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Acoustic Measurements of F-16
Aircraft Operating in Hush House,
NSN 4920-02-070-2721

Vincent

V. R. MILLER

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September 1981



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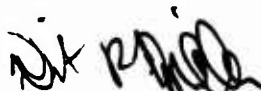
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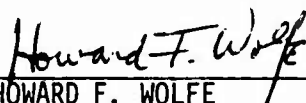
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The primary purpose of this test program was to measure the acoustic environment in the hush house facility located at Kelly Air Force Base, Texas, during operation of the F-16 aircraft to ensure that aircraft structural acoustic design limits were not exceeded. The acoustic measurements showed that no sonic fatigue problems are anticipated with the F-16 aircraft aft fuselage structure during operation in the hush house. The measured acoustic levels were less than those measured in an F-16 aircraft water-cooled hush house at Hill AFB, but were increased over that measured during ground run-up. (over)			

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→ It was recommended that the acoustic loads measured in this program should be specified in the structural design criteria for aircraft which will be subjected to hush house operation or defining requirements for associated equipment. ↗

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I. INTRODUCTION

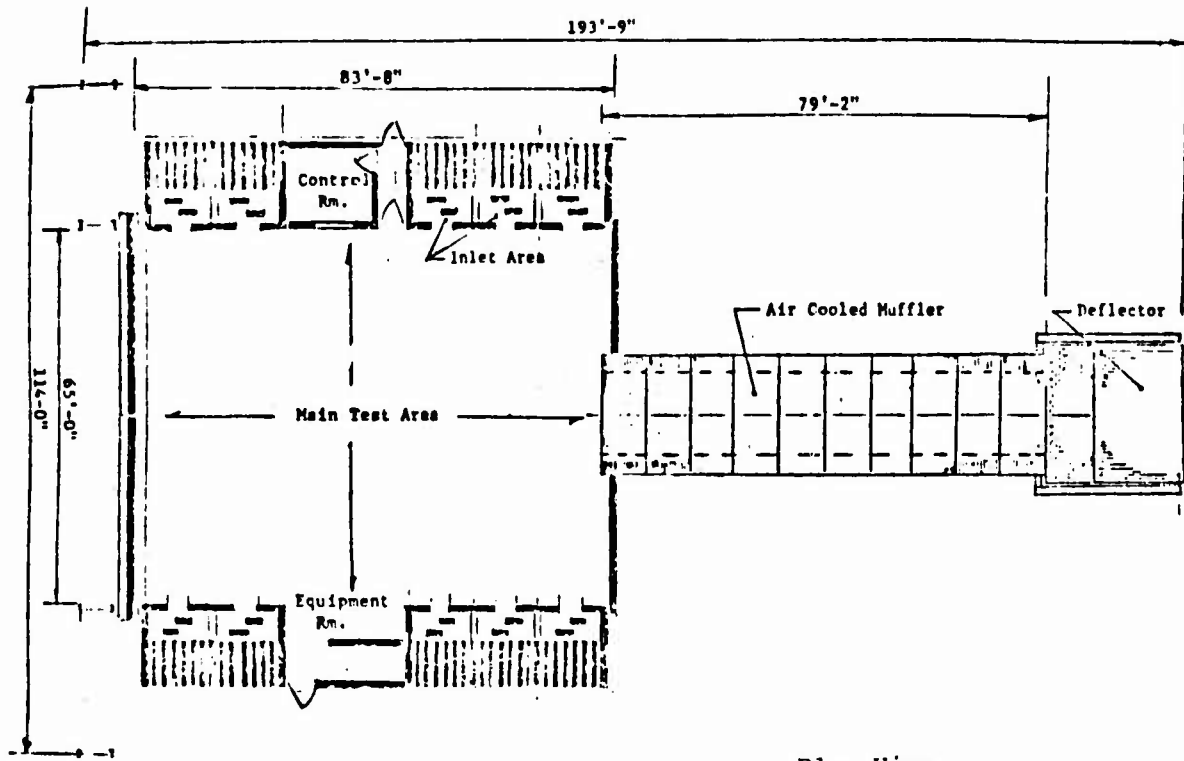
An Aero-Systems Engineering (ASE) hush house, NSN 4920-01-070-2721, was constructed at Kelly AFB, Texas. This hush house is an air-cooled noise suppressor system (NSS) which completely encloses the aircraft for environmental control purposes during ground run-up. The NSS is compatible with all types of USAF fighter aircraft and is also capable of testing uninstalled engines. Enclosing an aircraft in such a manner increases the sound pressure levels on the aircraft structure. Increasing the levels can decrease the fatigue life of the aircraft and compromise its structural integrity if structural acoustic design limits are exceeded. The F-16 Systems Program Office (SPO) requested (Ref. 1) the Structures and Dynamics Division of the Flight Dynamics Laboratory to perform a test program to measure the acoustic environment with the F-16 aircraft operating in the ASE hush house. The primary objective of this effort was to ensure that the acoustic environment within the hush house did not exceed structural design limits and to identify potential problems with the F-16 aircraft structure. Secondary objectives were to measure the sound pressure levels at the top of the hush house deflector, maintenance positions, and near field and compare with other measured data and noise criteria.

A brief description of the hush house is contained in Section II. Section III of this report describes the test, data acquisition, and data reduction procedures used during this program. A discussion of the results is included in Section IV. The conclusions determined from the program are given in Section V with recommendations shown in Section VI. Appendix A shows photographs taken at the test site to document transducer locations, aircraft orientation, etc. Data reduced from the measurements are included in Appendix B.

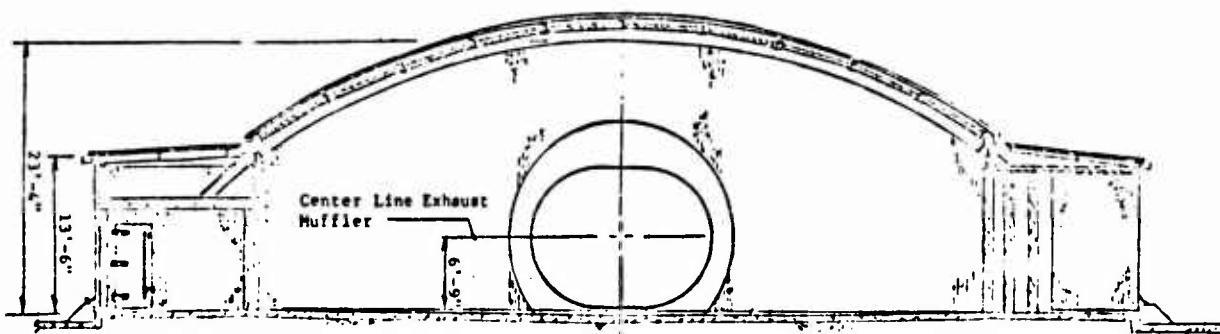
II. DESCRIPTION OF HUSH HOUSE

The hush house which was used during this program is shown in Figure 1. This structure consists of a sound-absorbent hangar with dimensions of approximately 84 by 65 feet (25.6 by 19.8 meter). The surfaces of the hangar were covered with approximately 10,500 square feet (975.5m²) of absorbing panels, 4 inches (10.2 cm) thick with a 20 gauge (0.093 cm) perforated face sheet (304 stainless steel), 16% open area, and filled with 4.8 lb/ft³ (76.9 kg/m³) thermal, fibertype fill. The fiberglass was wrapped in a fiberglass cloth. The hangar fully encloses both uninstalled engines and entire aircraft during ground run-up. The hush house is suitable for testing aircraft of any size and configuration which are geometrically compatible. The aircraft are restrained by tail hooks, wheel chocks, and/or conventional steel cable tie-downs during aircraft run-up. This hush house is also air-cooled which eliminates the need for a water spray system in the muffler.

The inlet area allows large air flows and low air velocity past the aircraft under test. The intake system has a bird screen downstream of which are sound-absorbent baffles arranged as a labyrinth. The aircraft jet exhausts into a muffler. The air-cooled muffler uses the jet engine as large pump. Large volumes of air are pumped through the intake system, over the aircraft and into the muffler to cool the engine exhaust. The muffler is made in sections, each of which consists of several chambers. The inner shell is made of perforated and corrugated 321 stainless steel with 4.5 lb/ft³ (72.1 kg/m³) of Basalt wool fill, 4 inches (10.2 cm) thick, behind the shell. The exhaust gases leaving the muffler are directed vertically by a deflector.



Plan View



Front Elevation

FIGURE 1 Layout of Hush House

III. TEST, DATA ACQUISITION, AND DATA REDUCTION PROCEDURES

The measurements were conducted at Kelly AFB, Texas, on 8 June 1981, with the F-16 aircraft (S/N 780061) operating in the hanger area of the hush house. The F-16 is a high performance fighter aircraft powered by one F100-PW-100 turbofan engine (S/N 703112) which is the major source of ground run-up noise.

The different test runs performed are identified in Table 1. The tests were made with the hangar doors closed. All data were recorded once the engine had stabilized except for the throttle snap runs. A snap is an abrupt movement of the throttle from idle to maximum afterburner (A/8). Estimates of typical engine data are also shown in Table 1. Table 2 lists the surface meteorological conditions during data acquisition.

The basic transducers used during the test program were located as shown in Figures 2 and 3 and Table 3. The test instrumentation consisted of 25 Gulon Industries Model MVA2100 5/8 inch (1.6 cm) microphones. The microphones which were surface-mounted on aircraft structure were located close to the edge of panels to minimize the vibration input to the microphones. The microphones were positioned two inches (5.1 cm) from the surface in question with the microphone diaphragms pointed toward the surface.

The test procedures which were used were as follows:

1. Install the F-16 in the hush house hangar area and locate microphones.
2. Calibrate all data recording instrumentation.
3. Record ambients prior to test runs.
4. Operate engine for 20-25 seconds at each of the conditions shown in Table 1.
5. Edit and review data tapes for quality.
6. Repeat any test condition shown to be deficient from step (5).

TABLE 1. SUMMARY OF TEST RUNS AND ESTIMATED COCKPIT READOUTS OF F-16 AIRCRAFT

Record Number	Engine Power Setting	Core Speed (% RPM)	Fan Turbine Inlet Temperature { ^{°C} / ^{°F} }	Fuel Flow (lbs/hr)/ (kg/hr)
15	Ambient	0	35/95	0/0
16	Idle	62	480/896	850/386
17	Military	91	930/1706	6500/2948
18	Max. Afterburner	91	930/1706	32,900/19,923
19	Snap (Idle to Max. A/B)	--	---	----

TABLE 2. METEOROLOGY

Temperature	35°C /95°F
Bar. Pressure	75.6 cm Hg./29.80 in. Hg.
Rel. Humidity	50%
Wind	
- Speed	9.25 km /hr/5 Knots
- Direction	170 deg.

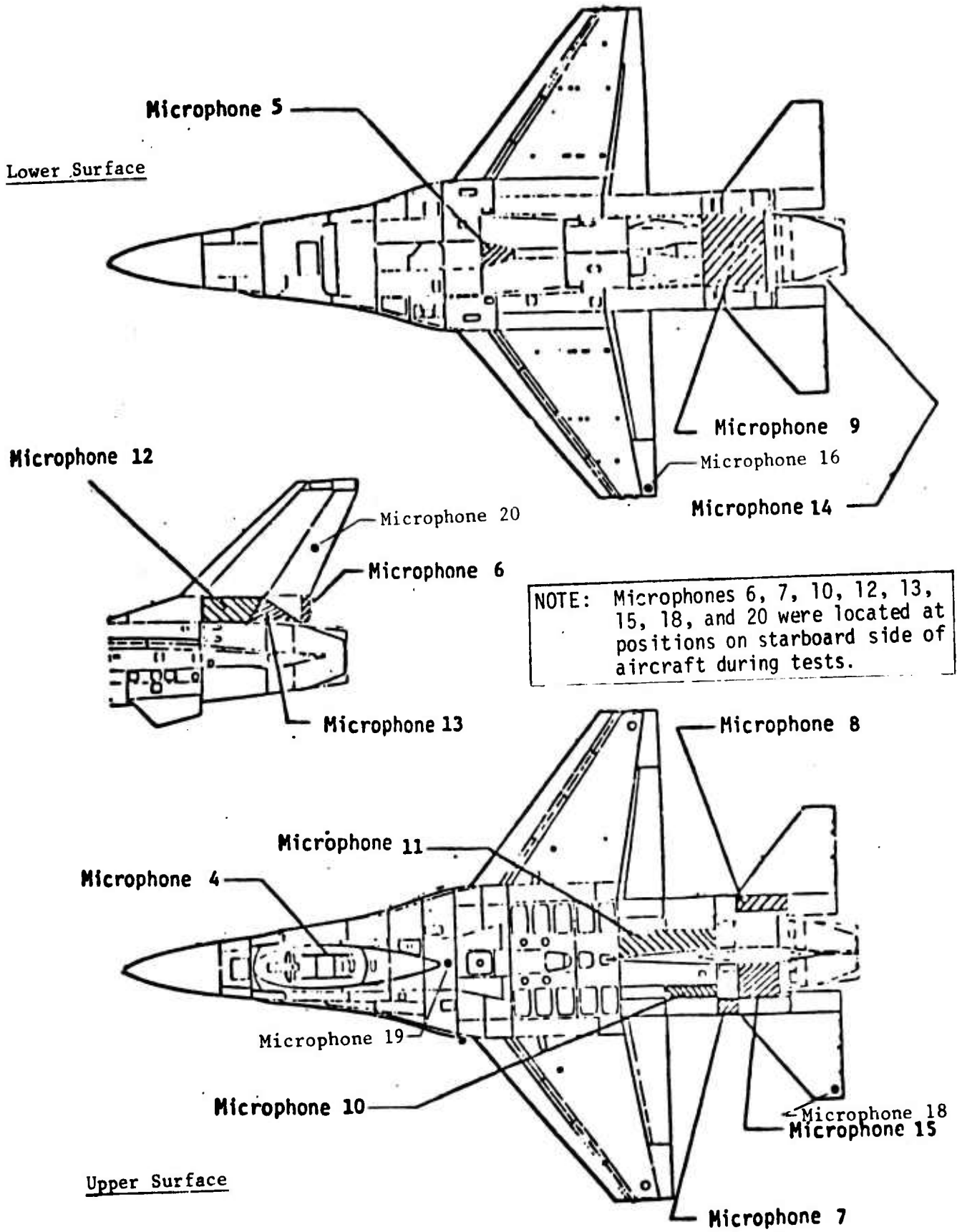


FIGURE 2 LOCATIONS OF MICROPHONES 4-16 and 18-20 on the F-16 Aircraft

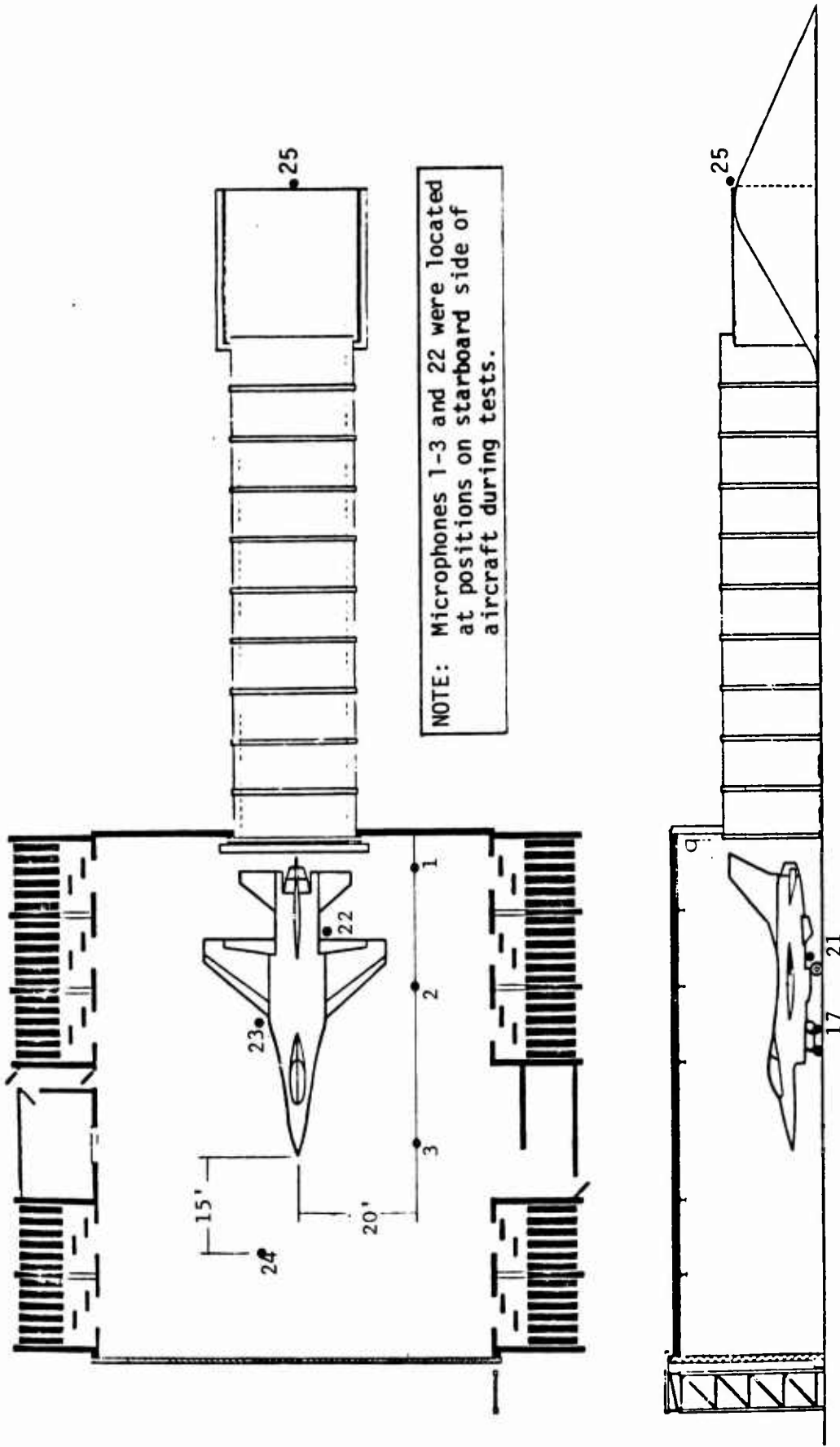


FIGURE 3 Location of Microphones 1-3, 17, and 21-25 Near F-16 Aircraft.

TABLE 3. INSTRUMENTATION LOCATIONS

Microphone	Location
<p>1 2 3 4 5 6</p>	<p>20 foot (6.1m) to port side of aircraft 20 foot (6.1m) to port side of aircraft 20 foot (6.1m) to port side of aircraft Cockpit, closed Lwr. fus. skin aft of ECS dump Rudder act. aft of fairing closure</p>
<p>7 8 9 10 11 12</p>	<p>Upper outbd. fus. skin H.T. act. access panel Engine access door Access cover-upper fus. Upper fus. skin Fiberglas fairing at base of V.T.</p>
<p>13 14 15 16 17 18</p>	<p>Fairing at base of rudder Engine exhaust Aft fus. skin Wing tip-lower Aft of nose gear door H.T. tip-upper</p>
<p>19 20 21 22 23 24</p>	<p>Aft of canopy Middle of rudder Aft of main gear door Leak check Intercom Marshaller</p>
<p>25</p>	<p>Top of hush house deflector</p>

The Flight Dynamics Laboratory's mobile data acquisition van contained the signal conditioning electronics and tape transports used for this test program. A block diagram of the instrumentation is shown in Figure 4. Landlines carry the data signal from each microphone to the van. The signal conditioning equipment is capable of producing either attenuation or amplification in 10dB steps over the range -10 dB to +60 dB. The tape recorders used were Honeywell Model 96 frequency modulation (FM) systems. A time code was produced by a Systron-Donner 8350 time code generator and recorded on one channel of magnetic tape recorder/reproducers.

The microphones were calibrated by means of a Bruel and Kjaer Type 4220 pistonphone. The magnetic tapes which recorded the data from the tests were played back in the laboratory at Wright-Patterson AFB on the Honeywell 96 record-reproduce system. All analyses were obtained using a General Radio 1921/1926 one-third octave band analyzer interfaced with an ITI 4900 A/D system. All analyses were processed by a Raytheon 704 computer interfaced with a Gould 4800 high speed plotter. Figure 5 shows a block diagram of the overall data reduction process.

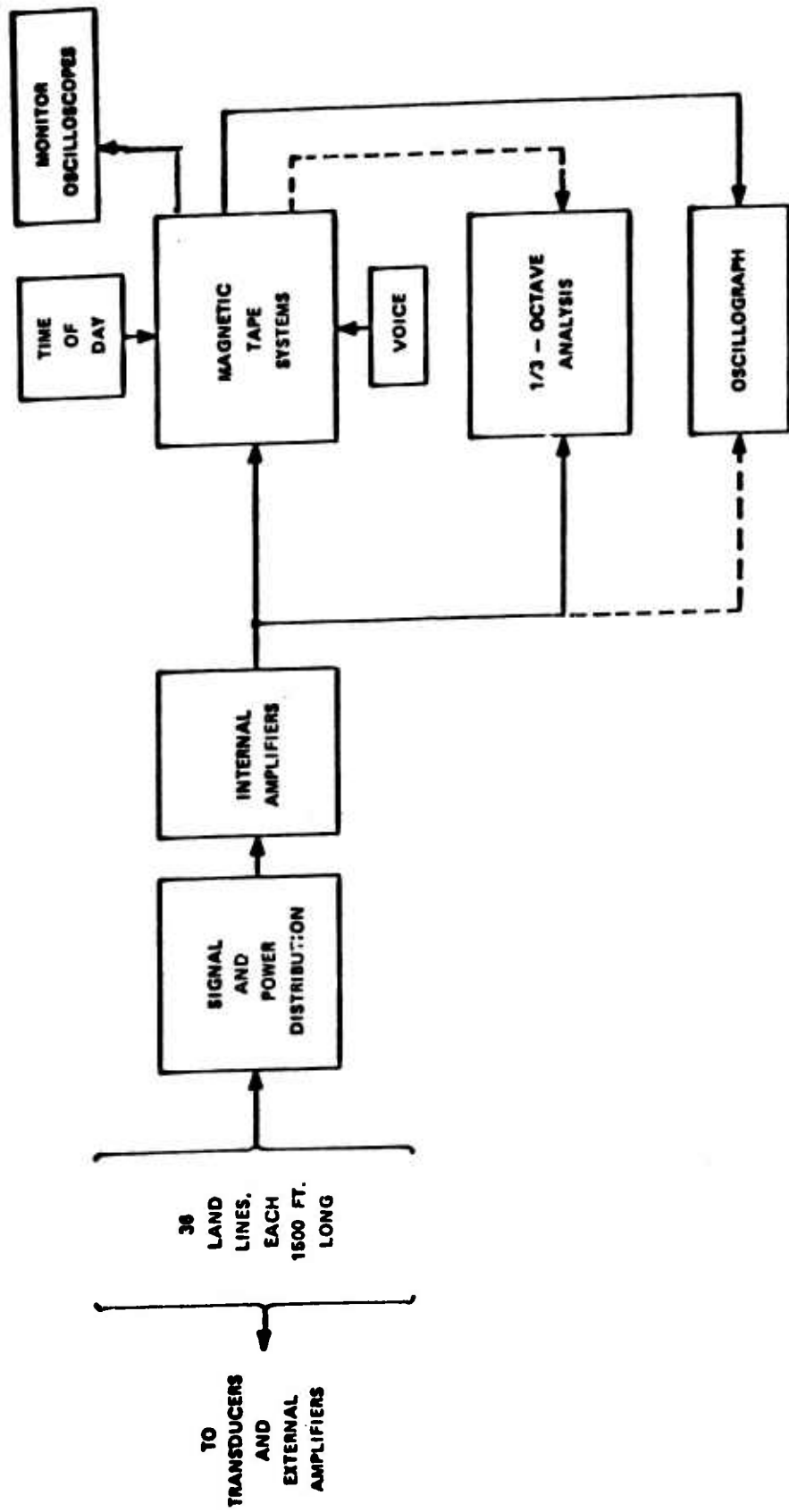


FIGURE 4 Schematic of Data Acquisition System

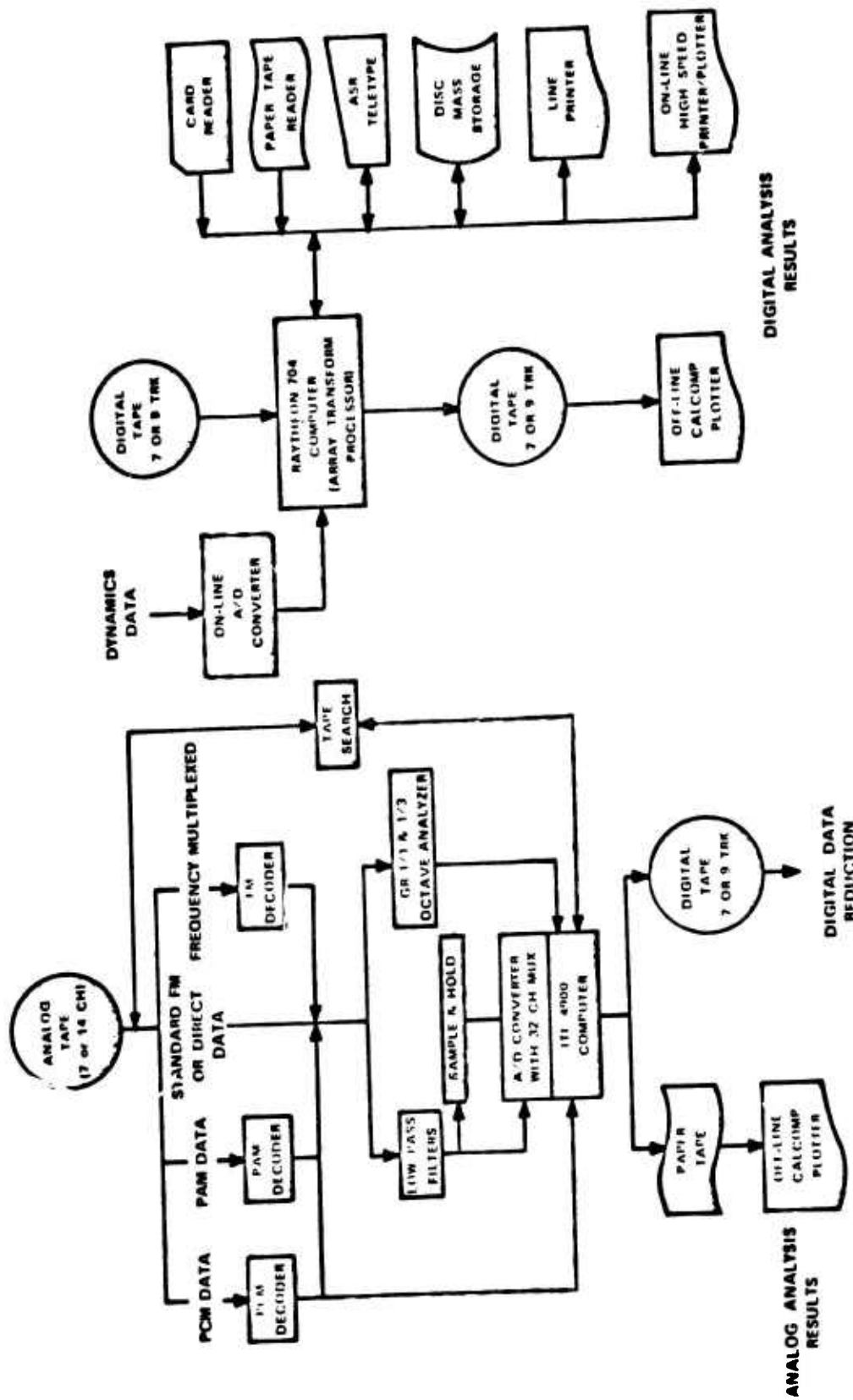


FIGURE 5 Data Reduction Process Diagram

IV. DISCUSSION OF RESULTS

A. Sound Pressure Level Near Aircraft Skin

The octave band sound pressure levels which should not be exceeded for microphones 6 through 15 are reported in USAF Specification ENEG-76-005B (Ref 2) and shown on Table 4. Levels much greater than those shown in this table could cause sonic fatigue problems with the aircraft structure. Octave band sound pressure levels for microphones 6 - 15 are plotted in Figure 6 along with the allowable levels from Table 4. This figure shows that the measured sound pressure levels with the engine at maximum afterburner (Record number 18, see Table 1) are, for the most part, well below the maximum allowable noise levels. Ref 3 also stated that the sound pressure levels at the aft end of the aircraft must not exceed 136 dB in the 250 hertz octave band. This requirement is also satisfied. Consequently, no sonic fatigue problems are anticipated with the F-16 aircraft structure during operation in the hush house.

Figure 6 also shows a comparison of octave band sound pressure levels (SPL) with data measured under similar conditions and microphone locations in an existing hush house at Hill AFB (Ref 4). The measured SPLs are 3 to 16 dB less across the spectrum than the Ref 4 data except at one location and frequency (microphone 9, 8,000 hertz). Since the measured SPL are less in the lower frequencies (less than 500 hertz), this could be important from a sonic fatigue and structural response standpoint. Another interesting result occurs when comparing the measured data with data obtained during ground run-up on a concrete pad (Ref 5). Figure 7 shows this comparison for four microphones on the aircraft surface (12, 16, 19, and 20). The SPLs in front of the tail section (microphones 12, 16, and 19) are increased on the aircraft during

Table 4 Sound Pressure Level Limits on F-16 Structure-
dB re 0.00002 Pascal (Ref. 2)

Structure	Octave Band Center Frequencies (Hz)									
	63	125	250	500	1000	2000	4000	8000		
Engine Nozzle	134	141	145	148	150	152	158	155		
Upper Fus Skin F.S. 479-494	136	143	143	145	145	146	146	147		
Lower Fus Skin Aft of ECS Dump	140	145	149	151	154	155	151	151		
Rudder Act Fair Aft Closure	136	140	140	141	143	143	144	144		
Upper Outlet Fus Skin F.S. 446-463	136	145	145	145	145	146	146	147		
H.T. Act Access Cover	141	146	150	152	152	152	152	152		
Engine Access Doors	137	142	146	146	146	147	147	148		
Upper Fus Access Cover 16B6505	137	142	146	146	146	147	147	148		
Upper Fus Skin F.S. 390-400	136	143	145	145	145	146	146	147		
Fiberglass Fairing at Base of V.T.	137	142	146	146	146	147	147	148		
Rudder Act Access Panel	136	140	140	141	143	143	144	144		

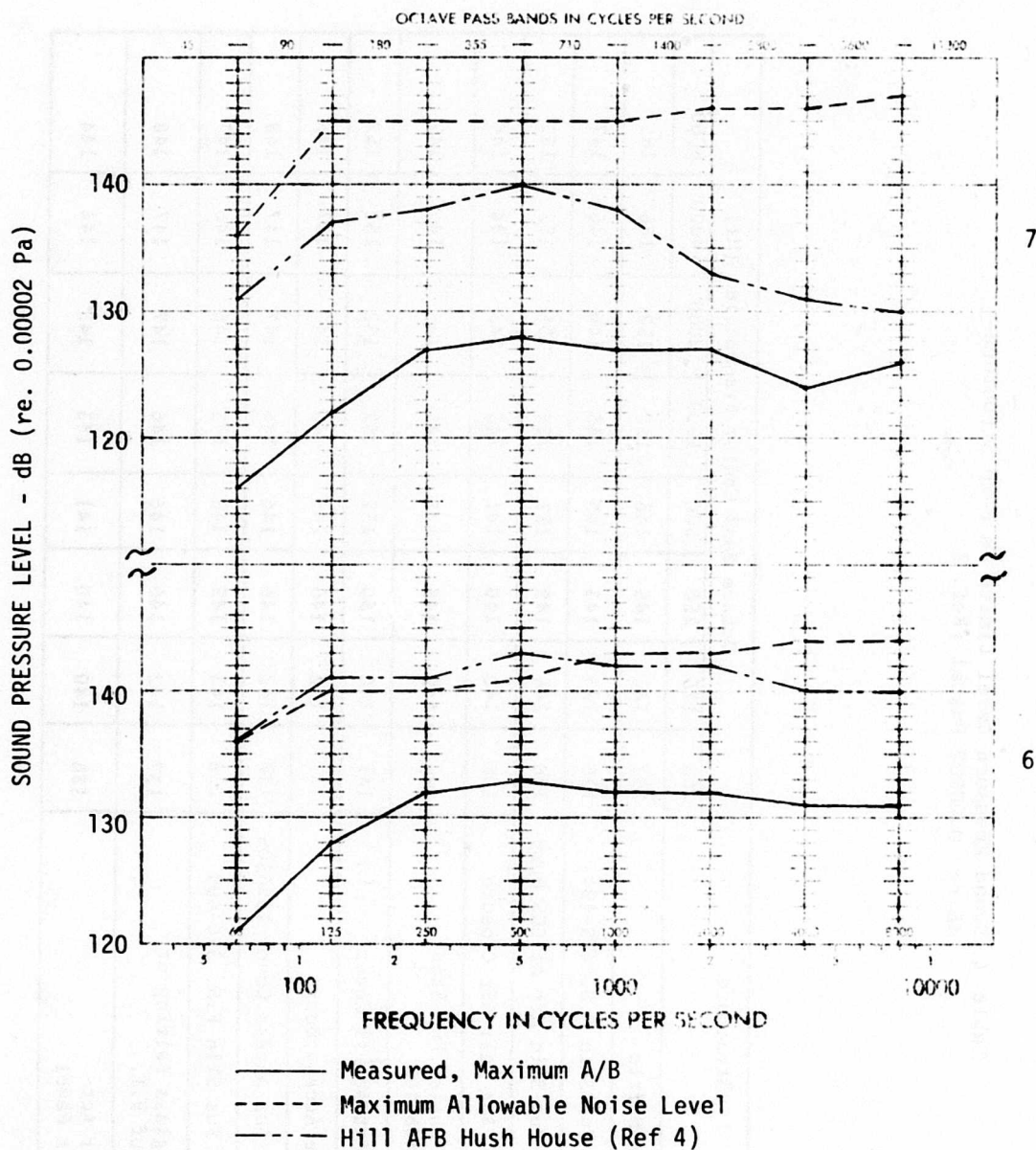


Figure 6. Comparison of Sound Pressure Levels Measured Near F-16 Aircraft Structure and Maximum Allowable Noise Levels

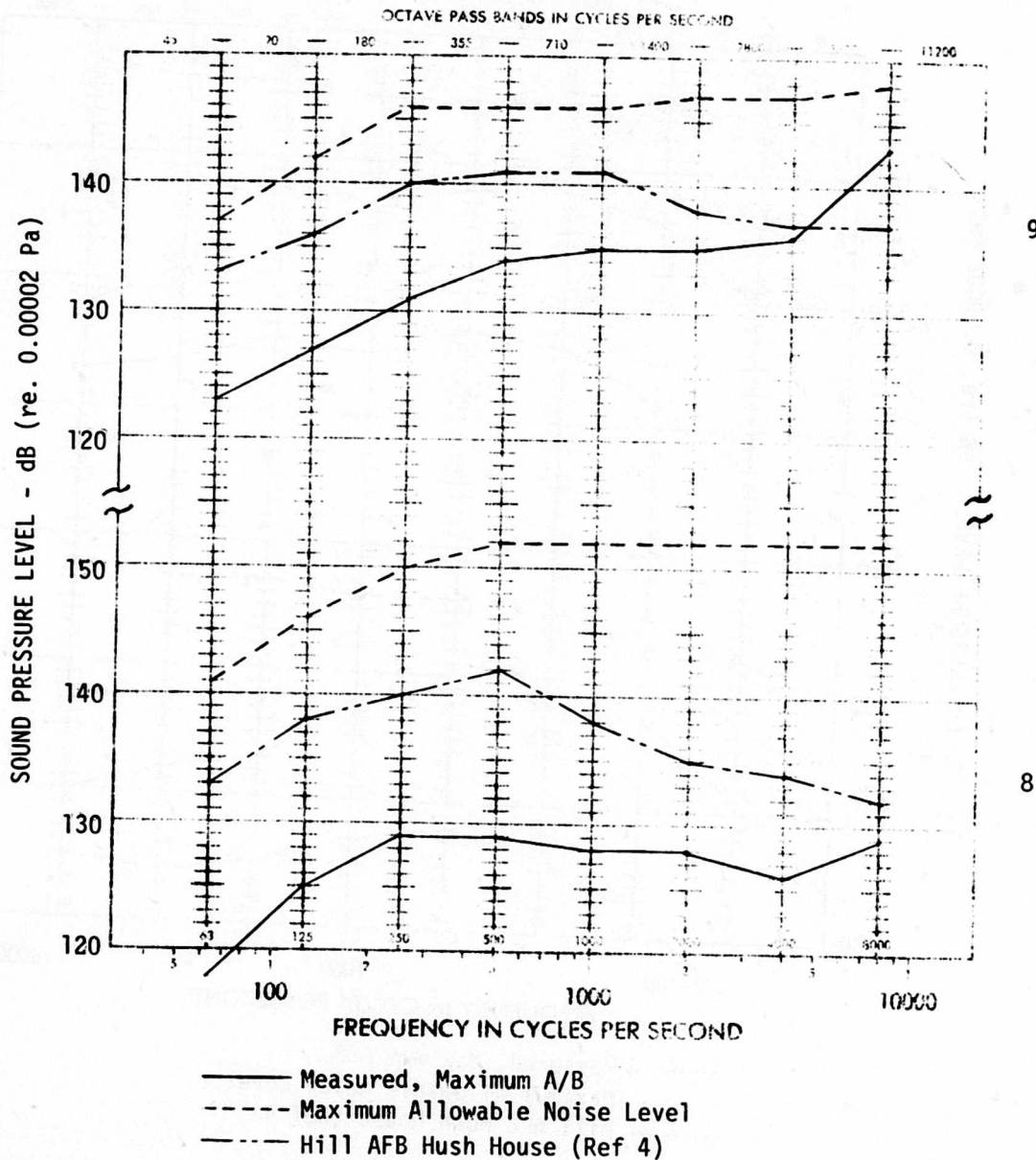


Figure 6. Comparison of Sound Pressure Levels Measured Near F-16 Aircraft Structure and Maximum Allowable Noise Levels (Cont'd)

