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CONCORDE NOISE-INDUCED BUILDING VIBRATIONS

JOHN F. KENNEDY INTERNATIONAL AIRPORT

REPORT NUMBER 3

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National Aeronautics and
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By Staff-Langley Research Center*

SUMMARY

The NASA, in cooperation with the FAA, made measurements of noise-induced building vibrations in the vicinity of John F. Kennedy International Airport on January 18-19 and on February 3-5, 1978, as part of the Concorde monitoring program. The purpose of these studies was to expand the data base developed at Dulles International Airport during the early months of Concorde operations by obtaining aircraft noise and building vibration data on typical residential structures in the New York area. The outdoor/indoor noise levels and associated vibration levels resulting from aircraft and nonaircraft events were recorded at eight homesites and a school. In addition, limited subjective tests were conducted to examine the human detection/annoyance thresholds for building vibration and rattle caused by aircraft noise. A description of the test plan and procedures along with sample data were presented in reference 1. Window and wall response data recorded for Concorde and subsonic aircraft flights directly overhead were reported in reference 2. This report presents floor response data for these same direct overflights, building response data for sideline flights and building response to nonaircraft events. Also presented are subjective response data from the limited tests involving vibration detection thresholds.

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INTRODUCTION

Measurements of aircraft noise-induced building vibrations are being conducted by the NASA as part of the DOT/FAA monitoring program to assess the environmental impact of Concorde operations at JFK (refs. 1, 2, and 3). The purpose of this element of the monitoring program is to make a comparative assessment of the building response resulting from Concorde, subsonic aircraft, and nonaircraft events.

The approach being followed in the assessment of Concorde noise-induced building vibrations involves the following steps: (1) the measurement of the vibratory response of selected buildings; (2) the development of functional relationships ("signatures") between the vibration response of building elements and the outdoor and/or indoor noise levels associated with events of interest; and (3) the comparison of Concorde-induced response with the response associated with other aircraft as well as common domestic events and/or criteria. This approach was followed by NASA in making measurements in the vicinity of Dulles International Airport during the early months of Concorde operations. Noise and vibration measurements were made at Sully Plantation, an historic site located near Dulles, and at three homes in Montgomery County, Maryland, where residents had complained of building vibration. The results of these studies were published in references 4 through 7. The JFK studies are directed at expanding the data base developed at Dulles by obtaining aircraft noise and vibration data on typical residential structures for both takeoff and approach operations and, secondly, to explore in some detail human response to building vibration and rattle. This latter issue requires that the physical measurements be augmented by subjective tests to determine the level of noise and/or vibration required to produce perceptible vibration and rattle and to determine, if possible, the degree of annoyance associated with perceptible building response. The subjective tests are exploratory in nature since neither the way in which a person perceives vibration (for example, tactile, wholebody, visual) nor the dominant building stimulus elements (for example, floor, window, wall) have been studied in any detail for human response to building vibrations.

A description of the test plan and test procedures for acquiring both physical and subjective data, along with sample data recorded on a window at one test site, were presented in reference 1 to illustrate the data reduction/analysis procedures and to indicate preliminary findings in the JFK area.

Window and wall response data recorded for Concorde and subsonic aircraft flights directly overhead were reported in reference 2. This report presents floor response data for these same direct overflights, building response data for sideline flights, and building response to nonaircraft events. Also presented are subjective response data from the limited tests involving vibration detection thresholds.

TEST SITES

The test sites for the January and February studies were located in the communities of Cedarhurst, Inwood, Rosedale, and Belle Harbor which are shown on the map, figure 1. The approximate locations of the houses relative to the main runways at JFK are shown in figure 2. Test sites 1, 3, and 6 were monitored on January 18, 1978, during landing operations on runway 31R, whereas test sites 9, 10, and 11 were monitored on January 19, 1978, for Concorde landings on runway 31R and subsonic departure operations on runway 04R. Additional measurements were obtained at test site 11 on February 3, 1978, and at test sites 2 and 11 on February 4, 1978, during landing operations on 31R.

Test sites 4 and 5 were monitored on February 5, 1978, for Concorde landing and takeoff operations on runways 31R and 31L and for subsonic operations. In addition, several nonaircraft events were recorded at each house including walking, jogging in place, dropping a book, closing doors and windows, etc.

The houses were selected from homeowners who had volunteered to participate in this phase of the assessment program. The houses represent a range of construction typical of the neighborhoods surrounding the airport. The room selection in a particular house was based on information provided by the homeowner concerning maximum noise and/or vibration exposure to aircraft flyovers. Accelerometers typically were located on a window, a wall, and on the floor, and microphones were located both in the test room and outside the house. Plan-view sketches of the houses and instrumentation locations are given in reference 2.

DATA ACQUISITION AND PROCEDURES

Instrumentation

Measurements of both interior and exterior sound pressure levels were recorded with special low-frequency response microphones used for the interior measurements. Vibration data were obtained from piezoelectric crystal accelerometers mounted on the window and from more sensitive, but heavier, servo-accelerometers mounted on the wall and the floor. (The mass of the servo-accelerometers precluded their use on the windows.) The floor measurements consisted of the vertical and horizontal acceleration imparted to a 50 kg (110 lb) cement block which was placed in the center of the room to simulate the loading of a person. All data were recorded on analog FM tape for subsequent analysis.

Frequency Response and Calibration

Extensive pretest documentation of all items of the acquisition systems was performed to include frequency response, deviation linearities, gain accuracies, and dynamic range. Daily calibrations in the field consisted of pink noise (exhibiting flat 1/3-octave band spectrum level) insertion in all microphone channels, a fixed sine wave reference voltage insertion into the accelerometer channels as well as a 1 g static calibration of the servo-accelerometers, and a 250 Hz piston-phone acoustic calibration of the microphone systems during pretest and posttest periods. Frequency response of the acoustic channels was nominally ± 1 dB over the range 5 Hz to 10 kHz for the exterior measurement systems and 1.5 Hz to 10 kHz for the lower frequency interior measurement systems. The accelerometer channel frequency response extended from dc to approximately 1 kHz for the servoaccelerometers and from 3 Hz to in excess of 3 kHz for the piezoelectric type. Amplitude response for both systems was nominally ± 1/2 dB over the applicable frequency range.

Test Procedures

Aircraft spotters were located near each test house to identify aircraft as well as to control and coordinate data acquisition. Time code was recorded at each test house to provide a common time base for use in subsequent analysis of the data.

Subjective tests were conducted utilizing members of the NASA Concorde monitoring team and residents of a particular test site. The members of the monitoring team participated at each house whereas the resident subjects participated only at their own home. The subjective test sessions were approximately 1 hour in length and were scheduled to include one or more Concorde operations at each house although this was not always possible due to variations in Concorde schedules. The subject instructions, rating forms, and test procedures are described in reference 1.

Analysis Procedure

Two channels of noise data (inside and outside) and four channels of vibration data (window, wall, vertical floor, and horizontal floor) were recorded on FM magnetic tape and later played back into a multichannel, true rms logarithmic digital voltmeter. The voltmeter sampled the data and performed the analog-to-digital conversion and averaging tasks necessary to convert these signals to overall levels suitable for digital processing. Overall (unweighted) noise and vibration levels were obtained in this way for each flyover. The voltmeter was interfaced to a digital computer which, with its associated peripherals, corrected the raw data for changes in gain settings and calibration levels and provided a printed time history for each flyover, listing the overall levels of noise and vibration for each of the six data channels at 1/2-second intervals. These data were then recorded on digital magnetic tape for subsequent analysis.

RESULTS

Scope

Residents of over one hundred and fifty houses in the JFK area who had complained of aircraft noise and resulting building vibrations were asked if they would permit vibration measurements to be made in their homes. Permission to make noise and vibration measurements was granted by 15 of these residents, and data were acquired at nine of these sites. (Severe snowstorm activity which forced the closing of JFK airport, prohibited the acquisition of data at 6 of the 15 available test sites.) Noise-induced vibration measurements were made on such structural elements as walls, windows, and floors of the nine test sites, which consisted of eight residential structures and a high school. During the 4 days of testing, five of the nine test sites experienced overflights, with the remaining four sites experiencing noise from ground operations and fairly distant flight trajectories. Window and wall response data recorded for Concorde and subsonic aircraft flights directly overhead were reported in reference 2. This report presents floor response data for the same direct overflights and building response data for both sideline flights and nonaircraft events. Also presented are subjective response data from the limited tests involving vibration detection thresholds.

DISCUSSION OF RESULTS

Physical Test Results

Representative sideline "response signatures" are presented in the Appendix for windows and walls. These signatures illustrate how window and wall acceleration levels vary with outdoor noise level for sideline flybys. The relationship between sideline overall outside sound pressure level and window and wall acceleration level is essentially the same for Concorde as for CTOL. Compared with the overhead signatures in references 1 and 2, the sideline signatures appear to have the same slope but an ordinate intercept which is generally greater. The similar slopes suggest that the same change in vibration level results for a given change in aircraft noise level whether the noise is generated by an overhead flyover or a sideline flyover. The difference in ordinate intercept suggests that for a given unweighted noise level, sideline noise may produce somewhat higher vibration levels than overhead noise. The apparent enhanced efficiency of sideline noise in inducing building vibrations may be due to propagation path length effects; since the path lengths were much longer for the sideline flybys than for overhead flyovers reported here, atmospheric absorption losses, which attenuate the higher audiofrequencies, would cause the sideline noise to contain proportionally more low-frequency energy than overhead noise. This difference in response may also be due to the fact that noise from sideline flybys impacted the test structures at a more nearly perpendicular angle of incidence than the noise from overhead flyovers.

Window and wall vibration measurements have been emphasized in the Concorde monitoring/assessment efforts conducted to date because original concerns centered on the possibility of structural damage induced by aircraft noise, and it was felt that walls and windows might be relatively vulnerable to such damage. Window and wall vibrations were also of interest in that they were assumed to play a central role in causing rattle. Results obtained so far indicate that for normal operations of both Concorde and conventional aircraft, the vibration levels induced in windows and walls are far below established damage criteria, and rattle, while occasionally observed during the test program during both SST and CTOL operations, was found to occur much less frequently than originally supposed. Subjects who had experienced vibration during aircraft flyovers reported sensing vibrations primarily through the floor. For these reasons, additional emphasis has been given to the analysis of floor vibrations in this study.

Average peak levels of floor acceleration are given in Tables I through III for three test sites having wooden floors over a crawl space. At other test sites, either the levels were not sufficient to excite a measurable floor response or the floors were concrete slabs which did not display any response when subjected to significant noise levels.

The response data for site 11, presented in Table III, are particularly interesting. The levels presented in this table are believed to be near the upper limit of noise-induced vibration levels which would normally be induced in residential structures within an airport community, since this site was close enough to the active JFK runways that approaching aircraft passed less than 100 m above the house. Another interesting point about the data in Table III is that the average horizontal component of the floor vibration exceeded the average vertical component for essentially all aircraft, the only exception being the Concorde, which excited the same response levels in both the horizontal and the vertical directions. The floor data of site 4 (Table II) reveal the same effect except that the amount by which the horizontal exceeds the vertical is somewhat less (2 to 4 dB vs. about 7 dB for site 11). The site 3 floor data (Table I) do not display a large horizontal component of floor acceleration relative to the vertical component. Relatively high levels of horizontal floor vibration were unexpected, and the mechanism is not clearly understood.

The average peak values of floor acceleration are plotted in figures 3 and 4 as a function of average peak noise level for each of several aircraft types. As was the case for the window and wall data presented in references 1 and 2, the floor data of figures 3 and 4 suggest that Concorde is no more efficient in exciting structural response than subsonic aircraft. Greater levels of floor vibration which may be associated with Concorde operations are attributed more to higher unweighted noise levels than to unique Concorde source characteristics.

Subjective Tests Results

The subjective response tests of vibration and rattle included both Concorde and a variety of subsonic aircraft operations. The tests were designed to obtain vibration and rattle thresholds, where threshold is defined as a positive (detection) rating by 50 percent of the subjects. The tests were conducted utilizing four members of the NASA monitoring team and the residents at each test site. Only the data obtained from the NASA subjects has been analyzed, since the residents experienced difficulty in differentiating between noise, vibration, and rattle due to the aircraft flyovers.

Detection of rattle.- A total of 109 aircraft flyovers at eight sites were assessed for vibration and rattle. On only three occasions did half the subjects detect rattle. Due to the sparse nature of these data, no further analyses have been undertaken.

Detection of vibration.- The subjects were seated for the vibration detection task and on most occasions reported sensing the vibration of the floor either through the chair in which they were sitting or through their feet. On a few occasions, whole-body vibration was reported. Attempts were made to correlate various noise and vibration measures with the judgments of vibration detection. The indoor sound pressure level and the floor acceleration levels were found to be the best predictors, whereas the peak outdoor sound pressure level and the wall and window acceleration levels were found to be poorer predictors.

Floor vibration was recorded in both the horizontal and vertical planes. Representative acceleration spectra for site 11 are presented in figures 5 and 6. It should be noted that the significant responses are below 100 Hz (the 60 Hz component is due to electrical rather than vibratory input).

Also shown in figures 5 and 6 are three lines corresponding to the ISO minimum complaint criteria (ref. 8). Curve A is for residents during the day, curve B is for residents during the night, and curve C is for other critical areas such as hospital operating theaters. This latter criteria is presumably close to the threshold of vibration detection. It is clear that, according to these criteria, the floor vibrations should be perceptible.

The spectra of the floor vibrations are in marked contrast to those derived from the wall and window vibrations. For example, the spectra of the wall and window due to a Concorde overflight at site 11 are presented in figure 7. The window and wall acceleration spectra are similar in shape to the outside sound pressure level spectrum, whereas the floor spectra (figures 5 and 6) are not.

