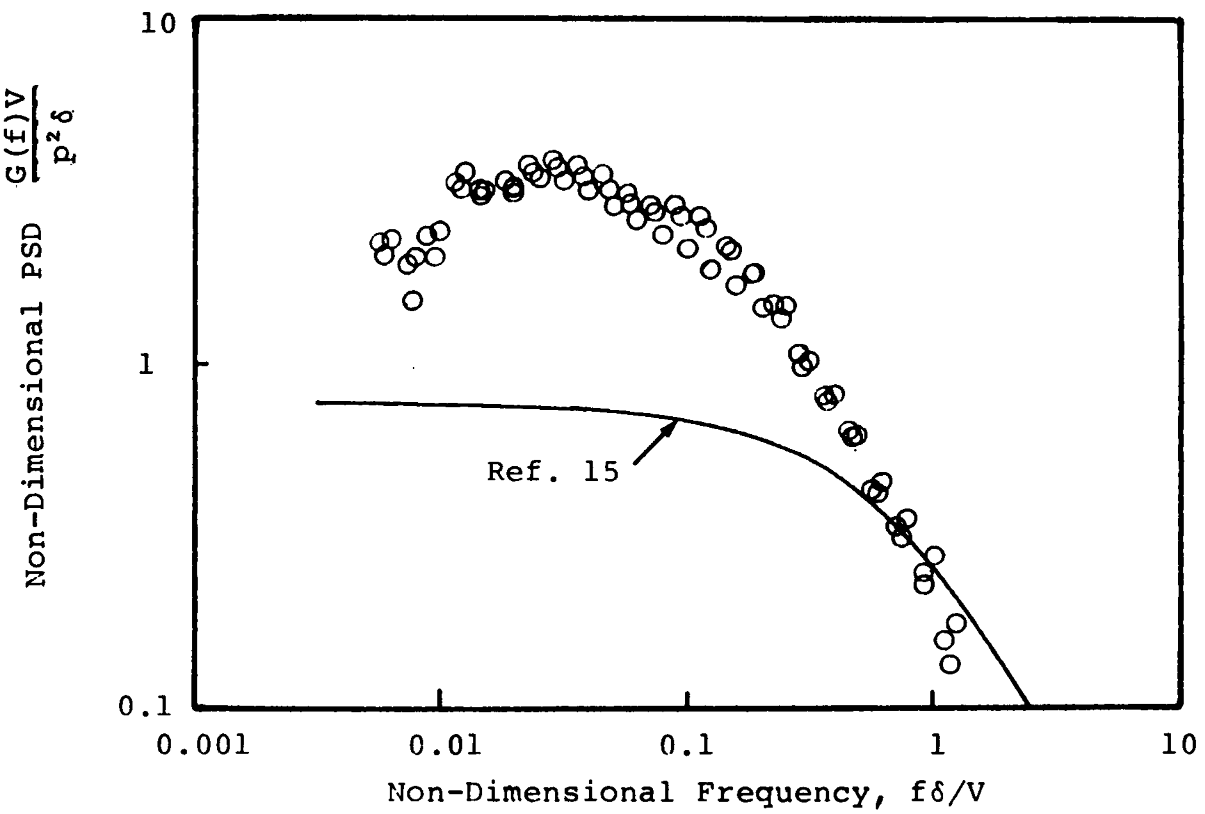


FIGURE 12. EXTERIOR BROADBAND PRESSURE SPECTRA NORMALIZED WITH RESPECT TO RMS PRESSURE.

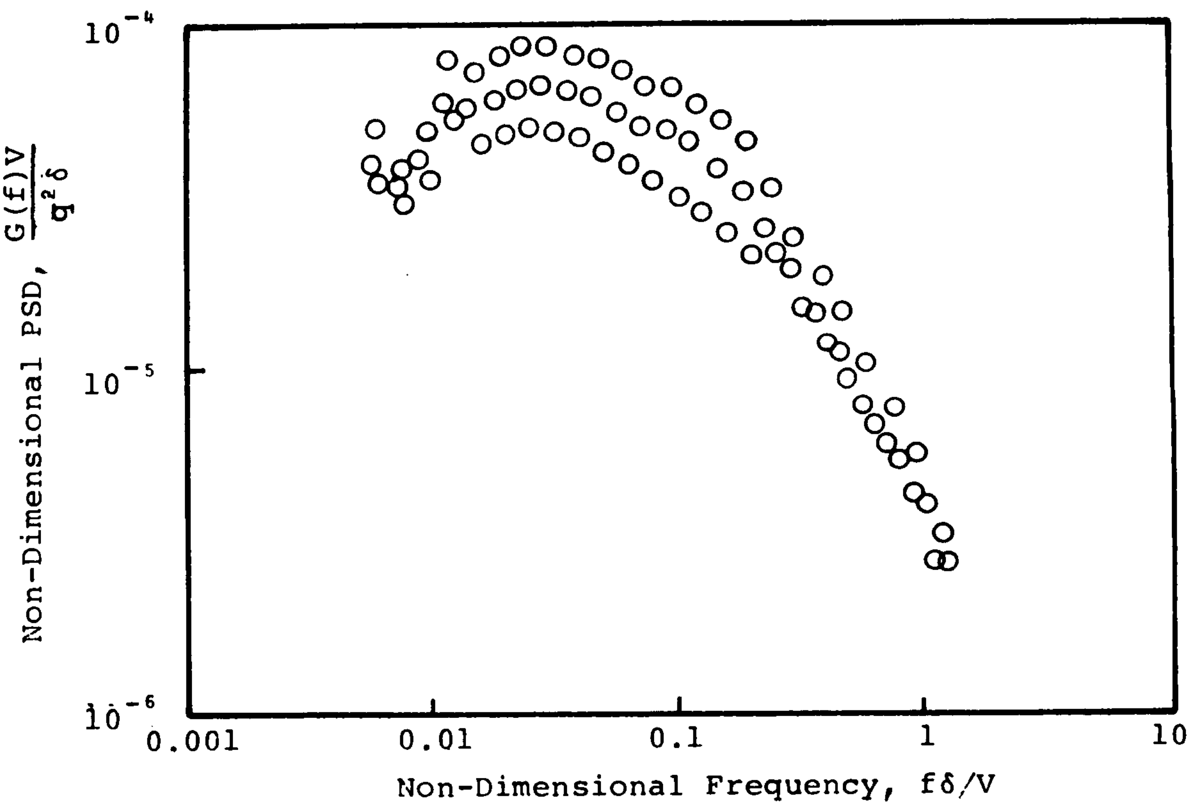


FIGURE 13. EXTERIOR BROADBAND PRESSURE SPECTRA NORMALIZED WITH RESPECT TO DYNAMIC PRESSURE.

5. INTERIOR HARMONIC SOUND PRESSURE LEVELS

The interior acoustic spectra can be considered as a combination of discrete frequency and broadband components, just as in the case of the exterior pressure field. However, the situation is much more complicated than for the exterior because of the influences of the structure and the cabin volume, and constructive or destructive interference between acoustic signals from the two propellers. The discussion in this section will consider the effects of these parameters on the cabin sound pressure levels.

5.1 Narrowband Spectra

Typical narrowband acoustic spectra measured in the untreated cabin of the test airplane are shown in Figure 14. The spectrum in Figure 14(a) refers to test conditions where the two propellers were operating at the same rotational speed and Figure 14(b) to conditions where the propellers were at differrent speeds. Inspection of the spectra shows several differences with respect to the exterior sound pressures. The harmonic levels vary irregularly with frequency whereas on the exterior the harmonic levels decrease monotonically as frequency increases. Also, the contributions of the two propellers to the interior acoustic field can be of similar magnitudes, whereas on the exterior, harmonic levels from one propeller were always 15 to 20 dB higher than those from the other propeller. The spectra contain secondary discrete frequency components that occur at multiples of the propeller rotational frequency, rather than the blade passage frequency, and at the turbine rotational frequency. The contributions of these secondary components are greater than on the exterior, suggesting that they may be structureborne rather than airborne.

The broadband components in the spectra also show characteristics that are different from those in the spectra of the exterior pressure field. The main difference is that the relatively uniform broadband levels seen in the exterior spectra have become very irregular, because of the influences of the transmission paths and the cabin acoustic volume.

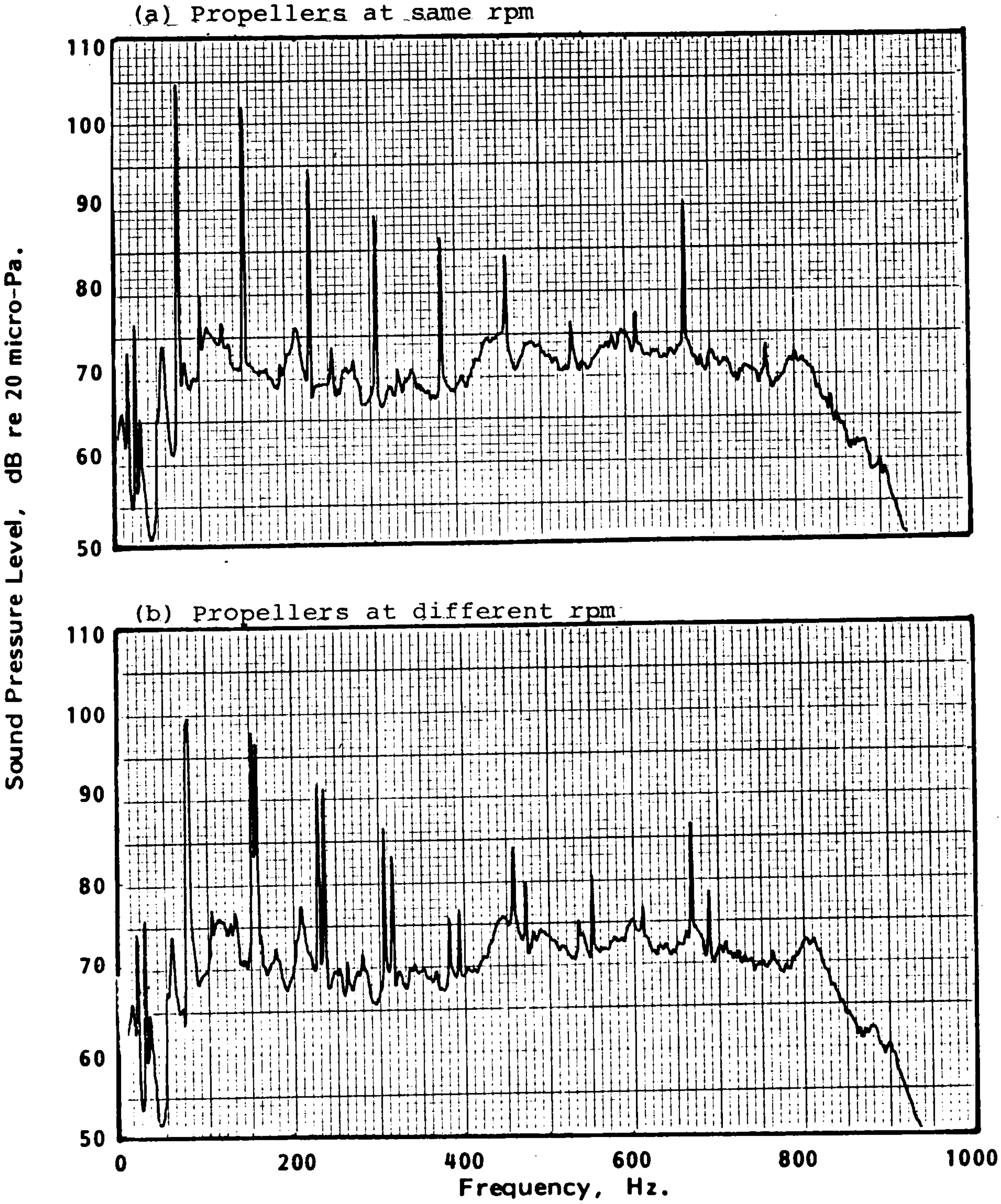


FIGURE 14. TYPICAL NARROWBAND SPECTRA OF SOUND PRESSURE LEVELS IN CABIN; 4600 M.

5.2 Data Variability

The variability of the interior harmonic sound pressure levels can be expressed in terms of mean value, standard deviation and confidence intervals, just as for the exterior pressures. However, the number of data samples available for a given test condition is much smaller than for the exterior, and the resulting variabilty of the data is greater. This is because the interior sound pressure levels are dependent on the interior furnishings of the cabin, the relative phase of the propellers and the pressure differential between the cabin and the exterior. These factors had no influence on the exterior pressures, so that data could be averaged over several tests. This is not true for the interior acoustic data, where the largest number of samples for a given test condition is three, that is, data from flights 1 through 3. Consequently, estimates of standard deviation for the interior sound pressures are often based on fewer samples that is the case for the exterior. Appendix B contains tabulated values for the mean sound pressure levels and associated standard deviations for the six microphone locations in the cabin and the various flight conditions. The standard deviations are quoted in decibel format and were calculated following the approach outlined in Section 2.5. Inspection of the tables indicates that the negative standard deviations are greater in magnitude than the corresponding positive values. This is due to the logarithmic presentation of the data. It will be noted that no standard deviations are quoted for some of the harmonics. In these cases there was only one data sample available from the three flights. At other harmonics, only the positive standard deviation is quoted. It will be noted that in these cases the positive standard deviation is greater than 3 dB, indicating that the standard deviation is greater than the mean value. In the logarithmic format, the corresponding lower standard deviation involves the logarithm of a negative number. Standard deviations greater than -5 dB are not uncommon for the interior harmonic levels whereas they are uncommon for the exterior pressures. This is indicative of the greater variability of the data for the interior acoustic levels.

Two of the test sequences were concerned with the influence of propeller relative phase on interior sound pressure levels, when both propellers were operating at the same rpm. The results of the study will be discussed later, but, in an evaluation of data variability, data for different relative phase angles were combined into a single data set. In this case, twelve data samples were used in the averaging process, so that confidence limits could be determined as well as standard deviations for the harmonic levels. Thus, average values, standard deviations and 90% confidence intervals are presented in the tables in Appendix B; mean harmonic levels and associated 90% confidence intervals are plotted in Figures B.1 through B.6 in Appendix B.

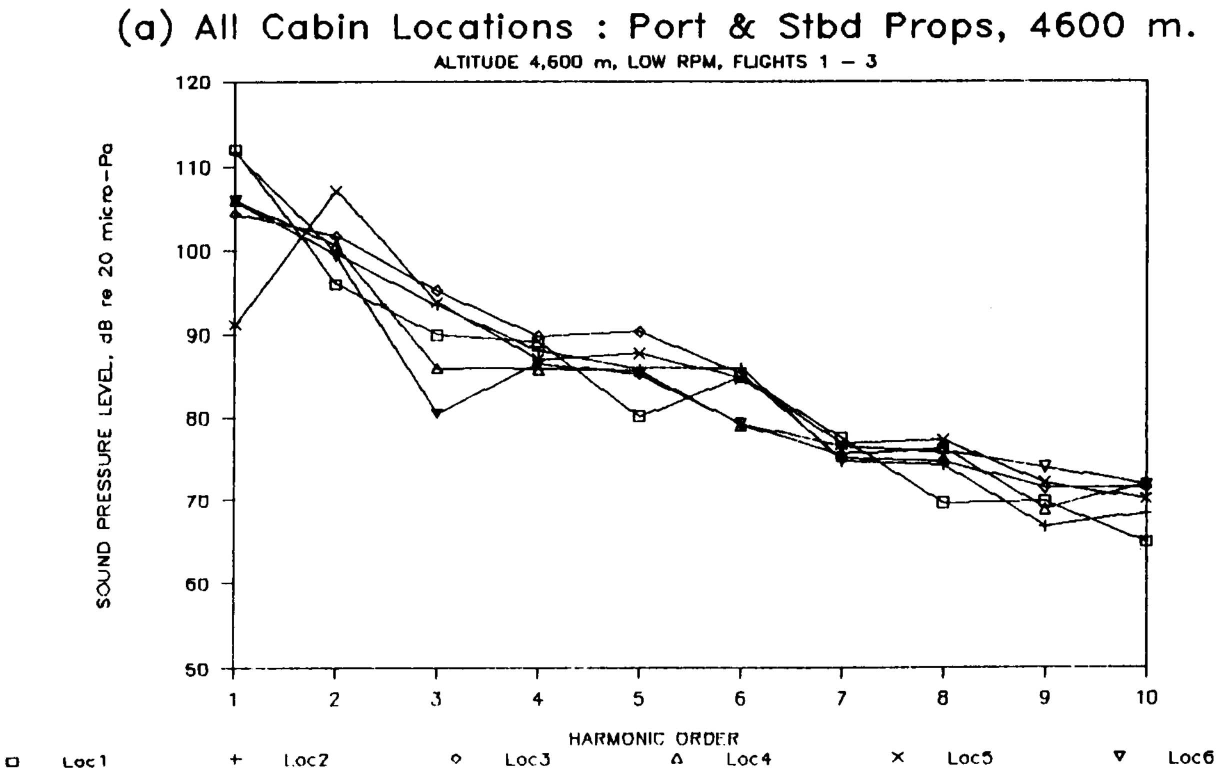
Two sets of data were averaged in this manner, one set associated with flight at 4600 m and the other at 9100 m. Both sets refer to propeller operating speeds of 96% of maximum rpm. When averaged over all harmonics and all six measurements locations in the cabin, it is found that the standard deviations of the harmonic sound pressure levels are typically +2.0 dB and -4.2 dB. Corresponding average values for the exterior pressure field are +1.3 dB and -1.9 dB. This is another indication of the greater variability in the harmonic sound pressures measured in the cabin, compared to the corresponding exterior levels.

A similar comparison can be made in terms of the average width of the spectral band defined by the 90% confidence limits. For the interior sound pressure levels measured at 4600 m altitude and 96% rpm, and averaged over all relative phase angles, the 90% confidence limits are typically 3.1 dB apart. The corresponding 90% confidence limits for the exterior harmonic pressures are typically 1.4 dB apart.

5.3 Influence of Location in Cabin

Mean harmonic levels, measured at different locations in the cabin when the propellers are operating at the same rpm (96% of maximum), are compared in Figure 15. The averaging associated with these data was performed without regard to the relative phase between the two propellers. Figure 15(a) refers to flight at an altitude of 4600 m and Figure 15(b) to 9100 m altitude.

The figures indicate that, at a given flight condition, the harmonic spectra have similar shapes at all locations in the cabin. Thus, at an altitude of 4600 m, the harmonic levels tend to decrease as harmonic order, or frequency,



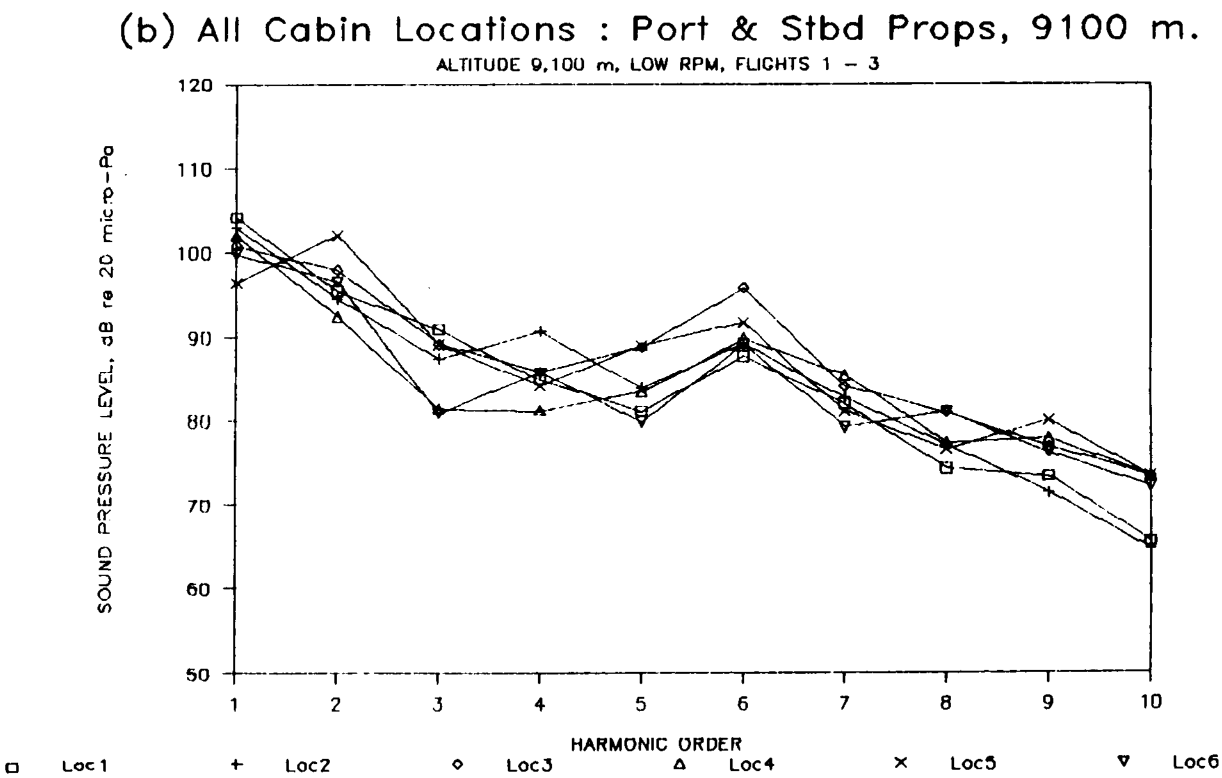


FIGURE 15. COMPARISON OF HARMONIC MEAN SOUND LEVELS AT DIFFERENT LOCATIONS IN CABIN.

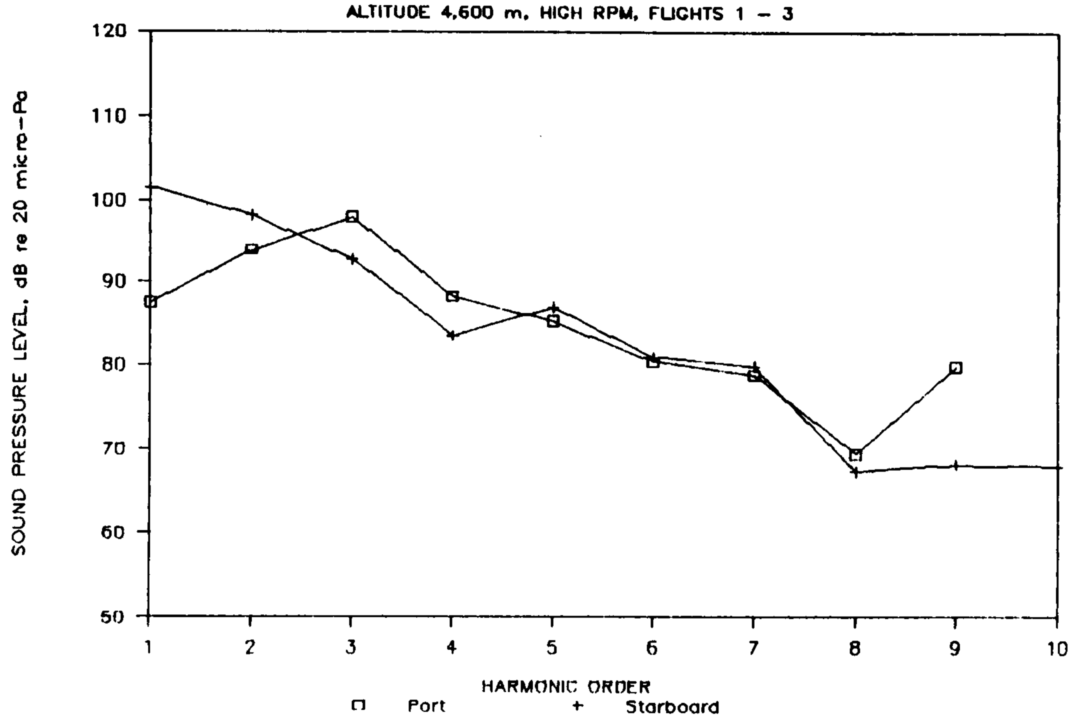
increases. At 9100 m, the spectra show a peak in harmonic level at the 6th harmonic. The data for these six locations indicate that the sound pressure levels in the interior can vary by 5 to 22 dB, depending on harmonic order, with the largest variations occurring at the lower order harmonics. Quite large differences in sound pressure level occur between locations on opposite side of the fuselage. For example, there are differences of 8 to 15 dB between the sound pressure levels for the third order harmonic measured at locations 3 and 6. At this frequency, the distance between the two measurement locations is approximately 40% of the acoustic wavelength. Differences of 6 to 14 dB were measured between locations 4 and 5 for the first harmonic; the distance between the two locations is only 15% of the acoustic wavelength for the first harmonic.

5.4 Port and Starboard Propellers

It was observed (in Section 3.1.2) from the measurements on the exterior of the fuselage that, at flight altitudes of 3000 m and 4600 m, the harmonic sound pressure levels associated with the port propeller were higher than those for the starboard propeller. At an altitude of 9100 m the two propellers generated similar sound pressure levels. The interior sound pressure levels do not exhibit such a definite trend. Several factors influence the relative magnitude of the port and starboard contributions to the interior sound field. One factor is the relative distance of the port and starboard propellers from the measurement location. Whereas on the exterior of the fuselage, the microphone on one side of the airplane is effectively shielded from the acoustic field generated by the propeller on the opposite side, the same is not true for the interior, as was seen in the narrowband spectra. Furthermore, the transmission path from a propeller to an interior observation point is influenced by the structure and the acoustic characteristics of the interior volume.

Examples of the contributions from the two propellers are contained in Figures 16 through 22. Figures 16 and 18 show harmonic levels measured at locations 3 and 6, in the plane of rotation of the propellers. On the port side (location 6) the levels associated with the port propeller are generally higher than those for the starboard propeller. This is physically reasonable since not

(a) Cabin Location 3 : Port & Stbd Propellers, High rpm



(b) Cabin Location 3 : Port & Stbd Propellers, Low rpm

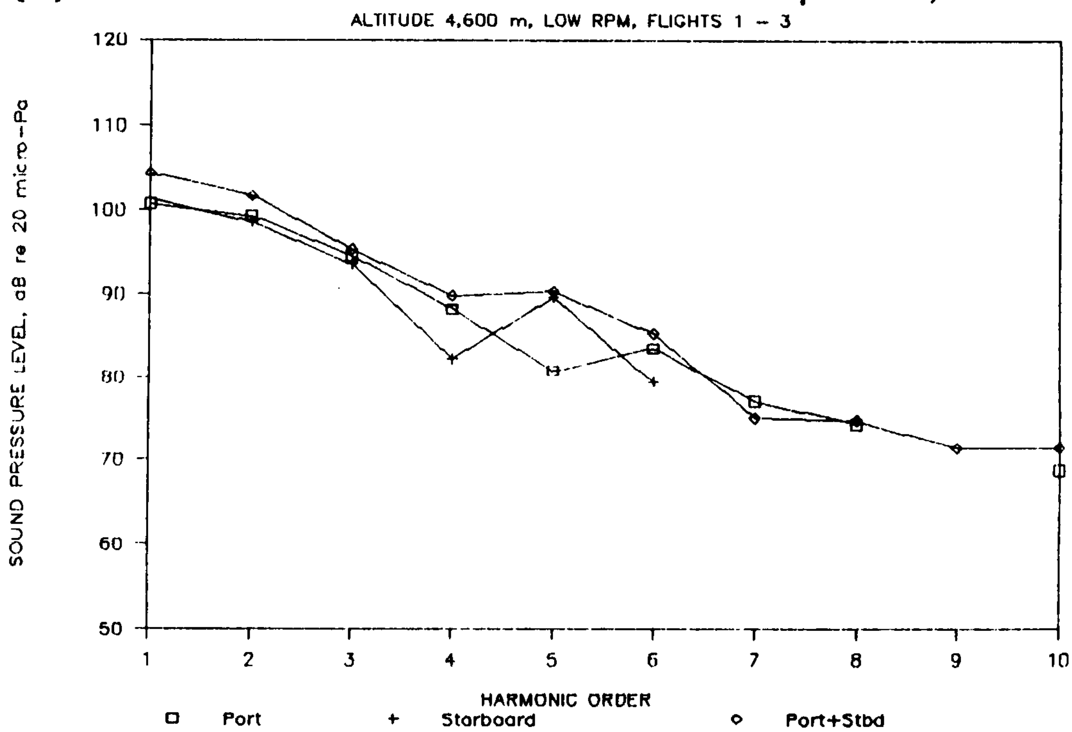
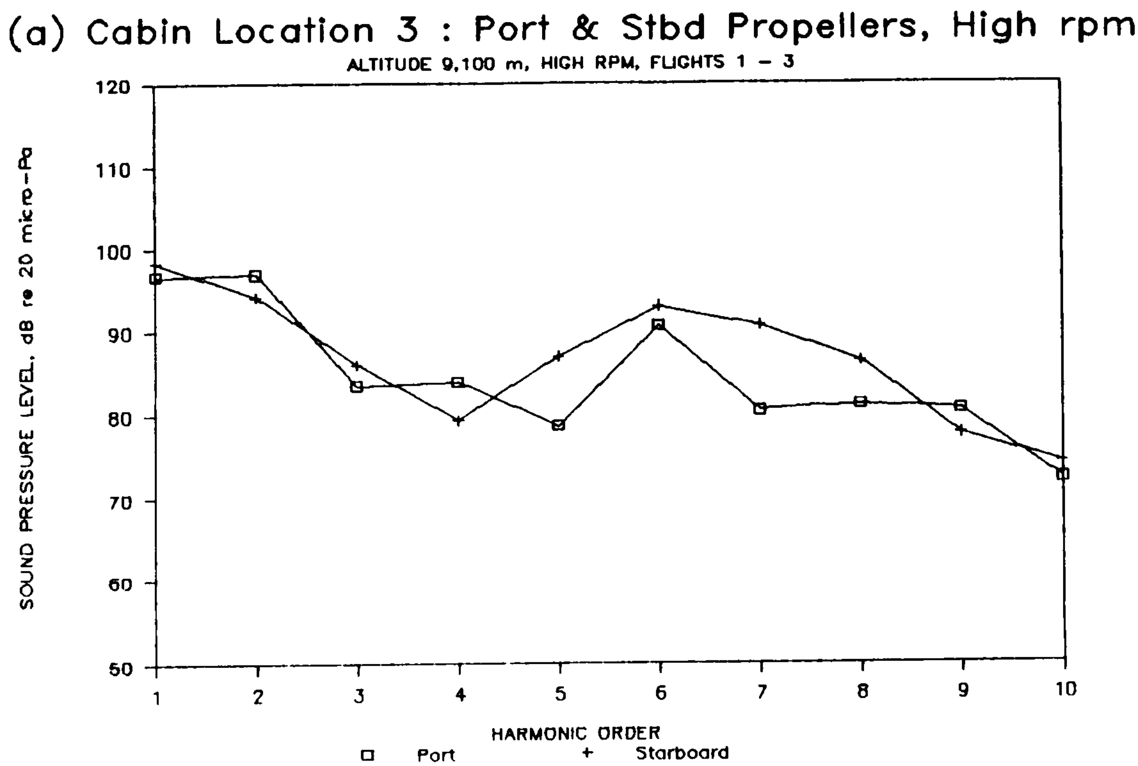


FIGURE 16. CONTRIBUTIONS OF PORT AND STARBOARD PROPELLERS TO HARMONIC SOUND PRESSURE LEVELS IN CABIN: 4600 M, LOCATION 3.



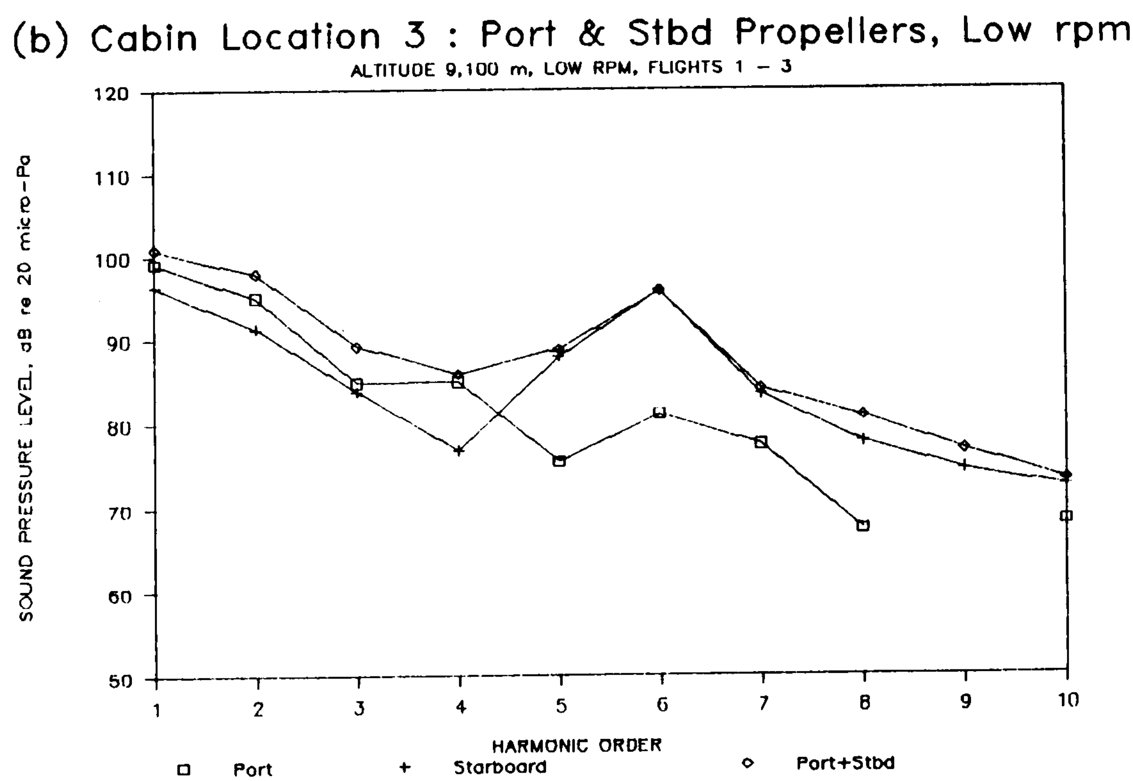


FIGURE 17. CONTRIBUTIONS OF PORT AND STARBOARD PROPELLERS TO HARMONIC SOUND PRESSURE LEVELS IN CABIN; 9100 M, LOCATION 3.

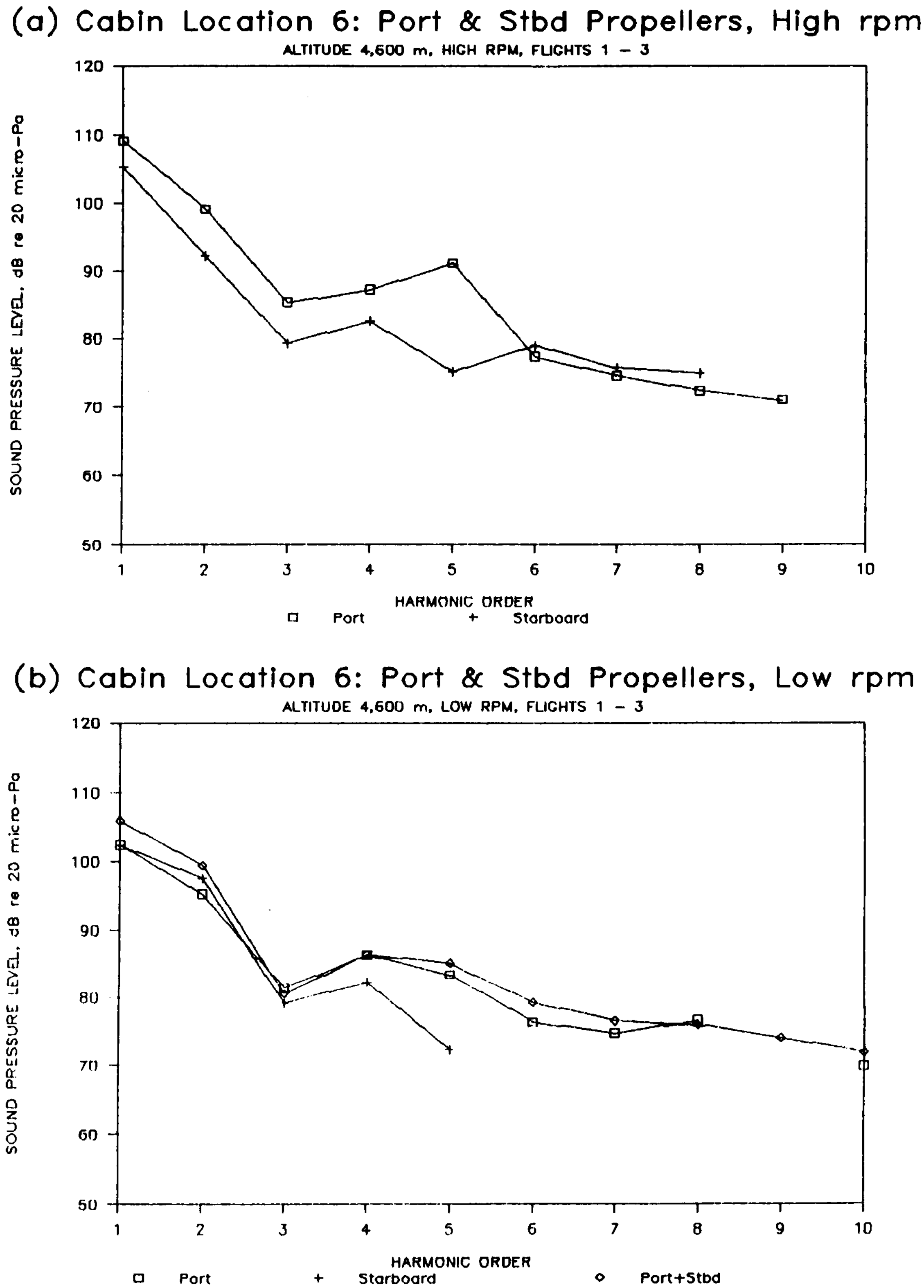
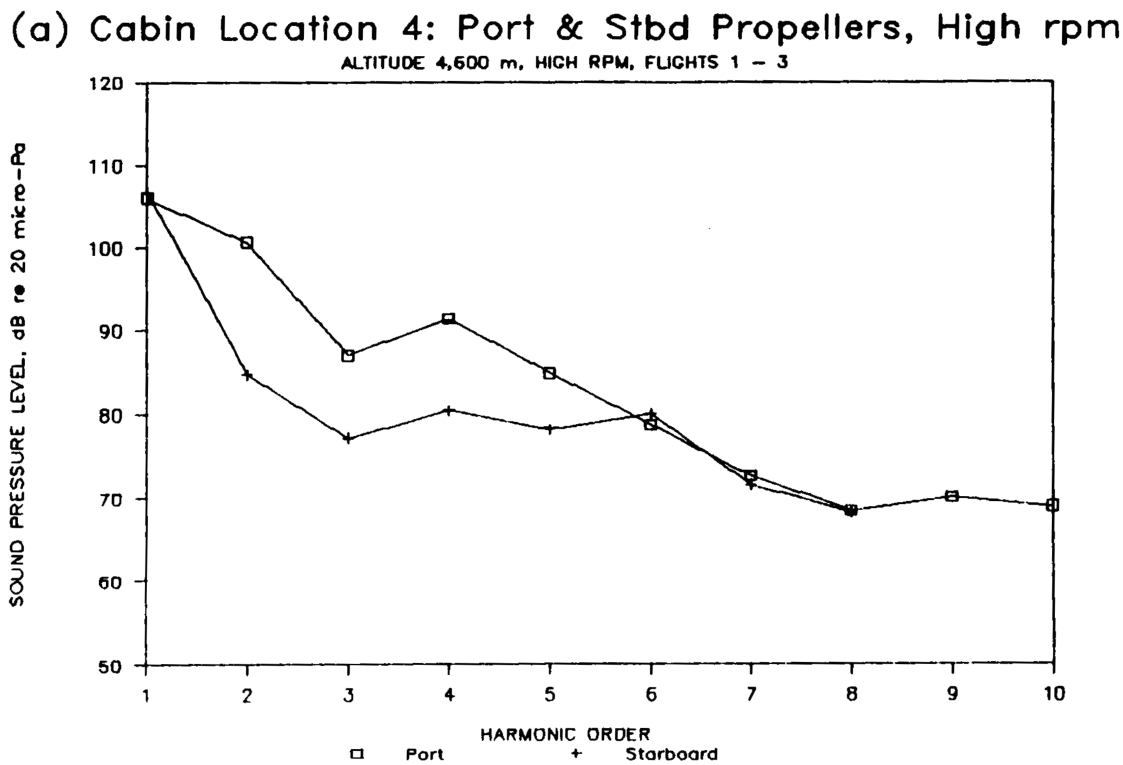


FIGURE 18. CONTRIBUTIONS OF PORT AND STARBOARD PROPELLERS TO HARMONIC SOUND PRESSURE LEVELS IN CABIN; 4600 M, LOCATION 6.