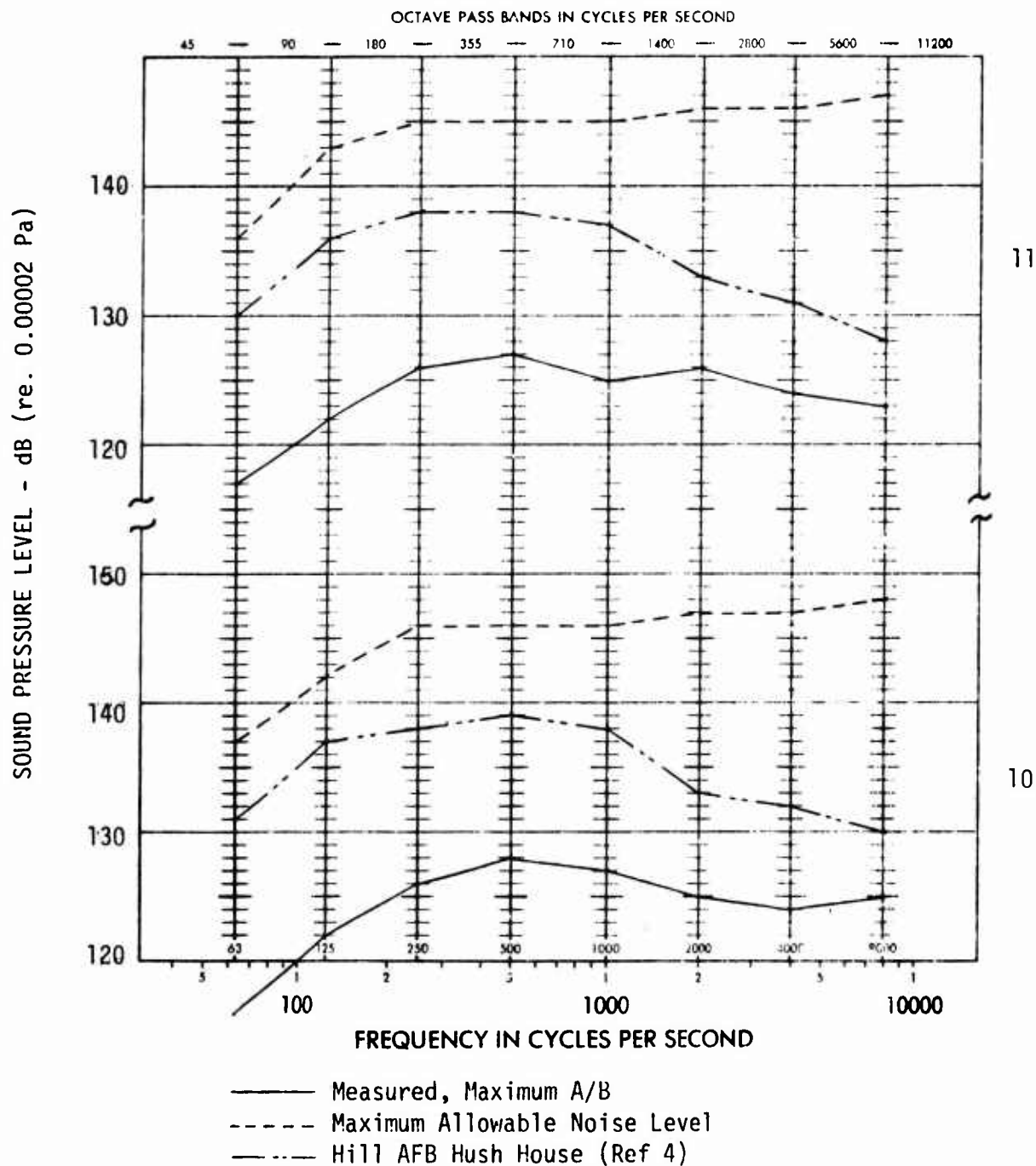


Figure 6. Comparison of Sound Pressure Levels Measured
(Cont'd) Near F-16 Aircraft Structure and Maximum Allowable
Noise Levels

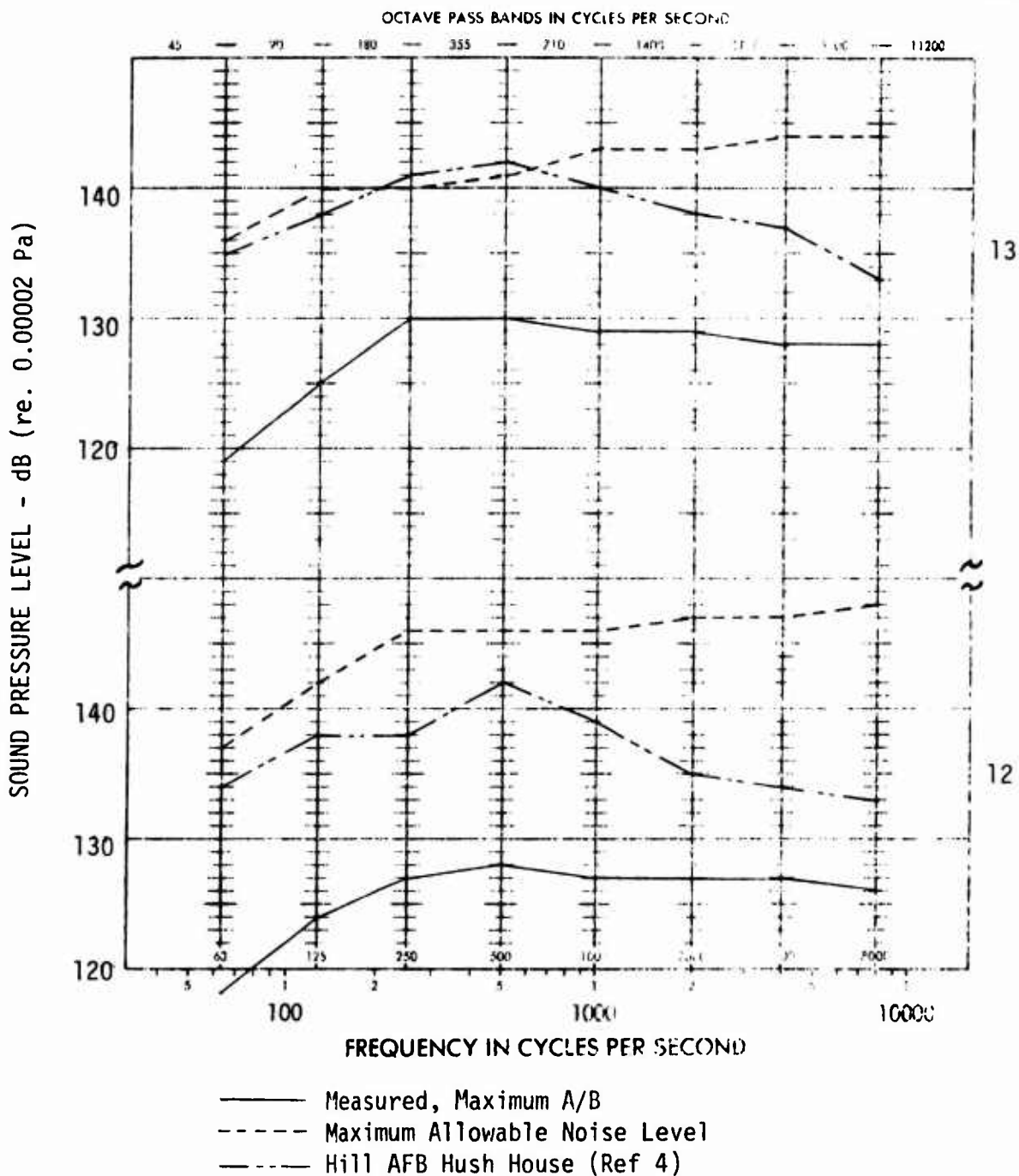


Figure 6. Comparison of Sound Pressure Levels Measured
(Cont'd) Near F-16 Aircraft Structure and Maximum Allowable
Noise Levels

Microphone Location

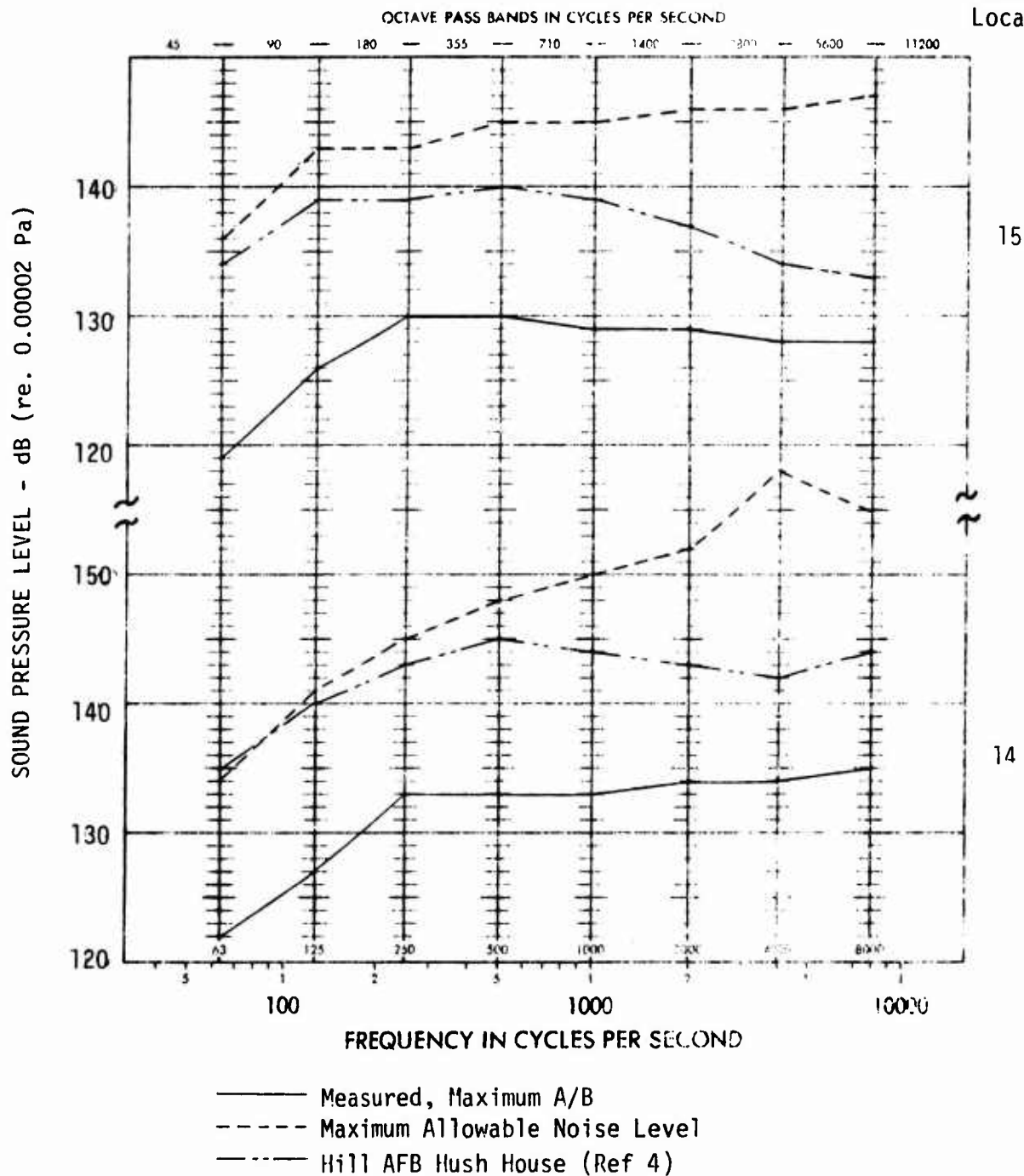


Figure 6. Comparison of Sound Pressure Levels Measured Near F-16 Aircraft Structure and Maximum Allowable Noise Levels (Cont'd)

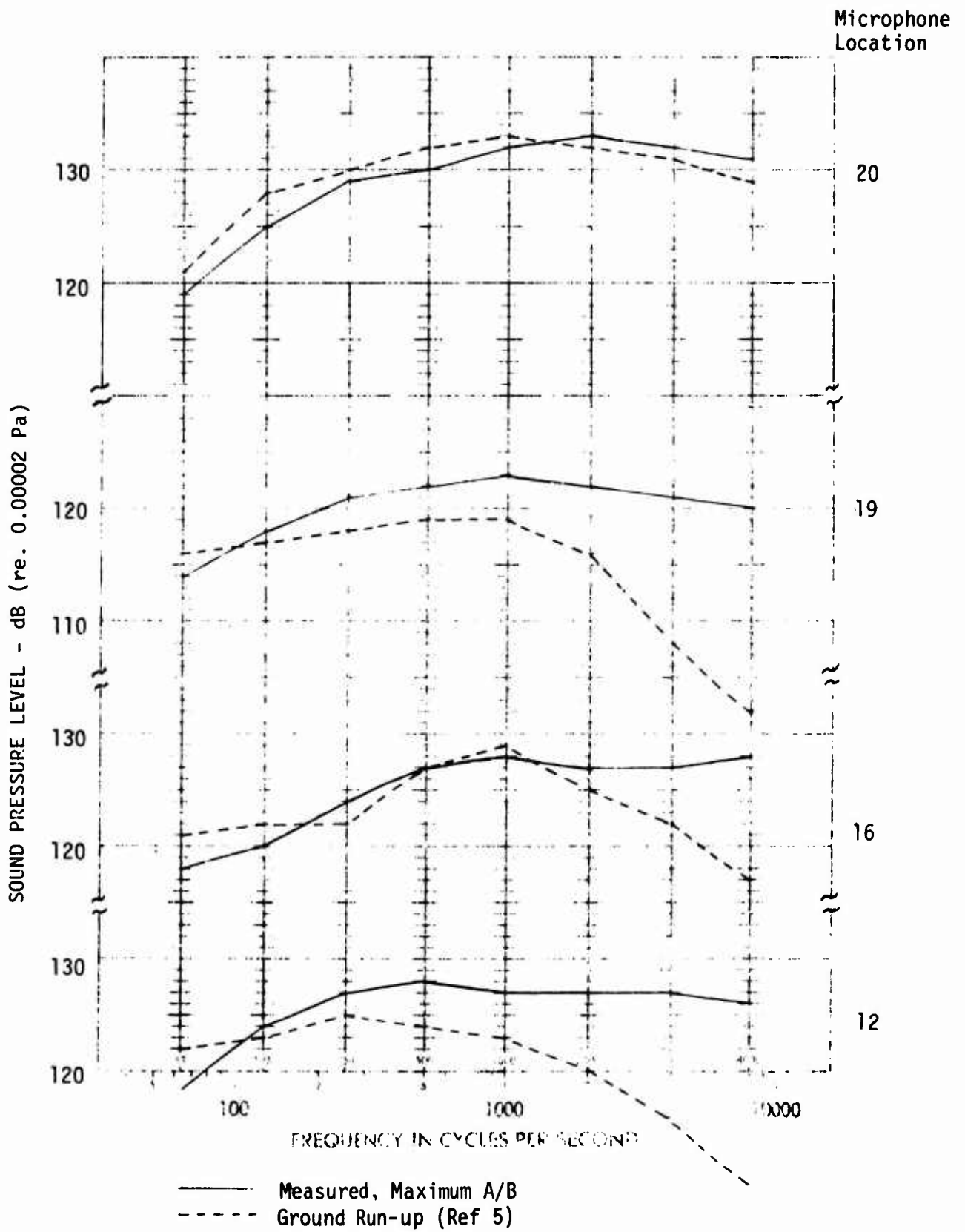


Figure 7. Comparison of Octave Band Sound Pressure Levels Measured in Hush House and Ground Run-up Near F-16 Aircraft Structures

operation in the hush house above approximately 125 hertz. Figure 8 shows increases in SPL in the hush house but not until the higher frequencies (2,000 - 8,000 hertz) are reached. This increase takes place at the aircraft tail section (see also microphone 20 spectra in Figure 7). An increase in the acoustic environment will produce a corresponding dynamic stress increase on the aircraft structure. If the SPL increase is assumed to be the same in a narrowband as the octave band, and is 3 dB (midway between the 1 to 5 dB mentioned above), the stress will be increased by a factor of 1.4. This stress increase for a typical aluminum stiffened panel will decrease the life of the structure. These increase loads should be considered in the structural design criteria for aircraft which are subjected to hush house operation.

Increasing the sound pressure levels can also cause problems with equipment and avionics. Equipment on-board the F-16 aircraft may not be qualified to the sound pressure levels reached during hush house operation and may be sensitive to acoustic excitation. The equipment could respond in such a manner that would modify or possibly disrupt its mode of operation or even result in mechanical failure or fatigue. F-16 equipment qualification levels should be checked against the increases in the sound pressure levels shown here to determine if the equipment has been qualified for this type of operation.

Figure 8 also shows that the measured hush house sound pressure levels are less than those measured during ground run-up in an existing F-16 water-cooled noise suppressor (Ref 6). These decreases exist across the entire spectrum and vary from 5 to 15 dB.

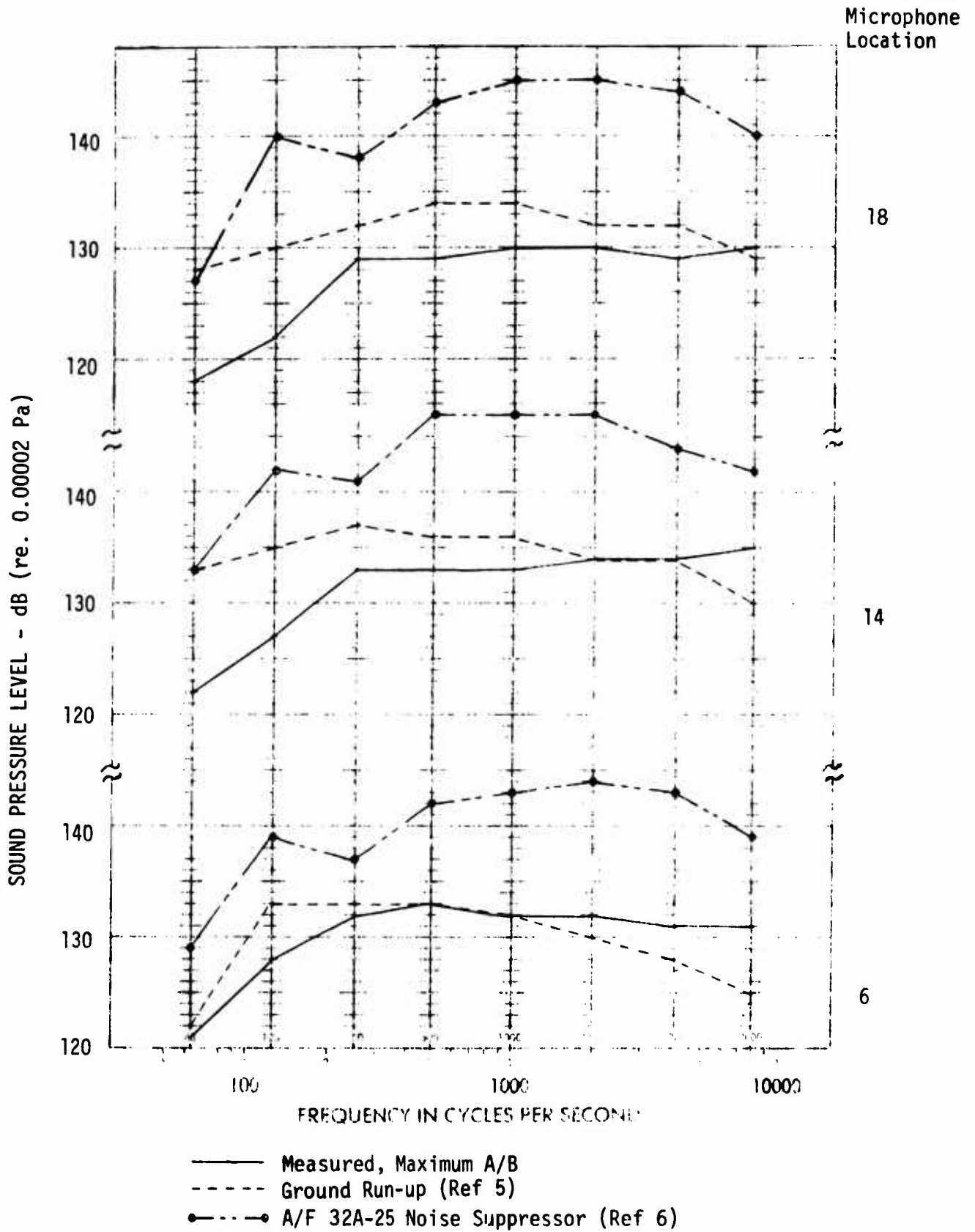


Figure 8. Comparison of Octave Band Sound Pressure Levels Measured in Hush House, Ground Run-up and A/F 32A-25 Noise Suppressor Near F-16 Aircraft Structure

B. Sound Pressure Level at Top of Hush House Deflector and Far Field

The sound pressure level at the end of the hush house muffler was evaluated using microphone 25 which was located at the jet exit deflector ramp, as shown in Figure 3. This microphone was located as close to the deflector as possible so that the measured levels were not affected by extraneous noise sources. Figure 9 presents a one-third octave band spectra for microphone 25 with the engine operating at military and maximum afterburner power (A/B). The muffler is attenuating all but the very low frequencies as seen by the spectrum shape. The overall sound pressure level at A/B is approximately 8 dB higher than military power. This increase is consistent with that measured at locations in the hangar area.

The data from microphone 25 can be used to extrapolate the sound pressure levels to positions 250 feet (76.2 m) away from the deflector. Extrapolating the max A/B SPLS of Figure 9 to 250 feet (76.2 m) the SPLS are shown in Figure 10. The SPL prediction does not include the effects of atmospheric or terrain absorption, thus giving conservative values. These sound pressure levels do not exceed the values specified for a grade II type of noise suppressor (Ref 7).

C. Sound Pressure Levels at Maintenance Positions and Cockpit

Several different locations were measured in and around the aircraft to determine the noise environment for the personnel stationed in these areas during aircraft tiedown and run-up. These microphones (1, 2, 3, 4, 17, 21, 22, 23, and 24) were positioned at approximately the ear level of the

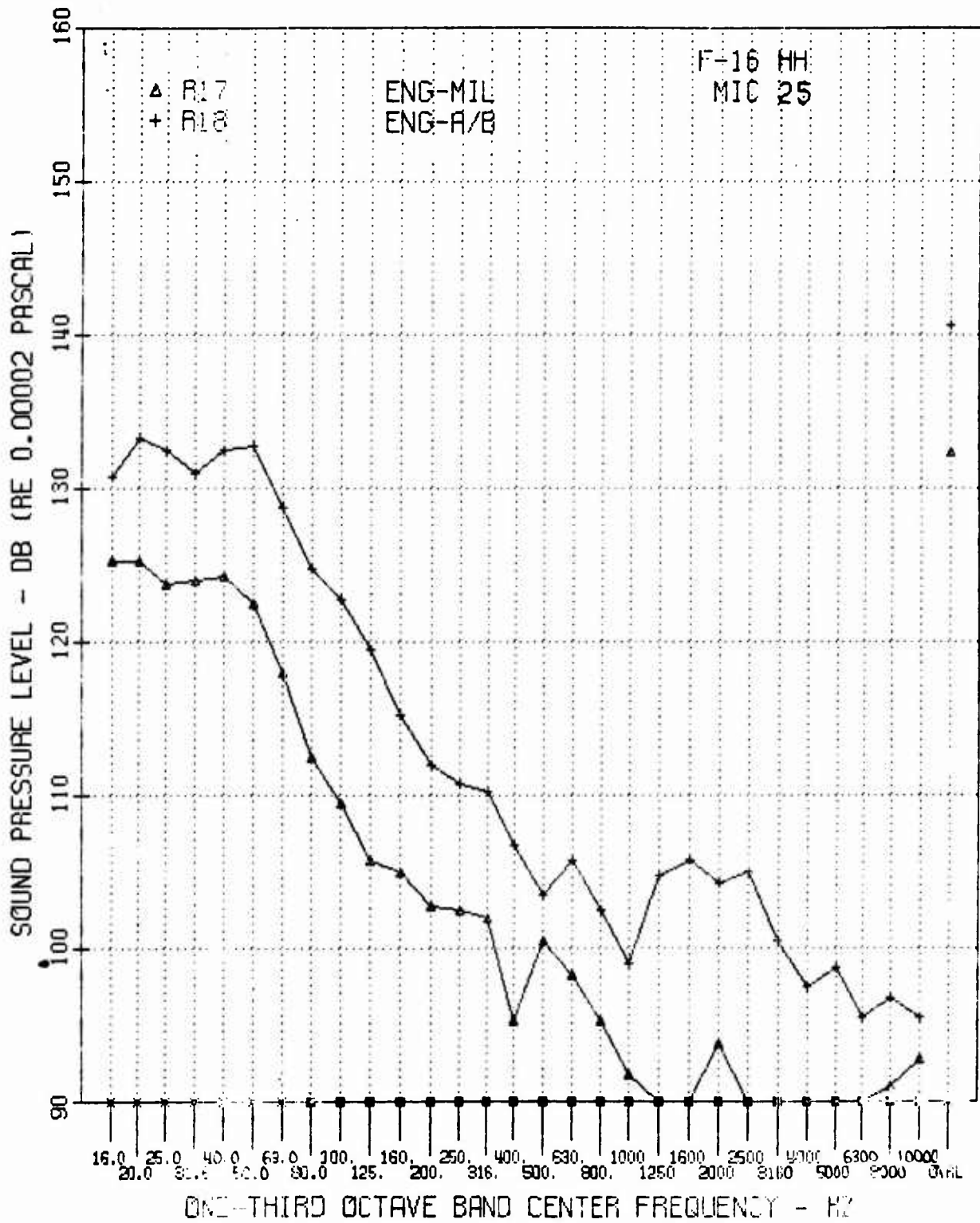


FIGURE 9. One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 17 and 18 - Microphone 25.

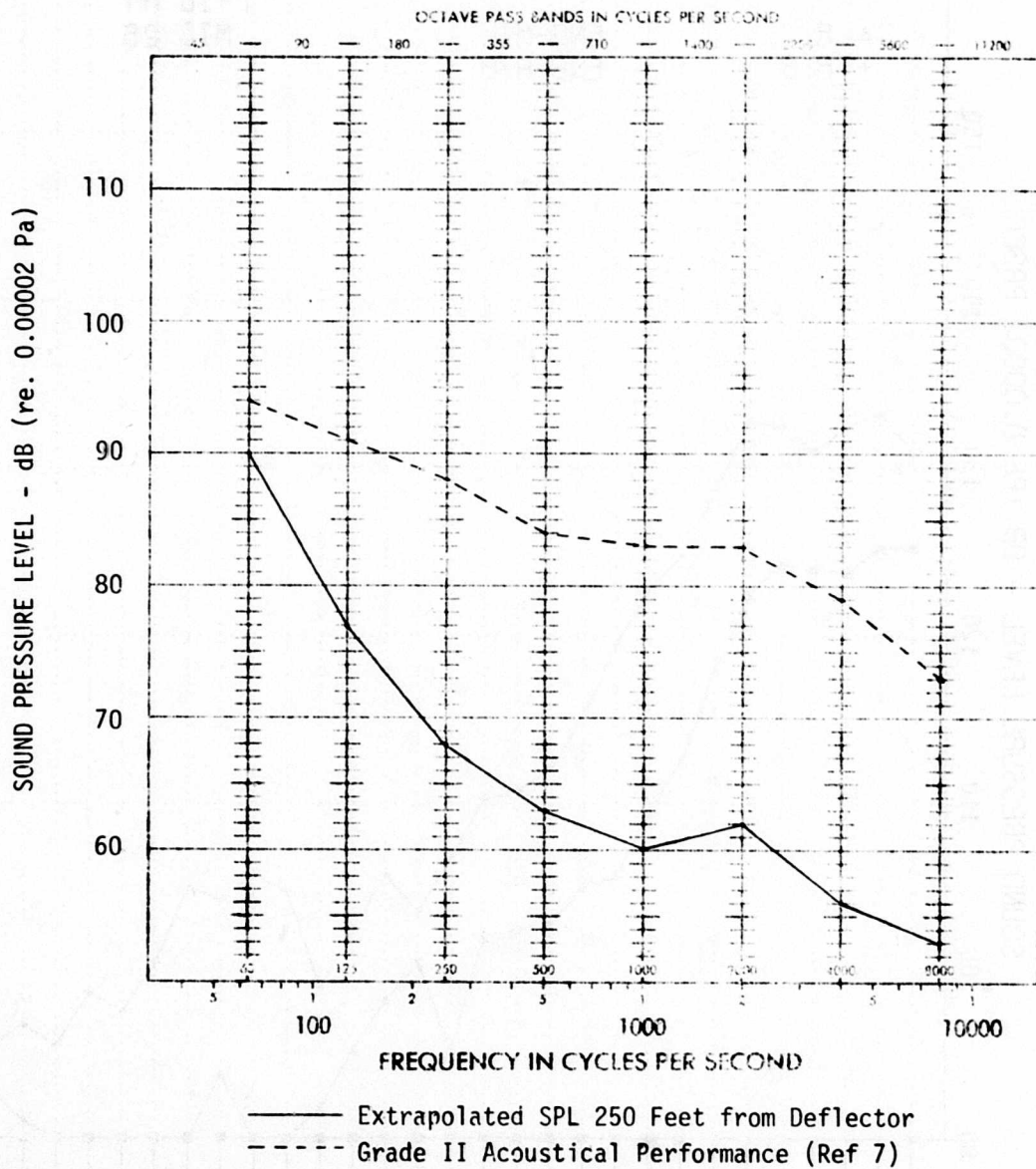


Figure 10. Comparison of Octave Band Spectra Predicted at 250 Feet from Hush House Deflector with Grade II Noise Suppressor Acoustical Performance

personnel. Figure 11 compares the one-third octave band spectra of four of these microphones (21 - 24) with data measured during ground run-up (Ref 8). The measured data are approximately equal to or less than ground run-up except in the higher frequencies (above approximately 2,000 hertz). Table 5 summarizes the data at these nine microphone locations in terms of A-weighted overall SPL to assess the effects of noise on personnel and their performance. These data are with the engine at maximum afterburner (record number 18). Four entries are made in the table. The first entry is for no hearing protection. The other entries are for ear protection commonly used in ground crew environments for which limiting exposure times were provided (Ref 9). Air Force Regulation 161-35 (Ref 10) sets forth the exposure limitations for the protection of hearing in terms of the A-weighted overall sound level and length of time exposed daily. Table 5 shows that some form of ear protection should be required at all locations. The amount of protection ultimately needed will be a function of the location and exposure time. The ground communication unit should probably be adequate for most situations.

Data were also recorded in the aircraft cockpit with the engine at military power. This data are shown in Figure 12 along with ground run-up measurements reported in Ref 11. Note that the measured data are less than the ground run-up SPL in three octave bands. Also plotted on this same figure is the 120 minute exposure limit as listed in MIL-S-008806B (Ref 12). This exposure time limit was not exceeded for the data which were recorded.

D. Near Field

The noise environment at positions to the side of the aircraft (microphones 1 - 3, see Figure 3) are summarized in Figure 13. These locations

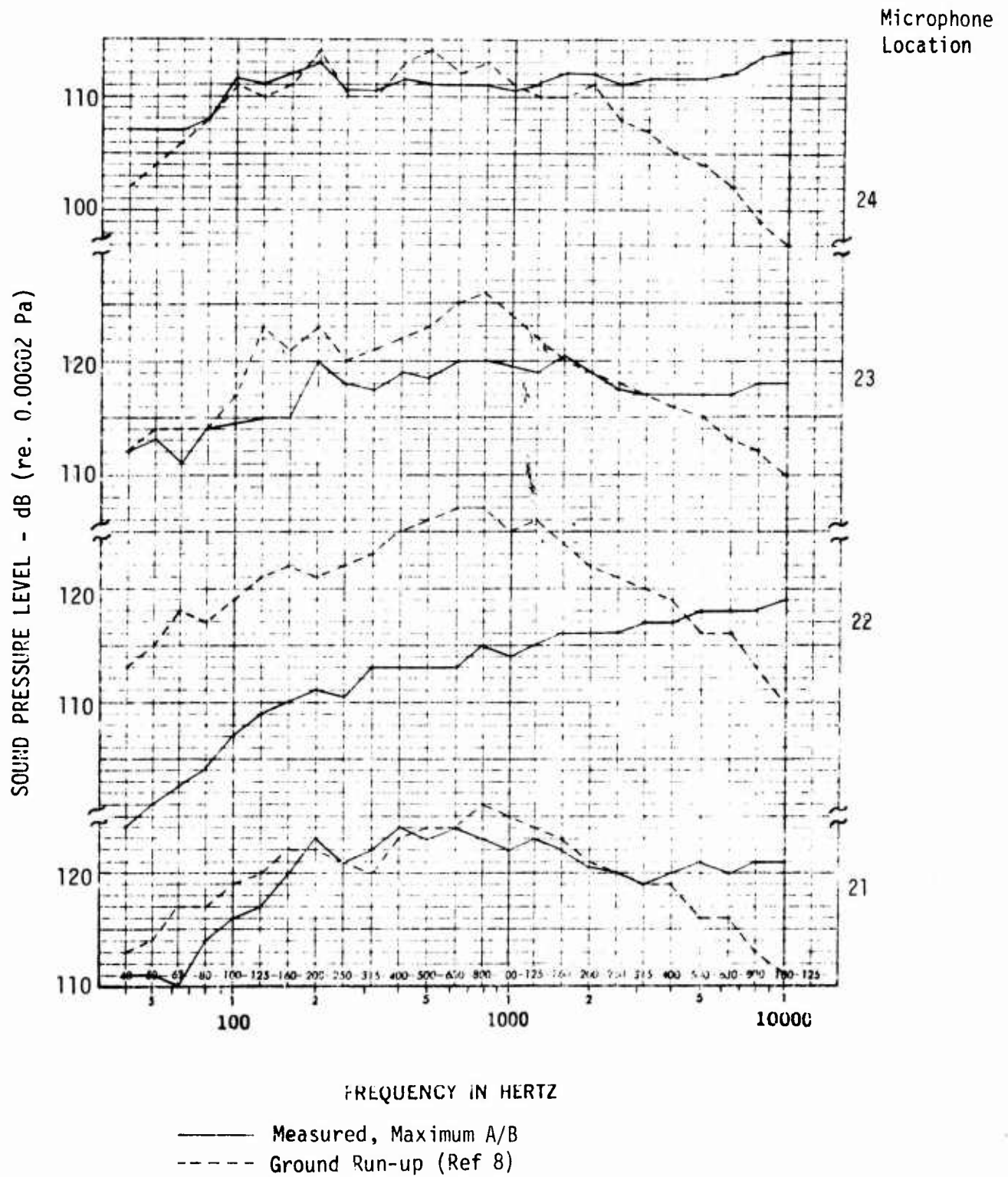


Figure 11. Comparison of One-Third Octave Spectra Measured in Hush House and Ground Run-up at Maintenance Positions

TABLE 5 MEASURE OF HUMAN NOISE EXPOSURE DURING F-16 AIRCRAFT
ENGINE OPERATION AT MAXIMUM AFTERBURNER

Type of Protection (from Ref 8)	A-Weighted Overall Sound Level, dBA*/Maximum Permissible Time, Minutes											
	Mic 1	Mic 2	Mic 3	Mic 4	Mic 17	Mic 21	Mic 22	Mic 23	Mic 24			
No Protection	135/P	132/P	126/P	106/11	133/P	135/P	128/P	130/P	123/P			
Minimum QPL Ear Muffs	111/4.5	108/7.5	102/21	82/679	109/6	111/4.5	104/15	106/11	99/36			
H-133 Ground Communication Unit	107/9	104/15	98/42	78/960	105/13	107/9	100/30	102/21	95/71			
American Optical 1700 Ear Muffs Plus V-51R Ear Plugs	95/71	92/120	86/339	66/960	93/101	95/71	88/240	90/170	83/571			

* Based on calculated SPL spectrum under protective device

P Additional ear protection required

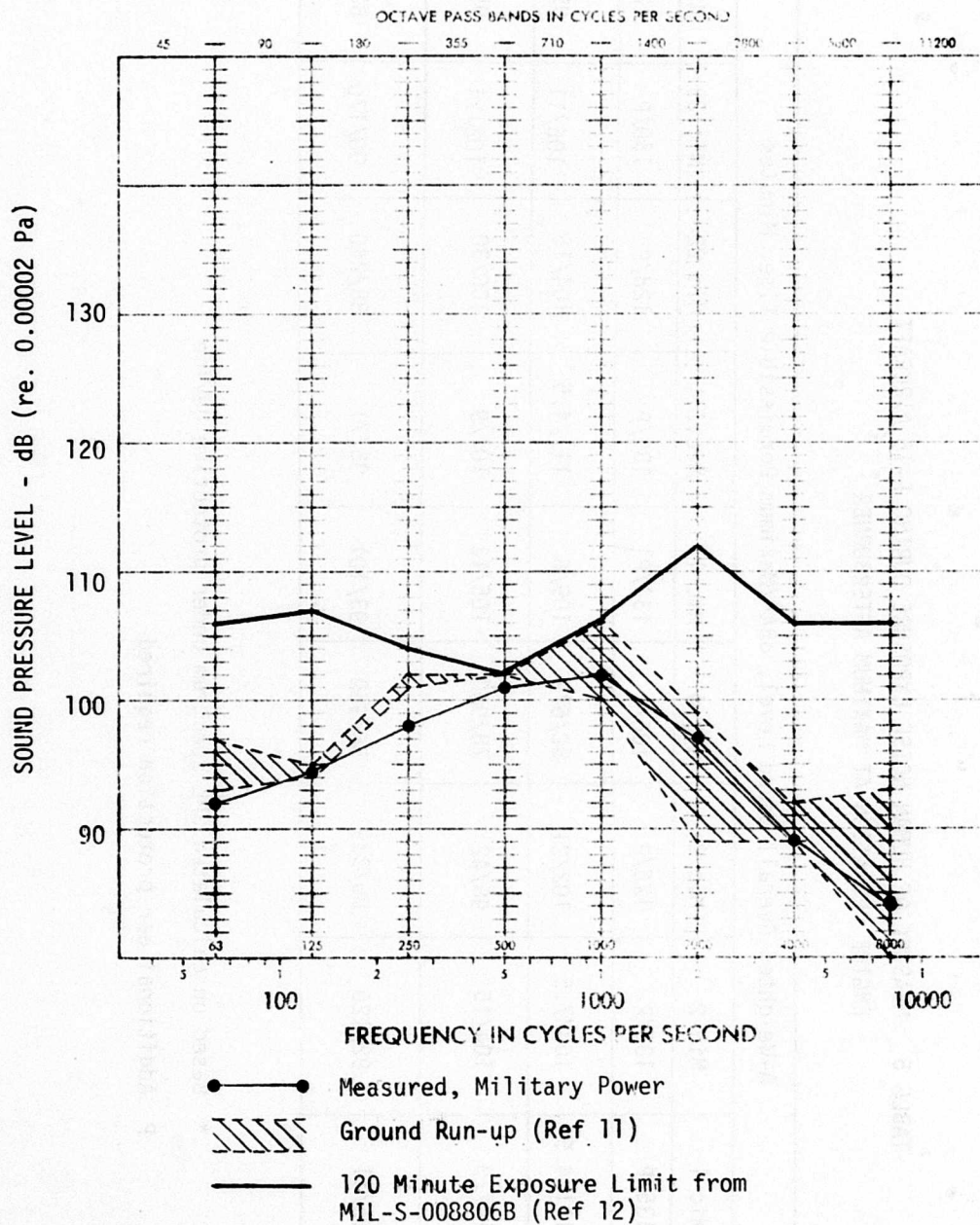


Figure 12. Comparison of Octave Band Spectra Measured in F-16 Cockpit Hush House and Ground Run-up with Exposure Limit from MIL-S-008806B

are major maintenance positions where personnel often are stationed during normal trim run-up operations. This figure includes the measured data as well as similar locations from ground run-up (Ref 8). Note that the measured hush house SPLs are greater in the higher frequencies than during ground run-up and lesser in the lower frequencies. This same trend also applied to the SPL measured near the aircraft skin.

