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Technical Note 4-68

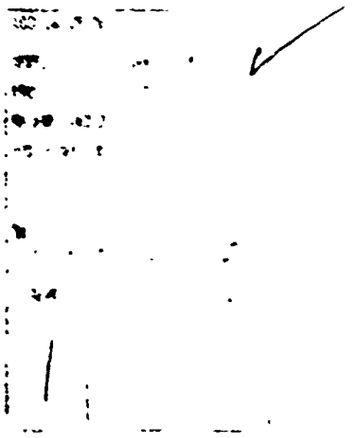
# ACOUSTICAL STUDY OF THE CH-47B (CHINOOK) HELICOPTER

Thomas S. Bragg

March 1968

## HUMAN ENGINEERING LABORATORIES

## ABERDEEN PROVING GROUND, MARYLAND



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## ABSTRACT

Sound measurements were conducted in the CH-47B (Chinook) Helicopter under conditions of normal cruise, maximum continuous power, level flight at various air speeds, hover, level accceleration and deceleration, and partial-power descent. Results are presented and compared with applicable parts of Military Specification MIL-A-8806A and U. S. Army Human Engineering Laboratories Standard S-1-63B. Variations of the noise from that specified in these documents are discussed, and it is recommended that the noise be reduced to conform to the specified levels.

CONTENTS

ABSTRACT . . . . . iii

INTRODUCTION . . . . . 1

METHOD . . . . . 1

RESULTS

Measurements at Normal Cruise-Power Air Speed. . . . . 3
Measurements at Maximum Continuous Power . . . . . 3
Measurements in Level Flight at Various Air Speeds . . . . . 3
Measurements During Hover Conditions . . . . . 4
Measurements During Level Accelerations and Decelerations . . . . 4
Measurements During Partial-Power Descents . . . . . 5

DISCUSSION

Measurements at Normal Cruise-Power Air Speed. . . . . 5
Measurements at Maximum Continuous Power . . . . . 6
Measurements in Level Flight at Various Air Speeds . . . . . 6
Measurements During Hover Conditions . . . . . 7
Measurements During Level Accelerations and Decelerations . . . . 7
Measurements During Partial Power Descents . . . . . 8

SUMMARY . . . . . 8

REFERENCES . . . . . 11

APPENDIX . . . . . 13

# ACOUSTICAL STUDY OF THE CH-47B (CHINOOK) HELICOPTER

## INTRODUCTION

Sound measurements were made in the CH-47B (Chinook) Helicopter at the request of the U. S. Army Aviation Test Activity Preliminary Evaluation Team, Edwards Air Force Base, Cal., on 13 and 14 April 1967. The tests were conducted at Philadelphia International Airport, Philadelphia, Pa. The Chinook tested was serial number 65-7992. Measurements were made during level flight at various speeds, during hover conditions, during level acceleration and decelerations, and during partial-power descents. The measurements were checked for compliance with Military Specification MIL-A-8806A (6). For reference purposes, the measurements were also compared with HEL Standard S-1-63B (5).

## METHOD

Measurements were made in all or some of three specific locations inside the aircraft for the various flight conditions tested. These locations were (1) Station 95 (in the cockpit) between the heads of the pilot and copilot at approximately ear height, (2) Station 320 (in the cargo area) on the longitudinal axis of the aircraft, and (3) Station 480 (in front of the rear ramp) also on the longitudinal axis of the aircraft (Fig. 86A). In addition, measurements were made outside the aircraft at four positions on the ground while the helicopter hovered 10 feet above. These positions were all approximately 20 meters from the aircraft and were located (1) at $0^{o}$ (directly in front of the aircraft), (2) at $90^{o}$ (on the starboard side of the aircraft), (3) at $180^{o}$ (directly behind the aircraft), and (4) at $270^{o}$ (on the port side of the aircraft) (Fig. 87A).

Measurements were made at two rotor speeds, 225 rpm and 230 rpm, for most flight conditions; however, data were obtained at only one rotor speed for a few conditions.

Equipment used in making the measurements was (1) A Bruel & Kjaer (B&K) Type 2203 sound-level meter, (2) a B&K Type 1613 octave-filter set, (3) a B&K Type 4131 microphone, and (4) a Nagra Type III-B tape recorder. Equipment was set up as shown in Figure 88A. A sample of noise was recorded in each of the test positions for each test condition. For these recordings, the octave-filter set was bypassed and the sound-level meter served as an attenuator-preamplifier, calibrated

in 10-decibel (dB) steps. To assure veracity of the recordings, the octave-filter set was used to make an on-site octave-band noise analysis, which was later compared with tape-recorded data taken under the same conditions to verify that the readings were the same.

The tape recordings thus obtained were analyzed in the laboratory using (1) the same Nagra Type III-B tape recorder, (2) A B&K Type 1612 band-pass filter set, (3) a B&K Type 2604 microphone amplifier, and (4) a B&K Type 2305 graphic level recorder. This equipment was set up as shown in Figure 89A. A noise sample was played back, using the microphone amplifier as an amplifier and attenuator, through the octave-filter set. The noise spectrum was then traced automatically by the graphic level recorder. For noise samples that do not vary with time such as those obtained during level flight, the octave-filter set sweeps through the octaves automatically, producing a record similar to that shown in Figure 90A. For noises that vary with time, as during an acceleration or deceleration, it is necessary to plot each frequency band separately, producing a set of records similar to that shown in Figure 91A.

Calibration of the above equipment was performed according to manufacturers' instructions and has National Bureau of Standards traceability. Procedures to be followed in calibrating sound-level meters and microphones are covered by ASA Standards (1, 3). A known sound level of 124.0 dB was produced by a B&K Type 4220 pistonphone calibrator. This known sound level was recorded on tape through the same microphone which was used to make the noise recordings. When the noise recordings were analyzed, the known sound level was used to adjust the output of the graphic recorder, assuring accuracy from source to final plot.

Some noise samples taken at Station 480 were taken again with all inside panels, insulation, etc., aft of Station 486 removed to expose the hydraulic lines, etc., in that section. This was done to simulate actual combat conditions, since these aircraft are being flown in the Republic of Vietnam with these panels, etc., removed so that hydraulic-line breaks caused by enemy fire can be quickly observed.

All noise analyses were performed using the "preferred" frequencies of the ASA Standards (2). Both HEL Standard S-1-63B and Military Specification MIL-A-8806A now use these "preferred" frequencies.

## RESULTS

### Measurements at Normal Cruise-Power Air Speed

These measurements were performed at all three interior positions at a rotor speed of 225 rpm. No data were obtained at a rotor speed of 230 rpm. The results are shown in Table 1A and in Figures 1A to 3A. For normal cruise-power air speed only, an exception was granted by the Detail Specification (4) which increased the allowable octave-band noise levels of the applicable part (Table IV A) of MIL-A-8806A. This new noise level is shown in table and graphs, along with the original level for reference. The HEL Standard was not altered by the Detail Specification, and it is also shown in the table and graphs for reference.

### Measurements at Maximum Continuous Power

These measurements were performed at all three interior locations at a rotor speed of 230 rpm. No data were obtained at a rotor speed of 225 rpm. The results are shown in Table 2A and in Figures 4A to 7A. For maximum continuous-power data, MIL-A-8806A has two parts that apply. One (Table III A) applies only when personnel wear protective helmets, and the other (Table I A) applies when helmets are not used. Both are shown for reference in the table and graphs, as is the HEL Standard.

Although the CH-47B's maximum continuous power is 1520 pounds torque, an additional set of measurements was performed under the short duration power of 1720 pounds torque. These data also were obtained only at a rotor speed of 230 rpm. The results are shown in Table 3A and in Figures 8A to 10A. The table and graphs also show the part (Table II B) of MIL-A-8806A that is applicable for short duration conditions, as well as the HEL Standard.

### Measurements in Level Flight at Various Air Speeds

These measurements were performed at all three interior locations at rotor speeds of 225 rpm and 230 rpm. The speeds selected for measurement were 30 knots, 40 knots, 60 knots, 80 knots, 100 knots, 120 knots, and 140 knots. The results are shown in Tables 4A to 10A and in Figures 11A to 56A. No data were obtained at Stations 320 and 480, rotor speed 225 rpm, air speed 140 knots, because equipment malfunctioned. Measurements were not made at Station 480 with insulating panels removed at any air speed for rotor speeds of 225 rpm, nor were they made at 30 knots at 230 rpm. In some other records either the first or last point was omitted because of limited dynamic range of the equipment.

The various air speeds may all be considered to be short-duration conditions; hence, the part (Table II A) of MIL-A-8806A that applies to these conditions is shown in the tables and graphs, as is the HEL Standard.

Measuremems During Hover Conditions

Measurements were performed at all three interior locations while the aircraft was hovering (out of ground effect) at rotor speeds of 225 rpm and 230 rpm. At Station 480 measurements were made both with insulating panels in place and with them removed. The results are shown in Table 11A and in Figures 57A to 64A. Since hovering may be considered to be a short-duration condition, the part (Table II A) of MIL-A-8806A that applies to those conditions is shown in the tables and graphs, as is the HEL Standard.

Measurements were also performed at the four exterior positions described earlier (Fig. 2A) while the helicopter was hovering (in ground effect) at approximately 10 feet. These results are shown in Table 12A and in Figures 65A to 68A. Since MIL-A-8806A applies just to noise inside the aircraft, the HEL Standard is the only one shown in the table and graphs.

Measurements During Level Accelerations and Decelerations

Measurements were performed at two interior locations (Stations 95 and 320) at rotor speeds of 225 rpm and 230 rpm during level accelerations from 40 knots true air speed to 140 knots true air speed. The data were analyzed to show the time history of the noise in each octave band. From these analyses the range of the highest to the lowest sound pressure level was obtained for each octave band. These results are shown in Table 13A and as the shaded area in Figures 69A to 72A. The table and graphs also show the part (Table II B) of MIL-A-8806A that is applicable for short-duration conditions as well as the HEL Standard.

Measurements were also performed in the same locations and at the same rotor speeds during level decelerations from 140 knots true air speed to 40 knots true air speed. This data was also analyzed to show time histories of the noise in each octave band from which the range between the highest and lowest sound pressure levels was obtained. These results are shown in Table 14A and as the shaded area in Figures 73A to 76A. The table and graphs also show the part (Table II B) of MIL-A-8806 that is applicable for short duration conditions, as well as the HEL Standard.

### Measurements During Partial-Power Descents

Partial-power descents were flown at true air speeds of 60 knots and 100 knots, both with rotor speeds of 230 rpm. Measurements were made at rates of descent of 500 feet per minute, 1000 feet per minute, and 1500 feet per minute. At 60 knots, measurements were made only at Station 95; at 100 knots, measurements were made at both Station 95 and Station 320. Power levels during tests at 60 knots were (1) for 500 feet per minute descent, 750 pounds torque; (2) for 1000 feet per minute descent, 590 pounds torque; and (3) for 1500 feet per minute descent, 120 pounds torque. Power levels during tests at 100 knots were (1) for 500 feet per minute descent, 750 pounds torque; (2) for 1000 feet per minute descent, 540 pounds torque; and (3) for 1500 feet per minute descent, 320 pounds torque.

These data were analyzed to show the time history of the noise in each octave band. From these analyses the range from the highest to the lowest sound pressure level was obtained for each octave band. These results are shown in Tables 15A and 16A and as the shaded area of Figures 77A to 85A. The tables and graphs also show the part (Table II B) of MIL-A-8806A that is applicable for short duration conditions, as well as the HEL Standard.

## DISCUSSION

### Measurements at Normal Cruise-Power Air Speed

The noise measured at this air speed can be said, in general, to meet the requirements of the exception to MIL-A-8806A. There are a few octave bands where the noise exceeds the specified level by two to four dB, but these instances should not be viewed as serious violations. There is a serious violation of the HEL Standard S-1-63B in the 2000-Hertz (Hz) octave band measured at Station 95, where the noise exceeds the standard by 11 dB. (The noise also exceeds the MIL Specification by three dB at this frequency. It should be noted that the exception to MIL-A-8806A is considerably more lenient than the HEL Standard in this middle frequency range, but it is only shown for reference. The Military Specification governs aircraft testing.) With this one exception, the noise at this air speed also meets the requirements of HEL S-1-63B, or is no more than three dB above the specified levels, at all other positions and octave bands.

Measurements at Maximum Continuous Power

For maximum continuous-power conditions MIL A-8806A specified one maximum noise level for those conditions where helmets are worn and another maximum noise level for conditions where helmets are not worn. Since it is conceivable that either condition could occur in the CH-47B, especially in the cargo area, both of the specified noise levels are included in Table 2A and Figures 4A to 7A.

From Figure 4A it can be seen that the cockpit noise is 14 dB above the specified levels of MIL-A-8806A only in the first octave band, and at other frequencies falls within the limits specified when helmets are used. When helmets are not used (an unlikely situation in the cockpit) the noise exceeds the specified levels in the 2000-Hz and 4000-Hz octave bands by four dB and seven dB. The cockpit noise is above the HEL Standard in all octave bands from 500 Hz to 4000 Hz.

In the cargo area the noise generally meets both the specified levels of the Military Specification and the HEL Standard with one exception which can be seen in Figure 6A. The noise in the 1000-Hz octave band at Station 480 exceeds the HEL Standard by seven dB.

A marked change in the noise at Station 480 occurs when the panels aft of Station 486 are removed, as can be seen in Figure 7A. The high-frequency noise does not meet the provisions of either the HEL Standard or the Military Specification.

For short-duration conditions, MIL-A-8806A specifies yet another set of maximum noise levels. These are shown with the measurements at 1720 pounds torque in Table 3A and Figures 8A to 10A. The noise level in general lies above the HEL Standard but below the Military Specification, and thus is acceptable.

Measurements in Level Flight at Various Air Speeds

The CH-47B meets the requirements of MIL-A-8806A in all three measuring positions at all air speeds tested from 30 knots to 140 knots, except when the panels aft of Station 486 are removed. When the panels are removed, the noise is excessive, with respect to MIL-A-8806A, in all octave bands above 2000 Hz for all the air speeds tested.