Figure 8 presents the percentage of the subjects that detected vibration as a function of the maximum vertical floor acceleration level. The curve shown was fitted to the data by assuming that the subjective judgments were drawn from a population having a normal distribution. There were no apparent differences between the judgments made at the three test sites or between the aircraft types. A similar curve for horizontal floor accelerations is given in figure 9.

The judgments of vibration detection were compared with the ISO criterion by applying a weighting to the vertical acceleration spectra equivalent to a low-pass filter having a corner frequency of 8 Hz and an attenuation of 2 dB per 1/3-octave (curve 1, ref. 8). The maximum ISO-weighted acceleration levels were related to the judgments of vibration detection (figures 10 and 11) and the threshold values (54 dB vertical, 59 dB horizontal) were found to be in close agreement with the ISO standard for hospital operating theaters and other critical areas.

The threshold of detection of floor vibration may be related to the outside sound pressure level by use of acceleration level/sound pressure level signatures (figures 3 and 4, for example). For example, at site 11, the threshold vertical floor acceleration level (67 dB, from figure 1) is equivalent to an outside sound pressure level of 98 to 109 dB depending upon the aircraft type.

Nonaircraft Events

Building response measurements were made at the test houses for several nonaircraft events including walking, dropping a book, closing a door, etc. Acceleration measurements were obtained from the same transducers and recording system used to record aircraft flyover events. However, because of the impulsive nature of the nonaircraft events, a different technique was used to analyze the data. Oscillograph time histories were made of the tape recorded signals to obtain instantaneous peak amplitudes. The maximum values of window, wall, and floor acceleration peak response amplitudes recorded at four of the test houses for the nonaircraft events are given in Tables IV-VII. To enable comparisons to be made with the measured aircraft responses, both the nonaircraft response and the aircraft response data were averaged across houses and responses relative to the narrow-body subsonic aircraft are shown in figures 12, 13, and 14 for the window, wall, and vertical floor responses, respectively. Also for comparative purposes, the rms amplitudes obtained for aircraft events were corrected to peak values assuming harmonic response (peak amplitude = $\sqrt{2}$ rms amplitude).

For the window response data shown in figure 12, it can be seen that Concorde-induced response exceeds the response due to other aircraft and all of the nonaircraft events recorded. Nonaircraft events and aircraft flyovers resulted in comparable wall vibration amplitudes as shown in figure 13, whereas floor vibrations were generally greater for nonaircraft events than for the aircraft flyovers, figure 14.

CONCLUDING REMARKS

Aircraft noise and building vibration measurements were made at eight residential home sites and a school in the vicinity of John F. Kennedy International Airport. These measurements were made in cooperation with the FAA as part of the Concorde SST environmental impact assessment. The data were acquired in two field trips to the JFK area which took place in January and February 1978.

Results of this study can be summarized as follows:

(1) Acceleration levels induced in buildings by aircraft noise increase essentially linearly with increasing sound pressure level (unweighted). Representative values of peak acceleration levels for typical structural elements of homes located near a commercial jet airport are as follows:

windows: 0.1 g - 1.0 g
walls: 0.01 g - 0.1 g
floors: 0.001 g - 0.01 g

(2) At a given noise level, Concorde induces no higher acceleration levels in a given structural element than subsonic aircraft for either direct overflights or for sideline flybys. Higher response levels which may occur during Concorde operations are attributed more to higher Concorde noise levels than to unique Concorde source characteristics.

(3) Acceleration levels induced in the floor of a typical residential structure by the impulsive loading of such nonaircraft events as walking and

the dropping of a book generally exceeded floor acceleration levels induced by aircraft noise. Aircraft noise generally resulted in higher acceleration levels on the windows and about the same levels on the walls compared with nonaircraft events.

(4) For seated individuals not in physical contact with other structural elements, floor vibration levels are a better predictor of vibration detection than window and wall vibration levels.

(5) A method for determining the detection threshold for noise-induced building vibration has been successfully demonstrated in a small pilot study. Results of this study indicate that the threshold for human detection of floor acceleration lies in the range of from .001 to .005 g's and that an outdoor noise level in excess of about 100 dB is required to induce this threshold response level.

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8. Amendment to ISO Standard 2631-1974 - Draft Proposal "Vibrations and Shock Limits for Occupants in Buildings, 1975.

TABLE I.- AVERAGE MAXIMUM LEVELS FOR APPROACHES AT SITE 3

A/C Type	No. of Flights	Average Maximum Level					
		OASPL, dB		Acceleration, dB re 1 μG			
		Outside	Inside	Window	Wall	Vert. Floor	Hor. Floor
707	5	94.0 ± 4.8	73.4 ± 2.2	95.5 ± 3.3	70.7 ± 3.1	60.1 ± 3.1	58.7 ± 2.0
DC-8	3	95.6 ± 3.1	73.9 ± 2.2	96.9 ± 3.5	72.8 ± 3.5	59.2 ± 1.1	58.1 ± 0.2
727	5	92.2 ± 2.5	72.0 ± 3.0	95.0 ± 3.4	70.2 ± 3.0	59.2 ± 2.3	59.3 ± 1.0
747	4	95.2 ± 3.8	74.8 ± 3.0	97.6 ± 4.8	72.7 ± 4.6	57.2 ± 0.4	58.9 ± 3.0
L1011	3	91.7 ± 1.8	74.6 ± 1.3	92.9 ± 1.3	68.9 ± 1.9	59.1 ± 0.6	56.9 ± 0.1
SST	1	107.2	84.6	110.6	83.8	---	---

TABLE II.- AVERAGE MAXIMUM LEVELS AT SITE 4

A/C Type	Config.	No. of Flts.	Average Maximum Level					
			OASPL, dB		Acceleration, dB re 1μG			
			Outside	Inside	Window	Wall	Vert. Floor	Horz. Floor
707	Ap	4	104.4 ± 3.2	82.0 ± 2.7	101.4 ± 2.7	85.3 ± 2.7	62.5 ± 4.9	65.1 ± 4.2
707	T/O	1	85.7	69.95	82.38	69.86	---	---
727	T/O	1	95.0	75.5	89.4	76.7	54.0	---
DC-9	Ap	1	92.7	73.4	93.1	76.5	61.8	65.5
747	T/O	5	92.1 ± 6.8	81.4 ± 5.0	89.7 ± 9.6	76.2 ± 8.4	59.1 ± 2.9	61.2 ± 3.1
DC-10	T/O	2	92.8 ± 0.0	82.3 ± 0.4	82.6 ± 0.4	69.4 ± 1.0	58.7 ± 6.8	61.8 ± 5.1
SST	Ap	1	113.3	94.0	117.4	98.2	68.3	70.3

TABLE III.- AVERAGE MAXIMUM LEVELS FOR APPROACHES AT SITE 11

A/C Type	No. of Flts.	Average Maximum Level					
		OASPL, dB		Acceleration, dB re 1μG			
		Outside	Inside	Window	Wall	Vert. Floor	Horiz. Floor
707	10	107.5 ± 1.4	84.4 ± 1.9	102.1 ± 2.2	81.5 ± 2.6	65.9 ± 3.0	71.5 ± 3.1
DC-8	5	102.4 ± 3.0	83.4 ± 1.5	99.2 ± 2.8	79.2 ± 3.2	64.9 ± 2.1	71.3 ± 2.9
727	8	100.3 ± 3.0	79.0 ± 2.0	102.1 ± 3.4	81.8 ± 2.6	64.3 ± 3.0	71.1 ± 3.3
DC-9	3	95.1 ± 3.6	78.2 ± 4.3	95.7 ± 5.1	77.2 ± 3.9	62.1 ± 2.6	69.5 ± 4.0
747	8	100.3 ± 1.9	85.0 ± 2.6	102.2 ± 0.9	81.8 ± 0.6	67.7 ± 2.3	74.5 ± 3.4
DC-10	4	97.5 ± 3.5	83.4 ± 4.5	98.0 ± 2.6	78.9 ± 3.6	64.8 ± 3.8	71.1 ± 3.4
L1011	2	97.5 ± 0.2	84.1 ± 4.4	99.0 ± 0.4	80.0 ± 0.7	69.5 ± 3.5	76.7 ± 2.4
SST	1	114.2	92.5	117.6	94.5	76.8	76.7

TABLE IV.- MAXIMUM VALUES OF VIBRATION RESPONSE DUE TO NONAIRCRAFT EVENTS AT SITE 1

Activity	Acceleration, g_{peak}			
	Window	Wall	Vert. Floor	Hor. Floor
Close door	.083	.012	.018	.007
Jump on floor	*	*	.018	.015
Walking	*	*	.016	.011
Jogging in place	*	*	.111	.022
Book drop	*	*	.010	*

*Level did not exceed ambient.

TABLE V.- MAXIMUM VALUES OF VIBRATION RESPONSE DUE TO NONAIRCRAFT EVENTS AT SITE 3

Activity	Acceleration, g_{peak}			
	Window	Wall	Vert. Floor	Hor. Floor
Close door	.265	.036	.018	.020
Jump on floor	.055	.010	.101	.048
Walking	*	*	.051	.037
Jogging in place	*	*	.031	.022
Drop book	.210	.036	.090	.057
Doorbell	.091	.052	*	*

*Level did not exceed ambient.

TABLE VI.- MAXIMUM VALUES OF VIBRATION RESPONSE DUE TO SPECIAL EVENTS AT SITE 4

Activity	Acceleration, g_{peak}			
	Window	Wall	Vert. Floor	Hor. Floor
Close door	.055	.014	.021	.007
Jump on floor	.115	.038	.142	.024
Walking	*	*	.103	.009
Jogging in place	*	*	.113	.007
Drop book	.160	.048	.131	.044

*Level did not exceed ambient.

TABLE VII.- MAXIMUM VALUES OF VIBRATION RESPONSE DUE TO NONAIRCRAFT EVENTS AT SITE 11

Activity	Acceleration, g_{peak}			
	Window	Wall	Vert. Floor	Hor. Floor
Close door	.161	.091	.017	.011
Jump on floor	.148	.026	.029	.024
Walking	*	*	.056	.064
Jogging in place	*	*	.029	.031
Drop book	.161	.138	.201	.128
Dog barking	*	.024	*	*

*Level did not exceed ambient.

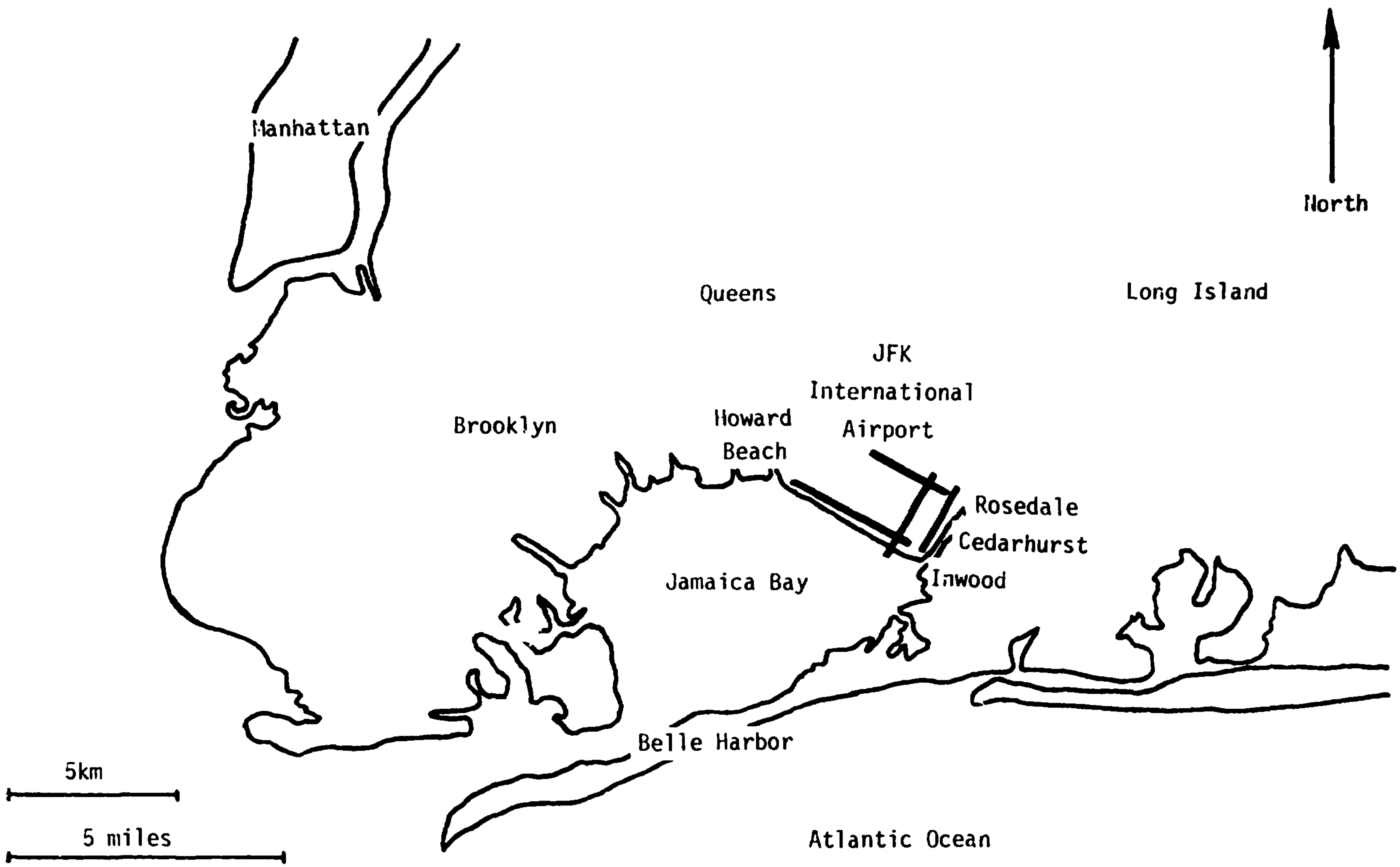

Figure 1. - JFK International Airport and surrounding area.