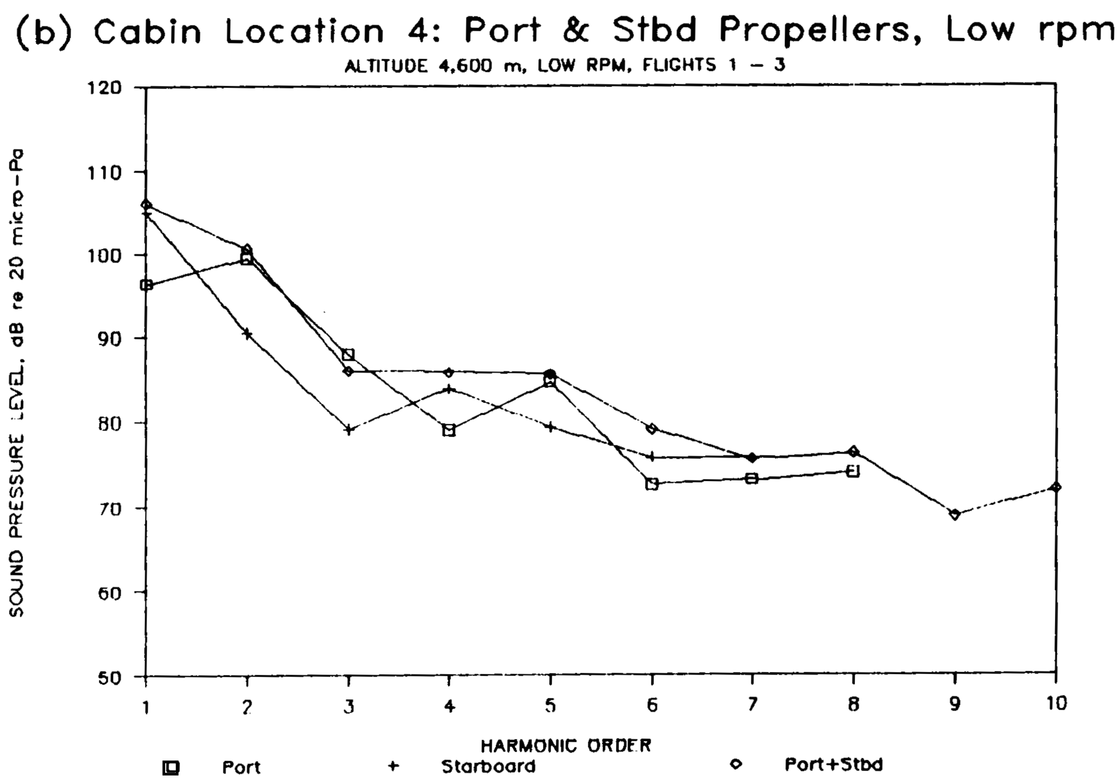


FIGURE 19. CONTRIBUTIONS OF PORT AND STARBOARD PROPELLERS TO HARMONIC SOUND PRESSURE LEVELS IN CABIN; 4600 M, LOCATION 4.

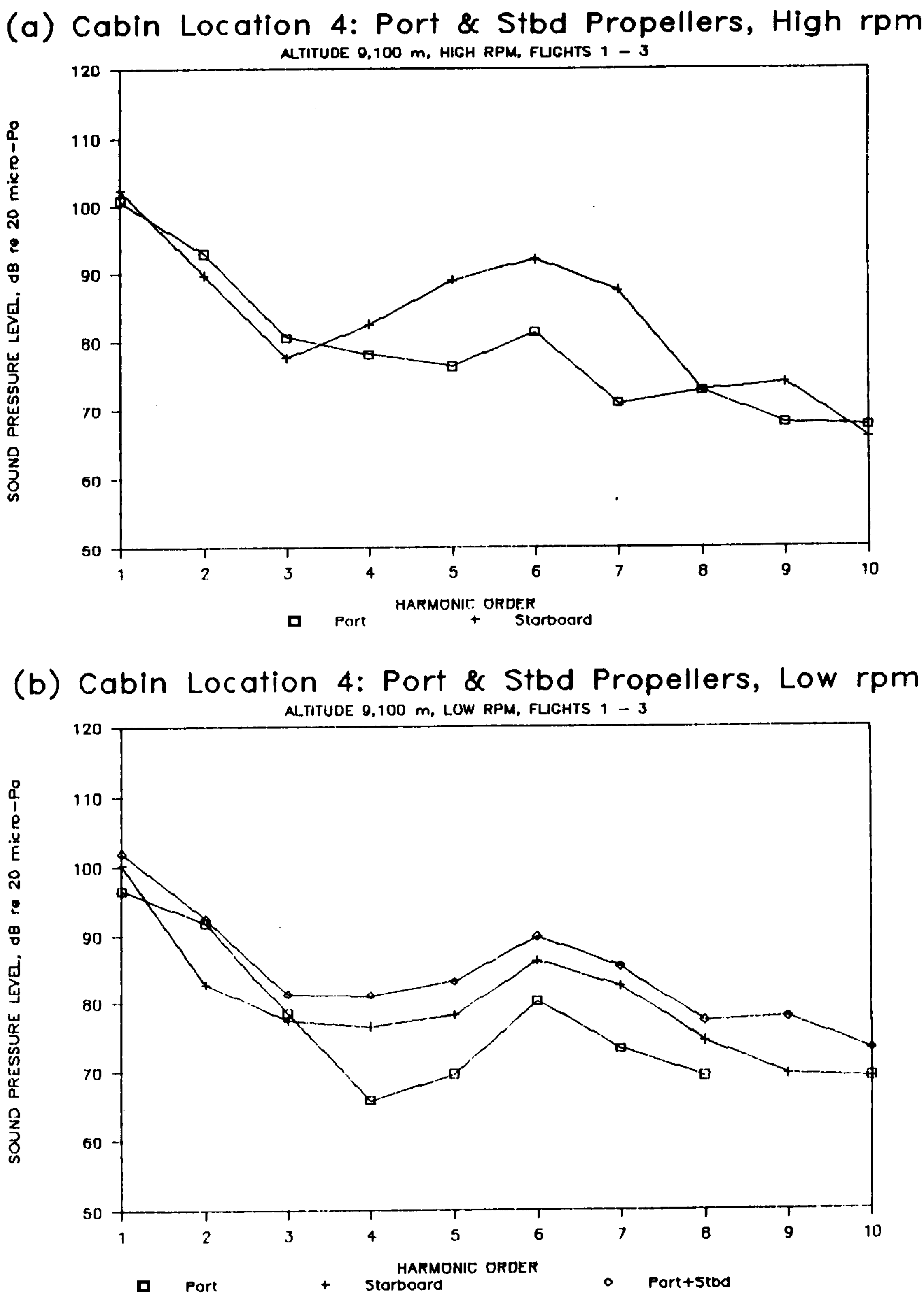


FIGURE 20. CONTRIBUTIONS OF PORT AND STARBOARD PROPELLERS TO HARMONIC SOUND PRESSURE LEVELS IN CABIN; 9100 M, LOCATION 4.

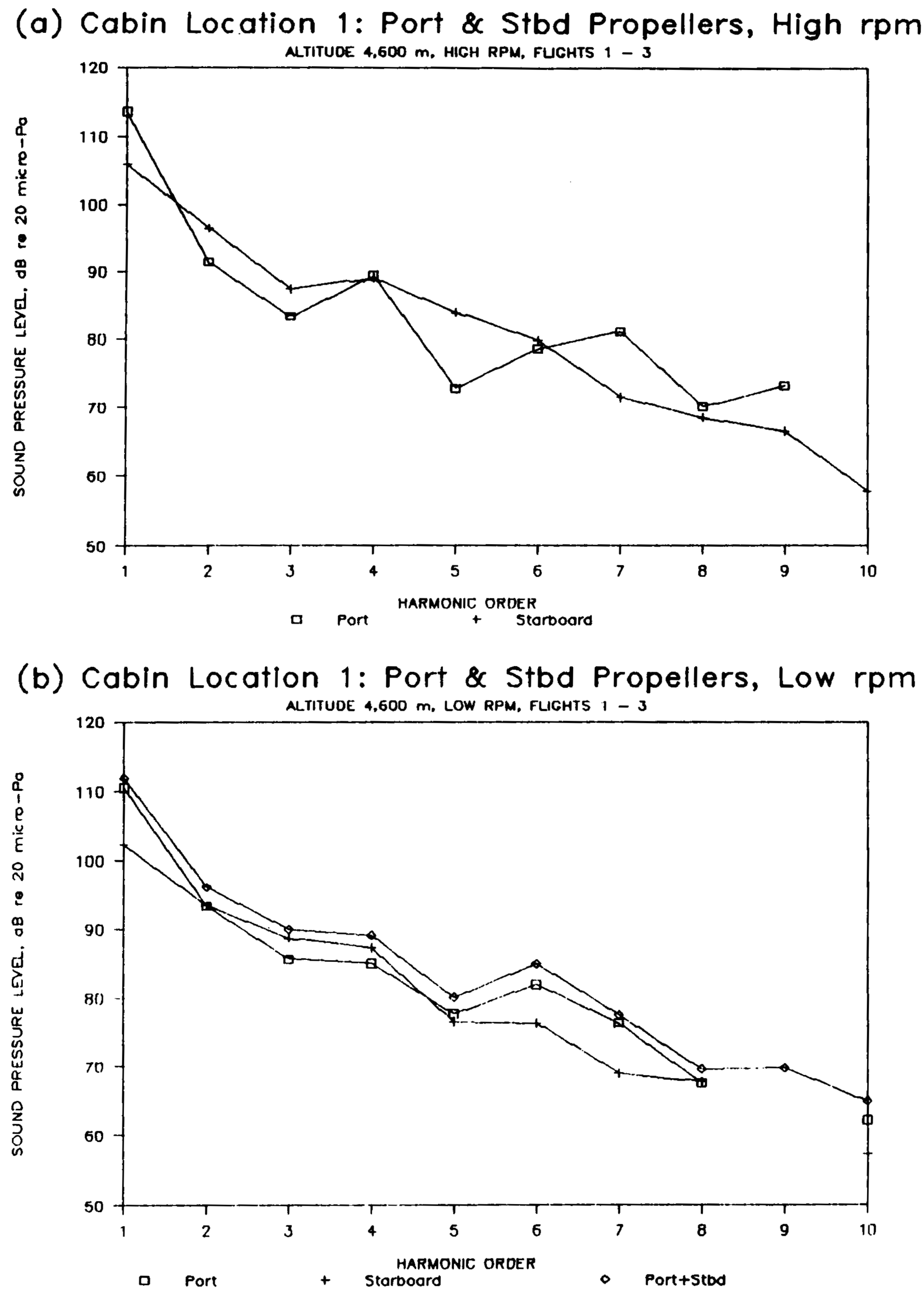


FIGURE 21. CONTRIBUTIONS OF PORT AND STARBOARD PROPELLERS TO HARMONIC SOUND PRESSURE LEVELS IN CABIN; 4600 M, LOCATION 1.

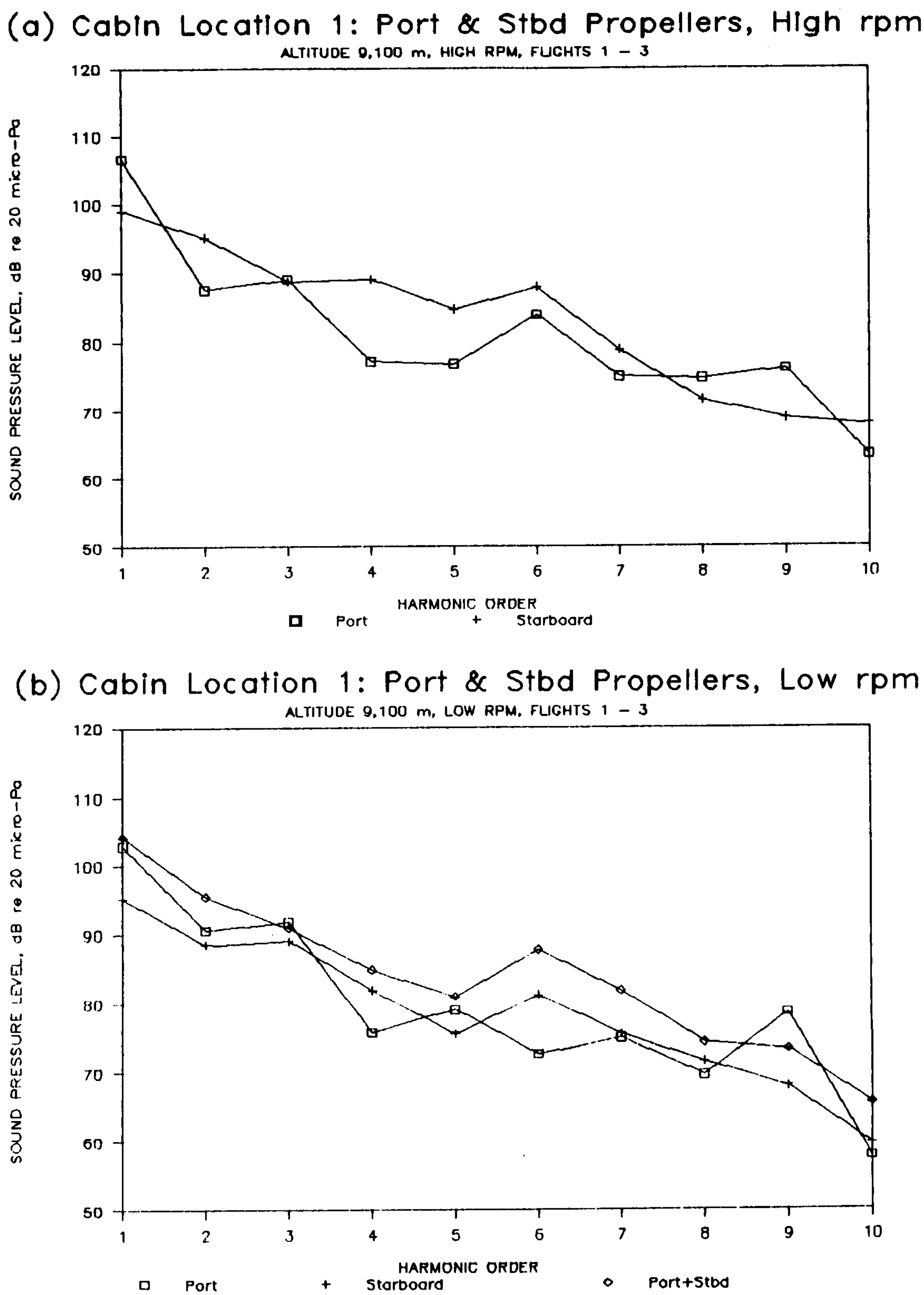


FIGURE 22. CONTRIBUTIONS OF PORT AND STARBOARD PROPELLERS TO HARMONIC SOUND PRESSURE LEVELS IN CABIN; 9100 M, LOCATION 1.

only is the port propeller the nearer propeller, it is also generating the higher exterior sound pressure levels. However, there are some harmonics for which the starboard propeller is the major source. On the starboard side (location 3) contributions from the two propellers are more similar in magnitude, although there are still large differences at some harmonics. When data for the 9100 m altitude conditions are considered, the starboard propeller is the major contributor to the sound pressure levels at location 3 for harmonics of order 5 and greater, but the port propeller is often the higher contributor at the lower order harmonics, even though it is the more distant propeller and the exterior sound pressure levels are essentially the same for the port and starboard propellers.

Further aft in the cabin, the contributions from the two propellers differ more widely than in the plane of rotation, as can be seen by comparing Figures 19 and 20 with Figures 16 and 17, respectively. In general, the port propeller makes the greater contribution to the lower order harmonics and the starboard propeller the greater contribution to the higher order harmonics. There is a shift in emphasis from 4600 m altitude to 9100 m altitude conditions, which is consistent with the relative changes in the exterior pressure levels. At location 1, the copilot's seat, the starboard propeller plays a more important role, being the major contributor for many of the harmonics, even at the lower altitude (Figures 21 and 22).

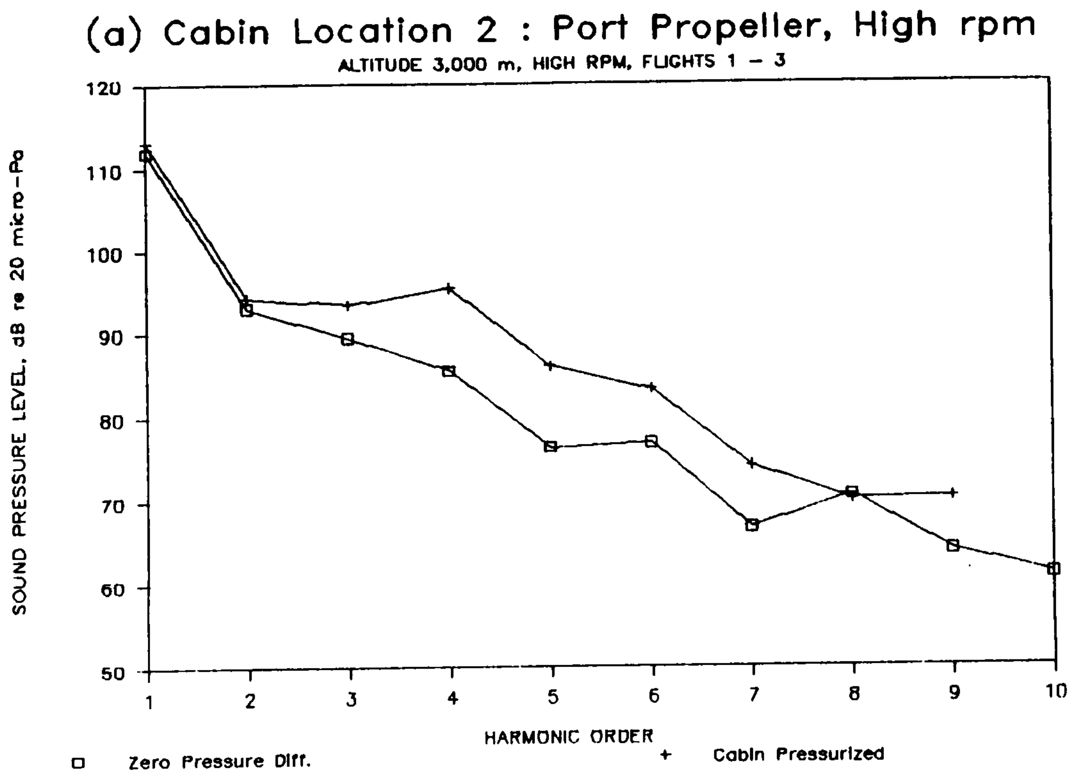
Figures 16 through 22 also contain mean harmonic levels associated with two-engine operation at the low rpm (96%) condition. These mean levels were obtained by averaging over all combinations of relative phase between the two propellers, as was done in Figures B.1 through B.6. The interest here is to compare the levels for two-engine operation with the levels obtained from a sum of the two components from the two individual propellers. Since the harmonics are essentially deterministic in character [13,14], the combined levels can be calculated from the individual propeller contributions only if both the amplitude and phase were known. If the contributions are in-phase, the amplitudes of the components will add directly and, if the components are of equal amplitude, the combined level will be 6 dB greater than either of the two components. If the components are out-of-phase, there will be destructive interference, the net effect of which will depend on the relative amplitudes of the components.

Inspection of the results indicates that the measured harmonic levels associated with two-engine operation are generally higher than the corresponding levels for either of the individual propellers. Harmonic levels for two-engine operation are lower than those for one of the components in only a very few cases. Furthermore, when one component is dominant, the two-engine operation levels are close to those of the dominant component. However, there are cases where the harmonic levels for the individual propellers are close in amplitude yet the levels associated with two-engine operation are only 1 or 2 dB higher. In those cases, phase differences between the two components are modifying the addition of the amplitudes.

5.5 Cabin Pressure Differential

Interior sound pressure levels were measured at two cabin pressure differentials (0 and approximately 26 kN/m^2) during flight at an altitude of 3000 m. The effect of pressure differential on the harmonic sound pressure levels is shown for two measurement locations in Figures 23 through 25. At location 2, the sound pressure levels in the cabin are generally higher when the cabin is pressurized than when it is unpressurized. However, in general, the trend is not so well defined, as is indicated by Figures 24 and 25. In these cases the harmonic sound pressure level increases with pressurization at some frequencies but decreases at others. It should be remembered when reviewing Figures 23 through 25 that the harmonics associated with the high (100%) rpm condition occur at frequencies that are different from those associated with the harmonic of the same order at the low rpm.

There are at least two phenomena that are influencing these results. First, increasing the pressure differential will increase the in-plane stresses in the fuselage skin. These stresses will, in turn, increase the effective stiffness of the structure and shift some of the structural resonances to higher frequencies. This change would affect the response of the structure to the exterior pressure field and the acoustic radiation into the cabin. Secondly, for a given level of vibration in the structure, the radiated acoustic pressures will be proportional to the air density in the cabin. In



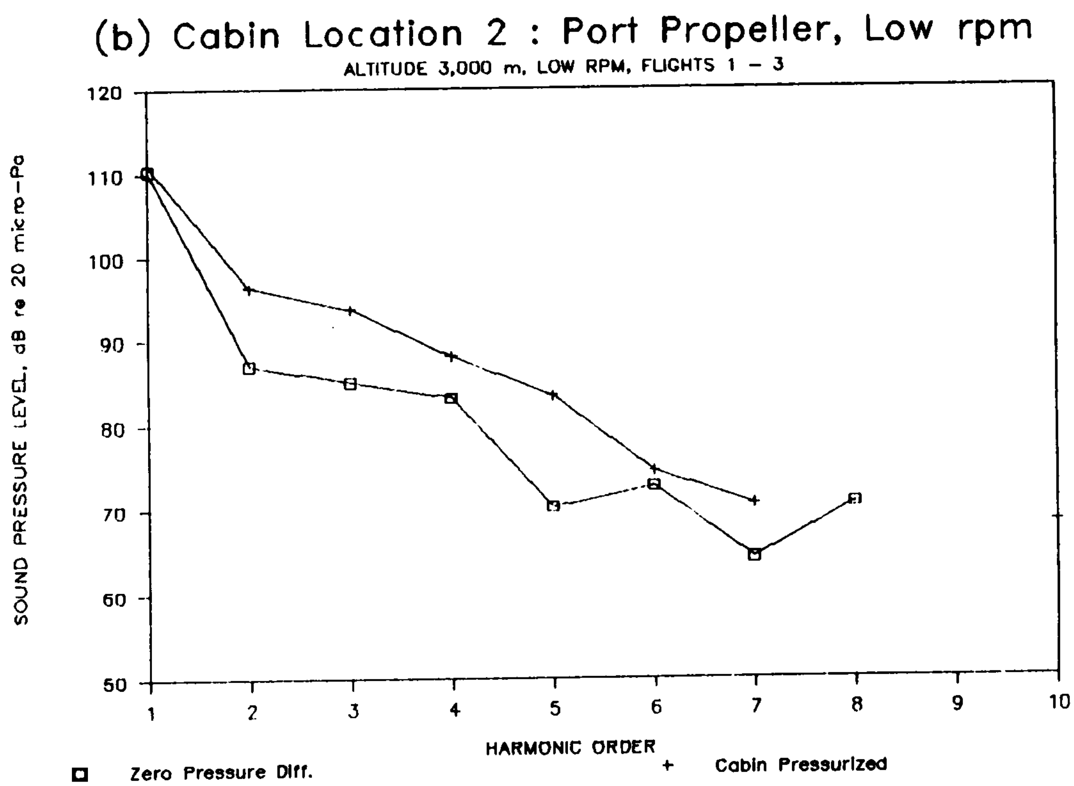
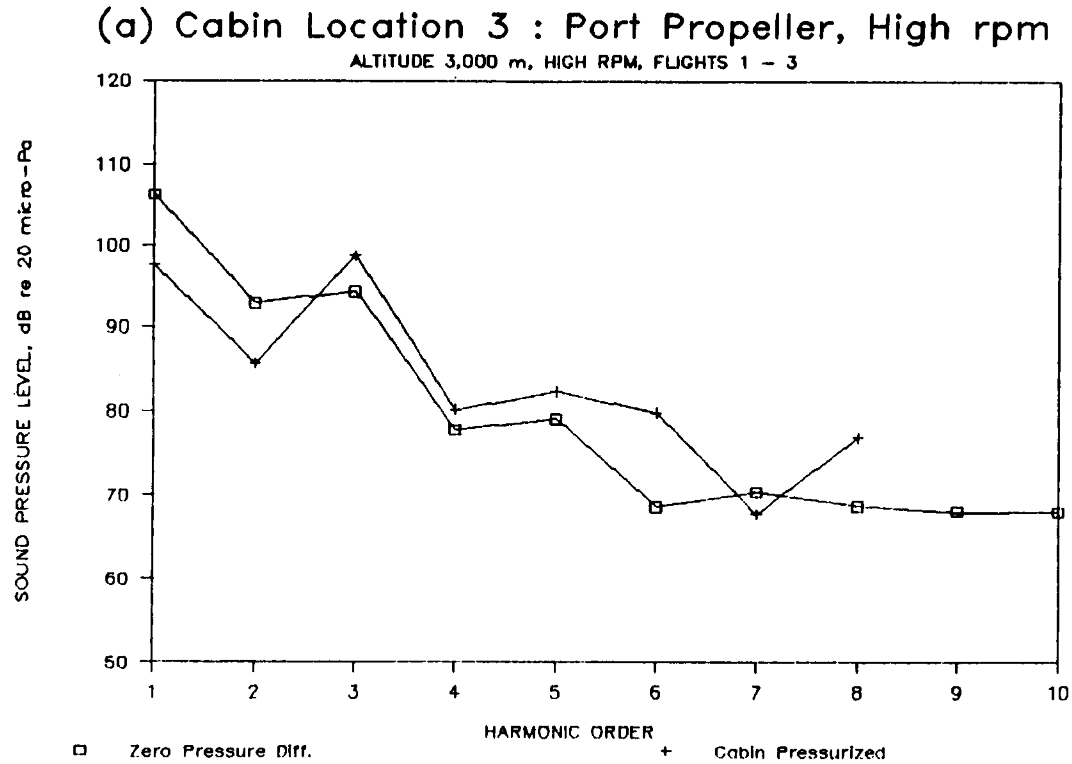


FIGURE 23, EFFECTS OF CABIN PRESSURE DIFFERENTIAL ON HARMONIC SOUND PRESSURE LEVELS; LOCATION 2, PORT PROPELLER.



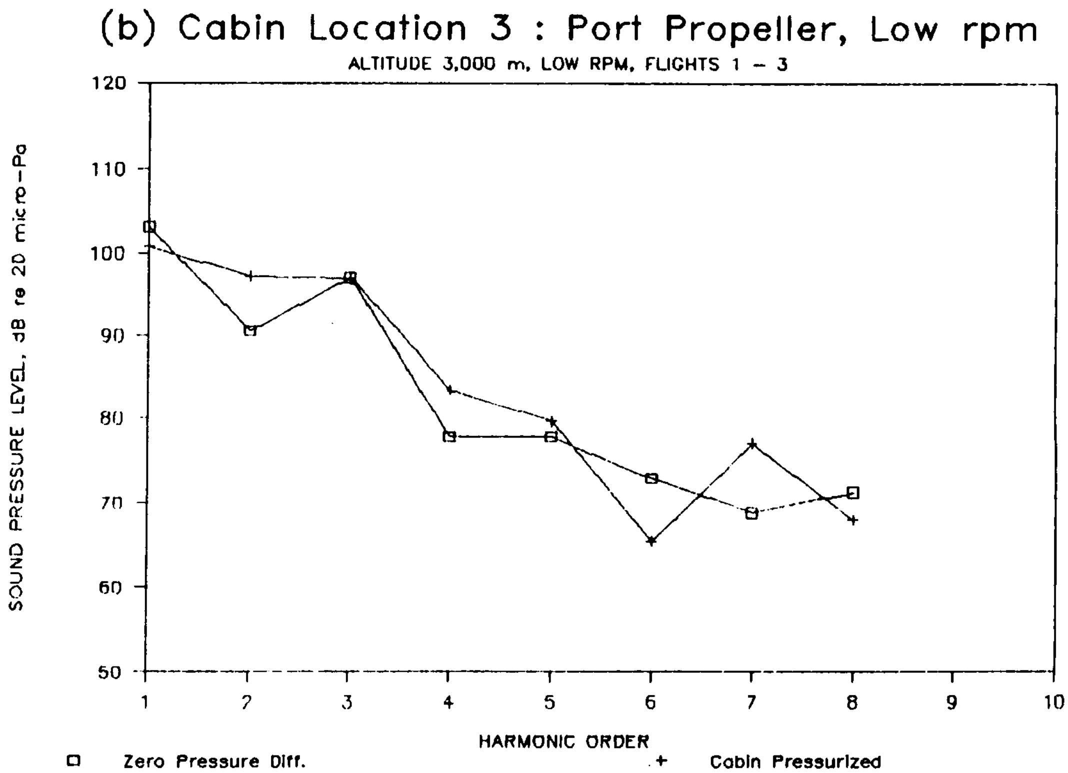
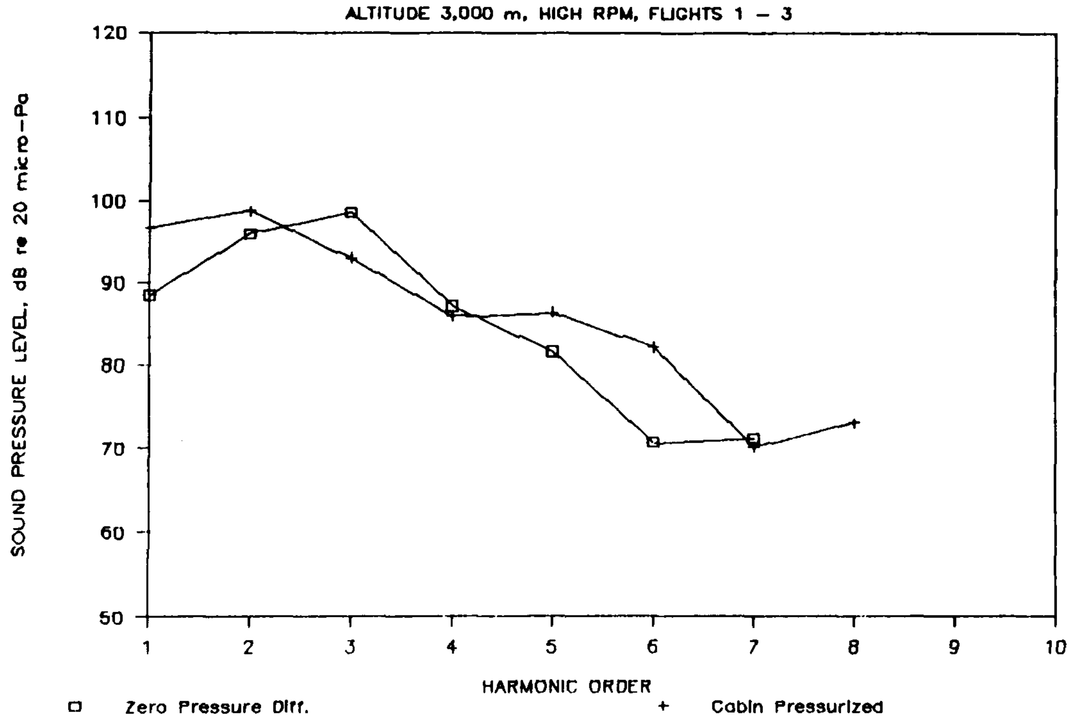


FIGURE 24. EFFECTS OF CABIN PRESSURE DIFFERENTIAL ON HARMONIC SOUND PRESSURE LEVELS; LOCATION 3, PORT PROPELLER.

(a) Cabin Location 3 : Starboard Propeller, High rpm



(b) Cabin Location 3 : Starboard Propeller, Low rpm

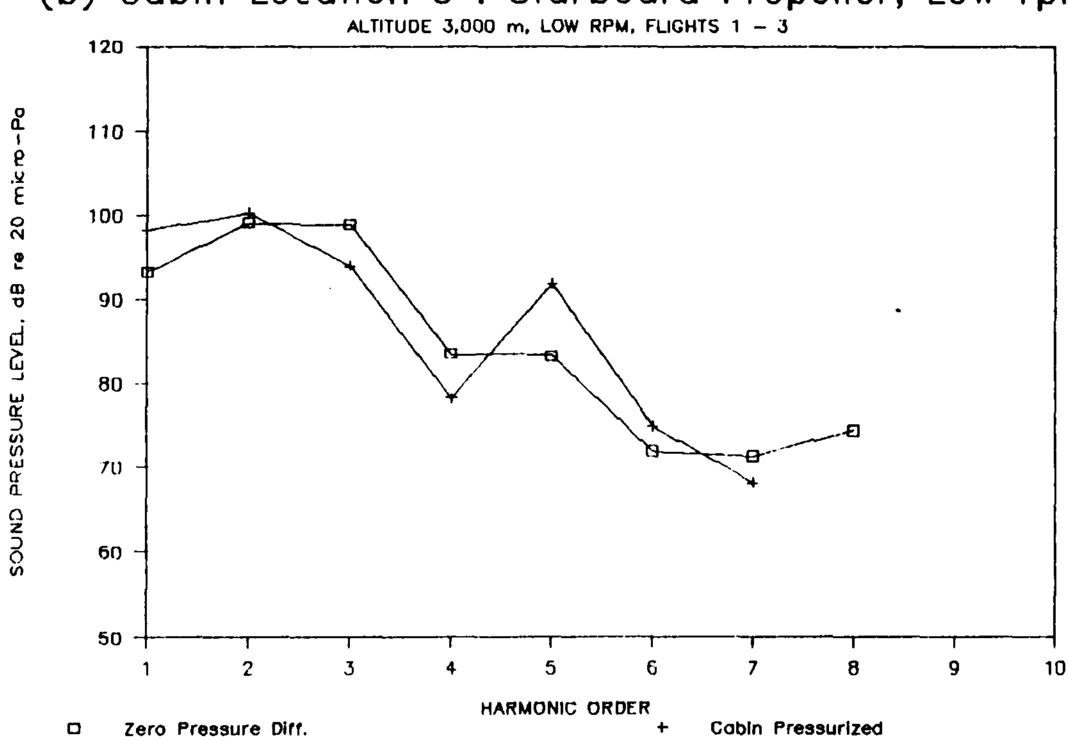


FIGURE 25, EFFECT OF CABIN PRESSURE DIFFERENTIAL ON HARMONIC SOUND PRESSURE LEVELS: LOCATION 3, STARBOARD PROPELLER.

the present case, assuming a negligible change in temperature in the cabin and a constant vibration level in the fuselage structure, it is predicted that the sound pressure levels in the cabin would increase by 3.3 dB when the cabin pressure differential increases from 0 to 26 kN/m^2.

5.6 Relative Phase between Propellers

One of the topics of interest to the investigation is the role played by relative phase between the two propellers. This has been alluded to in the preceding discussion on the mean sound pressure levels and the summation of component levels. It will now be considered in greater detail. As indicated in Section 2.2, it was not possible to determine in advance the relative phase between the two propellers. Instead, arbitrary settings were made to the synchrophase controller in the airplane and the phase angle was determined at a later date by analysis of the exterior acoustic data; results of this phase angle analysis are presented in Reference 4. It was found from the analysis that, of the four phase settings selected, two were, by chance, essentially the same and the data from those tests could be combined. Furthermore, it was determined that the relative phase angles for the tests at an altitude of 9100 m were very similar to those for the tests at an altitude of 4600 m, although they did not necessarily correspond to the same settings of the synchrophaser control knob. Measured phase angles between the two propellers, averaged over the appropriate flight tests, are listed in Table 7 where the angles are associated with the blade passage frequency. The corresponding relative phase angle for a particular harmonic component will be given by the product of the value in Table 7 and the appropriate harmonic order. Table 7 also indicates the range of values of the measured phase angle, relative to the quoted averages.

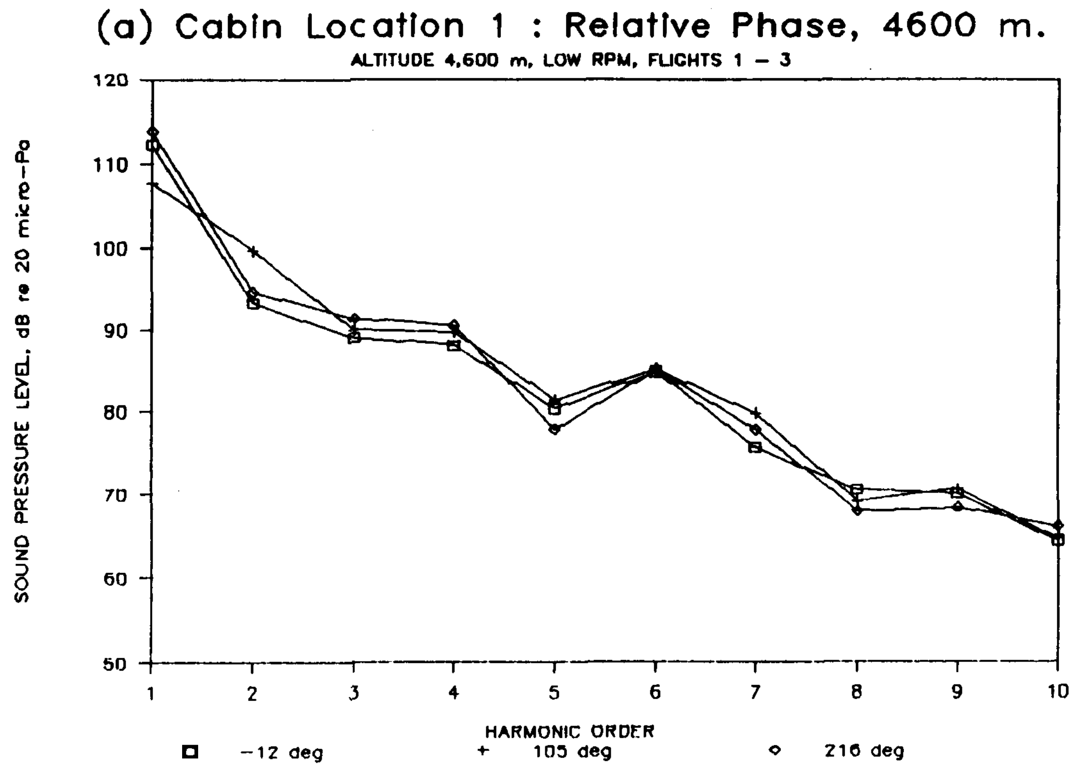
It should be remembered that the phase angles in Table 7 refer to the relative phase between blades on the two propellers (i.e. the noise sources). The relative phase between harmonic acoustic components at a measurement location in the cabin will result from the combined effects of the phase difference between the sources and the phase differences introduced by the propagation paths.