When compared with the HEL Standard, the noise is generally acceptable for all air speeds at the positions in the cargo area when the panels aft of Station 486 are in place. When the panels are removed, the noise is above HEL S-1-63B at all air speeds in all the octave bands above 250 Hz. In the cockpit, the noise falls above the levels of the HEL Standard in the 1000-Hz, 2000-Hz, and 4000-Hz octave bands for all air speeds. It is interesting to note the effect that rotor speed has on the shape of the noise spectrum. For all air speeds measured at Station 95, the noise spectrum tends to be flatter in the three octave bands mentioned above (1000 Hz,

2000 Hz and 4000 Hz) at 225 rpm rotor speed than it is at 230 rpm. At 230 rpm, evidence of a peak at 2000 Hz appears in all instances. If the noise in this octave band were reduced sufficiently, the noise in the octave bands on either side of it would probably also decrease and the noise spectrum could be lowered to the levels of HEL S-1-63B. This same peaking at 2000 Hz at 230 rpm is also evident to a lesser extent in measurements made at Station 480, near the rear rotor, indicating the front and rear rotors as possible sources of the noise in that octave band.

At the two highest air speeds, the 1000-Hz octave band at Station 480, shows a peak which raises the noise spectrum to a level exceeding the HEL Standard by four dB or more in the 1000-Hz and 2000-Hz octave bands. These and the occasional points where the noise exceeds the levels set by the HEL Standard by less than three dB may be viewed as insignificant, since the requirements of MIL-A-8806A are met.

Measurements During Hover Conditions

The results of interior measurements while hovering are very similar to those made in level flight. The noise is generally acceptable in the cargo-section positions as long as the panels aft of Station 486 are in place. When the panels are removed the noise exceeds the provisions of MIL-A-8806A in all octave bands 1000 Hz and above, and it exceeds the provisions of HEL S-1-63B in all octave bands 250 Hz and above.

At Station 95 and Station 480 the 2000-Hz octave band shows a peak which brings that part of the noise spectrum above the provisions of HEL S-1-63B, although it is still within the requirements of MIL-A-8806A.

Measurements made outside the helicopter while it was hovering nearby indicate that the noise spectrum at the positions tested exceeds the HEL Standard by as much as nine dB except at the position 20 meters in front of the aircraft. There the noise just meets the provisions of HEL S-1-63B. Prolonged exposure at the other three positions should be avoided.

Measurements During Level Accelerations and Decelerations

The CH-47B meets the requirements of HEL S-1-63B and MIL-A-8806A in the cargo area (Station 320) during level accelerations and decelerations at both rotor speeds tested. In the cockpit (Station 95), the range of noise is extremely loud in the first two octave bands, exceeding both the HEL Standard and the Military Specification. At 225 rpm rotor speed, the noise also exceeds MIL-A-8806A at 4000 Hz during both accelerations and decelerations, while at 230 rpm, the noise exceeds MIL-A-8806A in the 2000-Hz octave band, but only during deceleration. These peaks in the spectrum follow the tendency noted before for the higher rotor speed to give a peak at 2000 Hz, while the lower rotor speed gives a flatter spectrum or a peak at 4000 Hz.

Measurements During Partial Power Descents

At 60 knots true air speed, the CH-47B meets the requirements of MIL-A-8806A at all rates of descent, measured at Station 95. No measurements were made at Station 320 for this condition, but it can be assumed on the basis of other measurements in the aircraft that the noise at Station 320 is no louder than, and probably quieter than, that at Station 95, meaning that it, too, meets the provisions of MIL-A-8806A.

Measurements were made only at a rotor speed of 230 rpm and the peak in the 2000-Hz octave band is evident again in this test. The peak brings the noise above the HEL Standard at this frequency.

At 100 knots true air speed, the noise peak in the 2000-Hz octave band becomes considerably louder, and the noise in the octave bands flanking it (1000 Hz and 4000 Hz) also increases appreciably. The net effect is that the noise in the 2000-Hz and 4000-Hz octave bands either exceeds or just barely meets the criteria of MIL-A-8806A for those frequencies, again in both measuring positions and at all three rates of descent.

## SUMMARY

The results of this test indicate that the CH-47B helicopter does not meet all the provisions of MIL-A-8806A. The excess noise is not, however, so loud that it cannot be readily reduced to meet MIL-A-8806A. Principal noise-reduction effort should be aimed at reducing the noise in the 2000-Hz and 4000-Hz octave bands, especially in the short-term and high-power flight conditions. Under normal cruise conditions, the noise is acceptable to MIL-A-8806A.

Operation with the panels aft of Station 486 removed should be avoided. The noise at Station 480 is increased to a level that is considerably above the levels of MIL-A-8806A under all flight conditions.

It is the official position of the U. S. Army Human Engineering Laboratories that operating, training, or maintenance tasks shall not expose personnel to noise that exceeds the levels specified in HEL Standard S-1-63B in any equipment designed, developed or procured by the U. S. Army Materiel Command, with the exception of interior noise of aircraft, which is covered by MIL-A-8806A. The levels of HEL Standard S-1-63B have been included for comparison only, to aid in the study of where noise reduction effort should be concentrated. Since almost every test condition produced levels exceeding the HEL Standard at Station 95, usually in some or all of the octave bands between 500 Hz and 4000 Hz, noise reduction should be concentrated in those frequencies, with an eye toward reducing the overall level in the cockpit as well.

The HEL Standard does apply to exterior noise of the CH-47B. Exterior noise does exceed the HEL Standard on three sides of the aircraft and measures should be taken to assure that personnel are not exposed to these noise levels.

## REFERENCES


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3. American Standards Association. American standard specification for general-purpose sound level meters. New York, N. Y., 1961.

4. Boeing-Vertol Corporation. Detail specification for model CH-47B helicopter. Document 114-PJ-602, Philadelphia, Pa., 1967.

5. U. S. Army Human Engineering Laboratories. Maximum noise level for army materiel command equipment. HEL Standard S-1-63B, Aberdeen Proving Ground, Md., 1965.

6. Weapons Engineering Standardization Office. Acoustical noise level in aircraft, general specification for military specification MIL-A-8806A. Naval Engineering Center, Philadelphia, Pa., 1966.

# APPENDIX

## TABLE 1A

### Octave Band Noise Measurements During Level Flight at Normal Cruise Power Air Speed in the CH-47B Helicopter

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: | | | Measured Band Pressure Level* | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Rotor Speed = 225 rpm | | | Rotor Speed = 230 rpm | | |
| | HEL Std S-1-63B | MIL-A-8806A Table IV | Exception to MIL-A-8806A Table IV | Station 95 | Station 320 | Station 480 | Station 95 | Station 320 | Station 480 |
| 31.5 | - | 104 | 107** | - | - | - | | | |
| 63 | 119 | 104 | 107 | 107 | 107 | 104 | | | |
| 125 | 114 | 104 | 108 | 105 | 107 | 108 | | | |
| 250 | 107 | 104 | 107 | 100 | 104 | 105 | | | |
| 500 | 99 | 96 | 102 | 96 | 97 | 100 | | | |
| 1000 | 91 | 90 | 97 | 94 | 94 | 94 | | | |
| 2000 | 89 | 86 | 97 | 100 | 89 | 92 | | | |
| 4000 | 89 | 75 | 90 | 92 | 84 | 88 | | | |
| 8000 | 91 | 75 | 78 | 83 | 81 | 84 | | | |
| Linear | - | 106 | 110** | 111 | 111 | 112 | | | |

NOT DATA

* dB re 0.0002 ubar
** (extrapolated value)

## TABLE 2A

### Octave Band Noise Measurements During Level Flight at Maximum Continuous Power (1520 lbs Torque) in the CH-47B Helicopter

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: HEL Std S-1-63B | MIL-A-3806A Table III w/helmets | MIL-A-3806A Table I | Measured Band Pressure Level* Rotor Speed = 225 rpm Station 95 | Station 320 | Station 480 | Rotor Speed = 230 rpm Station 95 | Station 320 | Station 480 | Station 480 w/o panels** |
|---|---|---|---|---|---|---|---|---|---|---|
| 31.5 | - | 111 | 111 | | | | 121 | 120 | 119 | 117 |
| 63 | 111 | 111 | 111 | | | | 116 | 115 | 109 | 110 |
| 125 | 113 | 111 | 111 | | | | 113 | 110 | 104 | 104 |
| 250 | 107 | 111 | 111 | | | | 107 | 107 | 105 | 110 |
| 500 | 99 | 104 | 105 | | | | 104 | 98 | 100 | 105 |
| 1000 | 94 | 106 | 99 | | | | 99 | 93 | 98 | 106 |
| 2000 | 89 | 100 | 93 | | | | 97 | 88 | 90 | 107 |
| 4000 | 84 | 94 | 87 | | | | 91 | 86 | 89 | 104 |
| 8000 | 81 | 92 | 87 | | | | 86 | 82 | 86 | 98 |
| Linear | - | 117 | 113 | | | | 126 | 121 | 119 | 119 |

NOISE DATA

* dB re 0.0002 ubar

** Panels aft of Station 486 were removed.

## TABLE 3A

**Octave Band Noise Measurements During Level Flight at 1720 Lbs. Torque in the CH-47B Helicopter**

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: HEL Standard S-1-63B | Band Pressure Level* Specified By: MIL-A-8806A Table II | Measured Band Pressure Level* Rotor Speed = 225rpm Station 95 | Station 320 | Station 480 | Rotor Speed = 230rpm Station 95 | Station 320 | Station 480 |
|---|---|---|---|---|---|---|---|---|
| 31.5 | - | 118 | | | | 128 | 121 | 120 |
| 63 | 119 | 118 | | | | 117 | 115 | 112 |
| 125 | 114 | 118 | | | | 115 | 108 | 107 |
| 250 | 107 | 118 | | | | 109 | 107 | 105 |
| 500 | 99 | 112 | | | | 103 | 100 | 102 |
| 1000 | 91 | 106 | | | | 100 | 97 | 97 |
| 2000 | 89 | 100 | | | | 99 | 89 | 92 |
| 4000 | 89 | 94 | | | | 94 | 85 | 91 |
| 8000 | 91 | 94 | | | | 86 | 83 | 87 |
| Linear | - | 120 | | | | 128 | 121 | 121 |

NO DATA

* dB re 0.0002 ubar

## TABLE 4A

### Octave Band Noise Measurements During Level Flight at 30 Knots True Air Speed in the CH-47B Helicopter

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: HEL Standard S-1-63B | Band Pressure Level* Specified By: MIL-A-8806A Table II | Measured Band Pressure Level* Rotor Speed = 225rpm Station 95 | Station 320 | Station 480 | Rotor Speed = 230rpm Station 95 | Station 320 | Station 480 | Station 480 w/o panels** |
|---|---|---|---|---|---|---|---|---|---|
| 31.5 | — | 118 | 118 | 114 | 112 | 117 | 112 | 108 | |
| 63 | 110 | 118 | 105 | 104 | 102 | 108 | 107 | 101 | N |
| 125 | 114 | 113 | 100 | 106 | 103 | 100 | 106 | 101 | O |
| 250 | 107 | 118 | 94 | 99 | 104 | 94 | 101 | 102 | |
| 500 | 99 | 112 | 92 | 92 | 96 | 92 | 93 | 96 | A |
| 1000 | 91 | 106 | 92 | 88 | 91 | 93 | 87 | 93 | T |
| 2000 | 84 | 100 | 94 | 87 | 92 | 96 | 88 | 90 | A |
| 4000 | 89 | 94 | 95 | 85 | 80 | 91 | 82 | 89 | |
| 8000 | 91 | 94 | 85 | 81 | 81 | 87 | | 85 | |
| Linear | — | 120 | 118 | 119 | 117 | 117 | 115 | 113 | |

* dB re 0.0002 ubar

** Panels aft of Station 486 were removed.

## TABLE 5A

### Octave Band Noise Measurements During Level Flight at 40 Knots True Air Speed in the CH-47B Helicopter

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: | | Measured Band Pressure Level* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Rotor Speed = 225rpm | | | Rotor Speed = 230rpm | | | |
| | BEL Standard S-1-(?B | MIL-A-8806A Table II | Station [illegible] | Station 320 | Station 480 | Station 95 | Station 320 | Station 480 | Station 480 w/o panels** |
| [illegible] | — | 113 | — | — | — | 113 | 11[illegible] | 105 | 110 |
| 63 | 11 | 118 | 102 | 101 | 10[illegible] | 10[illegible] | 108 | [illegible]9 | 106 |
| 12[illegible] | 11[illegible] | 113 | 100 | 105 | 10[illegible] | 1[illegible]0 | 10[illegible] | 100 | 105 |
| 2[illegible] | 1[illegible]7 | 118 | [illegible]6 | 101 | 10[illegible] | 9[illegible] | [illegible]8 | 100 | 108 |
| [illegible]00 | [illegible]9 | 112 | [illegible]2 | [illegible]2 | [illegible]7 | [illegible]2 | [illegible]3 | [illegible]4 | 102 |
| 1[illegible]00 | 91 | 106 | [illegible] | 88 | [illegible]1 | [illegible]2 | 89 | 91 | 108 |
| 2000 | 8[illegible] | 1[illegible]0 | [illegible]8 | 88 | [illegible]5 | [illegible]8 | 87 | 90 | 105 |
| [illegible]000 | 8[illegible] | [illegible] | [illegible]4 | [illegible]2 | [illegible]0 | [illegible]0 | [illegible]4 | 88 | 103 |
| 8000 | [illegible]1 | [illegible]4 | [illegible]4 | [illegible]0 | [illegible]8 | [illegible]4 | [illegible]2 | [illegible]2 | [illegible]7 |
| Linear | — | 120 | 10[illegible] | 1[illegible]3 | 108 | 118 | 114 | 109 | 115 |