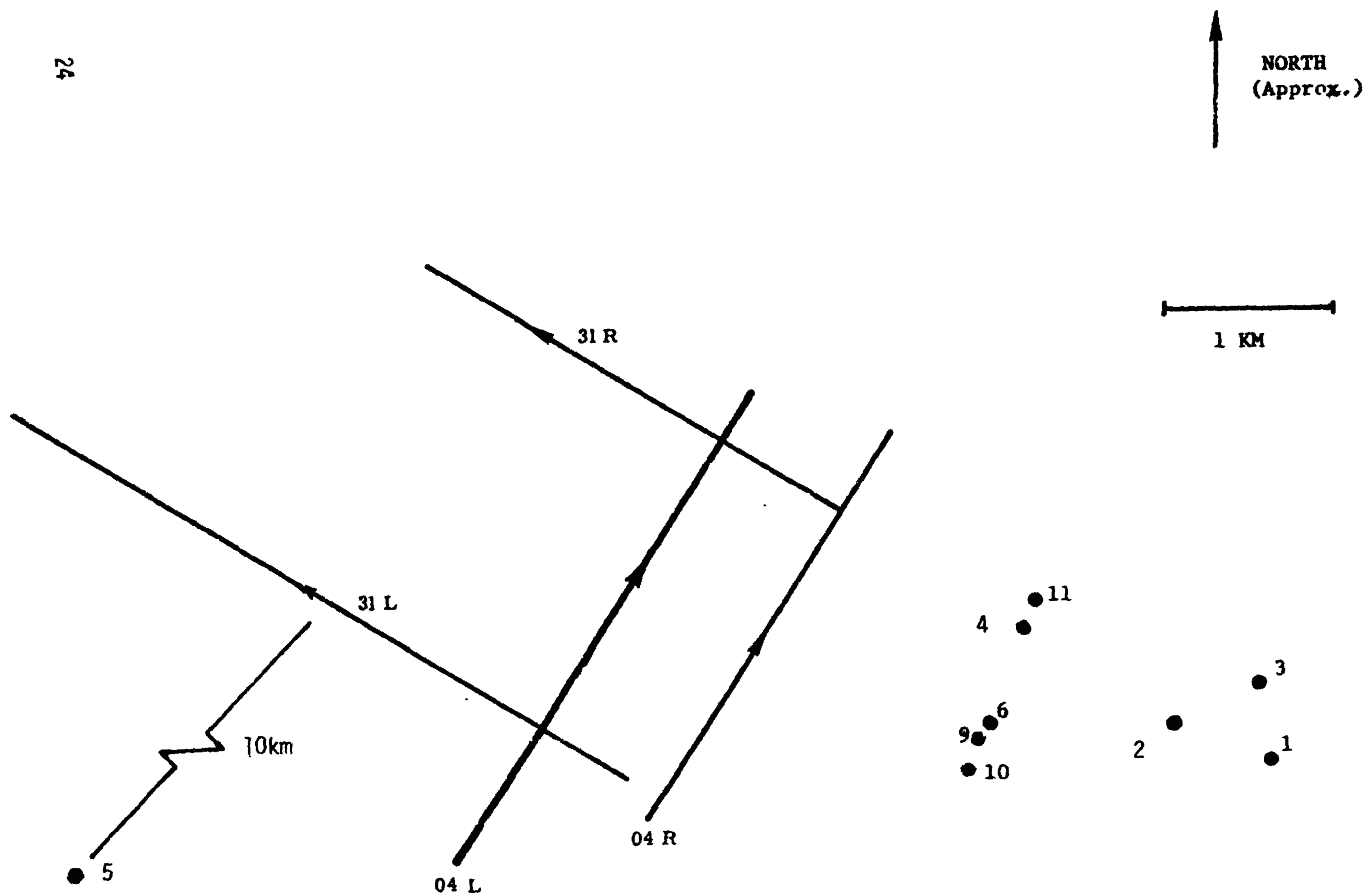

Figure 2. - Structural vibration test site locations.

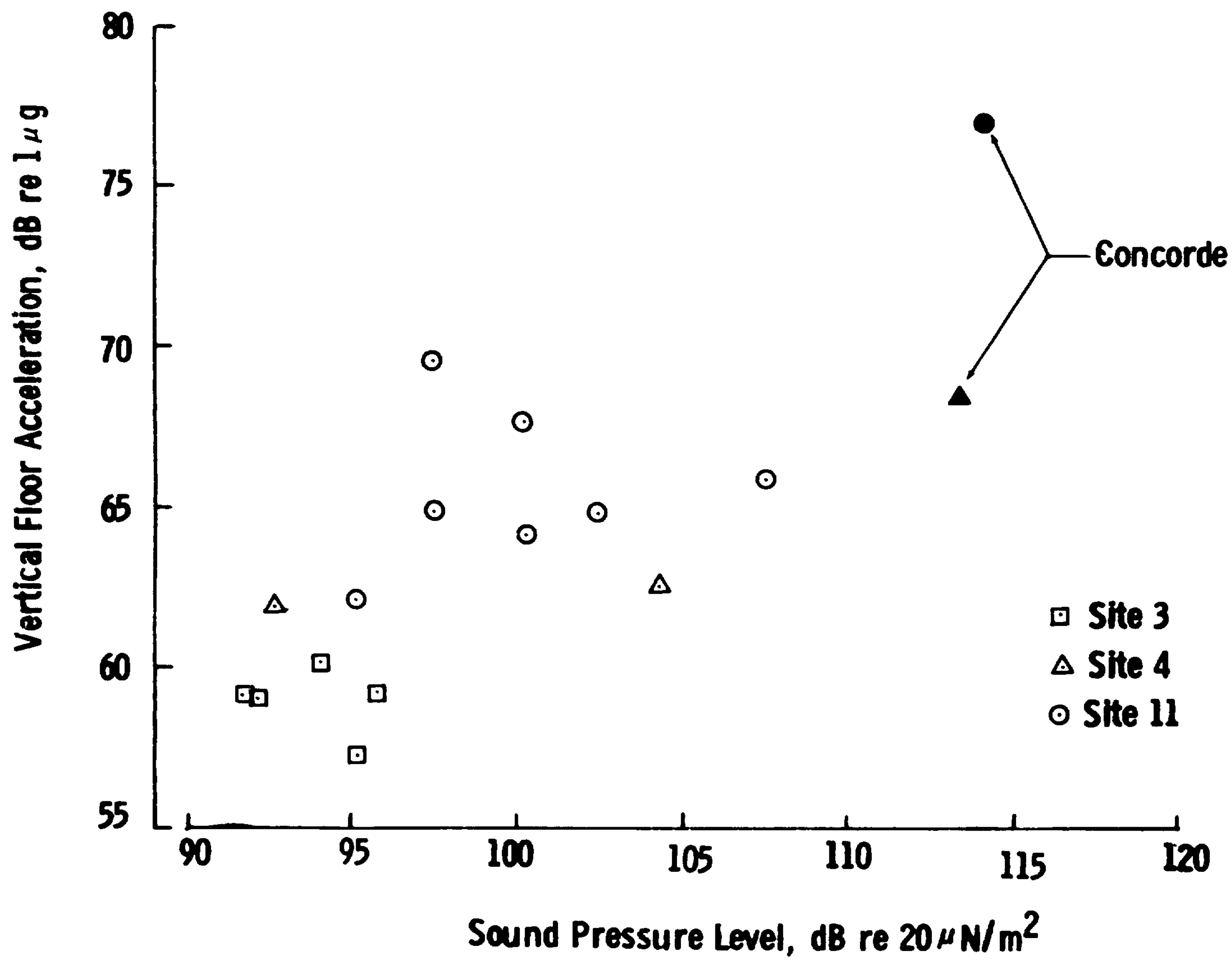

Figure 3.- Vertical floor response to aircraft noise.

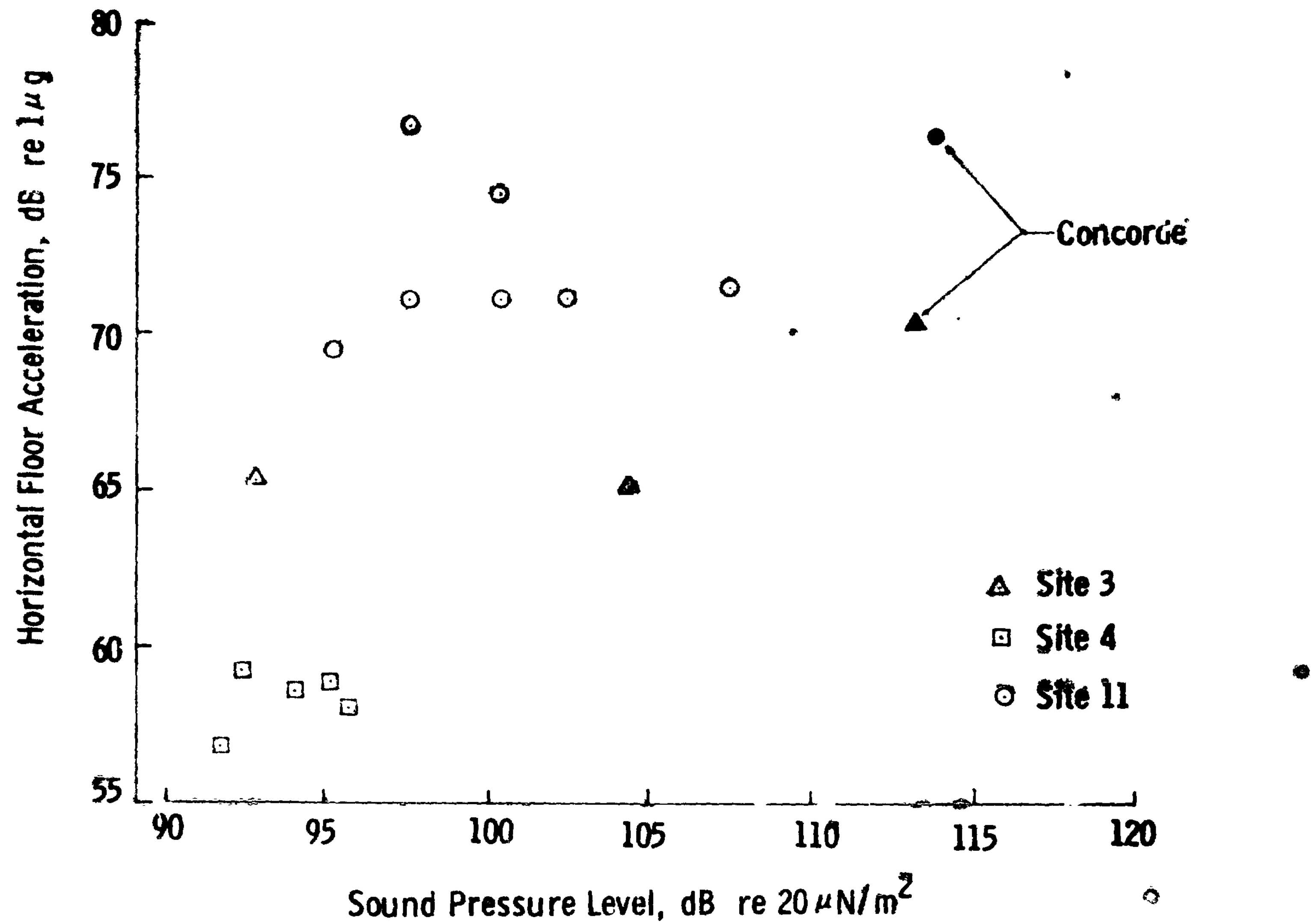

Figure 4.- Horizontal floor response to aircraft noise.

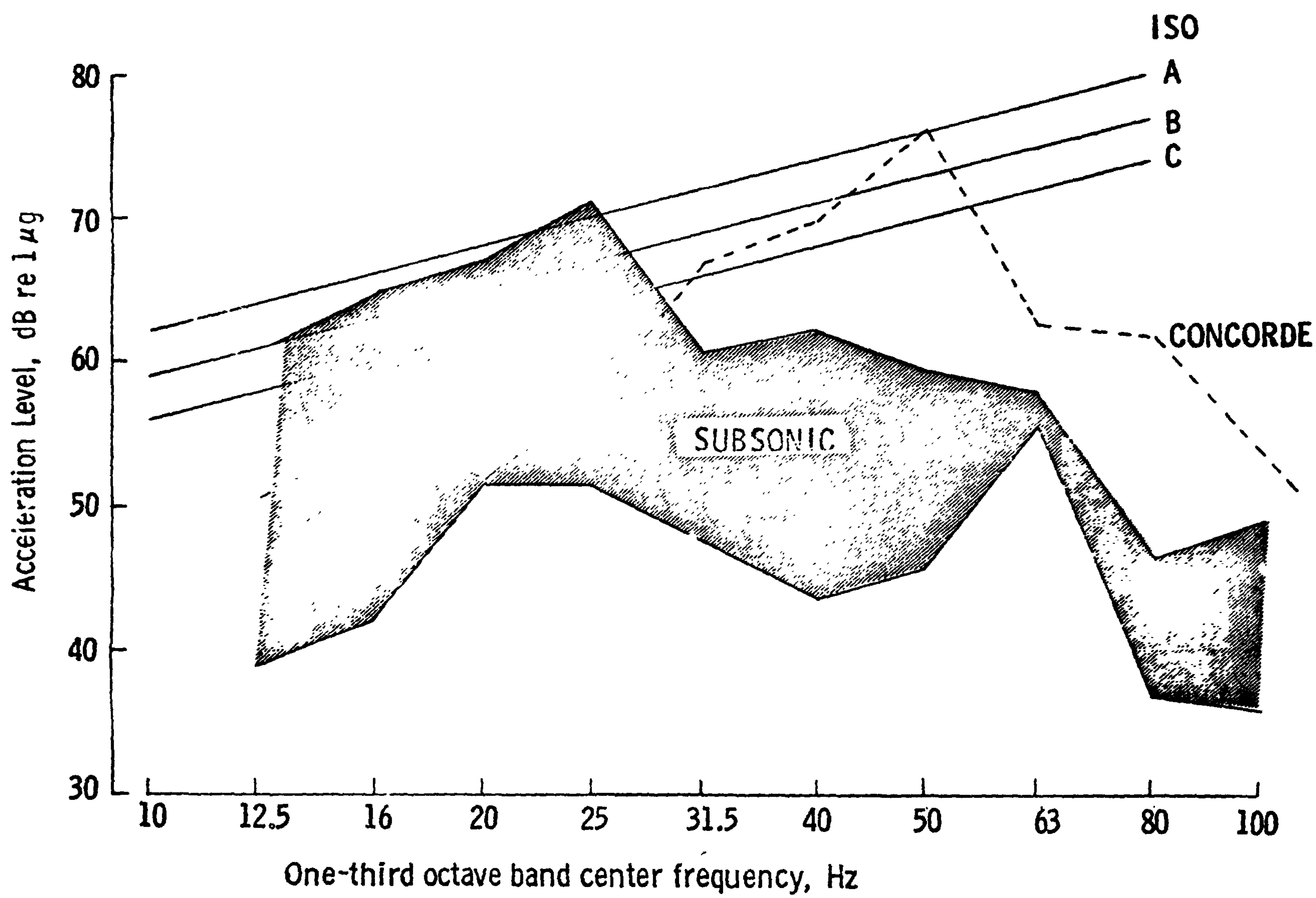

Figure 5.- Vertical floor acceleration spectra.