TABLE 7

RELATIVE PHASE BETWEEN PORT AND STARBOARD PROPELLERS

Flight Altitude (m)	Average Phase Angle (Degrees)		
4600	-12 ± 14	105 ± 6	216 ± 7
9100	4 ± 13	132 ± 18	248 ± 20

The effect of relative phase on harmonic sound pressure levels in the cabin is illustrated in Figures 26 through 28, which contain data for locations 1, 3 and 5, at flight conditions associated with the lower propeller speed. The figures indicate that the largest influence of relative phase occurs at the two lowest order harmonics.



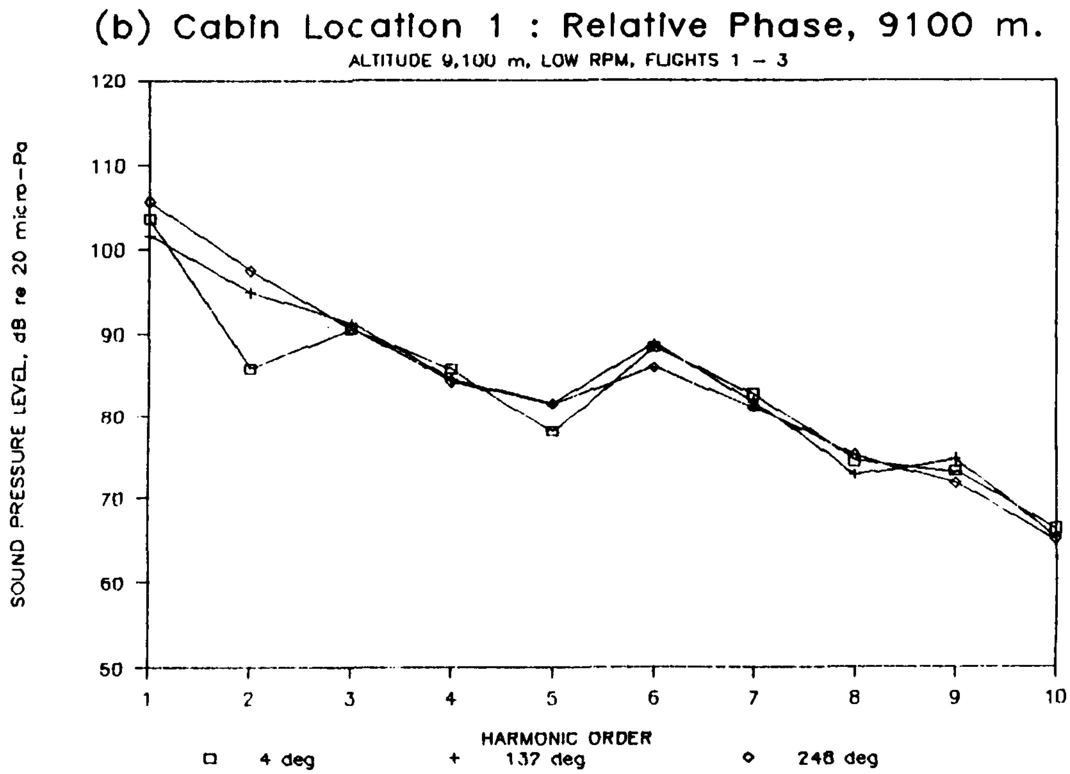
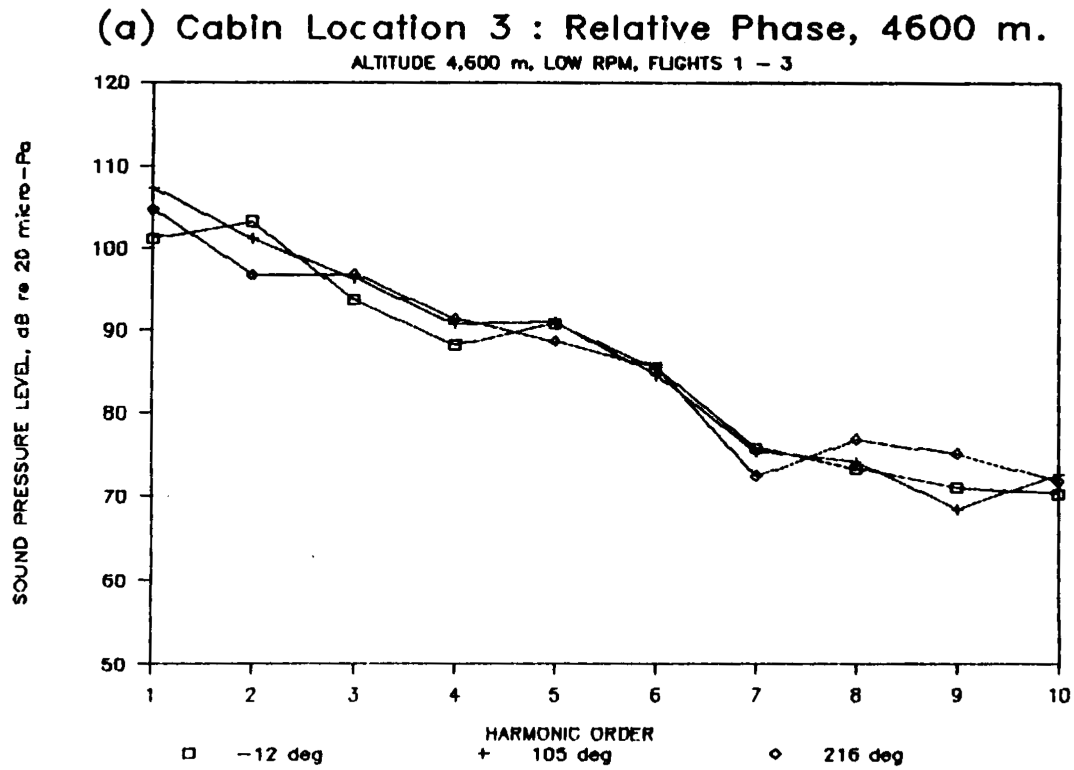


FIGURE 26. EFFECT OF PROPELLER RELATIVE PHASE ON HARMONIC SOUND PRESSURE LEVELS IN CABIN; LOCATION 1.



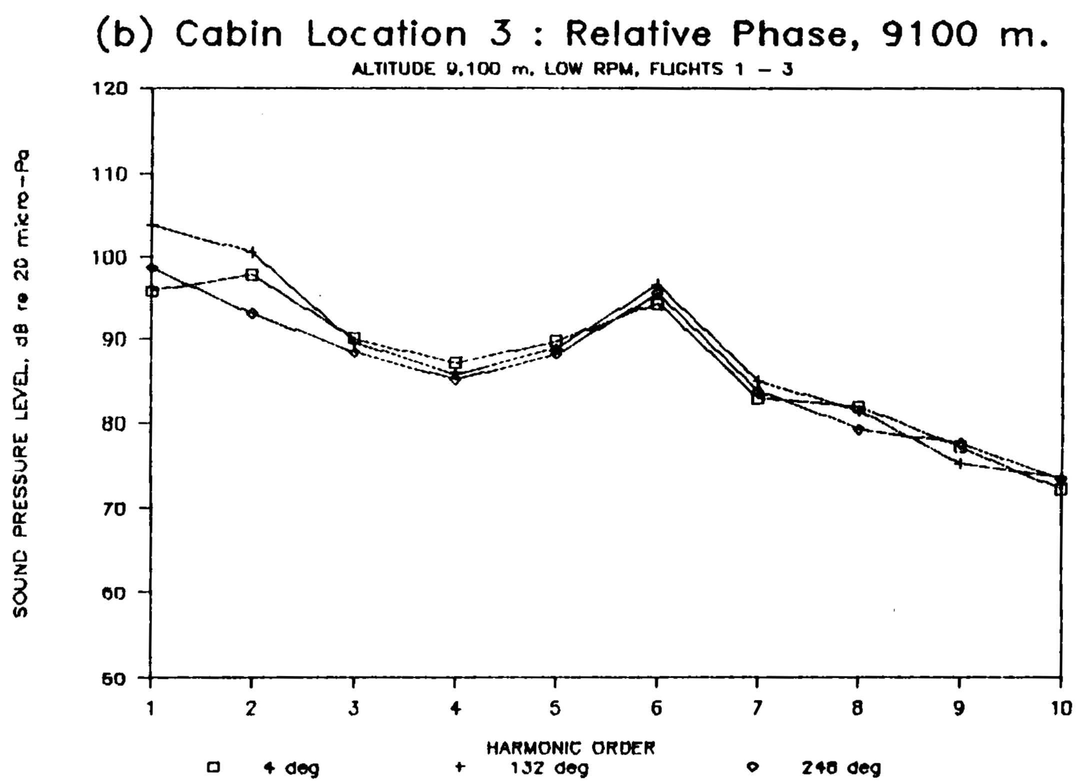
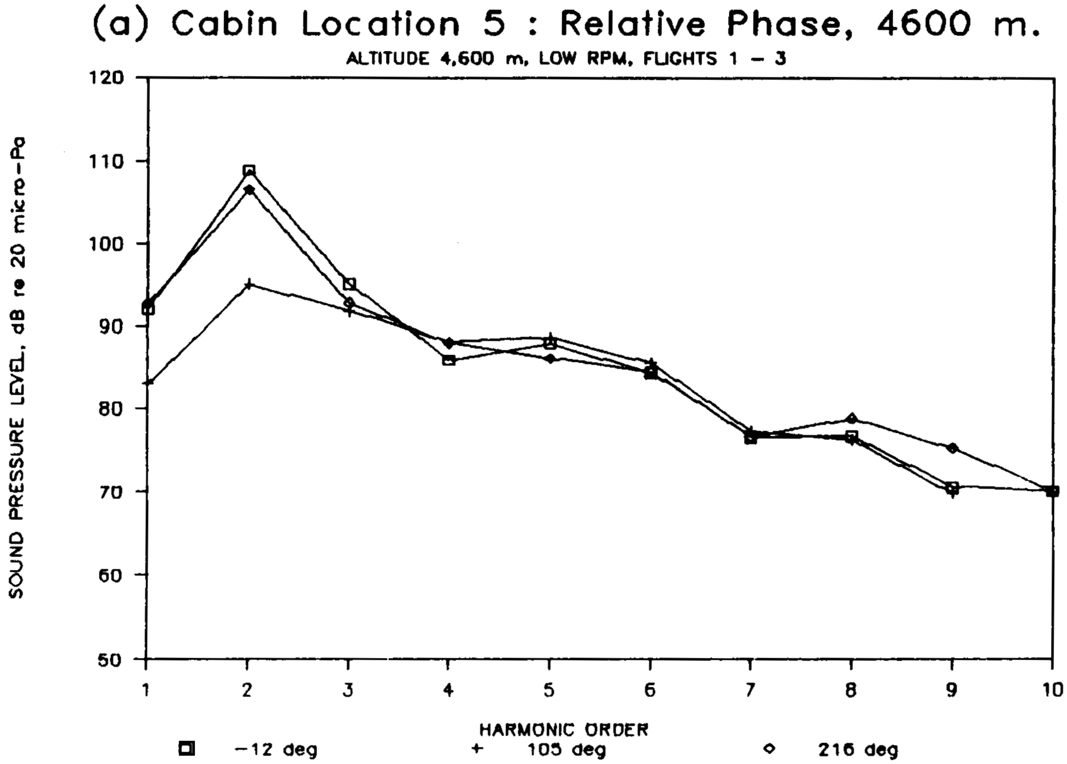


FIGURE 27. EFFECT OF PROPELLER RELATIVE PHASE ON HARMONIC SOUND PRESSURE LEVELS IN CABIN; LOCATION 3.



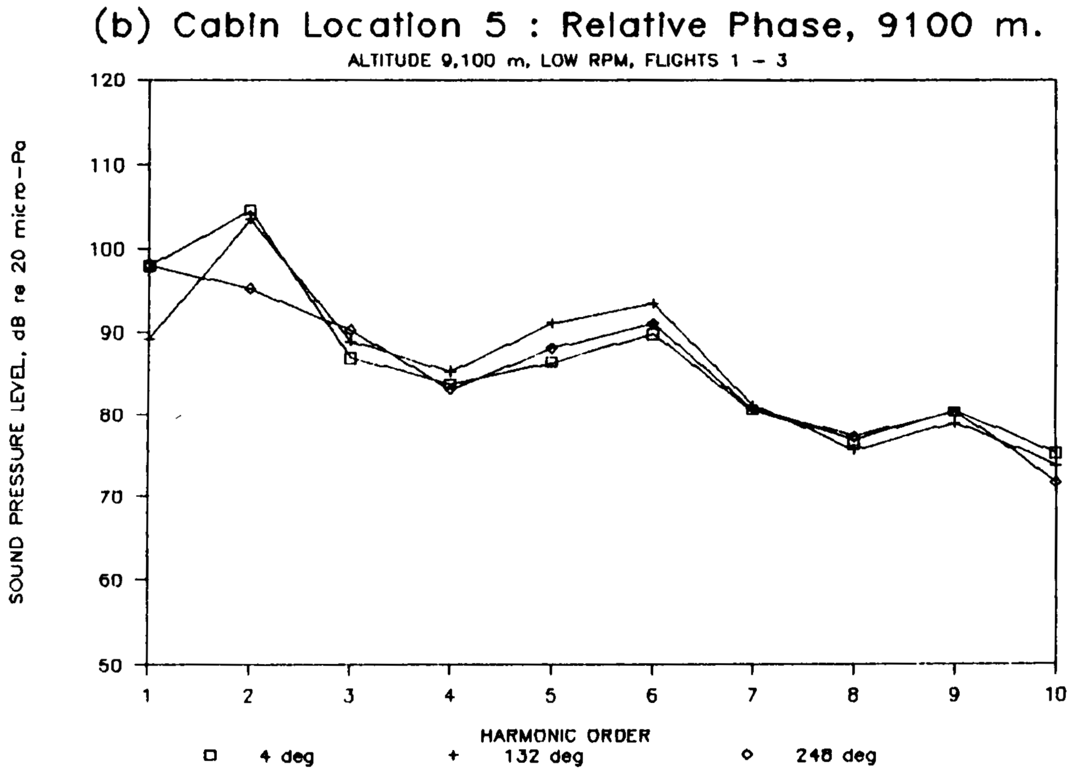


FIGURE 28. EFFECT OF PROPELLER RELATIVE PHASE ON HARMONIC SOUND PRESSURE LEVELS IN CABIN; LOCATION 5.

6. TREATMENT INSERTION LOSS

6.1 Introduction

One purpose of acoustic measurements in a propeller-driven airplane is the evaluation of noise control treatments. In past investigations [2-4], measurements of the insertion loss provided by noise control treatments have shown a wide variability in the results. Consequently, it was difficult to determine accurately the acoustic performance of the materials. The present analysis of the flight test data considers the accuracy of the insertion loss measurements.

The treatment installed in the test airplane consisted solely of fiberglass material, as described in Section 2.4. The treatment was not designed to provide a high transmission loss through the sidewall, the main intent being to increase the acoustic absorption within the cabin. The noise control provided by the treatment was described in Reference 4 using data for measurement location 3 and 6. It was found that, when data were used at harmonics of the blade passage frequency, there was large scatter in the results so that it was difficult to determine the insertion loss with any degree of accuracy. The data scatter was reduced when one-third octave band sound pressure levels were used to determine insertion loss.

The insertion loss provided by the treatment is computed as the difference between the cabin sound levels measured in the untreated and treated interiors. Thus, it is the difference between two measurements, each of which, as has been shown in Section 4, has significant variability. It is to be expected that the insertion loss will show even greater variability. This is borne out by the data. The results reported in Reference 4 were for individual test conditions and it is of interest now to explore the usefulness of averaging insertion loss measurements over various test conditions and measurement locations. Insertion losses measured at harmonics of the blade passage frequency will be considered first and the results will then be compared with corresponding data based on one-third octave band analysis.

The process of data analysis was as follows. Noise reductions (differences between exterior and interior sound pressure levels) were computed for all flight conditions of interest. Since only measurements for test conditions where the port and starboard propellers were operated at different rpm were used, the exterior reference sound pressure level was that of the associated propeller, whether it be on the port or starboard side of the fuselage. It is recognized that the term "noise reduction" is used rather loosely in the present context because of the spatial variation of the exterior pressure field, but the exterior pressure is used only as a reference for each interior measurement, to adjust data for variations of the exterior pressures. Noise reductions are then averaged over flights 1 through 3 to obtain mean values for the untreated cabin. The insertion loss of the treatment is then obtained from the difference between the noise reductions for the treated cabin (flight 4) and the noise reduction for the untreated cabin (flights 1 through 3). In this case, standard deviations are calculated directly in terms of insertion loss (in decibels).

It was observed in Reference 4 that, when analyzing insertion loss data associated with locations 3 and 6 in the cabin, it was difficult to identify any influence of flight conditions on the results. From physical arguments, there is no reason to expect significant variations in insertion loss from test to test at the same altitude. However, there are reasons, such as changes in the velocity of sound, for variations of insertion loss from altitude to altitude, but, since the cabin was air conditioned to some extent, the variations were probably small for a given interior treatment. Thus, measured insertion losses associated with a given location in the cabin have been averaged over all test conditions. Data were obtained for low and high rpm conditions and the harmonic components are presented in terms of frequency instead of harmonic order.

6.2 Narrowband Insertion Loss

Average insertion losses measured at harmonics of the blade passage frequency are presented in Figure 29 for each of the five locations (2-6) in the passenger cabin. The irregular nature of the insertion loss spectra is immediately apparent, although the general trend of increasing insertion loss

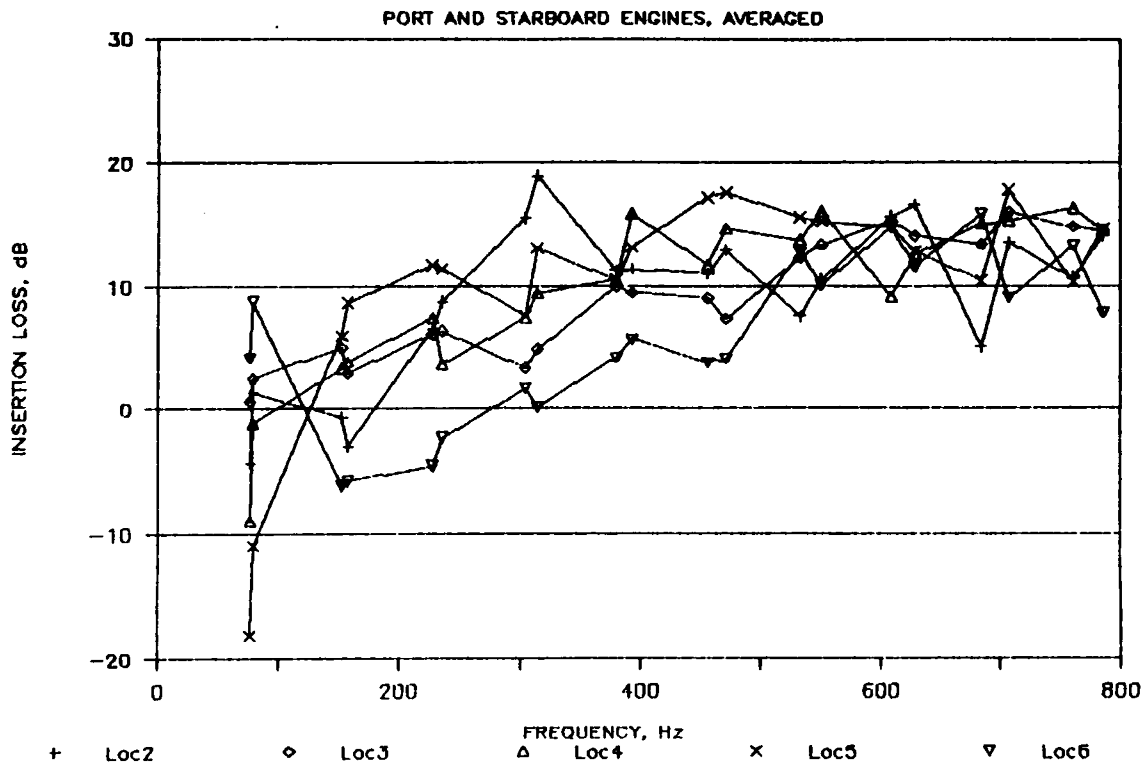


FIGURE 29. TREATMENT HARMONIC INSERTION LOSS MEASURED AT DIFFERENT LOCATIONS IN CABIN.

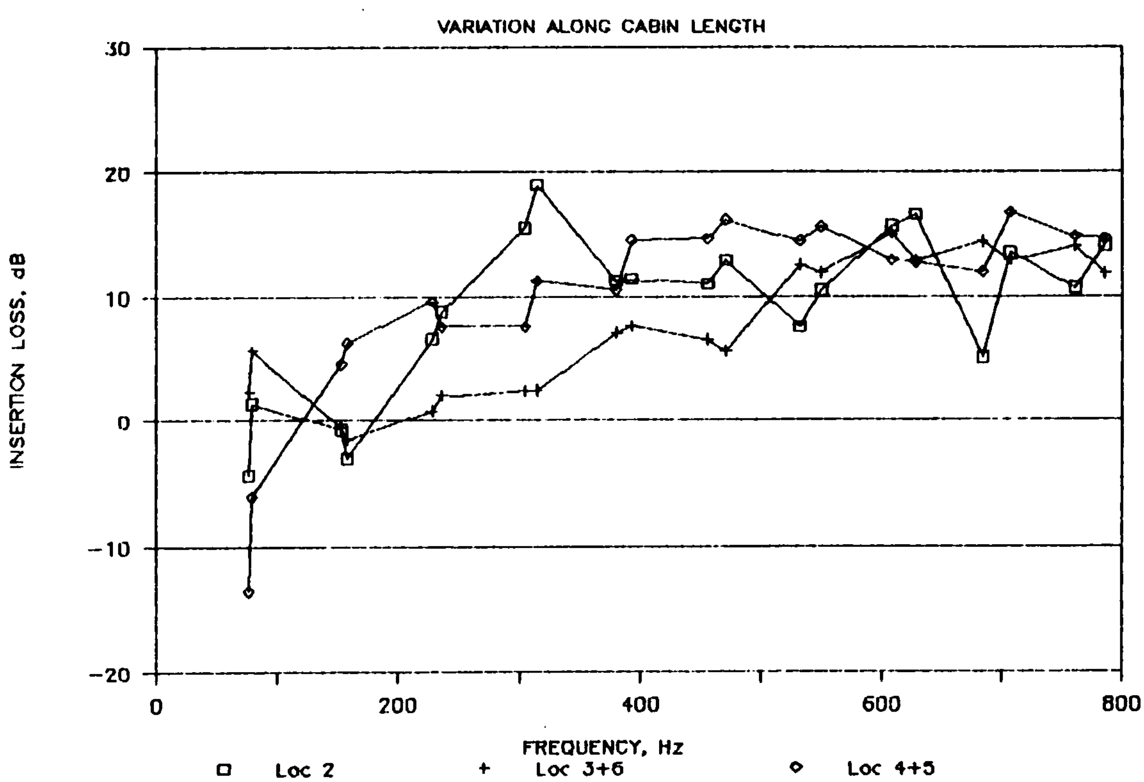


FIGURE 30. TREATMENT HARMONIC INSERTION LOSS AVERAGED AT DIFFERENT STATIONS.

with increasing frequency is observed at all locations. Since the fiberglass treatment provides broadband noise control, it would be unlikely to provide such an irregular insertion loss spectrum. Standard deviations for the data at each harmonic and each location are typically $\pm$6.5 dB. As expected, these deviations are higher than those associated with the measured interior sound pressure levels used in calculating the insertion losses.

The five measurement locations represent three stations along the cabin. Thus, it is reasonable to calculate average insertion losses for pairs of locations at the same longitudinal stations (i.e. average data for locations 3 and 6, and for locations 4 and 5). Insertion loss spectra averaged in this manner are compared in Figure 30. There is a suggestion in the results that, for the frequency range from 250 to 500 Hz, the insertion loss measured in the middle of the cabin (locations 3 and 6) is less than that in the forward (location 2) and aft (locations 4 and 5) regions. At other frequencies the insertion loss seems to be independent of location. As a next step, insertion losses have been averaged over all locations in the cabin and compared with insertion losses measured at location 1 in the cockpit (Figure 31). At frequencies below about 500 Hz, the insertion losses are similiar in the cabin and cockpit, but, at higher frequencies, the insertion loss for the cockpit diverges from that in the cabin, and approaches zero, whereas in the cabin the insertion loss is greater than 10 dB.

It should be remembered the there is no added treatment in the cockpit, except for the barrier between the cabin and the cockpit. The implication of these results is that the harmonic sound pressure levels in the cockpit, in the frequency range below 500 Hz, are associated with transmission via the cabin. At higher frequencies, where the cabin treatment has no influence on cockpit sound pressure levels, the transmission path must be via the cockpit windows or sidewall (either airborne or structureborne).

6.3 One-Third Ocatve Band Insertion Loss

Insertion losses were also determined using one-third octave band sound pressure levels. Resulting insertion loss spectra, averaged for the three stations along the cabin, are plotted in Figure 32. The spectra are much

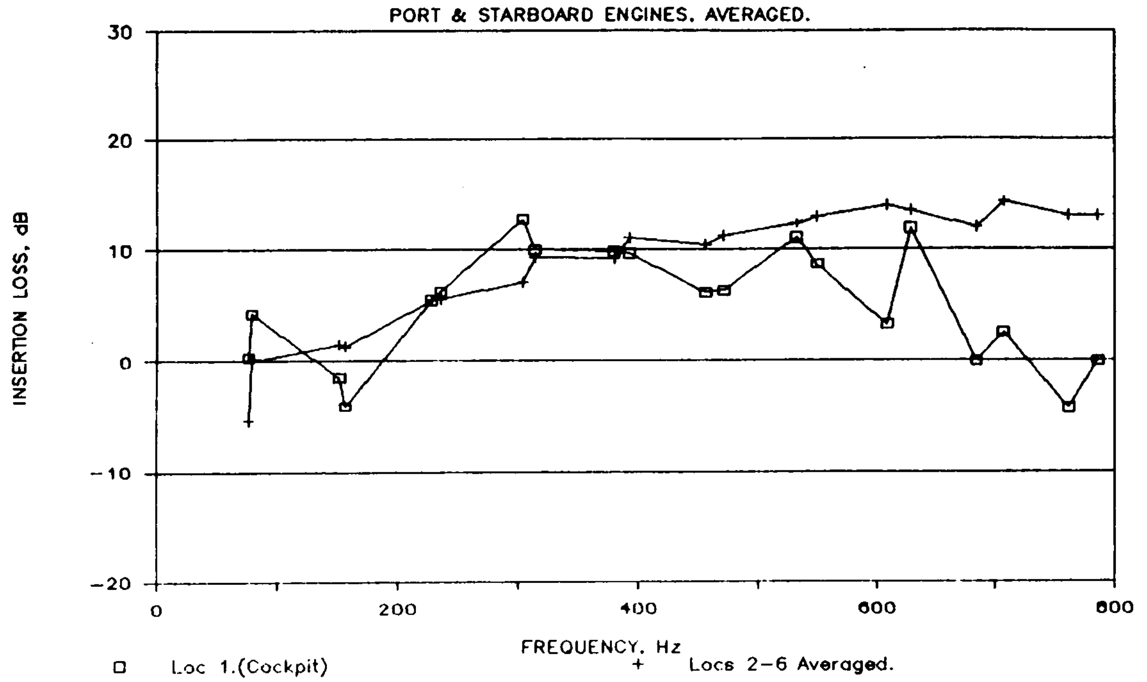


FIGURE 31. SPACE-AVERAGED TREATMENT HARMONIC INSERTION LOSS FOR CABIN AND MEASURED INSERTION LOSS AT LOCATION 1.

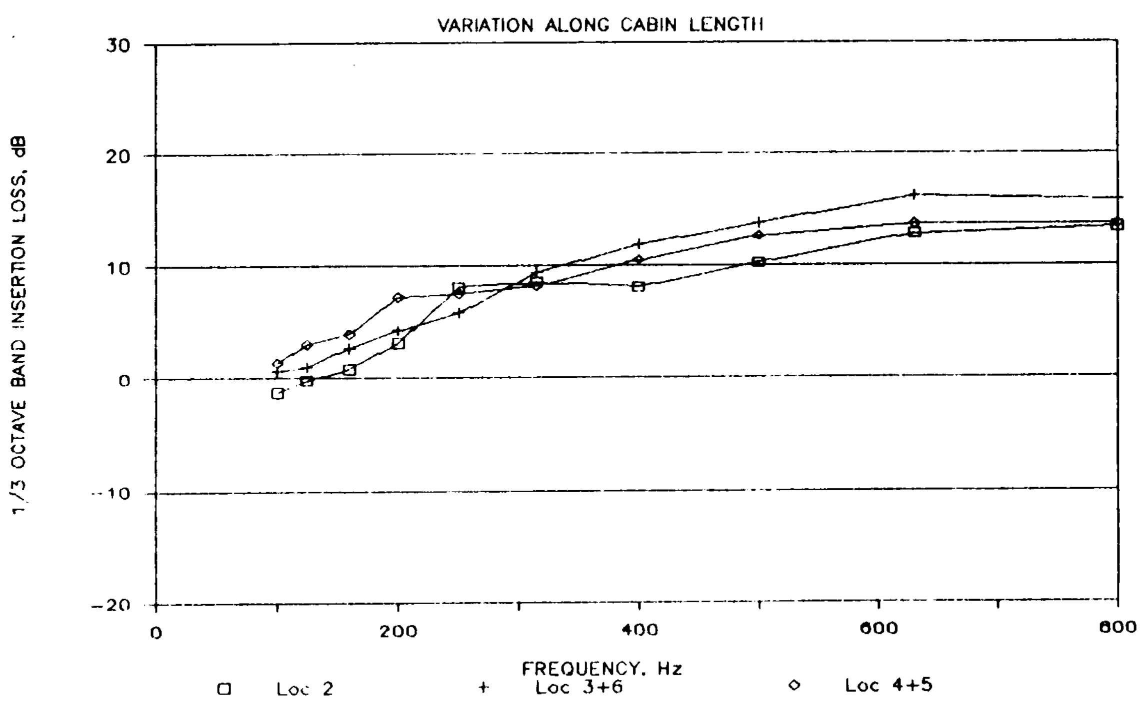


FIGURE 32. TREATMENT ONE-THIRD OCTAVE BAND INSERTION LOSS AVERAGED AT DIFFERENT STATIONS IN CABIN.

smoother than in the case of the harmonics (Figure 30) and show less dependency on the location along the cabin. Furthermore, typical standard deviations for the one-third octave band data are ± 1 dB, a value that is much lower than the ± 6.5 dB associated with the harmonic data. Averaging the insertion loss data for all five locations in the cabin results in a smooth spectrum (Figure 33) with typical standard deviation of ± 1.9 dB and 90% confidence limits that are typically ± 0.4 dB relative to the mean.

Finally, the harmonic and one-third octave band insertion losses, averaged over locations 2 through 6, are compared in Figure 34. After this extensive averaging, the two insertion loss spectra are very similar throughout the frequency range from 100 to 800 Hz. However, one peculiarity has survived all the averaging process. This is associated with the blade passage frequency at the low rpm of the propeller, where large negative insertion losses were measured at some locations (see Figure 29). The averaged insertion loss at this frequency (76.1 Hz) is approximately -6 dB, as shown in Figure 34, whereas the insertion losses shown at all other frequencies in Figure 34 are positive.

It has been speculated [2] that acoustic modal characteristics of the cabin volume could influence the measured sound pressure levels, especially when the cabin is untreated or has minimal treatment, such as in the case of the present tests. Test data presented in Reference 2 for the airplane used in the present program show that harmonic sound pressure levels measured close to a node of an acoustic mode could be sensitive to small changes in microphone locations or cabin contents. It was for this reason that the microphones were installed prior to the first flight and left inplace until the third flight had been completed. They had to be removed to allow installation of the treatment and it is possible that they may have been at slightly different locations when reinstalled.

Also, it has been shown by Heitman and Mixson [16] that small changes in air temperature in the cabin can have strong influences on the measured sound pressure levels, when measured in narrow frequency bands. In that case, the source was broadband white noise, so that the effect was small when measurements were made in one-third octave bands. Cabin air temperatures were

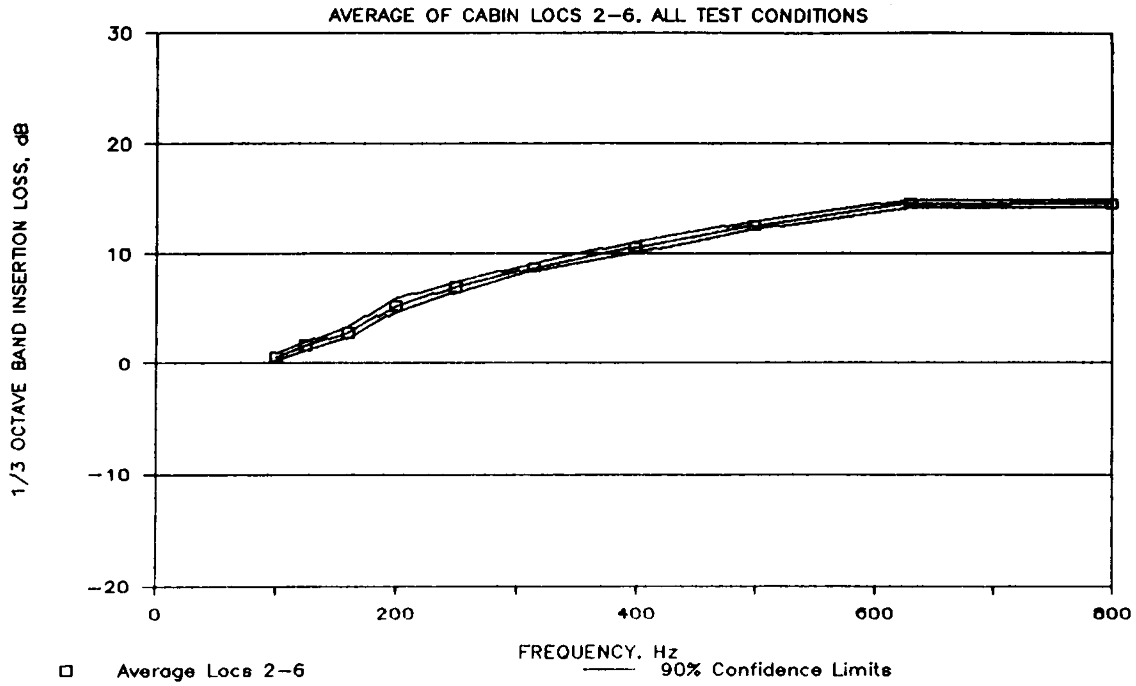


FIGURE 33. TREATMENT SPACE-AVERAGED ONE-THIRD OCTAVE BAND INSERTION LOSS AND 90% CONFIDENCE LIMITS.

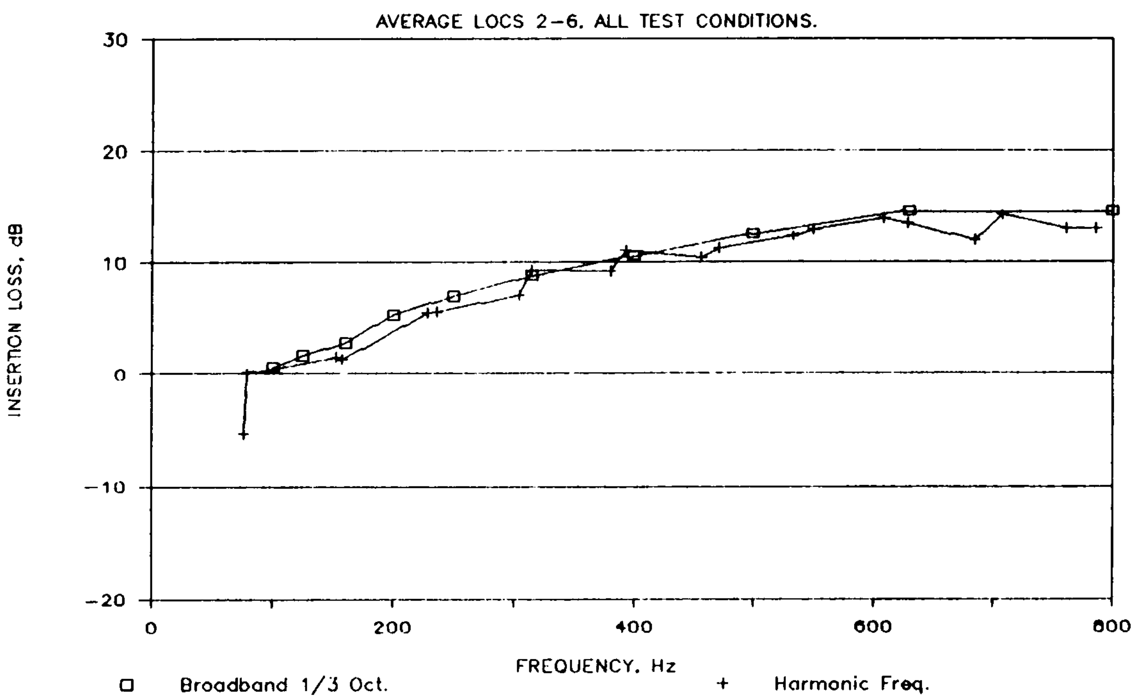


FIGURE 34. COMPARISON OF ONE-THIRD OCTAVE BAND AND HARMONIC SPACE-AVERAGED INSERTION LOSS SPECTRA.

not measured during the present flight tests, but it was observed by the acoustic test engineers that, subjectively, it was warmer in the cabin during the fourth flight, when the fiberglass was installed, than during the three preceding flights when the cabin was untreated. Heated air was supplied to the cabin during all four flights by means of the cabin air conditioning system.

Finally, the installation of the sound absorbing material on the sidewalls and aft bulkhead, and the introduction of the barrier between the cabin and the cockpit, would change the acoustic modes of the cabin.

6.4 Comparison with Prediction and Measurement

The insertion loss provided by the fiberglass batts results from the combined effects of transmission loss and absorption. An estimate of the contribution from absorption can be made using available data from the manufacturers of the material and approximations regarding the influences of other items in the cabin, such as the chairs and occupants. The assumptions are discussed in Reference 4. Two insertion loss spectra have been estimated for the effects of absorption alone, one spectrum being associated with an assumed absorption coefficent of 0.05 for the bare structure of the cabin and the other with an absorption coefficient of 0.1. These spectra are compared with the average measured insertion losses in Figure 35. The predictions are in close agreement with the measurements in the frequency range from 100 Hz to 300 Hz, and lie below the measured values at higher frequencies (where treatment transmission loss would start to play a major role). Thus the predictions and measurements are consistent.