* dB re 0.0002 ubar

** Panels aft of Station 436 were removed

## TABLE 6A

### Octave Band Noise Measurements During Level Flight at 60 Knots True Air Speed in the CH-47B Helicopter

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: | | Measured Band Pressure Level* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Rotor Speed = 225rpm | | | Rotor Speed = 230rpm | | | |
| | HEL Standard S-1-63B | MIL-A-8806A Table II | Station 95 | Station 320 | Station 480 | Station 95 | Station 320 | Station 480 | Station 480 w/o panels** |
| 31. | - | 118 | - | - | - | 120 | 113 | 111 | 113 |
| 63 | 119 | 118 | 103 | 105 | 92 | 106 | 106 | 104 | 103 |
| 125 | 114 | 118 | [illegible] | 106 | 102 | 99 | 104 | 102 | 105 |
| 250 | 107 | 118 | 4 | 104 | 103 | 92 | 100 | 101 | 108 |
| [illegible]00 | [illegible] | 112 | 92 | 95 | 96 | 92 | 93 | 96 | 106 |
| 1000 | 91 | 106 | 93 | 92 | 93 | 92 | 89 | 92 | 104 |
| 2000 | 89 | 100 | [illegible] | 89 | 93 | 90 | 86 | 94 | 103 |
| 4000 | 87 | 94 | 91 | 91 | 88 | 92 | 90 | 87 | 104 |
| 8000 | 91 | 94 | 83 | 81 | 84 | 83 | - | 81 | 97 |
| Linear | - | 120 | 106 | 109 | 106 | 120 | 113 | 111 | 116 |

* dB re 0.0002 µbar

** Panels aft of Station 486 were removed.

## TABLE 7A

### Octave Band Noise Measurements During Level Flight at 80 Knots True Air Speed in the CH-47B Helicopter

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: | | Measured Band Pressure Level* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | HEL Standard S-1-63B | MIL-A-8806A Table II | Rotor Speed = 225rpm | | | Rotor Speed = 230rpm | | | |
| | | | Station 95 | Station 320 | Station 480 | Station 95 | Station 320 | Station 480 | Station 480 w/o panels** |
| 31.5 | - | 113 | - | - | - | 122 | 115 | 113 | 116 |
| 63 | 110 | 113 | 104 | 104 | 99 | 103 | 106 | 103 | 107 |
| 125 | 114 | 118 | 103 | 105 | 104 | 101 | 107 | 104 | 105 |
| 250 | 107 | 118 | 96 | 102 | 104 | 93 | 102 | 103 | 109 |
| 500 | 99 | 112 | 93 | 94 | 98 | 93 | 94 | 97 | 107 |
| 1000 | 91 | 106 | 95 | 88 | 92 | 92 | 92 | 91 | 103 |
| 2000 | 85 | 100 | 91 | 86 | 91 | 100 | 87 | 91 | 106 |
| 4000 | 80 | 94 | 93 | 89 | 88 | 94 | 89 | 86 | 103 |
| 8000 | 71 | 94 | 83 | 81 | 83 | 84 | 82 | 82 | 97 |
| Linear | - | 120 | 108 | 108 | 108 | 122 | 115 | 114 | 118 |

* dB re 0.0002 ubar

** Panels aft of Station 486 were removed.

## TABLE 8A

### Octave Band Noise Measurements During Level Flight at 100 Knots True Air Speed in the CH-47B Helicopter

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: | | Measured Band Pressure Level* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | HEL Standard S-1-63B | MIL-A-8806A Table II | Rotor Speed = 225rpm | | | Rotor Speed = 230rpm | | | |
| | | | Station 95 | Station 320 | Station 480 | Station 95 | Station 320 | Station 480 | Station 480 w/o panels** |
| 31.5 | – | 118 | – | – | – | 121 | 115 | 115 | 120 |
| 63 | 119 | 118 | 107 | 111 | 102 | 101 | 108 | 104 | 109 |
| 125 | 114 | 113 | 104 | 108 | 103 | 101 | 108 | 102 | 103 |
| 250 | 107 | 118 | 98 | 104 | 105 | 99 | 101 | 101 | 108 |
| 500 | 99 | 112 | 94 | 94 | 98 | 92 | 96 | 96 | 107 |
| 1000 | 91 | 106 | 95 | 89 | 93 | 92 | 90 | 92 | 106 |
| 2000 | 86 | 100 | 87 | 87 | 93 | 99 | 88 | 89 | 110 |
| 4000 | 80 | 94 | 84 | 82 | 88 | 91 | 84 | 88 | 104 |
| 8000 | 71 | 84 | 83 | – | 84 | 84 | 82 | 84 | 99 |
| Linear | – | 120 | 109 | 113 | 108 | 121 | 116 | 115 | 120 |

* dB re 0.0002 ubar

** Panels aft of Station 486 were removed.

## TABLE 9A

**Octave Band Noise Measurements During Level Flight at 120 Knots True Air Speed in the CH-47B Helicopter**

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: | | Measured Band Pressure Level* | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | HEL Standard S-1-63B | MIL-A-8806A Table II | Rotor Speed = 225rpm | | | Rotor Speed = 230rpm | | | |
| | | | Station 95 | Station 320 | Station 480 | Station 95 | Station 320 | Station 480 | Station 480 w/o panels** |
| 31.5 | – | 118 | – | – | – | 122 | 115 | 118 | 119 |
| 63 | 119 | 118 | 109 | 107 | 104 | 110 | 114 | 108 | 108 |
| 125 | 114 | 118 | 107 | 106 | 105 | 109 | 109 | 107 | 104 |
| 250 | 107 | 118 | 100 | 105 | 104 | 106 | 106 | 106 | 109 |
| 500 | 99 | 112 | 100 | 97 | 100 | 97 | 97 | 98 | 106 |
| 1000 | 91 | 106 | 96 | 90 | 92 | 94 | 92 | 97 | 106 |
| 2000 | 89 | 100 | 99 | 86 | 93 | 100 | 90 | 90 | 109 |
| 4000 | 89 | 94 | 95 | 84 | 88 | 95 | 84 | 89 | 104 |
| 8000 | 91 | 94 | 84 | 81 | 87 | 84 | 82 | 86 | 99 |
| Linear | – | 120 | 110 | 111 | 109 | 122 | 119 | 119 | 121 |

* dB re 0.0002 ubar

** Panels aft of Station 486 were removed.

## TABLE 10A

### Octave Band Noise Measurements During Level Flight at 140 Knots True Air Speed in the CH-47B Helicopter

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: HEL Standard S-1-63B | Band Pressure Level* Specified By: MIL-A-8806A Table II | Measured Band Pressure Level* Rotor Speed = 225rpm Station 95 | Station 320 | Station 480 | Rotor Speed = 230rpm Station 95 | Station 320 | Station 480 | Station 480 w/o panels** |
|---|---|---|---|---|---|---|---|---|---|
| 31.5 | — | 118 | — | | | 126 | 119 | 118 | 118 |
| 63 | 119 | 118 | 104 | | | 112 | 114 | 109 | 106 |
| 125 | 114 | 118 | 105 | | | 105 | 107 | 105 | 104 |
| 250 | 107 | 118 | 98 | | | 98 | 104 | 104 | 110 |
| 500 | 99 | 112 | 98 | | | 97 | 97 | 99 | 106 |
| 1000 | 91 | 106 | 98 | | | 96 | 93 | 99 | 104 |
| 2000 | 87 | 100 | 100 | | | 97 | 88 | 92 | 106 |
| 4000 | 89 | 94 | 92 | | | 93 | 84 | 89 | 104 |
| 8000 | 91 | 94 | 83 | | | 84 | 82 | 86 | 88 |
| Linear | — | 120 | 109 | | | 126 | 120 | 118 | 119 |

NO DATA

* dB re 0.0002 ubar

** Panels aft of Station 436 were removed.

## TABLE 11A

### Octave Band Noise Measurements Hovering (Out of Ground Effect) in the CH-47B Helicopter

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: | | Measured Band Pressure Level* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Rotor Speed = 225rpm | | | | Rotor Speed = 230 rpm | | | |
| | HEL Standard S-1-63B | MIL-A-8806 Table II | Station 95 | Station 320 | Station 480 | Station 480 w/o panels** | Station 95 | Station 320 | Station 480 | Station 480 w/o panels** |
| 31.5 | - | 118 | 122 | 118 | 115 | 113 | 122 | 118 | 112 | 111 |
| 63 | 119 | 118 | 109 | 101 | 104 | 103 | 107 | 101 | 100 | 103 |
| 125 | 114 | 118 | 100 | 102 | 99 | 109 | 99 | 102 | 102 | 108 |
| 250 | 107 | 118 | 91 | 97 | 101 | 109 | 92 | 98 | 100 | 110 |
| 500 | 99 | 112 | 92 | 94 | 95 | 104 | 93 | 92 | 93 | 104 |
| 1000 | 91 | 106 | 92 | 88 | 93 | 107 | 92 | 91 | 93 | 109 |
| 2000 | 89 | 100 | 94 | 87 | 93 | 107 | 95 | 90 | 94 | 104 |
| 4000 | 89 | 94 | 92 | 85 | 87 | 104 | 91 | 85 | 89 | 103 |
| 8000 | 91 | 94 | 85 | 83 | 84 | 100 | 83 | 84 | 85 | 97 |
| Linear | - | 120 | 122 | 118 | 116 | 117 | 122 | 118 | 112 | 117 |

* dB re 0.000.2 ubar

** Panels aft of Station 486 were removed

TABLE 12A

Octave Band Noise Measurements-Exterior Noise-Hovering (IGE)
of the CH-47B Helicopter, 20 Feet Altitude, 20 M Away

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: HEL Standard S-1-63B | | Measured Band Pressure Level* | | | |
|---|---|---|---|---|---|---|
| | | | 0°(Front) | 90°(Starboard) | 180°(Aft) | 270°(Port) |
| 31.5 | - | | 116 | 116 | 116 | 121 |
| 63 | 119 | | 113 | 118 | 117 | 119 |
| 125 | 114 | | 111 | 116 | 117 | 117 |
| 250 | 107 | | 106 | 111 | 111 | 111 |
| 500 | 99 | | 98 | 105 | 106 | 105 |
| 1000 | 91 | | 91 | 100 | 95 | 97 |
| 2000 | 86 | | 80 | 94 | 92 | 93 |
| 4000 | 89 | | 87 | 91 | 91 | 91 |
| 8000 | 91 | | 86 | 90 | 88 | 91 |
| Linear | - | | 118 | 122 | 120 | 122 |

* dB re 0.0002 ubar

## TABLE 13A

**Octave Band Noise Measurements-Level Accelerations 40-140 Knots (TAS) in the CH-47B Helicopter**

| Octave Band Center Frequency (Hertz) | Band Pressure Level*Specified By: HEL Standard S-1-63B | Band Pressure Level*Specified By: MIL-A-8806A Table II | Measured Band Pressure Level* Rotor Speed = 225rpm Station 95 Low | Station 95 High | Station 320 Low | Station 320 High | Rotor Speed = 230rpm Station 95 Low | Station 95 High | Station 320 Low | Station 320 High |
|---|---|---|---|---|---|---|---|---|---|---|
| 31.5 | – | 118 | 114 | 123 | 110 | 117 | 111 | 125 | 112 | 118 |
| 63 | 119 | 118 | 105 | 125 | 100 | 113 | 107 | 116 | 100 | 115 |
| 125 | 114 | 118 | 102 | 113 | 100 | 108 | 106 | 112 | 101 | 106 |
| 250 | 107 | 118 | 96 | 105 | 97 | 105 | 100 | 106 | 96 | 104 |
| 500 | 99 | 112 | 95 | 102 | 91 | 98 | 97 | 101 | 91 | 97 |
| 1000 | 91 | 106 | 95 | 100 | 89 | 92 | 95 | 99 | 89 | 93 |
| 2000 | 89 | 100 | 95 | 98 | 86 | 89 | 96 | 100 | 86 | 90 |
| 4000 | 86 | 94 | 92 | 100 | 83 | 86 | 92 | 94 | 84 | 85 |
| 8000 | 91 | 94 | 83 | 84 | 80 | 82 | 82 | 85 | 81 | 82 |
| Linear | – | 120 | 115 | 125 | 112 | 118 | 116 | 125 | 115 | 119 |

*dB re 0.0002ubar

## TABLE 14A

### Octave Band Noise Measurements-Level Decelerations 140-40 Knots (TAS) in the CH-47B Helicopter

| Octave Band Center Frequency (Hertz) | Band Pressure Level*Specified By: HEL Standard S-1-63B | Band Pressure Level*Specified By: MIL-A-8806A Table II | Measured Band Pressure Level* Rotor Speed = 225rpm Station 95 Low | Station 95 High | Station 320 Low | Station 320 High | Rotor Speed = 230rpm Station 95 Low | Station 95 High | Station 320 Low | Station 320 High |
|---|---|---|---|---|---|---|---|---|---|---|
| 31.5 | - | 118 | 119 | 125 | 105 | 116 | 121 | 127 | 109 | 116 |
| 63 | 119 | 118 | 100 | 115 | 102 | 114 | 100 | 116 | 102 | 115 |
| 125 | 114 | 118 | 101 | 114 | 103 | 108 | 101 | 113 | 104 | 109 |
| 250 | 107 | 118 | 95 | 108 | 98 | 107 | 96 | 107 | 100 | 106 |
| 500 | 99 | 112 | 92 | 102 | 92 | 99 | 92 | 102 | 92 | 98 |
| 1000 | 91 | 106 | 91 | 98 | 89 | 92 | 92 | 98 | 90 | 92 |
| 2000 | 89 | 100 | 94 | 100 | 87 | 89 | 95 | 103 | 85 | 91 |
| 4000 | 89 | 94 | 89 | 98 | 83 | 85 | 91 | 95 | 83 | 85 |
| 8000 | 91 | 94 | 81 | 84 | 80 | 81 | 82 | 84 | 80 | 82 |
| Linear | - | 120 | 120 | 125 | 110 | 119 | 120 | 125 | 112 | 119 |

* dB re 0.0002 ubar

## TABLE 15A

**Octave Band Noise Measurements-Partial Power Descents, 60 Knots (TAS)**
**Rotor Speed 230 rpm**
**in the CH-47B Helicopter**