Another way to compare the noise environment in the hush house to that existing when the aircraft is operated during ground run-up is to compute the average SPL from the data for microphones 1, 2 and 3 in Figure 13. The average SPLs inside the hush house, together with their ranges, are given in Figure 14, where they may be compared directly with the average SPL measured during ground run-up. The range of SPL in the hush house data is relatively small. The average SPL is less than free field below 2,500 hertz, but it is greater above 2,500 hertz.

An investigation was made to determine the noise field within the hangar area when the engine was operated at maximum afterburner. The result is given in Figure 15 which presents a series of contours of equal SPL in 2 dB steps for one-half of the hangar area for the overall level and the octave bands from 63 to 8,000 hertz. This figure shows that the sound energy in the hangar area is radiated between the engine exhaust plane and the entrance to the muffler toward the forward part of the hangar area. Energy is reflected back from the muffler to the hangar area together with that generated in the gap between the aircraft engine exhaust and the muffler opening. The SPL increase which was measured in the higher frequencies when moving the aircraft from the open to the hangar area is controlled by this separation distance between exhaust nozzle and muffler.

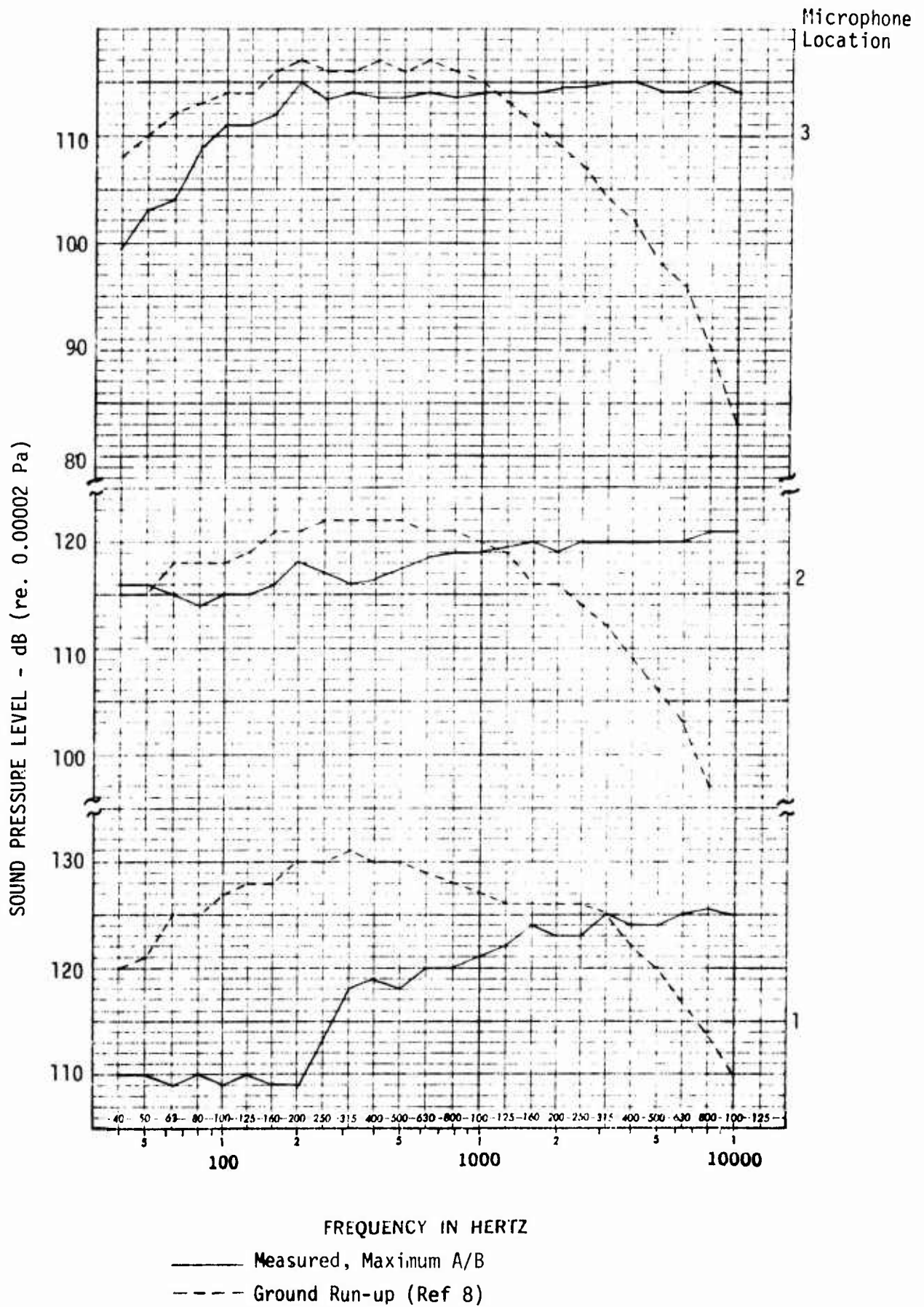


Figure 13. Comparison of One-Third Octave Spectra Measured in Hush House and Ground Run-up

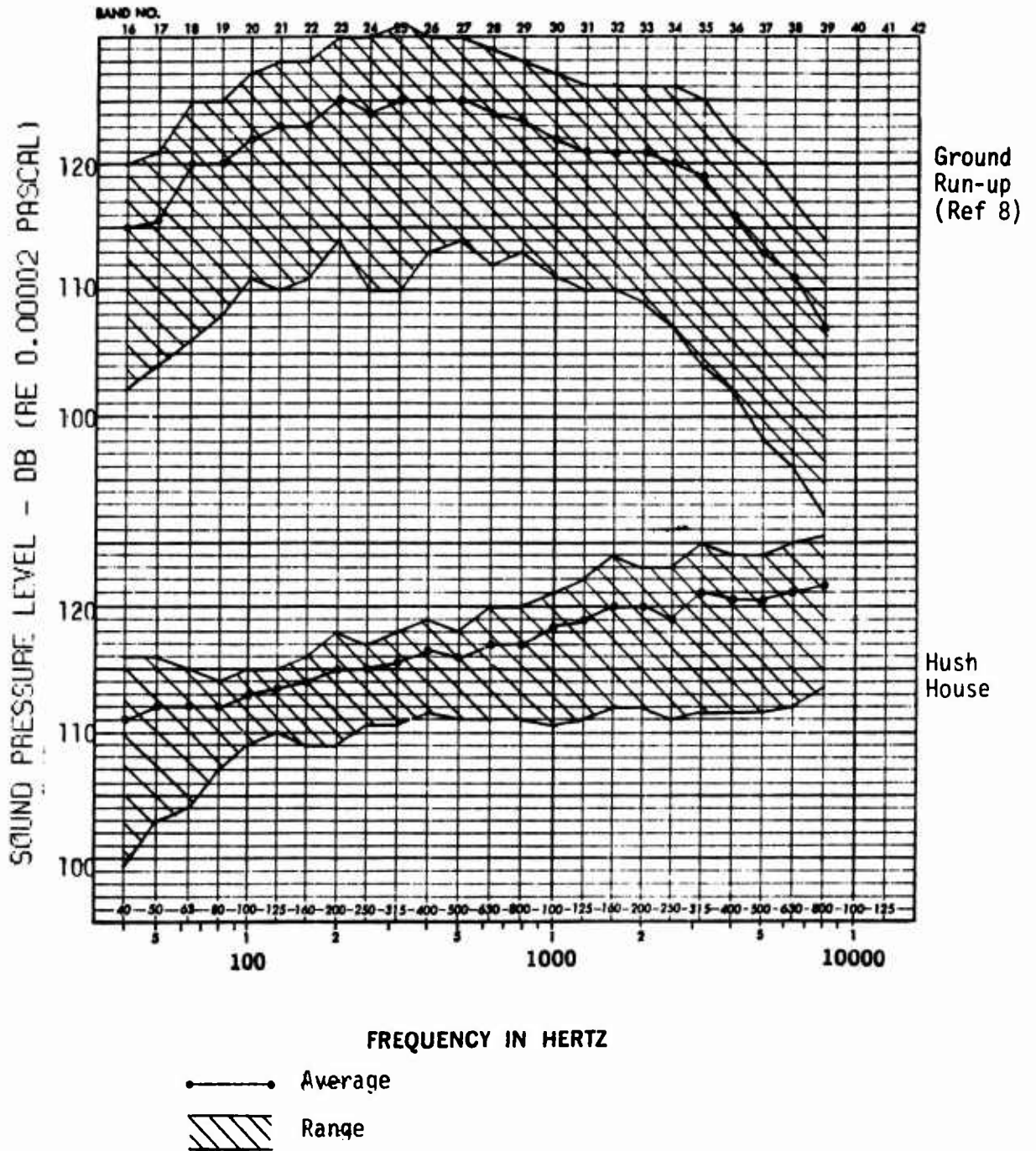


Figure 14. Average SPL and Range for Field Positions in Hush House and Ground Run-up

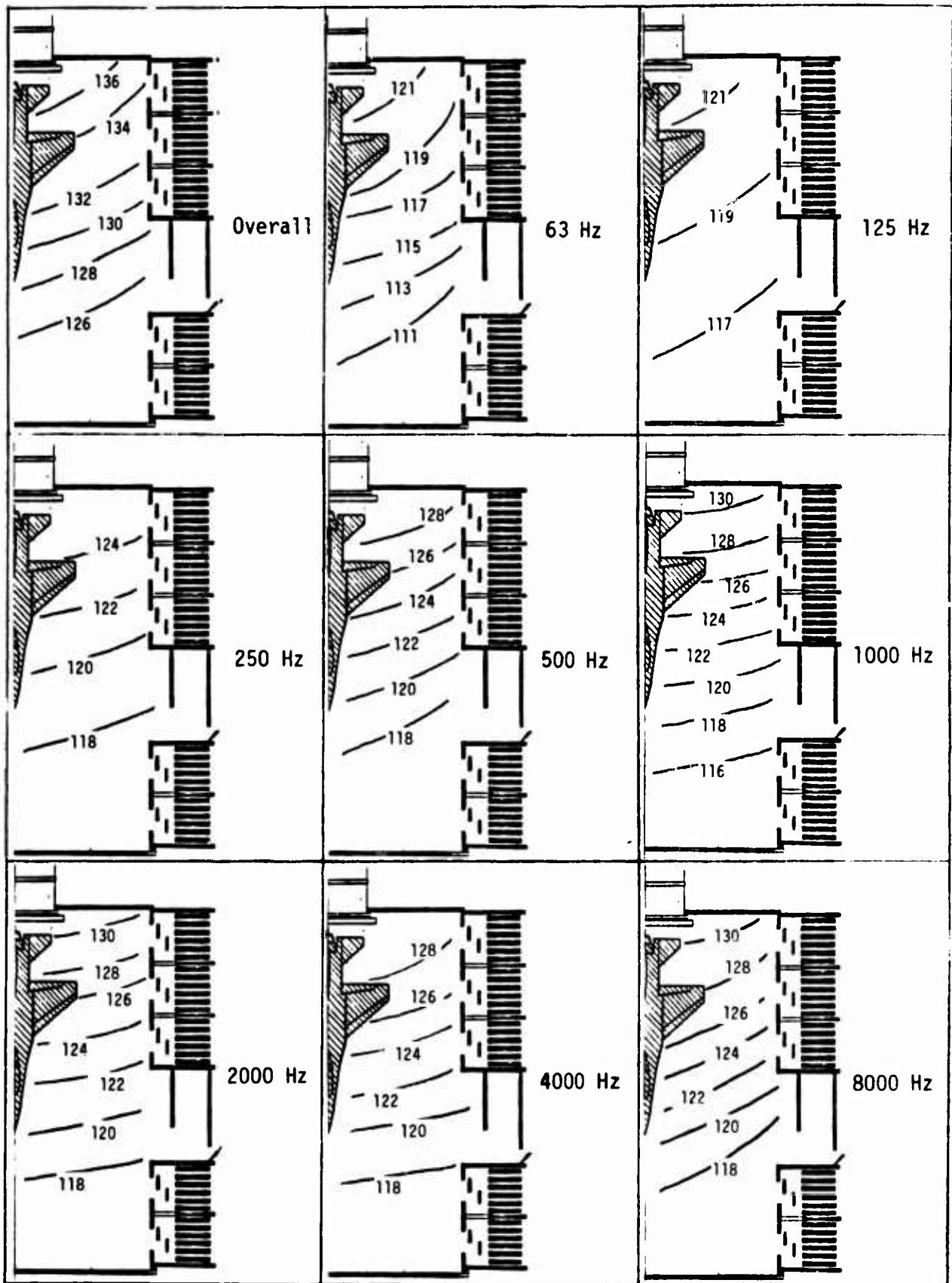


FIGURE 15 Smoothed Overall and Octave Band Contours of Equal Band Sound Pressure Level Inside Hangar Area with F-16 Aircraft Operating at Maximum Afterburner

The higher frequency energy is radiated directly into the hangar area rather than into the muffler. This suggests that the sound pressure levels in the hangar area can be lowered by proper positioning of the engine exhaust relative to the muffler entrance.

Note also that the distance between the SPL contours in the back portion of the hangar area tends to decrease with increasing frequency. This is indicative of the increased absorption at the higher frequencies provided by the acoustically treated hangar walls.

V. CONCLUSIONS

1. No structural damage due to sonic fatigue is anticipated with the F-16 aircraft structure during operation in the hush house hangar area at maximum afterburner power.
2. The sound pressure levels impinging on the F-16 aircraft structure are greater in the hush house in some frequency bands than during ground run-up. This increase could affect equipment, avionics, etc.
3. The sound pressure levels measured on the F-16 aircraft are 5 to 15 dB less than those measured in existing F-16 water-cooled noise suppressors.
4. The hush house muffler attenuates the sound pressure levels radiating to the far field so that the SPL are less than the requirements for a grade II type noise suppressor.
5. Ear protection will be needed for personnel stationed in and around the F-16 aircraft while operating in the hush house.

VI. RECOMMENDATIONS

1. F-16 aircraft equipment qualification levels should be checked against the sound pressure level increases measured in the hush house hangar area to determine if the equipment has been qualified for this type of operation.
2. If vibration qualification test requirements are desired for internal avionics, then response predictions should be made based on the acoustic measurements obtained during this program.
3. Hearing protection should be worn by personnel in close proximity to the F-16 aircraft while operating in the hush house.

APPENDIX A: PHOTOGRAPHS OF TEST SET-UP

Some of the photographs which were taken at the test site are included here. These photographs will serve to give the reader a better idea of where transducers were located, how the aircraft was positioned in the hush house, etc. These photos were furnished courtesy of the Base Photography Branch at Kelly AFB, Mr. M. A. Hart of AFWAL, and Mr. R. J. Reilly, consultant to ASE, Inc.

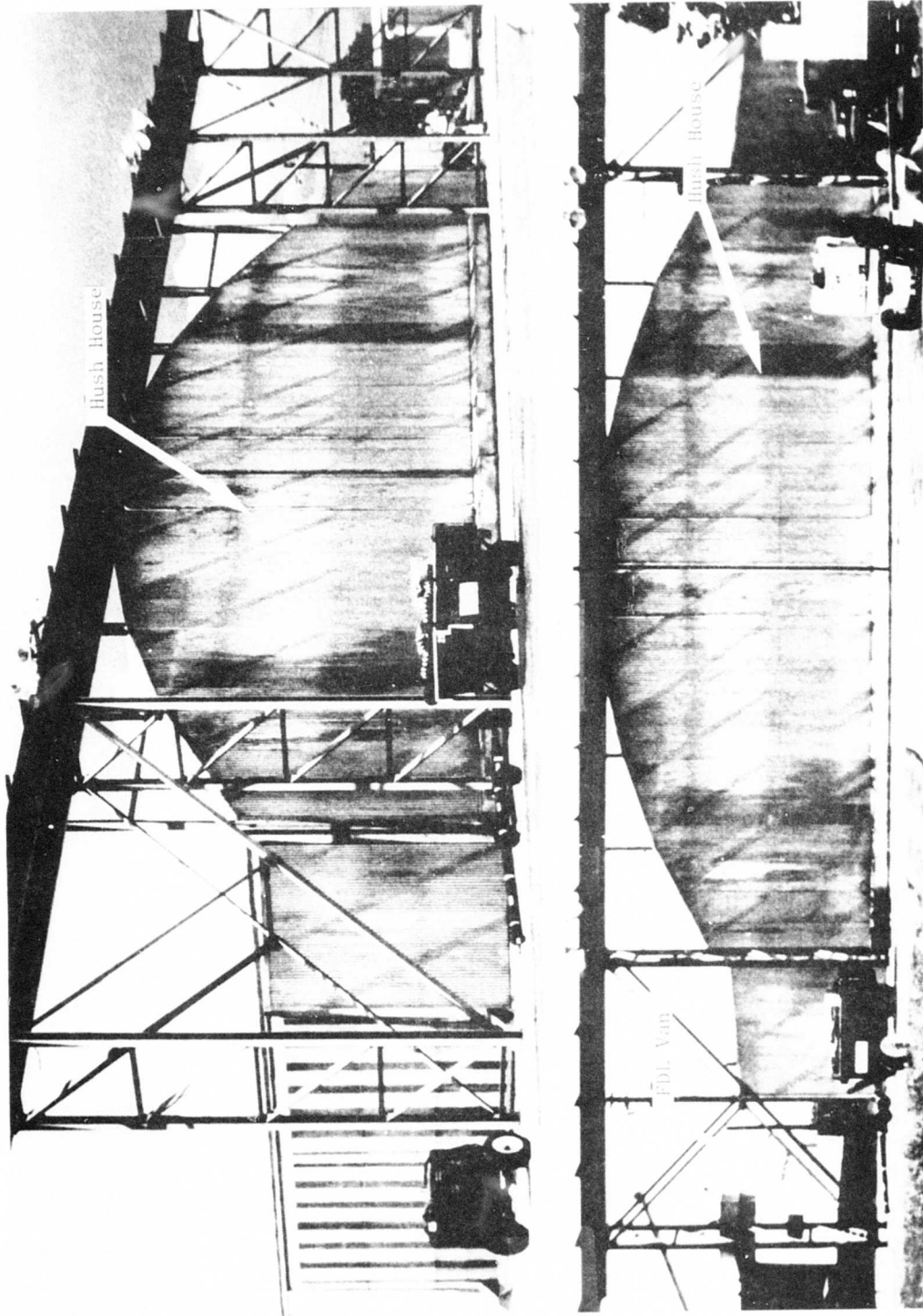


FIGURE A1 Location of FDL Mobile Data Acquisition Van Next to Hush House

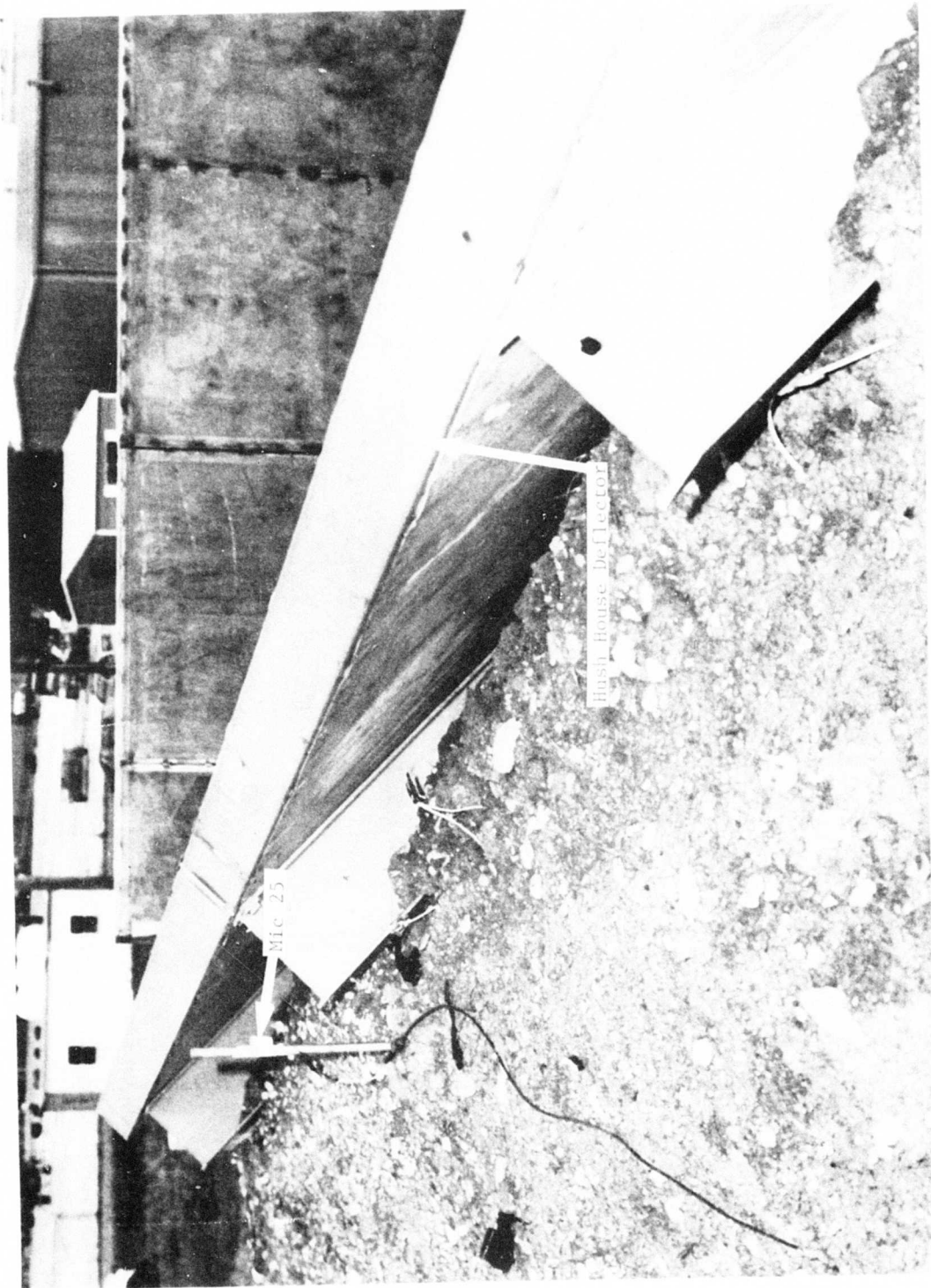


FIGURE A2 Location of Microphone 25 Next to Hush House Deflector



FIGURE A3 Location of Microphones 6-8, 10, 12-13, 15, 20 on F-16 Aircraft

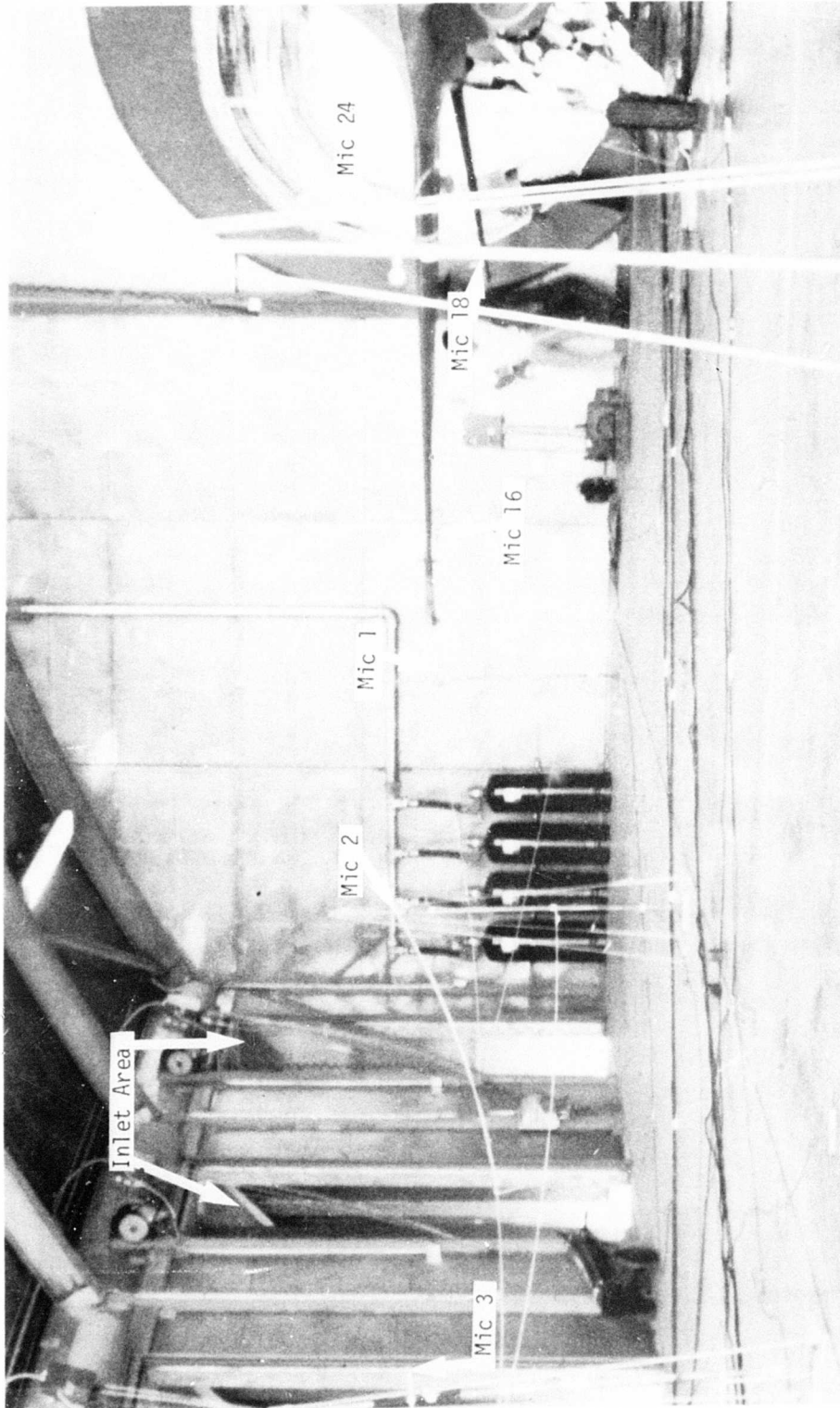


FIGURE A4 Location of Microphones 1-3, 16, 18, 24 on and around F-16 Aircraft.

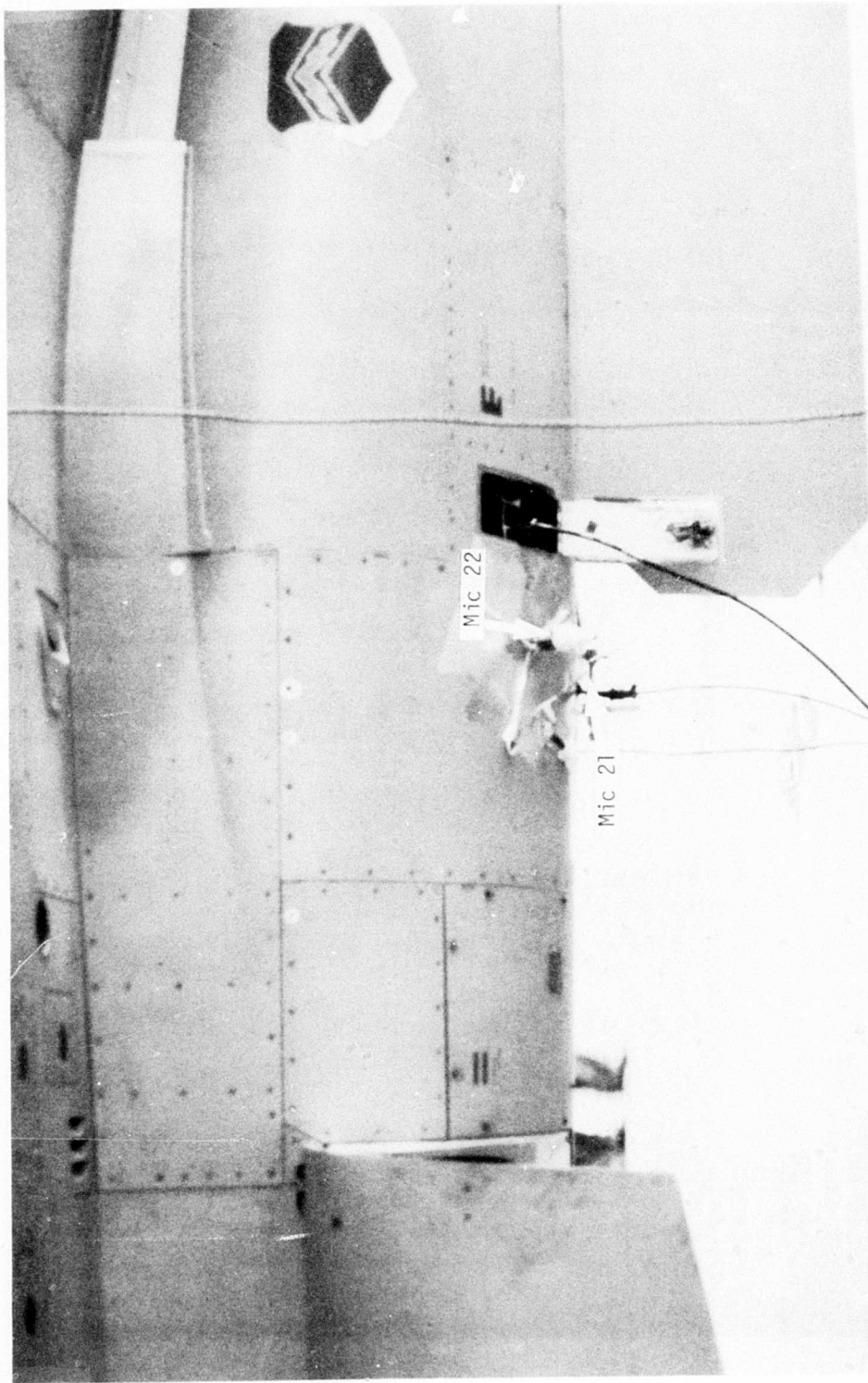


FIGURE A5 Location of Microphones 21 and 22 on F-16 Aircraft.

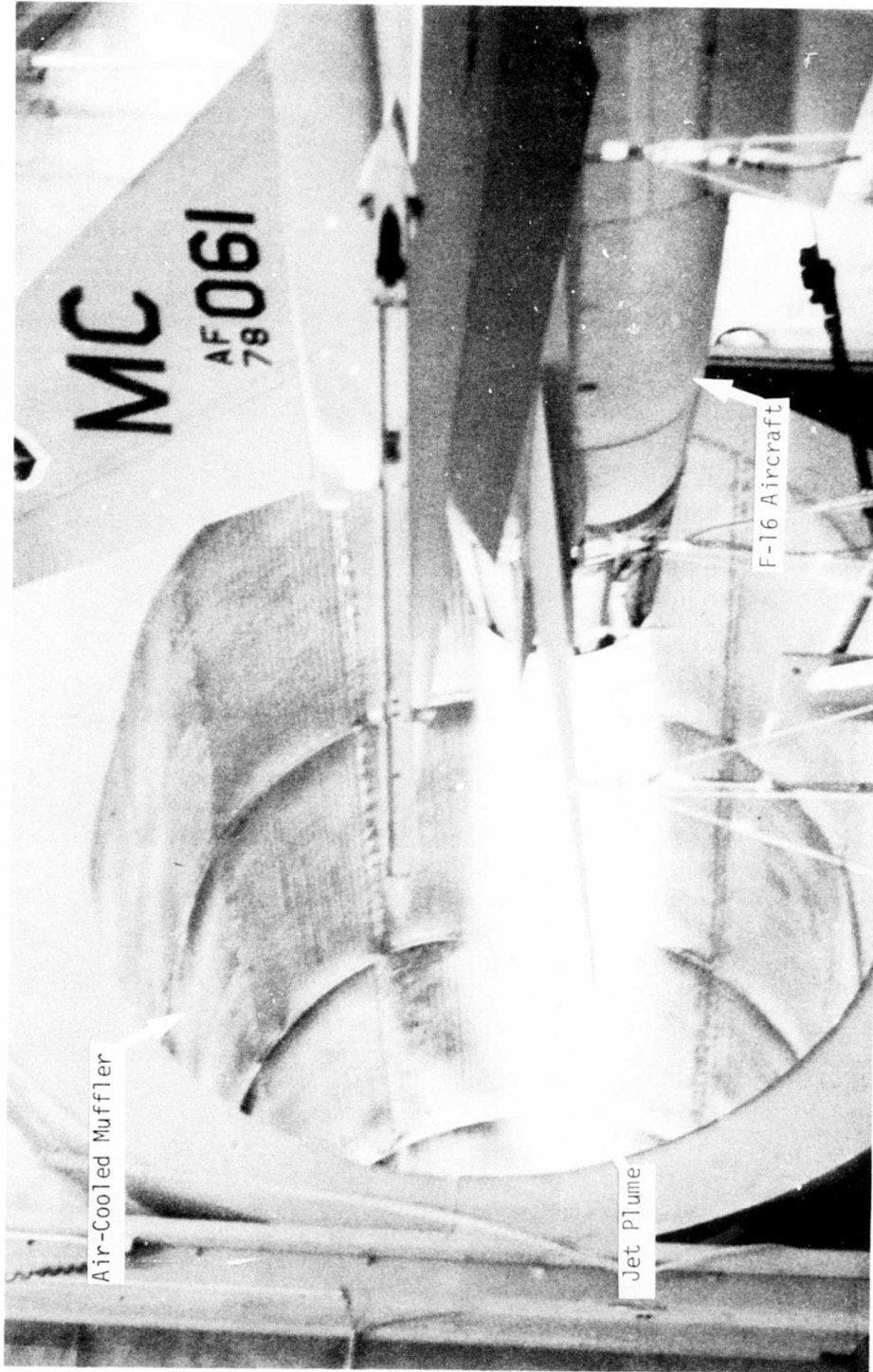


FIGURE A6 F-16 Aircraft During Maximum Afterburner Operation in Hush House.

APPENDIX B REDUCED DATA

The data which were recorded and analyzed from the test runs identified in Table 1 are included here. The octave band sound pressure levels for all 24 microphones are shown in Figures B1 through B13. Corresponding one-third octave band levels for the same microphones are shown in Figures B14 through B37. Figures B38 through B50 give A-weighted one-third octave band spectra. Two narrowband plots for microphone 25 are given in Figures B51 and B52.

GRAPH

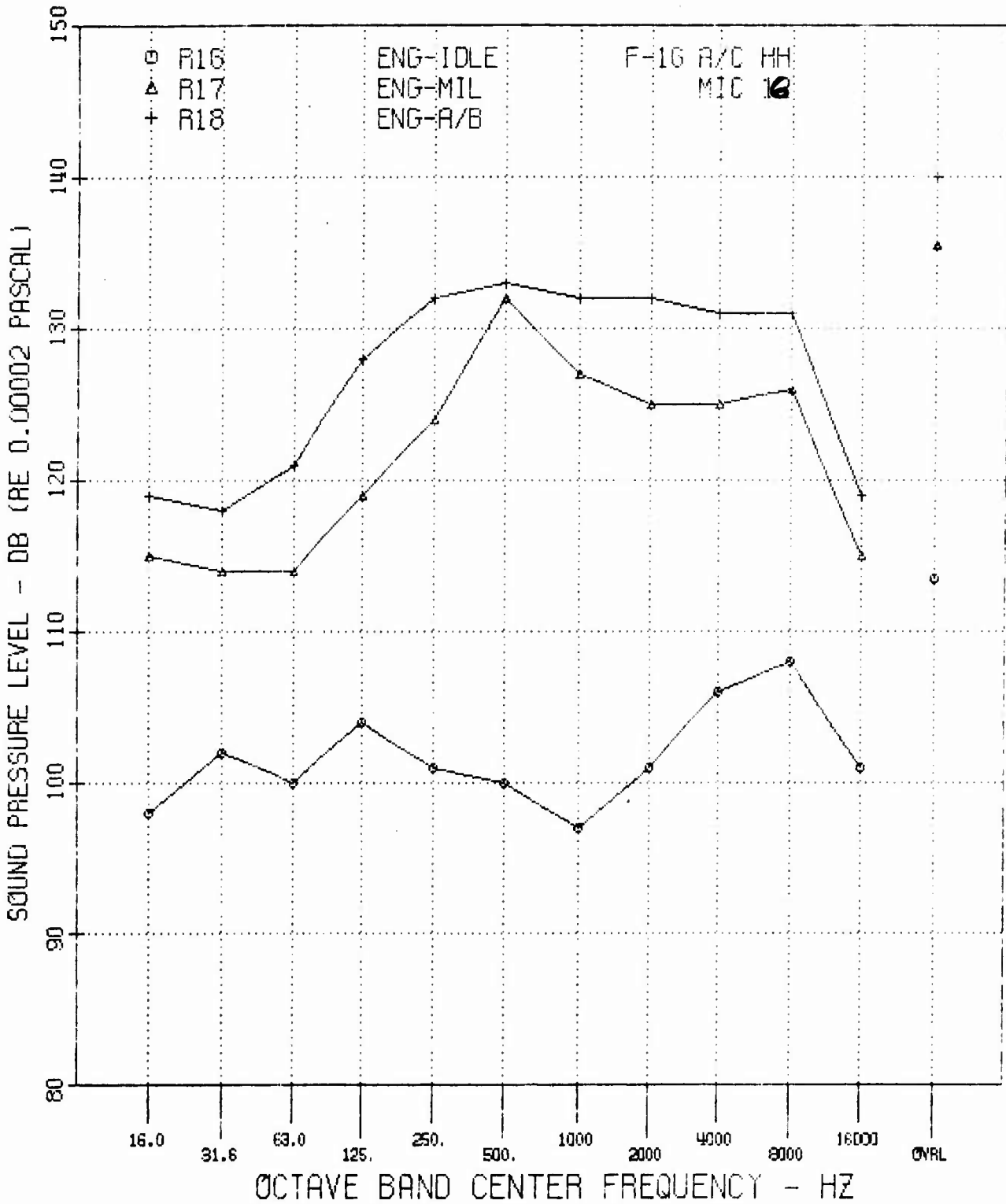


FIGURE B1 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 6.