Heitman and Mixson have measured the insertion loss provided by fiberglass material installed in a small general aviation airplane in the laboratory [17]. The airplane cabin was slightly smaller than the present test airplane (cabin volume about 75% of the present test airplane) and the external sound field was broadband white noise. The fiberglass was installed in two thicknesses, 3.8 cm (1.5 inches) and 7.6 cm (3 inches) as compared to the 5.1 cm in the flight test airplane. Insertion losses provided by the treatments were space-averaged over the cabin volume by Heitman and Mixson. Thus, the

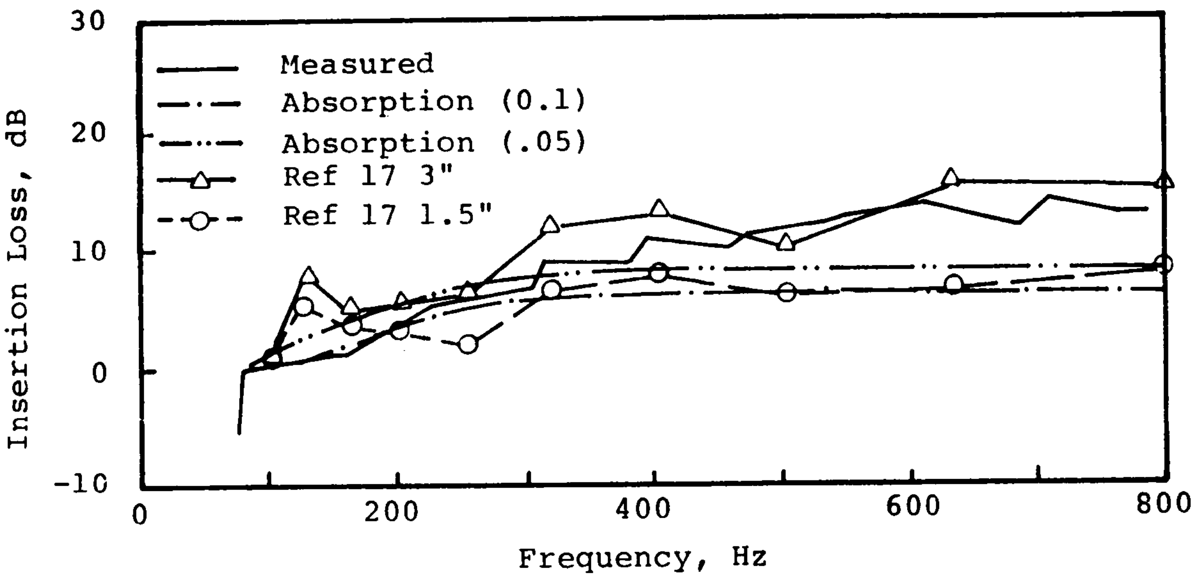


FIGURE 35. COMPARISON OF MEASURED SPACE-AVERAGED HARMONIC INSERTION LOSS WITH LABORATORY MEASUREMENTS AND PREDICTIONS.

data can be compared directly with the present flight test results, as is done in Figure 35. It is seen that the laboratory and flight test data are similar in value.

7. DISCUSSION

7.1 Summary of Results

One of the goals of the flight test program on the Commander airplane was to evaluate measurement techniques for the investigation of noise control treatments in propeller-driven aircraft. The impetus for making the evaluation was the difficulty encountered in measuring the insertion losses provided by candidate noise control treatments under flight test conditions, because of the variability of the data. It is now possible to apply the results of the flight test program to the planning of future flight test evaluations of interior noise control treatments.

First, it is appropriate to summarize the lessons learned from the present tests. Some of the items refer to broadband boundary layer noise, but the main interest of the program is concerned with the harmonics generated by the propeller. The boundary layer pressures are of interest only as a reference to current practices with respect to interior noise of current turbofan-powered aircraft.

The main results of the study are:

1. Under carefully controlled conditions of straight-and-level flight in turbulence free air, and under operating conditions that were repeated as closely as possible within air traffic control constraints, the variability in the propeller harmonic sound pressure levels on the exterior of the fuselage was greater than that for the turbulent boundary layer pressures. Typical standard deviations for harmonic levels were +1.4 dB and -2.3 dB, compared to +1.2 dB and -1.6 dB for boundary layer pressure fluctuations. Thus, the data variability is somewhat greater than would be expected based on boundary layer noise in turbofan-powered aircraft.

2. There is greater variability of the harmonic levels measured inside the cabin than there is for those measured on the exterior. Typical standard deviations of the data are +2.0 dB, -4.2 dB for the interior and +1.4 dB, -2.3 dB for the exterior. This is true even when care is taken not to move

the microphones between test conditions or between flights.

3. When interior sound pressure levels from different flights with different cabin treatments are used to evaluate insertion loss, and care is taken to adjust for any variation in the exterior pressure levels, insertion losses at harmonics have large standard deviations, typically ±6.5 dB. This is due, at least in part, to the variability of the two sets of sound pressure levels. However, other factors, associated with the acoustic modes of the cabin, could be involved. These are discussed below.

4. Harmonic sound pressure levels are often different on the two sides of the fuselage, but the differences change with flight condition. Wind tunnel data [6] indicate that aircraft attitude or angle of attack is one parameter influencing the sound pressures.

These results raise certain questions. For example, why is the variability of the interior sound pressures greater than that of the exterior pressures and why is the variability of the insertion loss data so high? Two possible factors are the influence of the air temperature in the cabin and the effect of the barrier installed between the cockpit and the cabin before the fourth flight. If the measured sound pressure levels are sensitive to changes in the modal character of the cabin, and this certainly seems likely when there is little or no treatment in the cabin, then temperature variations from flight to flight and changes in the effective length of the cabin can be significant. Laboratory studies [16] performed since the date of the flight test have shown that temperature in the cabin can have an important influence on cabin sound pressure levels. Cabin air temperature was not measured during the flight tests. It is possible that some of these effects were magnified because the interior had little or no treatment. However, that situation is quite common in airplane interior noise investigations. Airplane attitude may play some role in determining the relative contributions from the port and starboard propellers to the interior sound field [6], but this parameter was not measured during the Commander flights.

From the point of view of a controlled investigation of noise transmission phenomena, the data showed the usefulness of tests conducted when the port and starboard propellers were operating at different rpm but at the same power. However, it is also of interest to determine the sound pressure levels associated with operation of the propellers at the same rpm, as would occur during normal cruise. This can be accomplished satisfactorily only if there is accurate and repeatable control of the relative phase between the two propellers, a task that was not possible in the test airplane.

7.2 Recommendations for Future Flight Tests

Several recommendations can be made regarding the planning and performance of future flight tests to measure the interior noise of propeller-driven aircraft, whether they be high-speed advanced turboprop aircraft or general aviation aircraft. The recommendations are based on the results from the present flight tests and from published information regarding later wind tunnel, laboratory and flight tests conducted by others. The comments are directed towards twin-engined aircraft, but many of the recommendations have general application to a variety of propeller-driven aircraft. The recommendations are:

1. Measure exterior acoustic pressures with monitor microphones on port and starboard sides of fuselage. These measurements will help to interpret any anomalies in the interior acoustic data and to adjust interior sound pressure levels for variations in the exterior sound pressures.

2. Control and measure air temperature in the cabin. Ideally, the temperature should be held constant for all tests and all flights, but this may not be possible.

3. Use both fixed-position and swept microphones in the cabin. The goal is to have microphone locations that are highly repeatable and, at the same time, obtain space-averaged measurements that minimize the influence of node location of cabin modes. This combination of fixed and swept microphones has been used in a recent flight test program [18] where microphone sweep was conducted in a plane perpendicular to the axis of the fuselage. It is suggested here that the sweeping of the microphone should not be restricted to a given plane perpendicular to the fuselage axis, but should allow some

movement fore and aft of the plane.

4. Provide baseline absorption in the cabin for "untreated" cabin tests. The objective is to minimize the sensitivity of the results to acoustic modes (particularly the nodes of such modes) in the cabin.

5. Perform acoustic measurements with propellers at different rpm but same power. Equal power is required to avoid yaw of the airplane. Choose rpm separation so that beats do not cause data interpretation problems and so that fundamental blade passage frequencies can be separated by the data reduction instrumentation. A difference of 4% in rpm was adequate for the present tests.

6. If desired, perform additional measurements with propellers at the same rpm and with known relative phase. Measurements should be repeated for several settings of relative phase - phase angle should be selectable and repeatable.

7. Perform measurements during straight-and-level flight and avoid turns or turbulence. Determine airplane attitude for correlation with sound pressures measured on the two sides of the fuselage.

8. If barriers or bulkheads are to be installed in the cabin, consideration should be given to the influence on cabin modes, particularly the locations of nodes relative to microphone positions. It may be advisable to have sound absorbing material on the bulkheads for all test configurations, in order to minimize modal effects.

9. Measurements should be made in both narrowband and one-third octave band formats. Space averaging should be performed on the data either by averaging data from several fixed microphones or by the use of swept microphones.

10. Test conditions should be repeated, either on the same flight or on subsequent flights, so that ensemble averaging can be performed.

11. Finally, results from this flight test program can be used to assist in the estimation of standard deviations, confidence limits or other statistical parameters that describe the uncertainty of future test results.

8. CONCLUSIONS

The results of the flight test program on the Commander airplane have identified specific factors that make it difficult to obtain accurate data regarding the acoustic performance of noise control treatments in a propeller-driven airplane. Data variability was found to be greater for measured interior sound pressure levels than it was for corresponding exterior sound pressures. Since insertion loss is calculated from the difference between two measured interior sound pressures, the effects of data variability are magnified. This is true even though the flight tests were planned with the intent of minimizing many of the factors that cause scatter in the acoustic data.

On the basis of the flight test results, and results from wind tunnel, laboratory and flight test measurements conducted by other investigators since the Commander measurements were completed, several recommendations are proposed for future interior noise flight test measurements These recommendations are applicable to either high-speed advanced turboprop aircraft or general aviation aircraft.

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APPENDIX A

Propeller Harmonic Sound Pressure Levels Measured on Exterior of Fuselage

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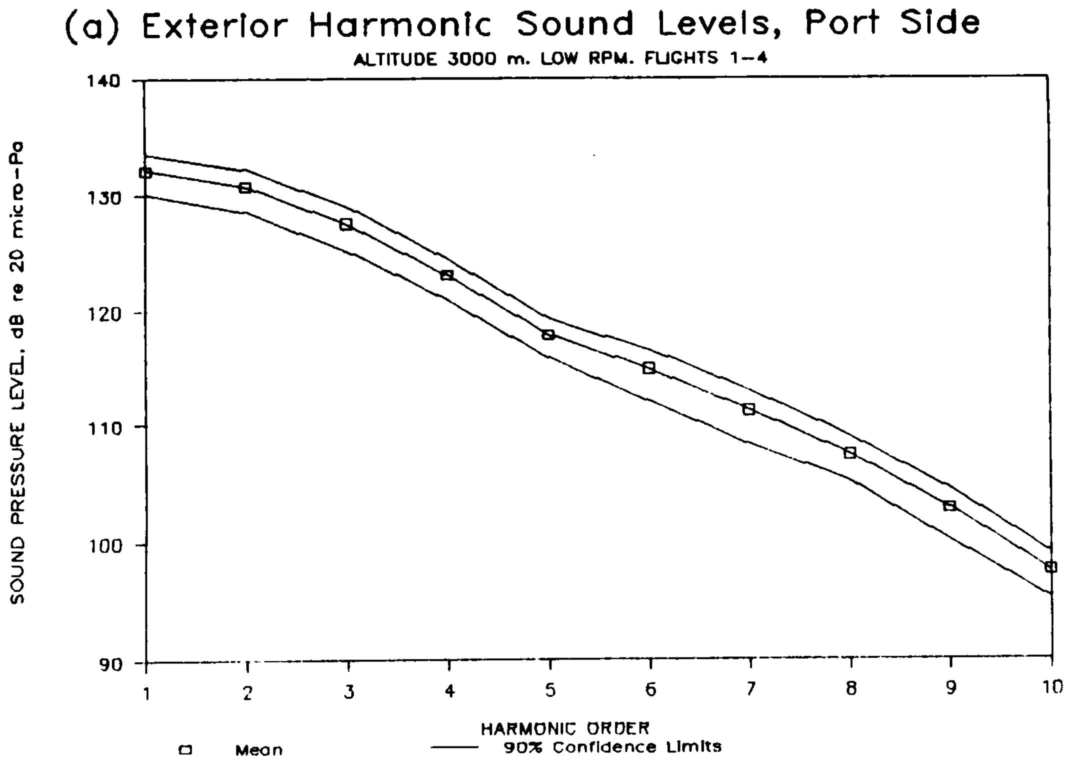


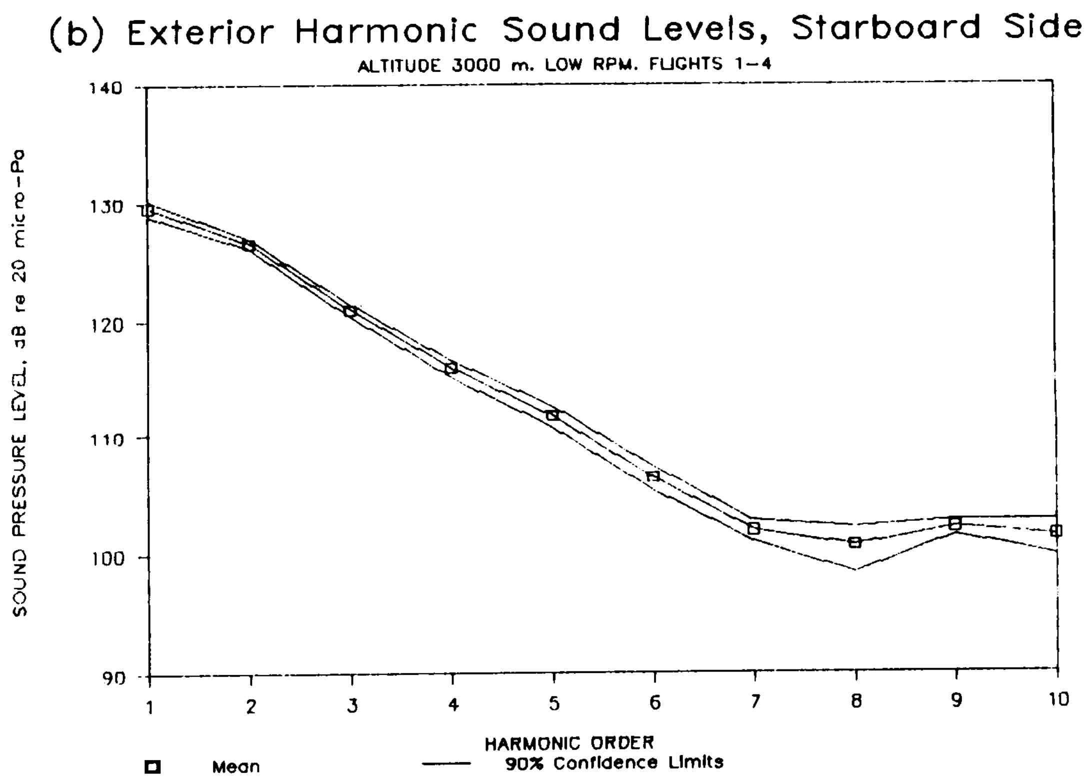
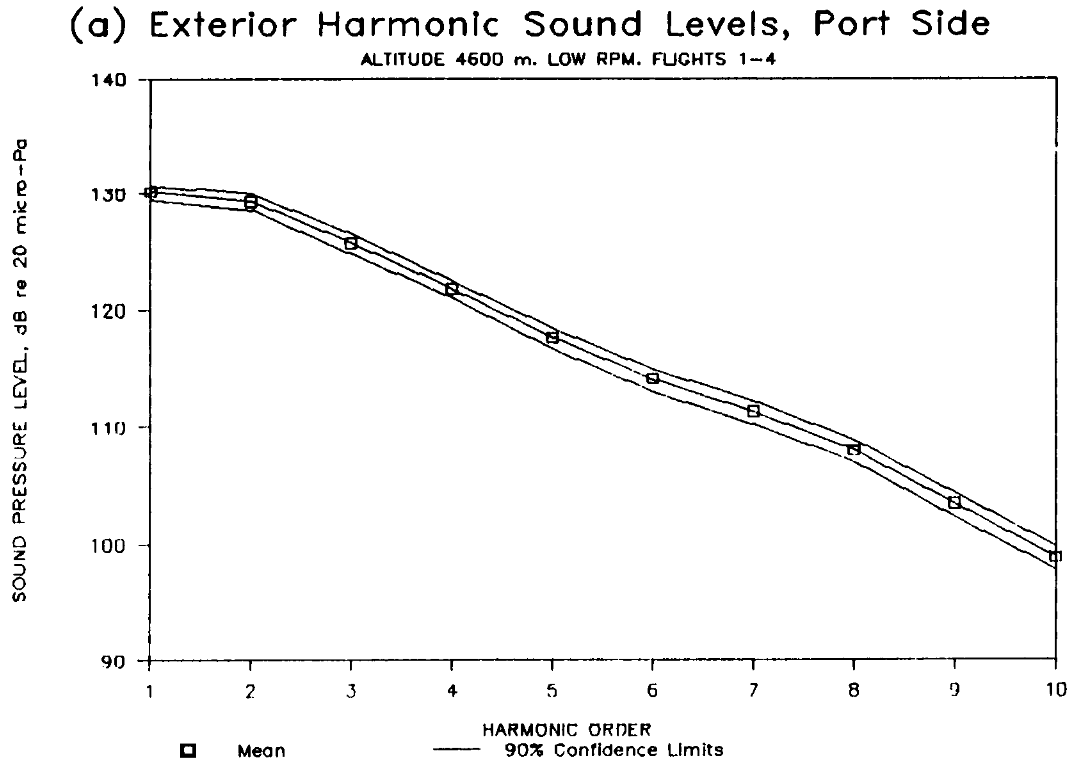


FIGURE A1. MEAN AND 90% CONFIDENCE LIMITS FOR EXTERIOR HARMONIC SOUND PRESSURE LEVELS: 96% RPM, 3000 M.



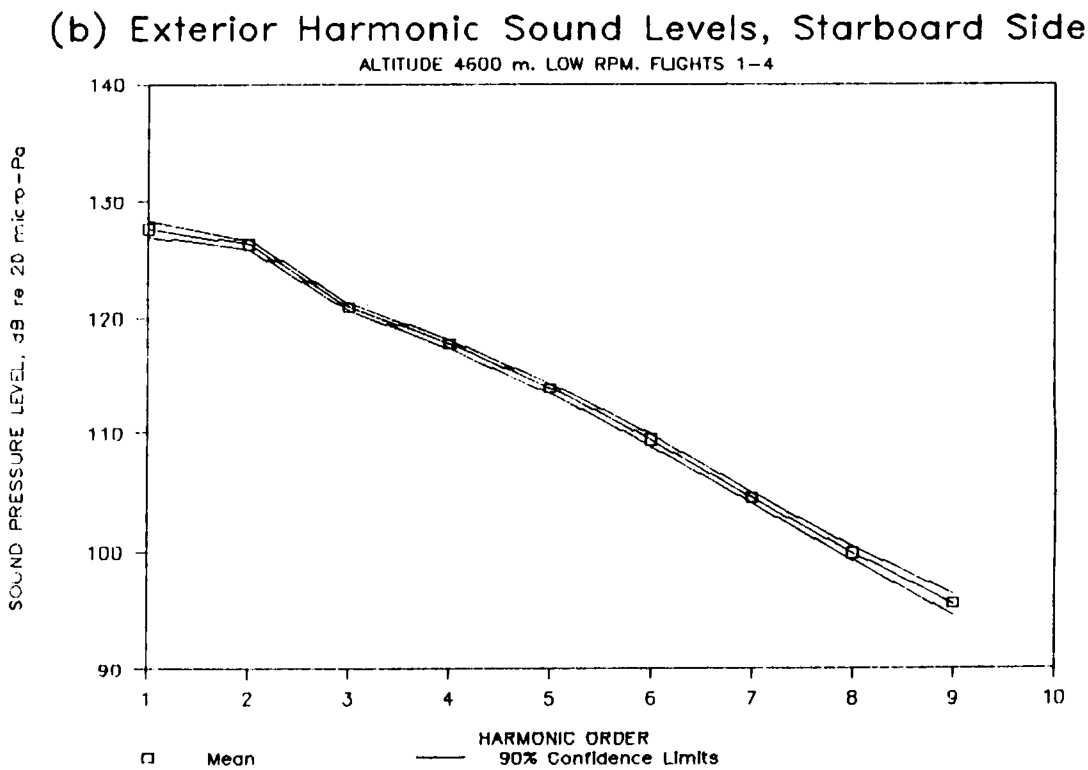
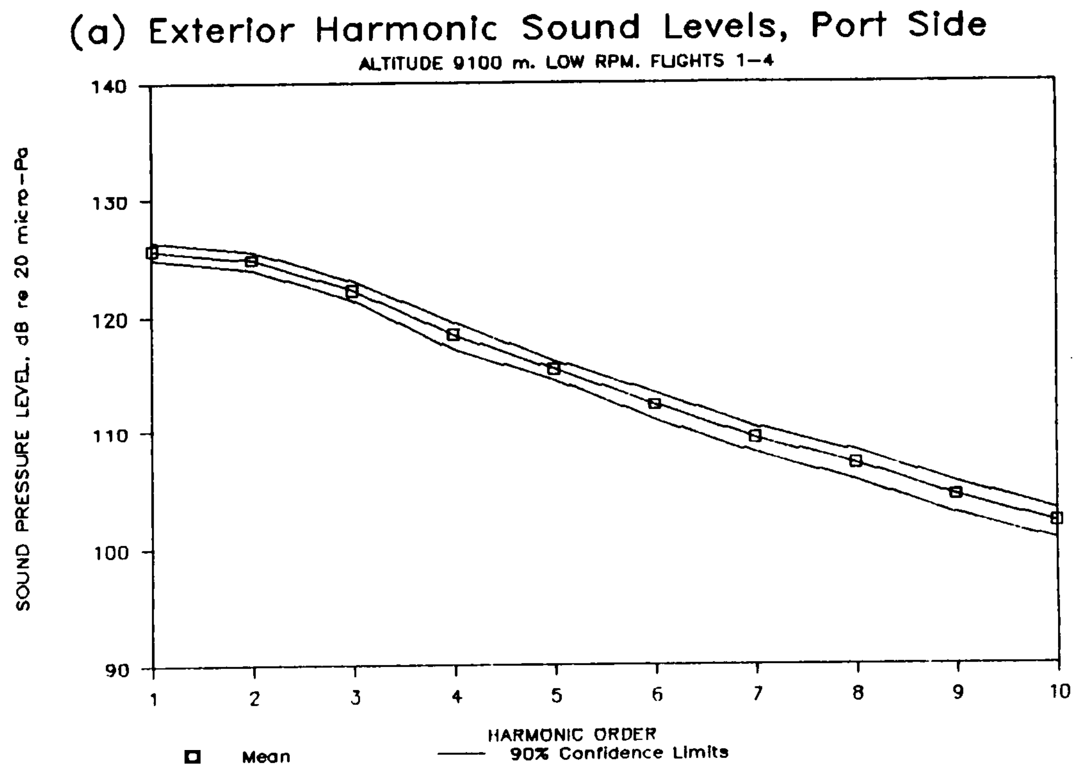


FIGURE A2. MEAN AND 90% CONFIDENCE LIMITS FOR EXTERIOR HARMONIC SOUND PRESSURE LEVELS: 96% RPM, 4600 M.



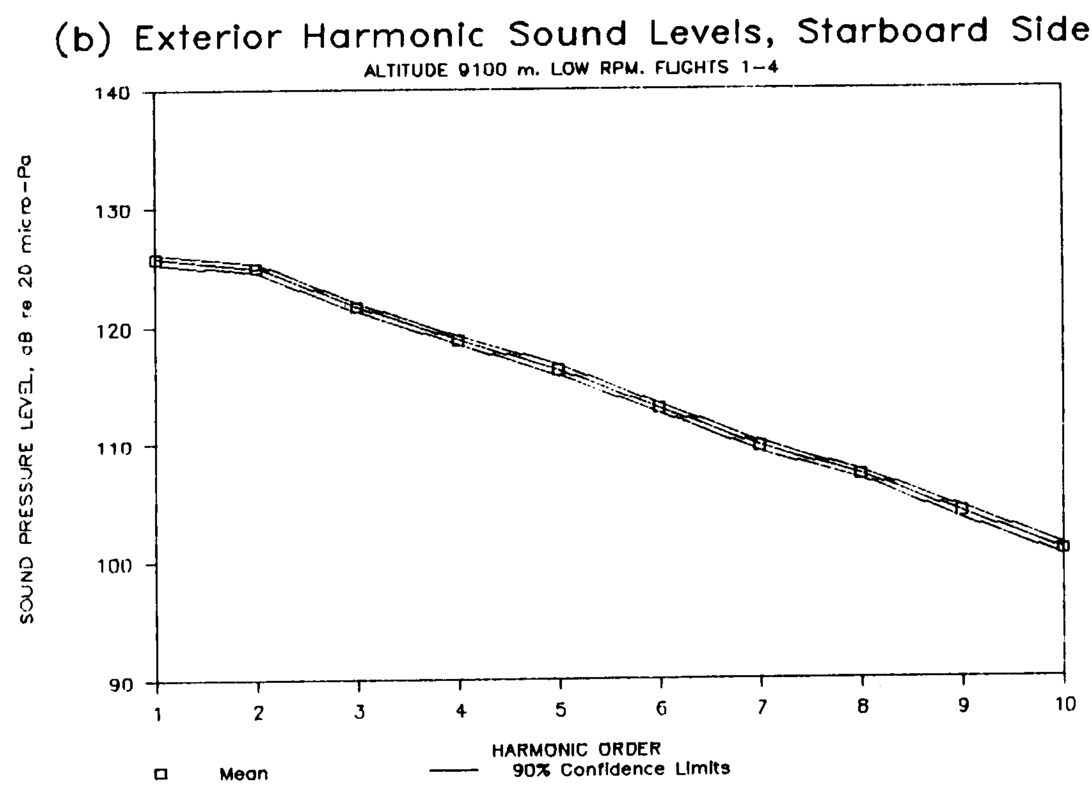


FIGURE A3. MEAN AND 90% CONFIDENCE LIMITS FOR EXTERIOR HARMONIC SOUND PRESSURE LEVELS; 96% RPM, 9100 M.

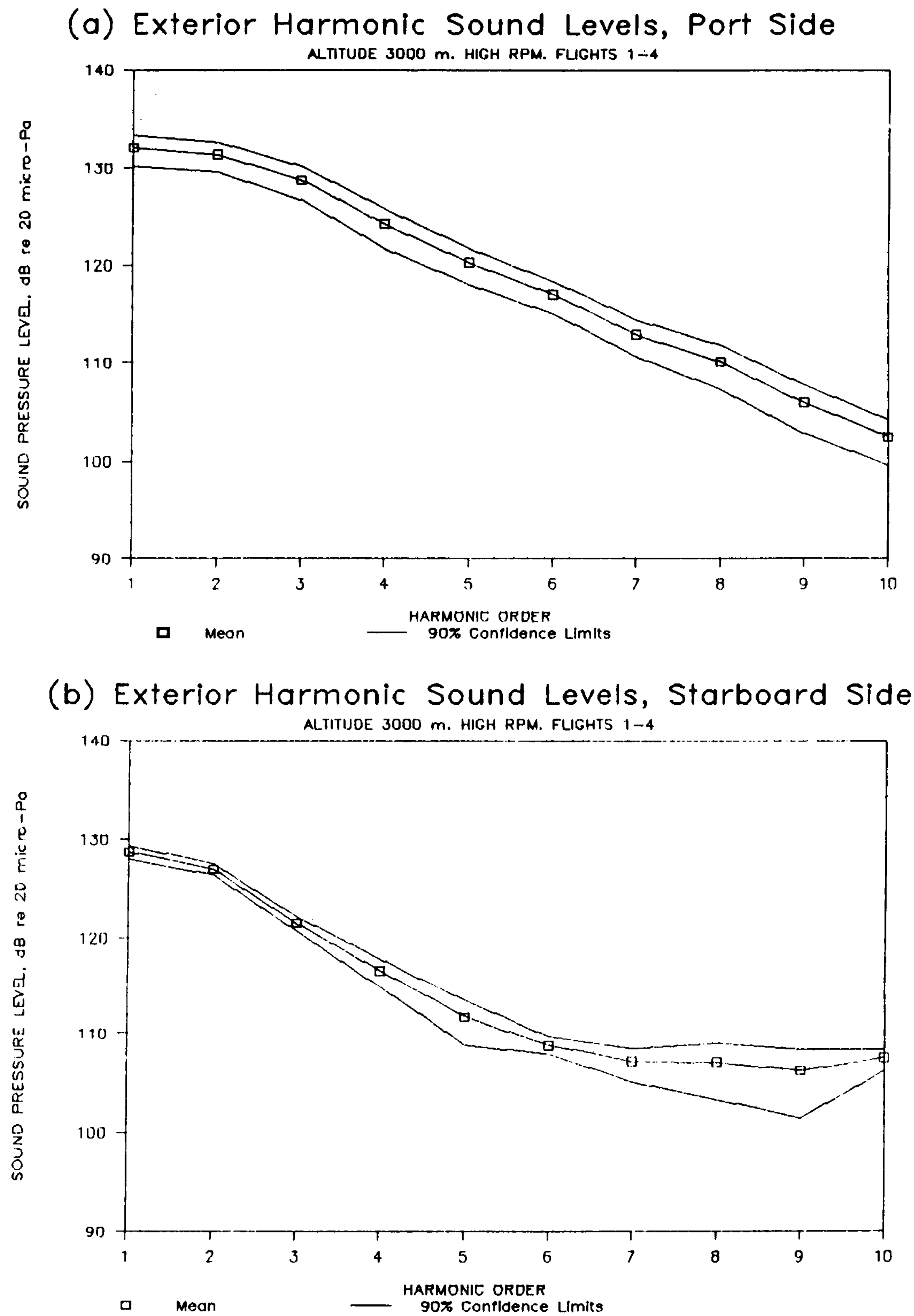
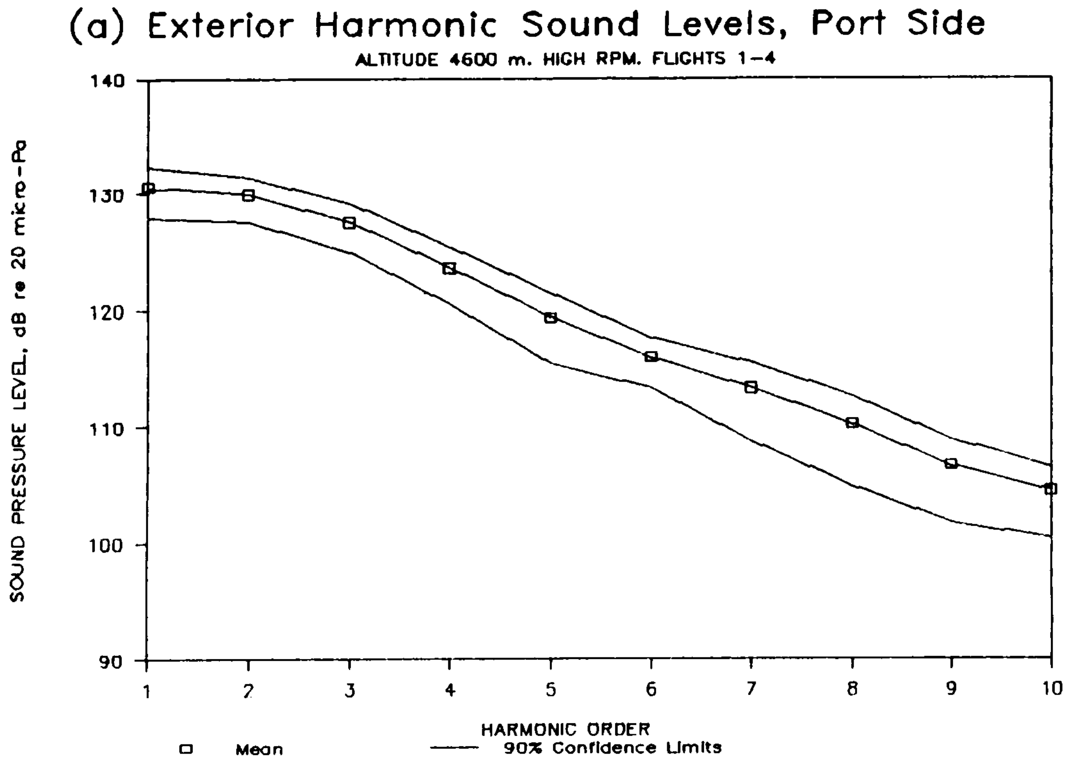


FIGURE A4. MEAN AND 90% CONFIDENCE LIMITS FOR EXTERIOR HARMONIC PRESSURE LEVELS: 100% RPM, 3000 M.



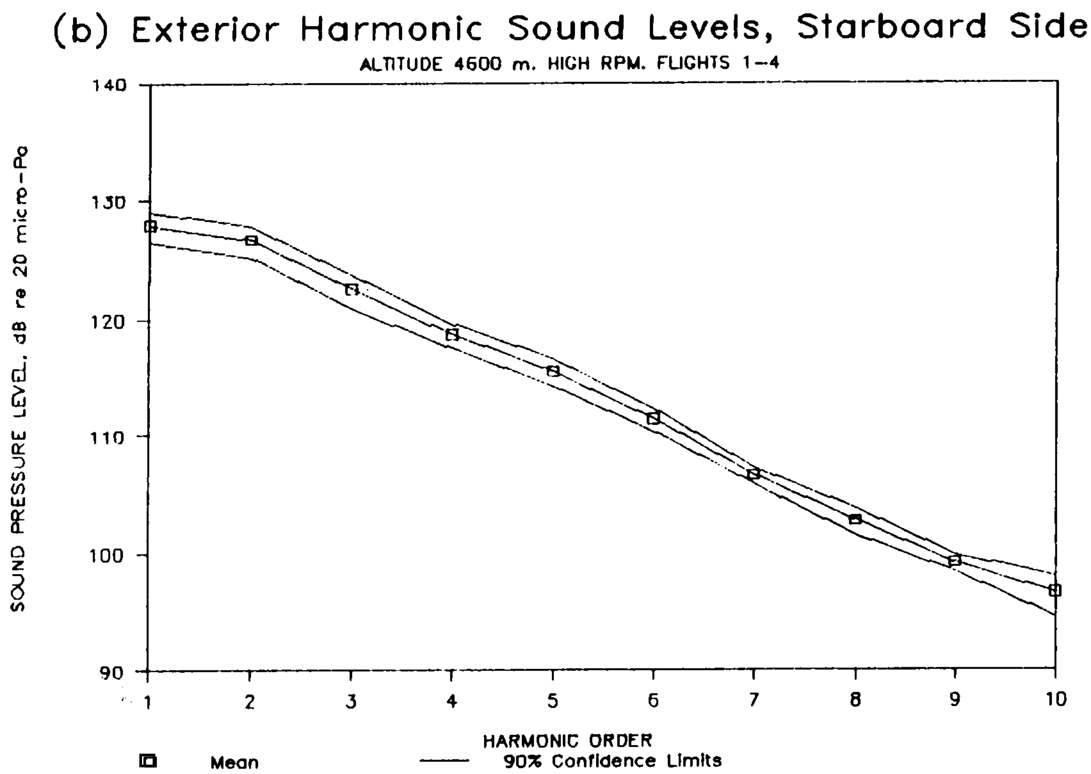
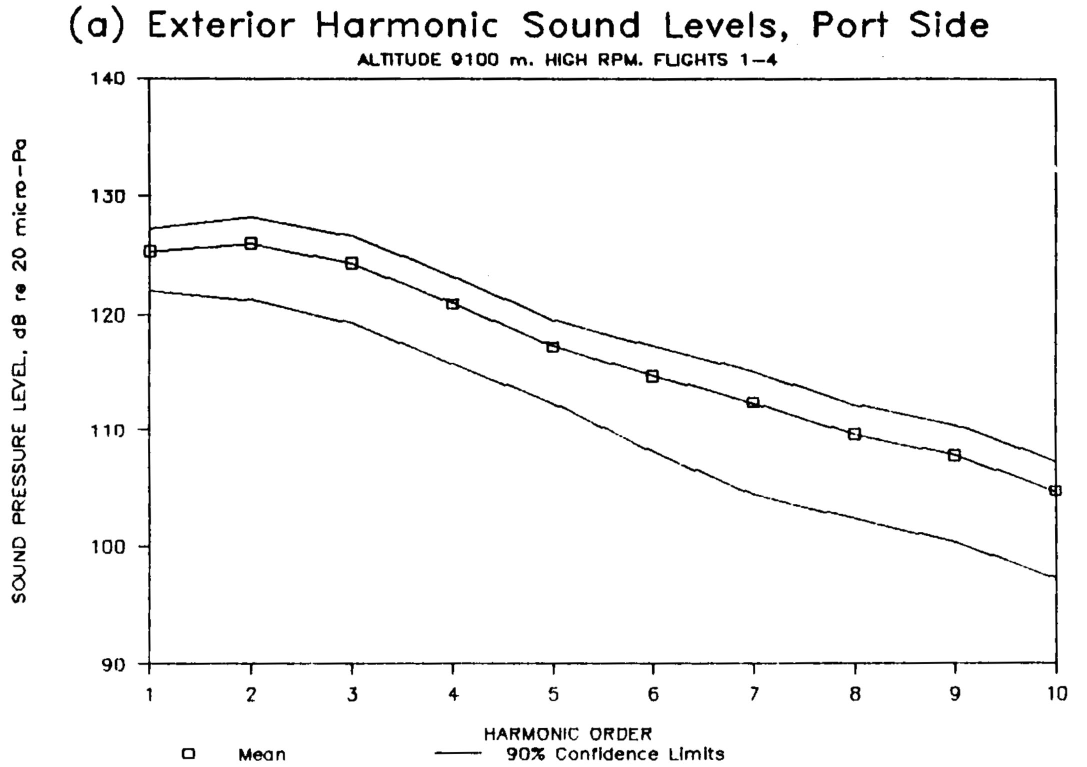


FIGURE A5. MEAN AND 90% CONFIDENCE LIMITS FOR EXTERIOR HARMONIC SOUND PRESSURE LEVELS; 100% RPM, 4600 M.



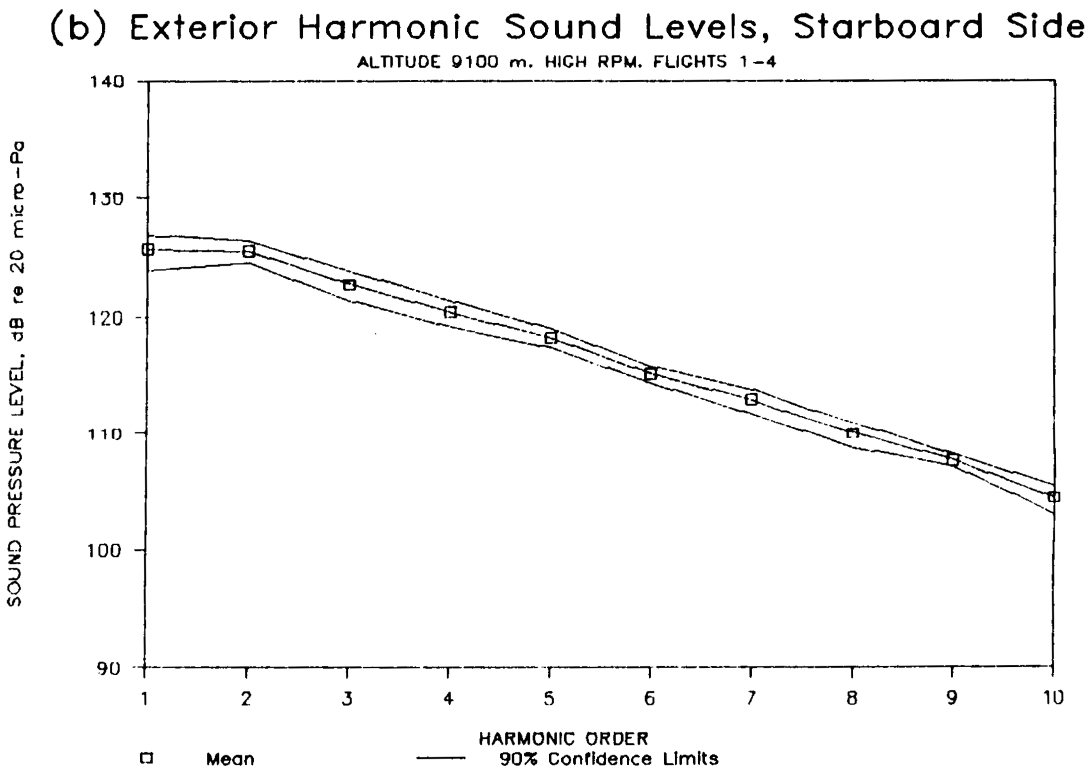


FIGURE A6. MEAN AND 90% CONFIDENCE LIMITS FOR EXTERIOR HARMONIC SOUND PRESSURE LEVELS; 100% RPM, 9100 M.