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: HEL Standard S-1-63B | Band Pressure Level* Specified By: MIL-A-8806A Table II | Measured Band Pressure Level* Rate of Descent = 500 '/min Station 95 Low | Station 95 High | Station 320 Low | Station 320 High | Rate of Descent = 1000 '/min Station 95 Low | Station 95 High | Station 320 Low | Station 320 High | Rate of Descent = 1500 '/min Station 95 Low | Station 95 High | Station 320 Low | Station 320 High |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31.5 | — | 118 | 116 | 120 | | | 118 | 123 | | | 120 | 122 | | |
| 63 | 11[illegible] | 113 | 102 | 109 | | N | 101 | 106 | | N | 98 | 103 | | N |
| 125 | 11[illegible] | 113 | 100 | 108 | | O | 98 | 104 | | O | 100 | 104 | | O |
| 250 | 10[illegible] | 113 | 95 | 103 | | | 94 | 100 | | | 96 | 101 | | |
| 500 | 9[illegible] | 112 | [illegible]1 | [illegible]7 | | D | 91 | 99 | | D | 91 | 94 | | D |
| 1000 | [illegible]1 | 107 | 1[illegible] | [illegible] | | A | [illegible]2 | [illegible] | | A | 90 | 92 | | A |
| 2000 | 8[illegible] | 10[illegible] | [illegible] | [illegible]2 | | T | [illegible] | [illegible]8 | | T | 91 | 7 | | T |
| 4000 | 8[illegible] | [illegible] | [illegible] | [illegible] | | A | 91 | [illegible] | | A | 87 | 90 | | A |
| 8000 | 91 | [illegible] | 82 | [illegible] | | | 82 | 85 | | | 81 | 8[illegible] | | |
| Linear | — | 120 | 117 | 12[illegible] | | | 117 | 122 | | | 120 | 122 | | |

* dB re 0.0002 ubar

## TABLE 16A

**Octave Band Noise Measurements-Partial Power Descents, 100 Knots (TAS)**
**Rotor Speed 230 rpm**
**in the CH-47B Helicopter**

| Octave Band Center Frequency (Hertz) | Band Pressure Level* Specified By: | | Measured Band Pressure Level* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | HEL Standard S-1-63B | MIL-A-8806A Table II | Rate of Descent = 500 '/min | | | | Rate of Descent = 1000 '/min | | | | Rate of Descent = 1500 '/min | | | |
| | | | Station 95 | | Station 320 | | Station 95 | | Station 320 | | Station 95 | | Station 320 | |
| | | | Low | High | Low | High | Low | High | Low | High | Low | High | Low | High |
| 31. | – | 118 | 123 | 125 | 113 | 116 | 122 | 124 | 113 | 116 | 123 | 125 | 117 | 119 |
| 63 | 119 | 118 | 108 | 114 | 104 | 111 | 110 | 114 | 107 | 110 | 111 | 115 | 108 | 110 |
| 12[illegible] | 114 | 118 | 109 | 113 | 106 | 109 | 109 | 113 | 107 | 110 | 110 | 114 | 105 | 108 |
| 25[illegible] | 107 | 118 | 103 | 108 | 104 | 108 | 103 | 108 | 103 | 107 | 105 | 108 | 101 | 10[illegible] |
| [illegible]0 | 99 | 112 | 97 | 102 | 98 | 101 | 98 | 102 | 97 | 99 | 99 | 104 | 98 | 100 |
| 1000 | 91 | 106 | 95 | 98 | 97 | 100 | 96 | 98 | 99 | 100 | 96 | 100 | 98 | 100 |
| 2000 | 89 | 100 | 90 | 102 | 96 | 102 | 96 | 99 | 98 | 103 | 96 | 99 | 99 | 101 |
| 4000 | 84 | 94 | 92 | 97 | [illegible] | 97 | 93 | 96 | [illegible] | 97 | 91 | 93 | 97 | 98 |
| 8000 | 81 | [illegible] | 84 | 86 | 87 | 90 | 84 | 86 | 87 | 88 | 83 | 85 | 88 | 90 |
| Linear | – | 120 | 123 | 125 | 116 | 118 | 122 | 124 | 116 | 118 | 123 | 125 | 118 | 11[illegible] |

*dB re 0.0002 ubar

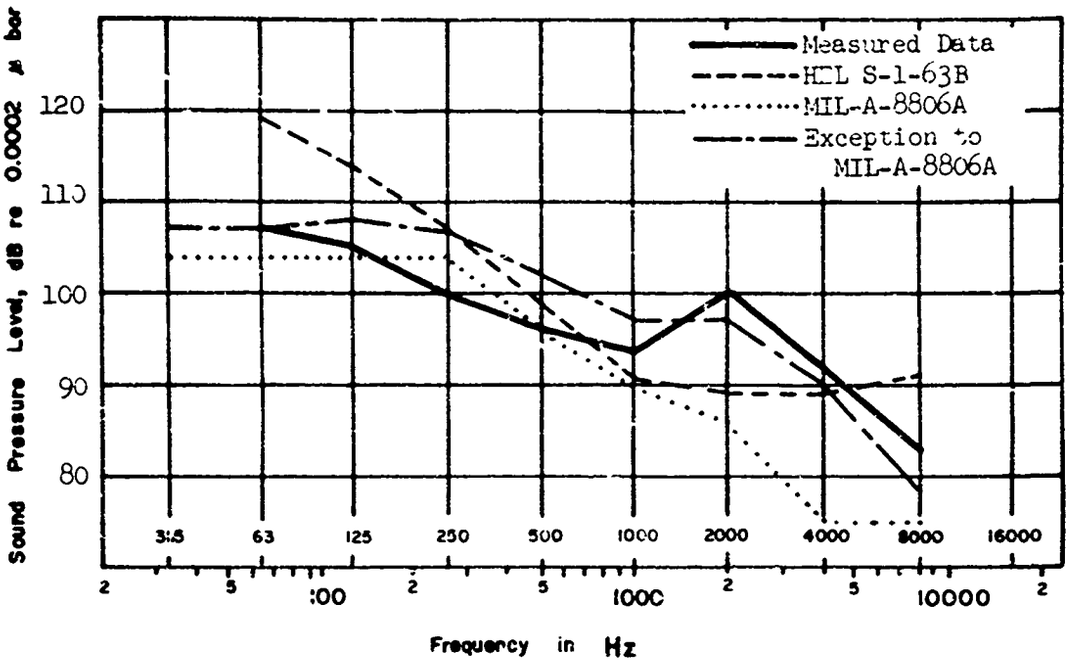


Fig. 1A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT NORMAL CRUISE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 95.)

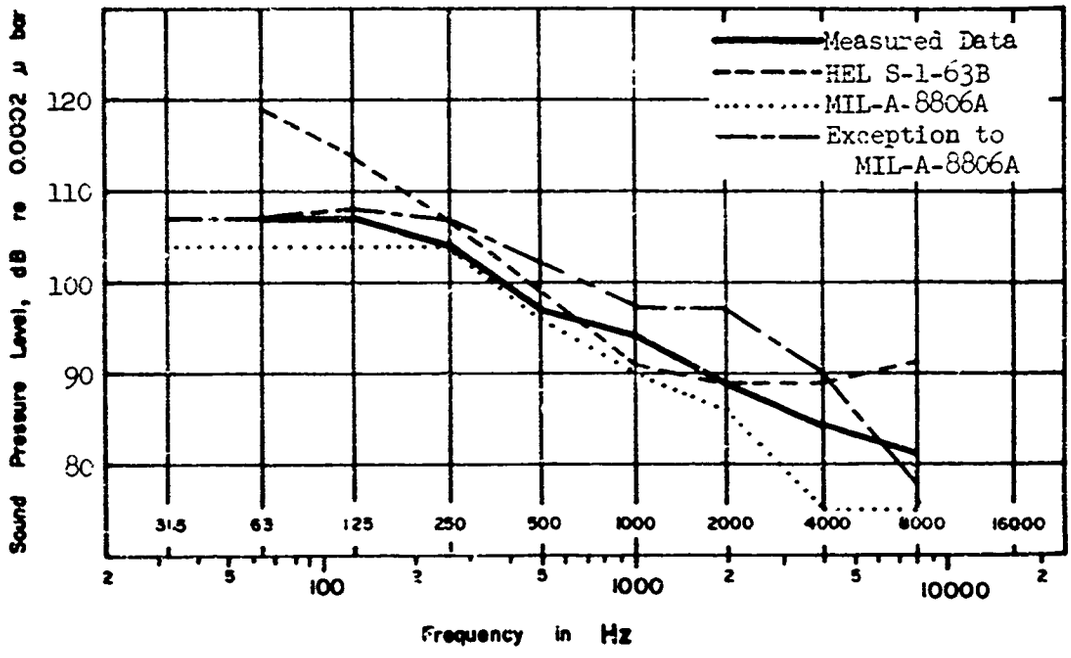


Fig. 2A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT NORMAL CRUISE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 320.)

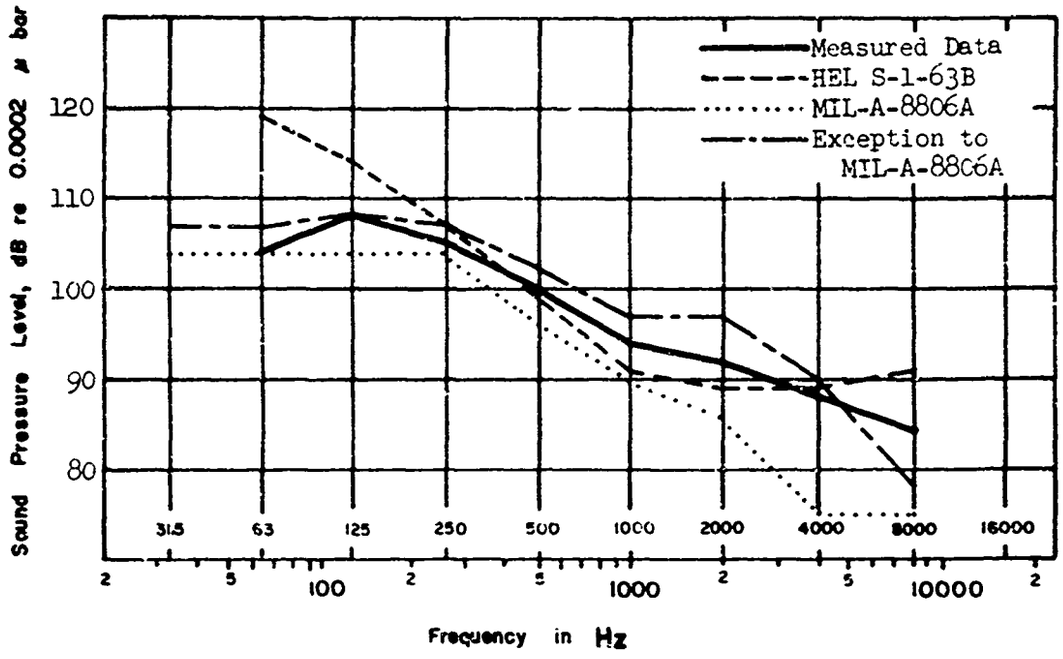


Fig. 3A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT NORMAL CRUISE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 480.)

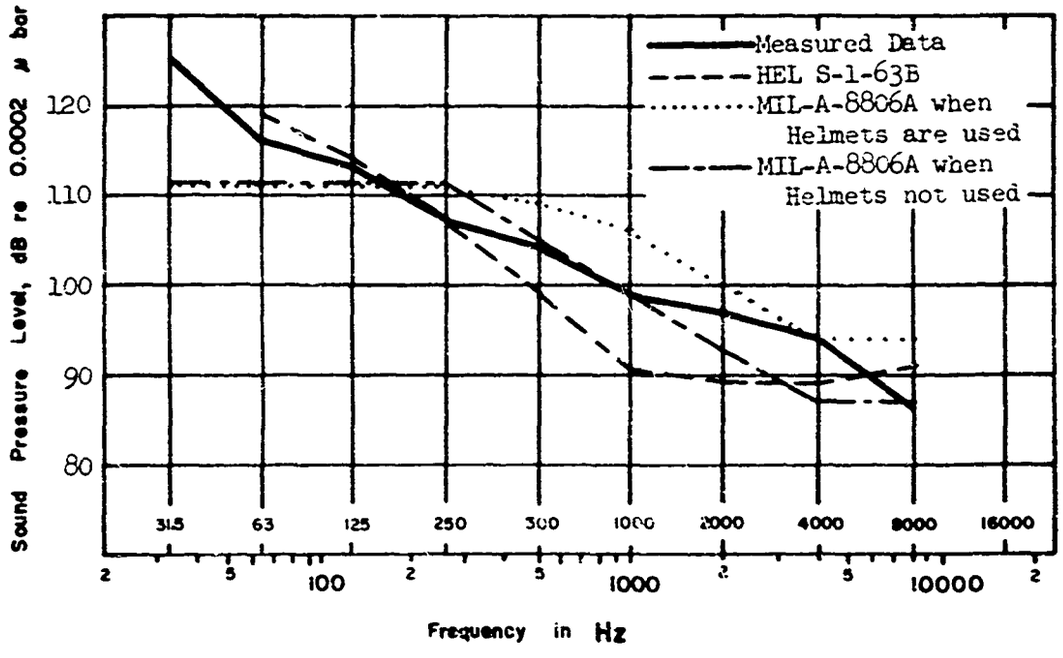


Fig. 4A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT MAXIMUM CONTINUOUS POWER (1520 lbs. torque)
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

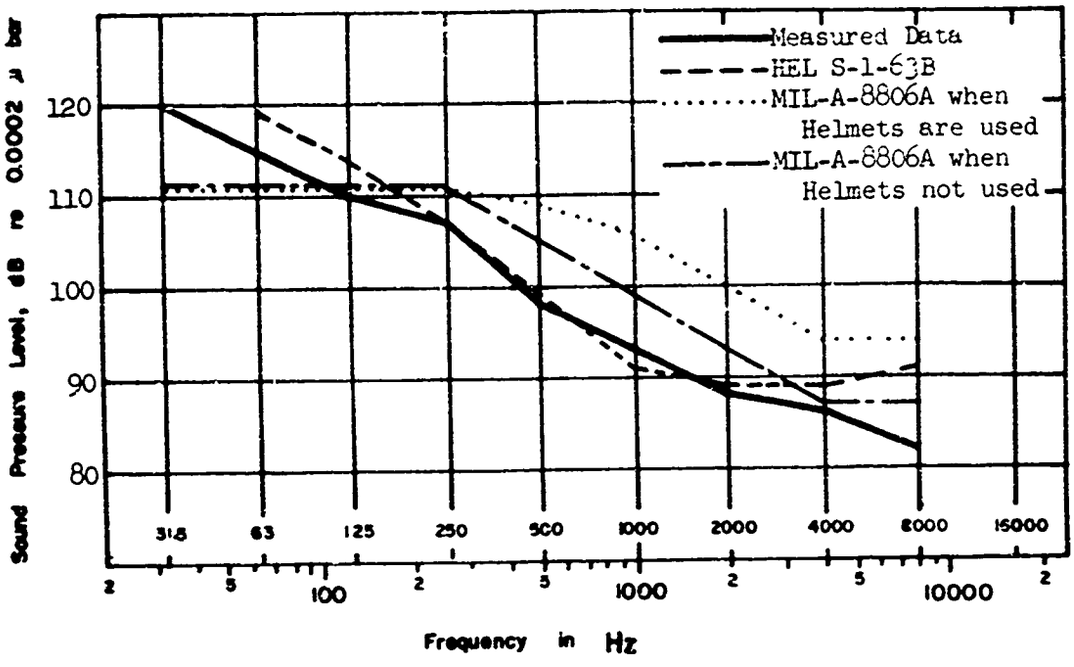


Fig. 5A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT MAXIMUM CONTINUOUS POWER (1520 lbs. torque) (Rotor speed is 230 rpm. Measuring position is at Station 320.)