GRAPH 3

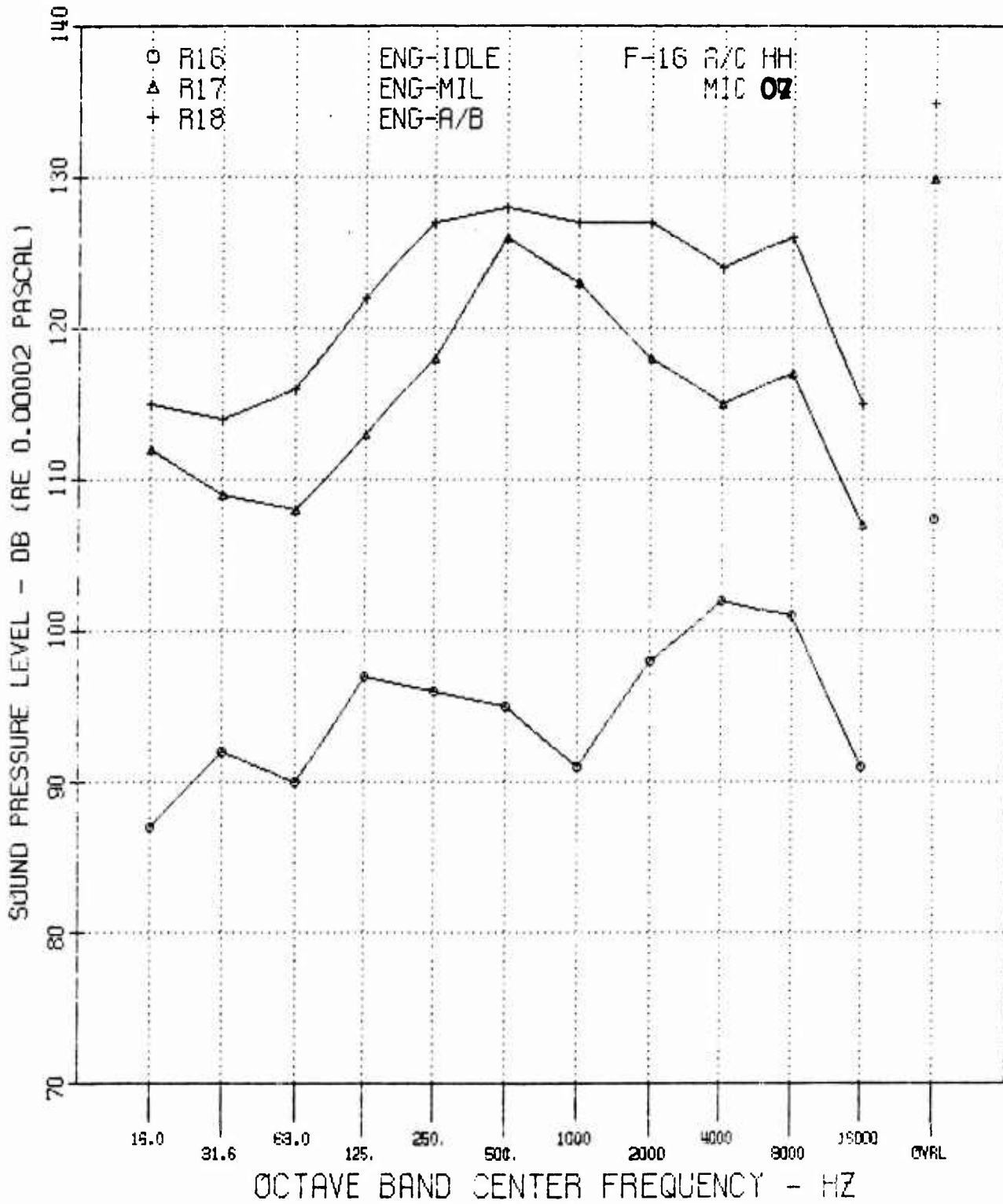


FIGURE B2 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 7.

GRAPH 4

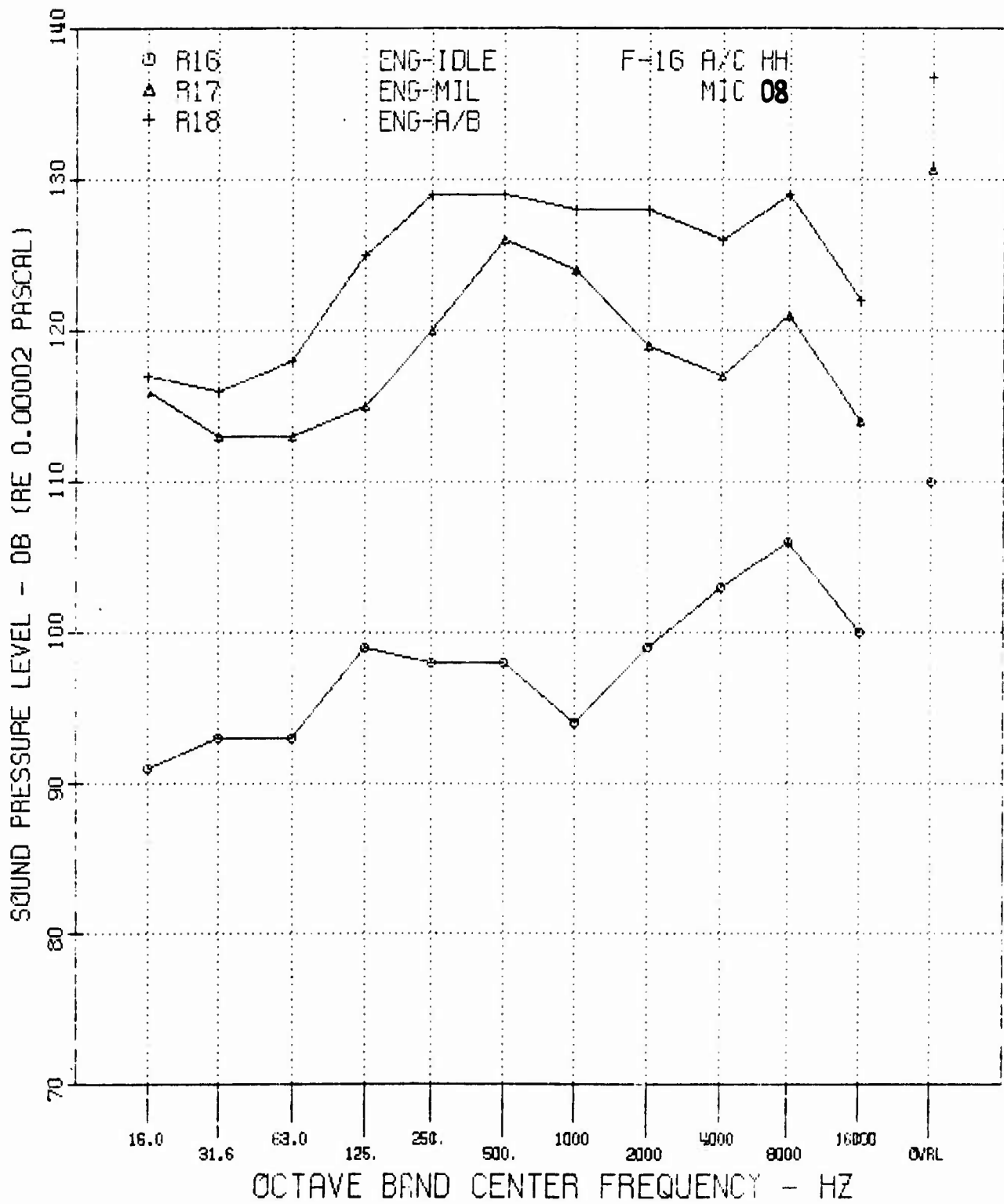


FIGURE B3 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 8.

GRAPH 4

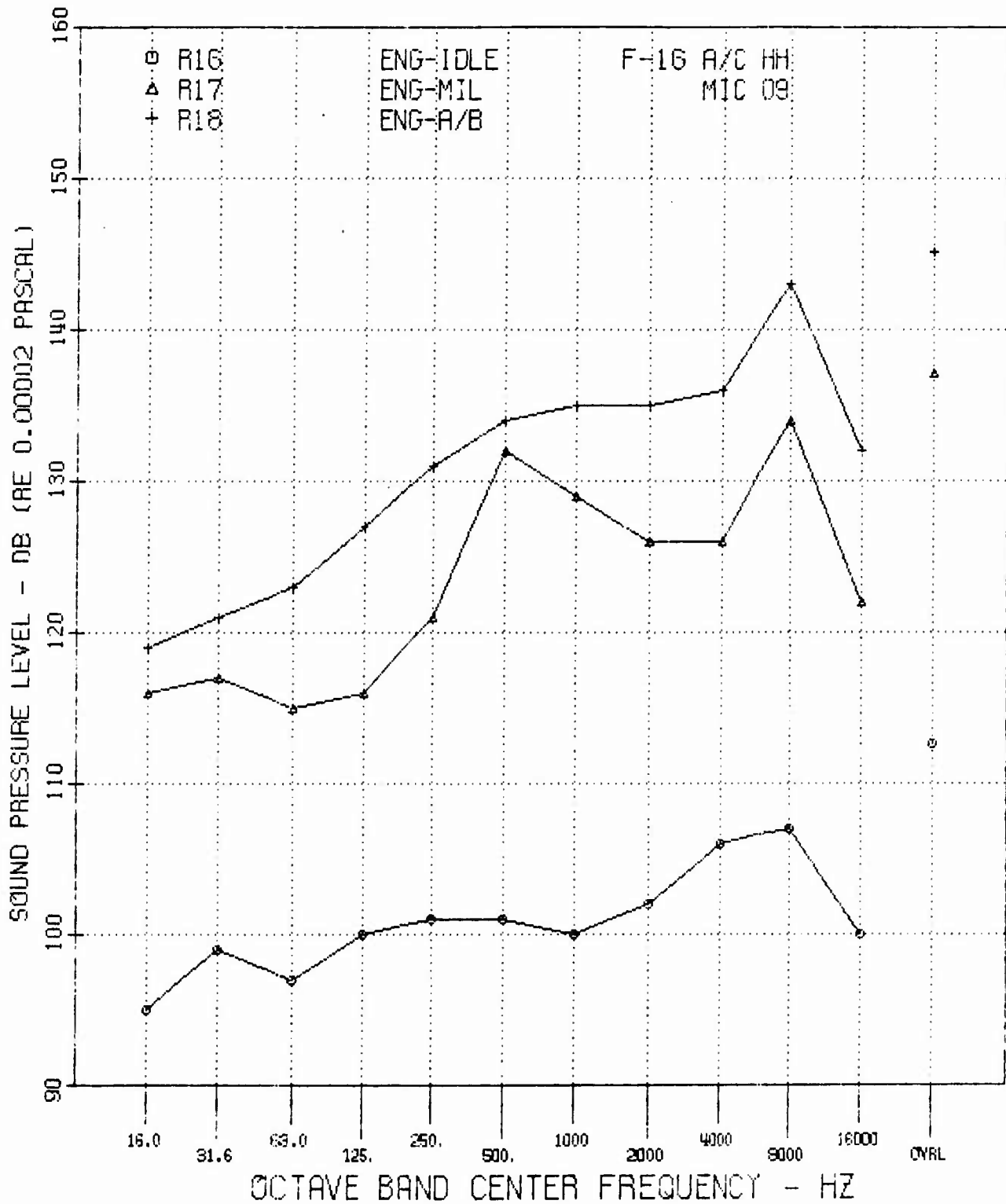


FIGURE B4 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 9.

GRAPH 5

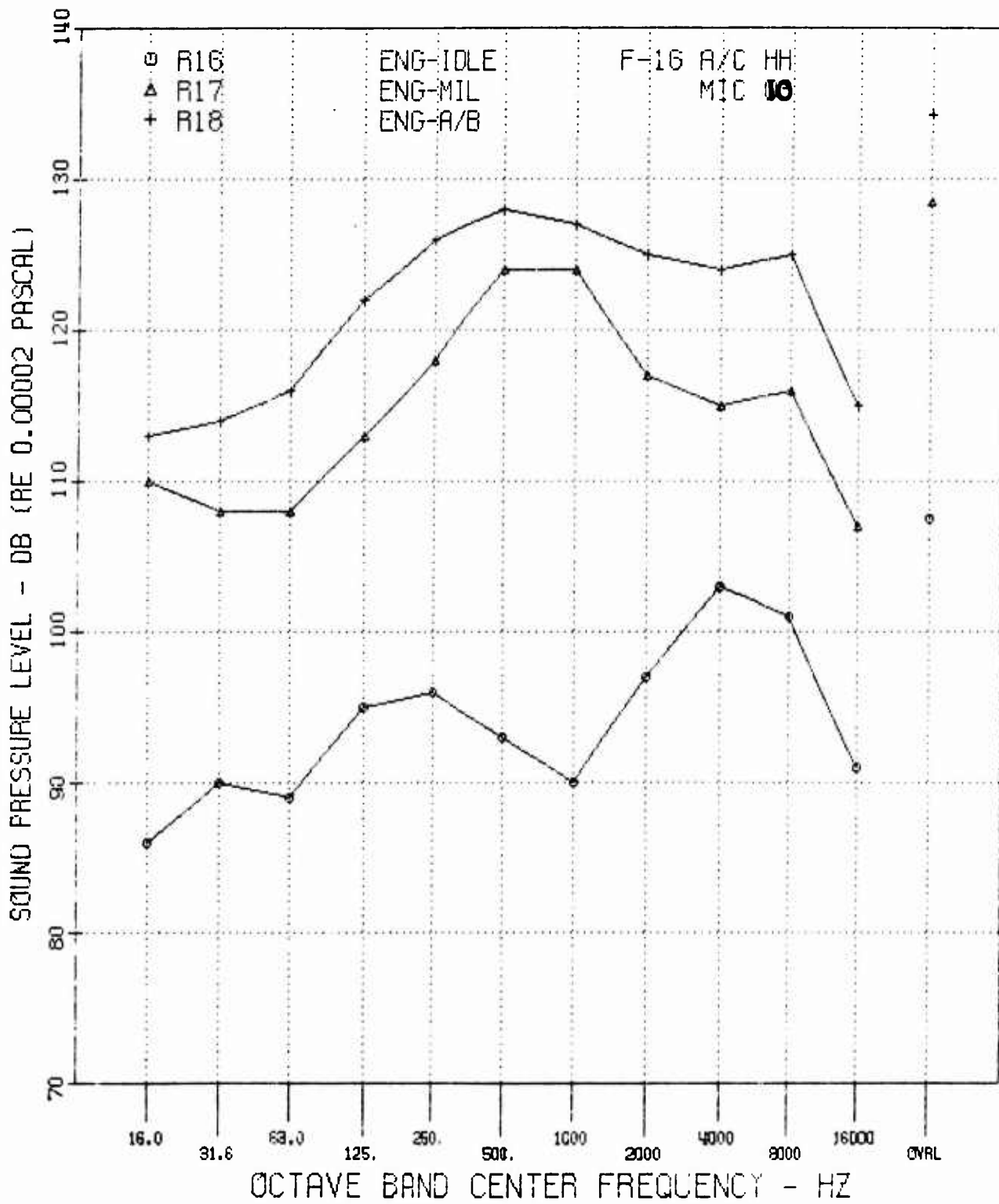


FIGURE B5 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 10.

GRAPH 1

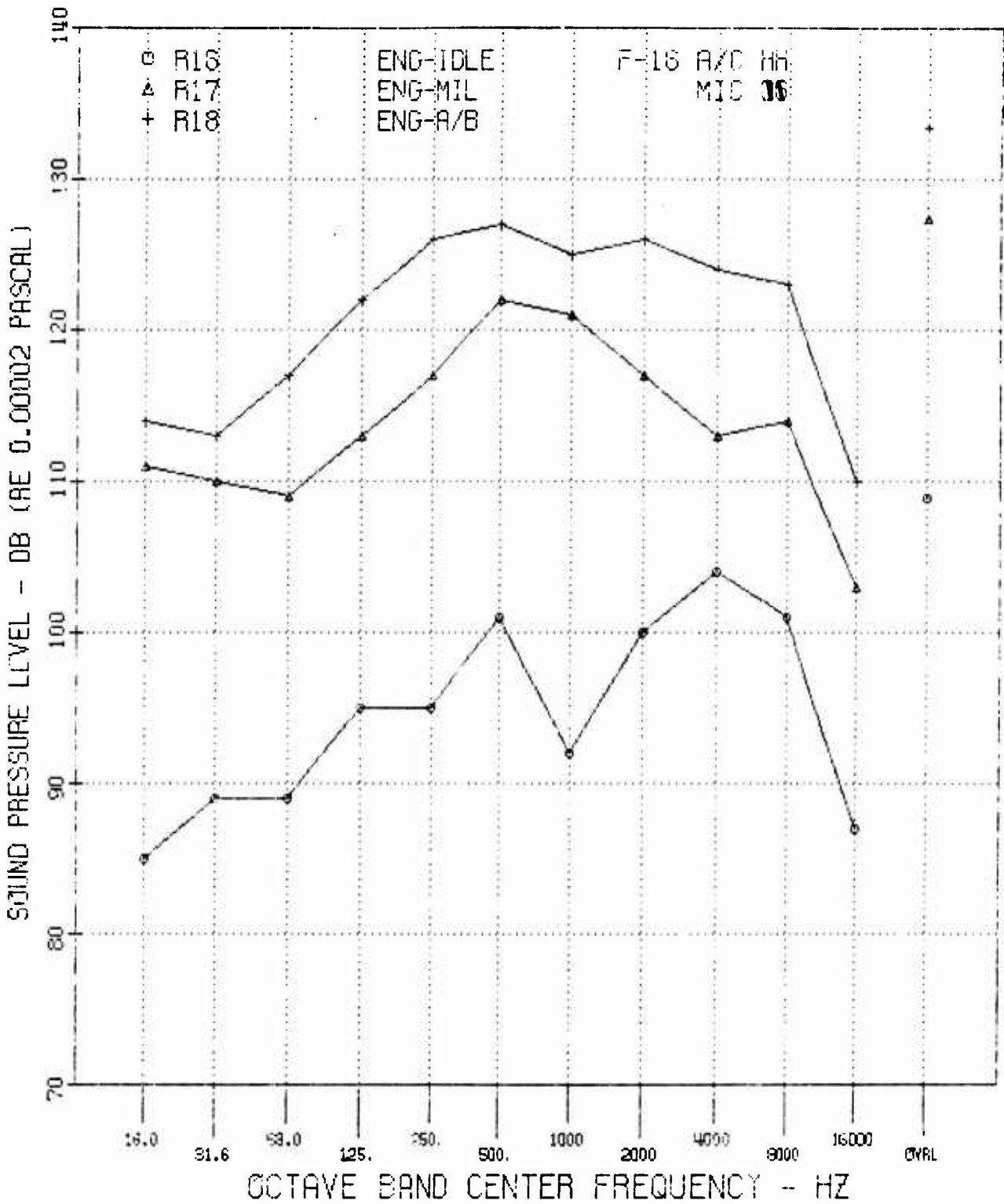


FIGURE B6 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 11.

GRAPH 5

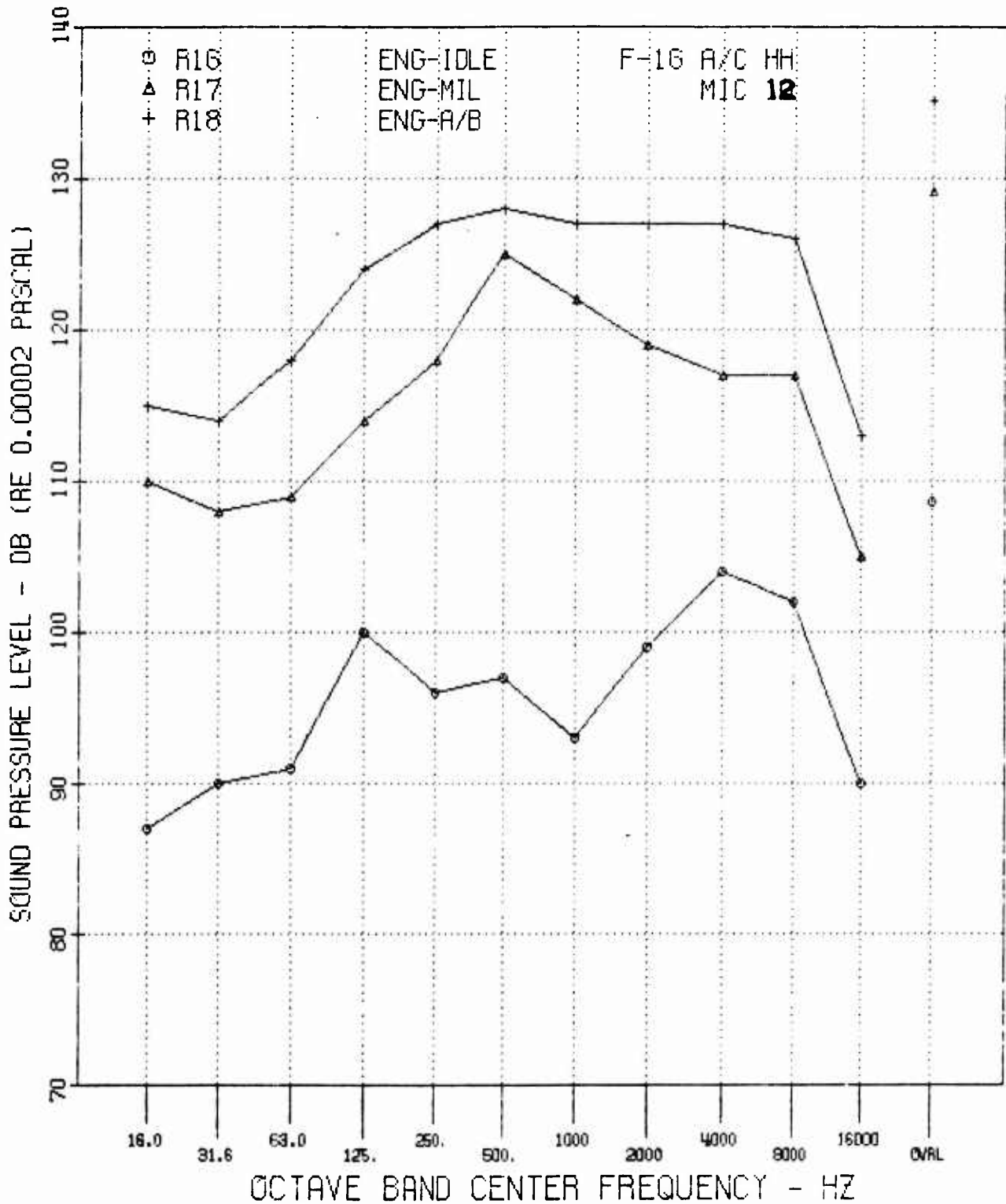


FIGURE B7 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 12.

GRAPH

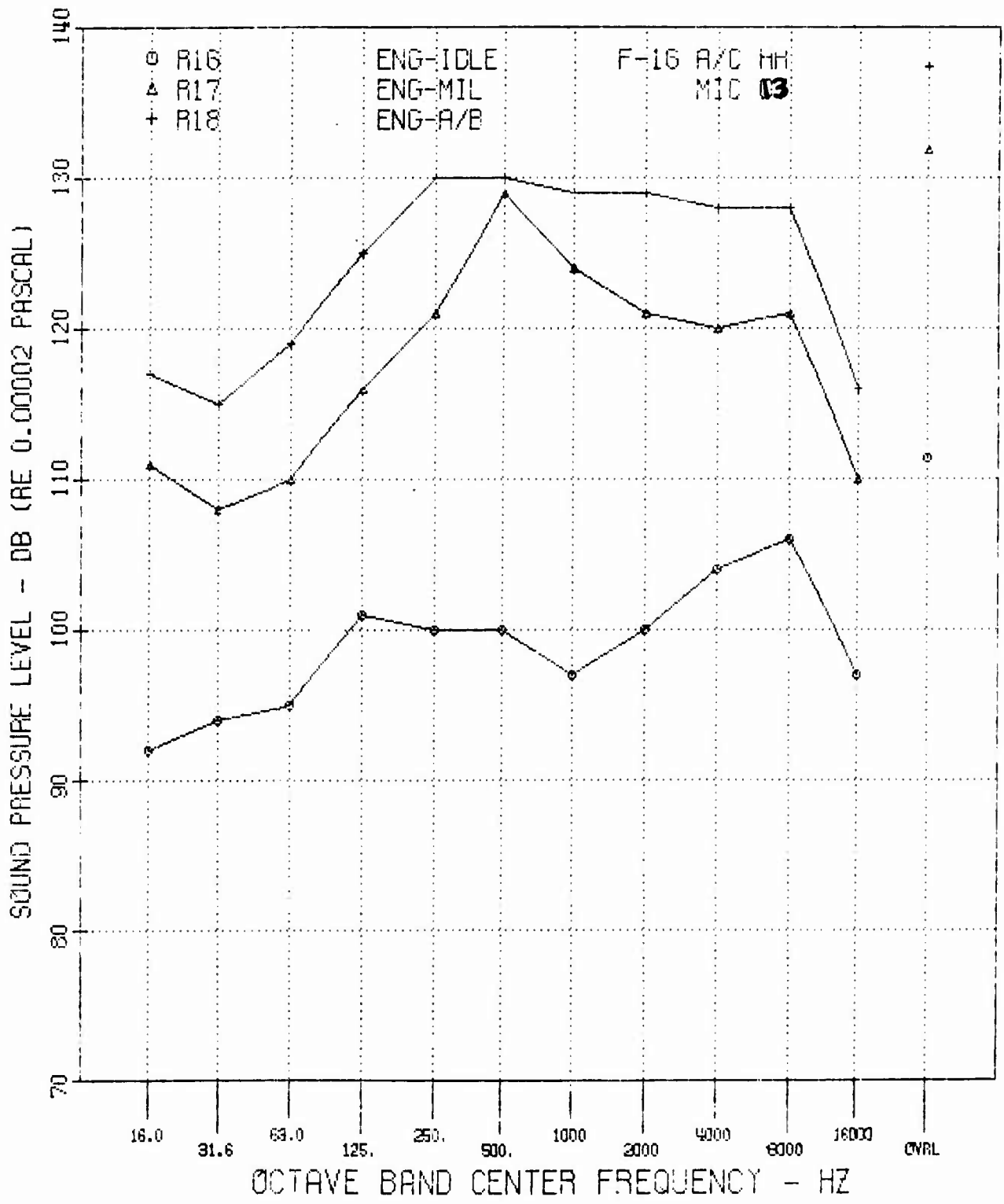


FIGURE B8 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 13.

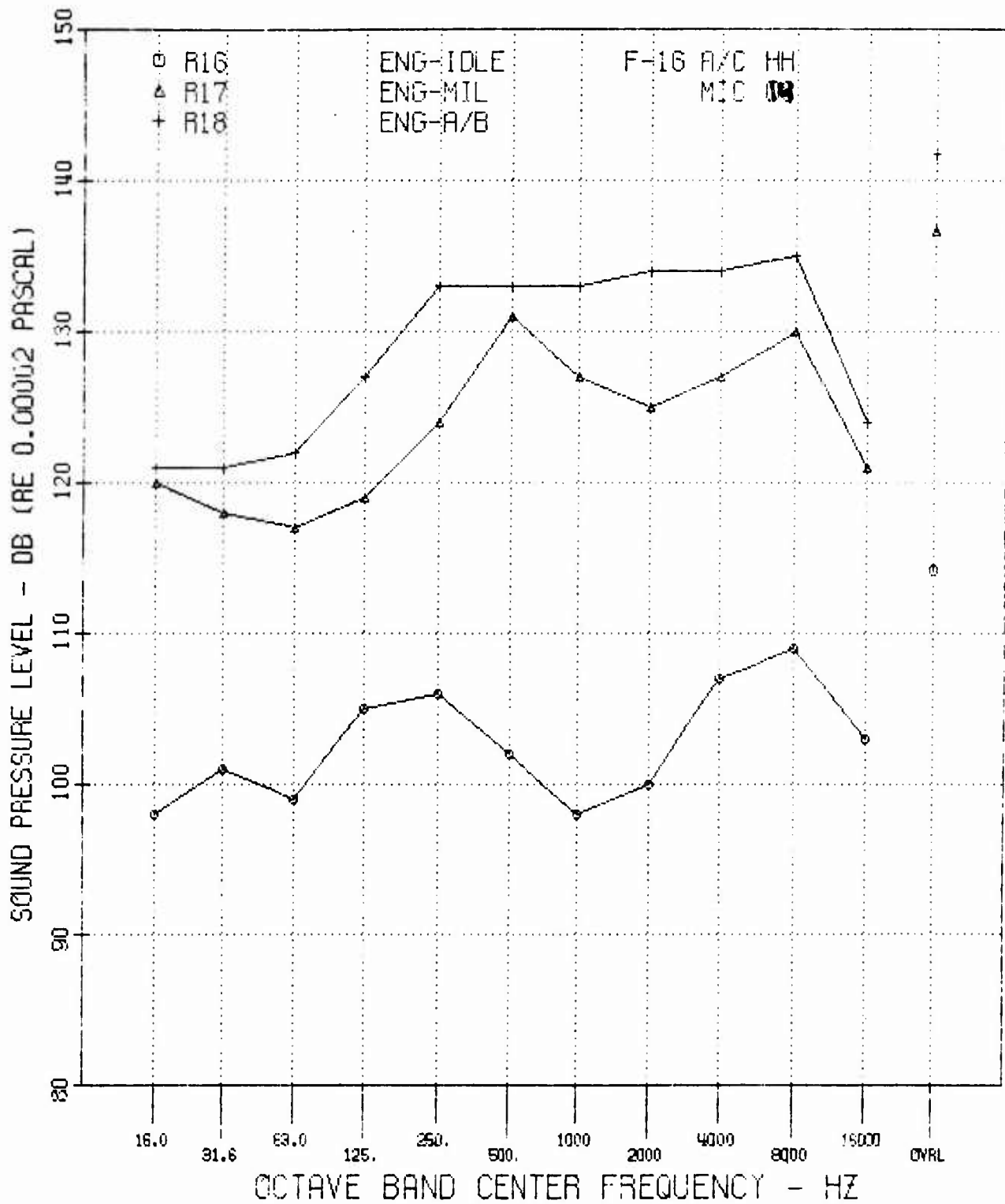


FIGURE B9 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 14.

GRAPH 6

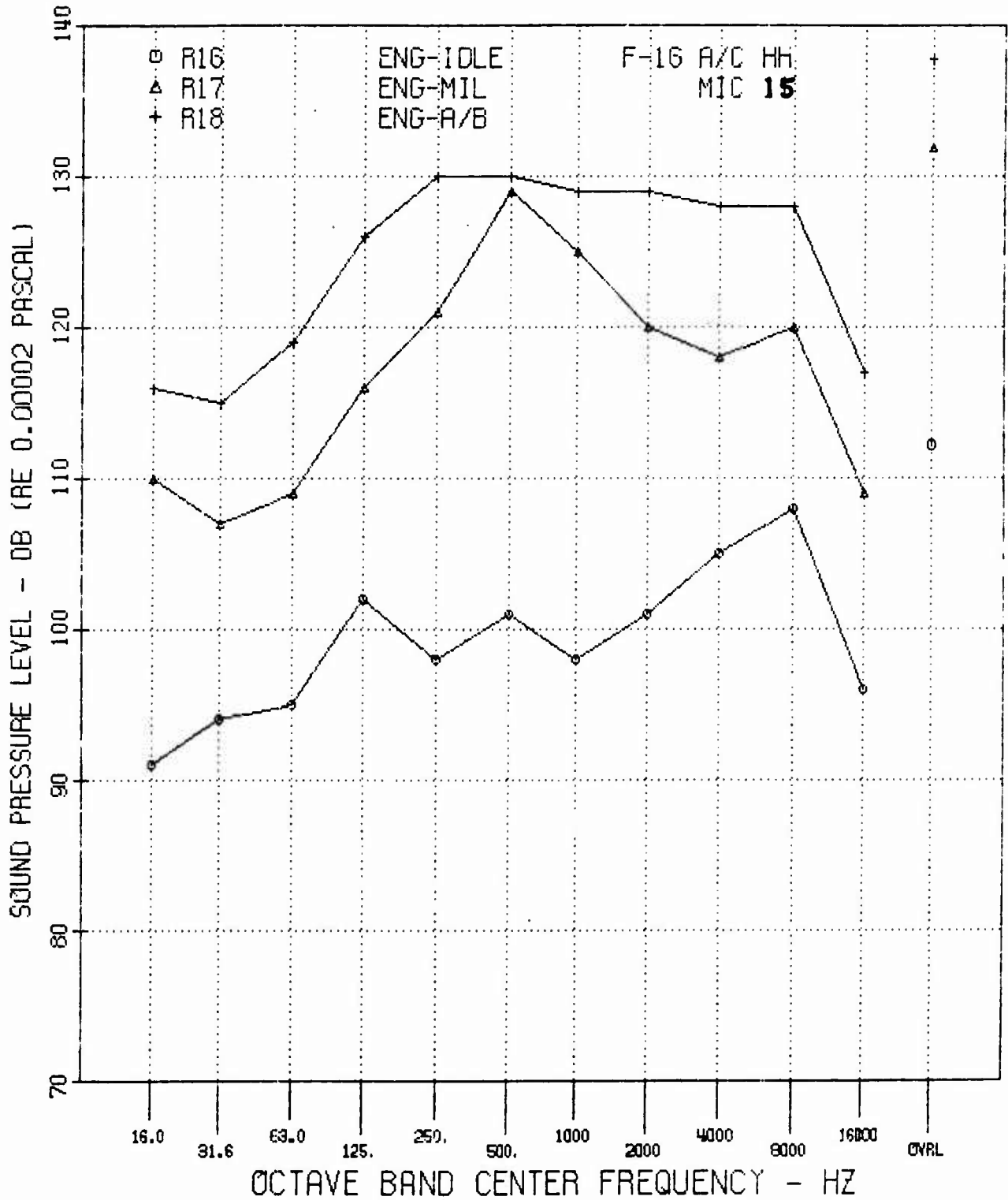


FIGURE B10 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 15.

GRAPH 10

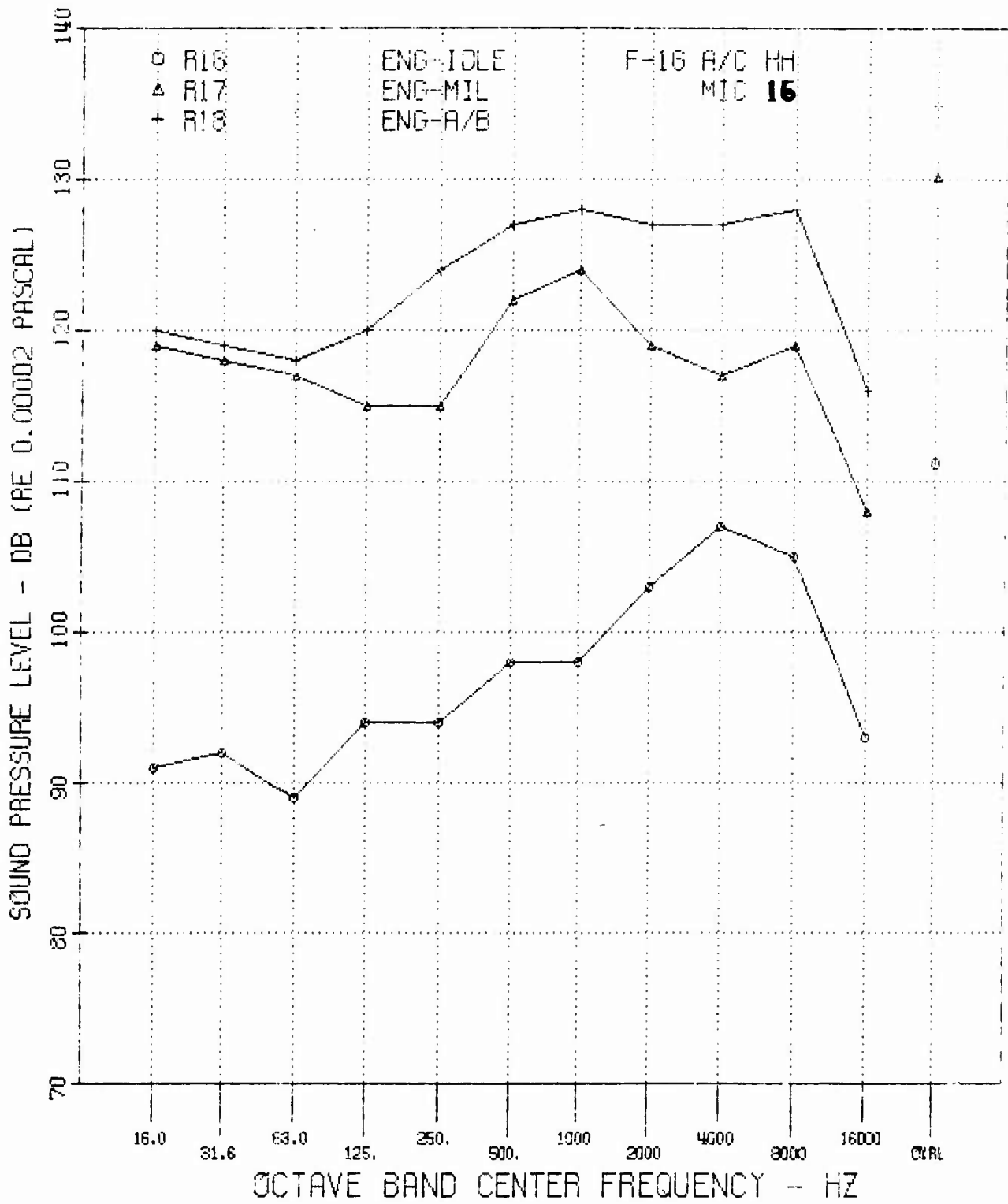


FIGURE B11 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 16.