EXTERIOR FLUSH-MOUNTED MICROPHONE : PORT SIDE

Test Condition	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10	OASPL dB
ALTITUDE 3,000 m. HIGH RPM.													
Mean	1572.9	78.7	132.1	131.4	128.7	124.2	120.2	117.0	112.9	110.1	106.0	102.5	136.2
Standard Deviation	1.02	0.05	1.57	1.49	1.63	1.87	1.73	1.59	1.73	1.98	2.11	2.02	1.57
Standard Deviation	1.02	0.05	-2.47	-2.28	-2.65	-3.34	-2.92	-2.54	-2.92	-3.73	-4.25	-3.91	-2.49
Upper 90% Conf.Limit	1573.8	78.7	133.4	132.7	130.1	125.8	121.7	118.3	114.3	111.8	107.8	104.3	137.6
Lower 90% Conf.Limit	1572.1	78.6	130.1	129.6	126.7	121.7	118.0	115.0	110.6	107.3	102.9	99.6	134.3
Maximum	1575.0	78.8	134.3	133.5	131.1	127.1	122.8	119.2	115.5	113.0	108.6	105.5	138.5
Minimum	1572.5	78.6	129.3	129.0	125.6	120.7	117.1	113.8	110.0	107.0	101.2	98.6	133.5
ALTITUDE 3,000 m. LOW RPM.													
Mean	1525.4	76.3	132.1	130.8	127.5	123.0	117.8	114.7	111.1	107.4	102.8	97.5	135.7
Standard Deviation	1.02	0.05	1.64	1.73	1.77	1.72	1.65	1.99	2.01	1.76	1.94	1.75	1.69
Standard Deviation	1.02	0.05	-2.67	-2.91	-3.02	-2.88	-2.70	-3.76	-3.84	-3.01	-3.60	-2.99	-2.81
Upper 90% Conf.Limit	1526.3	76.3	133.5	132.2	129.0	124.4	119.2	116.4	112.9	108.9	104.5	99.0	137.1
Lower 90% Conf.Limit	1524.6	76.2	130.1	128.5	125.2	120.8	115.7	111.9	108.3	105.1	100.1	95.2	133.5
Maximum	1527.5	76.4	134.6	133.2	130.1	125.5	120.0	117.7	114.1	109.8	105.5	100.0	138.2
Minimum	1525.0	76.3	129.0	127.0	123.6	119.2	113.9	110.0	106.3	103.5	98.1	93.0	132.2
ALTITUDE 4,600 m. HIGH RPM.													
Mean	1573.8	78.7	130.6	129.9	127.5	123.6	119.4	116.0	113.3	110.3	106.7	104.5	134.9
Standard Deviation	1.42	0.07	1.44	1.33	1.41	1.57	1.79	1.41	1.89	2.05	1.97	1.83	1.42
Standard Deviation	1.42	0.07	-2.16	-1.92	-2.10	-2.47	-3.10	-2.11	-3.43	-4.03	-3.71	-3.22	-2.13
Upper 90% Conf.Limit	1575.4	78.8	132.2	131.4	129.1	125.4	121.4	117.6	115.4	112.6	108.9	106.6	136.5
Lower 90% Conf.Limit	1572.1	78.6	127.9	127.5	124.9	120.5	115.4	113.3	108.8	104.9	101.8	100.4	132.2
Maximum	1575.0	78.8	132.1	131.2	129.0	125.2	121.3	117.3	115.1	112.1	108.5	106.2	136.3
Minimum	1572.5	78.6	128.7	128.0	125.7	121.2	116.7	114.0	110.0	106.0	102.3	101.8	133.0
ALTITUDE 4,600 m. LOW RPM.													
Mean	1529.3	76.5	130.2	129.4	125.8	121.8	117.6	114.0	111.3	108.0	103.5	98.9	134.0
Standard Deviation	2.67	0.13	1.21	1.28	1.55	1.28	1.56	1.66	1.66	1.55	1.76	1.69	1.25
Standard Deviation	2.67	0.13	-1.69	-1.82	-2.44	-1.82	-2.47	-2.72	-2.72	-2.44	-2.99	-2.81	-1.77
Upper 90% Conf.Limit	1530.6	76.5	130.8	130.0	126.6	122.4	118.4	114.9	112.2	108.9	104.4	99.7	134.7
Lower 90% Conf.Limit	1528.0	76.4	129.4	128.6	124.8	121.0	116.6	112.9	110.2	107.1	102.3	97.7	133.3
Maximum	1532.5	76.6	132.2	131.4	128.4	123.8	119.8	117.2	114.0	110.2	106.2	101.4	136.2
Minimum	1525.0	76.3	128.2	127.0	123.1	119.4	115.0	110.8	108.3	105.2	100.5	95.6	132.1
ALTITUDE 9,100 m. HIGH RPM.													
Mean	1570.0	78.5	125.4	125.9	124.3	120.9	117.2	114.7	112.3	109.6	107.8	104.7	131.0
Standard Deviation	0.00	0.00	1.20	1.44	1.49	1.50	1.46	1.65	1.76	1.71	1.73	1.73	1.39
Standard Deviation	0.00	0.00	-1.66	-2.17	-2.29	-2.32	-2.22	-2.70	-2.99	-2.87	-2.91	-2.91	-2.06
Upper 90% Conf.Limit	1570.0	78.5	127.2	128.1	126.6	123.2	119.4	117.2	115.0	112.2	110.4	107.3	133.1
Lower 90% Conf.Limit	1570.0	78.5	122.0	121.2	119.2	115.7	112.3	108.1	104.4	102.3	100.3	97.2	126.6
Maximum	1570.0	78.5	126.2	127.1	125.2	122.0	118.1	116.2	114.0	111.1	109.4	106.3	131.9
Minimum	1570.0	78.5	123.4	123.4	121.5	118.1	114.5	111.7	109.1	106.3	104.6	101.5	128.5
ALTITUDE 9,100 m. LOW RPM.													
Mean	1528.2	76.4	125.6	124.8	122.2	118.4	115.3	112.2	109.4	107.1	104.4	102.1	129.9
Standard Deviation	7.30	0.37	1.33	1.46	1.42	1.91	1.50	1.87	1.89	2.03	2.10	2.06	1.34
Standard Deviation	7.30	0.37	-1.92	-2.22	-2.12	-3.49	-2.32	-3.35	-3.44	-3.94	-4.23	-4.06	-1.94
Upper 90% Conf.Limit	1531.7	76.6	126.3	125.6	122.9	119.4	116.1	113.2	110.4	108.2	105.5	103.2	130.6
Lower 90% Conf.Limit	1524.8	76.2	124.8	123.9	121.3	117.1	114.3	111.0	108.1	105.7	102.9	100.6	129.1
Maximum	1540.0	77.0	128.0	127.4	124.3	122.2	117.3	115.8	113.0	111.2	108.2	105.7	131.8
Minimum	1517.5	75.9	122.3	121.2	119.9	114.7	111.0	107.7	105.0	102.2	99.7	97.3	127.2

EXTERIOR FLUSH-MOUNTED MICROPHONE : STARBOARD SIDE

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10	OASPL dB
ALTITUDE 3,000 m. HIGH RPM.														
Mean		1570.6	78.5	128.8	127.0	121.5	116.6	111.7	108.9	107.1	107.0	106.2	107.5	131.7
Standard Deviation		1.16	0.06	0.89	0.80	0.97	1.75	2.34	1.15	1.90	2.70	3.00	0.86	0.83
Standard Deviation		1.16	0.06	-1.13	-0.98	-1.25	-2.98	-5.42	-1.57	-3.47	-8.62	-21.82	-1.07	-1.03
Upper 90% Conf.Limit		1571.4	78.6	129.4	127.5	122.1	117.9	113.4	109.7	108.5	109.0	108.4	108.5	132.3
Lower 90% Conf.Limit		1569.8	78.5	128.0	126.4	120.7	114.9	108.9	107.9	105.1	103.3	101.5	106.2	131.0
Maximum		1572.5	78.6	130.2	128.3	123.0	119.0	115.0	110.6	109.8	110.5	110.1	108.6	132.9
Minimum		1570.0	78.5	127.6	126.1	120.3	113.0	106.2	106.1	102.7	99.6	92.6	106.6	130.8
ALTITUDE 3,000 m. LOW RPM.														
Mean		1520.0	76.0	129.6	126.6	120.9	115.9	111.7	106.5	102.0	100.7	102.2	101.6	131.9
Standard Deviation		2.31	0.11	0.81	0.57	0.75	0.95	1.22	1.27	1.13	1.96	0.35	0.77	0.70
Standard Deviation		2.31	0.11	-0.99	-0.65	-0.91	-1.23	-1.69	-1.80	-1.54	-3.66	-0.38	-0.93	-0.83
Upper 90% Conf.Limit		1521.6	76.1	130.1	127.0	121.5	116.6	112.6	107.4	102.7	102.2	102.8	102.8	132.4
Lower 90% Conf.Limit		1518.4	75.9	128.9	126.2	120.4	115.1	110.7	105.3	101.0	98.4	101.5	99.8	131.4
Maximum		1525.0	76.3	131.0	127.5	122.5	117.5	113.2	108.5	103.5	103.4	102.6	102.4	133.1
Minimum		1517.5	75.9	128.5	125.9	120.1	114.2	109.4	104.6	99.5	97.1	101.9	100.8	131.0
ALTITUDE 4,600 m. HIGH RPM.														
Mean		1571.9	78.6	127.9	126.7	122.4	118.6	115.4	111.4	106.6	102.8	99.2	96.6	131.4
Standard Deviation		1.25	0.07	0.95	0.99	0.99	0.82	0.86	0.74	0.56	0.86	0.59	1.22	0.94
Standard Deviation		1.25	0.07	-1.22	-1.28	-1.28	-1.02	-1.07	-0.89	-0.65	-1.07	-0.68	-1.71	-1.20
Upper 90% Conf.Limit		1573.3	78.7	129.0	127.8	123.5	119.5	116.4	112.3	107.3	103.8	99.9	98.0	132.5
Lower 90% Conf.Limit		1570.4	78.5	126.4	125.1	120.8	117.4	114.1	110.3	105.9	101.5	98.4	94.5	130.0
Maximum		1572.5	78.6	129.0	127.9	123.5	119.7	116.3	112.1	107.4	104.0	99.7	98.3	132.5
Minimum		1570.0	78.5	126.3	125.2	120.8	117.6	114.0	110.6	106.0	101.9	98.2	95.6	129.9
ALTITUDE 4,600 m. LOW RPM.														
Mean		1528.5	76.4	127.7	126.3	120.9	117.8	114.0	109.4	104.5	99.9	95.6		130.9
Standard Deviation		4.51	0.23	1.23	0.85	0.66	0.79	0.86	0.95	0.90	1.14	1.68		0.93
Standard Deviation		4.51	0.23	-1.72	-1.05	-0.78	-0.96	-1.08	-1.22	-1.14	-1.56	-2.79		-1.18
Upper 90% Conf.Limit		1530.6	76.5	128.3	126.7	121.2	118.2	114.4	109.9	105.0	100.4	96.4		131.4
Lower 90% Conf.Limit		1526.4	76.3	127.0	125.8	120.6	117.4	113.5	108.9	104.1	99.2	94.5		130.4
Maximum		1532.5	76.6	130.1	127.7	122.0	119.3	115.8	111.1	106.0	102.0	98.6		132.7
Minimum		1520.0	76.0	125.5	124.5	119.4	116.6	112.9	108.3	103.0	97.4	91.4		129.4
ALTITUDE 9,100 m. HIGH RPM.														
Mean		1572.5	78.6	125.6	125.5	122.7	120.4	118.2	115.2	113.0	110.0	107.6	104.4	130.6
Standard Deviation		2.04	0.10	1.08	0.69	0.91	0.84	0.61	0.54	0.82	0.83	0.40	0.93	0.83
Standard Deviation		2.04	0.10	-1.44	-0.81	-1.15	-1.04	-0.71	-0.61	-1.01	-1.03	-0.45	-1.18	-1.03
Upper 90% Conf.Limit		1574.9	78.7	126.9	126.3	123.8	121.3	118.9	115.9	114.0	111.0	108.1	105.5	131.6
Lower 90% Conf.Limit		1570.1	78.5	123.9	124.5	121.3	119.1	117.4	114.5	111.8	108.8	107.1	103.0	129.4
Maximum		1575.0	78.8	127.1	126.4	124.0	121.5	119.0	116.0	114.0	111.1	108.1	105.3	131.8
Minimum		1570.0	78.5	124.3	124.8	121.9	119.5	117.4	114.8	111.8	109.2	107.1	103.2	129.8
ALTITUDE 9,100 m. LOW RPM.														
Mean		1527.1	76.4	125.8	124.9	121.6	118.8	116.3	113.0	109.7	107.3	104.0	100.8	130.0
Standard Deviation		7.56	0.38	0.85	0.90	0.83	0.81	0.96	0.89	0.90	0.80	1.00	1.06	0.78
Standard Deviation		7.56	0.38	-1.06	-1.14	-1.03	-1.00	-1.23	-1.12	-1.14	-0.99	-1.31	-1.40	-0.95
Upper 90% Conf.Limit		1530.3	76.5	126.1	125.3	122.0	119.2	116.7	113.4	110.1	107.6	104.5	101.2	130.3
Lower 90% Conf.Limit		1523.9	76.2	125.3	124.5	121.2	118.4	115.8	112.5	109.2	106.9	103.5	100.2	129.6
Maximum		1540.0	77.0	127.3	126.6	123.0	120.2	117.7	114.1	111.1	108.2	105.6	102.6	131.2
Minimum		1517.5	75.9	124.4	123.4	120.2	117.2	114.1	110.7	107.7	105.7	102.0	98.2	128.8

EXTERIOR FLUSH-MOUNTED MICROPHONE : PORT SIDE

Test Condition	RPM	BPF Hz	Harmonic Level re Mean OASPL , dB 1	2	3	4	5	6	7	8	9	10	OASPL dB
Altitude 3,000 m. High rpm.													
Mean	1572.9	78.7	-4.2	-4.8	-7.5	-12.0	-16.0	-19.2	-23.3	-26.1	-30.2	-33.7	0.0
Upper 90% Conf.Limit	1573.8	78.7	-2.8	-3.6	-6.1	-10.5	-14.5	-17.9	-21.9	-24.4	-28.4	-32.0	1.3
Lower 90% Conf.Limit	1572.1	78.6	-6.1	-6.6	-9.5	-14.6	-18.2	-21.2	-25.6	-28.9	-33.4	-36.6	-1.9
Altitude 3,000 m. Low rpm.													
Mean	1525.4	76.3	-3.6	-4.9	-8.2	-12.7	-17.9	-20.9	-24.5	-28.2	-32.8	-38.2	0.0
Upper 90% Conf.Limit	1526.3	76.3	-2.2	-3.4	-6.7	-11.2	-16.5	-19.3	-22.8	-26.7	-31.2	-36.7	1.4
Lower 90% Conf.Limit	1524.6	76.2	-5.6	-7.2	-10.5	-14.9	-20.0	-23.8	-27.4	-30.5	-35.5	-40.5	-2.2
Altitude 4,600 m. High rpm.													
Mean	1573.8	78.7	-4.3	-5.0	-7.4	-11.2	-15.5	-18.9	-21.6	-24.6	-28.2	-30.4	0.0
Upper 90% Conf.Limit	1575.4	78.8	-2.7	-3.5	-5.7	-9.5	-13.5	-17.3	-19.4	-22.3	-26.0	-28.3	1.6
Lower 90% Conf.Limit	1572.1	78.6	-7.0	-7.4	-10.0	-14.4	-19.5	-21.5	-26.1	-30.0	-33.1	-34.5	-2.6
Altitude 4,600 m. Low rpm.													
Mean	1529.3	76.5	-3.9	-4.7	-8.3	-12.3	-16.5	-20.0	-22.8	-26.0	-30.6	-35.2	0.0
Upper 90% Conf.Limit	1530.6	76.5	-3.3	-4.0	-7.5	-11.6	-15.7	-19.2	-21.9	-25.2	-29.7	-34.3	0.6
Lower 90% Conf.Limit	1528.0	76.4	-4.6	-5.4	-9.3	-13.1	-17.5	-21.1	-23.8	-27.0	-31.7	-36.3	-0.7
Altitude 9,100 m. High rpm.													
Mean	1570.0	78.5	-5.6	-5.0	-6.7	-10.1	-13.8	-16.3	-18.6	-21.3	-23.2	-26.3	0.0
Upper 90% Conf.Limit	1570.0	78.5	-3.7	-2.8	-4.4	-7.8	-11.5	-13.8	-16.0	-18.8	-20.5	-23.6	2.1
Lower 90% Conf.Limit	1570.0	78.5	-8.9	-9.7	-11.8	-15.3	-18.6	-22.9	-26.6	-28.7	-30.7	-33.8	-4.4
Altitude 9,100 m. Low rpm.													
Mean	1528.2	76.4	-4.2	-5.1	-7.7	-11.5	-14.6	-17.6	-20.5	-22.7	-25.5	-27.8	0.0
Upper 90% Conf.Limit	1531.7	76.6	-3.6	-4.3	-7.0	-10.5	-13.8	-16.7	-19.5	-21.7	-24.4	-26.7	0.7
Lower 90% Conf.Limit	1524.8	76.2	-5.1	-6.0	-8.6	-12.8	-15.5	-18.9	-21.8	-24.2	-27.0	-29.2	-0.8

EXTERIOR FLUSH-MOUNTED MICROPHONE : STARBOARD SIDE

Test Condition	RPM	BPF Hz	1	2	3	4	5	6	7	8	9	10	OASPL dB
			Harmonic Level re Mean OASPL , dB										
Altitude 3,000 m. High rpm.													
Mean	1570.6	78.5	-2.9	-4.7	-10.2	-15.1	-20.0	-22.8	-24.6	-24.7	-25.5	-24.2	0.0
Upper 90% Conf.Limit	1571.4	78.6	-2.3	-4.1	-9.5	-13.8	-18.3	-22.0	-23.2	-22.7	-23.2	-23.2	0.6
Lower 90% Conf.Limit	1569.8	78.5	-3.7	-5.3	-11.0	-16.8	-22.8	-23.8	-26.6	-28.4	-30.2	-25.5	-0.7
Altitude 3,000 m. Low rpm.													
Mean	1520.0	76.0	-2.3	-5.3	-11.0	-16.0	-20.2	-25.4	-30.0	-31.2	-29.7	-30.4	0.0
Upper 90% Conf.Limit	1521.6	76.1	-1.8	-4.9	-10.4	-15.4	-19.3	-24.6	-29.2	-29.7	-29.1	-29.1	0.5
Lower 90% Conf.Limit	1518.4	75.9	-3.0	-5.7	-11.6	-16.8	-21.2	-26.6	-30.9	-33.5	-30.4	-32.1	-0.5
Altitude 4,600 m. High rpm.													
Mean	1571.9	78.6	-3.5	-4.8	-9.0	-12.8	-16.0	-20.0	-24.8	-28.6	-32.2	-34.8	0.0
Upper 90% Conf.Limit	1573.3	78.7	-2.4	-3.6	-7.9	-11.9	-15.0	-19.1	-24.1	-27.6	-31.5	-33.4	1.1
Lower 90% Conf.Limit	1570.4	78.5	-5.0	-6.3	-10.6	-14.0	-17.3	-21.1	-25.5	-29.9	-33.0	-36.9	-1.5
Altitude 4,600 m. Low rpm.													
Mean	1528.5	76.4	-3.2	-4.6	-10.0	-13.1	-16.9	-21.5	-26.4	-31.0	-35.3	-130.9	0.0
Upper 90% Conf.Limit	1530.6	76.5	-2.6	-4.2	-9.7	-12.7	-16.5	-21.0	-25.9	-30.5	-34.5	-130.9	0.4
Lower 90% Conf.Limit	1526.4	76.3	-3.9	-5.1	-10.3	-13.5	-17.4	-22.0	-26.9	-31.7	-36.4	-130.9	-0.5
Altitude 9,100 m. High rpm.													
Mean	1572.5	78.6	-5.0	-5.1	-7.9	-10.3	-12.4	-15.4	-17.6	-20.6	-23.0	-26.2	0.0
Upper 90% Conf.Limit	1574.9	78.7	-3.7	-4.3	-6.9	-9.3	-11.7	-14.8	-16.7	-19.6	-22.5	-25.2	1.0
Lower 90% Conf.Limit	1570.1	78.5	-6.7	-6.1	-9.3	-11.5	-13.2	-16.1	-18.8	-21.9	-23.5	-27.7	-1.2
Altitude 9,100 m. Low rpm.													
Mean	1527.1	76.4	-4.2	-5.0	-8.3	-11.1	-13.7	-17.0	-20.3	-22.7	-26.0	-29.2	0.0
Upper 90% Conf.Limit	1530.3	76.5	-3.8	-4.6	-8.0	-10.8	-13.3	-16.6	-19.9	-22.3	-25.5	-28.7	0.3
Lower 90% Conf.Limit	1523.9	76.2	-4.6	-5.5	-8.7	-11.5	-14.2	-17.4	-20.7	-23.1	-26.5	-29.7	-0.4

APPENDIX B

Propeller Harmonic Sound Pressure Levels Measured in Cabin

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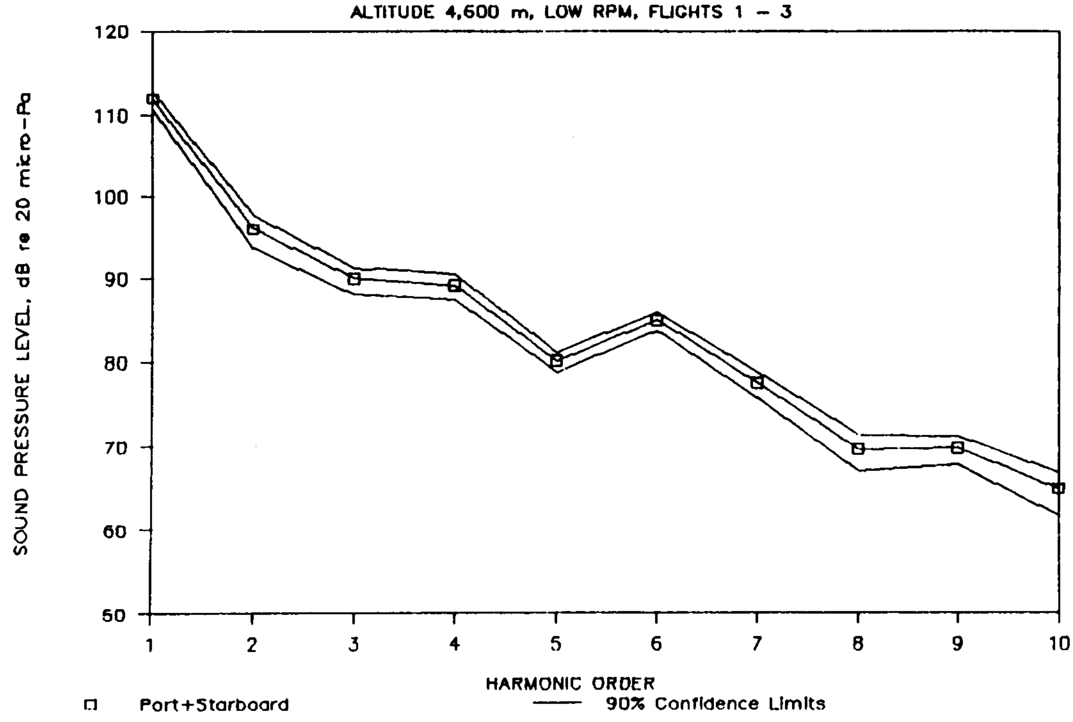
(a) Cabin Location 1 : Port & Stbd Propellers, 4600 m.



(b) Cabin Location 1 : Port & Stbd Propellers, 9100 m.

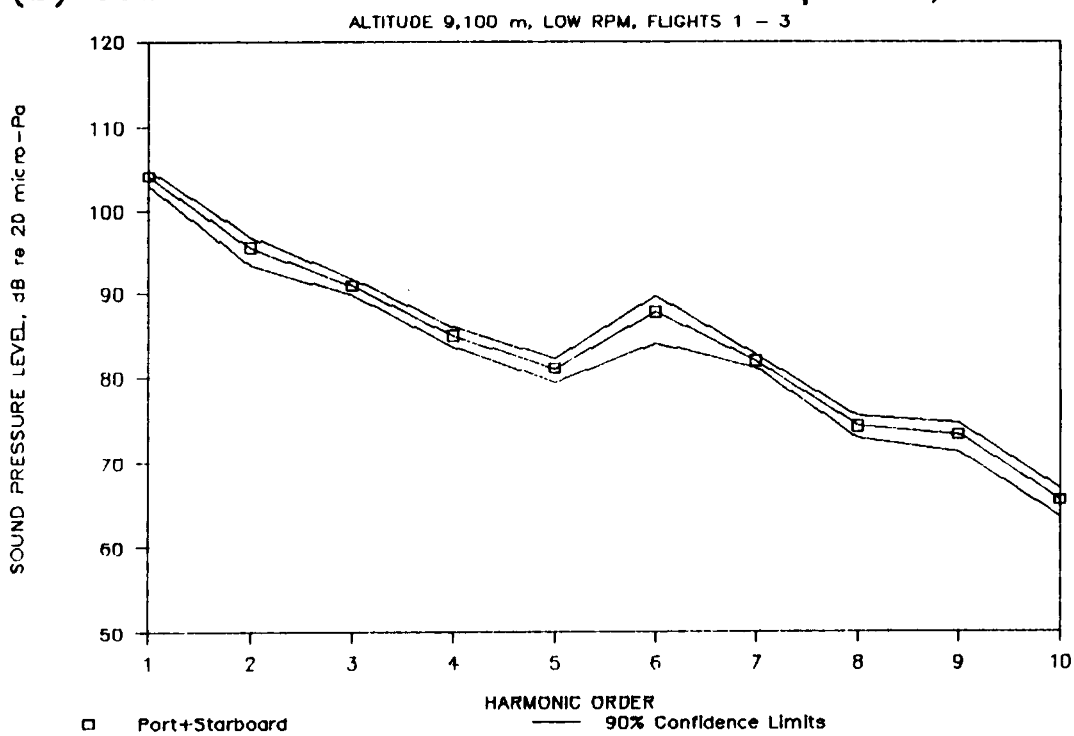
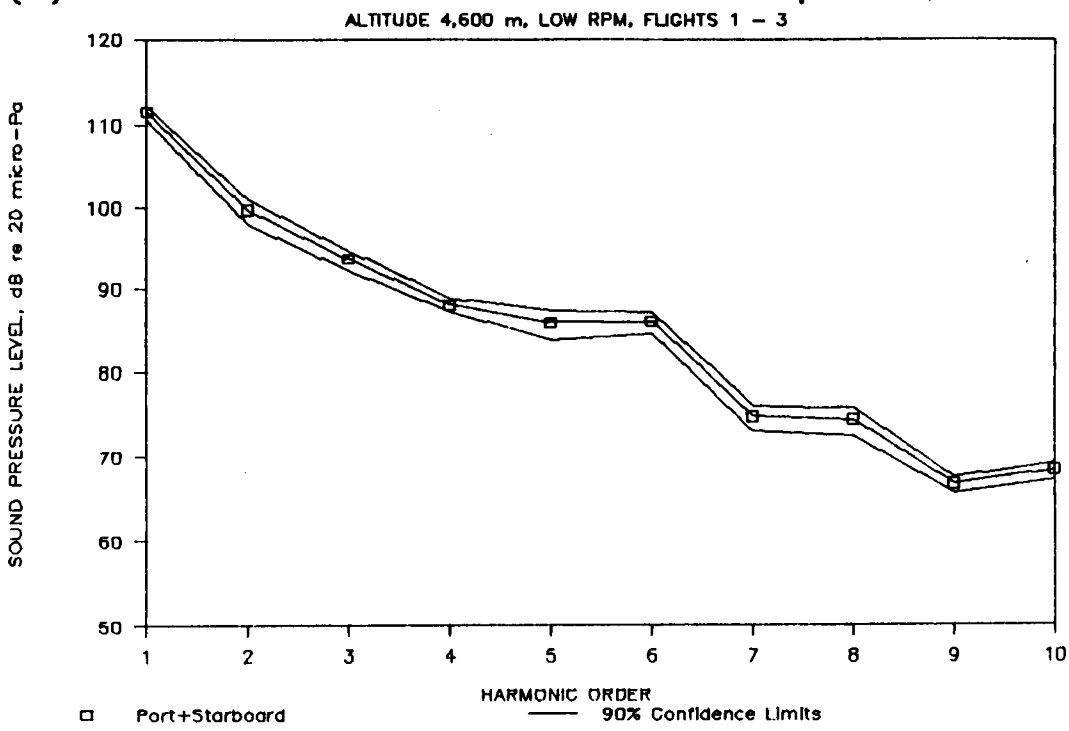


FIGURE B1. MEAN AND 90% CONFIDENCE LIMITS FOR INTERIOR HARMONIC SOUND PRESSURE LEVELS; LOCATION 1.

(a) Cabin Location 2 : Port & Stbd Propellers, 4600 m.



(b) Cabin Location 2 : Port & Stbd Propellers, 9100 m.

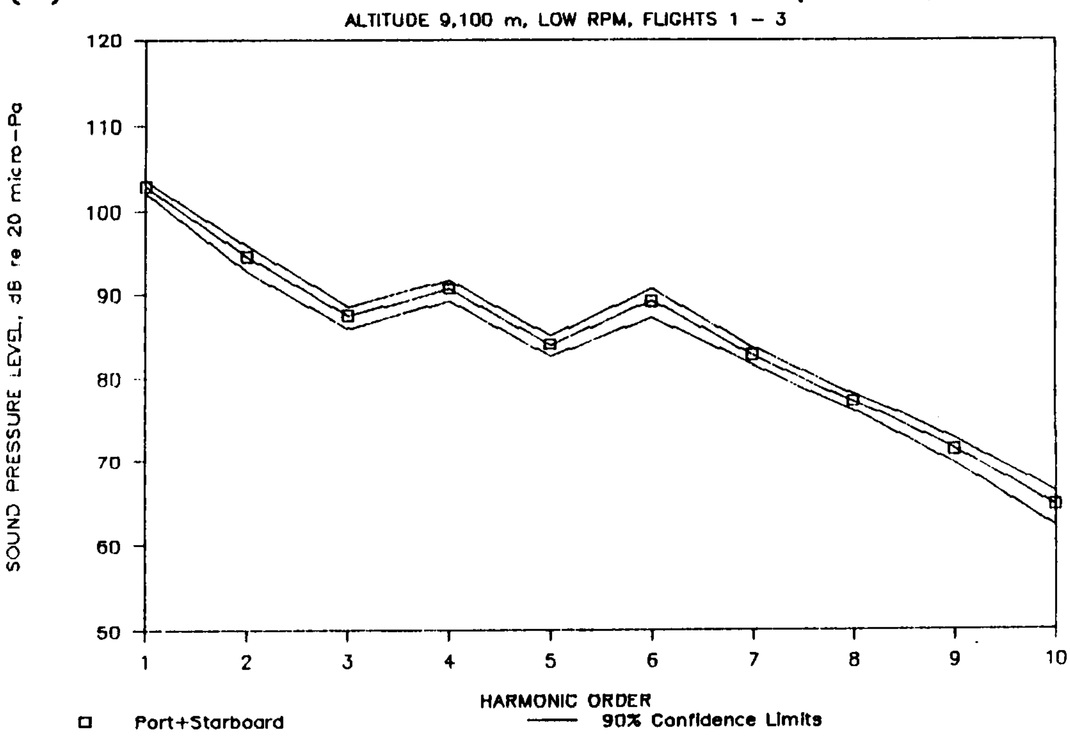
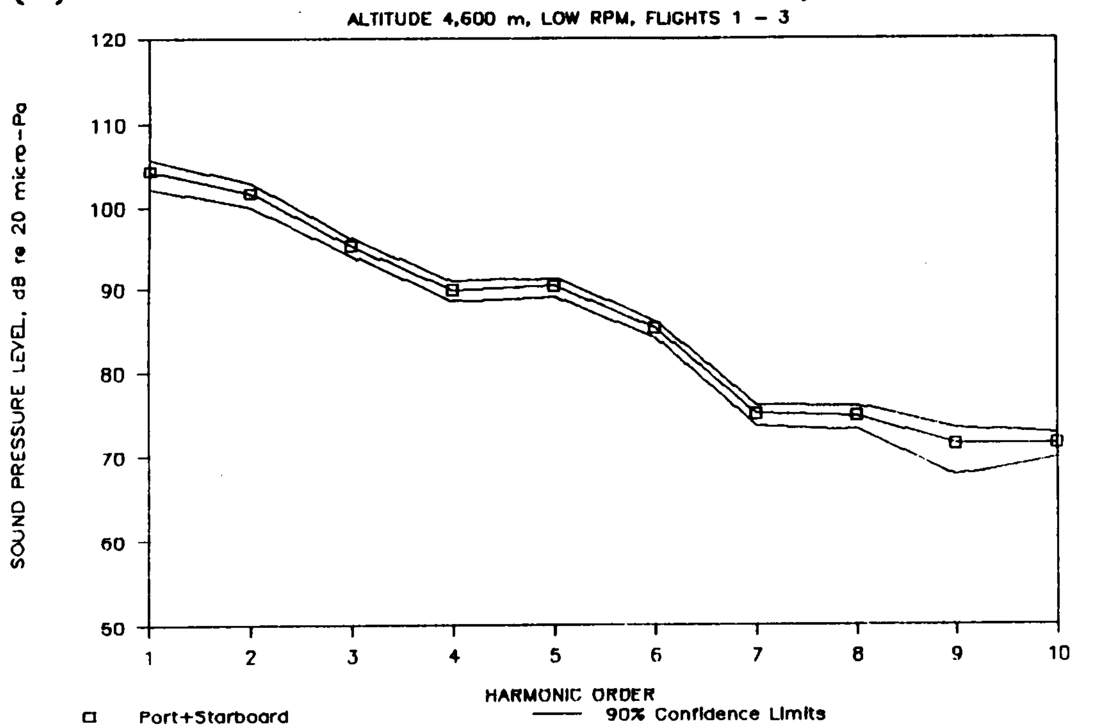


FIGURE B2. MEAN AND 90% CONFIDENCE LIMITS FOR INTERIOR HARMONIC SOUND PRESSURE LEVELS; LOCATION 2.

(a) Cabin Location 3 : Port & Stbd Propellers, 4600 m.



(b) Cabin Location 3 : Port & Stbd Propellers, 9100 m.

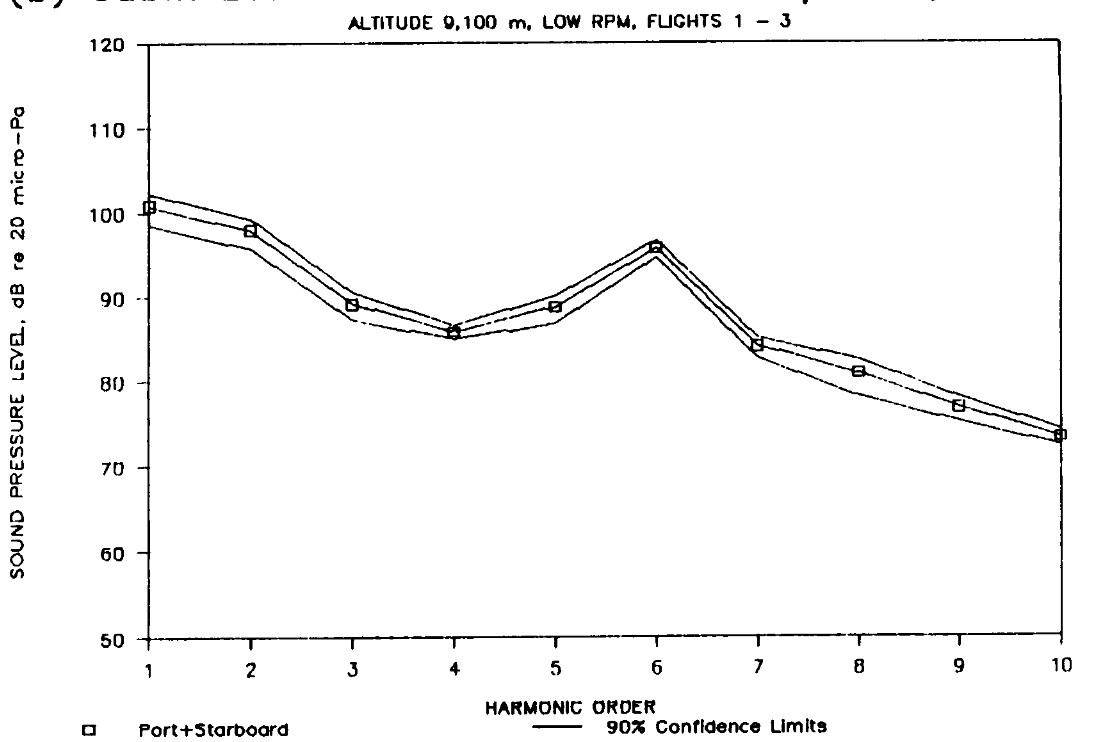
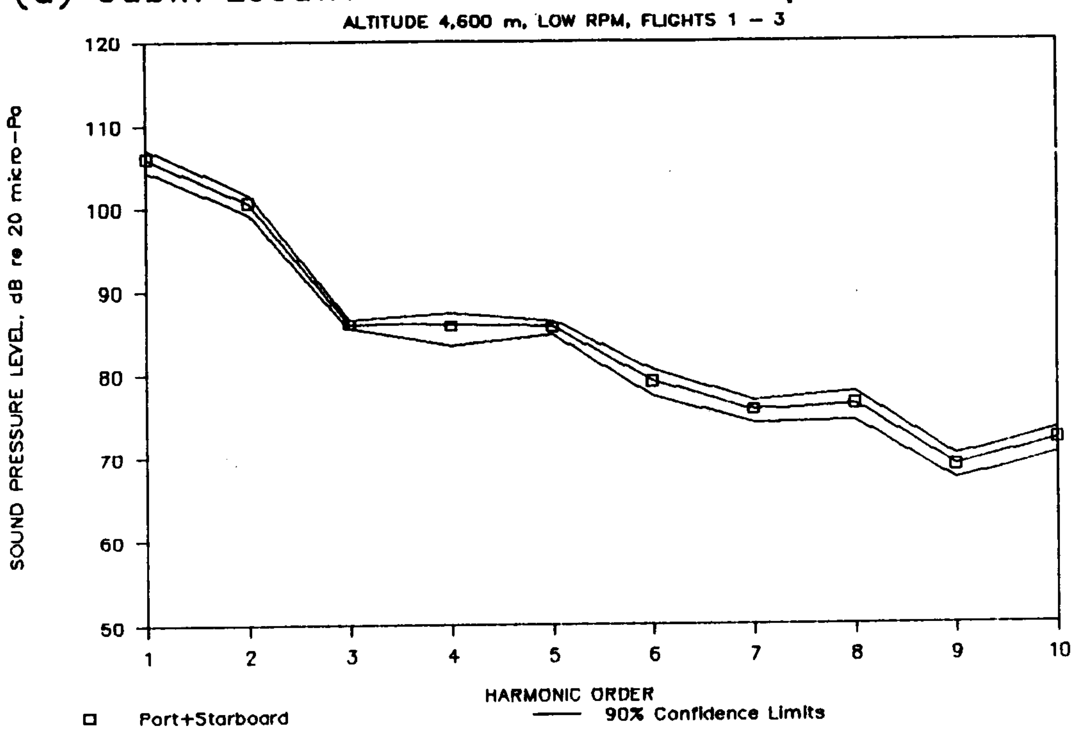


FIGURE B3. MEAN AND 90% CONFIDENCE LIMITS FOR INTERIOR HARMONIC SOUND PRESSURE LEVELS; LOCATION 3.