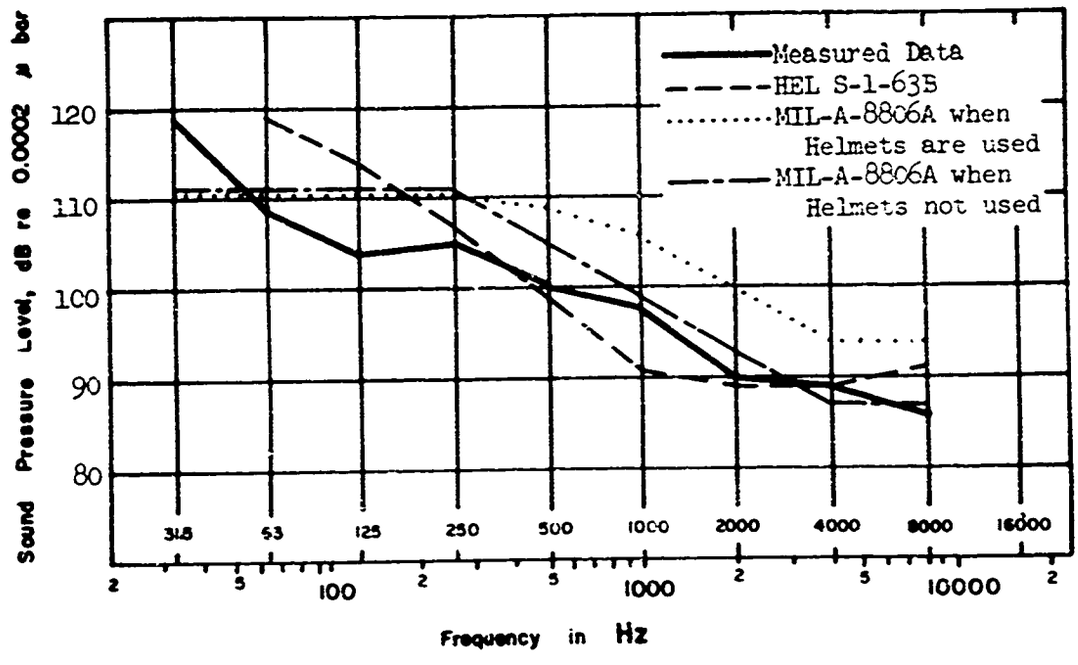


Fig. 6A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT MAXIMUM CONTINUOUS POWER (1520 lbs. torque) (Rotor speed is 230 rpm. Measuring position is at Station 480.)

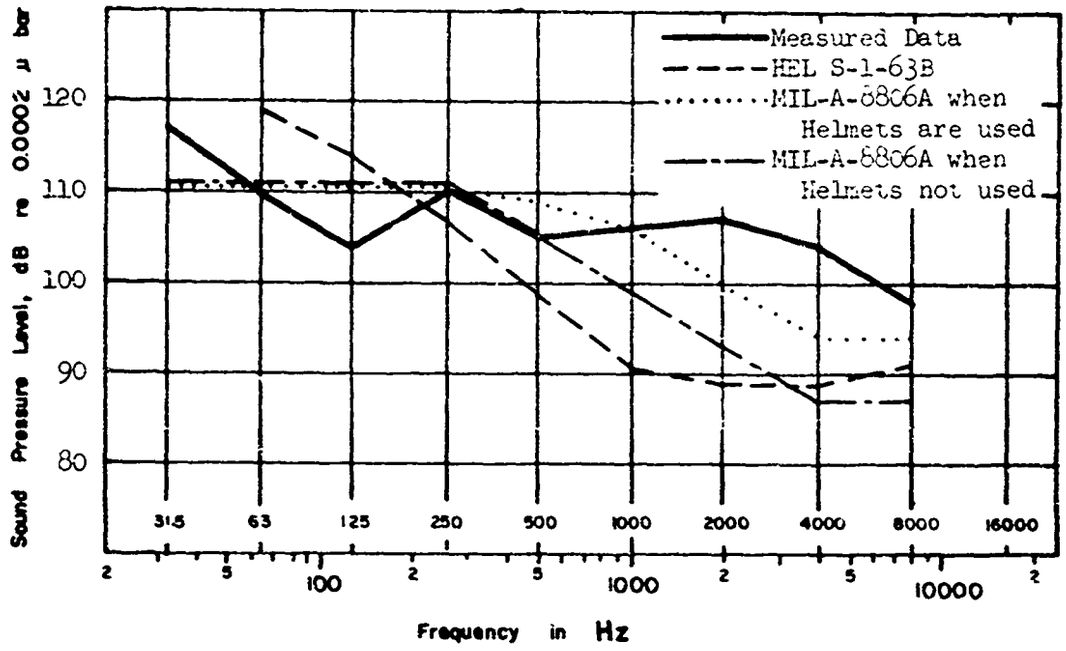


Fig. 7A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT MAXIMUM CONTINUOUS POWER (1520 lbs. torque) (Rotor speed is 230 rpm. Measuring position is at Station 480. All panels aft of Station 486 removed.)

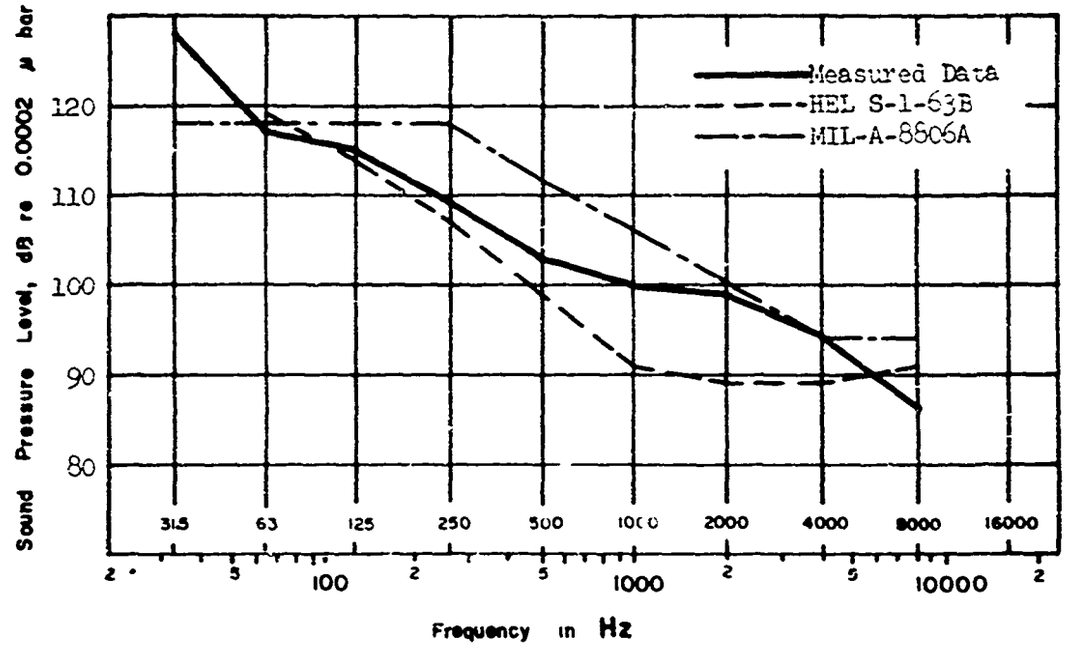


Fig. 8A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT (1720 lbs. torque) (Rotor speed is 230 rpm. Measuring position is at Station 95.)

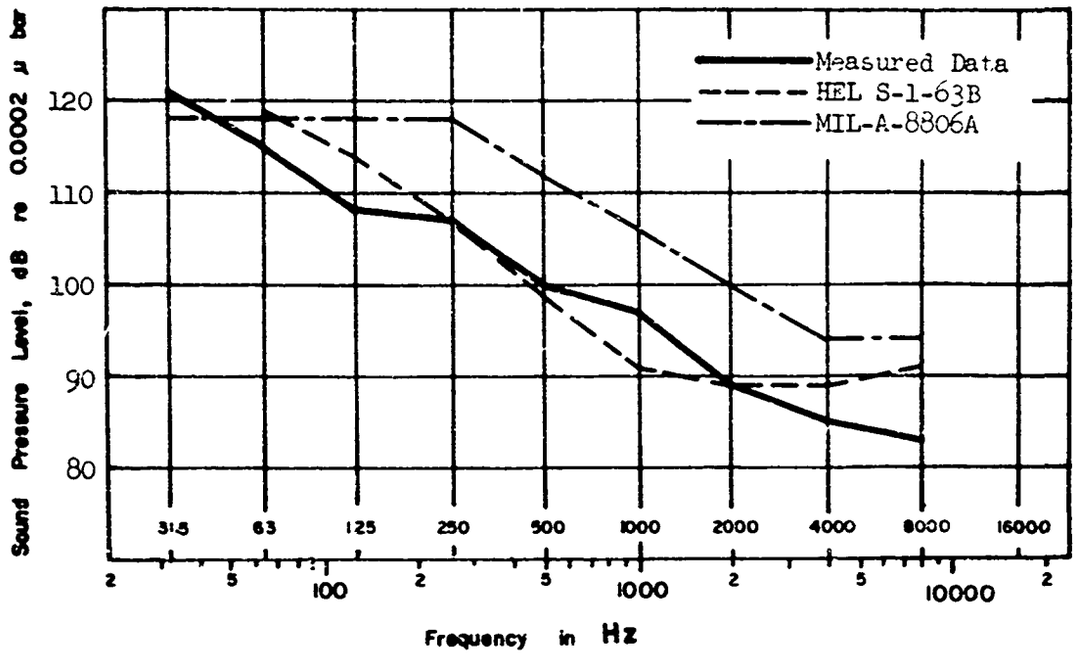


Fig. 9A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT (1720 lbs. torque) (Rotor speed is 230 rpm. Measuring position is at Station 320.)

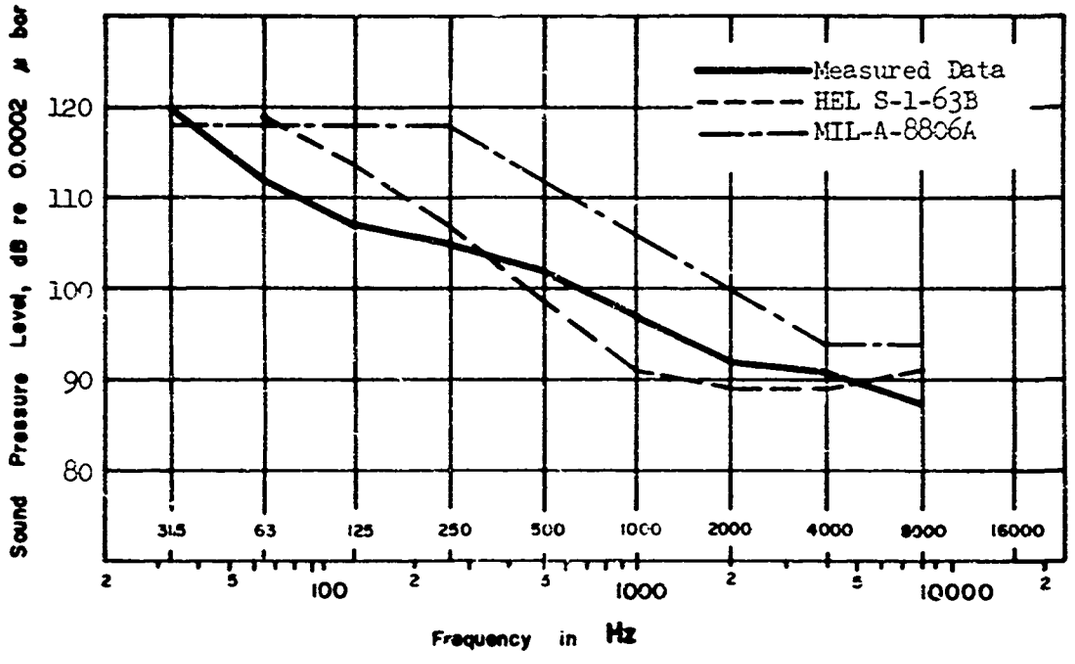


Fig. 10A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT (1720 lbs. torque) (Rotor speed is 230 rpm. Measuring position is at Station 480.)