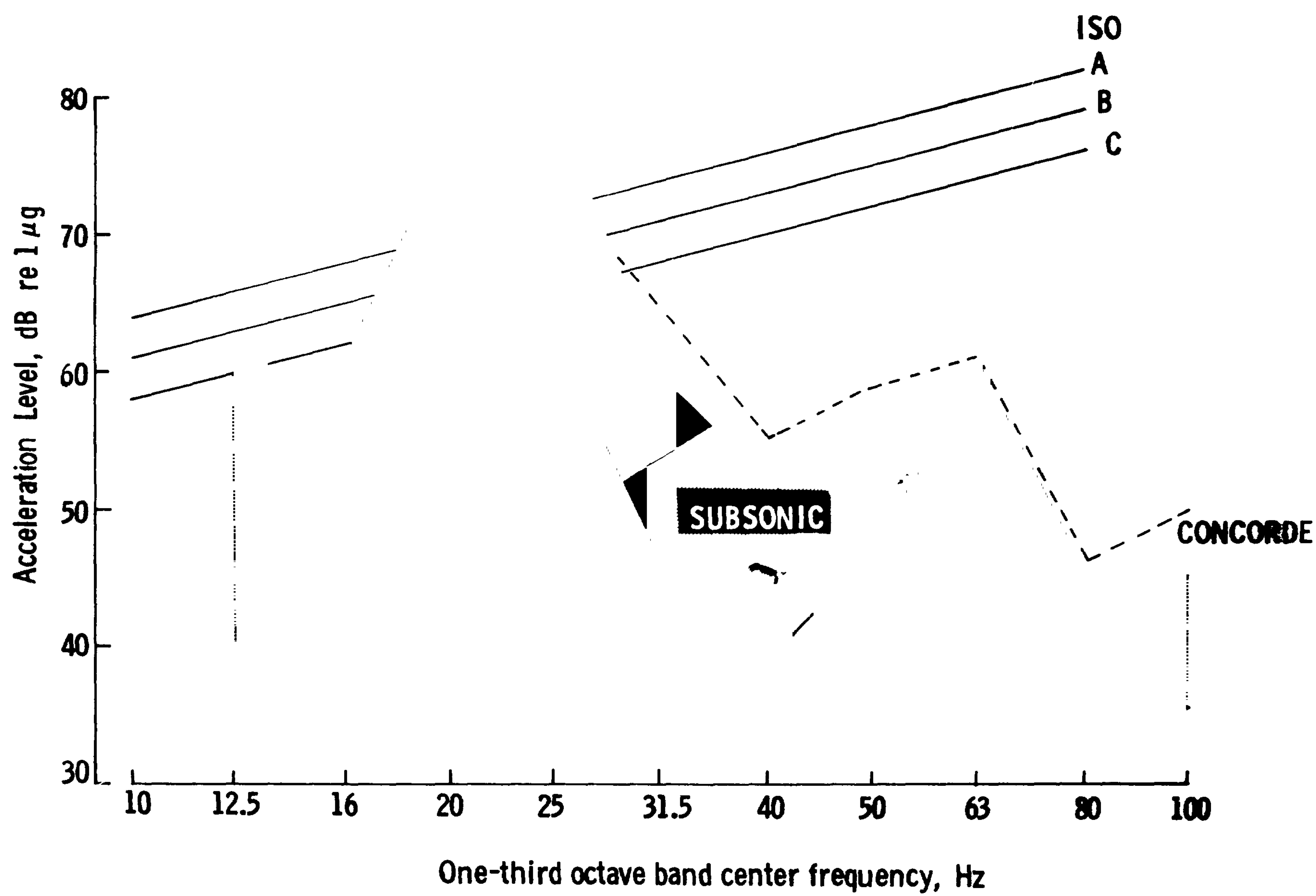

Figure 6.- Horizontal floor acceleration spectra.

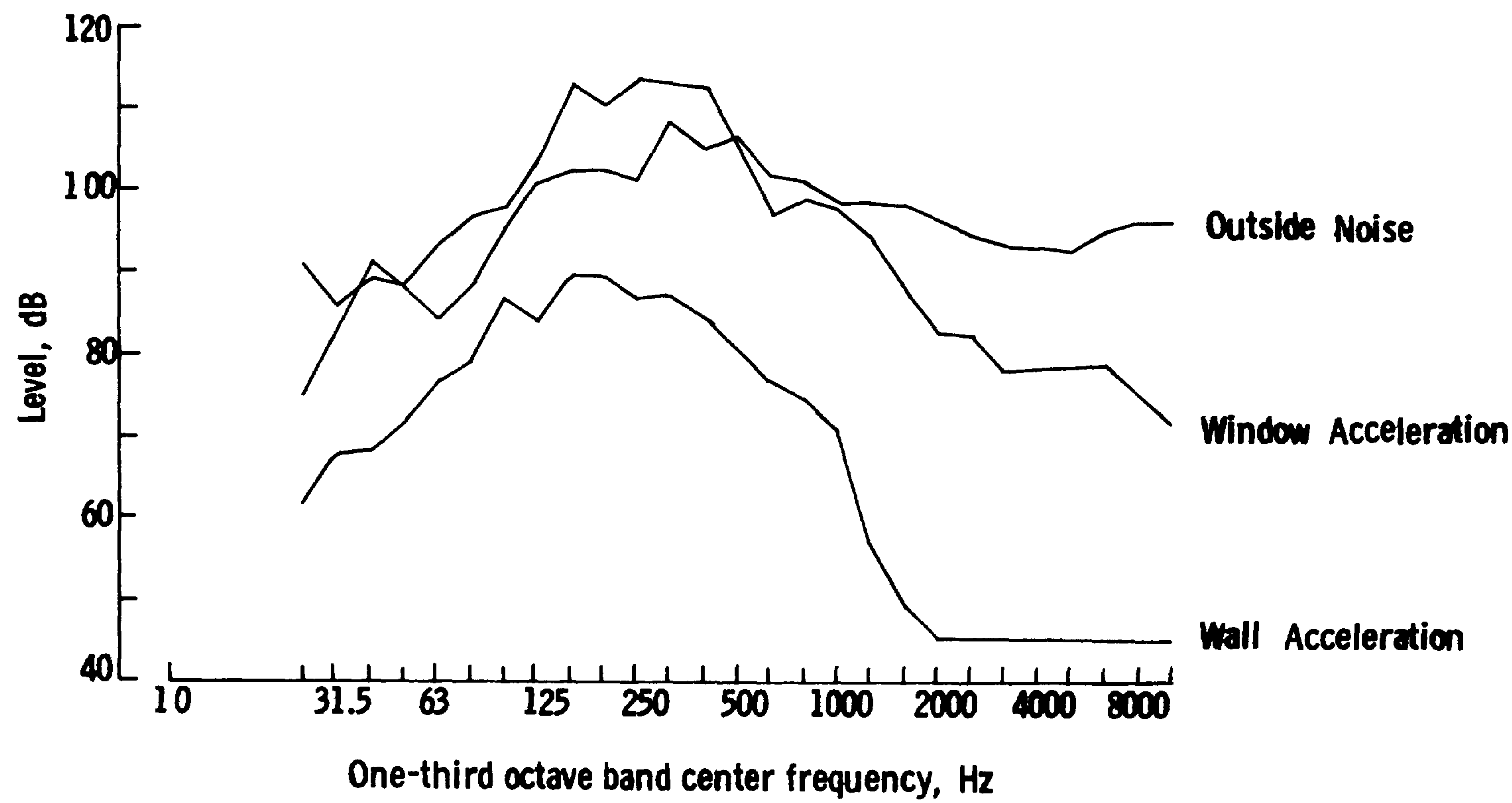

Figure 7.- Representative Concorde noise and building response spectra.

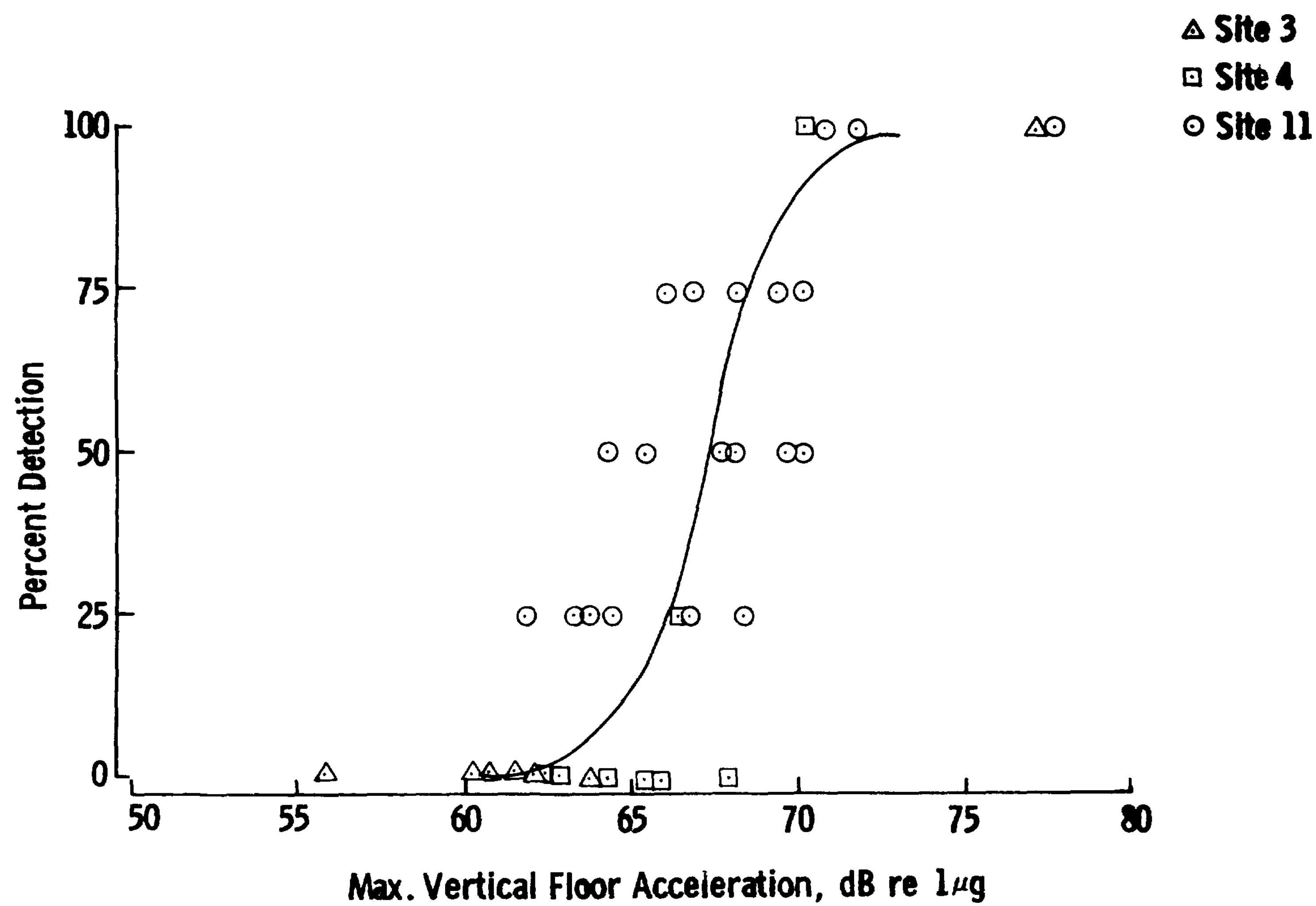

Figure 8.- Vertical floor acceleration detection threshold (unweighted).