(a) Cabin Location 4: Port & Stbd Propellers, 4600 m.



(b) Cabin Location 4: Port & Stbd Propellers, 9100 m.

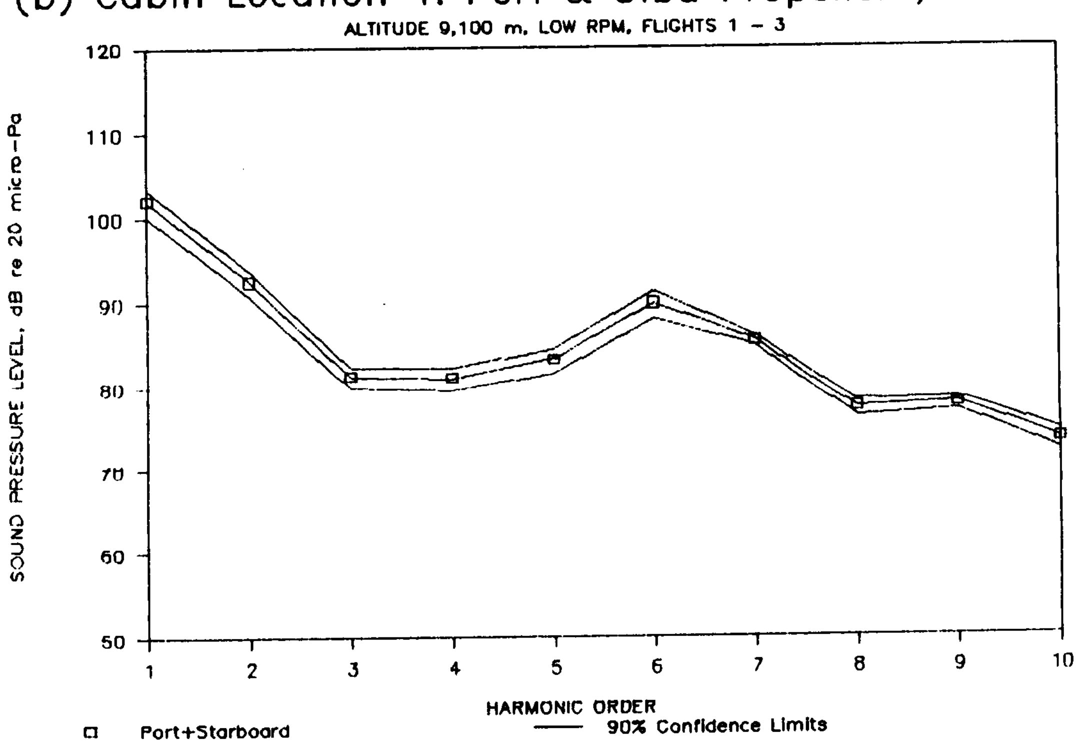
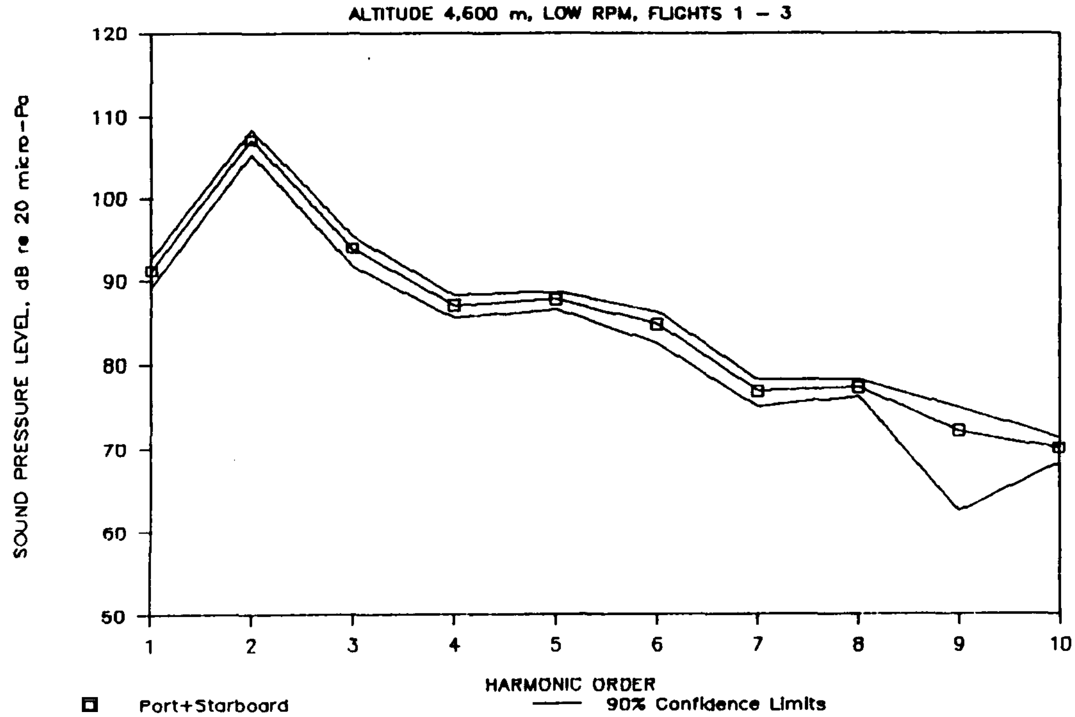


FIGURE B4. MEAN AND 90% CONFIDENCE LIMITS FOR INTERIOR HARMONIC SOUND PRESSURE LEVELS; LOCATION 4.

(a) Cabin Location 5 : Port & Stbd Propellers, 4600 m.



(b) Cabin Location 5 : Port & Stbd Propellers, 9100 m.

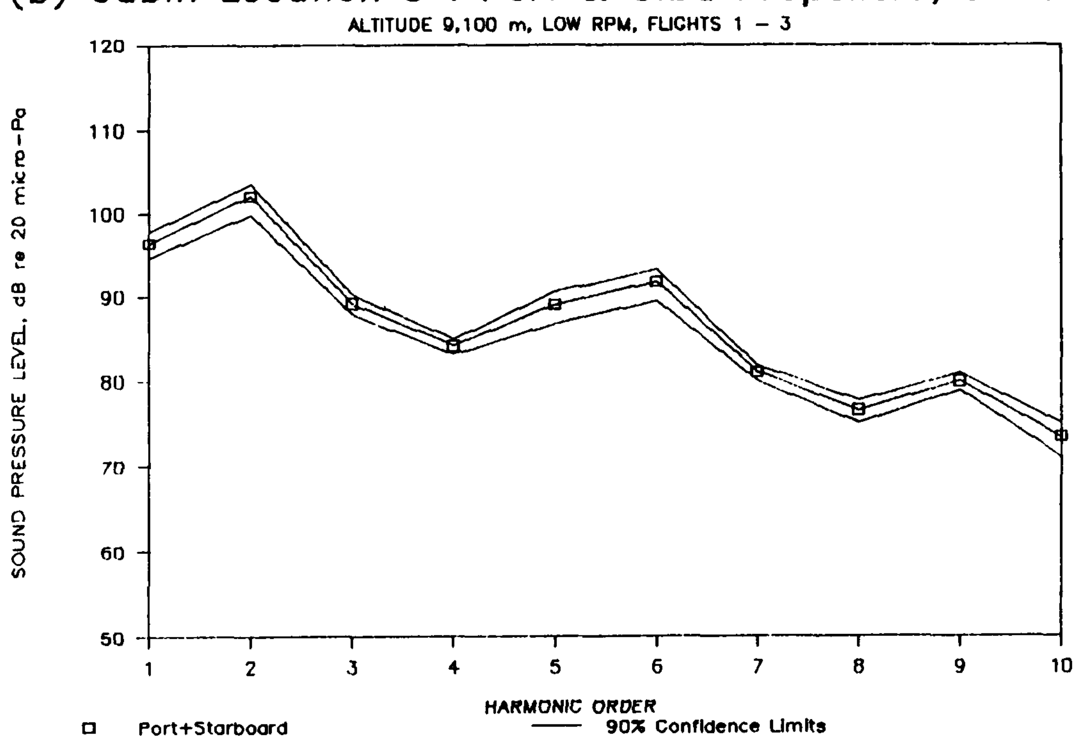
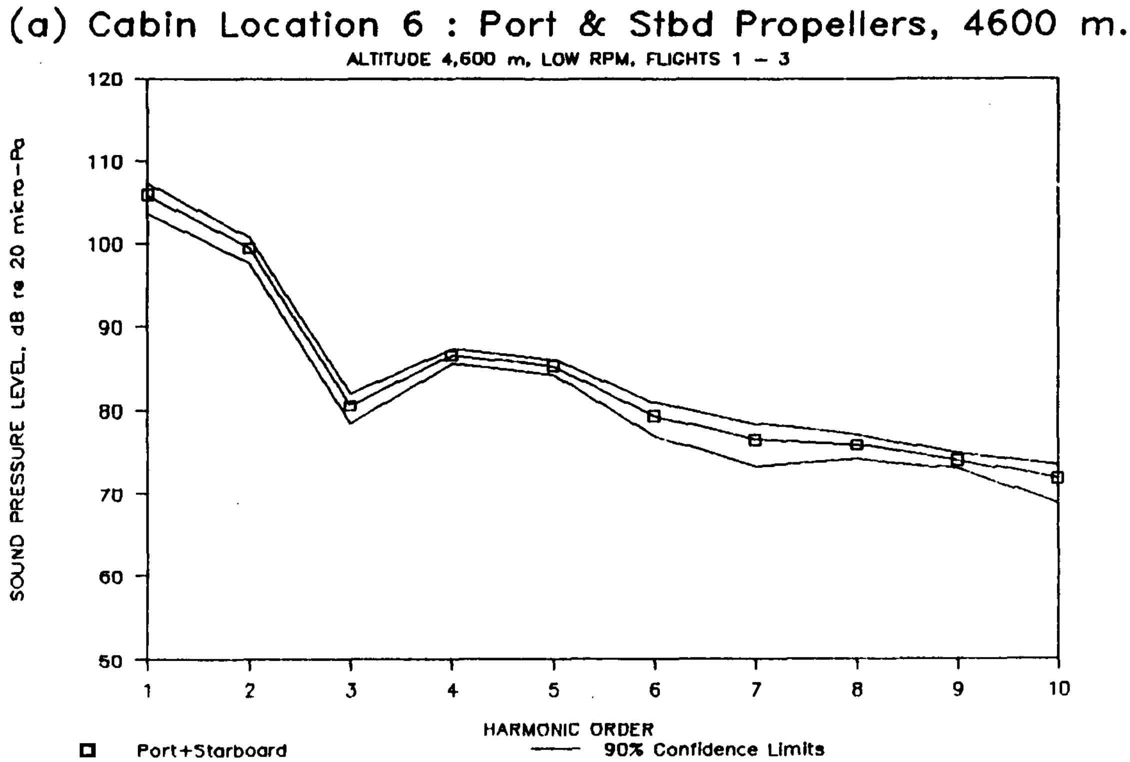


FIGURE B5, MEAN AND 90% CONFIDENCE LIMITS FOR INTERIOR HARMONIC SOUND PRESSURE LEVELS; LOCATION 5.



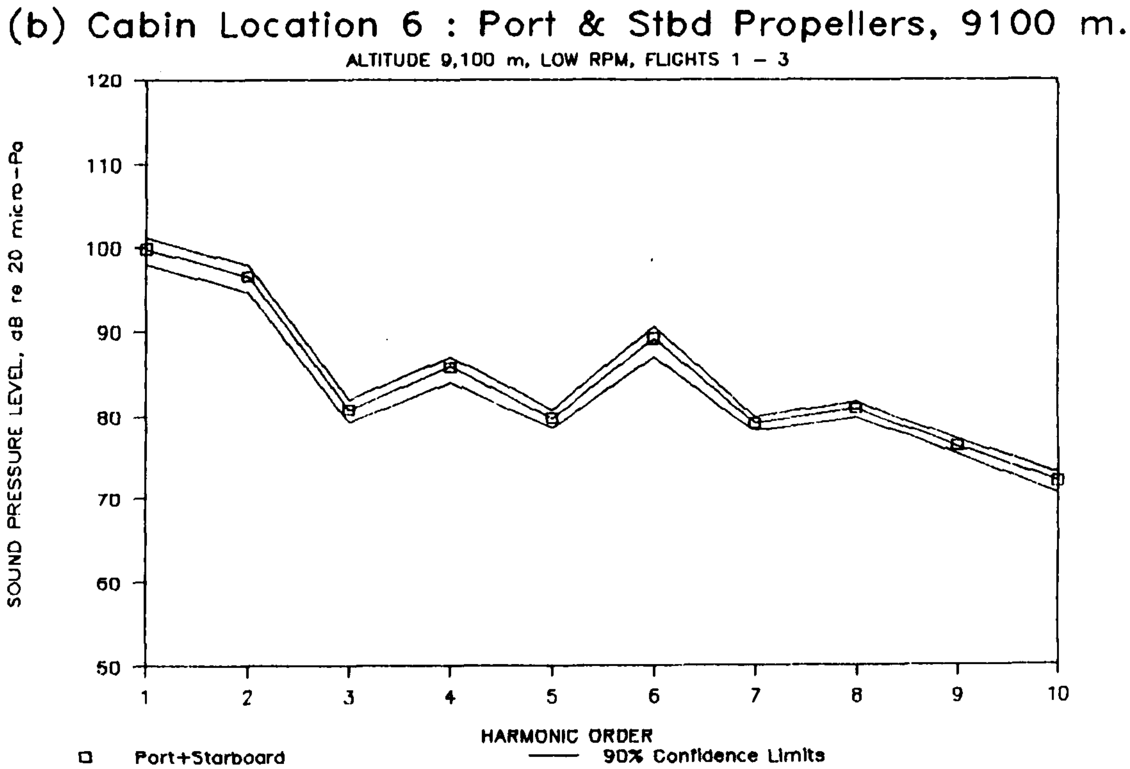


FIGURE B6. MEAN AND 90% CONFIDENCE LIMITS FOR INTERIOR HARMONIC SOUND PRESSURE LEVELS; LOCATION 6.

CABIN MICROPHONE 1 : PORT ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential													
Mean		1575.0	78.8	112.0	96.0	90.3	75.2	72.7	79.2	70.8	63.6	65.4	54.2
Standard Deviation		4.33	0.21	0.38	1.66	2.30	2.91	3.16		2.96	1.88	2.07	
Standard Deviation		4.33	0.21	-0.41	-2.72	-5.22	-13.25			-16.73	-3.38	-4.08	
Maximum		1580.0	79.0	112.2	97.7	92.8	77.4	76.2	79.2	73.1	65.0	67.0	54.2
Minimum		1572.5	78.6	111.5	93.5	86.7	70.3	67.5	79.2	65.7	61.5	63.0	54.2
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
Mean		1572.5	78.6	113.4	85.1	83.5	90.6	85.0	76.1	67.1	63.3	64.1	61.7
Standard Deviation		0.00	0.00	0.34	2.75	1.39	0.89	3.00	3.15	1.43			
Standard Deviation		0.00	0.00	-0.37	-9.28	-2.05	-1.12	-24.57		-2.14			
Maximum		1572.5	78.6	113.7	88.1	84.8	91.5	88.3	78.5	68.5	63.3	64.1	61.7
Minimum		1572.5	78.6	113.0	80.5	81.3	89.5	81.0	70.0	64.9	63.3	64.1	61.7
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
Mean		1525.0	76.3	109.9	93.3	88.7	75.3	67.8	66.0	63.6	61.0		60.7
Standard Deviation		0.00	0.00	0.24	1.29	2.99	2.54	2.48	1.67	0.77	1.21		1.45
Standard Deviation		0.00	0.00	-0.26	-1.84	-21.04	-6.86	-6.36	-2.76	-0.94	-1.67		-2.19
Maximum		1525.0	76.3	110.1	94.7	92.0	77.7	70.3	67.2	64.2	61.9		61.8
Minimum		1525.0	76.3	109.6	92.0	83.8	67.2	61.5	64.2	63.0	59.9		59.3
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
Mean		1525.8	76.3	110.6	86.6	76.7	87.3	77.3	79.4	75.7	68.0		63.0
Standard Deviation		1.44	0.08	0.38	2.20	1.40	1.52	3.51	1.30	1.81	1.33		2.80
Standard Deviation		1.44	0.08	-0.42	-4.68	-2.07	-2.37		-1.87	-3.15	-1.92		-10.29
Maximum		1527.5	76.4	111.0	88.8	78.3	88.9	81.1	80.2	77.7	69.5		65.2
Minimum		1525.0	76.3	110.2	82.1	75.5	85.3	65.9	77.1	73.7	66.8		58.6
ALTITUDE 4,600 m. HIGH RPM.													
Mean		1573.3	78.7	113.5	91.5	83.3	89.5	72.8	78.6	81.0	70.1	73.1	
Standard Deviation		1.44	0.07	0.25	2.04	2.02	1.20	2.83	1.98	1.35	2.68	2.59	
Standard Deviation		1.44	0.07	-0.27	-3.96	-3.88	-1.66	-10.95	-3.74	-1.98	-8.29	-7.36	
Maximum		1575.0	78.8	113.7	92.9	85.2	90.6	75.9	80.7	82.1	72.9	75.8	
Minimum		1572.5	78.6	113.2	86.4	79.0	87.7	68.9	75.7	78.7	62.9	66.6	
ALTITUDE 4,600 m. LOW RPM.													
Mean		1525.0	76.3	110.5	93.4	85.8	85.1	77.7	82.0	76.3	67.6		62.1
Standard Deviation		0.00	0.00	0.46	0.56	2.54	0.30	2.18	0.96	1.90	2.22		0.14
Standard Deviation		0.00	0.00	-0.51	-0.64	-6.84	-0.32	-4.59	-1.23	-3.46	-4.79		-0.14
Maximum		1525.0	76.3	111.0	93.9	87.8	85.4	79.3	82.9	78.2	70.1		62.2
Minimum		1525.0	76.3	110.1	92.7	75.8	84.8	71.7	80.7	72.9	65.2		62.0
ALTITUDE 9,100 m. HIGH RPM.													
Mean		1570.8	78.5	106.6	87.6	89.0	77.2	76.8	83.9	74.9	74.7	76.1	63.5
Standard Deviation		1.44	0.08	0.52	2.83	0.86	2.15	1.56	2.07	0.80	1.65	2.29	3.23
Standard Deviation		1.44	0.08	-0.59	-10.99	-1.07	-4.43	-2.45	-4.09	-0.99	-2.69	-5.13	
Maximum		1572.5	78.6	107.0	90.7	89.9	79.5	78.5	86.2	75.7	76.4	78.3	67.1
Minimum		1570.0	78.5	105.9	83.8	88.0	73.9	74.9	81.7	73.9	72.3	70.5	58.0
ALTITUDE 9,100 m. LOW RPM.													
Mean		1521.7	76.1	102.8	90.6	91.9	75.8	79.1	72.6	74.9	69.5	78.6	57.8
Standard Deviation		1.44	0.08	0.58	0.88	1.10	0.84	2.18	3.31	1.03	0.25	0.77	2.63
Standard Deviation		1.44	0.08	-0.67	-1.11	-1.47	-1.05	-4.60		-1.36	-0.26	-0.94	-7.72
Maximum		1522.5	76.1	103.4	91.6	92.9	76.5	81.5	75.2	76.1	69.8	79.2	60.7
Minimum		1520.0	76.0	102.2	89.7	90.3	74.6	76.1	65.5	74.1	69.3	78.0	54.0

CABIN MICROPHONE 1 : STARBOARD ENGINE COMPONENTS

Test Condition | Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa: 1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential												
Mean	1570.8	78.5	104.7	94.9	95.1	82.5	76.2	66.9	64.6	58.7	56.6	
Standard Deviation	1.44	0.08	0.62	1.49	3.10	2.17	1.74	0.88	3.46	0.59		
Standard Deviation	1.44	0.08	-0.72	-2.29		-4.51	-2.94	-1.11		-0.69		
Maximum	1572.5	78.6	105.4	96.2	98.5	84.9	77.9	67.5	67.3	59.1	56.6	
Minimum	1570.0	78.5	104.1	92.3	90.5	80.4	73.2	66.1	56.0	58.2	56.6	
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized												
Mean	1570.0	78.5	106.5	98.1	89.3	87.7	79.2	69.5	65.0	68.1	62.3	
Standard Deviation	0.00	0.00	0.90	1.41	1.14	0.77	1.54	3.29	0.27	1.44	1.15	
Standard Deviation	0.00	0.00	-1.14	-2.10	-1.56	-0.93	-2.41		-0.29	-2.18	-1.58	
Maximum	1570.0	78.5	107.2	99.4	90.2	88.4	80.5	72.1	65.2	69.7	63.1	
Minimum	1570.0	78.5	105.2	95.8	87.5	86.7	76.4	62.5	64.8	66.9	61.2	
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential												
Mean	1521.7	76.1	103.4	96.2	95.3	83.9	71.0	66.3	69.2	55.2		
Standard Deviation	2.89	0.14	0.24	0.79	0.92	0.34	1.57	2.39	2.64			
Standard Deviation	2.89	0.14	-0.26	-0.96	-1.17	-0.37	-2.48	-5.76	-7.84			
Maximum	1525.0	76.3	103.6	96.7	96.3	84.2	72.4	68.1	72.0	55.2		
Minimum	1520.0	76.0	103.1	95.1	94.3	83.5	68.2	63.1	64.0	55.2		
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized												
Mean	1519.2	76.0	104.5	98.6	88.4	82.6	76.5	68.0	68.0	63.8		60.0
Standard Deviation	1.44	0.07	0.52	1.23	1.19	0.62	2.62	0.27	2.53	0.94		
Standard Deviation	1.44	0.07	-0.59	-1.72	-1.65	-0.72	-7.68	-0.29	-6.81	-1.20		
Maximum	1520.0	76.0	104.8	99.6	89.5	83.3	79.3	68.2	70.5	64.5		60.0
Minimum	1517.5	75.9	103.8	96.6	86.6	82.1	70.8	67.8	61.1	63.0		60.0
ALTITUDE 4,600 m. HIGH RPM.												
Mean	1571.7	78.6	105.8	96.5	87.4	89.1	83.9	79.7	71.5	68.5	66.6	57.9
Standard Deviation	1.44	0.08	0.75	1.60	1.60	0.55	2.40	1.27	1.65	1.56	2.27	
Standard Deviation	1.44	0.08	-0.90	-2.55	-2.56	-0.62	-5.84	-1.80	-2.70	-2.46	-5.03	
Maximum	1572.5	78.6	106.7	98.3	89.0	89.7	86.6	81.1	72.7	70.3	68.3	57.9
Minimum	1570.0	78.5	105.3	94.7	84.8	88.6	81.2	78.2	68.2	67.0	63.7	57.9
ALTITUDE 4,600 m. LOW RPM.												
Mean	1520.0	76.0	102.3	93.5	88.8	87.3	76.5	76.4	69.0	67.8		57.3
Standard Deviation	0.00	0.00	0.24	1.93	1.11	1.67	2.31	2.03	2.87	1.45		
Standard Deviation	0.00	0.00	-0.26	-3.57	-1.49	-2.75	-5.25	-3.92	-11.85	-2.19		
Maximum	1520.0	76.0	102.5	95.6	89.5	89.2	78.3	78.4	71.2	68.9		57.3
Minimum	1520.0	76.0	102.0	91.1	87.0	85.7	69.5	72.5	64.3	66.4		57.3
ALTITUDE 9,100 m. HIGH RPM.												
Mean	1572.5	78.6	99.1	95.1	88.8	89.1	84.7	87.8	78.8	71.5	68.9	67.9
Standard Deviation	2.50	0.13	0.52	0.62	1.06	2.39	1.40	2.17	2.22	1.13	2.39	0.87
Standard Deviation	2.50	0.13	-0.59	-0.72	-1.41	-5.77	-2.07	-4.55	-4.76	-1.53	-5.77	-1.09
Maximum	1575.0	78.8	99.6	95.8	89.7	91.4	86.3	89.3	81.2	72.3	71.1	68.9
Minimum	1570.0	78.5	98.5	94.6	87.2	83.0	83.6	81.8	75.1	69.7	62.0	67.1
ALTITUDE 9,100 m. LOW RPM.												
Mean	1517.5	75.9	95.1	88.6	89.1	82.0	75.5	81.3	75.4	71.5	68.0	59.7
Standard Deviation	0.00	0.00	1.11	0.85	1.26	2.49	1.75	1.38	2.79	1.35	2.75	1.26
Standard Deviation	0.00	0.00	-1.49	-1.06	-1.79	-6.49	-2.98	-2.04	-9.98	-1.97	-9.35	-1.77
Maximum	1517.5	75.9	96.4	89.5	90.3	83.8	77.4	82.4	78.0	73.0	71.0	60.6
Minimum	1517.5	75.9	94.3	87.7	87.2	72.3	73.0	78.9	60.1	70.0	63.5	58.5

CABIN MICROPHONE 1 : PORT & STARBOARD ENGINE COMPONENTS

Test Condition | Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 4,600 m. LOW RPM. All Phase Settings												
Mean	1530.8	76.5	111.9	96.1	90.0	89.2	80.1	84.9	77.5	69.6	69.8	64.9
Standard Deviation	1.23	0.06	1.62	2.66	2.23	2.15	1.81	1.67	2.22	2.75	2.12	2.66
Standard Deviation	1.23	0.06	-2.62	-8.07	-4.81	-4.45	-3.17	-2.75	-4.79	-9.36	-4.31	-8.11
Upper 90% Conf.Limit	1531.47	76.58	112.84	97.72	91.28	90.47	81.14	85.89	78.77	71.28	71.14	66.73
Lower 90% Conf.Limit	1530.20	76.51	110.76	93.64	88.13	87.47	78.75	83.74	75.63	66.97	67.82	61.68
Maximum	1532.5	76.6	114.0	100.5	93.0	92.3	82.6	87.2	81.3	74.8	72.8	68.8
Minimum	1530.0	76.5	107.6	83.2	82.8	81.4	73.4	79.3	69.4	64.4	65.8	58.1
ALTITUDE 4,600 m. LOW RPM. (1) 9 o'clock + 3 o'clock												
Mean	1530.8	76.5	112.2	93.3	89.0	88.1	80.3	84.8	75.6	70.5	70.0	64.3
Standard Deviation	1.29	0.07	0.84	2.27	2.58	2.94	1.96	1.63	2.46	2.75	2.14	2.48
Standard Deviation	1.29	0.07	-1.04	-5.06	-7.25	-15.04	-3.65	-2.63	-6.24	-9.35	-4.40	-6.36
Maximum	1532.5	76.6	113.1	96.7	93.0	92.3	82.6	86.8	79.3	74.8	72.8	66.7
Minimum	1530.0	76.5	110.8	83.2	84.2	81.4	73.4	79.3	69.4	66.8	66.6	58.1
ALTITUDE 4,600 m. LOW RPM. (2) 11 o'clock												
Mean	1531.7	76.6	107.7	99.7	90.0	89.7	81.4	85.2	79.7	69.1	70.6	64.6
Standard Deviation	1.44	0.08	0.11	0.79	2.31	1.13	0.65	2.19	1.48	3.16	2.20	2.88
Standard Deviation	1.44	0.08	-0.12	-0.96	-5.23	-1.53	-0.77	-4.64	-2.27		-4.68	-12.31
Maximum	1532.5	76.6	107.8	100.5	91.5	90.5	82.1	87.2	81.3	72.6	72.8	67.8
Minimum	1530.0	76.5	107.6	98.8	82.8	87.9	80.8	79.9	78.0	64.4	66.1	60.3
ALTITUDE 4,600 m. LOW RPM. (3) 1 o'clock												
Mean	1530.0	76.5	113.7	94.7	91.4	90.5	77.8	85.0	77.7	68.0	68.4	66.2
Standard Deviation	0.00	0.00	0.23	2.35	1.88	1.69	2.03	1.71	2.01	2.15	2.47	3.39
Standard Deviation	0.00	0.00	-0.24	-5.50	-3.38	-2.81	-3.95	-2.87	-3.85	-4.43	-6.34	
Maximum	1530.0	76.5	114.0	97.3	93.0	92.2	80.0	86.2	79.8	70.3	71.2	68.8
Minimum	1530.0	76.5	113.6	92.0	87.4	87.8	74.9	81.5	74.4	64.8	65.8	58.3
ALTITUDE 9,100 m. LOW RPM. All Phase Settings												
Mean	1530.8	76.5	104.1	95.4	90.9	84.9	81.1	87.8	81.9	74.3	73.3	65.6
Standard Deviation	5.47	0.27	1.55	2.44	1.56	1.79	2.06	3.26	1.23	1.96	2.33	2.34
Standard Deviation	5.47	0.27	-2.44	-6.08	-2.46	-3.10	-4.04		-1.72	-3.67	-5.36	-5.43
Upper 90% Conf.Limit	1532.50	76.63	104.94	96.85	91.76	85.94	82.24	89.76	82.60	75.40	74.63	66.93
Lower 90% Conf.Limit	1532.50	76.63	102.97	93.27	89.78	83.59	79.42	84.01	81.11	72.76	71.28	63.56
Maximum	1540.0	77.0	106.6	99.0	93.5	88.1	84.0	92.5	84.1	77.1	76.1	69.0
Minimum	1525.0	76.3	99.2	83.7	86.3	78.5	74.0	79.0	78.0	68.0	63.4	58.7
ALTITUDE 9,100 m. LOW RPM. (1) 9 o'clock + 3 o'clock												
Mean	1530.8	76.5	103.6	85.9	90.6	85.9	78.1	88.5	82.8	74.5	73.2	66.4
Standard Deviation	5.77	0.29	0.57	1.95	1.02	2.03	2.15	3.68	1.27	1.38	2.62	2.51
Standard Deviation	5.77	0.29	-0.65	-3.63	-1.33	-3.95	-4.45		-1.81	-2.03	-7.65	-6.60
Maximum	1537.5	76.9	104.2	88.1	91.7	88.1	80.3	92.5	84.1	75.3	76.0	69.0
Minimum	1527.5	76.4	103.1	83.7	89.4	83.1	74.0	79.1	81.0	72.0	67.2	60.5
ALTITUDE 9,100 m. LOW RPM. (2) 11 o'clock												
Mean	1533.1	76.7	101.6	94.9	91.3	84.7	81.8	88.9	81.9	72.8	74.6	65.5
Standard Deviation	6.57	0.33	1.22	2.28	1.63	1.63	2.24	2.99	0.58	2.06	2.08	2.34
Standard Deviation	6.57	0.33	-1.71	-5.08	-2.63	-2.65	-4.89	-19.88	-0.67	-4.06	-4.13	-5.42
Maximum	1540.0	77.0	102.9	97.5	93.5	86.3	83.8	92.3	82.5	75.1	76.1	68.3
Minimum	1527.5	76.4	99.2	85.7	89.3	81.9	76.7	81.1	81.0	68.0	64.6	60.6
ALTITUDE 9,100 m. LOW RPM. (3) 1 o'clock												
Mean	1529.0	76.5	105.6	97.5	90.7	84.5	81.7	86.0	81.2	75.1	71.8	65.1
Standard Deviation	4.87	0.24	0.70	1.05	1.92	1.89	1.52	3.61	1.48	2.07	2.42	2.61
Standard Deviation	4.87	0.24	-0.84	-1.39	-3.52	-3.42	-2.37		-2.27	-4.10	-5.98	-7.50
Maximum	1537.5	76.9	106.6	99.0	93.2	86.6	84.0	91.2	83.1	77.1	74.6	68.7
Minimum	1525.0	76.3	104.7	95.8	86.3	78.5	79.9	79.0	78.0	70.0	63.4	58.7

CABIN MICROPHONE 2 : PORT ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential													
Mean		1575.0	78.8	111.8	92.9	89.4	85.5	76.2	76.8	66.8	70.6	63.9	61.1
Standard Deviation		4.33	0.21	0.32	0.99	1.28	2.48	1.42	1.94	2.65	0.77	0.77	
Standard Deviation		4.33	0.21	-0.34	-1.29	-1.82	-6.41	-2.12	-3.61	-7.94	-0.94	-0.94	
Maximum		1580.0	79.0	112.2	93.8	90.7	87.4	77.8	78.9	69.7	71.2	64.5	61.1
Minimum		1572.5	78.6	111.6	91.5	87.6	76.2	74.6	73.9	63.1	70.0	63.3	61.1
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
Mean		1572.5	78.6	113.1	94.3	93.4	95.4	86.0	83.2	74.1	70.1	70.2	
Standard Deviation		0.00	0.00	0.58	0.96	1.00	0.77	1.63	1.33	2.66	0.83	1.64	
Standard Deviation		0.00	0.00	-0.67	-1.23	-1.30	-0.93	-2.65	-1.92	-8.09	-1.02	-2.67	
Maximum		1572.5	78.6	113.7	95.1	94.5	96.2	87.5	84.7	77.0	70.7	72.0	
Minimum		1572.5	78.6	112.5	92.9	92.4	94.6	83.1	82.1	69.4	69.4	68.0	
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
Mean		1525.0	76.3	110.2	87.0	85.0	83.2	70.3	72.7	64.3	70.7		
Standard Deviation		0.00	0.00	0.34	2.19	0.90	2.29	2.11	1.70		1.54		
Standard Deviation		0.00	0.00	-0.37	-4.61	-1.14	-5.13	-4.27	-2.83		-2.41		
Maximum		1525.0	76.3	110.6	89.2	85.7	85.5	72.2	74.6	64.3	72.4		
Minimum		1525.0	76.3	109.9	82.5	83.7	78.3	65.4	70.8	64.3	68.8		
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
Mean		1525.8	76.3	110.9	96.2	93.7	88.1	83.3	74.5	70.6			68.4
Standard Deviation		1.44	0.08	0.00	0.96	1.51	1.47	1.13	2.94				
Standard Deviation		1.44	0.08	0.00	-1.23	-2.33	-2.24	-1.53	-14.70				
Maximum		1527.5	76.4	110.9	97.0	95.2	89.6	84.4	77.7	70.6			68.4
Minimum		1525.0	76.3	110.9	94.8	91.4	85.9	81.7	70.0	70.6			68.4
ALTITUDE 4,600 m. HIGH RPM.													
Mean		1573.3	78.7	112.8	97.8	93.4	91.8	86.4	88.0	75.1	68.4	73.6	68.8
Standard Deviation		1.44	0.07	0.43	1.37	0.88	0.86	0.97	1.98	0.99	1.54	1.90	2.69
Standard Deviation		1.44	0.07	-0.47	-2.02	-1.10	-1.07	-1.24	-3.74	-1.28	-2.41	-3.46	-8.44
Maximum		1575.0	78.8	113.2	99.4	94.4	92.7	87.2	90.0	75.8	69.5	75.3	70.9
Minimum		1572.5	78.6	112.3	96.7	92.8	90.8	85.0	84.3	73.6	66.8	69.6	64.8
ALTITUDE 4,600 m. LOW RPM.													
Mean		1525.0	76.3	110.3	98.9	94.1	80.3	82.3	83.4	72.5	72.3		69.0
Standard Deviation		0.00	0.00	0.10	0.21	1.40	3.16	2.40	1.93	1.09	0.53		1.93
Standard Deviation		0.00	0.00	-0.10	-0.22	-2.08		-5.79	-3.56	-1.45	-0.60		-3.55
Maximum		1525.0	76.3	110.4	99.1	95.6	83.7	84.7	85.0	73.7	72.7		71.2
Minimum		1525.0	76.3	110.2	98.7	92.4	71.4	76.4	79.1	71.5	71.9		67.1
ALTITUDE 9,100 m. HIGH RPM.													
Mean		1570.8	78.5	105.2	91.5	87.0	83.2	84.7	89.2	83.5	72.7	73.0	75.6
Standard Deviation		1.44	0.08	0.40	0.88	1.54	1.04	1.85	0.32	1.01	1.98	0.43	1.34
Standard Deviation		1.44	0.08	-0.45	-1.10	-2.42	-1.37	-3.27	-0.34	-1.31	-3.73	-0.47	-1.95
Maximum		1572.5	78.6	105.7	92.3	88.3	83.9	86.6	89.6	84.6	74.9	73.3	77.1
Minimum		1570.0	78.5	104.9	90.3	84.2	81.6	81.7	89.0	82.7	70.0	72.5	74.2
ALTITUDE 9,100 m. LOW RPM.													
Mean		1521.7	76.1	102.1	94.2	81.3	86.5	81.9	84.7	73.0	69.8		64.1
Standard Deviation		1.44	0.08	0.20	0.30	2.55	1.07	1.50	1.41	1.41	1.00		1.28
Standard Deviation		1.44	0.08	-0.21	-0.32	-6.93	-1.43	-2.31	-2.10	-2.10	-1.30		-1.83
Maximum		1522.5	76.1	102.3	94.5	83.0	87.2	83.3	86.0	73.9	70.8		65.5
Minimum		1520.0	76.0	101.9	93.9	70.3	84.8	79.4	82.4	70.5	68.5		62.9