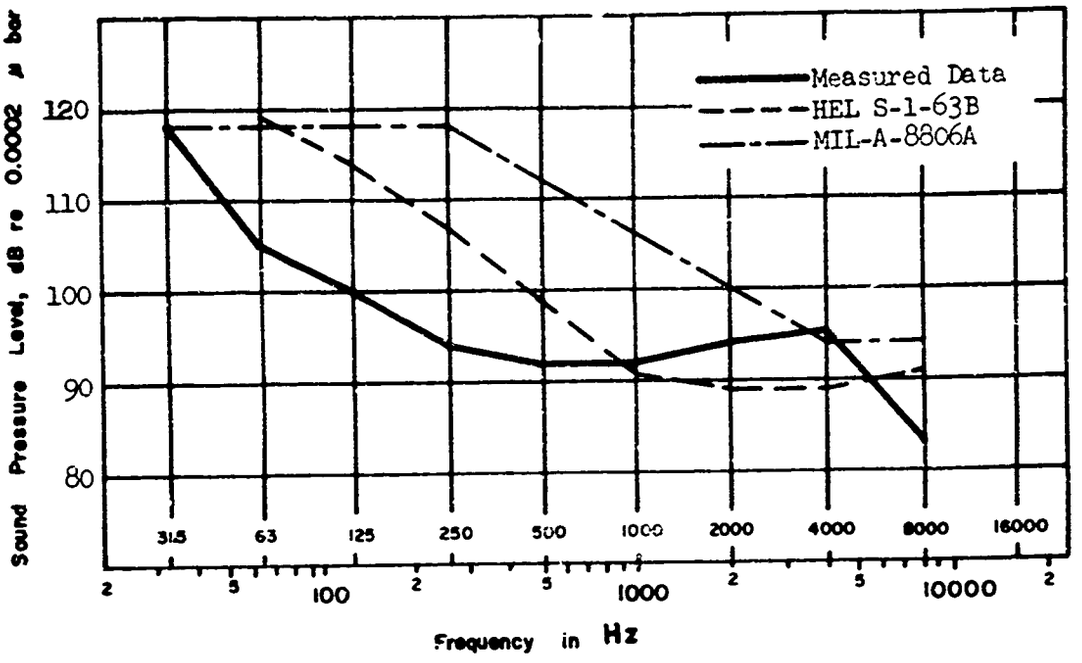


Fig. 11A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 30 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 95.)

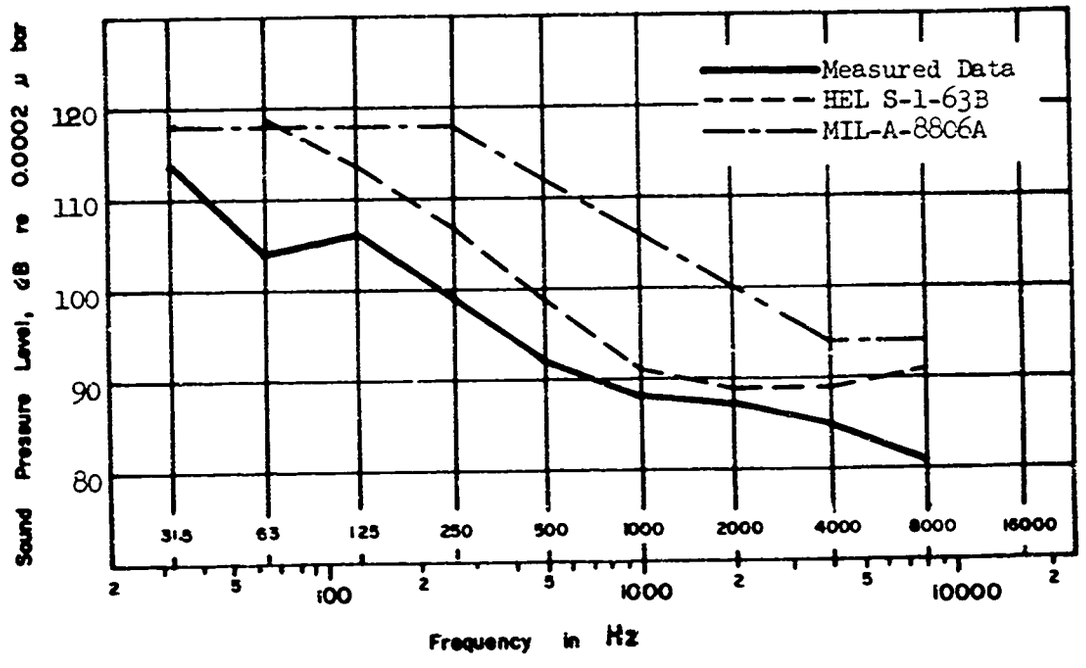


Fig. 12A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 30 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 320.)

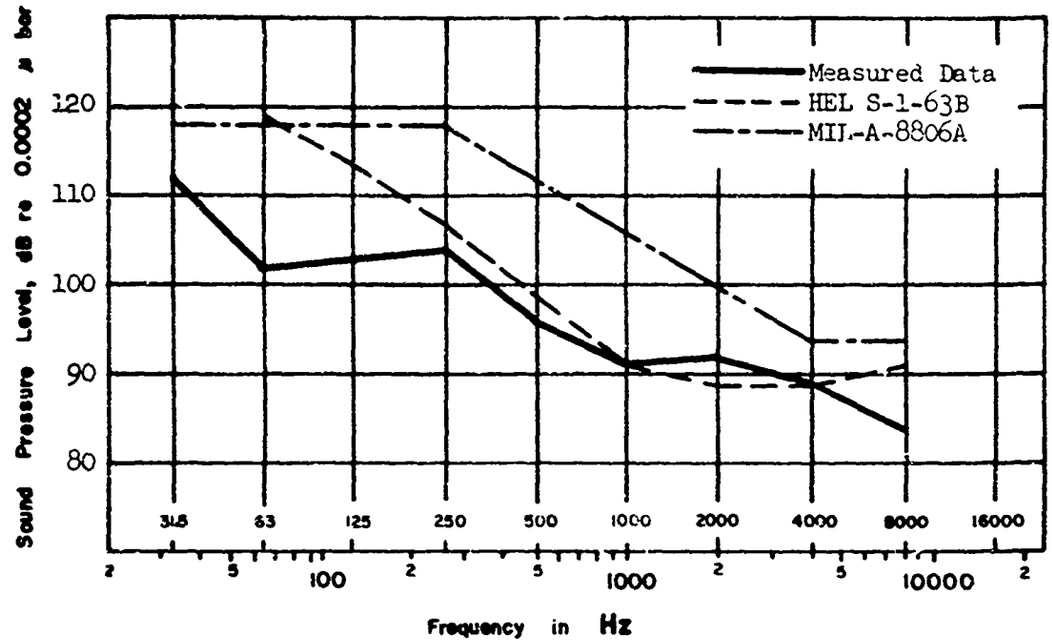


Fig. 13A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 30 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 480.)

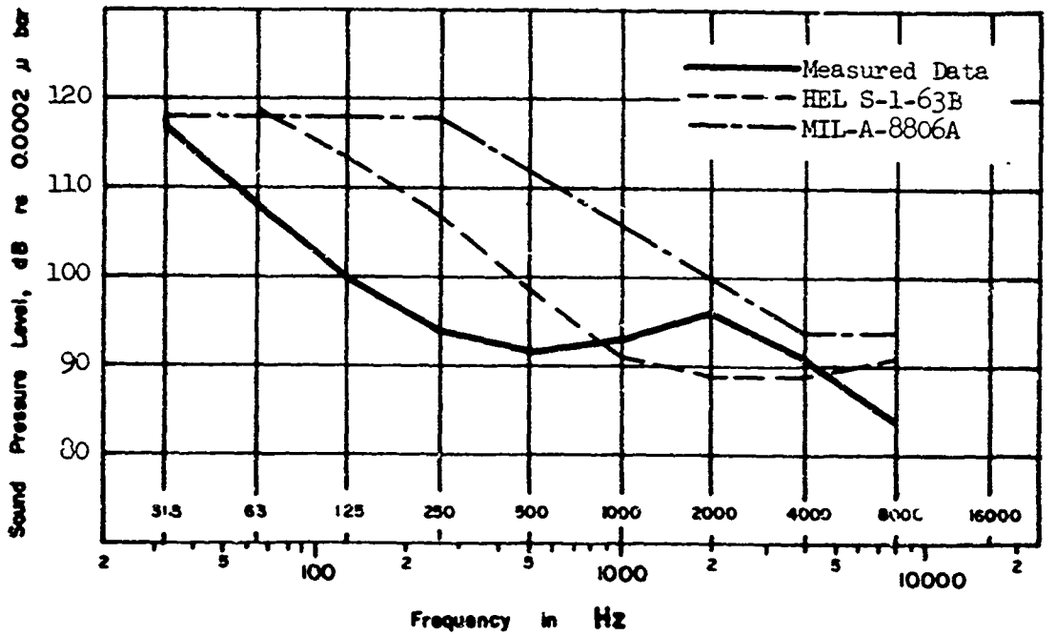


Fig. 14A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 30 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

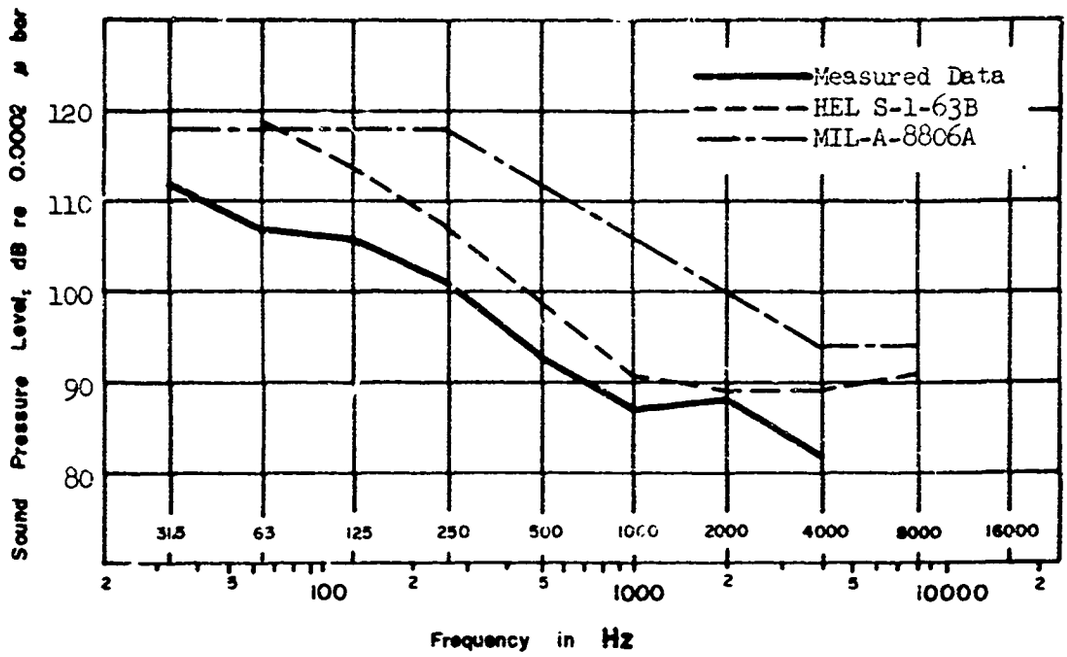


Fig. 15A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 30 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

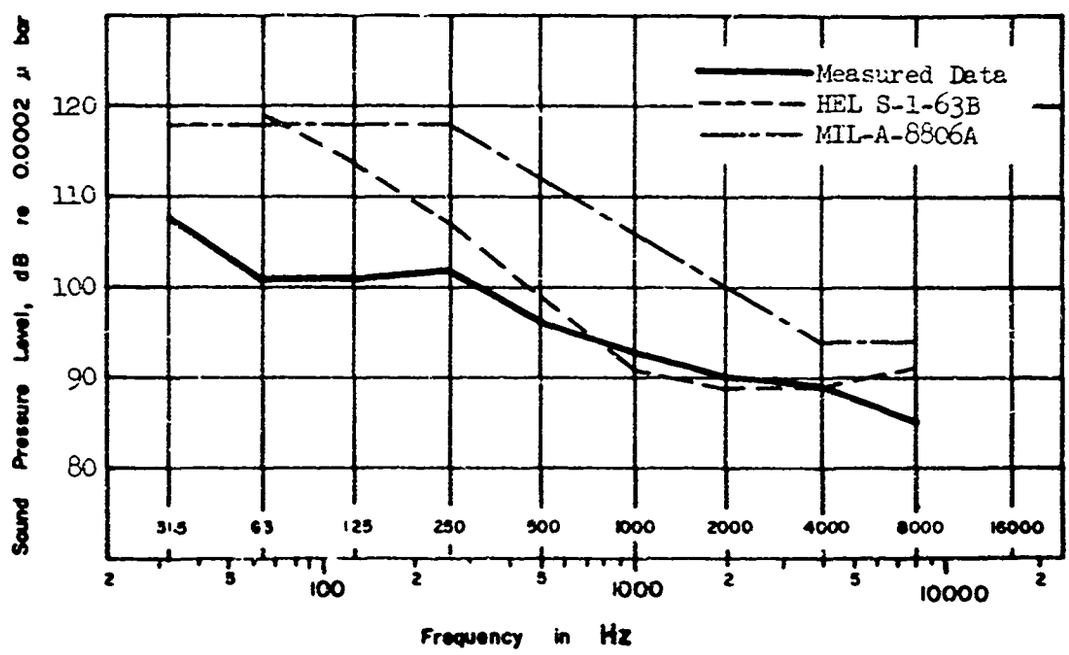


Fig. 16A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 30 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)

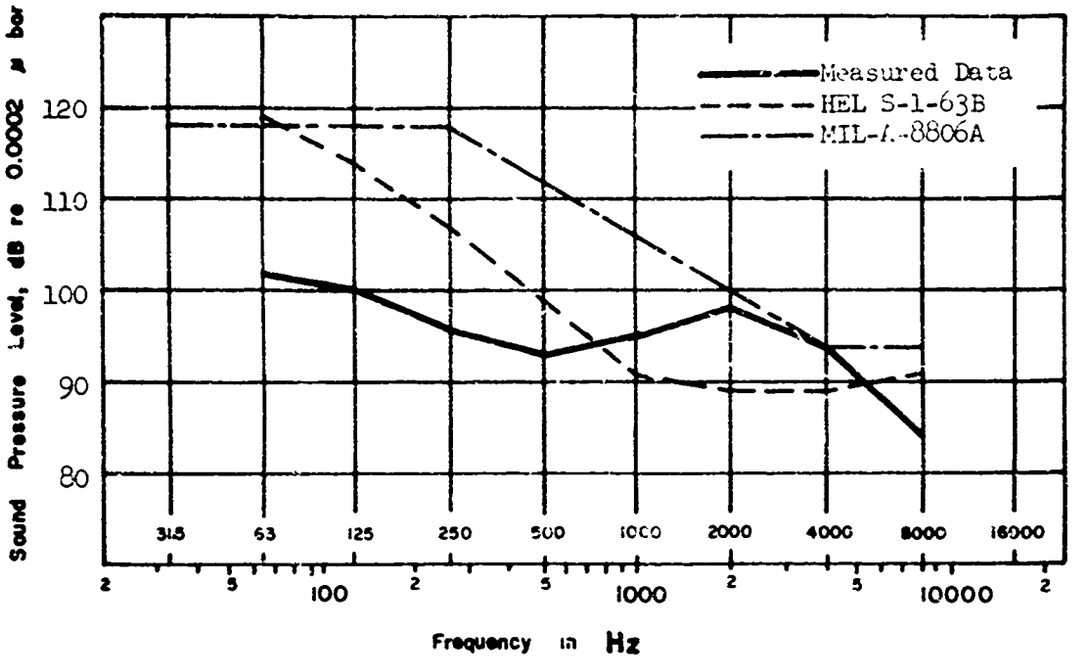


Fig. 17A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 40 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 95.)