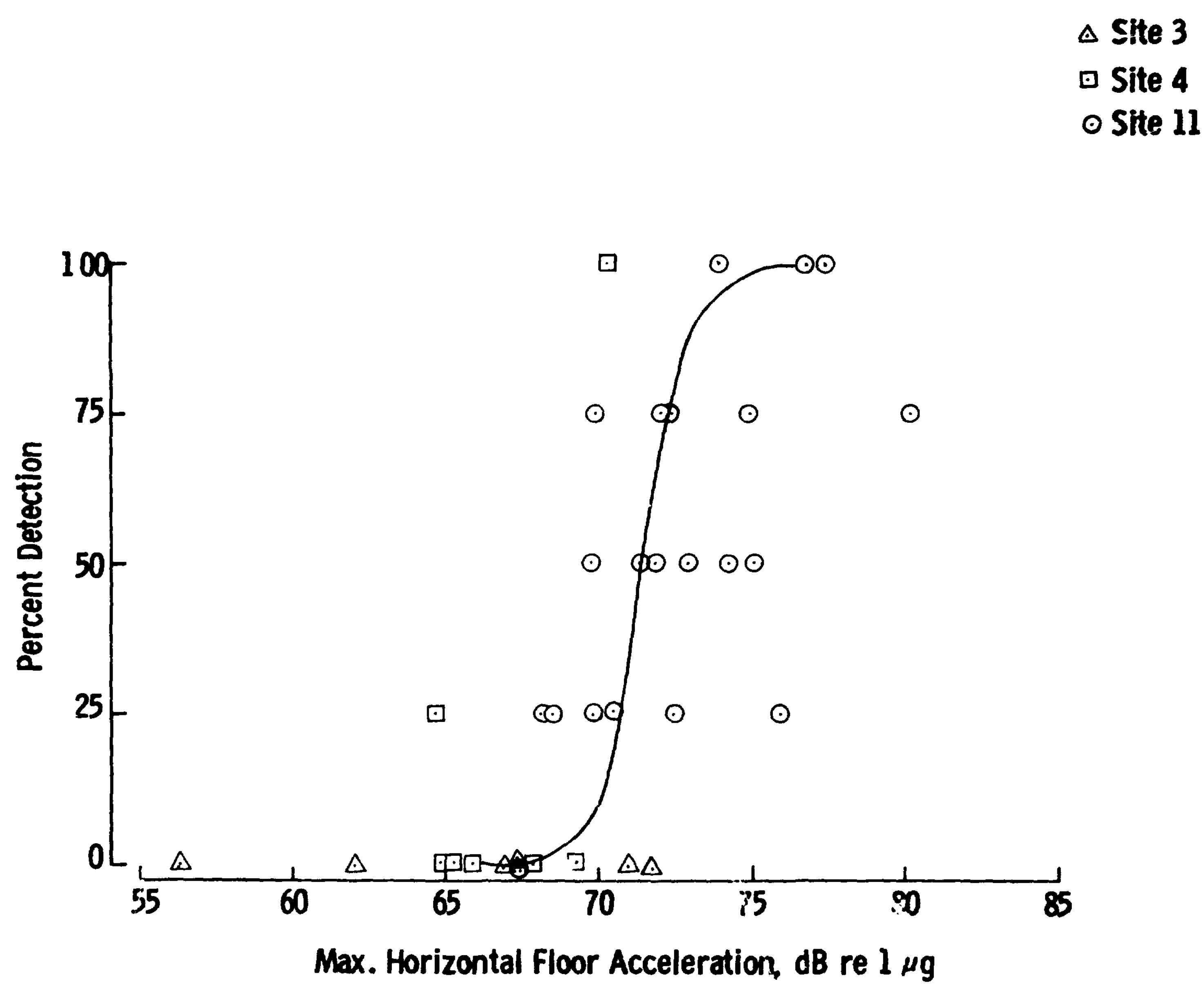

Figure 9.- Horizontal floor acceleration detection threshold (unweighted).

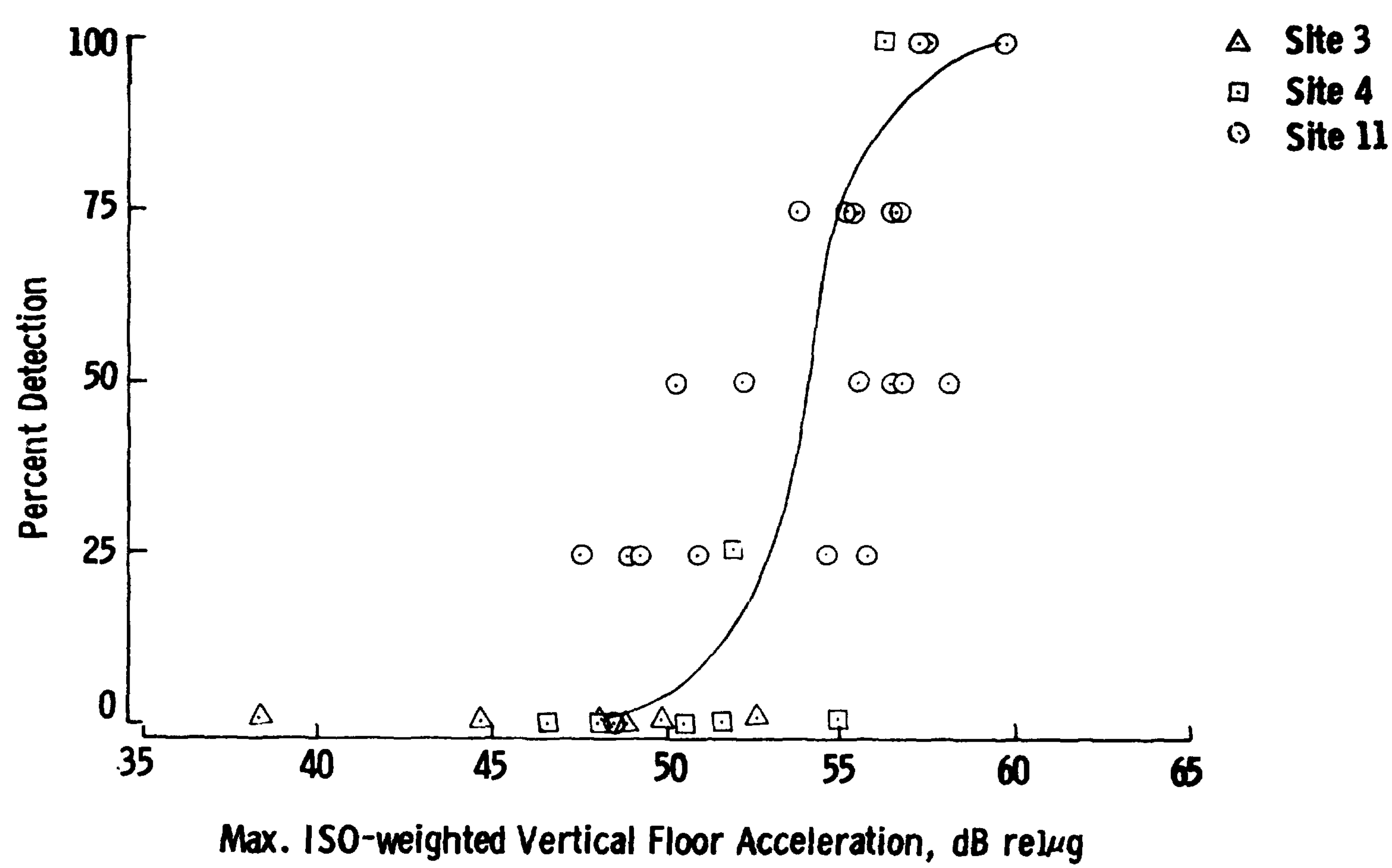

Figure 10.- Vertical floor acceleration detection threshold (ISO weighted).

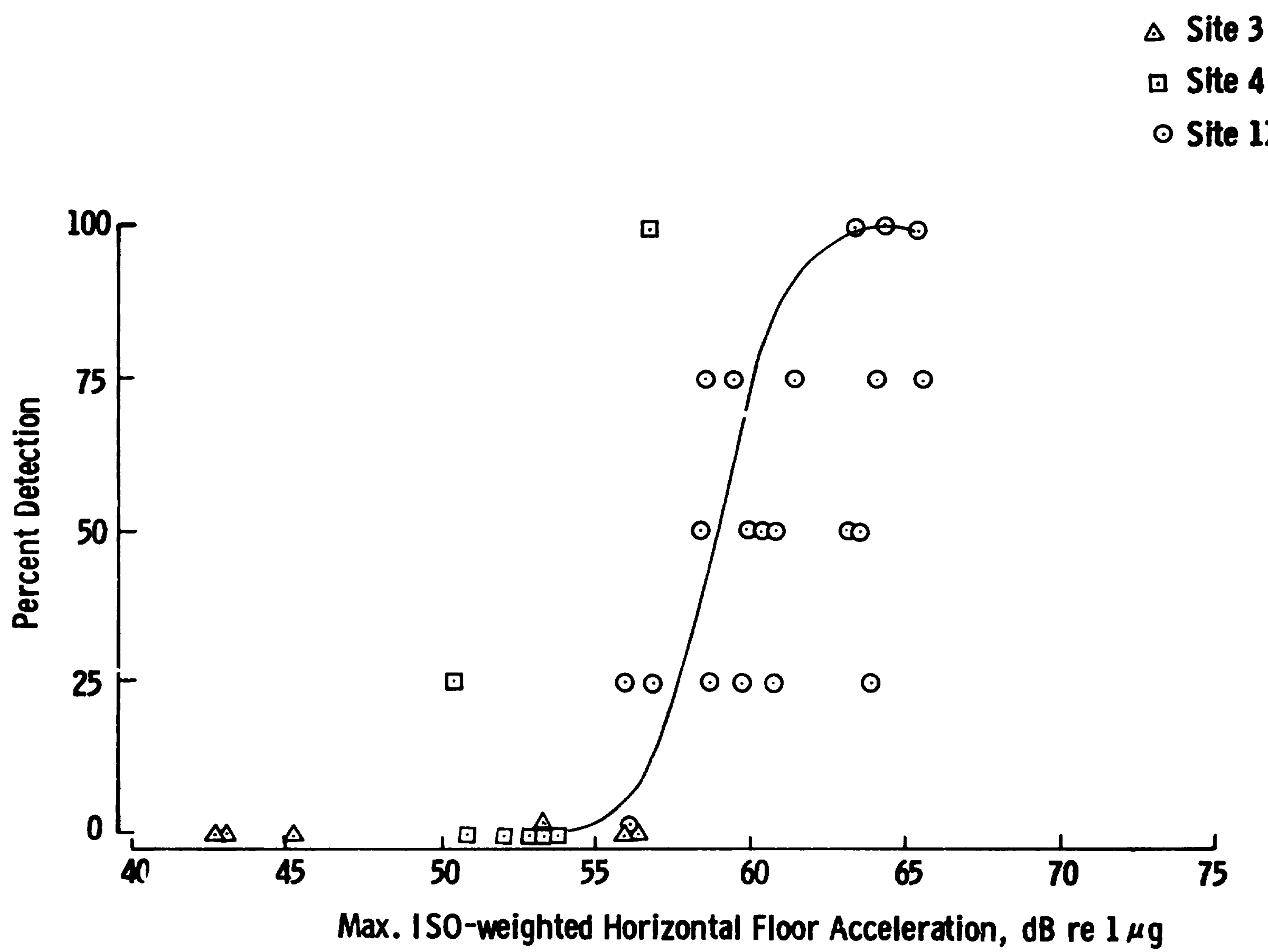

Figure 11.- Horizontal floor acceleration detection threshold (ISO weighted).

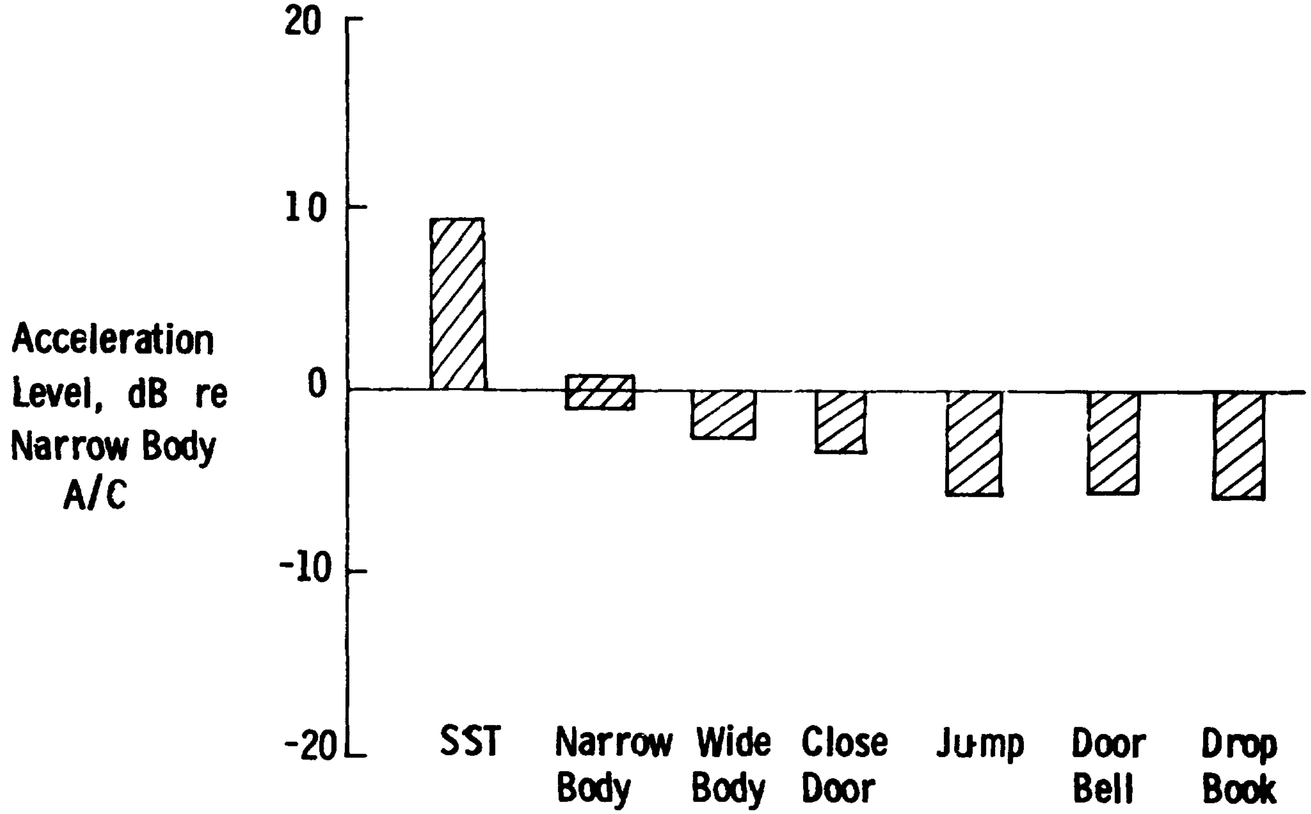

Figure 12.- Average peak window response to aircraft and nonaircraft events (relative to narrow-body aircraft).