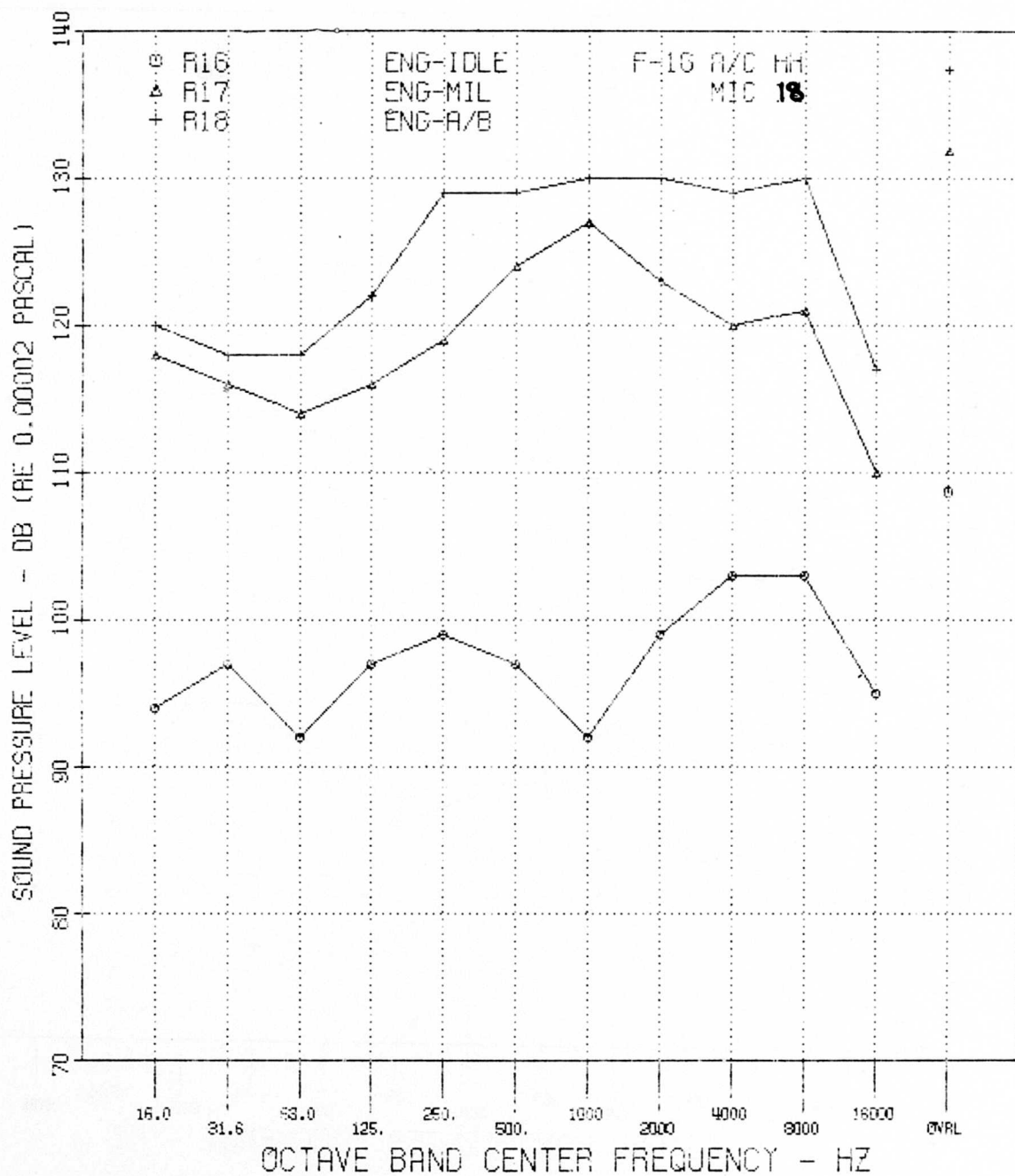


FIGURE B12 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 18.

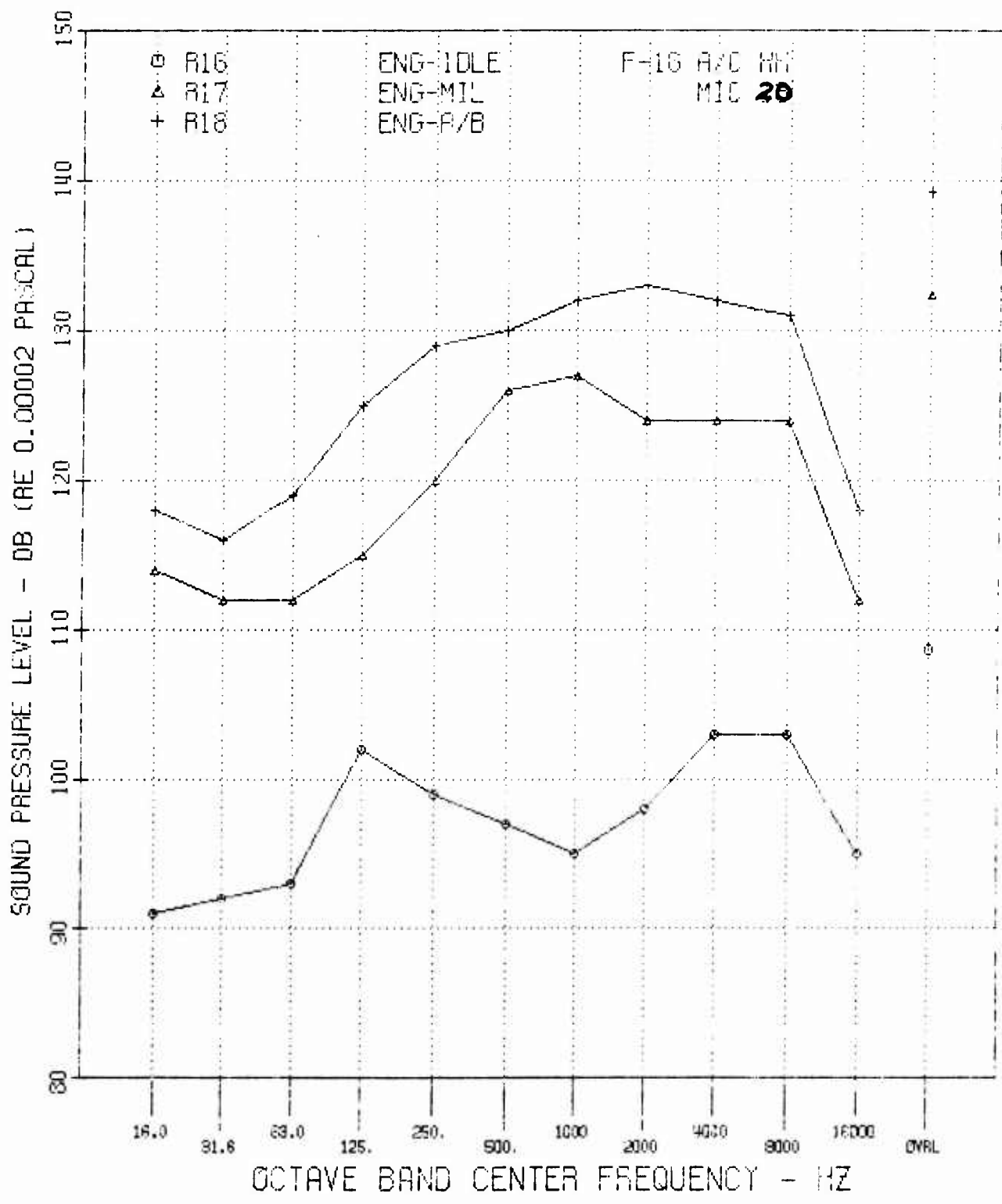


FIGURE B13 Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 20.

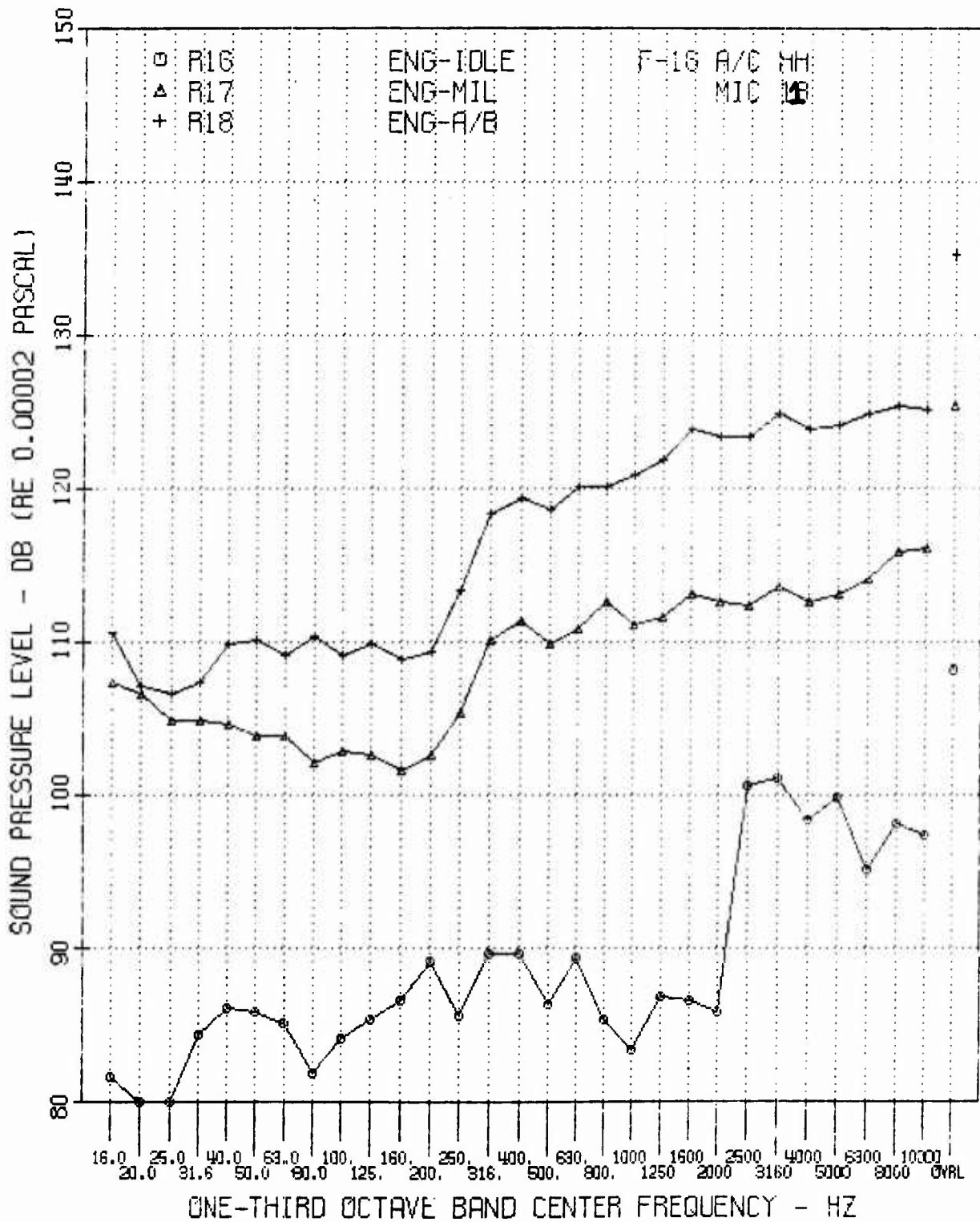


FIGURE B14 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 1.

GRAPH 19

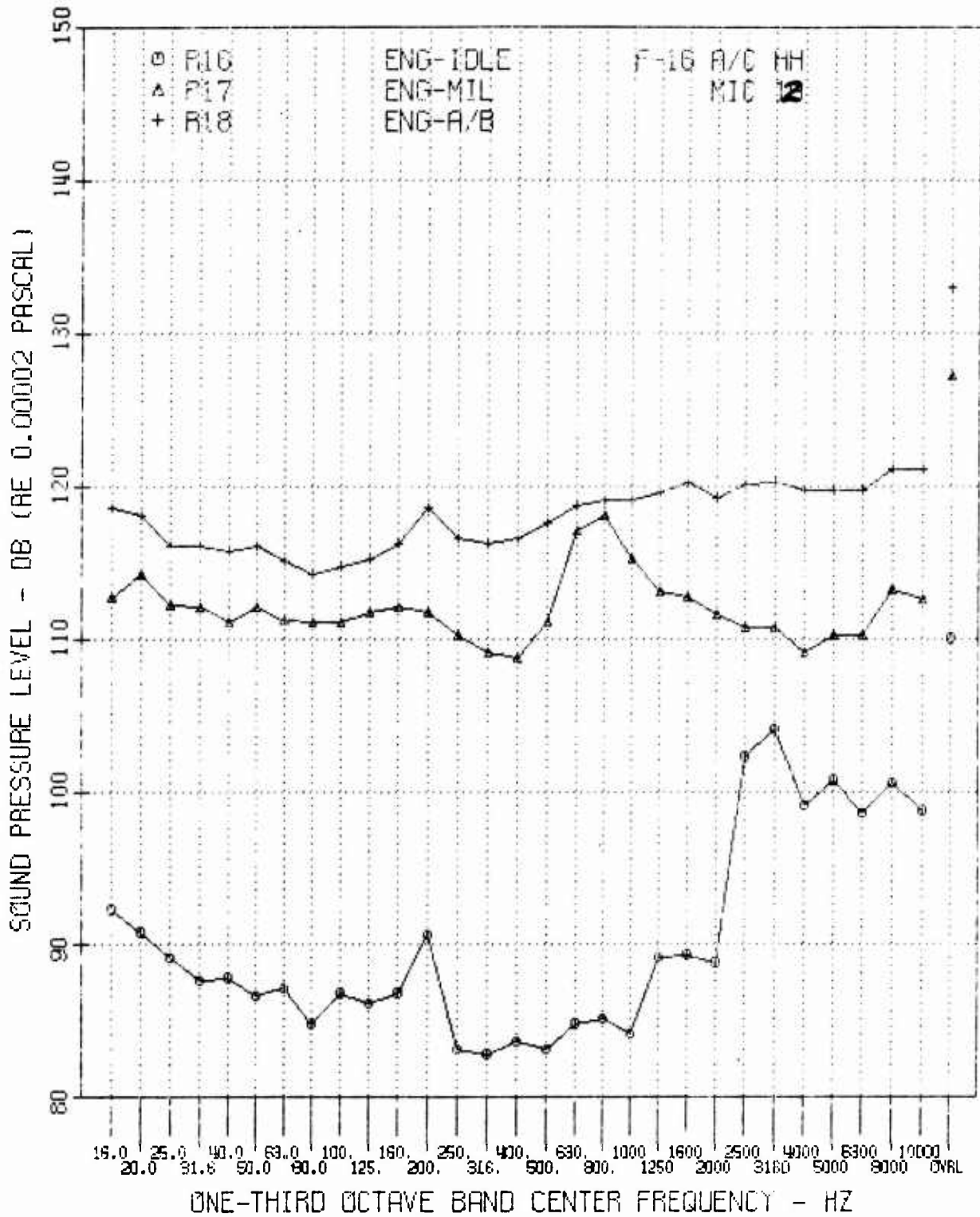


FIGURE B15 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 2.

GRAPH

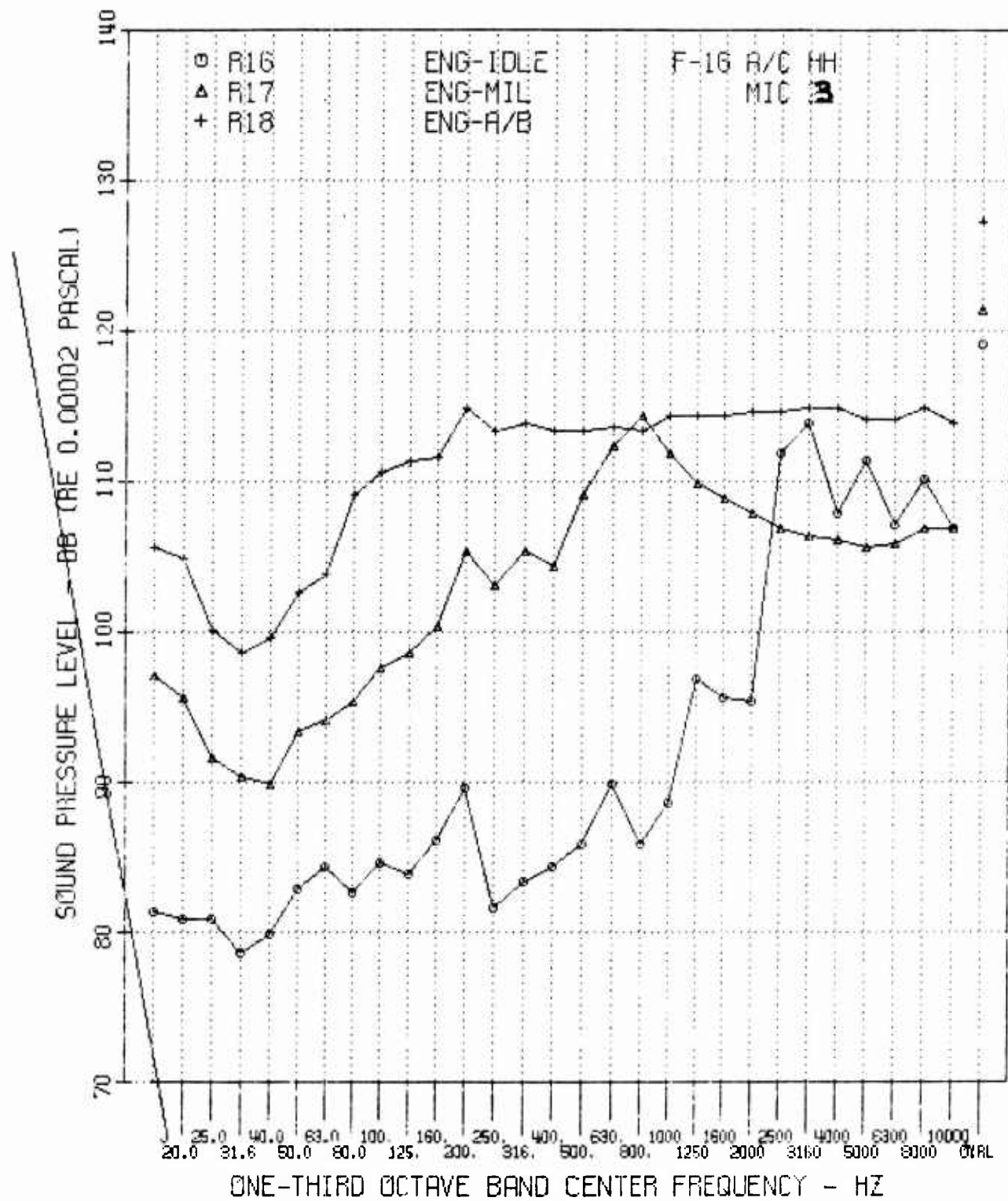


FIGURE B16 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 3.

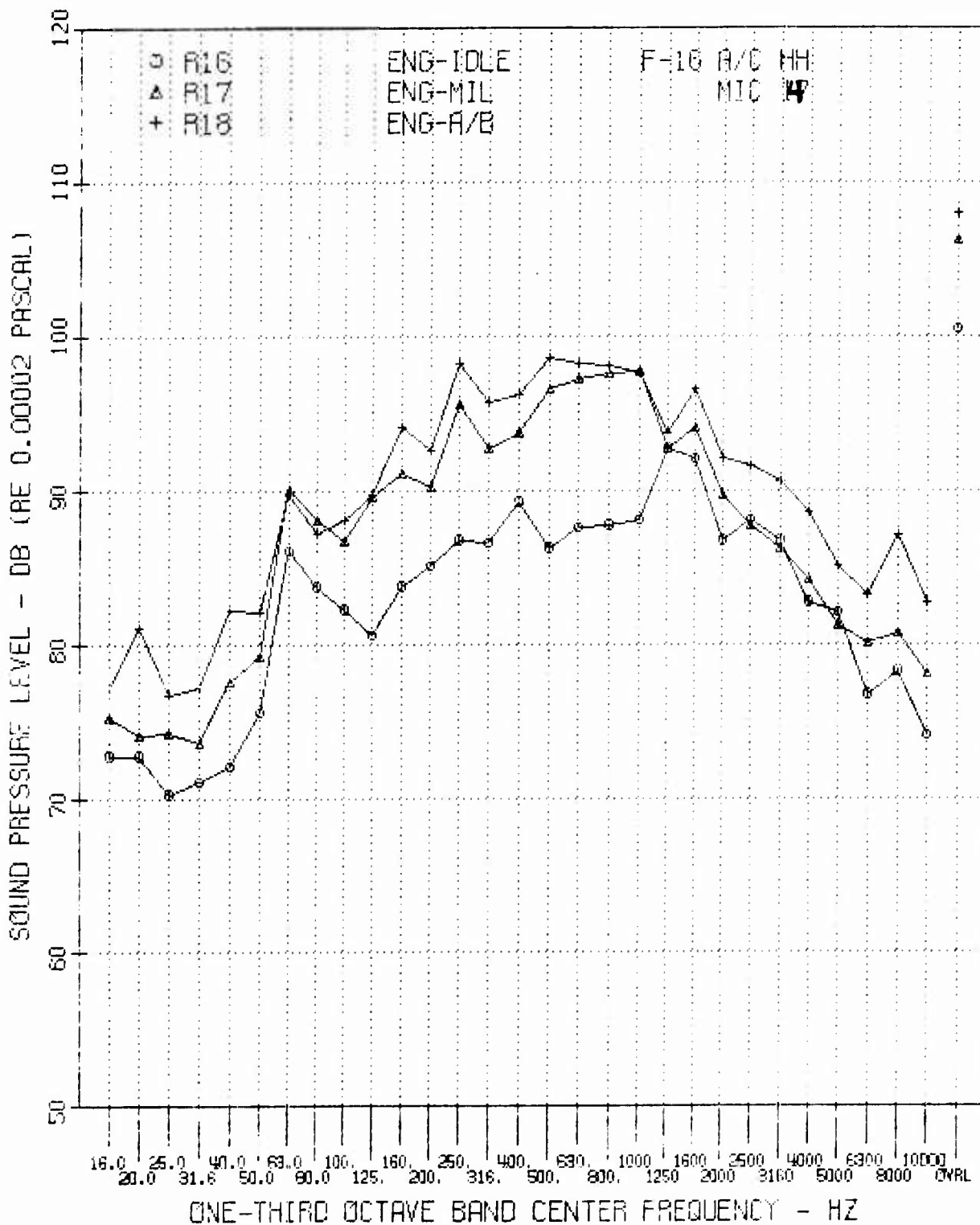


FIGURE B17 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 4.

GPA 12

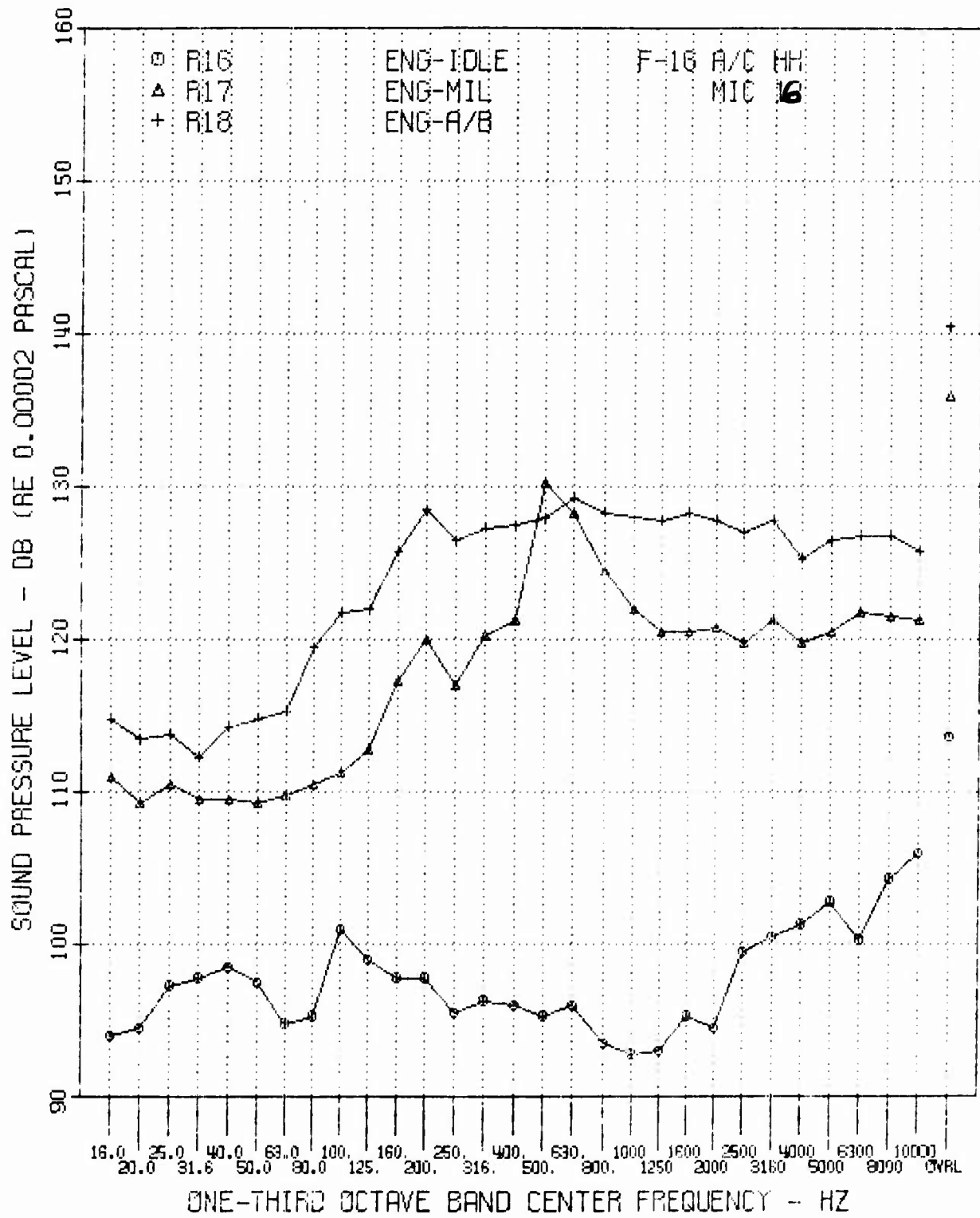


FIGURE B18 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 6.

GRAPH 4

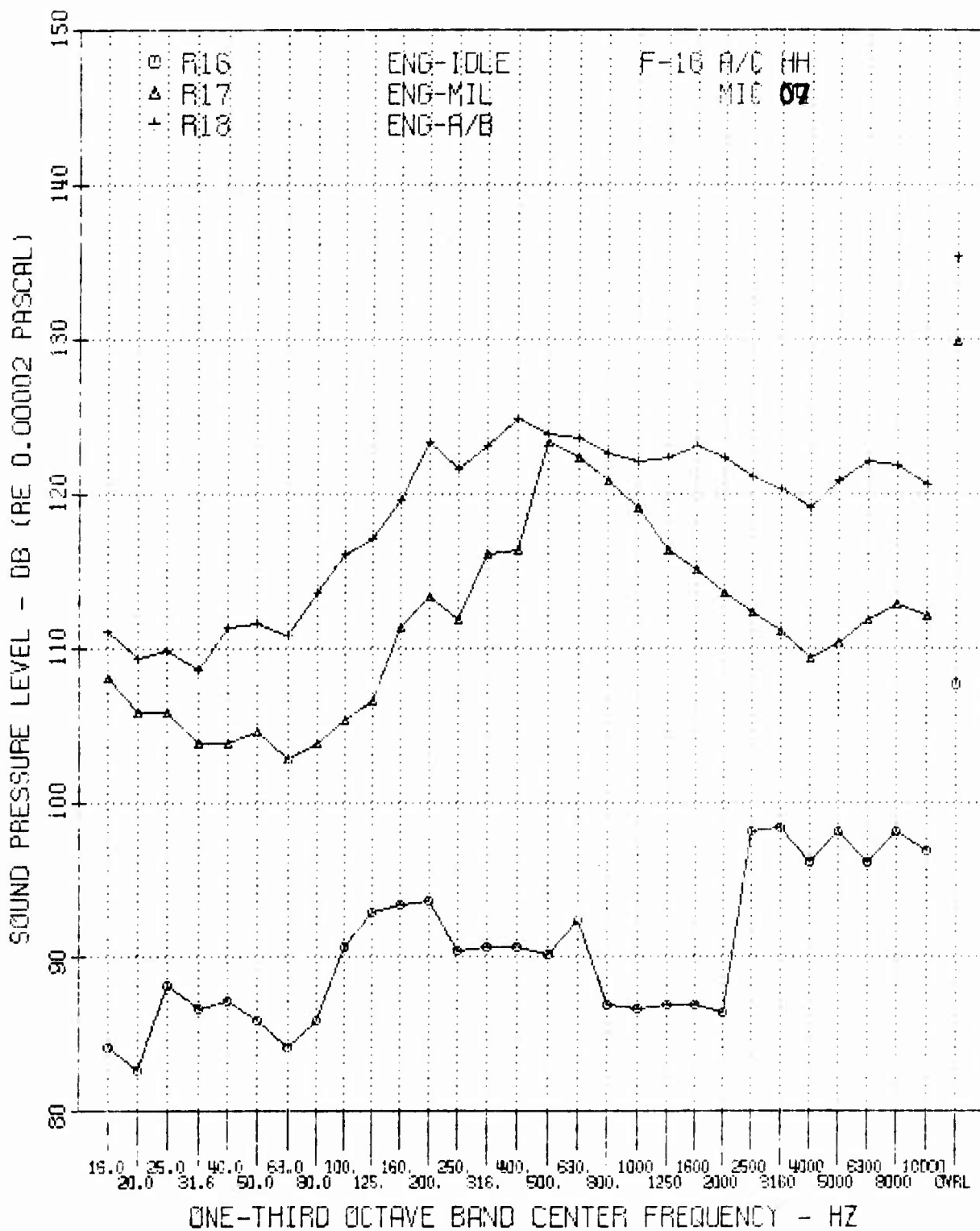


FIGURE B19 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 7.

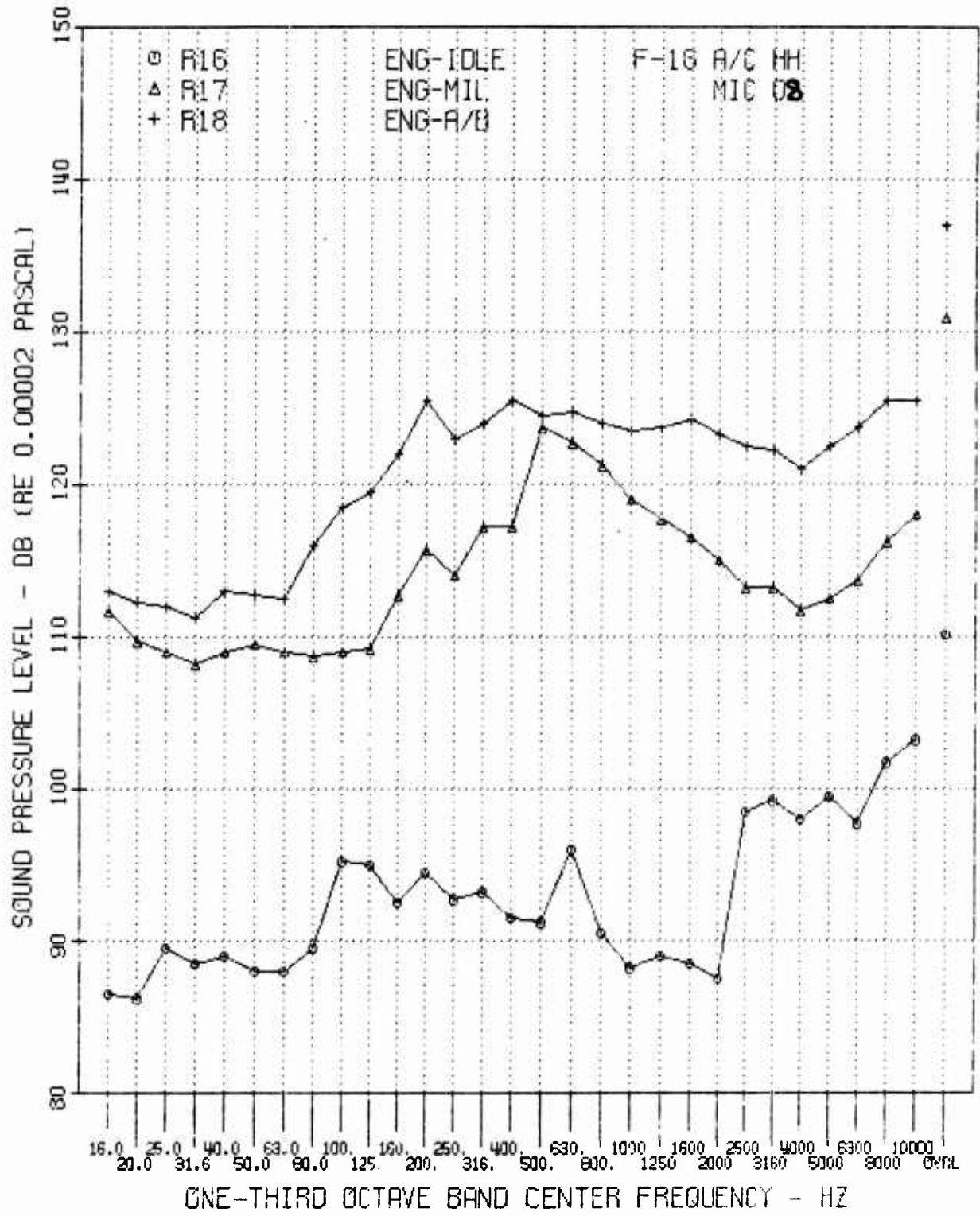


FIGURE B20 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 8.

GRAPH 9

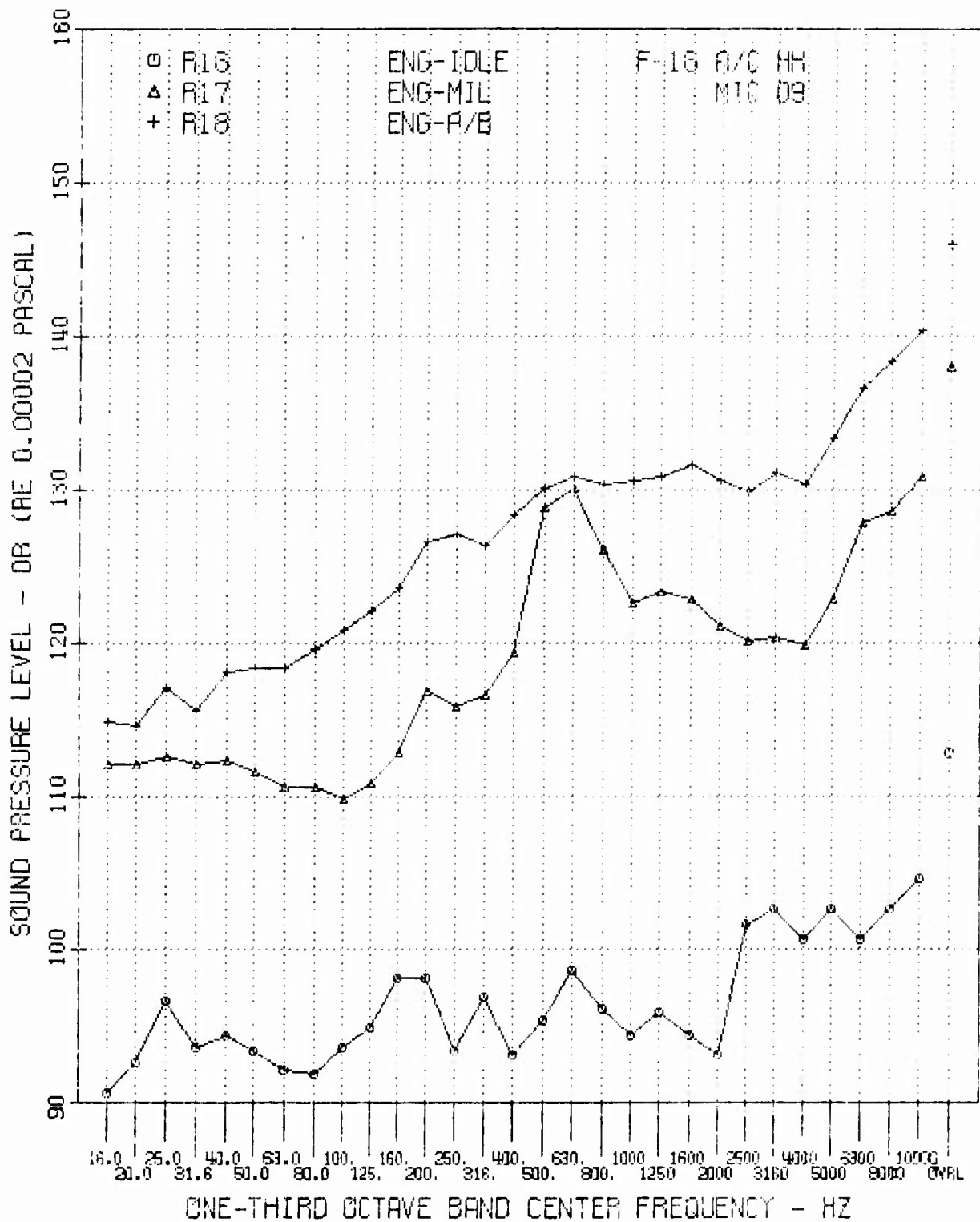


FIGURE B21 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 9.