CABIN MICROPHONE 2 : STARBOARD ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential													
Mean		1570.8	78.5	103.6	92.6	85.3	84.4	79.2	69.7	68.3	65.0		
Standard Deviation		1.44	0.08	0.59	0.75	0.53	3.21	1.83		2.36			
Standard Deviation		1.44	0.08	-0.68	-0.91	-0.61		-3.23		-5.57			
Maximum		1572.5	78.6	104.3	93.4	85.9	88.0	81.2	69.7	70.1	65.0		
Minimum		1570.0	78.5	103.2	91.8	84.9	79.9	76.5	69.7	65.2	65.0		
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
Mean		1570.0	78.5	105.2	93.5	77.1	87.0	81.3	76.9	70.2	67.3	64.1	
Standard Deviation		0.00	0.00	0.81	0.65	3.26	0.43	2.35	2.80	2.93			
Standard Deviation		0.00	0.00	-1.00	-0.77		-0.47	-5.48	-10.34	-14.15			
Maximum		1570.0	78.5	105.9	94.0	80.7	87.5	83.4	79.9	72.5	67.3	64.1	
Minimum		1570.0	78.5	104.1	92.6	70.3	86.7	74.6	70.2	65.3	67.3	64.1	
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
Mean		1521.7	76.1	102.4	90.3	80.4	81.9	79.4					
Standard Deviation		2.89	0.14	0.25	0.79	1.20	1.44	0.88					
Standard Deviation		2.89	0.14	-0.26	-0.96	-1.66	-2.17	-1.11					
Maximum		1525.0	76.3	102.7	91.1	81.5	82.9	80.2					
Minimum		1520.0	76.0	102.2	89.4	78.6	79.3	78.2					
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
Mean		1518.3	76.9	102.9	94.8	85.9	85.8	84.5		66.1	68.5		
Standard Deviation		1.44	1.70	0.73	0.92	0.95	0.75	3.03		0.77			
Standard Deviation		1.44	1.70	-0.87	-1.17	-1.22	-0.91			-0.94			
Maximum		1520.0	78.9	103.6	95.7	86.6	86.7	87.9		66.7	68.5		
Minimum		1517.5	75.9	102.0	93.6	84.5	85.2	80.5		65.5	68.5		
ALTITUDE 4,600 m. HIGH RPM.													
Mean		1571.7	78.6	103.4	94.7	84.4	88.7	88.3	81.6	71.4		65.2	
Standard Deviation		1.44	0.08	1.08	1.87	1.34	0.88	1.62	1.10	2.51			
Standard Deviation		1.44	0.08	-1.45	-3.34	-1.95	-1.11	-2.61	-1.47	-6.60			
Maximum		1572.5	78.6	104.6	96.8	85.9	89.7	90.1	82.6	73.3		65.2	
Minimum		1570.0	78.5	102.5	92.7	83.0	87.8	86.4	80.0	67.9		65.2	
ALTITUDE 4,600 m. LOW RPM.													
Mean		1520.0	76.0	99.2	91.4	88.1	89.4	82.7	79.9	64.9	68.9		
Standard Deviation		0.00	0.00	0.48	1.52	0.99	0.44	2.15	2.14		0.56		
Standard Deviation		0.00	0.00	-0.54	-2.35	-1.29	-0.49	-4.47	-4.39		-0.64		
Maximum		1520.0	76.0	99.7	92.7	89.1	89.7	84.8	82.1	64.9	69.4		
Minimum		1520.0	76.0	98.7	88.7	86.8	88.8	77.9	75.8	64.9	68.2		
ALTITUDE 9,100 m. HIGH RPM.													
Mean		1572.5	78.6	95.5	88.8	84.8	89.5	86.2	89.7	80.5	79.0	70.5	68.7
Standard Deviation		2.50	0.13	0.95	1.16	2.01	1.99	1.36	0.93	2.44	1.82	2.44	2.12
Standard Deviation		2.50	0.13	-1.22	-1.59	-3.85	-3.78	-1.99	-1.18	-6.11	-3.18	-6.07	-4.31
Maximum		1575.0	78.8	96.5	89.8	87.0	91.7	87.5	90.4	82.7	80.2	73.1	70.8
Minimum		1570.0	78.5	94.4	87.0	82.7	87.3	84.1	88.3	72.8	75.0	66.0	64.2
ALTITUDE 9,100 m. LOW RPM.													
Mean		1517.5	75.9	89.0	88.3	89.3	87.0	80.7	90.4	83.2	78.1	65.2	59.7
Standard Deviation		0.00	0.00	1.16	1.82	1.66	1.75	2.58	1.76	1.83	1.70	0.83	2.39
Standard Deviation		0.00	0.00	-1.59	-3.18	-2.73	-2.98	-7.29	-3.02	-3.21	-2.82	-1.02	-5.76
Maximum		1517.5	75.9	89.8	89.8	90.3	88.8	82.7	92.1	85.0	80.0	65.8	61.5
Minimum		1517.5	75.9	87.1	84.5	85.9	84.2	69.2	87.2	80.0	76.4	64.5	56.5

CABIN MICROPHONE 2 : PORT & STARBOARD ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	1	2	3	4	5	6	7	8	9	10
				Harmonic Level, dB re 20 micro Pa									
ALTITUDE 4,600 m. LOW RPM. All Phase Settings													
Mean		1530.6	76.5	111.5	99.7	93.6	88.1	85.9	86.0	74.7	74.3	66.8	68.4
Standard Deviation		1.13	0.06	1.32	2.14	1.87	1.36	2.35	1.92	2.17	2.31	0.71	1.54
Standard Deviation		1.13	0.06	-1.91	-4.39	-3.34	-1.99	-5.50	-3.54	-4.52	-5.28	-0.84	-2.40
Upper 90% Conf.Limit		1531.21	76.56	112.27	100.96	94.67	88.86	87.31	87.15	75.94	75.66	67.59	69.30
Lower 90% Conf.Limit		1530.04	76.50	110.65	97.98	92.19	87.19	83.91	84.57	72.91	72.34	65.76	67.25
Maximum		1532.5	76.6	113.4	103.4	96.5	90.3	89.3	88.6	78.3	78.7	67.7	71.1
Minimum		1530.0	76.5	108.2	92.1	87.5	84.6	76.2	78.7	69.8	67.5	65.9	65.2
ALTITUDE 4,600 m. LOW RPM. (1) 9 o'clock + 3 o'clock													
Mean		1530.4	76.5	111.8	100.4	92.3	88.6	86.3	84.6	72.8	72.2	67.0	68.0
Standard Deviation		1.02	0.05	0.74	1.94	2.37	1.19	2.38	2.34	1.54	1.29	0.60	1.44
Standard Deviation		1.02	0.05	-0.89	-3.61	-5.63	-1.65	-5.68	-5.45	-2.40	-1.84	-0.69	-2.16
Maximum		1532.5	76.6	112.7	103.4	95.6	90.3	89.3	88.1	75.0	73.7	67.7	70.0
Minimum		1530.0	76.5	110.6	96.9	87.5	85.9	80.1	78.7	69.8	69.9	66.5	65.8
ALTITUDE 4,600 m. LOW RPM. (2) 11 o'clock													
Mean		1531.7	76.6	108.6	100.9	93.9	87.9	85.6	87.3	77.6	73.6	65.9	67.1
Standard Deviation		1.44	0.08	0.35	1.35	1.24	1.72	2.50	0.90	0.99	2.27		1.76
Standard Deviation		1.44	0.08	-0.39	-1.97	-1.75	-2.89	-6.55	-1.14	-1.28	-5.02		-3.00
Maximum		1532.5	76.6	108.9	102.1	95.1	89.8	87.6	88.0	78.3	75.6	65.9	68.4
Minimum		1530.0	76.5	108.2	98.7	92.1	85.6	76.2	86.0	76.1	67.5	65.9	65.2
ALTITUDE 4,600 m. LOW RPM. (3) 1 o'clock													
Mean		1530.0	76.5	112.9	95.1	95.3	87.1	85.5	86.9	73.3	77.1		69.7
Standard Deviation		0.00	0.00	0.44	1.59	1.17	1.39	2.87	1.94	0.59	1.37		1.34
Standard Deviation		0.00	0.00	-0.49	-2.54	-1.60	-2.06	-11.83	-3.59	-0.68	-2.02		-1.95
Maximum		1530.0	76.5	113.4	96.4	96.5	88.1	88.7	88.6	74.0	78.7		71.1
Minimum		1530.0	76.5	112.5	92.1	93.8	84.6	81.9	82.7	72.9	76.0		67.9
ALTITUDE 9,100 m. LOW RPM. All Phase Settings													
Mean		1530.8	76.5	102.8	94.6	87.5	90.7	83.9	89.3	82.7	77.1	71.3	64.7
Standard Deviation		5.47	0.27	1.15	2.20	2.03	1.85	1.85	2.36	1.63	1.68	2.09	2.67
Standard Deviation		5.47	0.27	-1.56	-4.68	-3.92	-3.30	-3.28	-5.56	-2.63	-2.78	-4.16	-8.17
Upper 90% Conf.Limit		1532.50	76.63	103.47	95.84	88.70	91.76	85.00	90.67	83.61	78.05	72.55	66.25
Lower 90% Conf.Limit		1532.50	76.63	102.10	92.75	85.93	89.29	82.55	87.25	81.53	75.87	69.67	62.15
Maximum		1540.0	77.0	104.3	98.3	91.3	93.4	87.2	92.7	85.1	80.0	75.3	69.4
Minimum		1525.0	76.3	99.8	86.4	83.2	84.1	75.4	83.9	78.0	71.0	67.7	58.0
ALTITUDE 9,100 m. LOW RPM. (1) 9 o'clock + 3 o'clock													
Mean		1530.8	76.5	103.5	93.8	85.2	92.8	82.3	88.6	82.6	78.4	70.5	62.8
Standard Deviation		5.77	0.29	0.11	1.41	1.66	0.64	2.34	3.15	1.65	1.58	2.18	1.26
Standard Deviation		5.77	0.29	-0.12	-2.10	-2.73	-0.75	-5.41		-2.69	-2.50	-4.60	-1.78
Maximum		1537.5	76.9	103.6	95.0	87.0	93.4	84.3	92.1	84.1	80.0	72.9	63.9
Minimum		1527.5	76.4	103.4	91.4	83.2	92.0	75.4	83.9	79.6	75.9	68.1	60.8
ALTITUDE 9,100 m. LOW RPM. (2) 11 o'clock													
Mean		1533.1	76.7	100.7	91.5	88.0	89.2	84.7	88.5	83.0	75.9	72.1	65.1
Standard Deviation		6.57	0.33	0.54	1.76	2.48	1.40	0.48	2.38	1.82	0.84	2.43	2.29
Standard Deviation		6.57	0.33	-0.62	-3.02	-6.37	-2.07	-0.54	-5.66	-3.19	-1.05	-6.01	-5.17
Maximum		1540.0	77.0	101.2	93.2	91.3	91.1	85.4	91.5	85.0	77.1	75.3	67.9
Minimum		1527.5	76.4	99.8	86.4	84.0	87.5	84.2	84.3	78.0	75.1	68.1	58.6
ALTITUDE 9,100 m. LOW RPM. (3) 1 o'clock													
Mean		1529.0	76.5	103.7	96.3	88.1	90.0	84.0	90.1	82.5	77.0	71.2	65.2
Standard Deviation		4.87	0.24	0.49	1.70	1.42	2.16	2.32	2.19	1.75	1.83	1.81	3.12
Standard Deviation		4.87	0.24	-0.56	-2.84	-2.12	-4.47	-5.32	-4.64	-2.97	-3.22	-3.15	
Maximum		1537.5	76.9	104.3	98.3	90.3	92.8	87.2	92.7	85.1	78.8	73.1	69.4
Minimum		1525.0	76.3	103.1	92.8	86.5	84.1	77.4	85.8	80.1	71.0	67.7	58.0

CABIN MICROPHONE 3 : PORT ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential													
Mean		1575.0	78.8	106.3	92.9	94.4	77.7	79.1	68.7	70.4	68.8	68.1	68.0
Standard Deviation		4.33	0.21	0.40	1.96	0.57	2.37	1.91	1.59	2.39			
Standard Deviation		4.33	0.21	-0.45	-3.69	-0.66	-5.61	-3.49	-2.52	-5.76			
Maximum		1580.0	79.0	106.6	95.0	95.0	80.0	81.2	69.9	72.2	68.8	68.1	68.0
Minimum		1572.5	78.6	105.8	89.9	93.8	71.6	76.8	67.1	67.2	68.8	68.1	68.0
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
Mean		1572.5	78.6	97.6	85.7	98.7	80.1	82.3	79.8	67.8	77.0		
Standard Deviation		0.00	0.00	1.98	1.26	0.06	1.71	2.15	2.03	0.71	0.07		
Standard Deviation		0.00	0.00	-3.75	-1.78	-0.06	-2.86	-4.43	-3.93	-0.85	-0.07		
Maximum		1572.5	78.6	99.7	87.1	98.7	81.6	84.4	82.1	68.3	77.0		
Minimum		1572.5	78.6	94.2	84.5	98.6	76.8	77.7	78.0	67.2	76.9		
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
Mean		1525.0	76.3	103.1	90.6	97.1	77.8	77.8	72.9	68.9	71.2		
Standard Deviation		0.00	0.00	0.56	1.51	1.07	2.75	1.58	2.06				
Standard Deviation		0.00	0.00	-0.64	-2.34	-1.42	-9.42	-2.52	-4.05				
Maximum		1525.0	76.3	103.6	92.3	98.1	80.8	79.5	74.8	68.9	71.2		
Minimum		1525.0	76.3	102.4	89.3	95.6	73.4	75.8	66.4	68.9	71.2		
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
Mean		1525.8	76.3	100.7	97.2	97.0	83.6	79.6	65.5	77.0	68.0		
Standard Deviation		1.44	0.08	1.63	1.71	0.96	0.92	2.35		1.89			
Standard Deviation		1.44	0.08	-2.63	-2.86	-1.23	-1.17	-5.52		-3.41			
Maximum		1527.5	76.4	102.5	98.7	97.9	84.5	81.2	65.5	79.1	68.0		
Minimum		1525.0	76.3	98.7	93.9	95.7	82.4	71.9	65.5	75.1	68.0		
ALTITUDE 4,600 m. HIGH RPM.													
Mean		1573.3	78.7	87.5	93.9	97.9	88.3	85.2	80.4	78.8	69.4	79.8	
Standard Deviation		1.44	0.07	0.61	2.76	0.96	0.65	1.17	3.32	2.37	1.29	2.08	
Standard Deviation		1.44	0.07	-0.71	-9.55	-1.23	-0.77	-1.61		-5.62	-1.85	-4.13	
Maximum		1575.0	78.8	88.1	97.0	99.0	89.0	86.4	84.0	81.1	70.3	81.8	
Minimum		1572.5	78.6	86.8	90.5	97.2	87.7	83.6	73.6	72.8	67.2	75.4	
ALTITUDE 4,600 m. LOW RPM.													
Mean		1525.0	76.3	100.7	99.3	94.6	88.3	80.8	83.6	77.0	74.4		68.9
Standard Deviation		0.00	0.00	0.77	0.89	1.91	0.51	2.08	2.27	2.44	0.14		
Standard Deviation		0.00	0.00	-0.93	-1.12	-3.49	-0.58	-4.15	-5.01	-6.08	-0.14		
Maximum		1525.0	76.3	101.2	100.0	96.7	88.8	82.9	85.7	79.5	74.5		68.9
Minimum		1525.0	76.3	99.6	98.0	92.4	87.7	76.6	77.9	71.2	74.3		68.9
ALTITUDE 9,100 m. HIGH RPM.													
Mean		1570.8	78.5	96.7	96.9	83.5	83.9	78.6	90.6	80.4	81.1	80.5	72.2
Standard Deviation		1.44	0.08	0.40	1.23	0.94	0.81	3.53	0.65	2.59	2.15	2.26	2.67
Standard Deviation		1.44	0.08	-0.45	-1.72	-1.20	-0.99		-0.77	-7.35	-4.45	-4.99	-8.20
Maximum		1572.5	78.6	97.0	98.3	84.5	84.6	82.5	91.3	83.2	83.2	82.9	75.2
Minimum		1570.0	78.5	96.2	95.6	82.4	82.8	72.4	90.0	75.3	76.4	76.2	68.9
ALTITUDE 9,100 m. LOW RPM.													
Mean		1521.7	76.1	99.0	95.0	84.9	85.0	75.6	81.1	77.5	67.5		68.3
Standard Deviation		1.44	0.08	0.27	0.20	1.01	0.57	1.91	0.06	1.42	1.41		2.02
Standard Deviation		1.44	0.08	-0.29	-0.20	-1.32	-0.65	-3.48	-0.06	-2.12	-2.11		-3.89
Maximum		1522.5	76.1	99.2	95.2	86.0	85.6	77.7	81.1	79.1	69.0		70.5
Minimum		1520.0	76.0	98.7	94.8	83.8	84.5	73.8	81.0	76.3	65.6		65.3

CABIN MICROPHONE 3 : STARBOARD ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa									
				1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. *Zero Pressure Differential*													
Mean		1570.8	77.9	88.5	96.0	98.5	87.2	81.6	70.7	71.1			
Standard Deviation		1.44	1.08	1.57	1.15	2.70	2.49	1.67	2.66	0.88			
Standard Deviation		1.44	1.08	-2.49	-1.58	-8.56	-6.50	-2.75	-8.09	-1.11			
Maximum		1572.5	78.5	89.6	97.3	101.5	90.0	83.5	73.6	72.0			
Minimum		1570.0	76.6	85.5	94.8	94.9	83.6	80.2	66.0	70.0			
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
Mean		1570.8	78.5	96.8	98.7	92.9	86.0	86.4	82.1	70.2	73.0		
Standard Deviation		1.44	0.08	1.22	2.47	1.56	0.83	2.88	2.57	1.07			
Standard Deviation		1.44	0.08	-1.70	-6.34	-2.46	-1.02	-12.29	-7.16	-1.42			
Maximum		1572.5	78.6	98.0	100.6	94.7	86.9	89.6	84.7	71.2	73.0		
Minimum		1570.0	78.5	95.1	89.6	91.4	85.3	82.8	75.2	68.7	73.0		
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
Mean		1521.7	76.1	93.3	99.1	98.9	83.6	83.3	71.9	71.3	74.4		
Standard Deviation		2.89	0.14	1.06	1.38	0.55	2.11	1.21	1.26				
Standard Deviation		2.89	0.14	-1.41	-2.03	-0.62	-4.26	-1.68	-1.77				
Maximum		1525.0	76.3	94.2	100.6	99.5	85.9	84.2	72.8	71.3	74.4		
Minimum		1520.0	76.0	91.7	97.7	98.4	81.0	81.3	70.7	71.3	74.4		
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
Mean		1517.5	75.9	98.1	100.2	94.0	78.2	91.9	74.8	68.2			
Standard Deviation		0.00	0.00	0.25	1.80	0.25	3.23	2.53	1.87				
Standard Deviation		0.00	0.00	-0.26	-3.12	-0.26		-6.75	-3.35				
Maximum		1517.5	75.9	98.4	101.7	94.3	81.8	94.7	76.9	68.2			
Minimum		1517.5	75.9	97.9	96.5	93.8	72.3	89.2	72.7	68.2			
ALTITUDE 4,600 m. HIGH RPM.													
Mean		1571.7	78.6	101.7	98.1	92.7	83.6	87.0	80.9	79.8	67.3	68.2	67.9
Standard Deviation		1.44	0.08	1.61	0.43	0.72	1.23	3.26	0.68	0.74			
Standard Deviation		1.44	0.08	-2.58	-0.48	-0.87	-1.72		-0.81	-0.89			
Maximum		1572.5	78.6	103.4	98.6	93.4	84.6	90.5	81.4	80.6	67.3	68.2	67.9
Minimum		1570.0	78.5	99.6	97.7	91.8	81.6	77.8	80.0	79.0	67.3	68.2	67.9
ALTITUDE 4,600 m. LOW RPM.													
Mean		1520.0	76.0	101.3	98.5	93.6	82.3	89.7	79.4				
Standard Deviation		0.00	0.00	1.07	0.86	1.35	3.18	2.31	3.14				
Standard Deviation		0.00	0.00	-1.42	-1.07	-1.97		-5.28					
Maximum		1520.0	76.0	102.5	99.2	95.1	85.8	91.7	82.9				
Minimum		1520.0	76.0	100.3	97.3	92.4	76.6	83.1	73.5				
ALTITUDE 9,100 m. HIGH RPM.													
Mean		1572.5	78.6	98.3	94.2	86.0	79.3	87.0	92.8	90.6	86.4	77.6	74.1
Standard Deviation		2.50	0.13	0.47	1.23	0.57	1.16	1.35	1.27	0.68	1.44	2.38	0.91
Standard Deviation		2.50	0.13	-0.53	-1.72	-0.65	-1.58	-1.97	-1.80	-0.81	-2.18	-5.67	-1.14
Maximum		1575.0	78.8	98.8	95.6	86.5	80.6	88.5	94.2	91.2	88.0	79.2	75.1
Minimum		1570.0	78.5	97.8	93.2	85.3	78.3	85.9	91.3	89.7	85.2	69.6	73.1
ALTITUDE 9,100 m. LOW RPM.													
Mean		1517.5	75.9	96.3	91.4	83.8	76.9	87.9	95.8	83.4	77.8	74.5	72.5
Standard Deviation		0.00	0.00	1.14	1.44	2.06	2.19	2.10	1.58	1.54	4.01	2.85	
Standard Deviation		0.00	0.00	-1.55	-2.16	-4.08	-4.62	-4.24	-2.50	-2.40		-11.45	
Maximum		1517.5	75.9	97.4	92.6	85.7	79.1	89.8	97.3	85.1	82.2	77.5	72.5
Minimum		1517.5	75.9	94.7	88.9	79.2	72.3	83.0	93.1	82.0	66.8	65.5	72.5

CABIN MICROPHONE 3 : PORT & STARBOARD ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 4,600 m. LOW RPM.			All Phase Settings										
Mean		1530.6	76.5	104.3	101.7	95.3	89.9	90.4	85.3	75.0	74.8	71.5	71.5
Standard Deviation		1.13	0.06	2.40	2.05	1.66	1.83	1.73	1.59	1.85	1.98	2.30	1.58
Standard Deviation		1.13	0.06	-5.78	-4.02	-2.73	-3.23	-2.92	-2.54	-3.29	-3.73	-5.23	-2.52
Upper 90% Conf.Limit		1531.21	76.56	105.73	102.85	96.25	90.92	91.34	86.17	76.08	75.98	73.47	72.71
Lower 90% Conf.Limit		1530.04	76.50	102.23	100.04	94.10	88.49	89.09	84.14	73.63	73.15	67.77	69.80
Maximum		1532.5	76.6	108.3	105.0	98.0	92.7	92.6	88.0	77.9	78.3	75.1	73.7
Minimum		1530.0	76.5	92.9	95.2	86.2	79.1	81.8	82.5	69.5	69.7	67.2	68.2
ALTITUDE 4,600 m. LOW RPM.			(1)	9 o'clock + 3 o'clock									
Mean		1530.4	76.5	101.1	103.1	93.6	88.2	90.7	85.5	75.8	73.3	71.0	70.3
Standard Deviation		1.02	0.05	2.74	1.32	1.83	2.47	1.62	1.91	1.73	1.85	1.34	0.75
Standard Deviation		1.02	0.05	-9.20	-1.91	-3.23	-6.30	-2.62	-3.48	-2.91	-3.30	-1.95	-0.91
Maximum		1532.5	76.6	105.2	105.0	96.1	91.2	92.6	88.0	77.9	75.6	72.0	71.1
Minimum		1530.0	76.5	92.9	101.2	86.2	79.1	87.5	82.5	72.2	69.7	68.7	69.5
ALTITUDE 4,600 m. LOW RPM.			(2)	11 o'clock									
Mean		1531.7	76.6	107.2	101.1	96.2	90.7	90.9	84.5	75.3	74.2	68.5	72.6
Standard Deviation		1.44	0.08	0.93	1.69	0.85	0.38	1.66	0.44	1.48	1.82	1.35	0.65
Standard Deviation		1.44	0.08	-1.19	-2.81	-1.06	-0.42	-2.72	-0.49	-2.26	-3.20	-1.98	-0.77
Maximum		1532.5	76.6	108.3	103.0	97.1	91.1	92.1	85.0	76.9	75.8	69.5	73.1
Minimum		1530.0	76.5	106.5	99.6	95.2	90.3	87.6	84.1	73.3	70.5	67.2	72.1
ALTITUDE 4,600 m. LOW RPM.			(3)	1 o'clock									
Mean		1530.0	76.5	104.6	96.8	96.8	91.4	88.7	85.6	72.4	76.9	75.1	71.8
Standard Deviation		0.00	0.00	1.17	1.48	1.11	1.18	2.28	1.49	2.00	1.34		2.53
Standard Deviation		0.00	0.00	-1.61	-2.26	-1.49	-1.63	-5.10	-2.29	-3.82	-1.95		-6.83
Maximum		1530.0	76.5	105.8	98.4	98.0	92.7	90.3	86.9	74.6	78.3	75.1	73.7
Minimum		1530.0	76.5	103.0	95.2	95.6	90.4	81.8	83.0	69.5	75.1	75.1	68.2
ALTITUDE 9,100 m. LOW RPM.			All Phase Settings										
Mean		1530.8	76.5	100.8	97.8	89.3	86.0	88.8	95.7	84.1	80.9	76.9	73.3
Standard Deviation		5.47	0.27	2.48	2.41	2.30	1.35	2.29	1.59	1.84	2.76	2.08	1.58
Standard Deviation		5.47	0.27	-6.42	-5.90	-5.19	-1.97	-5.15	-2.54	-3.27	-9.52	-4.16	-2.51
Upper 90% Conf.Limit		1532.50	76.63	102.23	99.26	90.62	86.71	90.15	96.64	85.13	82.50	78.06	74.21
Lower 90% Conf.Limit		1532.50	76.63	98.55	95.73	87.34	85.05	86.88	94.61	82.69	78.17	75.18	72.20
Maximum		1540.0	77.0	104.2	101.3	92.9	88.7	92.5	98.3	86.2	85.3	80.5	76.1
Minimum		1525.0	76.3	93.7	84.7	79.3	83.0	82.9	92.6	79.1	72.7	71.4	70.1
ALTITUDE 9,100 m. LOW RPM.			(1)	9 o'clock + 3 o'clock									
Mean		1530.8	76.5	95.9	97.8	90.1	87.2	89.8	94.4	83.0	82.0	77.2	72.3
Standard Deviation		5.77	0.29	1.35	1.43	1.26	1.38	2.53	1.13	1.89	3.05	1.67	1.37
Standard Deviation		5.77	0.29	-1.97	-2.14	-1.78	-2.03	-6.82	-1.53	-3.41		-2.75	-2.02
Maximum		1537.5	76.9	97.1	99.2	91.2	88.7	92.5	95.2	85.0	85.3	78.5	73.7
Minimum		1527.5	76.4	93.7	95.6	88.1	85.8	85.2	92.6	80.2	74.9	73.9	70.4
ALTITUDE 9,100 m. LOW RPM.			(2)	11 o'clock									
Mean		1533.1	76.7	103.7	100.5	89.6	85.8	88.8	96.7	85.0	81.5	75.3	73.8
Standard Deviation		6.57	0.33	0.47	0.84	2.42	0.96	1.87	1.53	1.45	2.49	2.06	1.02
Standard Deviation		6.57	0.33	-0.53	-1.04	-5.94	-1.24	-3.34	-2.39	-2.19	-6.48	-4.04	-1.34
Maximum		1540.0	77.0	104.2	101.3	92.4	86.9	90.5	98.3	86.0	84.4	78.0	75.0
Minimum		1527.5	76.4	103.2	99.0	79.3	84.2	82.9	93.1	81.3	72.7	72.2	72.3
ALTITUDE 9,100 m. LOW RPM.			(3)	1 o'clock									
Mean		1529.0	76.5	98.7	93.1	88.4	85.2	88.1	95.6	83.9	79.3	77.6	73.5
Standard Deviation		4.87	0.24	1.76	2.67	3.05	1.34	2.72	1.64	2.23	3.03	2.24	2.01
Standard Deviation		4.87	0.24	-3.01	-8.23		-1.96	-8.89	-2.67	-4.85		-4.86	-3.85
Maximum		1537.5	76.9	101.2	96.2	92.9	86.5	92.0	97.8	86.2	83.7	80.5	76.1
Minimum		1525.0	76.3	95.5	84.7	83.9	83.0	83.0	93.0	79.1	74.1	71.4	70.1

CABIN MICROPHONE 4 : PORT ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential													
	Mean	1574.2	78.7	108.3	89.0	83.0	84.2	80.2	73.1	75.4	72.6	69.9	
Standard Deviation		5.20	0.26	0.65	1.57	0.20	3.56	1.84		3.13			
Standard Deviation		5.20	0.26	-0.77	-2.50	-0.21		-3.25					
	Maximum	1580.0	79.0	108.8	90.2	83.2	88.1	81.6	73.1	78.9	72.6	69.9	
	Minimum	1570.0	78.5	107.4	86.0	82.8	78.1	76.2	73.1	70.2	72.6	69.9	
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
	Mean	1572.5	78.6	106.8	101.9	79.6	88.0	82.3	75.8				
Standard Deviation		0.00	0.00	0.78	0.55	0.99	1.79	1.21	1.50				
Standard Deviation		0.00	0.00	-0.95	-0.62	-1.28	-3.09	-1.68	-2.30				
	Maximum	1572.5	78.6	107.7	102.5	80.5	89.9	83.2	76.9				
	Minimum	1572.5	78.6	106.2	101.4	78.2	85.2	80.3	74.3				
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
	Mean	1525.0	76.3	102.3	94.4	86.1	79.4	76.6	71.0	74.3			
Standard Deviation		0.00	0.00	1.27	1.37	2.14	0.21	1.77		2.02			
Standard Deviation		0.00	0.00	-1.80	-2.02	-4.38	-0.22	-3.03		-3.89			
	Maximum	1525.0	76.3	103.5	95.8	87.5	79.5	78.5	71.0	75.8			
	Minimum	1525.0	76.3	100.4	92.5	80.4	79.2	74.1	71.0	69.4			
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
	Mean	1525.8	76.3	97.0	101.5	82.7	82.5	80.2	70.4	76.7	77.0		
Standard Deviation		2.89	0.14	1.23	0.74	1.36	1.64	1.43	0.27	2.10			
Standard Deviation		2.89	0.14	-1.72	-0.89	-1.98	-2.67	-2.16	-0.29	-4.23			
	Maximum	1527.5	76.4	98.1	102.3	84.1	83.9	81.6	70.6	78.3	77.0		
	Minimum	1522.5	76.1	95.1	100.8	80.9	79.4	78.0	70.2	74.2	77.0		
ALTITUDE 4,600 m. HIGH RPM.													
	Mean	1573.3	78.7	105.9	100.6	87.0	91.3	84.9	78.7	72.6	68.5	70.0	68.9
Standard Deviation		1.44	0.07	0.89	0.30	0.34	0.25	1.65	2.60	1.23		1.84	0.77
Standard Deviation		1.44	0.07	-1.12	-0.33	-0.37	-0.26	-2.69	-7.39	-1.72		-3.25	-0.94
	Maximum	1575.0	78.8	106.5	100.8	87.3	91.6	86.5	81.3	73.9	68.5	71.4	69.5
	Minimum	1572.5	78.6	104.6	100.2	86.6	91.1	82.1	71.7	71.0	68.5	68.0	68.3
ALTITUDE 4,600 m. LOW RPM.													
	Mean	1525.0	76.3	96.4	99.5	87.9	79.0	84.7	72.5	73.2	74.1		
Standard Deviation		0.00	0.00	0.10	0.98	1.14	2.26	0.99	2.63	1.66	0.59		
Standard Deviation		0.00	0.00	-0.10	-1.27	-1.54	-4.96	-1.29	-7.71	-2.73	-0.69		
	Maximum	1525.0	76.3	96.5	100.1	89.2	81.1	85.6	75.4	74.2	74.5		
	Minimum	1525.0	76.3	96.3	98.0	86.9	73.3	83.3	68.2	69.8	73.6		
ALTITUDE 9,100 m. HIGH RPM.													
	Mean	1570.8	78.5	100.8	92.9	80.6	78.1	76.4	81.3	71.0	72.8	68.2	67.7
Standard Deviation		1.44	0.08	0.52	1.60	1.29	1.67	3.11	2.09	1.26	2.03	2.42	1.63
Standard Deviation		1.44	0.08	-0.59	-2.57	-1.84	-2.75		-4.19	-1.77	-3.93	-5.96	-2.63
	Maximum	1572.5	78.6	101.2	94.4	81.4	79.8	79.8	83.0	72.4	75.1	70.5	69.5
	Minimum	1570.0	78.5	100.1	90.1	78.4	75.4	68.9	76.1	69.9	70.8	61.7	66.2
ALTITUDE 9,100 m. LOW RPM.													
	Mean	1522.5	76.1	96.5	91.9	78.5	65.8	69.6	80.2	73.3	69.3		69.2
Standard Deviation		0.00	0.00	0.20	1.51	1.99	1.35	2.16	0.72	1.78	0.59		3.26
Standard Deviation		0.00	0.00	-0.20	-2.34	-3.78	-1.97	-4.51	-0.87	-3.07	-0.69		
	Maximum	1522.5	76.1	96.7	93.6	80.2	67.2	72.0	80.7	75.3	69.7		72.8
	Minimum	1522.5	76.1	96.3	90.7	74.0	63.9	67.0	79.2	71.5	68.8		63.2

CABIN MICROPHONE 4 : STARBOARD ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential													
Mean		1570.8	78.5	100.6	90.8	82.1	77.8	79.2		68.0			
Standard Deviation		1.44	0.08	1.16	1.12	1.82	2.83	1.44					
Standard Deviation		1.44	0.08	-1.58	-1.51	-3.19	-10.89	-2.18					
Maximum		1572.5	78.6	101.8	91.6	83.7	80.9	80.8		68.0			
Minimum		1570.0	78.5	99.1	89.0	78.4	73.8	78.0		68.0			
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
Mean		1570.8	78.5	104.7	89.9	74.3	78.1	81.3	73.0		72.8	69.5	
Standard Deviation		1.44	0.08	0.96	2.42	2.67	0.72	1.27	0.34			1.15	
Standard Deviation		1.44	0.08	-1.24	-5.94	-8.18	-0.86	-1.81	-0.37			-1.58	
Maximum		1572.5	78.6	105.3	92.6	77.2	78.9	82.6	73.2		72.8	70.3	
Minimum		1570.0	78.5	103.2	86.9	69.4	77.6	79.6	72.7		72.8	68.4	
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
Mean		1521.7	76.1	100.5	93.1	84.3	78.9	77.9	73.6	70.6			
Standard Deviation		2.89	0.14	0.43	1.11	1.65	0.29	1.45	2.76	0.27			
Standard Deviation		2.89	0.14	-0.47	-1.49	-2.69	-0.31	-2.20	-9.47	-0.29			
Maximum		1525.0	76.3	100.9	94.0	85.9	79.2	79.3	75.7	70.8			
Minimum		1520.0	76.0	100.0	91.4	81.5	78.6	75.6	69.3	70.4			
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
Mean		1519.2	76.0	104.0	90.0	74.7	77.9	81.8	74.1	72.2			
Standard Deviation		1.44	0.07	0.43	0.64	2.31	1.99	0.77		1.01			
Standard Deviation		1.44	0.07	-0.47	-0.75	-5.25	-3.76	-0.94		-1.31			
Maximum		1520.0	76.0	104.4	90.4	76.4	79.3	82.4	74.1	73.2			
Minimum		1517.5	75.9	103.5	89.1	67.6	73.1	80.7	74.1	70.9			
ALTITUDE 4,600 m. HIGH RPM.													
Mean		1571.7	78.6	106.8	84.8	77.1	80.4	78.1	80.0	71.5	68.3		
Standard Deviation		1.44	0.08	1.16	3.02	1.87	2.48	0.77	2.37	0.15	1.83		
Standard Deviation		1.44	0.08	-1.58		-3.36	-6.37	-0.94	-5.65	-0.16	-3.21		
Maximum		1572.5	78.6	108.0	88.1	79.1	82.5	78.9	82.5	71.7	70.3		
Minimum		1570.0	78.5	105.3	80.1	74.3	72.0	77.2	75.6	71.4	66.2		
ALTITUDE 4,600 m. LOW RPM.													
Mean		1520.0	76.0	105.0	90.5	79.2	83.9	79.4	75.8	75.7			
Standard Deviation		0.00	0.00	0.90	0.75	1.26	1.87	1.44	3.16	0.37			
Standard Deviation		0.00	0.00	-1.14	-0.91	-1.79	-3.34	-2.18		-0.41			
Maximum		1520.0	76.0	106.0	91.3	80.2	86.0	81.0	79.3	76.1			
Minimum		1520.0	76.0	104.3	89.7	77.1	82.0	78.2	71.0	75.4			
ALTITUDE 9,100 m. HIGH RPM.													
Mean		1572.5	78.6	102.4	89.7	77.6	82.5	89.0	92.0	87.5	72.9	74.1	66.0
Standard Deviation		2.50	0.13	0.48	1.08	2.26	1.72	1.30	2.56	1.06	3.08	1.62	1.84
Standard Deviation		2.50	0.13	-0.54	-1.44	-4.96	-2.88	-1.86	-7.10	-1.41		-2.61	-3.25
Maximum		1575.0	78.8	102.9	90.9	80.1	84.0	90.2	94.2	88.5	76.2	75.7	67.4
Minimum		1570.0	78.5	101.9	88.6	74.6	79.2	87.0	82.0	86.0	65.1	71.5	64.0
ALTITUDE 9,100 m. LOW RPM.													
Mean		1517.5	75.9	100.2	82.9	77.4	76.6	78.2	86.4	82.6	74.5	69.6	69.1
Standard Deviation		0.00	0.00	0.81	3.20	2.13	1.02	1.06	1.88	0.51	2.71	0.52	
Standard Deviation		0.00	0.00	-0.99		-4.35	-1.33	-1.41	-3.39	-0.58	-8.81	-0.59	
Maximum		1517.5	75.9	101.0	86.4	79.7	77.7	79.2	88.3	83.1	77.0	70.1	69.1
Minimum		1517.5	75.9	99.2	75.6	74.1	75.6	76.7	83.1	82.0	63.1	69.0	69.1