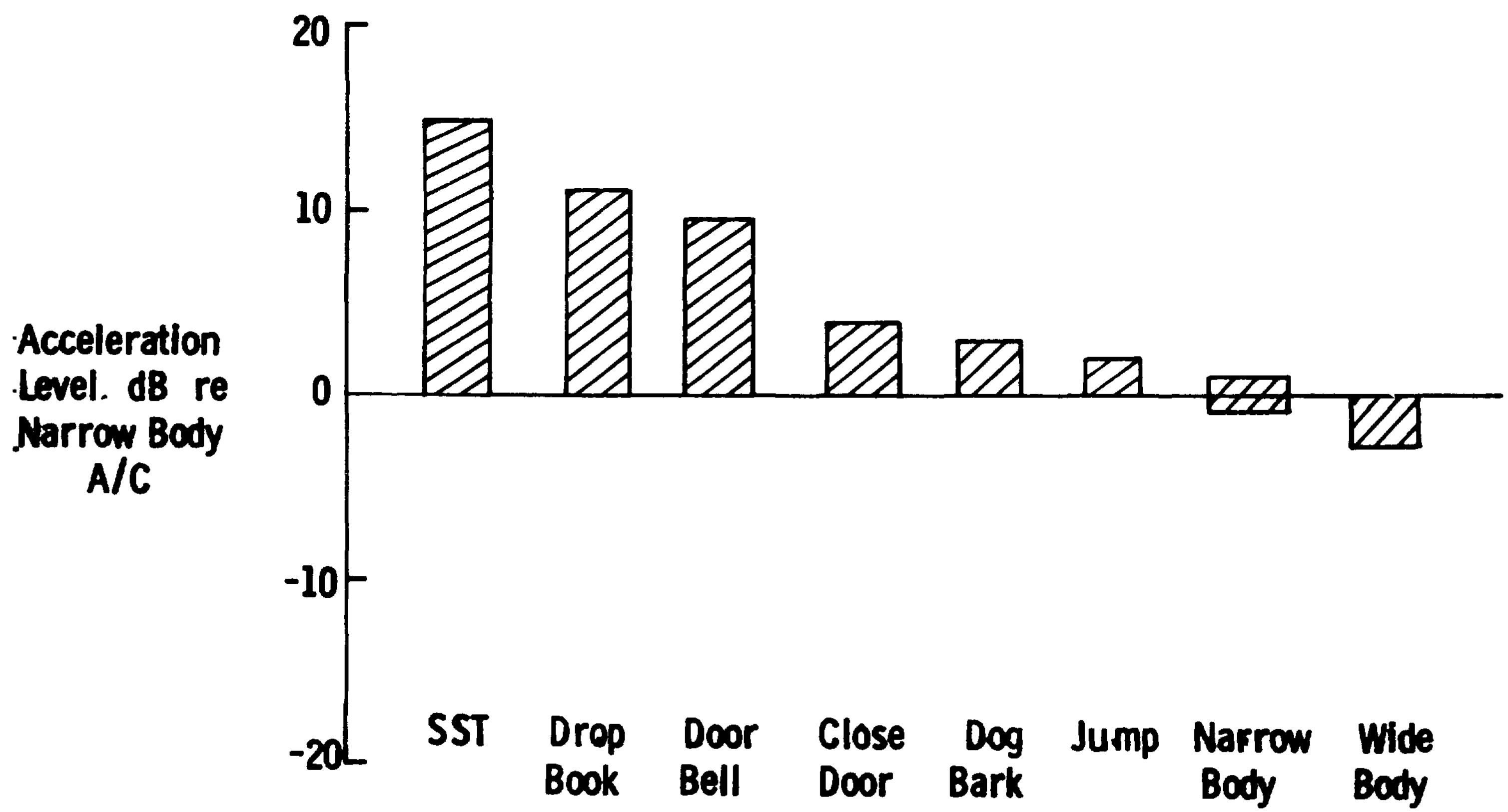

Figure 13.- Average peak wall response to aircraft and nonaircraft events (relative to narrow-body aircraft).

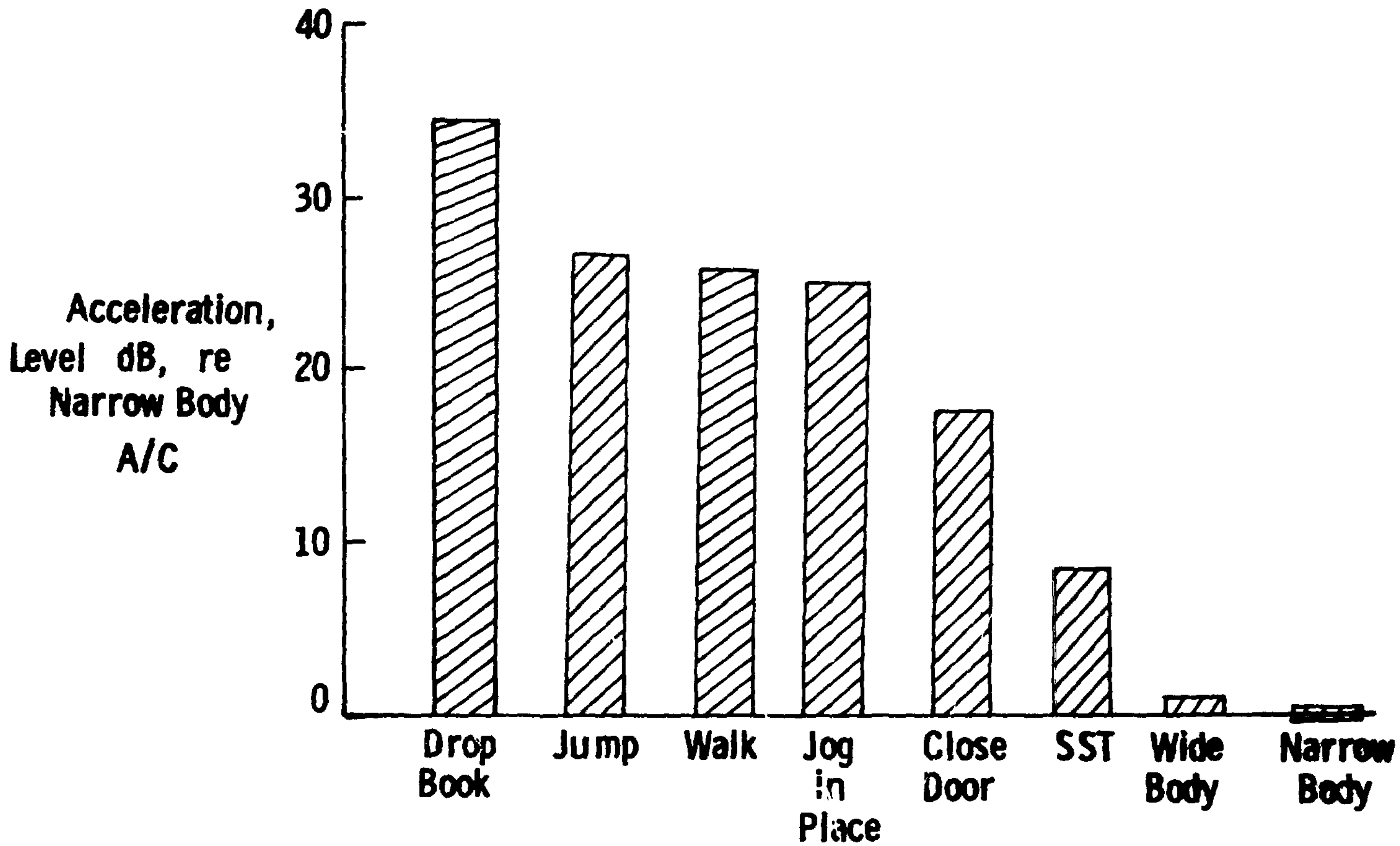

Figure 14.- Average peak floor response to aircraft and nonaircraft events (relative to narrow-body aircraft).

APPENDIX

WINDOW AND WALL RESPONSE TO AIRCRAFT SIDELINE NOISE

Window and wall response data are presented in this appendix for sideline aircraft flyover events recorded at site 11, for which the aircraft did not fly directly over the test site. The data are presented in the form of composite response signatures which illustrate the relationship between response level, expressed in decibels relative to a micro-g, and unweighted aircraft noise level for a given aircraft type. Each response signature contains data for from one to ten flybys and typifies the response of a particular aircraft type.

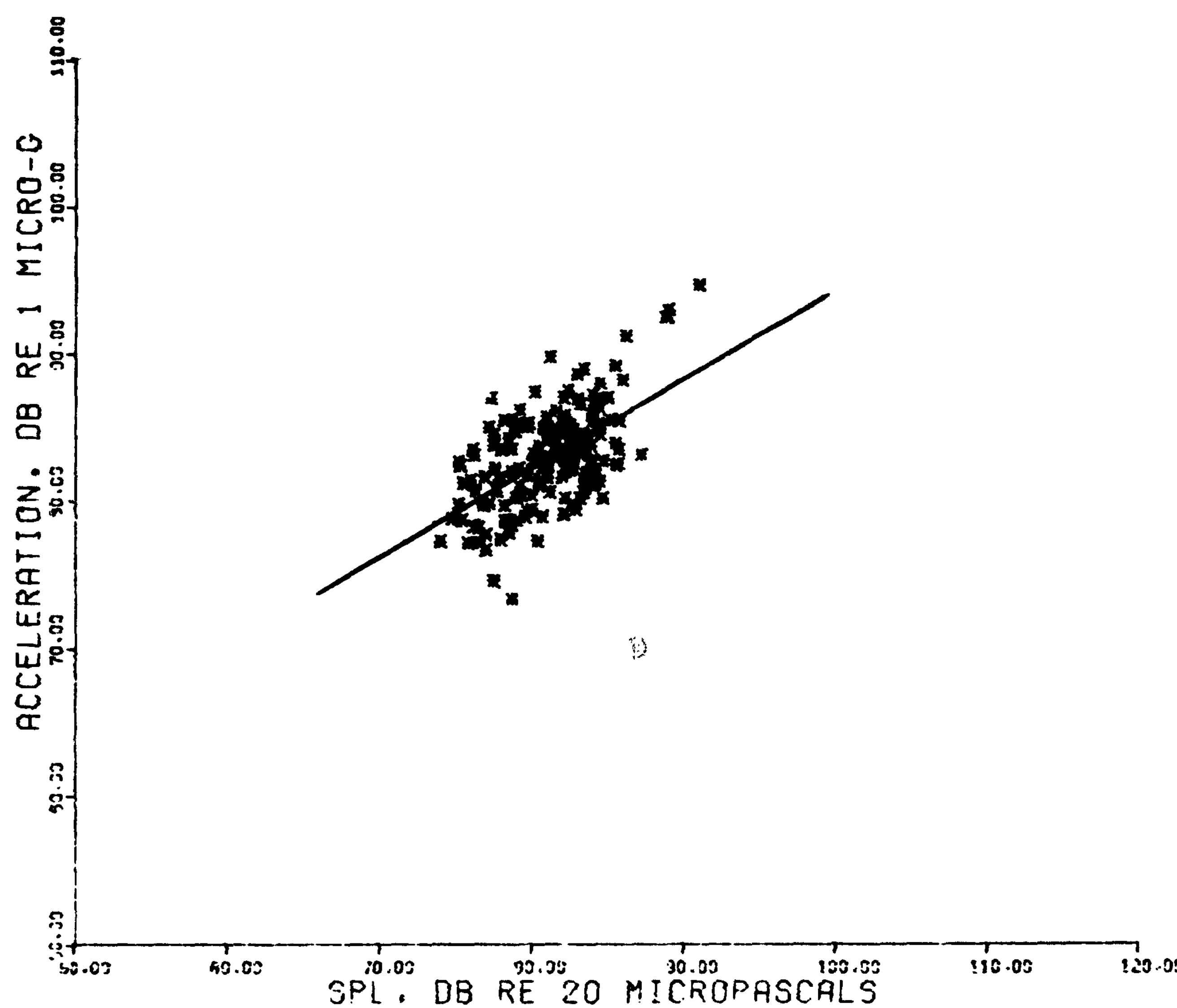

Figure A1.- Sideline window response signature for SST flyby.