GRAPH 3

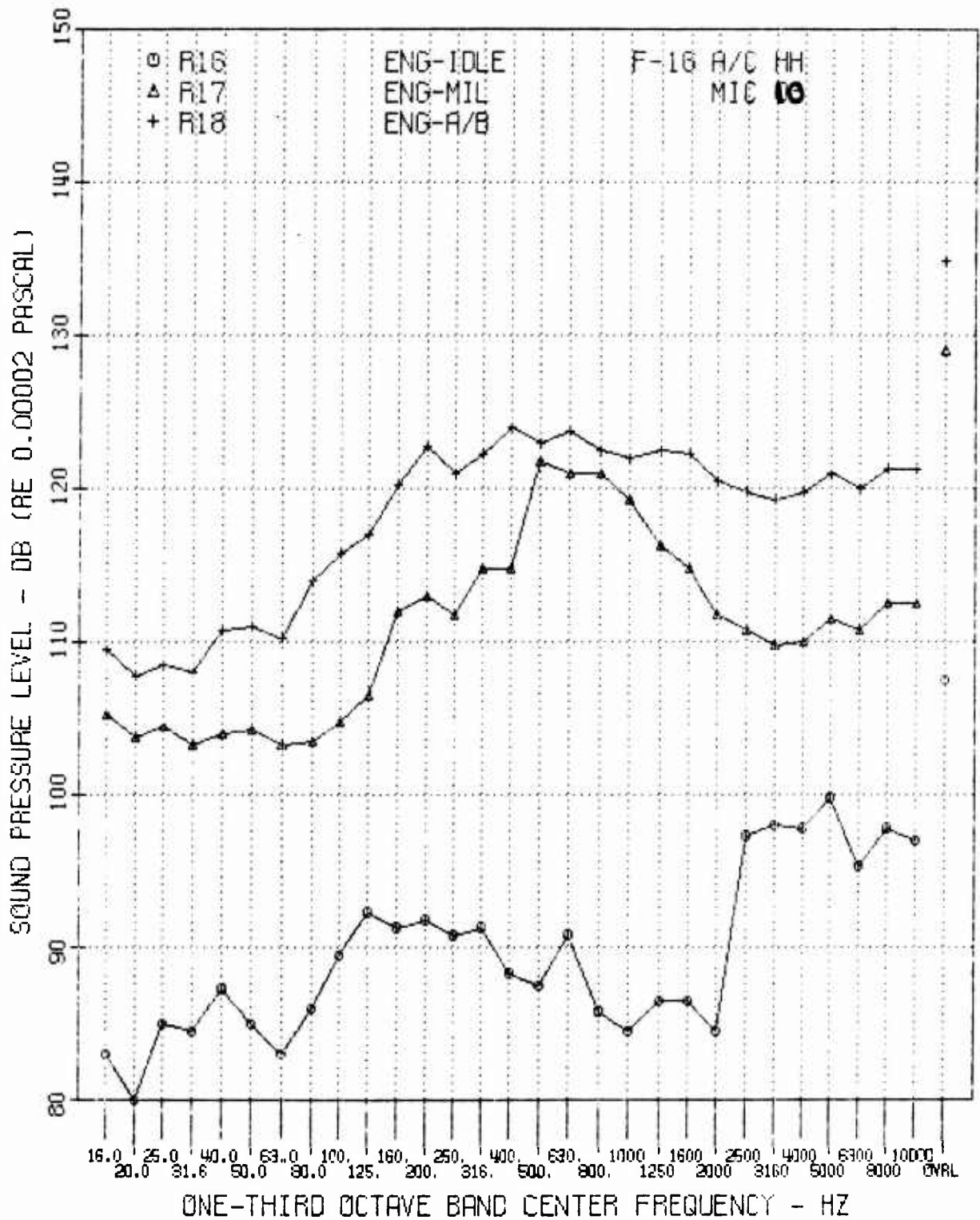


FIGURE B22 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 10.

GRAPH 6

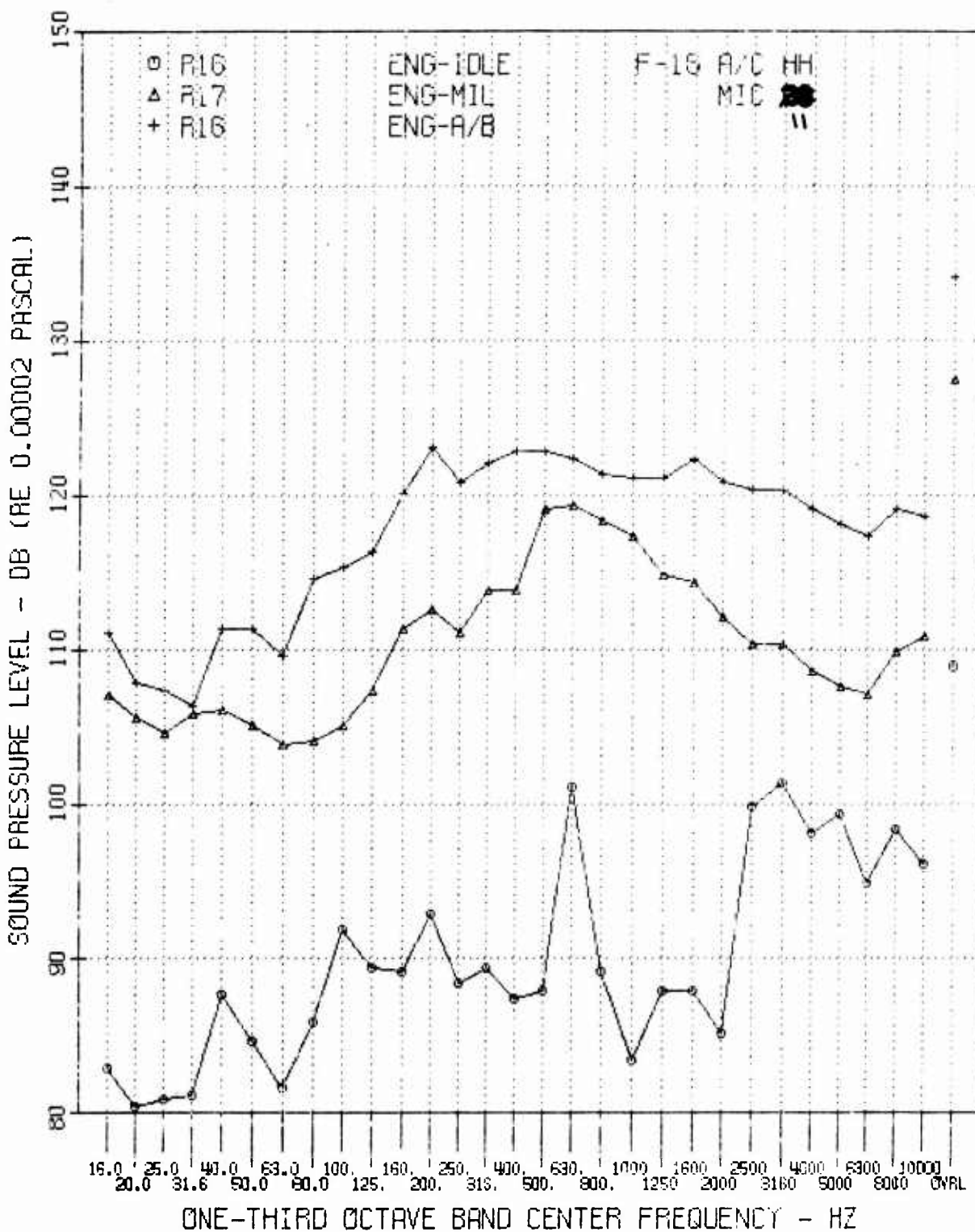


FIGURE B23 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 11.

GRAPH 10

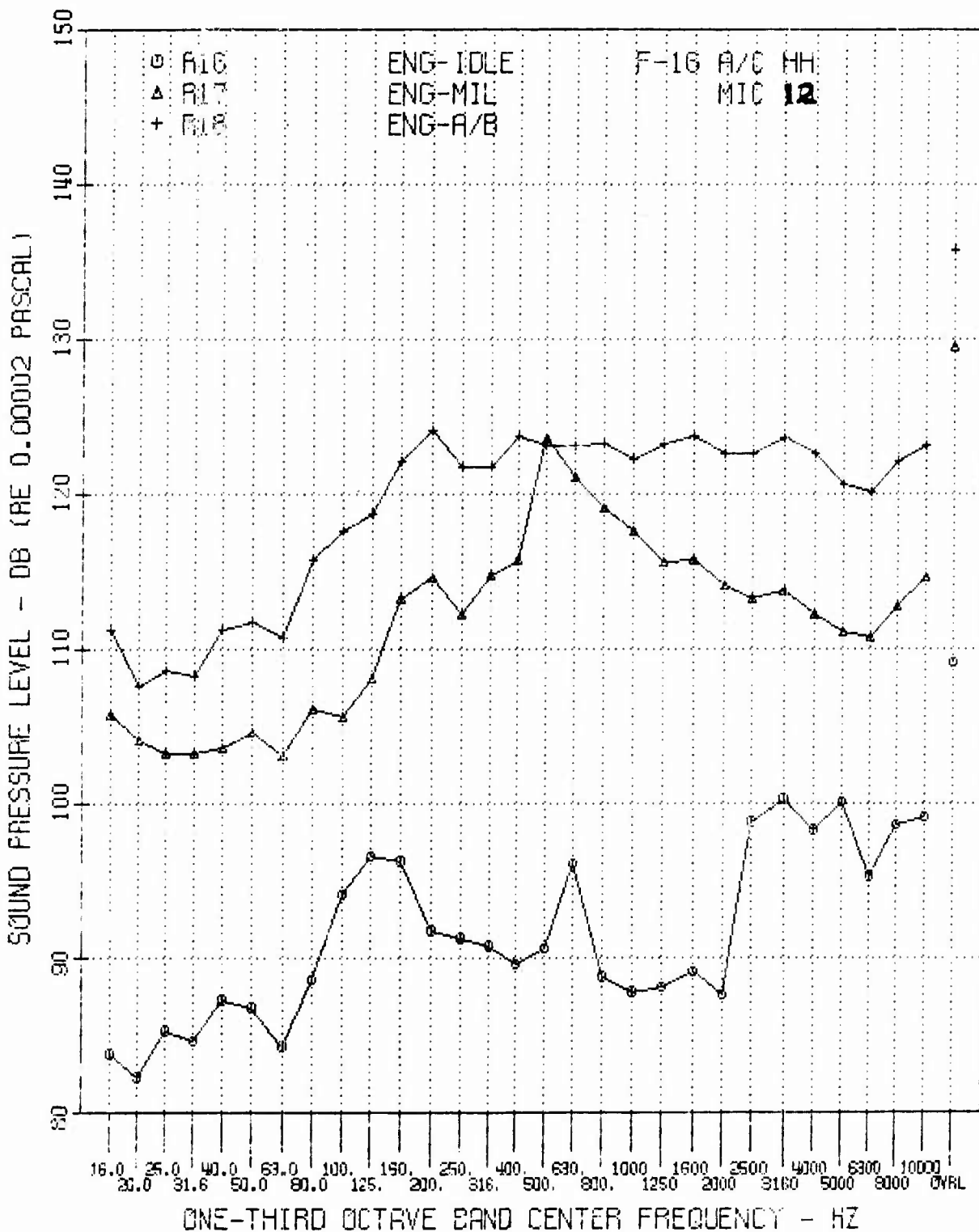


FIGURE B24 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 12.

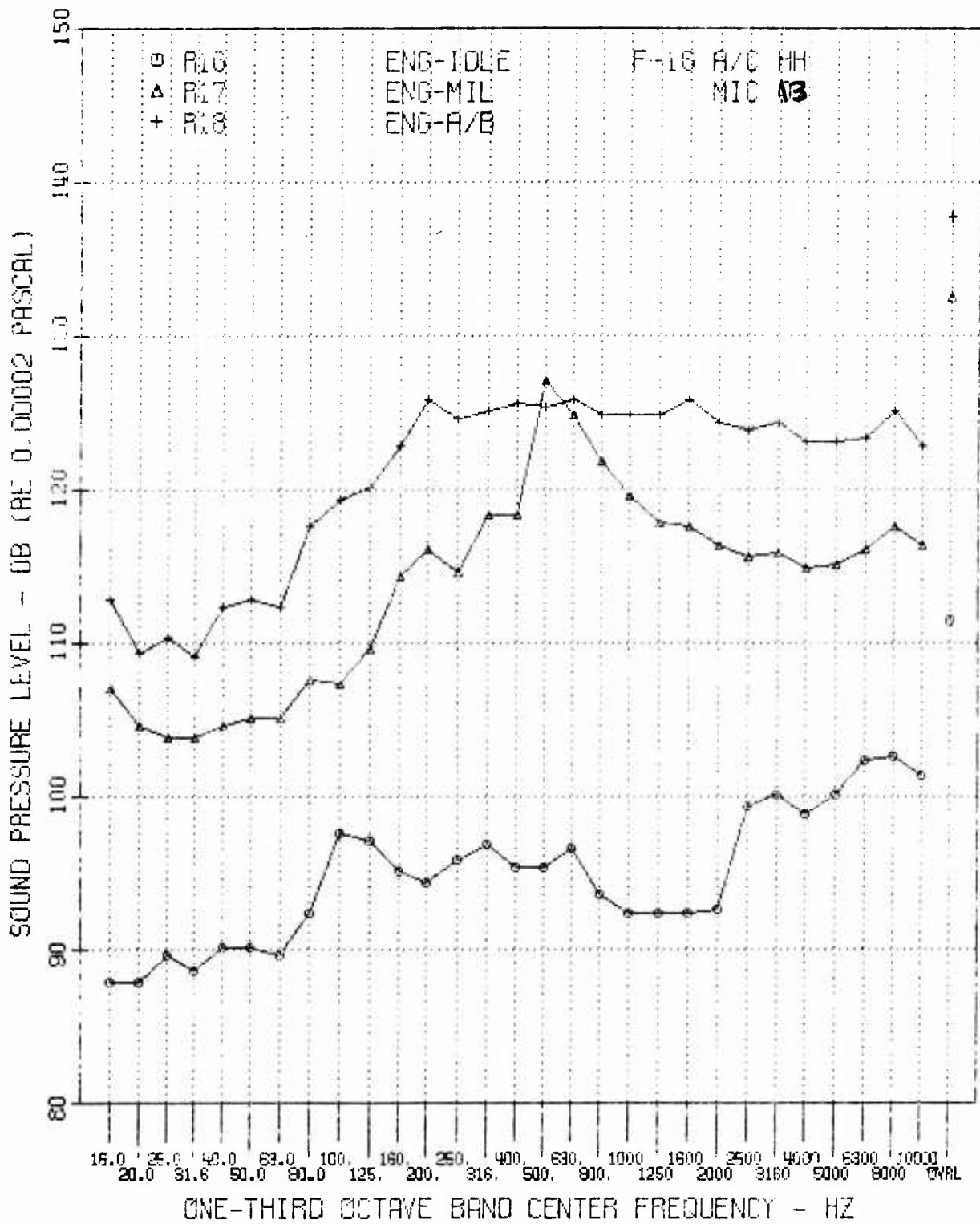


FIGURE B25 One-Third Octave Band Spectra for F-16 Aircraft
 Installed in Hush House for Record Numbers
 16, 17, 18 - Microphone 13.

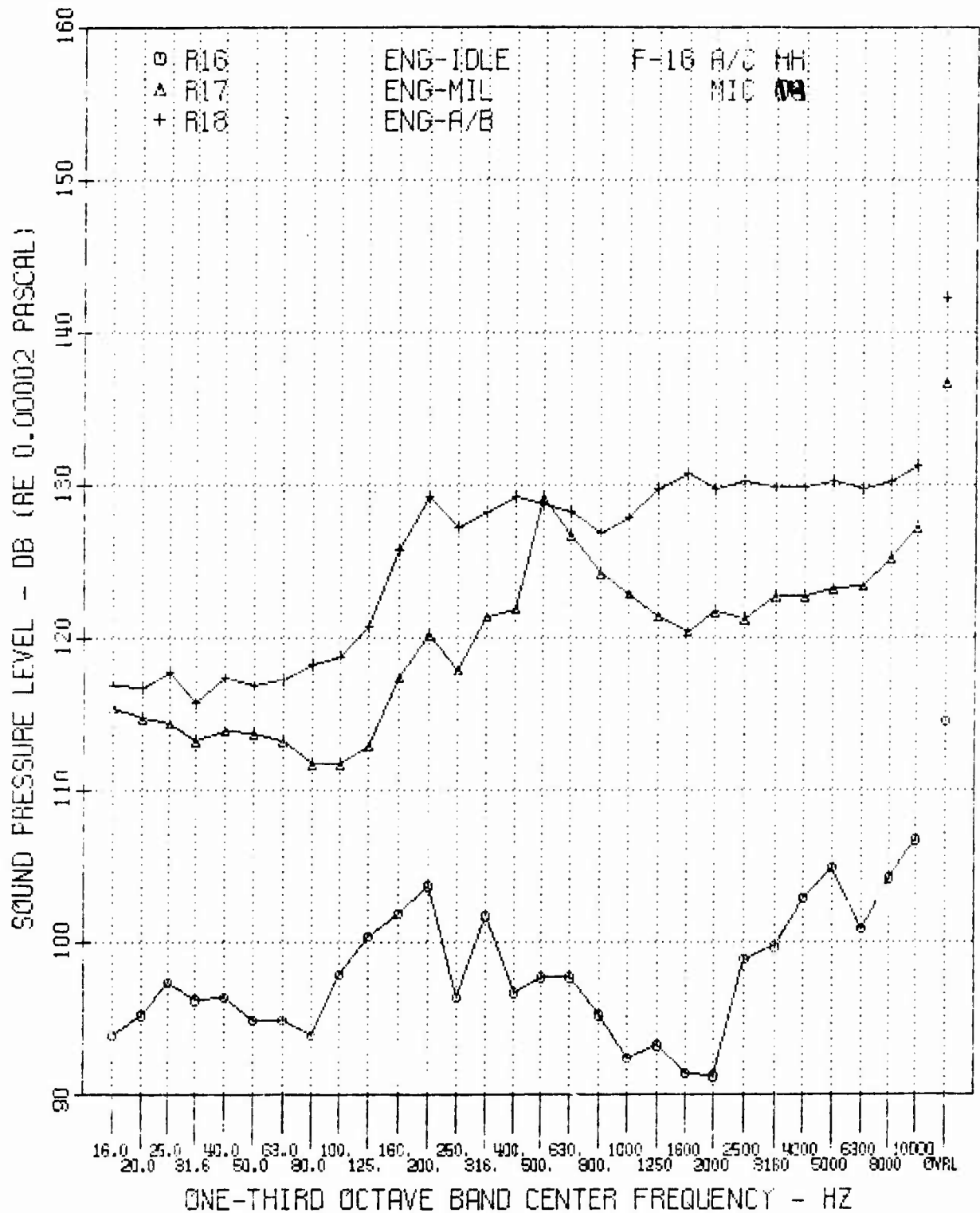


FIGURE B26 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 14.

GRAPH

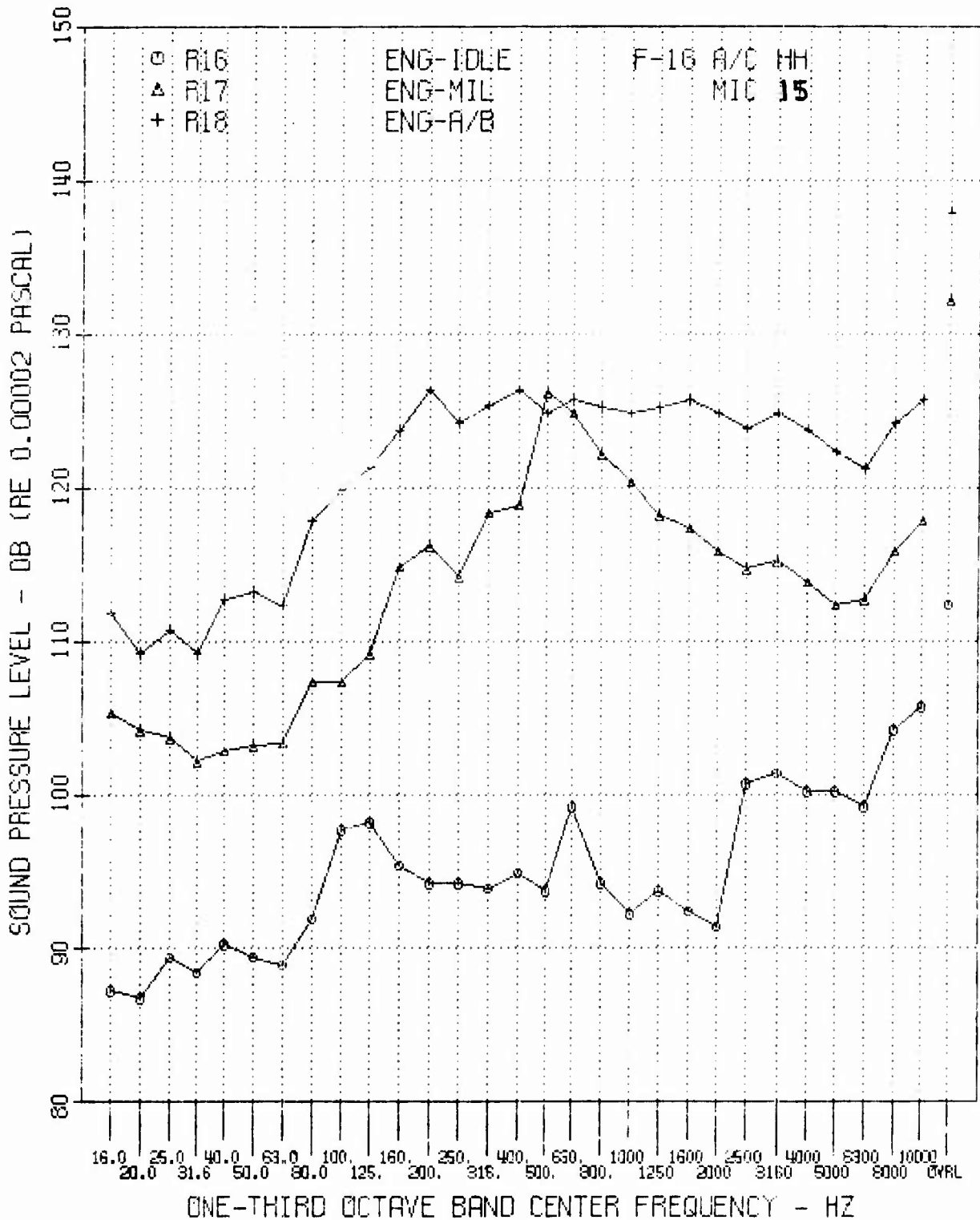


FIGURE B27 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 15.

GRAPH 15

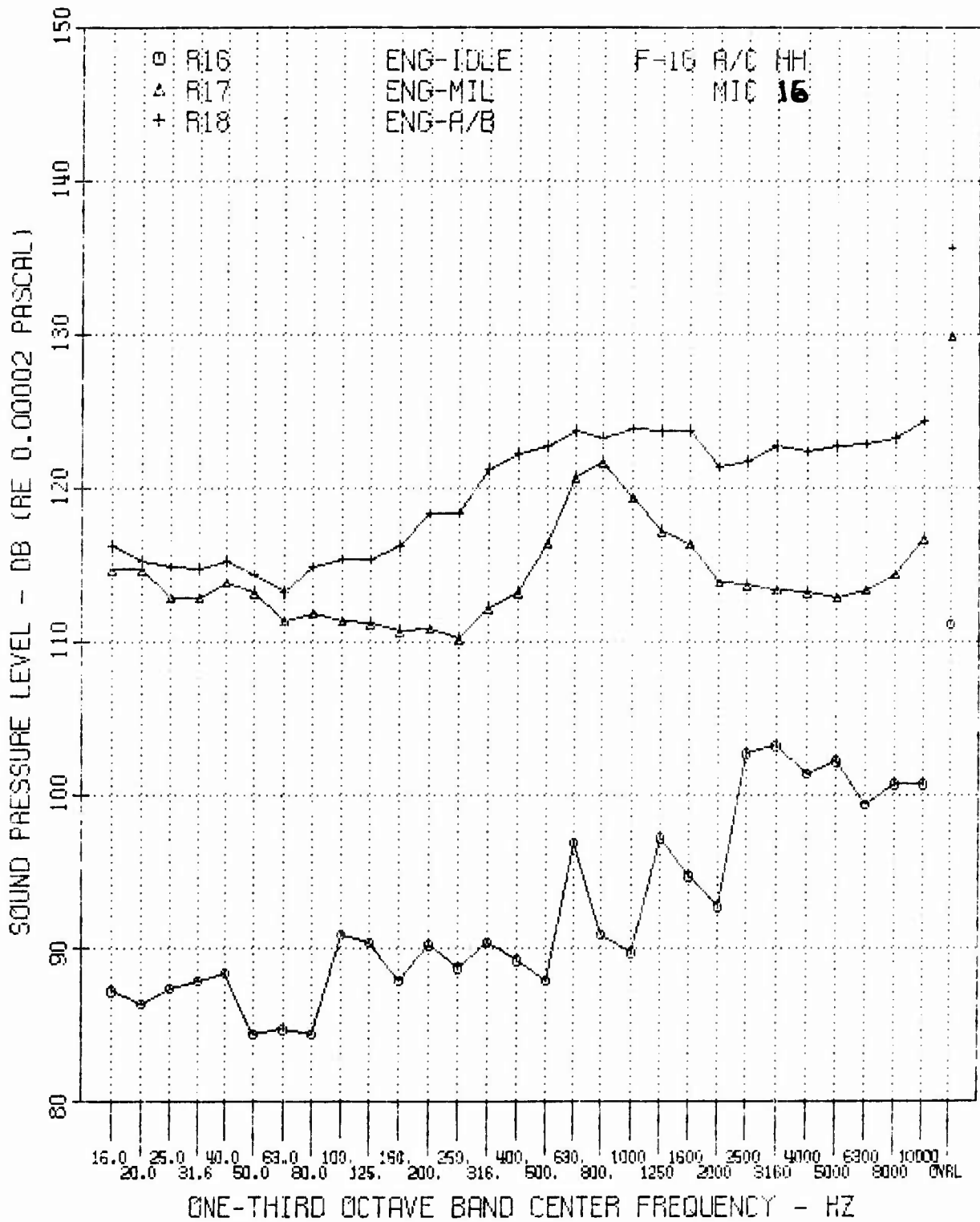


FIGURE B28 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 16.

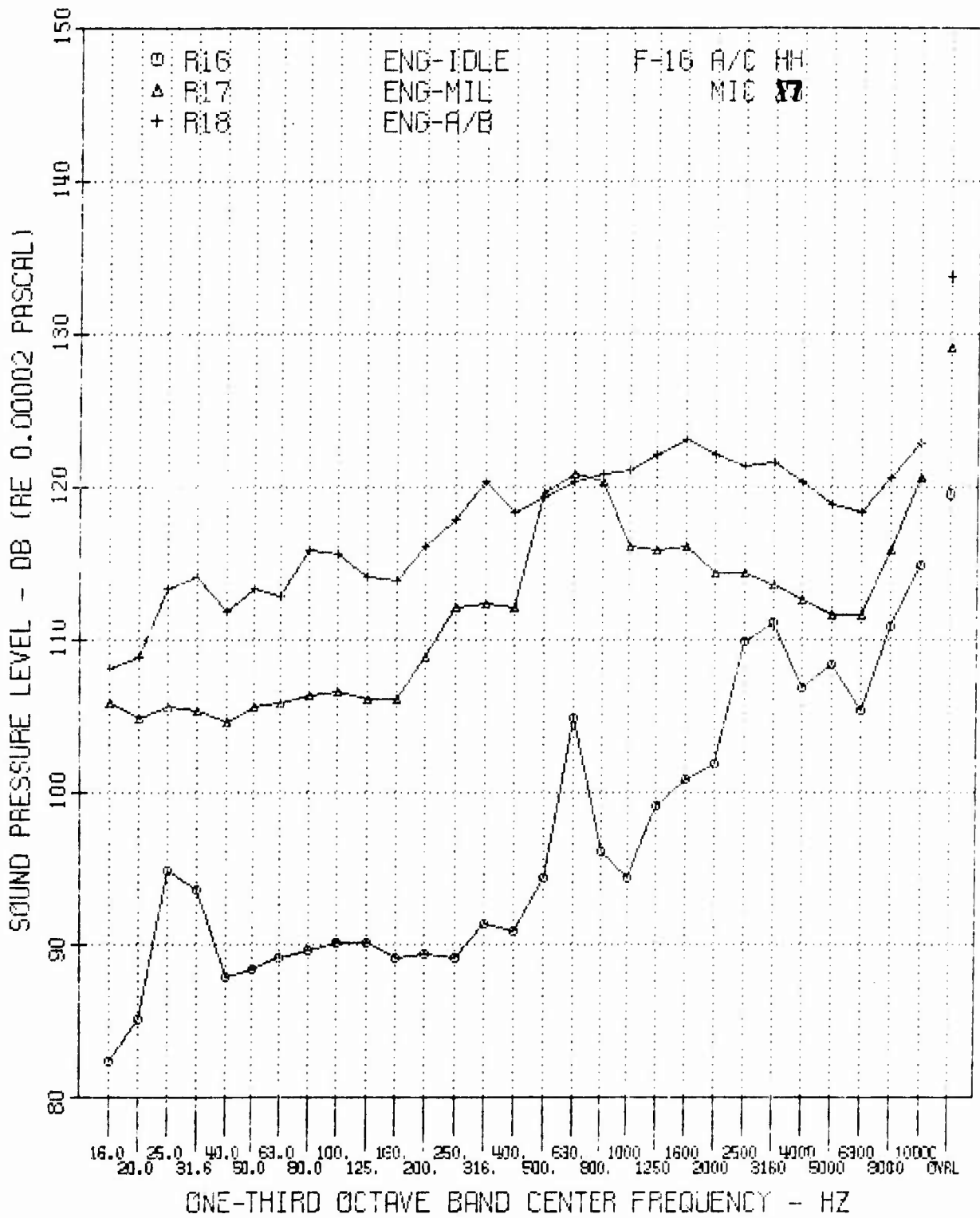


FIGURE B29 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 17.

GRAPH 14

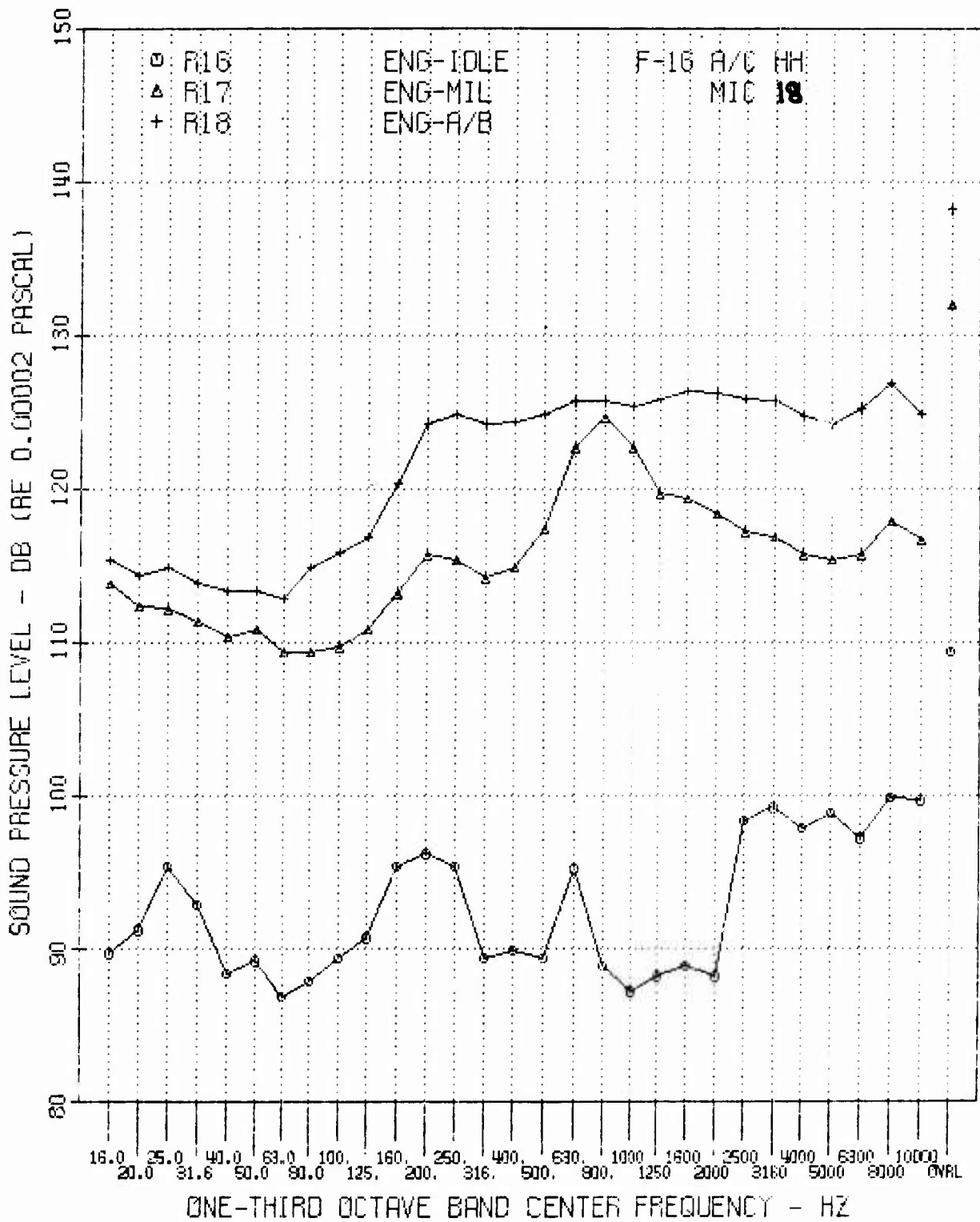


FIGURE B30 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 18.

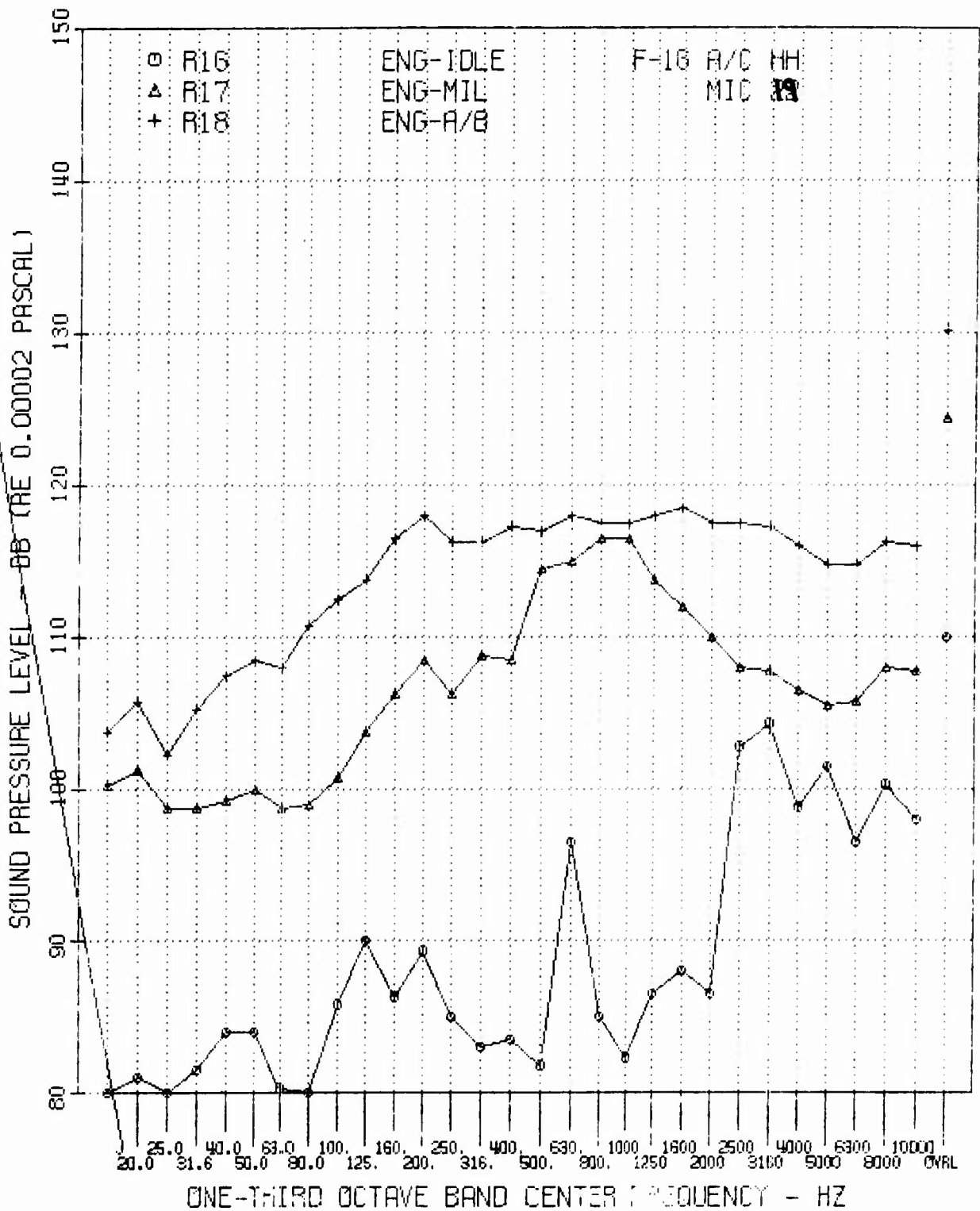


FIGURE B31 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 19.

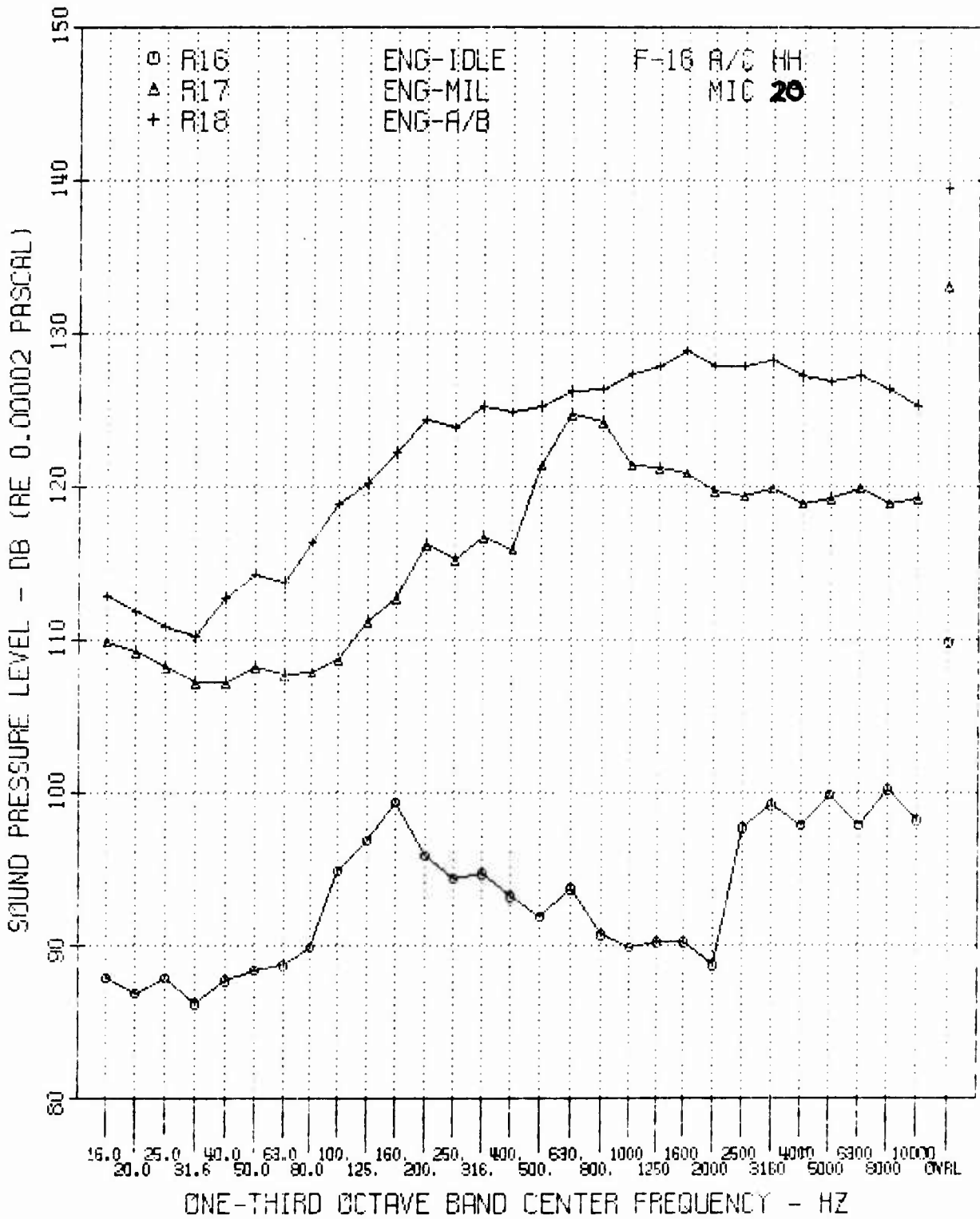


FIGURE B32 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 20.