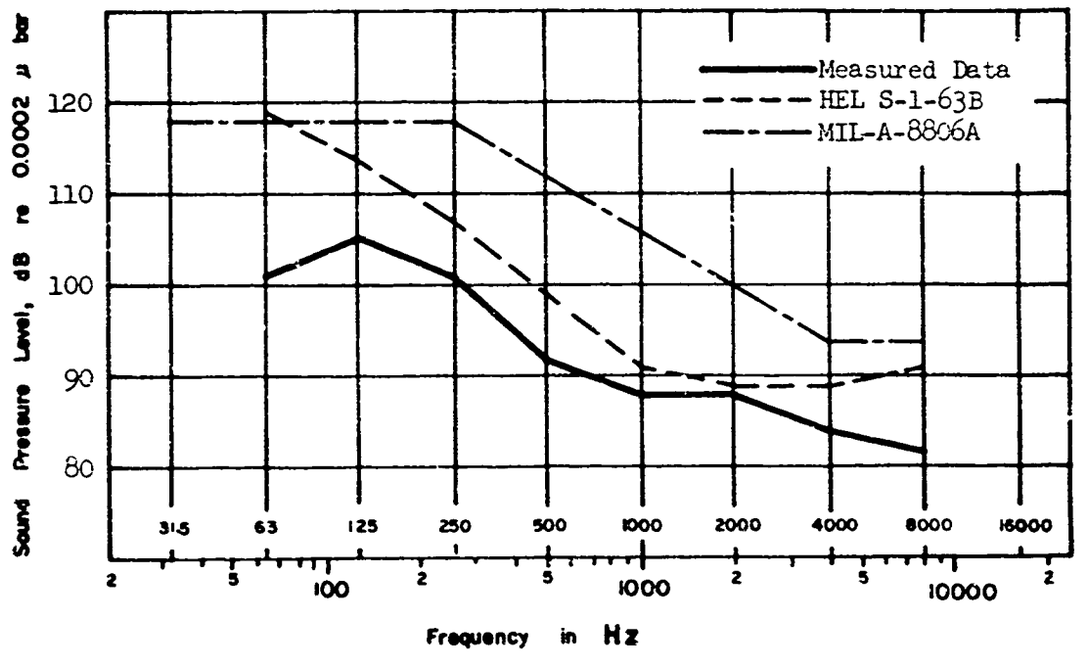


Fig. 18A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 40 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 320.)

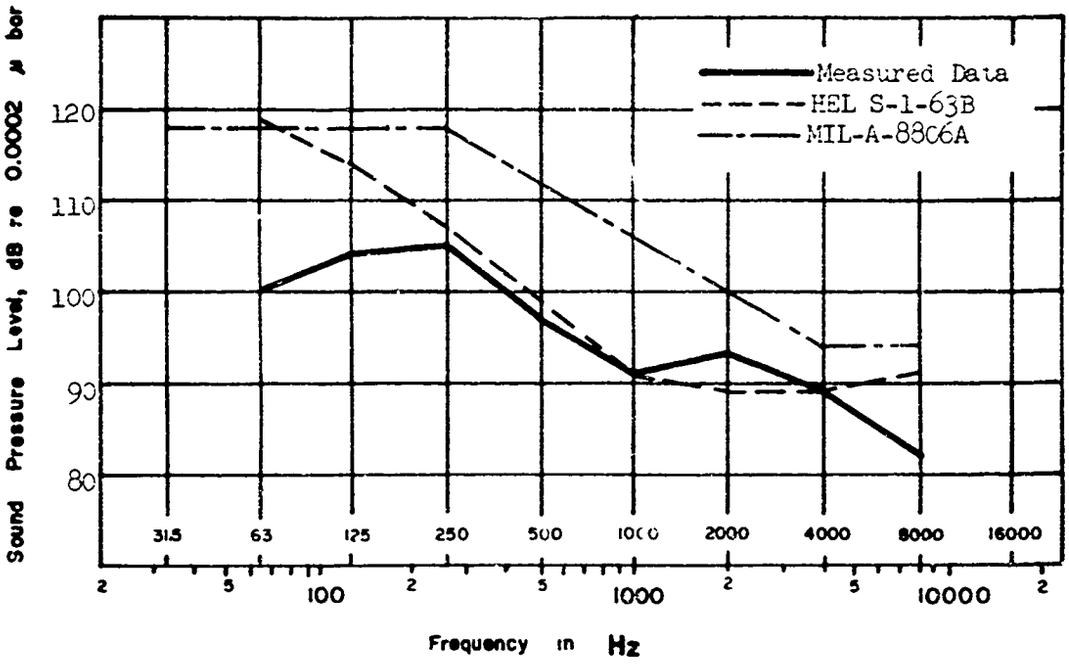


Fig. 19A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 40 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 480.)

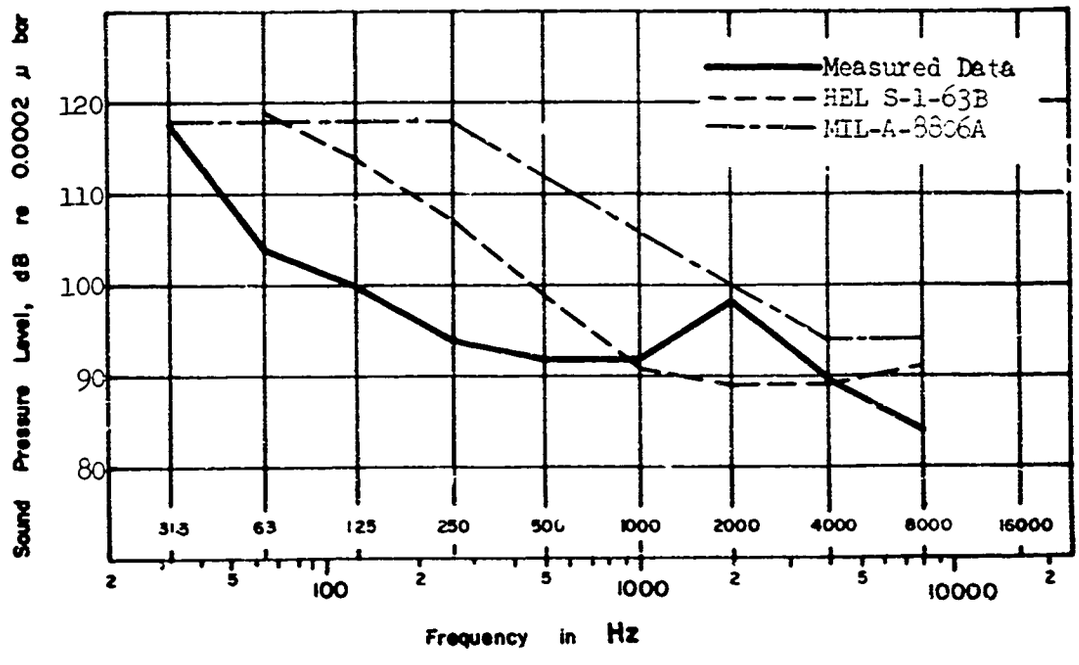


Fig. 20A. NOISE OF THE CH-47b HELICOPTER IN LEVEL FLIGHT AT 40 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

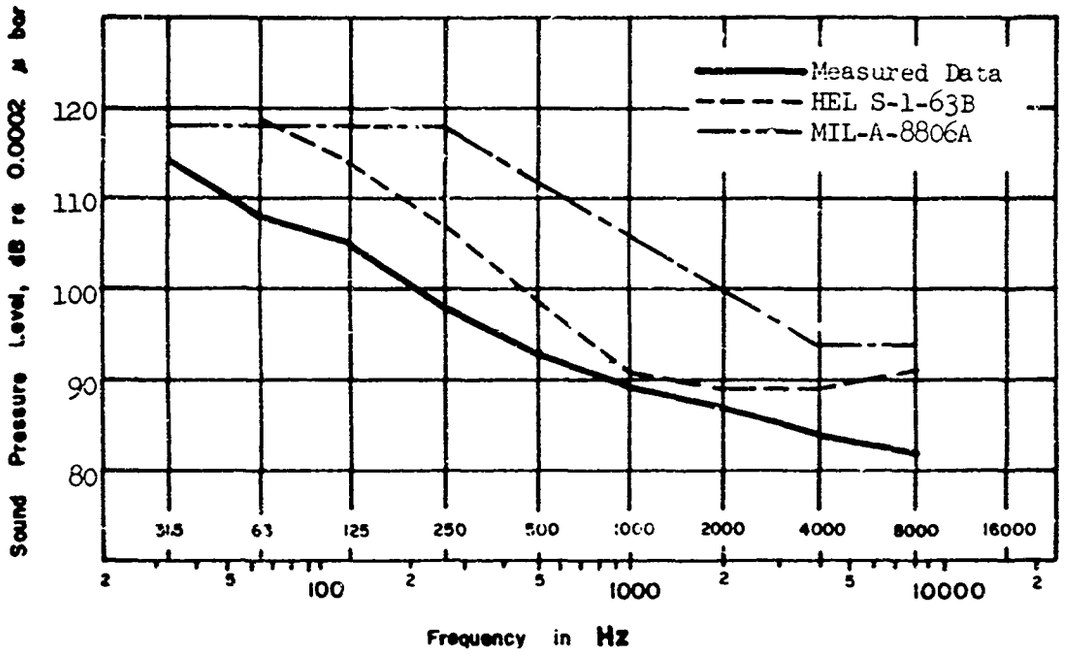


Fig. 21A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 40 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

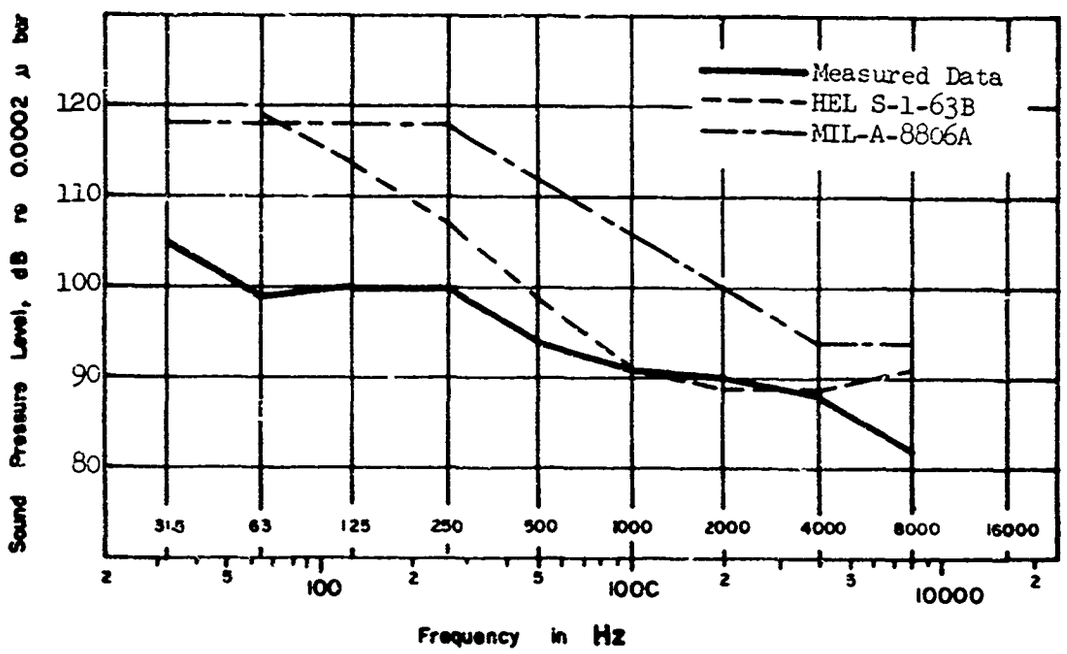


Fig. 22A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 40 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)

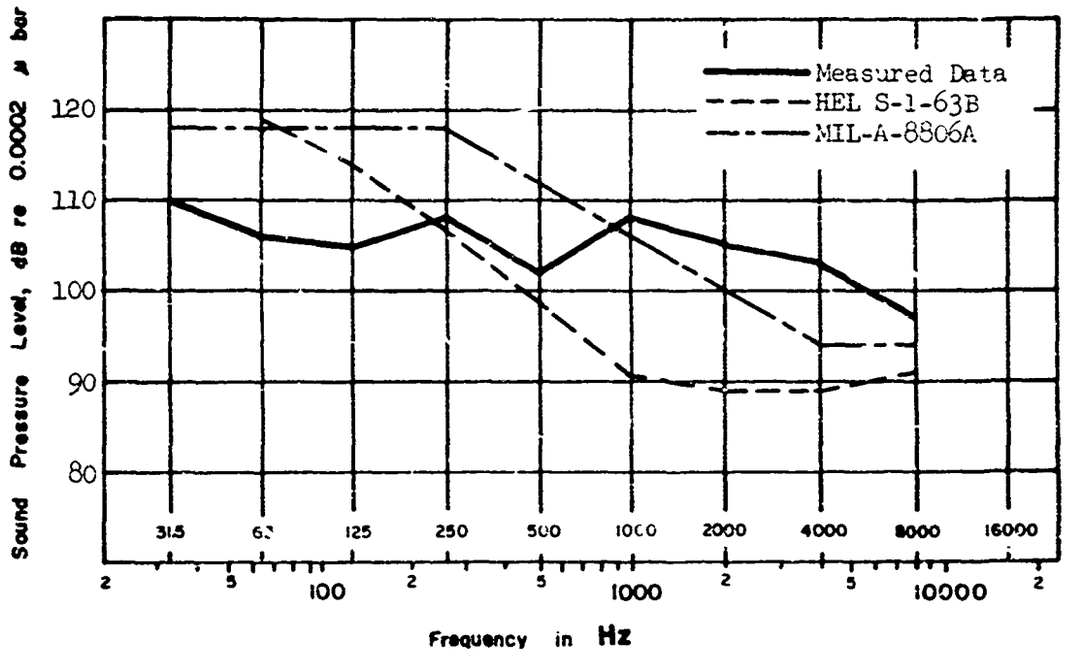


Fig. 23A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 40 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)
(All panels aft of Station 486 removed.)