CABIN MICROPHONE 4 : PORT & STARBOARD ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 4,600 m. LOW RPM. All Phase Settings													
Mean		1530.6	76.5	105.9	100.6	86.1	85.8	85.6	79.1	75.6	76.4	68.9	71.9
Standard Deviation		1.13	0.06	1.94	1.76	0.98	2.52	1.39	2.22	1.77	2.27	1.07	1.45
Standard Deviation		1.13	0.06	-3.58	-3.01	-1.26	-6.67	-2.06	-4.77	-3.04	-5.03	-1.42	-2.18
Upper 90% Conf.Limit		1531.21	76.56	107.02	101.56	86.60	87.31	86.42	80.41	76.73	77.73	70.14	73.15
Lower 90% Conf.Limit		1530.04	76.50	104.42	99.26	85.46	83.56	84.69	77.28	74.12	74.31	67.17	70.23
Maximum		1532.5	76.6	109.1	102.6	87.5	89.6	87.5	82.9	78.4	80.6		74.0
Minimum		1530.0	76.5	100.0	95.0	84.2	75.9	81.0	72.3	72.6	70.6		69.5
ALTITUDE 4,600 m. LOW RPM. (1) 9 o'clock + 3 o'clock													
Mean		1530.8	76.5	105.6	102.1	86.3	86.0	85.7	79.4	75.7	77.6	70.1	70.2
Standard Deviation		1.29	0.07	1.08	0.33	1.01	2.37	1.33	2.25	1.56	2.05	0.00	0.55
Standard Deviation		1.29	0.07	-1.44	-0.35	-1.32	-5.63	-1.93	-4.94	-2.47	-4.03	0.00	-0.63
Maximum		1532.5	76.6	106.8	102.6	87.5	89.5	87.5	82.9	78.0	80.6		70.6
Minimum		1530.0	76.5	102.8	101.8	84.6	80.6	84.2	74.5	73.3	71.1		69.5
ALTITUDE 4,600 m. LOW RPM. (2) 11 o'clock													
Mean		1530.8	76.5	101.7	95.8	84.8	83.1	84.3	78.6	74.2	74.5	68.8	72.9
Standard Deviation		1.44	0.08	1.67	0.59	0.63	3.59	1.94	2.56	1.54	0.53	0.94	0.00
Standard Deviation		1.44	0.08	-2.76	-0.69	-0.74		-3.60	-7.09	-2.41	-0.60	-1.20	0.00
Maximum		1532.5	76.6	103.6	96.2	85.5	87.1	86.3	81.2	75.3	74.9	69.5	72.9
Minimum		1530.0	76.5	100.0	95.0	84.2	75.9	81.0	72.3	72.6	74.1	68.0	72.9
ALTITUDE 4,600 m. LOW RPM. (3) 1 o'clock													
Mean		1530.0	76.5	108.3	99.7	86.5	87.3	86.5	79.0	76.4	74.1	67.5	73.3
Standard Deviation		0.00	0.00	0.70	1.23	0.40	2.30	0.96	2.50	2.56	1.73	0.00	1.00
Standard Deviation		0.00	0.00	-0.84	-1.71	-0.45	-5.21	-1.24	-6.54	-7.06	-2.93	0.00	-1.29
Maximum		1530.0	76.5	109.1	100.4	87.0	89.6	87.5	81.5	78.4	75.5	67.5	74.0
Minimum		1530.0	76.5	107.6	97.6	86.2	82.3	85.3	72.3	72.8	70.6	67.5	72.4
ALTITUDE 9,100 m. LOW RPM. All Phase Settings													
Mean		1530.8	76.5	102.0	92.5	81.4	81.2	83.4	89.9	85.5	77.3	77.8	73.3
Standard Deviation		5.47	0.27	2.26	2.15	1.93	1.97	2.12	2.23	1.02	1.58	1.38	1.82
Standard Deviation		5.47	0.27	-4.99	-4.44	-3.54	-3.70	-4.32	-4.80	-1.33	-2.51	-2.03	-3.21
Upper 90% Conf.Limit		1532.50	76.63	103.27	93.72	82.50	82.32	84.60	91.19	86.08	78.23	78.56	74.33
Lower 90% Conf.Limit		1532.50	76.63	100.06	90.73	79.91	79.65	81.66	88.04	84.88	76.22	76.85	71.92
Maximum		1540.0	77.0	105.3	96.4	84.0	84.2	87.2	93.3	86.9	80.1	80.0	76.2
Minimum		1525.0	76.3	88.2	78.8	74.1	72.1	79.3	84.1	82.4	75.0	74.4	65.1
ALTITUDE 9,100 m. LOW RPM. (1) 9 o'clock + 3 o'clock													
Mean		1530.8	76.5	91.4	91.7	83.1	78.5	85.3	87.3	85.7	76.5	78.1	74.2
Standard Deviation		5.77	0.29	2.02	1.71	0.30	1.33	1.88	1.41	0.56	1.52	0.84	1.20
Standard Deviation		5.77	0.29	-3.91	-2.85	-0.33	-1.92	-3.38	-2.10	-0.64	-2.35	-1.04	-1.66
Maximum		1537.5	76.9	93.6	93.5	83.3	79.5	87.2	88.3	86.2	78.2	78.9	75.2
Minimum		1527.5	76.4	88.2	89.1	82.7	76.2	81.9	84.8	85.0	75.0	77.0	72.3
ALTITUDE 9,100 m. LOW RPM. (2) 11 o'clock													
Mean		1533.1	76.7	103.9	94.7	81.0	81.7	82.6	91.2	86.1	77.4	77.5	73.4
Standard Deviation		6.57	0.33	1.01	1.20	2.55	2.33	1.78	1.89	0.71	1.70	1.94	2.33
Standard Deviation		6.57	0.33	-1.32	-1.66	-6.93	-5.40	-3.06	-3.44	-0.85	-2.82	-3.61	-5.37
Maximum		1540.0	77.0	105.3	96.4	84.0	84.2	84.7	92.7	86.9	79.5	80.0	76.2
Minimum		1527.5	76.4	102.9	93.5	74.5	72.1	79.3	84.1	85.0	75.3	74.4	67.9
ALTITUDE 9,100 m. LOW RPM. (3) 1 o'clock													
Mean		1529.0	76.5	102.3	89.9	80.4	81.9	82.4	89.8	84.9	77.7	77.8	72.5
Standard Deviation		4.87	0.24	1.49	1.88	2.04	1.34	2.19	2.38	1.37	1.67	1.38	1.84
Standard Deviation		4.87	0.24	-2.29	-3.39	-3.97	-1.95	-4.64	-5.70	-2.02	-2.75	-2.03	-3.24
Maximum		1537.5	76.9	104.6	91.6	83.0	83.5	85.7	93.3	86.4	80.1	80.0	74.6
Minimum		1525.0	76.3	99.9	78.8	74.1	79.3	80.1	84.8	82.4	75.2	76.3	65.1

CABIN MICROPHONE 5 : PORT ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential													
Mean		1575.0	78.8	99.3	104.0	94.3	83.2	76.3	75.8	69.9	67.2	71.2	64.3
Standard Deviation		4.33	0.21	0.77	0.64	0.49	2.42	1.94	2.86	0.88		0.71	
Standard Deviation		4.33	0.21	-0.93	-0.75	-0.56	-5.93	-3.58	-11.55	-1.11		-0.85	
Maximum		1580.0	79.0	100.0	104.7	94.8	85.9	78.4	78.9	70.9	67.2	71.7	64.3
Minimum		1572.5	78.6	98.3	103.5	93.8	80.1	73.7	69.0	69.2	67.2	70.6	64.3
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
Mean		1572.5	78.6	99.6	105.6	90.5	87.1	87.4	88.7	81.1	76.1	75.3	73.6
Standard Deviation		0.00	0.00	1.45	1.08	2.11	1.38	3.07	0.69	1.32	1.76	1.89	
Standard Deviation		0.00	0.00	-2.20	-1.43	-4.27	-2.04		-0.82	-1.91	-3.01	-3.41	
Maximum		1572.5	78.6	101.2	106.8	92.8	88.6	90.8	89.4	82.2	77.7	77.3	73.6
Minimum		1572.5	78.6	98.1	104.4	87.4	85.3	81.8	87.9	78.9	72.7	72.5	73.6
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
Mean		1525.0	76.3	92.2	103.9	95.8	80.8	74.3	74.7	66.5			
Standard Deviation		0.00	0.00	1.07	0.83	1.85	0.56	2.54	1.78	0.53			
Standard Deviation		0.00	0.00	-1.42	-1.02	-3.30	-0.64	-6.90	-3.08	-0.60			
Maximum		1525.0	76.3	93.1	104.8	97.7	81.3	77.1	75.9	66.9			
Minimum		1525.0	76.3	90.6	103.2	92.7	80.1	70.5	70.9	66.1			
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
Mean		1525.8	76.3	87.0	103.4	93.9	76.5	85.4	84.0	80.4	73.0		
Standard Deviation		1.44	0.08	2.79	0.82	1.19	1.32	1.09	2.55	2.44			
Standard Deviation		1.44	0.08	-10.13	-1.01	-1.65	-1.91	-1.47	-6.97	-6.08			
Maximum		1527.5	76.4	90.0	104.0	95.2	77.8	86.4	86.8	82.1	73.0		
Minimum		1525.0	76.3	80.0	102.2	92.7	74.6	83.8	80.5	71.6	73.0		
ALTITUDE 4,600 m. HIGH RPM.													
Mean		1573.3	78.7	96.6	105.6	91.4	89.9	91.2	89.5	81.9		70.3	72.7
Standard Deviation		1.44	0.07	1.80	0.35	2.08	1.35	0.58	1.75	1.97		2.33	1.84
Standard Deviation		1.44	0.07	-3.14	-0.39	-4.12	-1.98	-0.66	-2.99	-3.70		-5.39	-3.25
Maximum		1575.0	78.8	98.2	105.9	93.6	91.4	91.6	91.0	84.1		72.1	74.1
Minimum		1572.5	78.6	93.0	105.2	88.1	88.6	90.4	86.0	80.1		67.3	70.7
ALTITUDE 4,600 m. LOW RPM.													
Mean		1525.0	76.3	86.9	104.5	93.2	82.7	82.6	85.3	75.5	74.4		
Standard Deviation		0.00	0.00	1.81	0.69	1.53	0.43	1.36	2.62	0.73	1.20		
Standard Deviation		0.00	0.00	-3.15	-0.83	-2.39	-0.47	-1.99	-7.64	-0.88	-1.66		
Maximum		1525.0	76.3	88.8	105.2	94.8	83.2	83.7	87.9	76.3	75.7		
Minimum		1525.0	76.3	84.3	103.7	91.0	82.4	80.3	77.8	74.7	73.0		
ALTITUDE 9,100 m. HIGH RPM.													
Mean		1570.8	78.5	89.3	102.3	81.5	80.5	86.0	91.3	78.2	68.3	79.3	68.5
Standard Deviation		1.44	0.08	1.20	0.81	1.29	1.29	1.06	1.59	2.64	1.37	1.51	1.40
Standard Deviation		1.44	0.08	-1.66	-0.99	-1.84	-1.85	-1.41	-2.52	-7.91	-2.01	-2.34	-2.08
Maximum		1572.5	78.6	90.1	102.8	82.3	81.6	86.9	93.0	81.1	69.8	80.4	69.5
Minimum		1570.0	78.5	87.3	101.1	79.3	78.4	84.4	89.1	73.2	66.6	76.5	67.1
ALTITUDE 9,100 m. LOW RPM.													
Mean		1521.7	76.1	89.0	97.7	84.9	73.9	85.3	88.1	79.8	71.5		62.4
Standard Deviation		1.44	0.08	1.12	1.89	2.67	2.25	0.85	0.68	2.01	3.20		
Standard Deviation		1.44	0.08	-1.51	-3.43	-8.23	-4.91	-1.06	-0.81	-3.85			
Maximum		1522.5	76.1	90.1	99.2	87.9	76.2	86.0	88.6	81.8	75.0		62.4
Minimum		1520.0	76.0	87.5	93.5	81.9	69.4	84.1	87.2	76.0	66.3		62.4

CABIN MICROPHONE 5 : STARBOARD ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential													
	Mean	1570.8	78.5	99.0	99.2	83.4	81.2	81.2	78.1	70.2		67.4	
Standard Deviation		1.44	0.08	0.72	0.48	1.22	1.16	1.85	2.13	1.05			
Standard Deviation		1.44	0.08	-0.87	-0.54	-1.70	-1.59	-3.29	-4.35	-1.39			
	Maximum	1572.5	78.6	99.6	99.7	84.8	82.2	83.2	80.2	71.0		67.4	
	Minimum	1570.0	78.5	98.0	98.7	82.2	79.4	78.5	73.7	69.3		67.4	
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
	Mean	1570.8	78.5	95.1	102.4	90.2	86.6	78.6	79.8	72.3			
Standard Deviation		1.44	0.08	0.29	0.83	0.79	0.72	1.80	3.86	1.04			
Standard Deviation		1.44	0.08	-0.31	-1.03	-0.96	-0.86	-3.12		-1.38			
	Maximum	1572.5	78.6	95.4	103.0	91.0	87.4	80.1	84.0	73.4			
	Minimum	1570.0	78.5	94.8	101.2	89.3	86.1	74.9	71.6	71.1			
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
	Mean	1521.7	76.1	94.2	99.1	86.6	72.0	71.8	71.4	68.1			64.2
Standard Deviation		2.89	0.14	1.44	1.29	3.37	1.96	1.24	1.80				
Standard Deviation		2.89	0.14	-2.16	-1.83		-3.67	-1.75	-3.12				
	Maximum	1525.0	76.3	95.5	100.5	90.3	74.0	72.6	72.7	68.1			64.2
	Minimum	1520.0	76.0	91.8	97.5	81.4	68.4	69.7	69.4	68.1			64.2
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
	Mean	1518.3	75.9	93.1	100.9	88.3	80.5	83.8	71.3				
Standard Deviation		1.44	0.07	0.76	1.03	1.18	1.47	1.41					
Standard Deviation		1.44	0.07	-0.93	-1.35	-1.62	-2.23	-2.09					
	Maximum	1520.0	76.0	93.8	102.1	89.1	82.2	85.4	71.3				
	Minimum	1517.5	75.9	92.1	100.2	86.4	79.4	82.4	71.3				
ALTITUDE 4,600 m. HIGH RPM.													
	Mean	1571.7	78.6	93.9	103.6	88.6	87.9	89.3		75.5	72.7	70.4	67.7
Standard Deviation		1.44	0.08	1.59	0.72	1.32	1.04	1.93		2.16		0.40	
Standard Deviation		1.44	0.08	-2.54	-0.86	-1.91	-1.37	-3.57		-4.51		-0.45	
	Maximum	1572.5	78.6	94.9	104.4	89.9	88.6	91.3		77.9	72.7	70.7	67.7
	Minimum	1570.0	78.5	90.8	102.9	86.7	86.3	85.9		72.8	72.7	70.1	67.7
ALTITUDE 4,600 m. LOW RPM.													
	Mean	1520.0	76.0	90.1	101.2	88.3	83.4	83.1	76.7				
Standard Deviation		0.00	0.00	0.90	0.61	0.25	0.21	2.53	1.60				
Standard Deviation		0.00	0.00	-1.14	-0.71	-0.27	-0.22	-6.83	-2.57				
	Maximum	1520.0	76.0	91.1	101.6	88.5	83.6	85.8	78.5				
	Minimum	1520.0	76.0	89.4	100.4	88.0	83.2	77.5	75.3				
ALTITUDE 9,100 m. HIGH RPM.													
	Mean	1572.5	78.6	89.4	102.2	91.0	87.5	91.3	89.3	83.0	75.3	81.4	73.2
Standard Deviation		2.50	0.13	1.07	0.99	0.30	1.32	1.28	3.12	2.48	1.40	0.81	1.88
Standard Deviation		2.50	0.13	-1.43	-1.28	-0.32	-1.91	-1.82		-6.41	-2.08	-0.99	-3.38
	Maximum	1575.0	78.8	90.2	103.3	91.3	88.7	92.6	92.7	85.1	76.3	82.3	75.2
	Minimum	1570.0	78.5	87.7	101.3	90.7	85.4	89.5	84.0	74.3	73.9	80.7	70.6
ALTITUDE 9,100 m. LOW RPM.													
	Mean	1517.5	75.9	93.7	95.4	86.4	82.6	82.6	88.4	72.2	76.1	73.3	68.6
Standard Deviation		0.00	0.00	0.66	1.39	1.26	0.79	1.76	1.27	2.76	1.43	2.05	1.82
Standard Deviation		0.00	0.00	-0.77	-2.05	-1.78	-0.96	-3.02	-1.81	-9.47	-2.14	-4.01	-3.20
	Maximum	1517.5	75.9	94.4	96.9	87.5	83.1	84.2	89.7	75.0	77.5	75.6	70.6
	Minimum	1517.5	75.9	93.0	93.7	84.4	81.5	79.2	86.6	63.8	73.9	71.3	66.8

CABIN MICROPHONE 5 : PORT & STARBOARD ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 4,600 m. LOW RPM. All Phase Settings													
Mean		1530.8	76.5	91.3	107.0	93.9	87.1	87.8	84.8	76.8	77.3	72.1	70.1
Standard Deviation		1.23	0.06	2.38	2.14	2.47	2.01	1.60	2.58	2.03	1.50	2.45	1.66
Standard Deviation		1.23	0.06	-5.70	-4.39	-6.30	-3.87	-2.56	-7.29	-3.93	-2.32	-6.14	-2.72
Upper 90% Conf.Limit		1531.47	76.58	92.65	108.26	95.39	88.25	88.67	86.29	78.11	78.12	74.85	71.33
Lower 90% Conf.Limit		1530.20	76.51	89.18	105.28	91.74	85.51	86.63	82.39	74.98	76.23	62.49	68.23
Maximum		1532.5	76.6	95.3	109.1	98.1	89.9	89.9	88.9	80.1	80.5	75.3	72.2
Minimum		1530.0	76.5	77.2	92.4	85.5	80.4	80.4	74.5	69.0	74.0	67.8	66.2
ALTITUDE 4,600 m. LOW RPM. (1) 9 o'clock + 3 o'clock													
Mean		1530.8	76.5	92.1	108.8	95.1	85.9	87.9	84.4	76.6	76.7	70.6	70.0
Standard Deviation		1.29	0.07	2.06	0.36	2.25	2.68	1.67	2.16	2.01	1.25	0.00	1.82
Standard Deviation		1.29	0.07	-4.07	-0.39	-4.96	-8.32	-2.75	-4.50	-3.87	-1.76	0.00	-3.20
Maximum		1532.5	76.6	95.3	109.1	98.1	89.7	89.9	87.4	78.6	78.3	70.6	72.2
Minimum		1530.0	76.5	88.1	108.1	87.5	80.4	84.4	74.5	69.0	74.0	70.6	66.2
ALTITUDE 4,600 m. LOW RPM. (2) 11 o'clock													
Mean		1531.7	76.6	83.0	95.1	91.9	88.1	88.7	85.6	77.2	76.3	69.8	
Standard Deviation		1.44	0.08	2.19	1.87	2.83	1.65	0.73	3.07	2.59	0.51	1.84	
Standard Deviation		1.44	0.08	-4.61	-3.34	-10.93	-2.70	-0.87		-7.36	-0.58	-3.25	
Maximum		1532.5	76.6	84.8	97.1	94.9	89.9	89.4	88.9	80.1	76.8	71.2	
Minimum		1530.0	76.5	77.2	92.4	85.5	86.4	87.8	77.3	73.4	75.7	67.8	
ALTITUDE 4,600 m. LOW RPM. (3) 1 o'clock													
Mean		1530.0	76.5	92.7	106.5	92.7	88.0	86.2	84.5	76.7	78.8	75.3	70.2
Standard Deviation		0.00	0.00	0.72	0.77	2.39	1.31	2.25	3.26	1.88	1.49	0.00	1.67
Standard Deviation		0.00	0.00	-0.87	-0.94	-5.72	-1.89	-4.92		-3.38	-2.29	0.00	-2.76
Maximum		1530.0	76.5	93.4	107.4	95.2	89.4	88.2	88.1	78.1	80.5	75.3	71.4
Minimum		1530.0	76.5	91.8	106.0	87.6	86.4	80.4	78.4	74.6	77.4	75.3	68.4
ALTITUDE 9,100 m. LOW RPM. All Phase Settings													
Mean		1530.8	76.5	96.5	102.0	89.2	84.2	89.1	91.7	81.0	76.6	80.0	73.4
Standard Deviation		5.47	0.27	2.23	2.45	1.81	1.46	2.51	2.48	1.44	1.95	1.48	2.59
Standard Deviation		5.47	0.27	-4.81	-6.17	-3.15	-2.20	-6.63	-6.36	-2.18	-3.63	-2.25	-7.39
Upper 90% Conf.Limit		1532.50	76.63	97.75	103.45	90.24	85.03	90.54	93.19	81.79	77.69	80.80	74.91
Lower 90% Conf.Limit		1532.50	76.63	94.61	99.84	87.85	83.21	86.80	89.52	79.99	75.06	78.95	70.98
Maximum		1540.0	77.0	99.4	105.0	92.9	86.3	93.9	96.8	83.0	79.9	82.9	78.4
Minimum		1525.0	76.3	88.0	90.1	86.8	80.8	83.0	87.1	76.1	72.3	77.9	69.2
ALTITUDE 9,100 m. LOW RPM. (1) 9 o'clock + 3 o'clock													
Mean		1530.8	76.5	97.9	104.5	87.0	83.9	86.4	89.8	80.6	76.8	80.5	75.0
Standard Deviation		5.77	0.29	0.56	0.27	0.34	1.29	1.30	1.55	1.72	2.85	2.18	3.07
Standard Deviation		5.77	0.29	-0.64	-0.29	-0.37	-1.84	-1.87	-2.43	-2.89	-11.28	-4.60	
Maximum		1537.5	76.9	98.5	104.7	87.4	85.2	87.4	91.2	82.5	79.9	82.9	78.4
Minimum		1527.5	76.4	97.3	104.2	86.8	82.1	84.2	87.1	78.3	72.3	78.3	70.3
ALTITUDE 9,100 m. LOW RPM. (2) 11 o'clock													
Mean		1533.1	76.7	89.3	103.4	89.0	85.4	91.1	93.4	81.3	75.5	78.9	73.6
Standard Deviation		6.57	0.33	0.92	1.18	1.45	0.99	2.41	2.62	0.38	1.25	0.76	1.91
Standard Deviation		6.57	0.33	-1.17	-1.62	-2.19	-1.29	-5.88	-7.60	-0.42	-1.76	-0.92	-3.51
Maximum		1540.0	77.0	90.5	105.0	90.6	86.3	93.9	96.8	81.9	77.0	79.8	76.2
Minimum		1527.5	76.4	88.0	102.0	87.0	83.4	83.0	89.2	81.1	73.8	77.9	71.4
ALTITUDE 9,100 m. LOW RPM. (3) 1 o'clock													
Mean		1529.0	76.5	97.9	95.2	90.3	83.3	88.1	91.0	80.9	77.2	80.4	71.7
Standard Deviation		4.87	0.24	1.30	2.65	1.77	1.76	1.23	1.65	1.95	1.68	1.09	2.05
Standard Deviation		4.87	0.24	-1.86	-8.00	-3.04	-2.99	-1.73	-2.68	-3.63	-2.77	-1.46	-4.02
Maximum		1537.5	76.9	99.4	98.7	92.9	85.6	89.6	93.1	83.0	79.7	81.9	74.8
Minimum		1525.0	76.3	94.6	90.1	87.4	80.8	85.9	88.4	76.1	74.7	79.1	69.2

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CABIN MICROPHONE 6 : PORT ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	Harmonic Level, dB re 20 micro Pa 1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential													
Mean		1575.0	78.8	108.4	98.4	86.1	80.2	83.2	70.9	71.2		69.7	
Standard Deviation		4.33	0.21	0.61	0.98	1.43	1.81	1.08	1.95	0.40			
Standard Deviation		4.33	0.21	-0.71	-1.27	-2.14	-3.15	-1.45	-3.65	-0.45			
Maximum		1580.0	79.0	109.0	99.5	87.6	82.2	84.0	72.4	71.5		69.7	
Minimum		1572.5	78.6	107.7	97.6	84.1	78.2	81.5	68.7	70.7		69.7	
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
Mean		1572.5	78.6	109.7	99.0	84.2	87.8	91.4	81.9	78.0	75.4		
Standard Deviation		0.00	0.00	0.67	0.81	1.64	0.97	2.22	1.04	2.45	2.69		
Standard Deviation		0.00	0.00	-0.79	-0.99	-2.67	-1.25	-4.76	-1.37	-6.16	-8.44		
Maximum		1572.5	78.6	110.5	99.5	85.6	88.9	93.8	83.1	79.9	77.5		
Minimum		1572.5	78.6	109.2	97.8	81.1	86.9	87.9	81.0	74.7	71.4		
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
Mean		1525.0	76.3	103.4	95.3	87.9	83.0	77.2	72.0	73.0			
Standard Deviation		0.00	0.00	0.69	0.99	1.94	2.29	2.33	1.43	0.27			
Standard Deviation		0.00	0.00	-0.82	-1.29	-3.59	-5.14	-5.39	-2.14	-0.29			
Maximum		1525.0	76.3	104.0	96.2	89.3	85.2	79.0	73.5	73.2			
Minimum		1525.0	76.3	102.5	93.9	83.4	77.3	74.2	70.0	72.8			
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
Mean		1525.8	76.3	103.9	94.4	76.6	82.0	83.0	78.3	76.5	72.2		
Standard Deviation		1.44	0.08	0.59	1.30	2.24	2.79	1.17	2.69	0.77	0.99		
Standard Deviation		1.44	0.08	-0.69	-1.87	-4.88	-10.13	-1.60	-8.49	-0.94	-1.29		
Maximum		1527.5	76.4	104.3	95.4	79.1	85.0	84.3	81.3	77.1	73.2		
Minimum		1525.0	76.3	103.1	92.2	73.9	75.0	81.7	74.5	75.9	70.9		
ALTITUDE 4,600 m. HIGH RPM.													
Mean		1573.3	78.7	109.1	99.1	85.3	87.3	91.1	77.3	74.6	72.4	71.0	
Standard Deviation		1.44	0.07	0.89	1.41	1.58	1.42	0.72	1.59	1.98	1.67		
Standard Deviation		1.44	0.07	-1.12	-2.11	-2.50	-2.11	-0.87	-2.52	-3.76	-2.76		
Maximum		1575.0	78.8	109.8	100.6	86.9	88.4	91.8	78.5	75.9	73.6	71.0	
Minimum		1572.5	78.6	107.8	97.2	82.8	84.8	90.2	75.7	69.8	70.6	71.0	
ALTITUDE 4,600 m. LOW RPM.													
Mean		1525.0	76.3	102.4	95.2	81.5	86.5	83.5	76.3	74.7	76.6		69.9
Standard Deviation		0.00	0.00	0.51	0.40	3.03	0.47	1.03	2.12	0.21			
Standard Deviation		0.00	0.00	-0.58	-0.45		-0.53	-1.36	-4.30	-0.22			
Maximum		1525.0	76.3	103.0	95.5	84.8	86.9	84.4	78.5	74.8	76.6		69.9
Minimum		1525.0	76.3	102.0	94.7	73.6	85.9	82.0	72.4	74.5	76.6		69.9
ALTITUDE 9,100 m. HIGH RPM.													
Mean		1570.8	78.5	102.4	93.6	82.4	84.4	81.5	84.5	75.2	75.9	72.0	66.8
Standard Deviation		1.44	0.08	0.66	1.07	1.47	1.40	2.06	1.56	1.60	2.25	1.89	1.00
Standard Deviation		1.44	0.08	-0.77	-1.42	-2.25	-2.08	-4.06	-2.45	-2.57	-4.92	-3.43	-1.29
Maximum		1572.5	78.6	103.1	94.8	83.8	85.8	83.2	85.7	77.0	78.3	73.5	67.5
Minimum		1570.0	78.5	101.7	92.6	80.0	82.4	76.5	81.6	73.8	71.8	67.8	65.9
ALTITUDE 9,100 m. LOW RPM.													
Mean		1521.7	76.1	96.9	91.4	79.0	83.9	75.6	88.3	77.4	72.6		63.9
Standard Deviation		1.44	0.08	0.39	0.48	3.23	1.94	2.89	1.75	1.67	2.03		0.71
Standard Deviation		1.44	0.08	-0.43	-0.54		-3.60	-12.69	-2.97	-2.75	-3.94		-0.85
Maximum		1522.5	76.1	97.3	91.9	82.5	85.9	78.8	89.9	79.1	74.6		64.4
Minimum		1520.0	76.0	96.5	91.0	72.1	80.4	70.2	85.0	74.8	68.6		63.3

CABIN MICROPHONE 6 : STARBOARD ENGINE COMPONENTS

Test Condition	Flight Number	RPM	BPF Hz	1	2	3	4	5	6	7	8	9	10
ALTITUDE 3,000 m. HIGH RPM. Zero Pressure Differential													
	Mean	1570.8	78.5	103.0	95.0	88.7	77.1	78.5	71.0				
Standard Deviation		1.44	0.08	0.81	1.13	1.34	2.31	2.35					
Standard Deviation		1.44	0.08	-0.99	-1.53	-1.95	-5.25	-5.50					
	Maximum	1572.5	78.6	103.9	96.0	90.2	78.8	80.9	71.0				
	Minimum	1570.0	78.5	102.3	93.3	87.3	70.0	73.1	71.0				
ALTITUDE 3,000 m. HIGH RPM. Cabin Pressurized													
	Mean	1570.8	78.5	103.4	96.5	77.6	78.1	77.0	77.5				
Standard Deviation		1.44	0.08	1.20	2.63	2.35	2.37	1.61	1.78				
Standard Deviation		1.44	0.08	-1.66	-7.80	-5.47	-5.63	-2.59	-3.06				
	Maximum	1572.5	78.6	104.4	99.4	80.2	80.7	78.8	79.0				
	Minimum	1570.0	78.5	101.5	92.4	74.5	74.4	75.3	73.9				
ALTITUDE 3,000 m. LOW RPM. Zero Pressure Differential													
	Mean	1521.7	76.1	100.2	90.0	84.4	81.1	74.8	67.4	68.7			
Standard Deviation		2.89	0.14	0.34	1.61	2.65	1.19	1.46					
Standard Deviation		2.89	0.14	-0.37	-2.59	-7.97	-1.64	-2.22					
	Maximum	1525.0	76.3	100.5	91.8	86.5	82.3	76.1	67.4	68.7			
	Minimum	1520.0	76.0	99.8	88.3	70.7	79.5	72.3	67.4	68.7			
ALTITUDE 3,000 m. LOW RPM. Cabin Pressurized													
	Mean	1518.3	75.9	101.0	96.2	77.0	74.8	81.6	74.7	72.9			72.6
Standard Deviation		1.44	0.07	0.40	0.78	1.85	1.53	1.31	1.05				
Standard Deviation		1.44	0.07	-0.45	-0.95	-3.28	-2.38	-1.89	-1.39				
	Maximum	1520.0	76.0	101.3	96.8	78.8	76.2	83.0	75.5	72.9			72.6
	Minimum	1517.5	75.9	100.5	95.1	73.5	72.2	80.0	73.8	72.9			72.6
ALTITUDE 4,600 m. HIGH RPM.													
	Mean	1571.7	78.6	105.3	92.2	79.3	82.6	75.1	79.0	75.7	74.9		
Standard Deviation		1.44	0.08	1.26	2.03	1.16	2.41	3.06	1.68				
Standard Deviation		1.44	0.08	-1.78	-3.92	-1.59	-5.85		-2.76				
	Maximum	1572.5	78.6	106.6	94.2	80.4	85.1	78.5	80.2	75.7	74.9		
	Minimum	1570.0	78.5	103.6	88.1	77.6	77.6	69.7	75.6	75.7	74.9		
ALTITUDE 4,600 m. LOW RPM.													
	Mean	1520.0	76.0	102.3	97.5	79.2	82.4	72.2					
Standard Deviation		0.00	0.00	1.14	1.50	0.65	1.67						
Standard Deviation		0.00	0.00	-1.56	-2.30	-0.76	-2.74						
	Maximum	1520.0	76.0	103.6	98.9	79.9	83.5	72.2					
	Minimum	1520.0	76.0	101.2	95.0	78.5	79.0	72.2					
ALTITUDE 9,100 m. HIGH RPM.													
	Mean	1572.5	78.6	99.1	92.9	88.1	77.5	82.7	85.5	78.6	77.1	73.2	65.9
Standard Deviation		2.50	0.13	0.61	1.78	0.84	2.20	1.25	2.30	1.62	2.00	2.61	1.51
Standard Deviation		2.50	0.13	-0.72	-3.06	-1.04	-4.69	-1.76	-5.23	-2.61	-3.81	-7.50	-2.33
	Maximum	1575.0	78.8	99.8	94.6	89.0	79.9	84.1	87.6	79.9	79.0	76.1	67.6
	Minimum	1570.0	78.5	98.7	89.6	87.2	74.8	81.4	79.3	75.5	73.0	70.1	64.2
ALTITUDE 9,100 m. LOW RPM.													
	Mean	1517.5	75.9	95.1	93.7	83.4	69.7	74.1	85.7	78.2	76.8	75.1	68.1
Standard Deviation		0.00	0.00	1.08	0.43	1.02	2.60	1.57	2.52	0.74	1.93	1.75	0.60
Standard Deviation		0.00	0.00	-1.45	-0.48	-1.34	-7.44	-2.50	-6.66	-0.89	-3.58	-2.99	-0.70
	Maximum	1517.5	75.9	95.9	94.2	84.1	72.6	75.3	88.4	78.8	78.6	76.5	68.6
	Minimum	1517.5	75.9	93.4	93.3	81.8	66.2	71.1	80.7	77.2	72.9	71.5	67.3

Harmonic Level, dB re 20 micro Pa (columns 1–10)

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ORIGINAL PAGE IS
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CABIN MICROPHONE 6 : PORT & STARBOARD ENGINE COMPONENTS

Test Condition | Flight Number	RPM	BPF Hz	1	2	3	4	5	6	7	8	9	10
			Harmonic Level, dB re 20 micro Pa									
ALTITUDE 4,600 m. LOW RPM. All Phase Settings												
Mean	1530.6	76.5	105.8	99.4	80.6	86.6	85.2	79.3	76.5	75.9	74.0	71.8
Standard Deviation	1.13	0.06	2.53	2.16	2.42	1.45	1.46	2.53	2.92	1.94	1.38	1.54
Standard Deviation	1.13	0.06	-6.82	-4.51	-5.95	-2.20	-2.21	-6.81	-13.63	-3.58	-2.04	-2.40
Upper 90% Conf.Limit	1531.21	76.56	107.29	100.67	82.03	87.37	86.06	80.84	78.34	77.08	74.85	73.57
Lower 90% Conf.Limit	1530.04	76.50	103.50	97.64	78.49	85.56	84.23	76.82	73.30	74.15	72.93	68.79
Maximum	1532.5	76.6	109.7	102.2	84.5	88.4	87.0	84.1	82.1	79.8	76.5	73.9
Minimum	1530.0	76.5	91.9	88.7	68.4	79.8	80.9	73.3	71.6	72.7	70.0	70.4
ALTITUDE 4,600 m. LOW RPM. (1) 9 o'clock + 3 o'clock												
Mean	1530.4	76.5	105.5	101.2	79.9	87.1	85.1	80.6	75.4	76.1	73.9	70.4
Standard Deviation	1.02	0.05	1.32	0.94	2.21	0.87	1.57	2.25	2.33	0.25	0.86	0.00
Standard Deviation	1.02	0.05	-1.91	-1.21	-4.73	-1.09	-2.47	-4.94	-5.35	-0.27	-1.07	0.00
Maximum	1532.5	76.6	107.5	102.2	82.3	88.4	86.9	84.1	78.0	76.3	74.5	70.4
Minimum	1530.0	76.5	102.8	99.7	68.4	85.7	80.9	75.0	71.6	75.7	72.3	70.4
ALTITUDE 4,600 m. LOW RPM. (2) 11 o'clock												
Mean	1531.7	76.6	94.0	92.7	82.0	87.5	85.8	75.4	78.9	73.5	74.6	71.5
Standard Deviation	1.44	0.08	1.83	1.93	2.32	0.64	1.57	1.29	2.92	0.65	2.06	
Standard Deviation	1.44	0.08	-3.21	-3.56	-5.30	-0.75	-2.50	-1.85	-14.03	-0.76	-4.08	
Maximum	1532.5	76.6	96.0	94.5	84.5	88.1	87.0	76.5	82.1	74.1	76.5	71.5
Minimum	1530.0	76.5	91.9	88.7	78.1	86.7	82.8	73.3	73.0	72.7	70.0	71.5
ALTITUDE 4,600 m. LOW RPM. (3) 1 o'clock												
Mean	1530.0	76.5	108.9	98.1	80.2	83.4	84.9	78.5	74.6	77.2	73.3	73.9
Standard Deviation	0.00	0.00	0.73	1.39	3.24	2.43	1.52	1.80	1.42	2.37	0.14	
Standard Deviation	0.00	0.00	-0.88	-2.06		-5.99	-2.36	-3.12	-2.11	-5.60	-0.14	
Maximum	1530.0	76.5	109.7	99.4	83.8	86.1	86.5	79.8	76.0	79.8	73.4	73.9
Minimum	1530.0	76.5	108.1	95.9	75.3	79.8	82.7	76.5	72.5	74.4	73.2	73.9
ALTITUDE 9,100 m. LOW RPM. All Phase Settings												
Mean	1530.8	76.5	99.8	96.5	80.9	85.8	79.8	89.2	79.2	80.9	76.1	72.0
Standard Deviation	5.47	0.27	2.19	2.30	2.03	2.17	1.70	2.41	1.49	1.53	1.47	1.81
Standard Deviation	5.47	0.27	-4.61	-5.19	-3.94	-4.53	-2.84	-5.91	-2.29	-2.38	-2.24	-3.18
Upper 90% Conf.Limit	1532.50	76.63	101.04	97.88	82.06	87.07	80.78	90.63	80.00	81.80	76.97	73.04
Lower 90% Conf.Limit	1532.50	76.63	97.97	94.59	79.28	84.04	78.58	87.10	78.12	79.87	75.13	70.65
Maximum	1540.0	77.0	103.0	99.4	83.9	89.3	82.3	92.9	82.0	82.5	78.7	75.2
Minimum	1525.0	76.3	90.0	86.7	76.6	81.7	74.0	83.1	76.1	71.5	72.1	66.9
ALTITUDE 9,100 m. LOW RPM. (1) 9 o'clock + 3 o'clock												
Mean	1530.8	76.5	91.3	99.0	78.7	82.5	80.6	87.5	77.7	81.7	77.0	71.5
Standard Deviation	5.77	0.29	1.49	0.55	1.68	0.98	1.58	3.12	1.39	0.43	1.49	2.50
Standard Deviation	5.77	0.29	-2.29	-0.63	-2.77	-1.27	-2.50		-2.06	-0.48	-2.29	-6.53
Maximum	1537.5	76.9	93.0	99.4	80.6	83.6	82.3	90.9	79.2	82.2	78.7	74.2
Minimum	1527.5	76.4	90.0	98.3	76.9	81.7	78.5	83.1	76.1	81.3	75.6	66.9
ALTITUDE 9,100 m. LOW RPM. (2) 11 o'clock												
Mean	1533.1	76.7	101.0	97.8	80.0	86.4	79.3	90.0	80.3	79.9	77.2	72.7
Standard Deviation	6.57	0.33	1.28	0.20	2.38	1.84	2.06	2.55	1.49	2.51	0.10	2.03
Standard Deviation	6.57	0.33	-1.82	-0.21	-5.66	-3.25	-4.06	-6.92	-2.28	-6.60	-0.10	-3.94
Maximum	1540.0	77.0	102.7	98.1	83.2	88.2	81.9	92.9	82.0	82.2	77.3	75.2
Minimum	1527.5	76.4	99.3	97.6	76.6	83.2	75.1	84.3	78.0	71.5	77.1	69.7
ALTITUDE 9,100 m. LOW RPM. (3) 1 o'clock												
Mean	1529.0	76.5	100.7	90.7	82.3	86.6	79.7	89.4	78.9	81.1	74.3	71.7
Standard Deviation	4.87	0.24	1.54	2.83	1.54	2.13	1.75	2.18	1.01	1.24	1.34	1.17
Standard Deviation	4.87	0.24	-2.40	-10.81	-2.40	-4.36	-2.99	-4.59	-1.33	-1.74	-1.95	-1.61
Maximum	1537.5	76.9	103.0	94.8	83.9	89.3	81.8	92.3	80.1	82.5	76.1	73.0
Minimum	1525.0	76.3	98.0	86.7	80.0	82.8	74.0	84.8	77.1	79.1	72.1	69.8

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Final Report

16. Abstract

Acoustic measurements were made on the exterior and interior of a general aviation turboprop airplane during four flight tests. The test conditions were carefully controlled and repeated for each flight in order to determine data variability. For the first three flights the cabin was untreated and for the fourth flight the fuselage was treated with glass fiber batts. On the exterior, measured propeller harmonic sound pressure levels showed typical standard deviations of +1.4 dB, -2.3 dB, and turbulent boundary layer pressure levels, +1.2 dB, -1.6. Propeller harmonic levels in the cabin showed greater variability, with typical standard deviations of +2.0 dB, -4.2 dB. When interior sound pressure levels from different flights with different cabin treatments were used to evaluate insertion loss, the standard deviations were typically ± 6.5 dB. This is due in part to the variability of the sound pressure level measurements, but probably is also influenced by changes in the modal characteristics of the cabin. Recommendations are made for the planning and performance of future flight tests to measure interior noise of propeller-driven aircraft, either high-speed advanced turboprop or general aviation propellers.

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