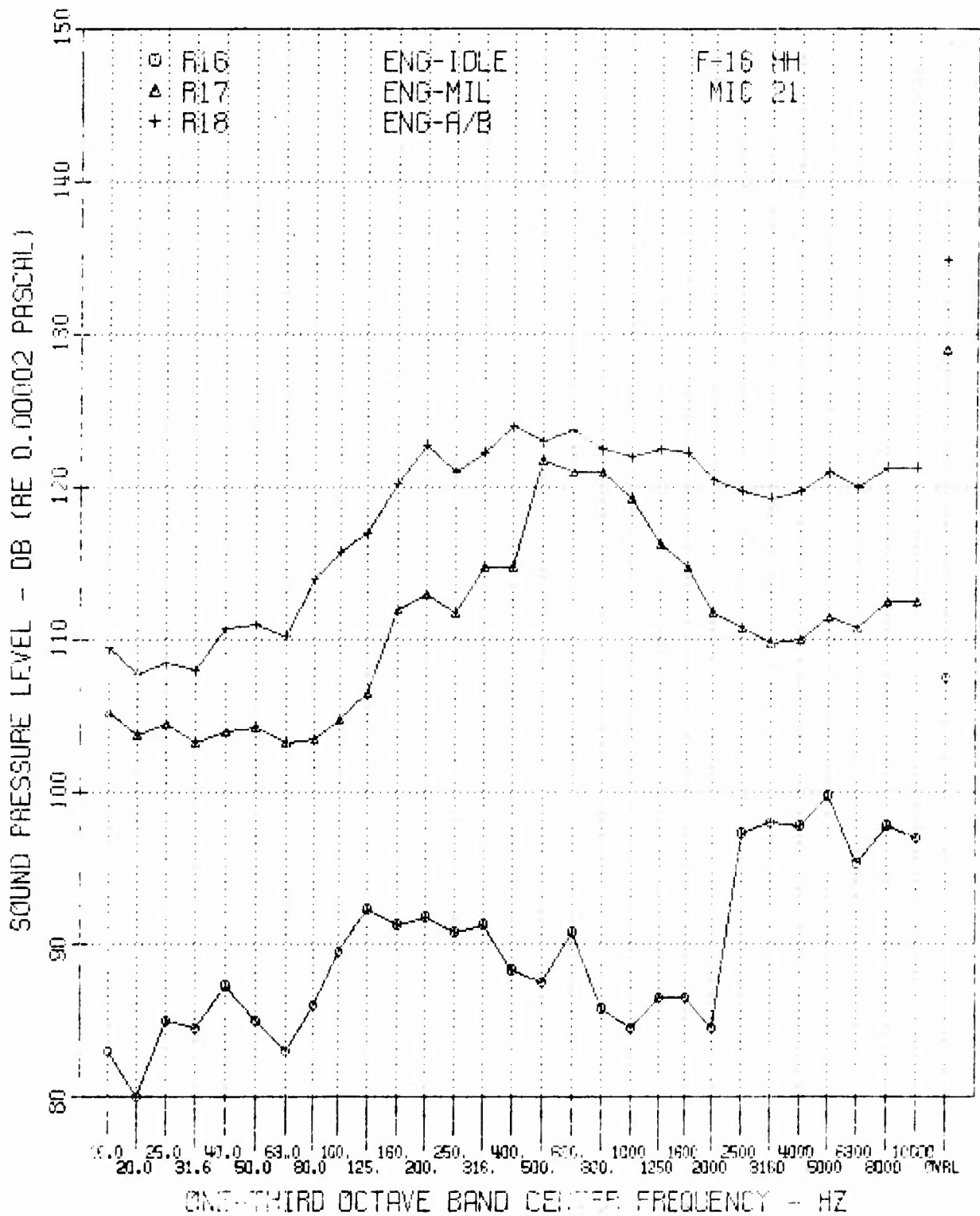


FIGURE B33 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 21.

GRAPH 1

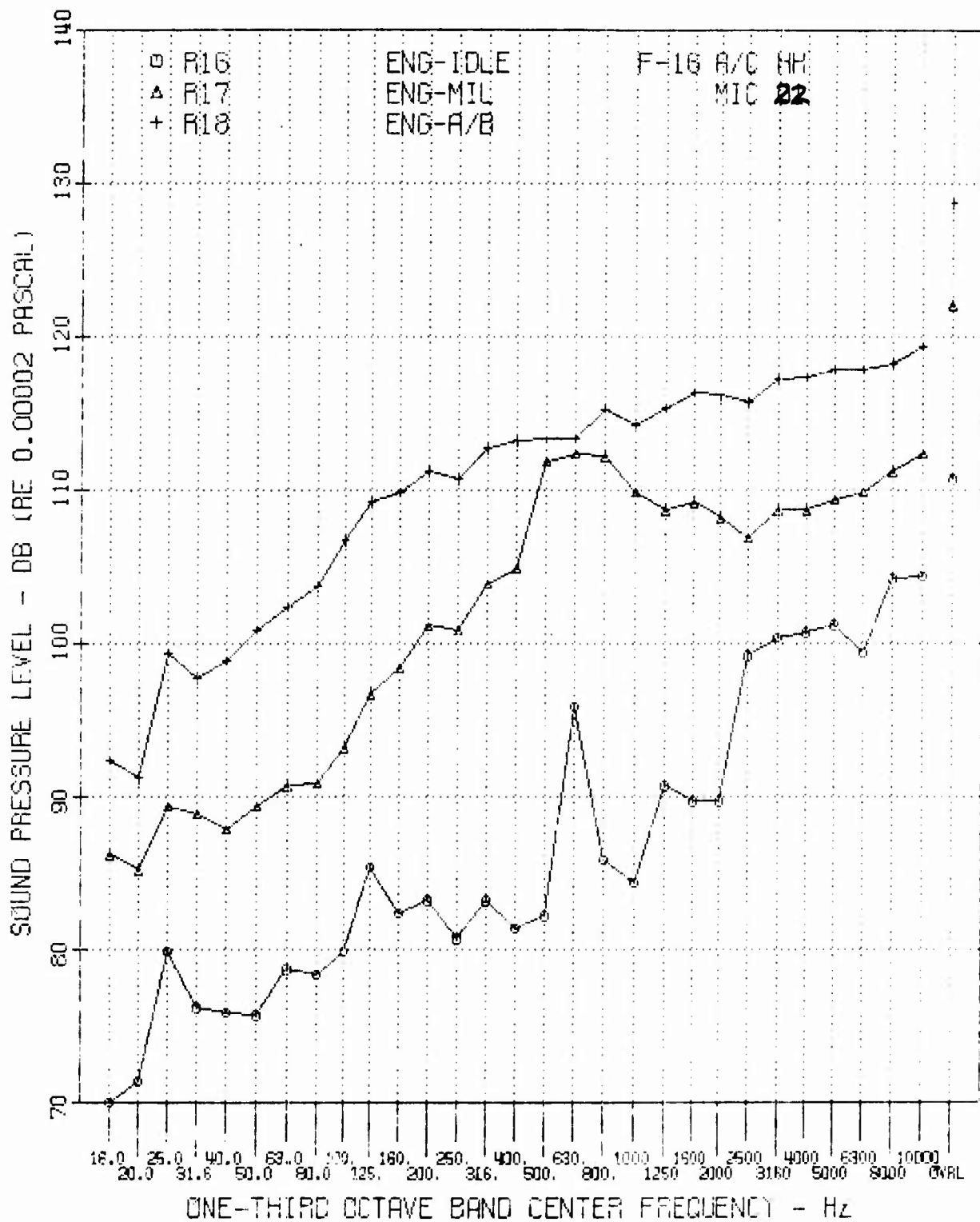


FIGURE B34 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 22.

GRAPH 24

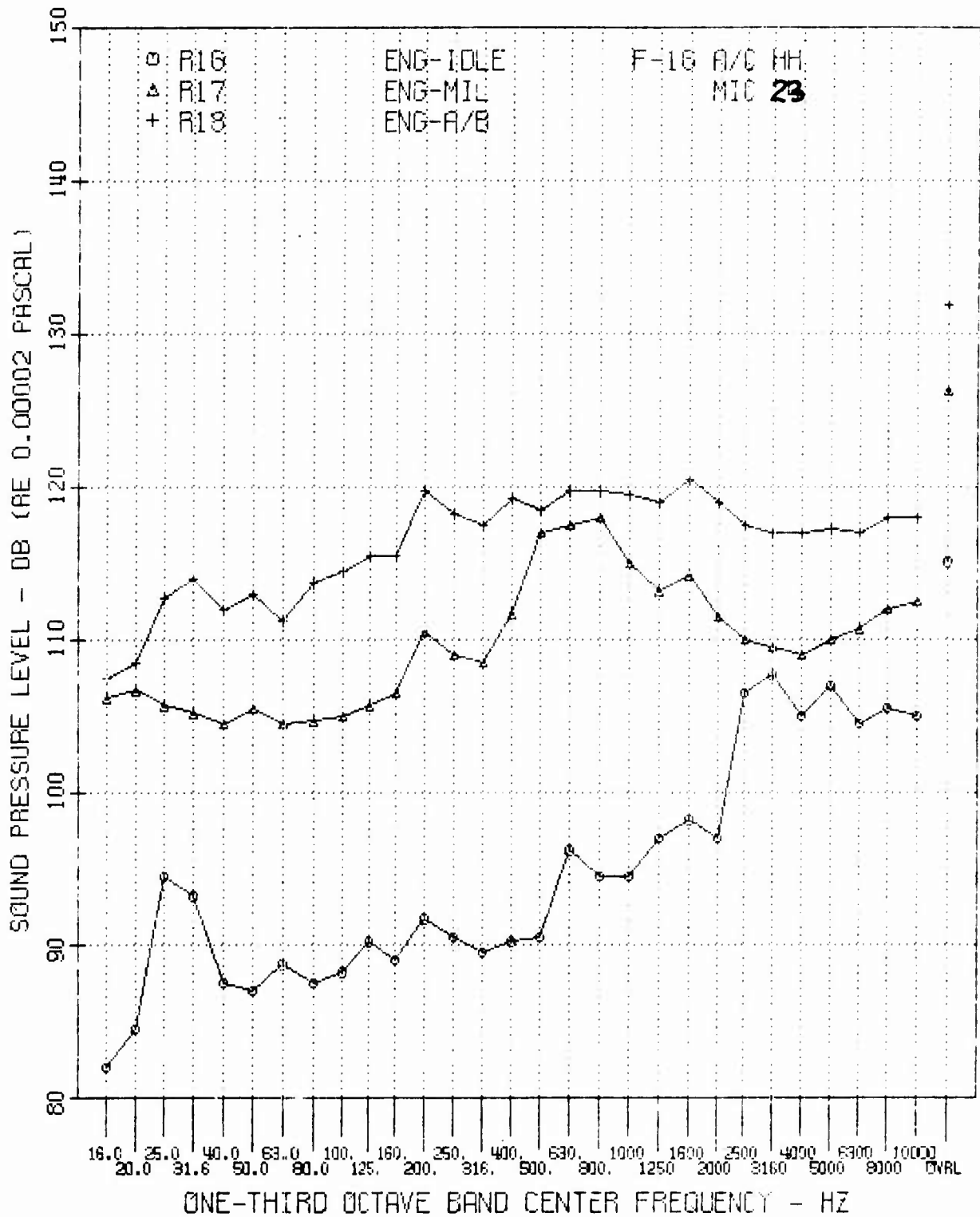


FIGURE B35 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 23.

GRAPH 20

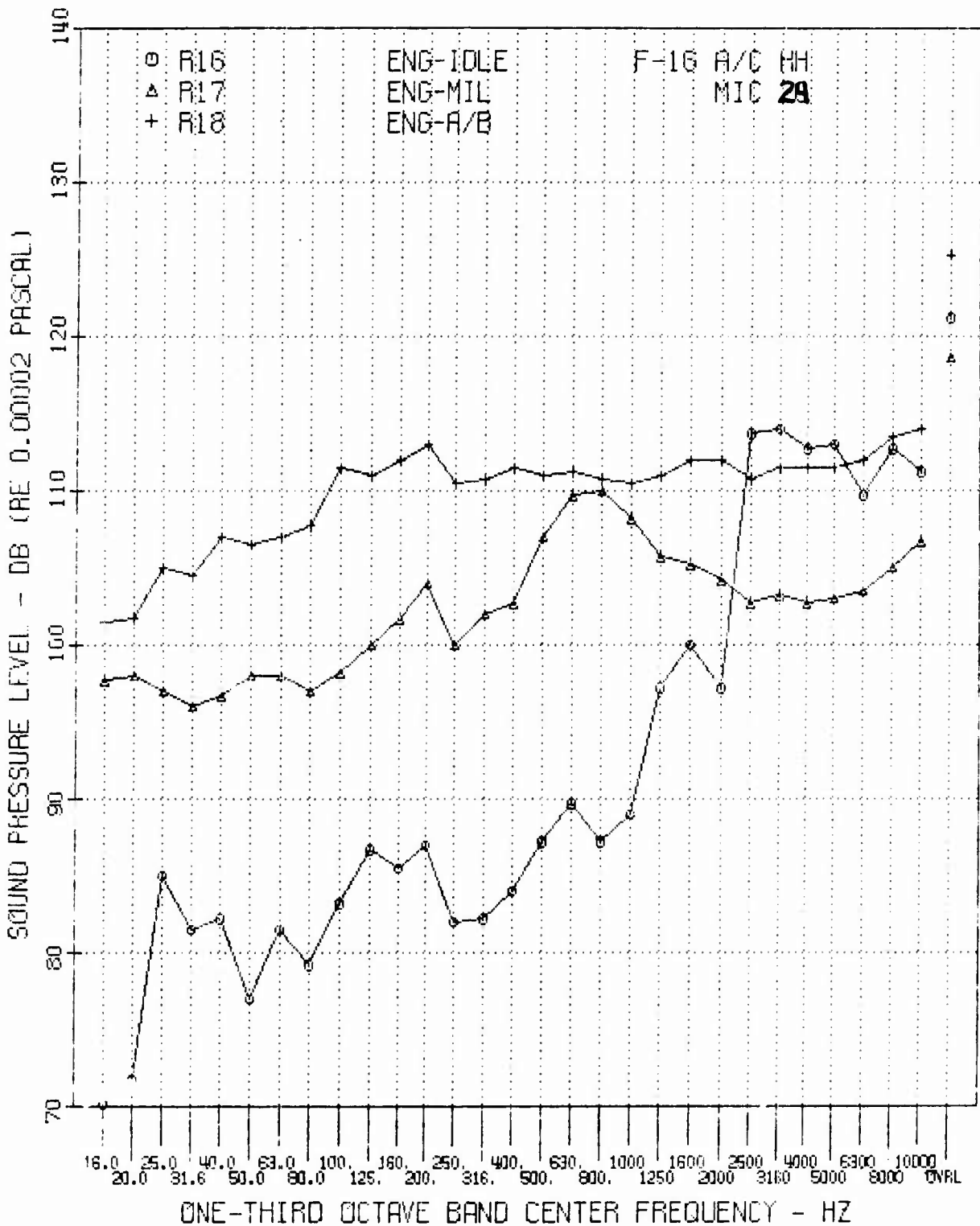


FIGURE B36 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 24.

GRAPH 1

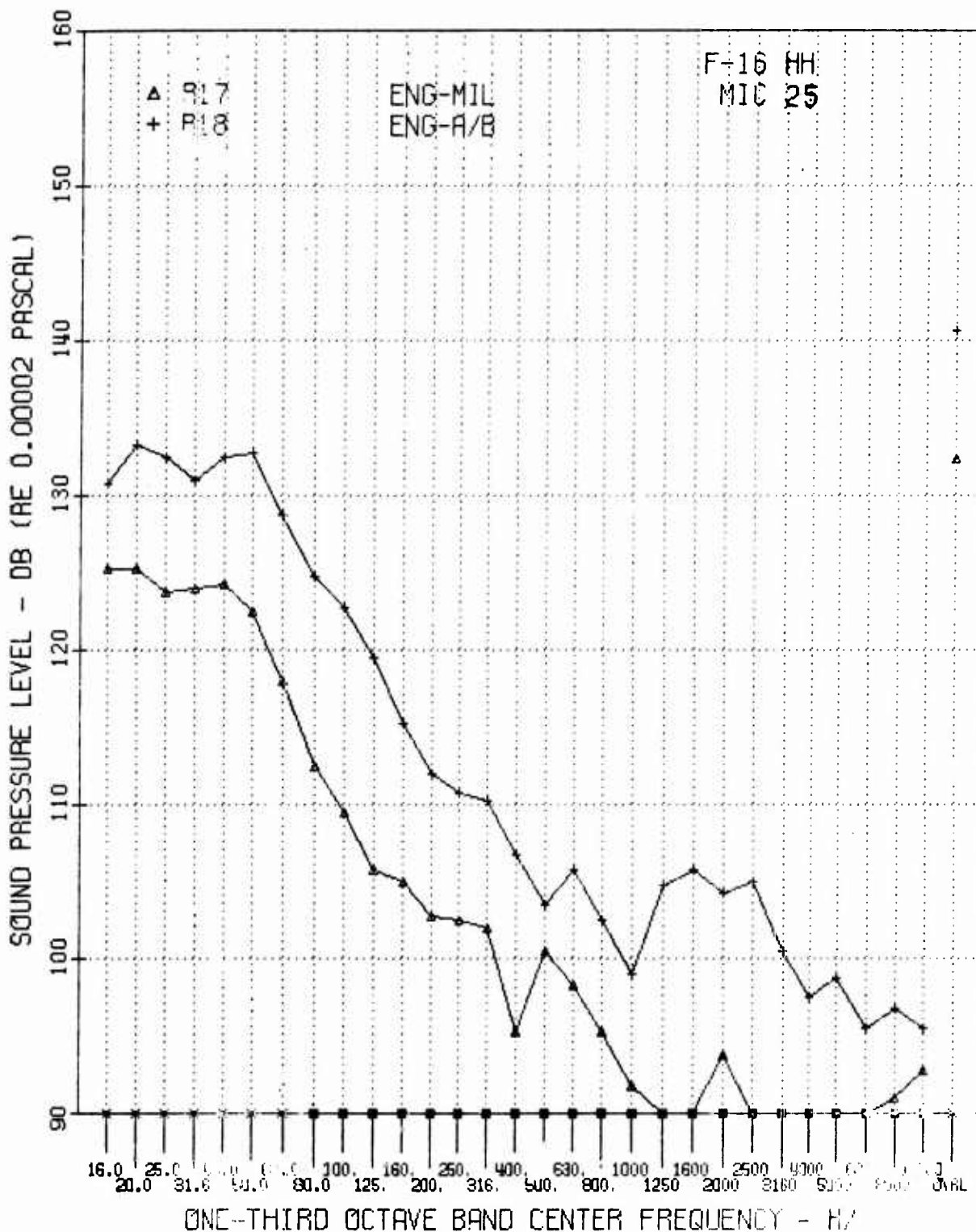


FIGURE B37 One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 17 and 18 - Microphone 25.

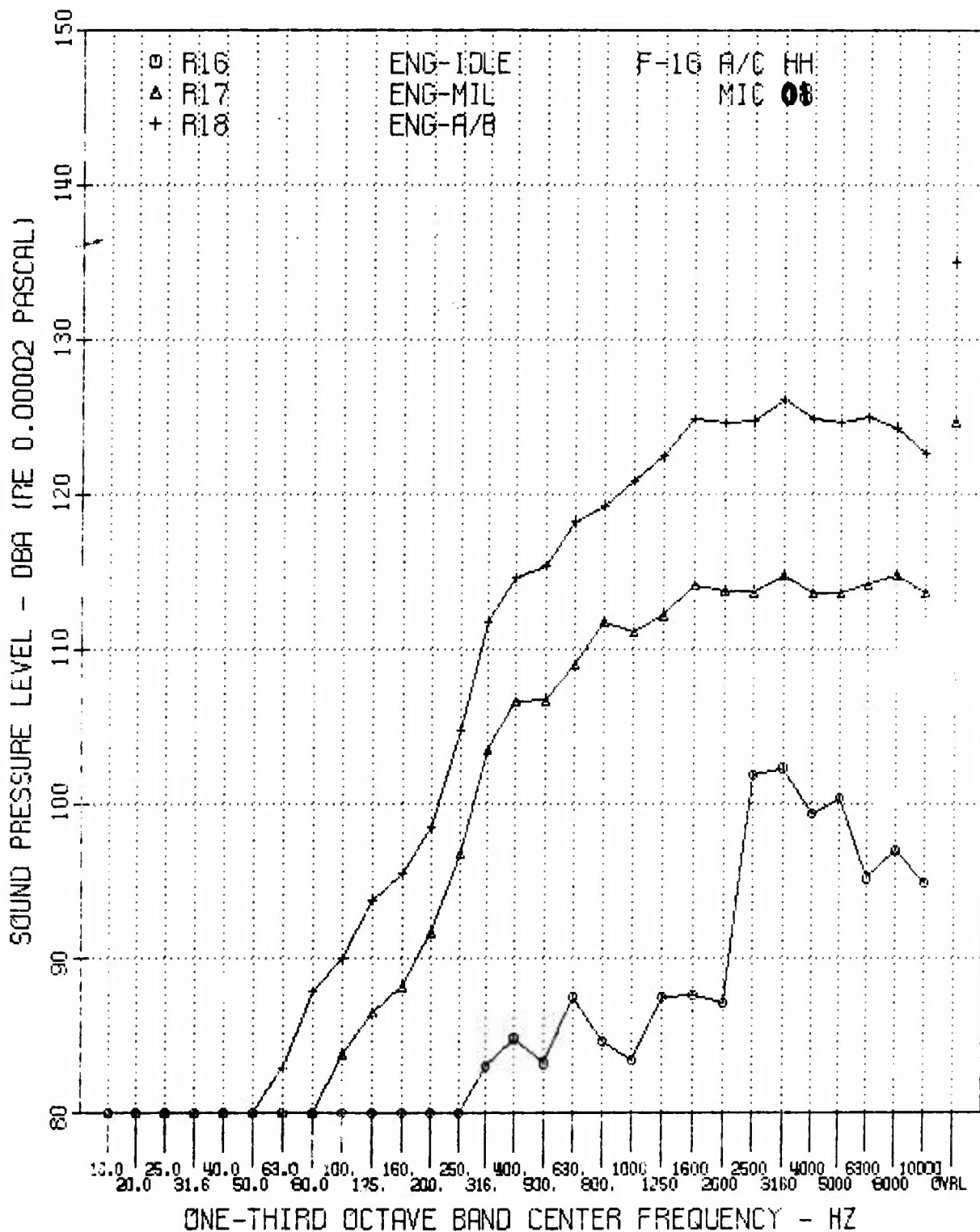


FIGURE B38 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 1.

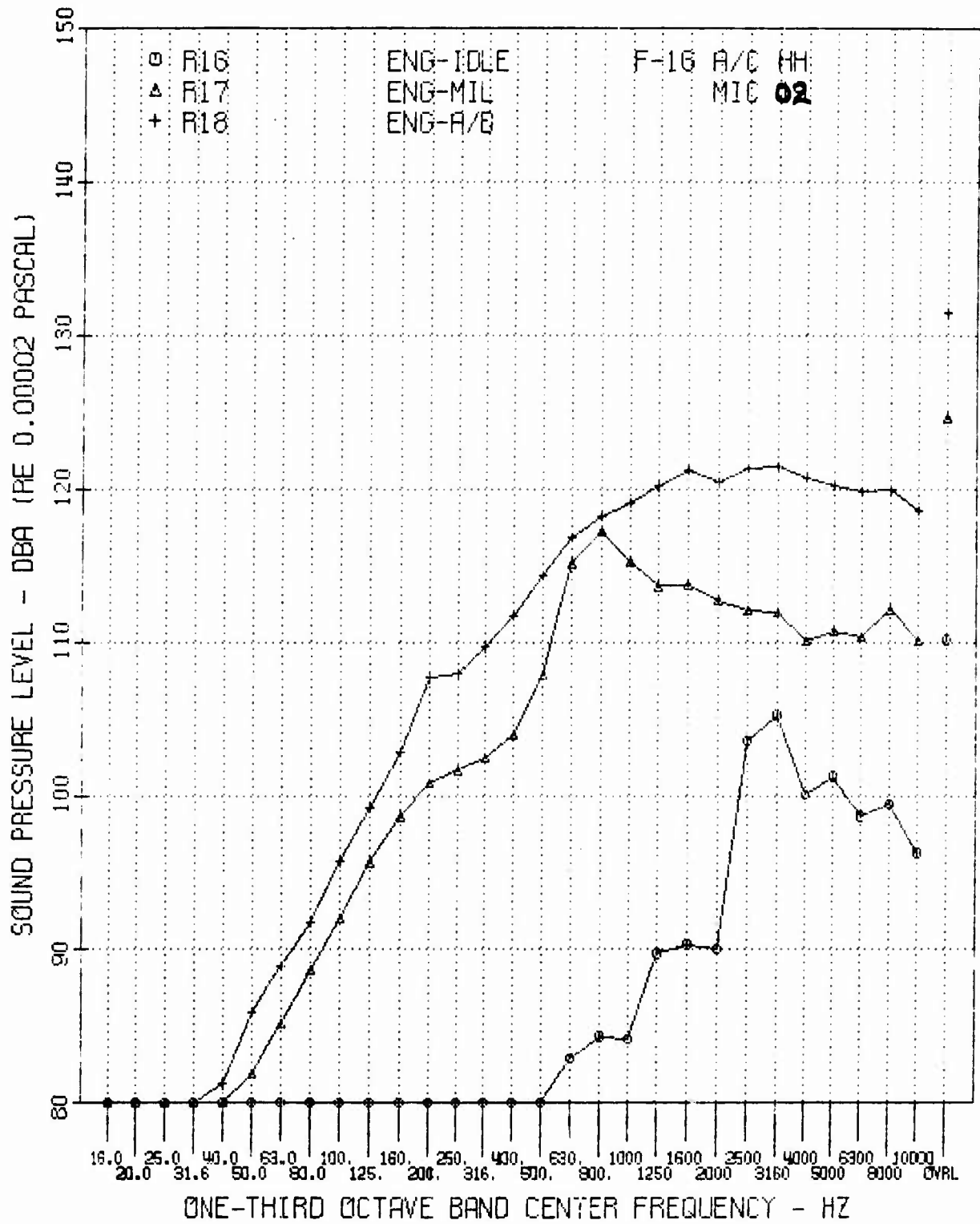


FIGURE B39 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 2.

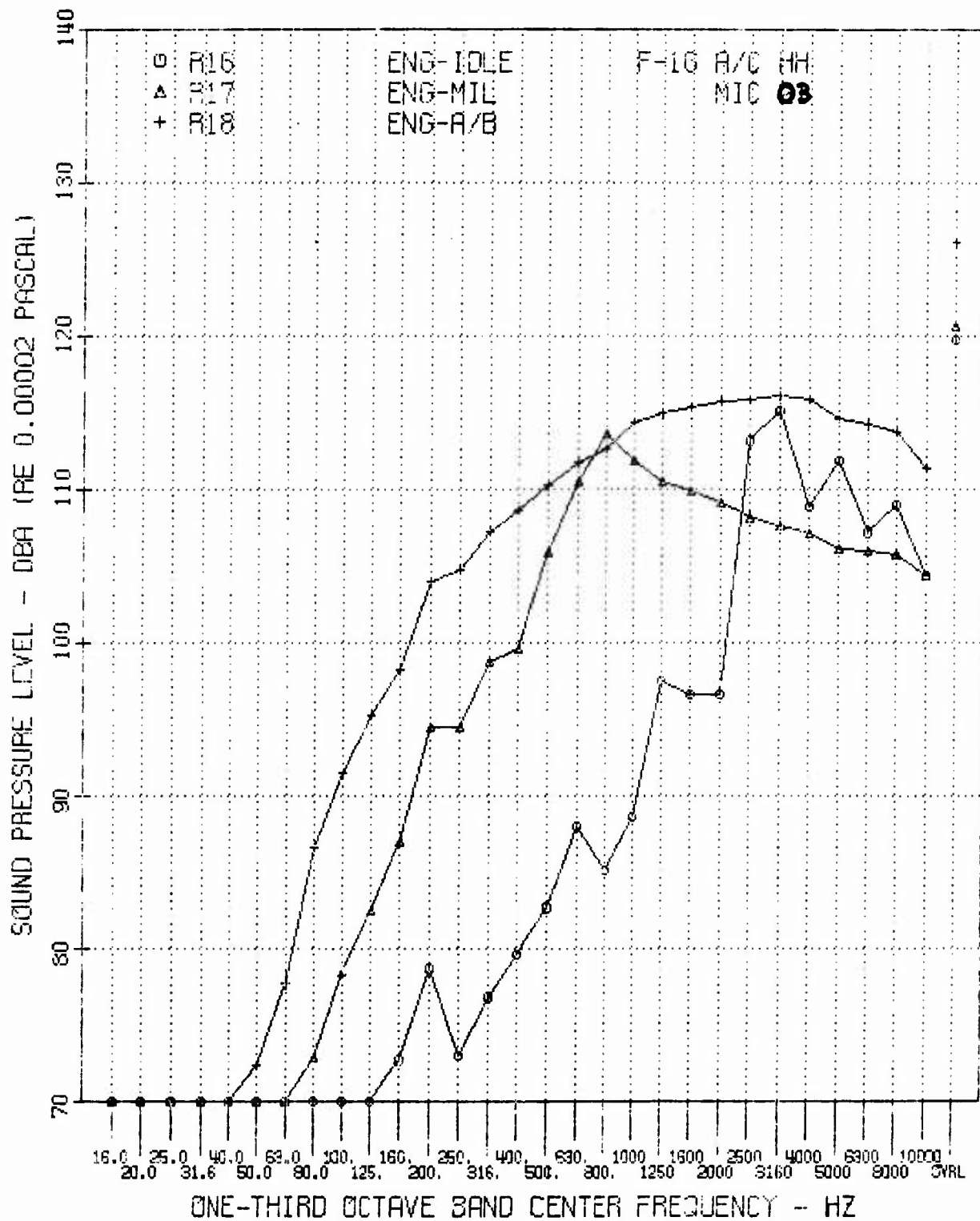


FIGURE B40 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 3.

GRAPH 9

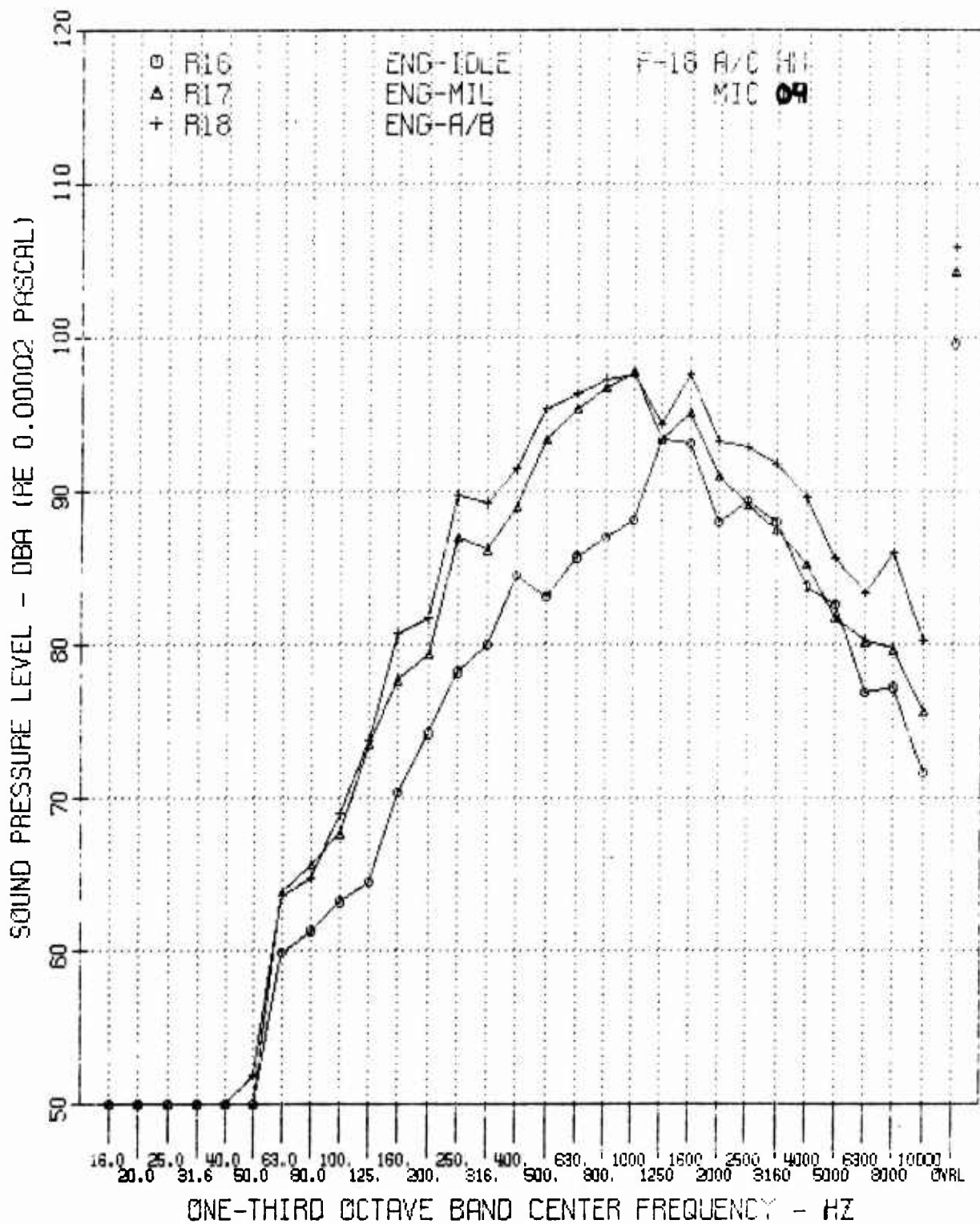


FIGURE B41 A-weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 4.

GRAPH 4

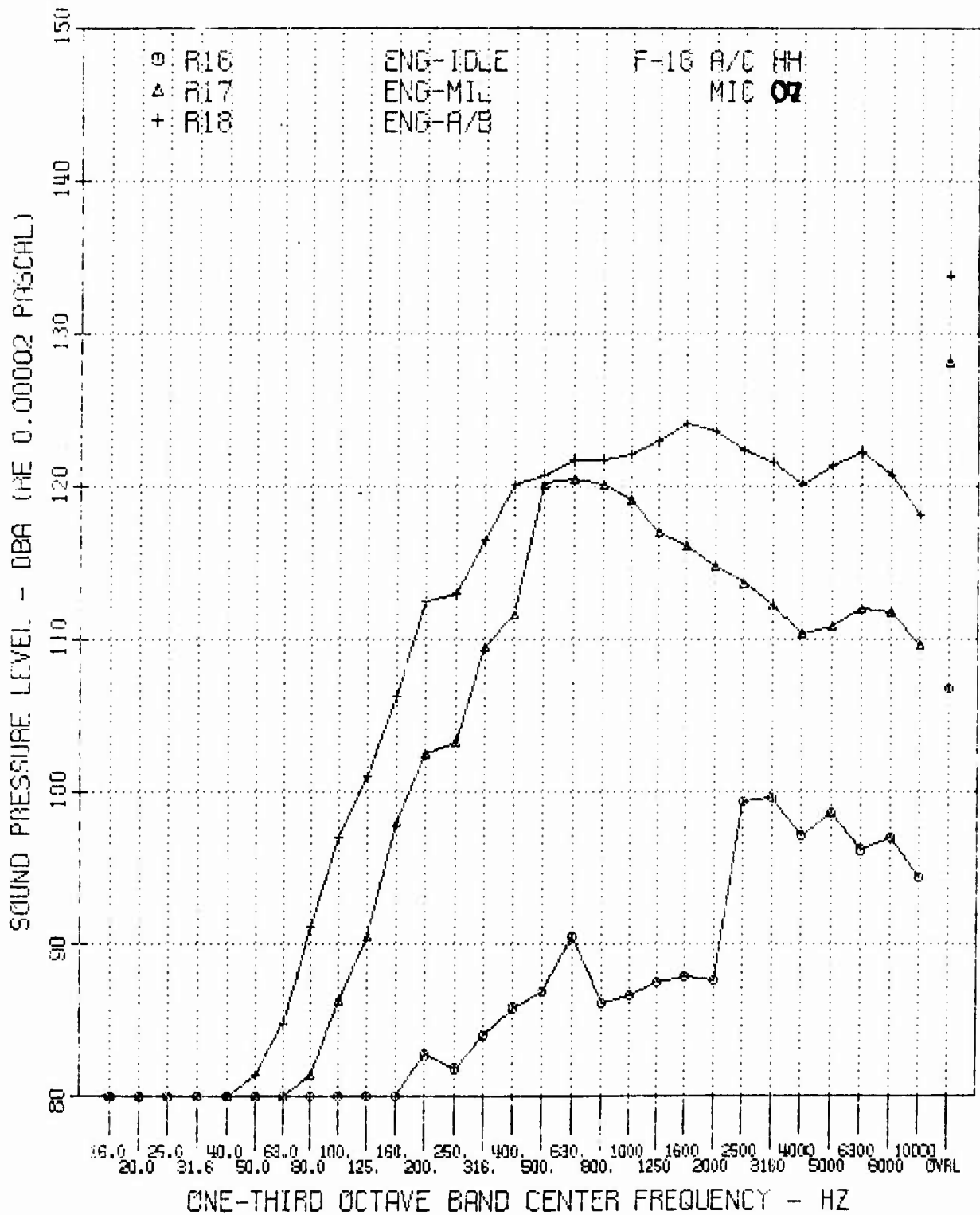


FIGURE B42 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 7.