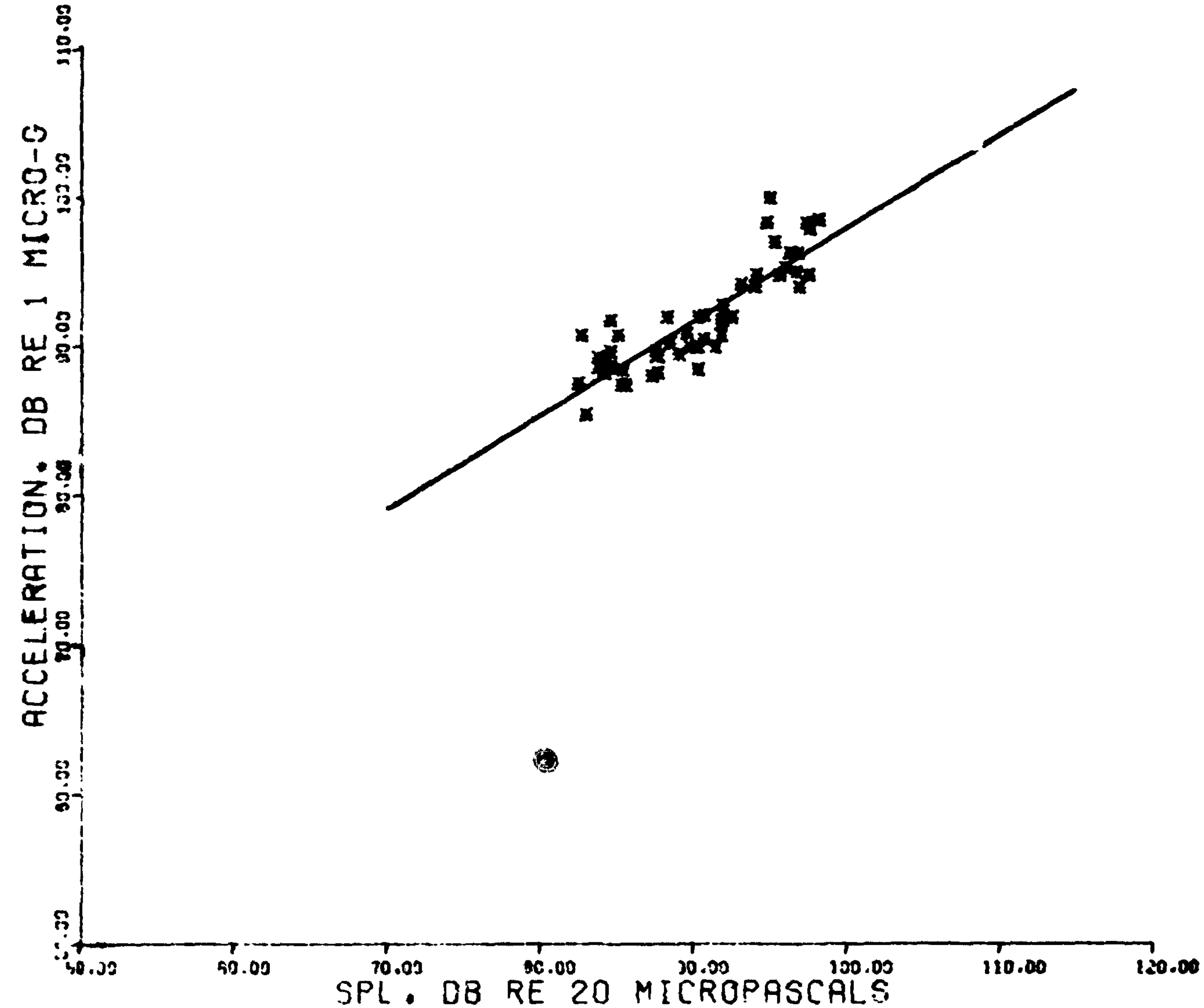

Figure A2.- Sideline window response signature for DC-8 flyby.

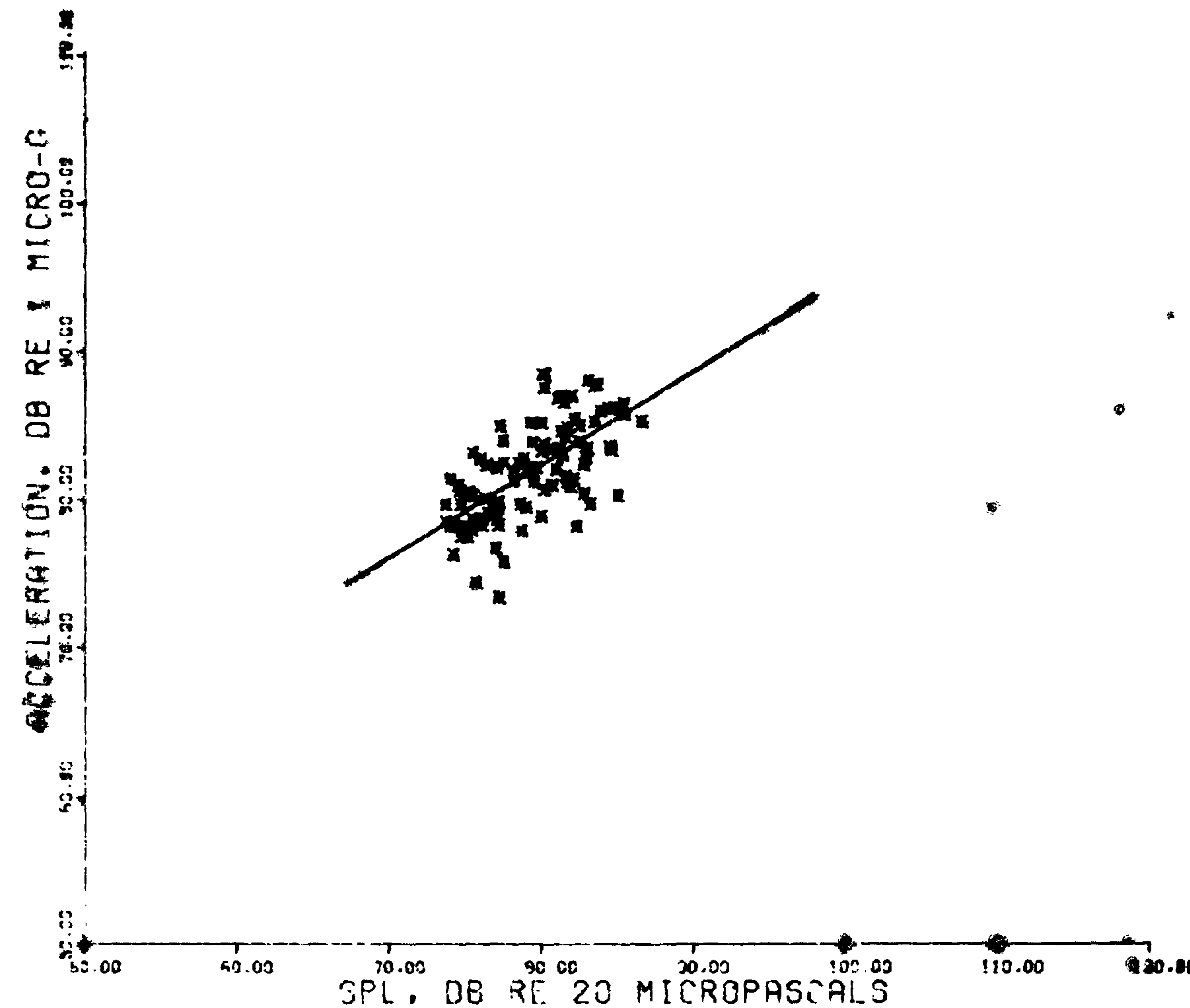

Figure A3.- Sideline window response signature for 727 flyby.

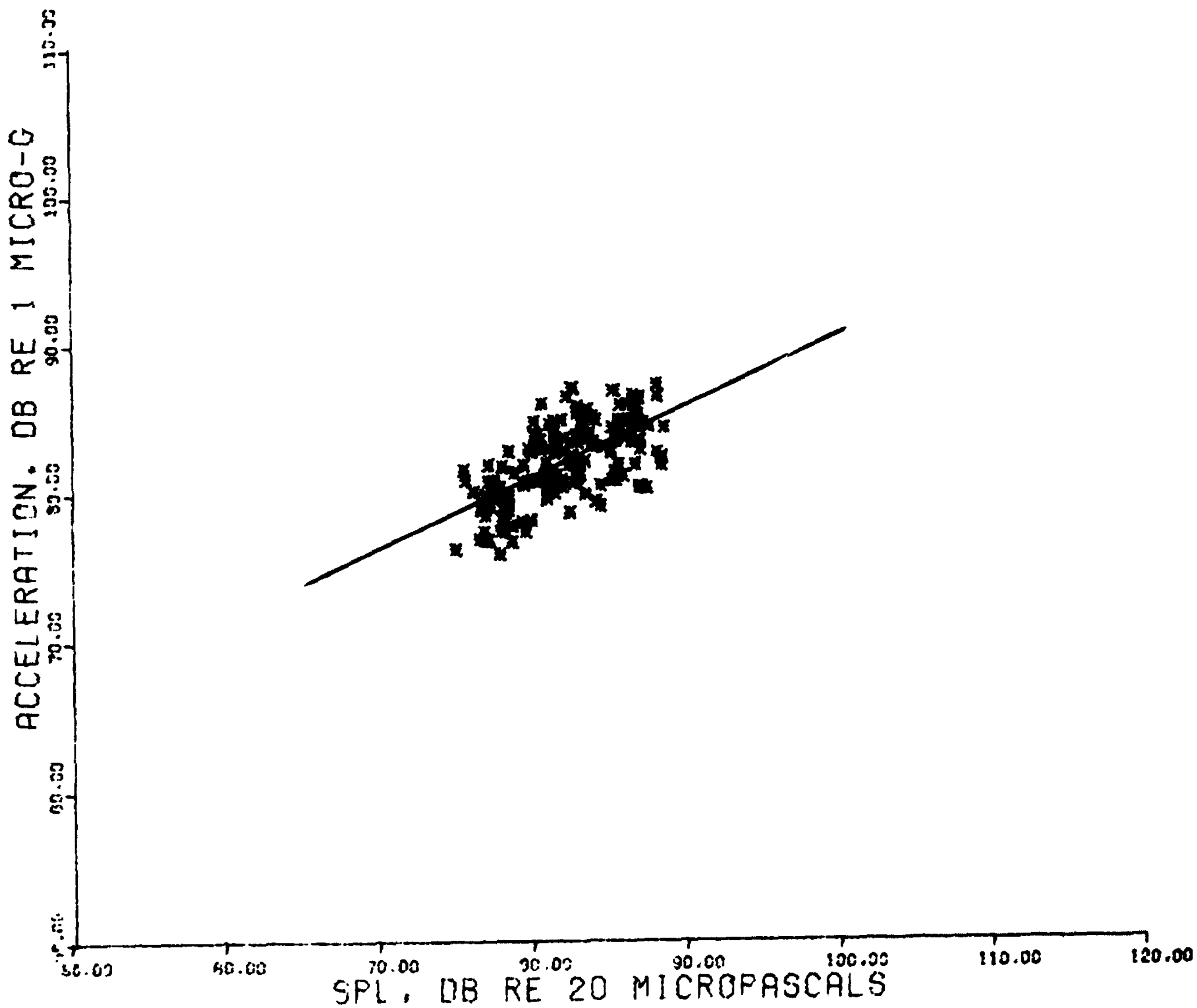

Figure A4.- Sideline window response signature for 747 flyby.

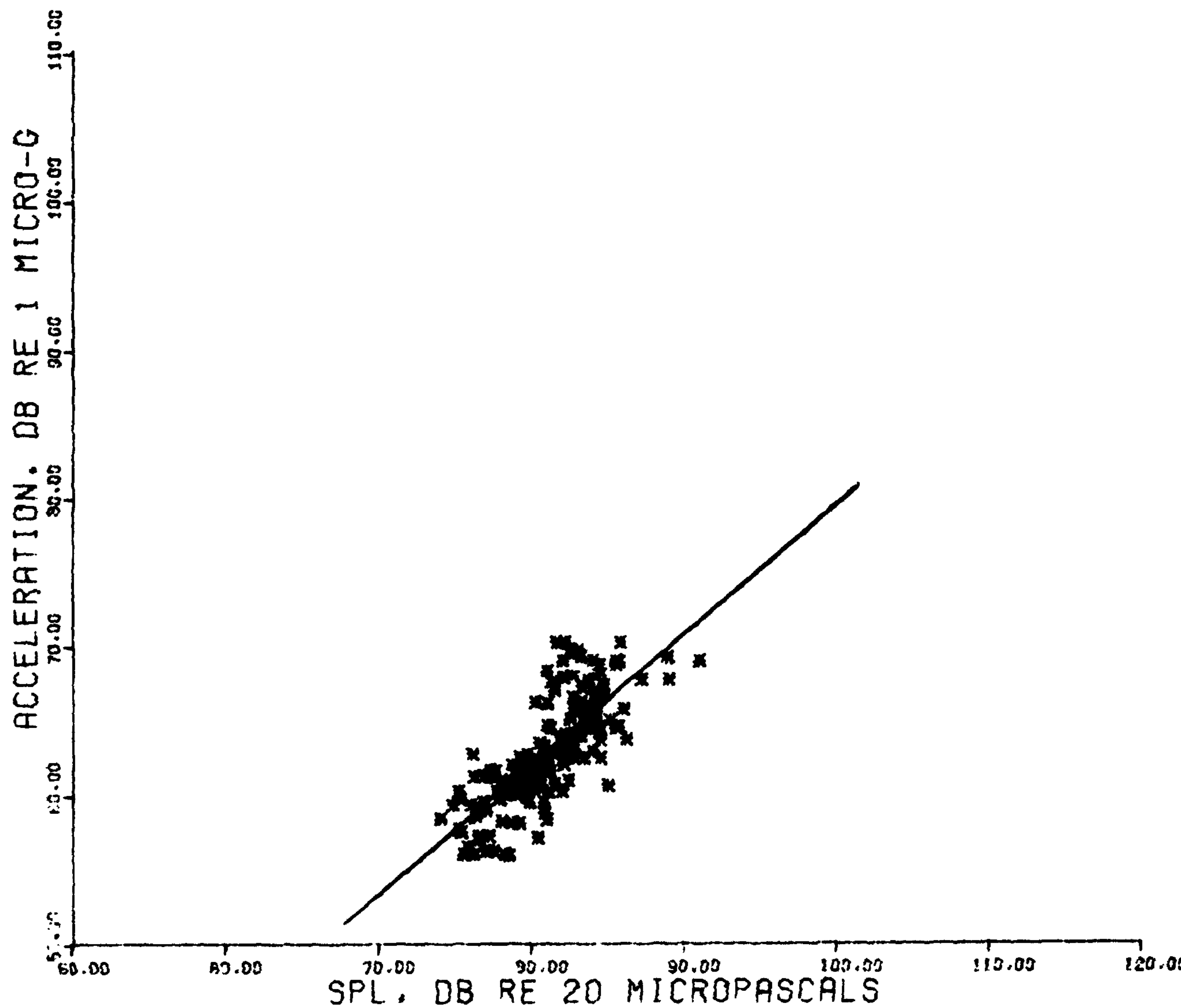

Figure A5.- Sideline wall response signature for SST flyby.