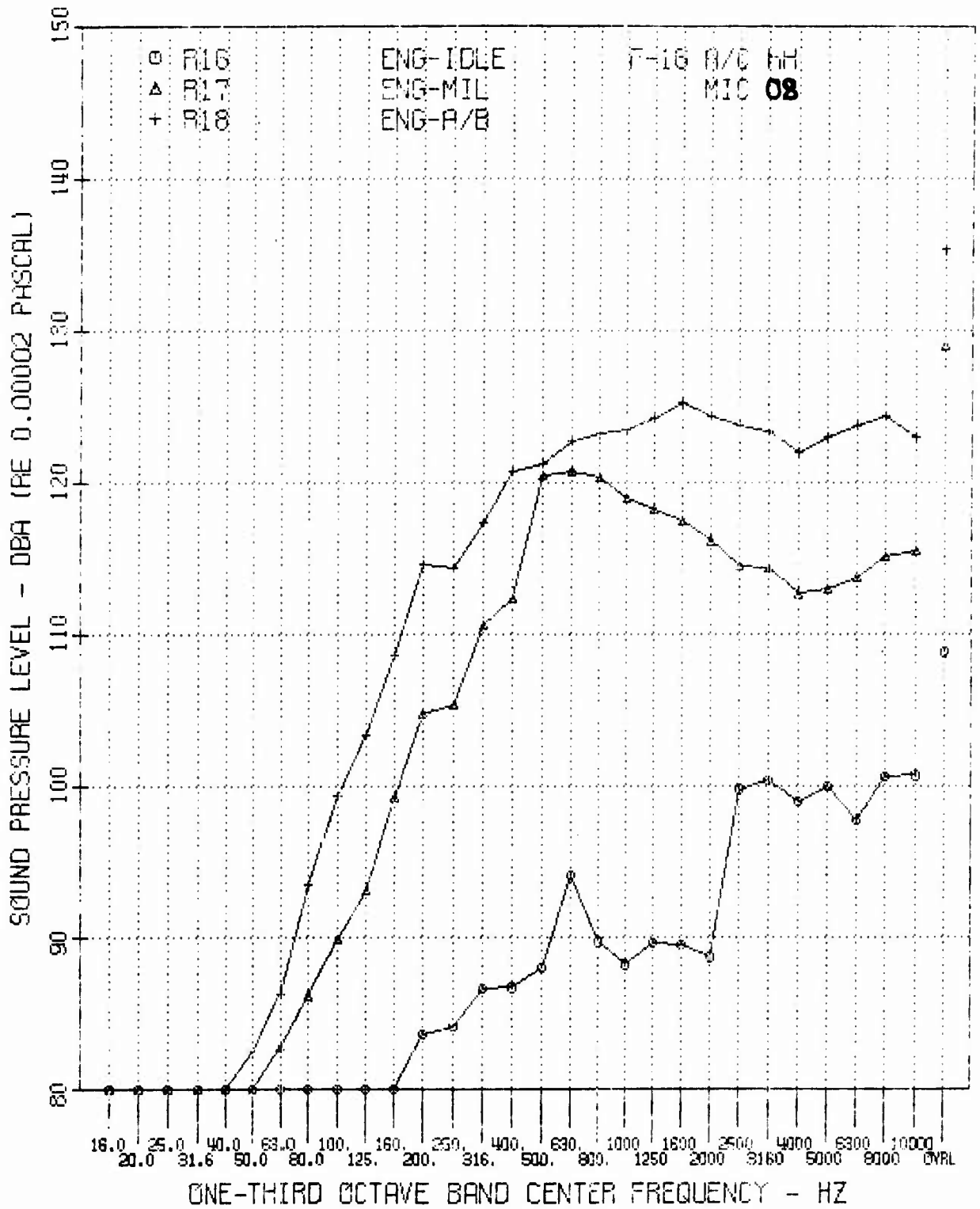


FIGURE B43 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 8.

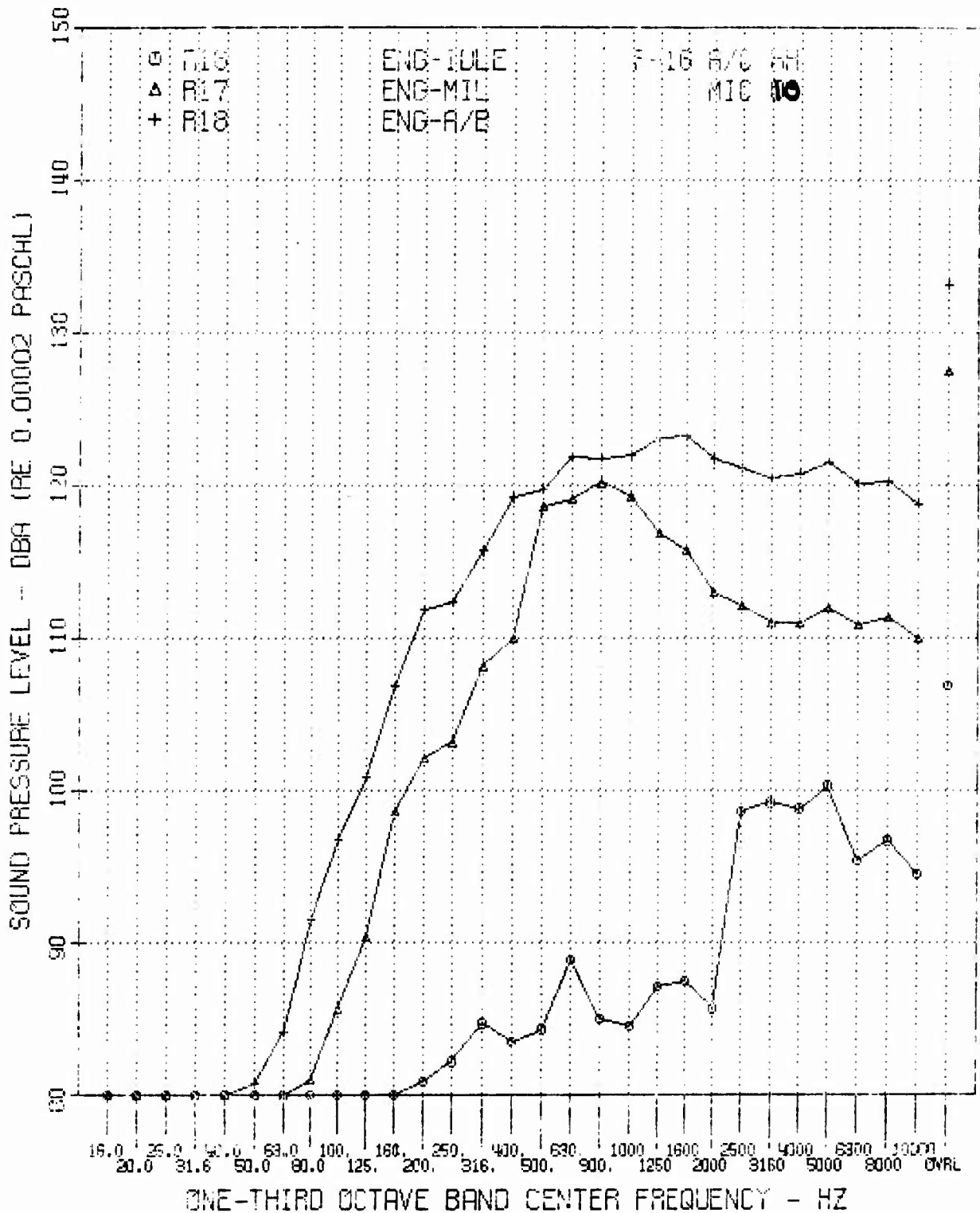


FIGURE B44 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 10.

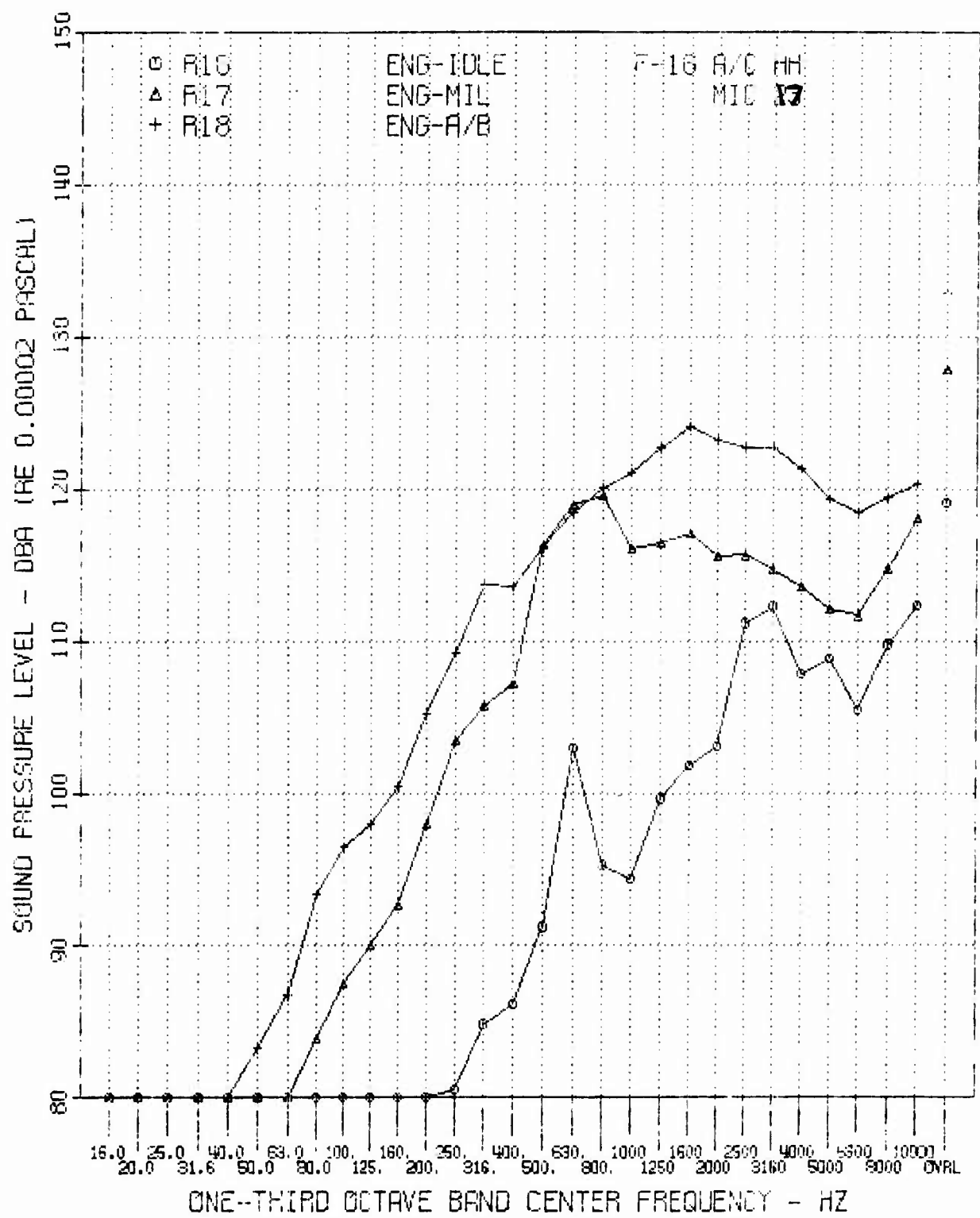


FIGURE B45 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 17.

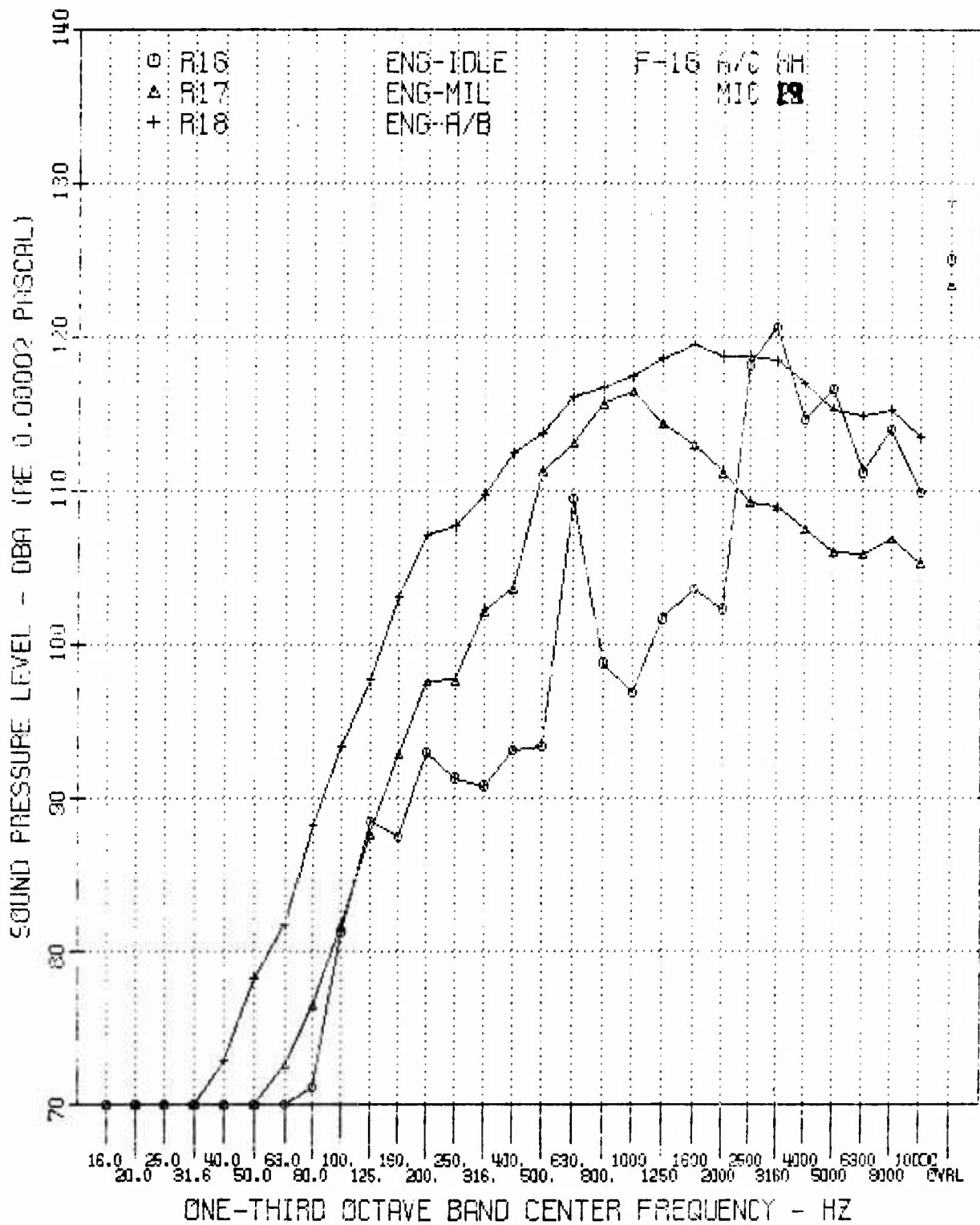


FIGURE B46 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 19.

GRAPH 6

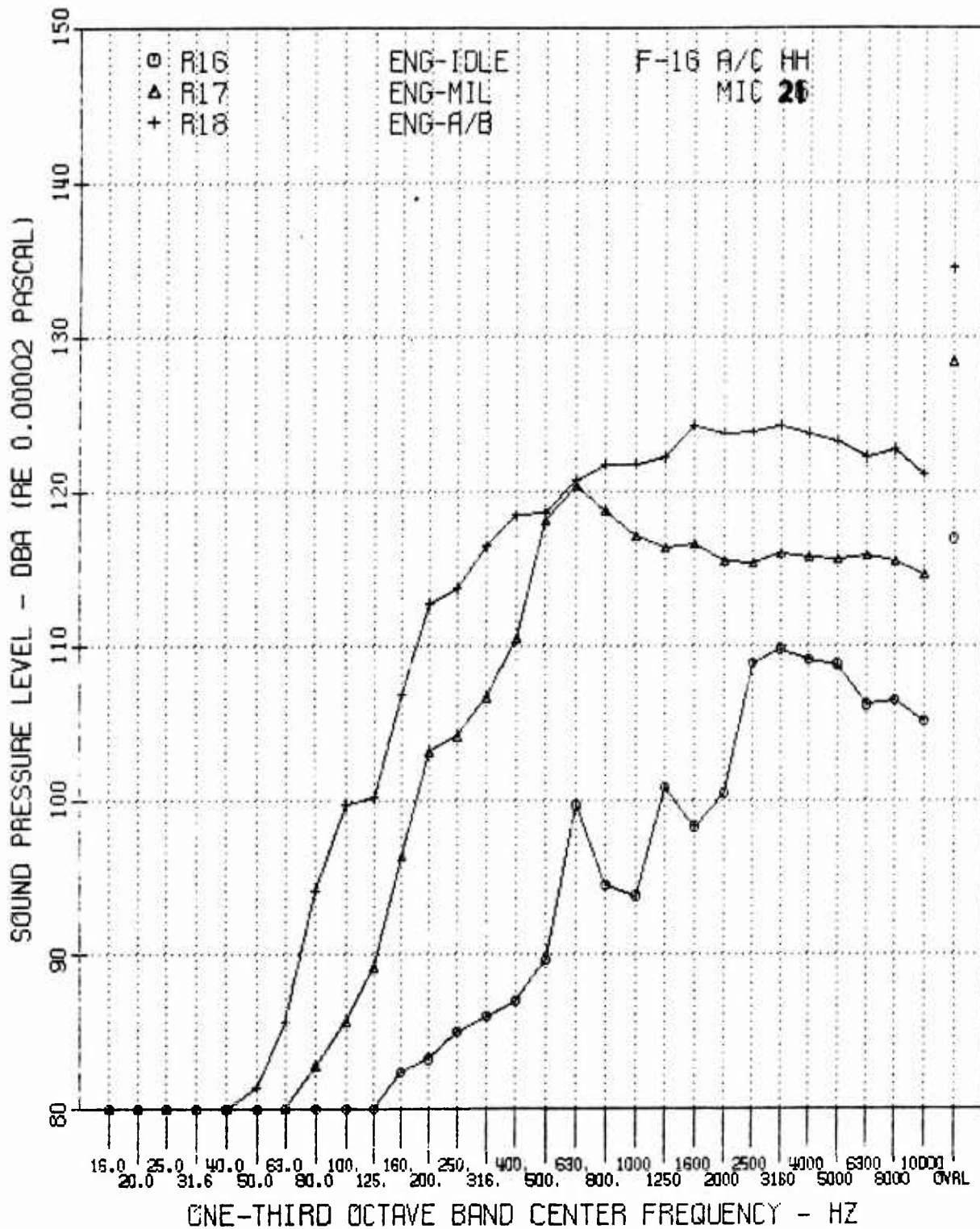


FIGURE B47 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 21.

GHF

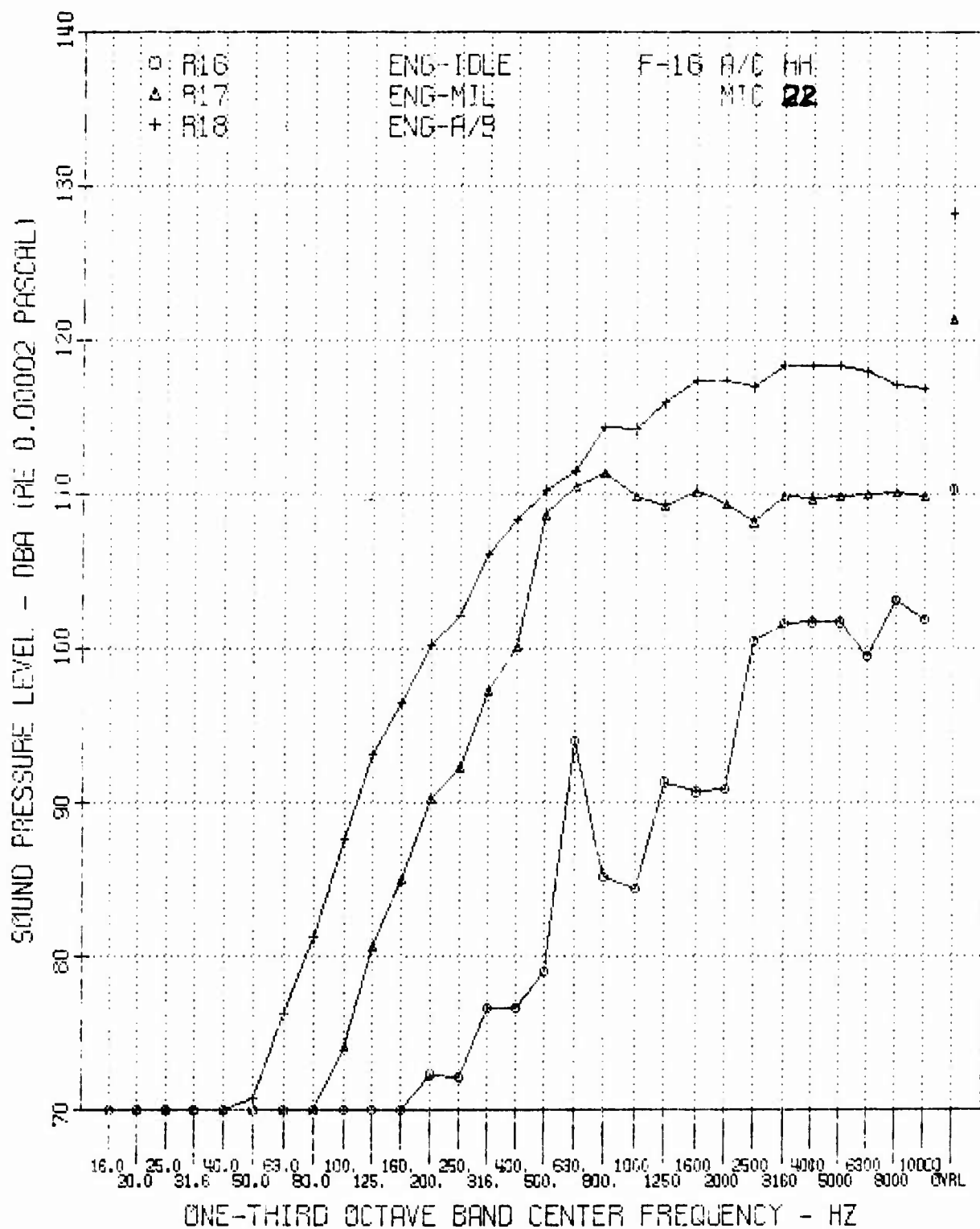


FIGURE B48 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 22.

GRAPH 9

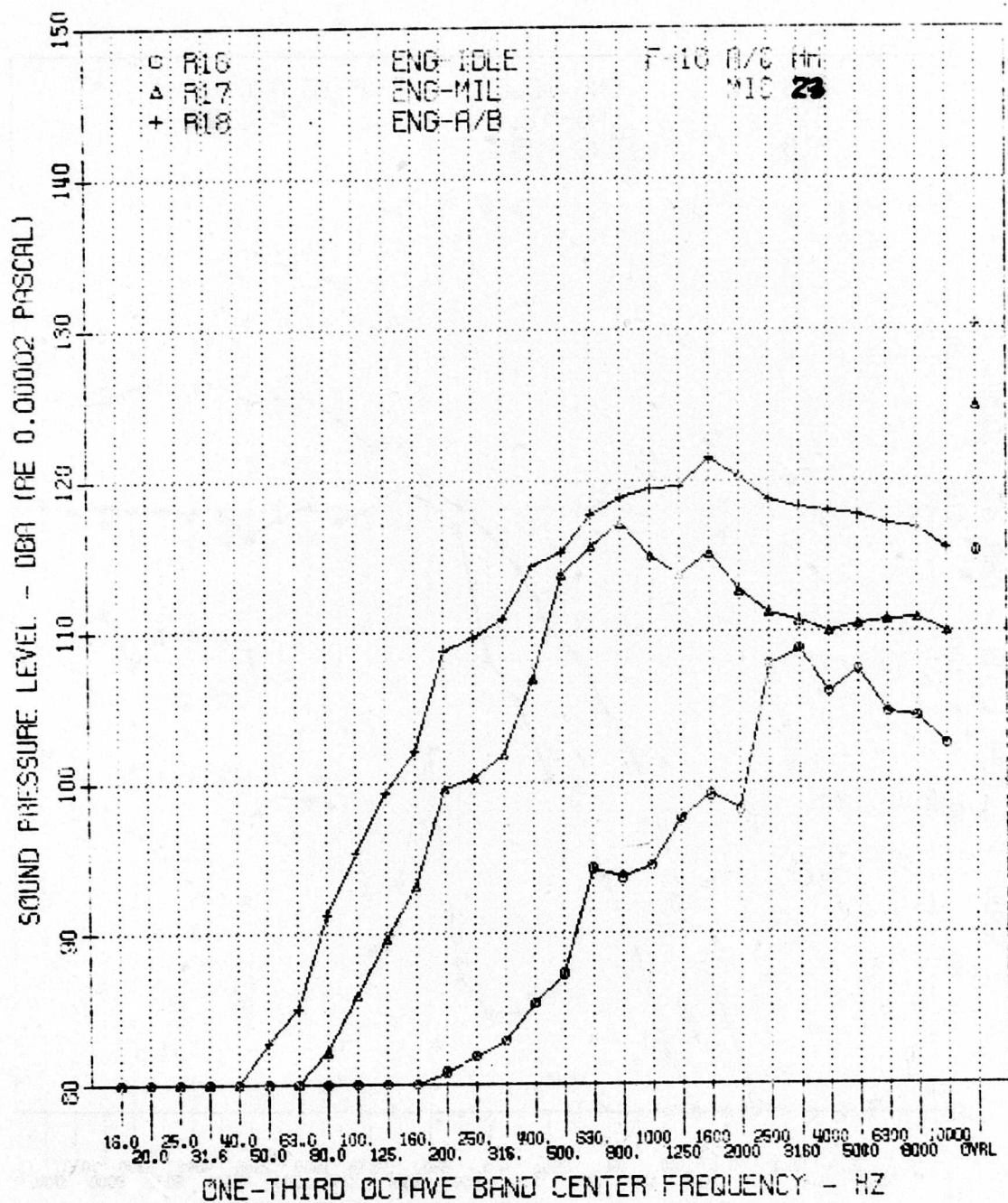


FIGURE B49 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 23.

GRAPH 9

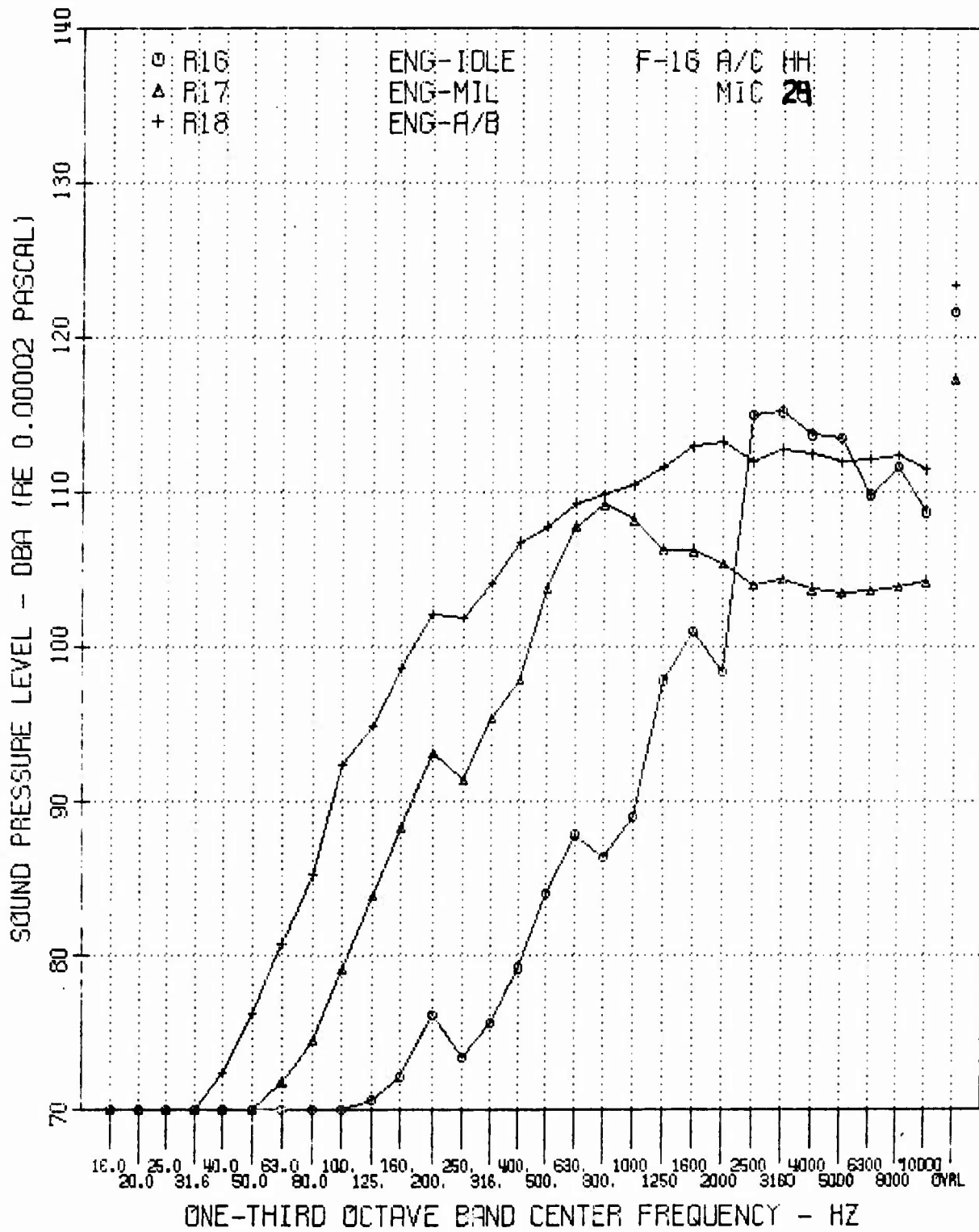


FIGURE B50 A-Weighted One-Third Octave Band Spectra for F-16 Aircraft Installed in Hush House for Record Numbers 16, 17, 18 - Microphone 24.

HUSH HOUSE TEST AIRCRAFT: F-16
MICROPHONE 25 RECORD 17

RMS 133.9353

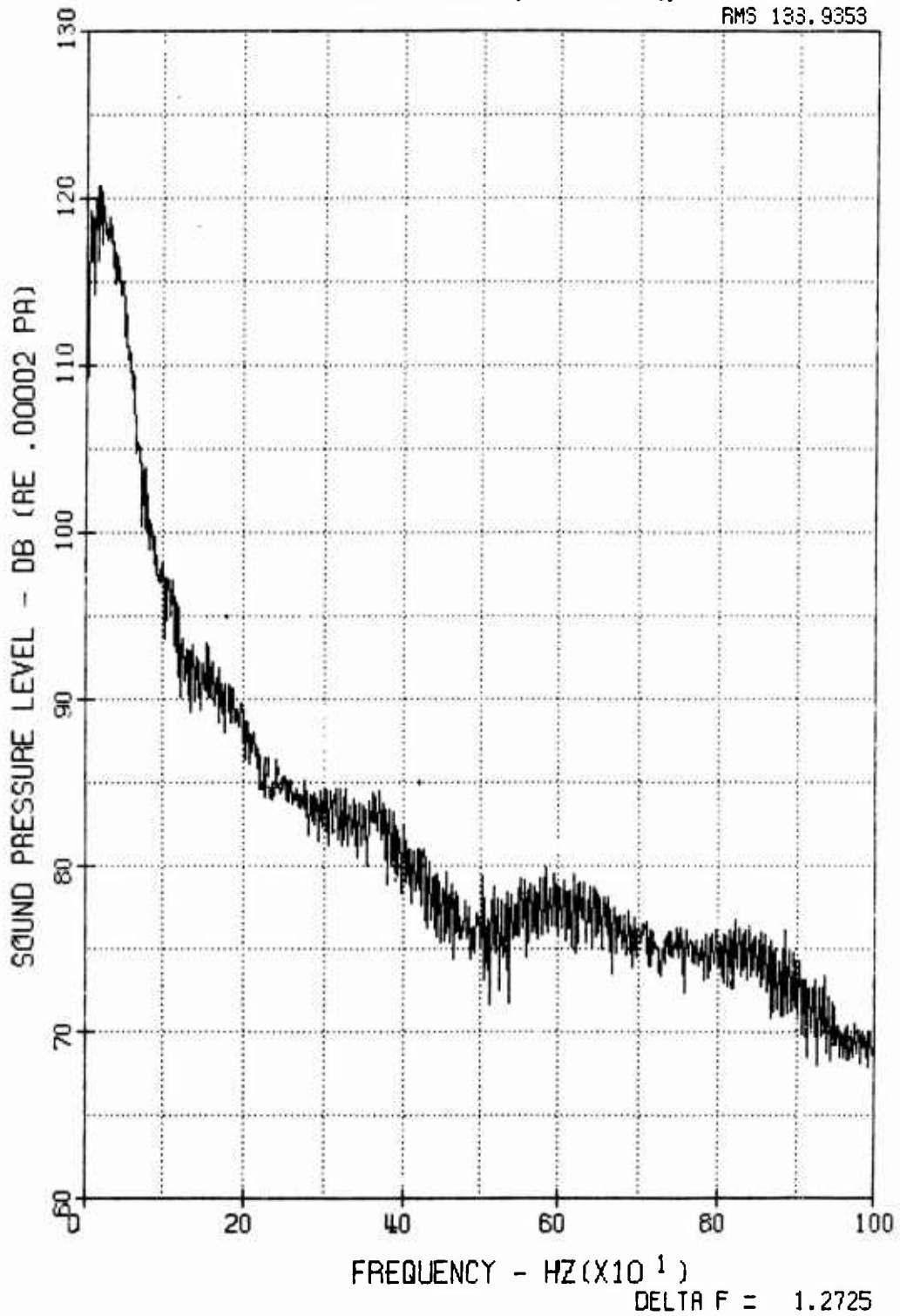


FIGURE B51 Narrowband (1.27 Hz) Spectra for F-16 Aircraft
Installed in Hush House for Record Number
17 - Microphone 25.

HUSH HOUSE TEST AIRCRAFT: F-16
MICROPHONE 25 RECORD 18

RMS 141.9390

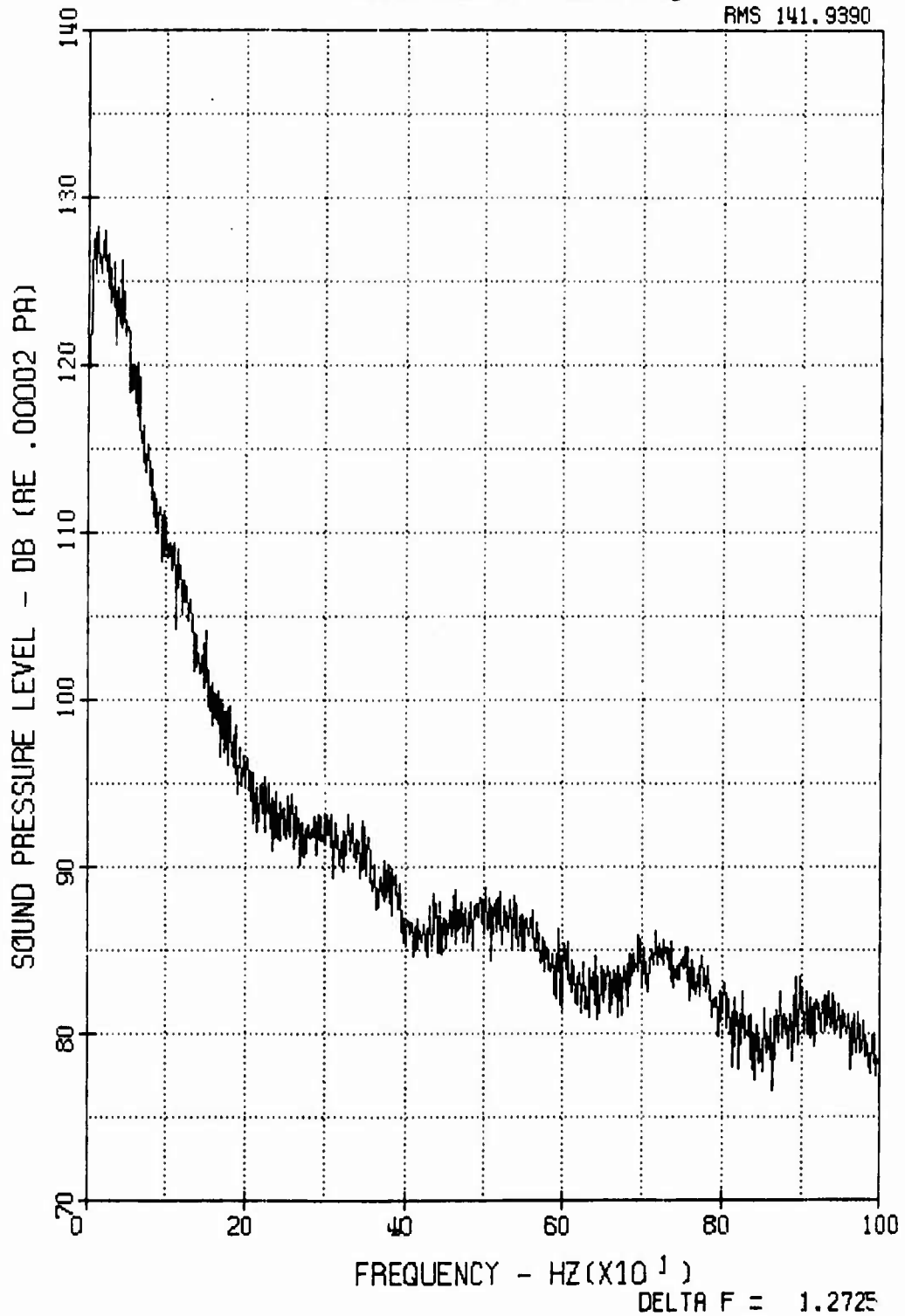


FIGURE B52 Narrowband (1.27 Hz) Spectra for F-16 Aircraft Installed in Hush House for Record Number 18 - Microphone 25.

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