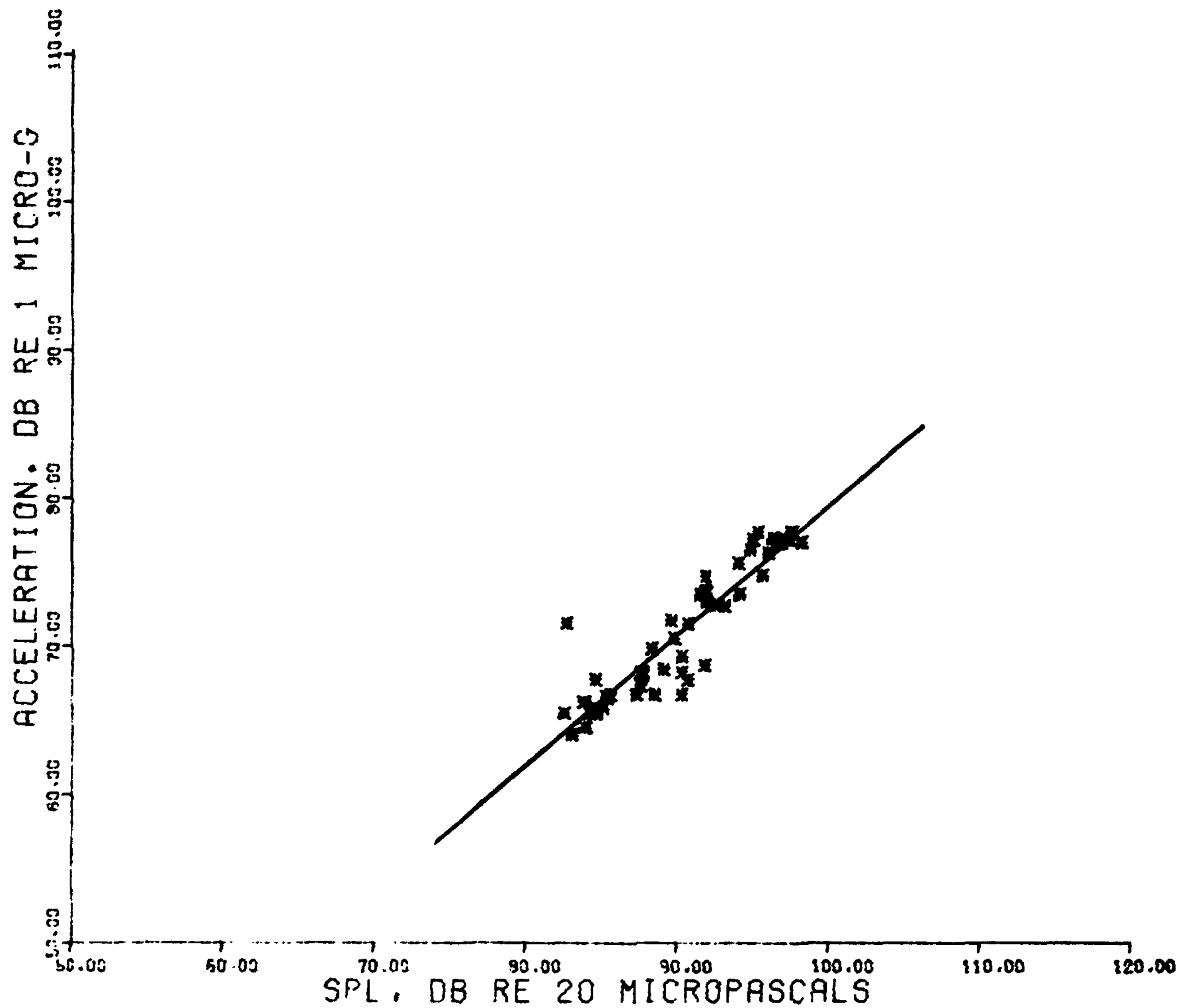

Figure A6.- Sideline wall response signature for DC-8 flyby.

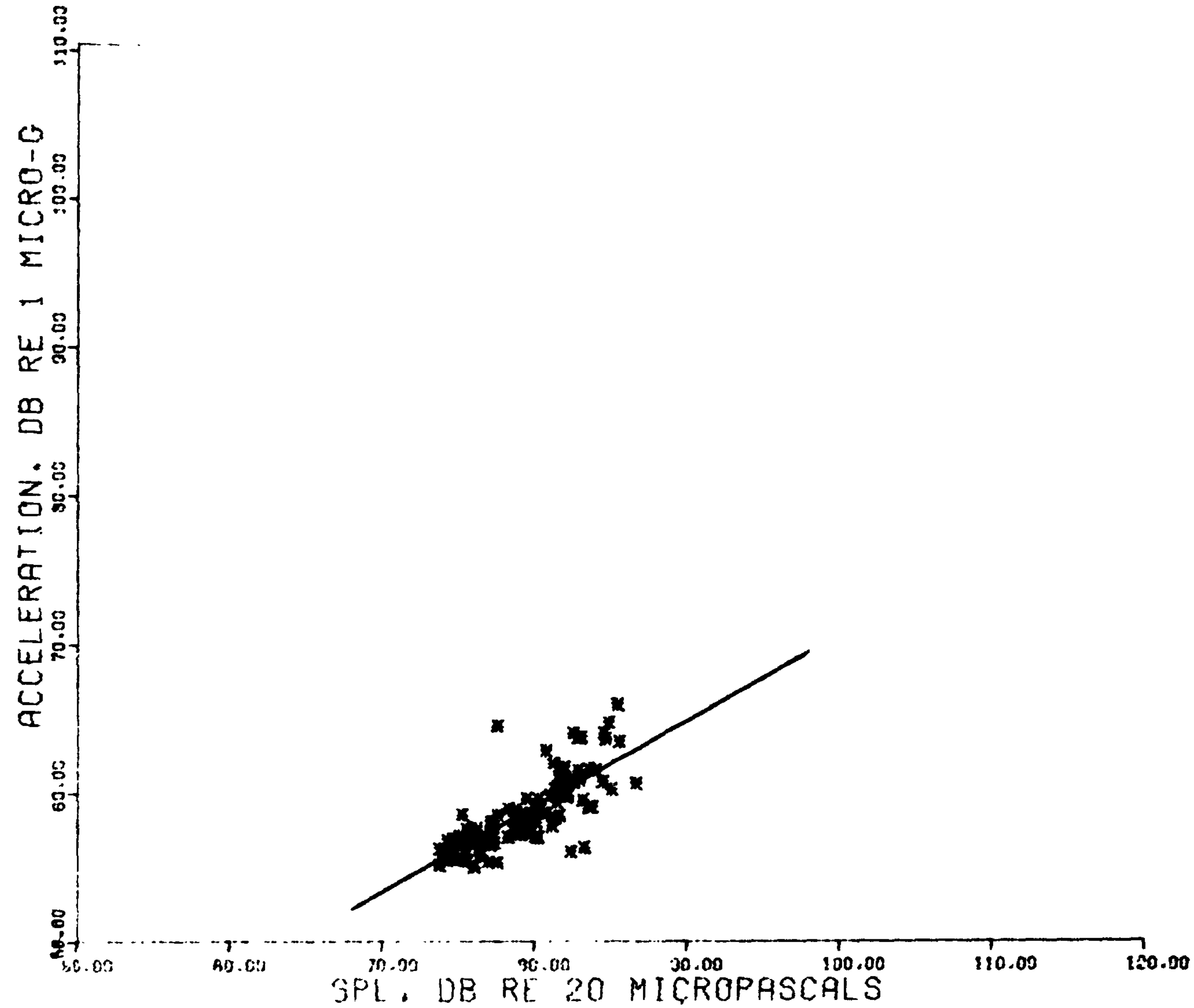

Figure A7.- Sideline wall response signature for 727 flyby.

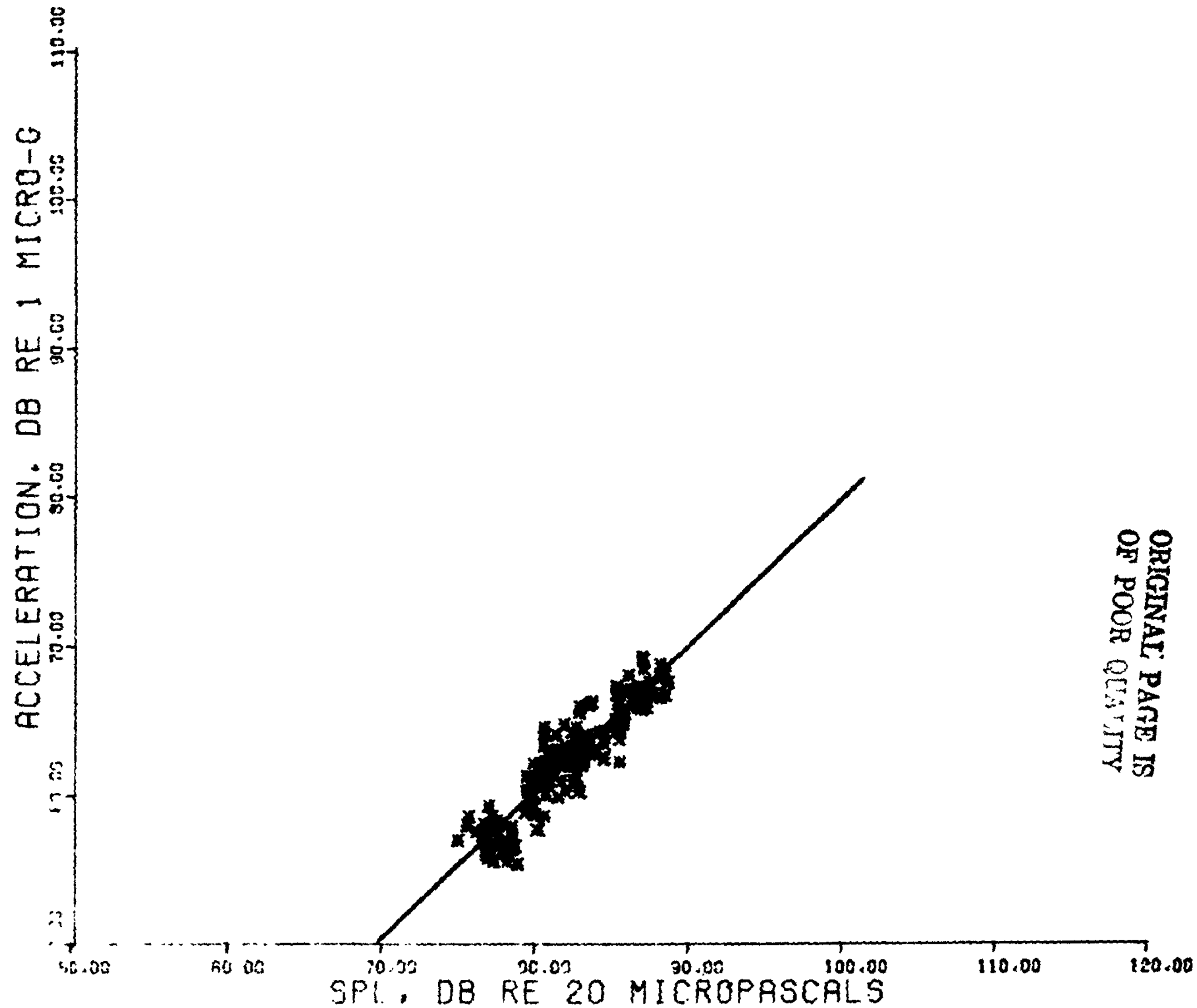

Figure A8.- Sideline wall response signature for 747 flyby.

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15. Supplementary Notes

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16. Abstract

The NASA, in cooperation with the FAA, made measurements of noise-induced building vibrations near John F. Kennedy International Airport on January 18-19 and on February 3-5, 1978, as part of the Concorde monitoring program. Outdoor and indoor noise levels resulting from aircraft flyovers and certain nonaircraft events were recorded at eight homesites and a school along with the associated vibration levels in the walls, windows, and floors at these test sites. In addition, limited subjective tests were conducted to examine the human detection and annoyance thresholds for building vibration and rattle caused by aircraft noise. The following results were obtained:

o Both vibration and rattle were detected subjectively in several houses for some operations of both the Concorde and subsonic aircraft.
- seated subjects detected floor vibrations more readily than wall or window vibrations, which suggests that tactile or whole-body perception dominates other possible detection mechanisms.

o Aircraft noise generally caused more window vibrations than common nonaircraft events such as walking and closing doors. Nonaircraft events and aircraft flyovers resulted in comparable wall vibration levels, while floor vibrations were generally greater for nonaircraft events than for aircraft flyovers.

o The relationship between structural vibration and aircraft noise is:
- linear, with vibration levels being accurately predicted from OASPL levels measured near the structure
- consistent from flyover to flyover for a given aircraft type
- the same for approach and departure operations
- the same for Concorde and conventional jet transports

o Relatively high levels of structural vibration measured during Concorde operations are due more to higher OASPL levels than to unique Concorde-source characteristics.

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