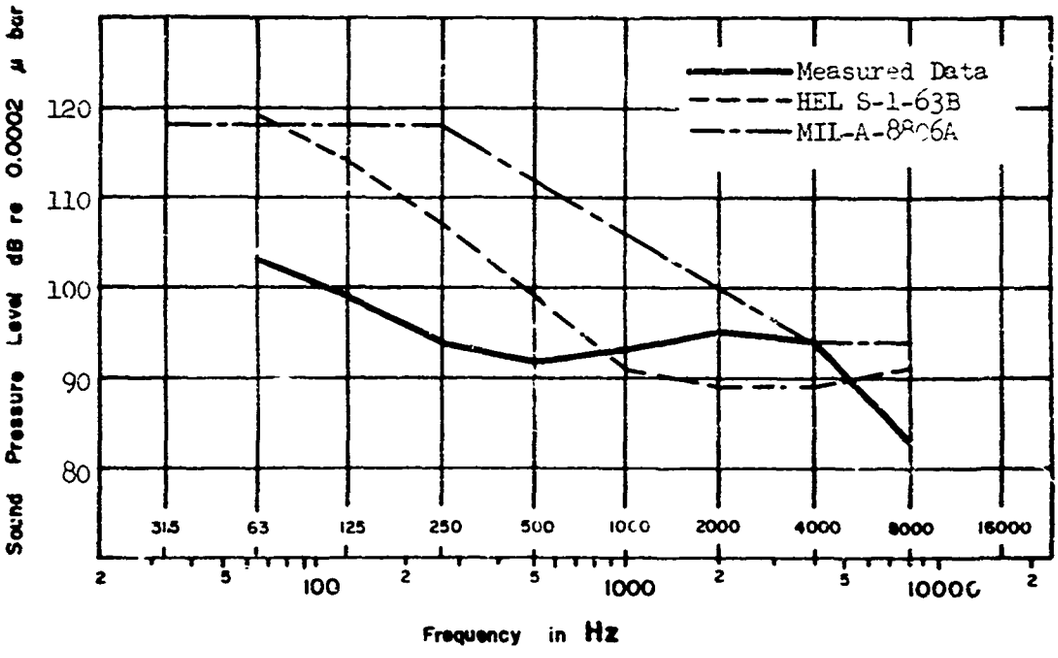


Fig. 24A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 60 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 95.)

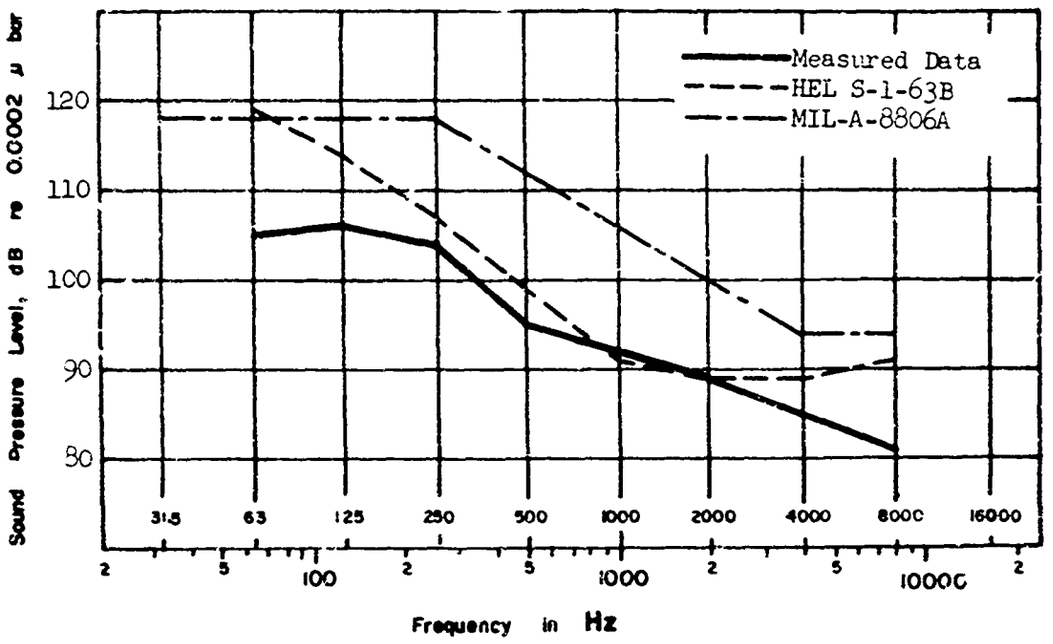


Fig. 25A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 60 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 320.)

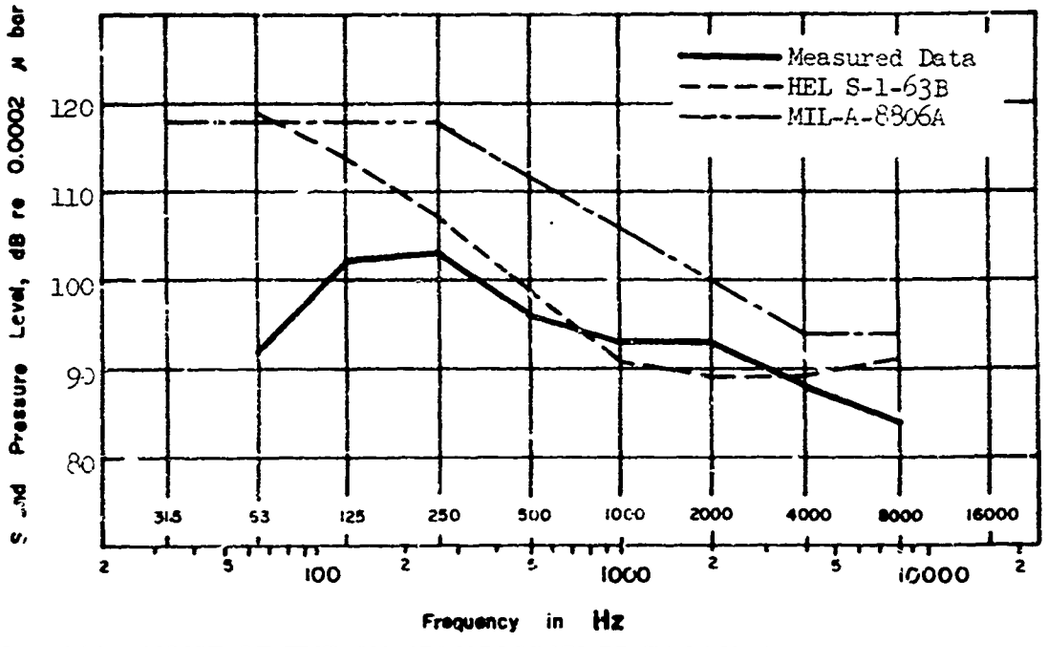


Fig. 26A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 60 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 480.)

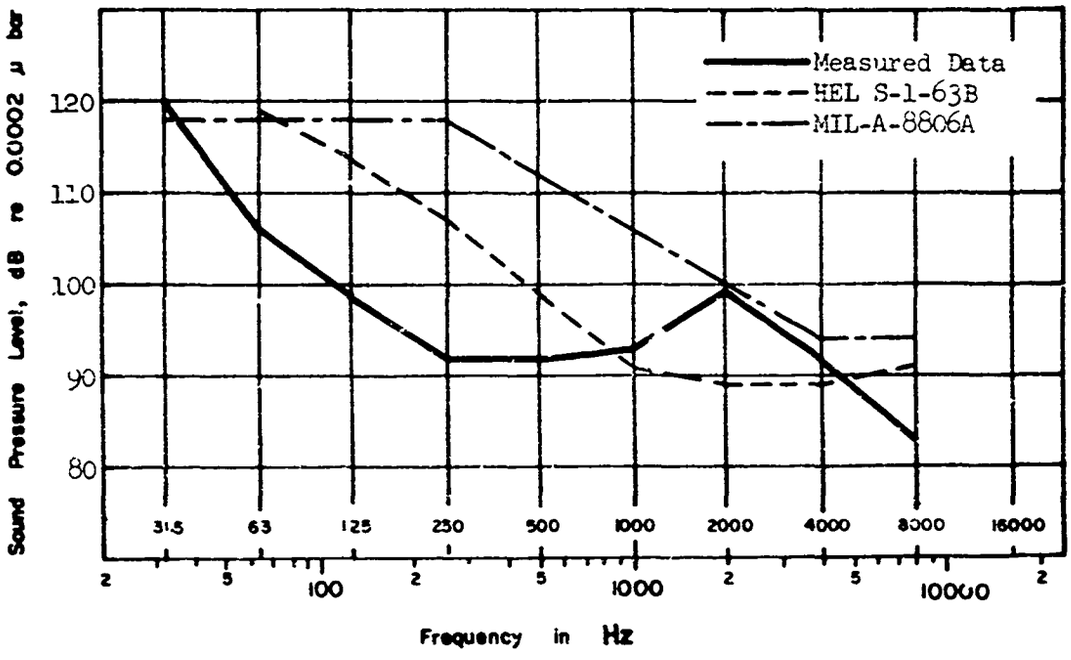


Fig. 27A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 60 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

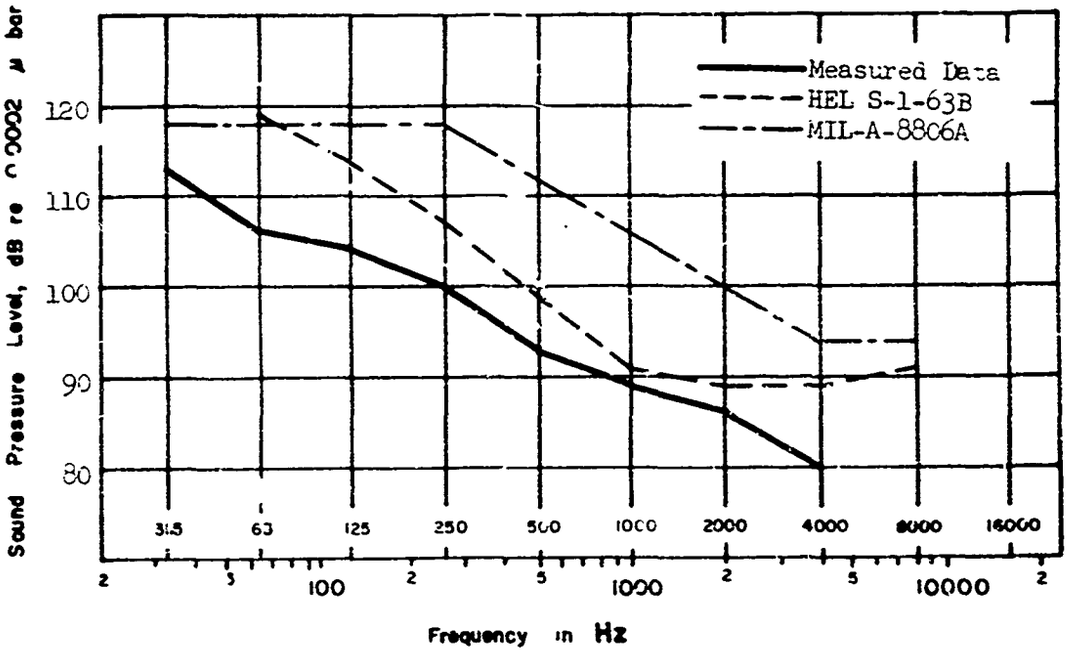


Fig. 28A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 60 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

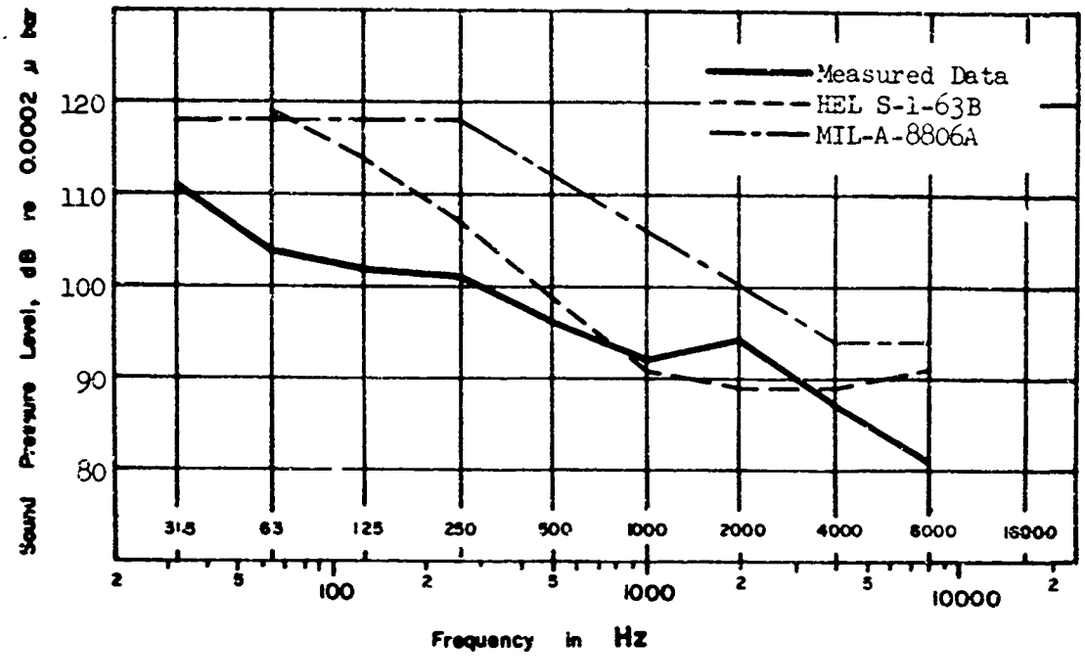


Fig. 29A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 60 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)

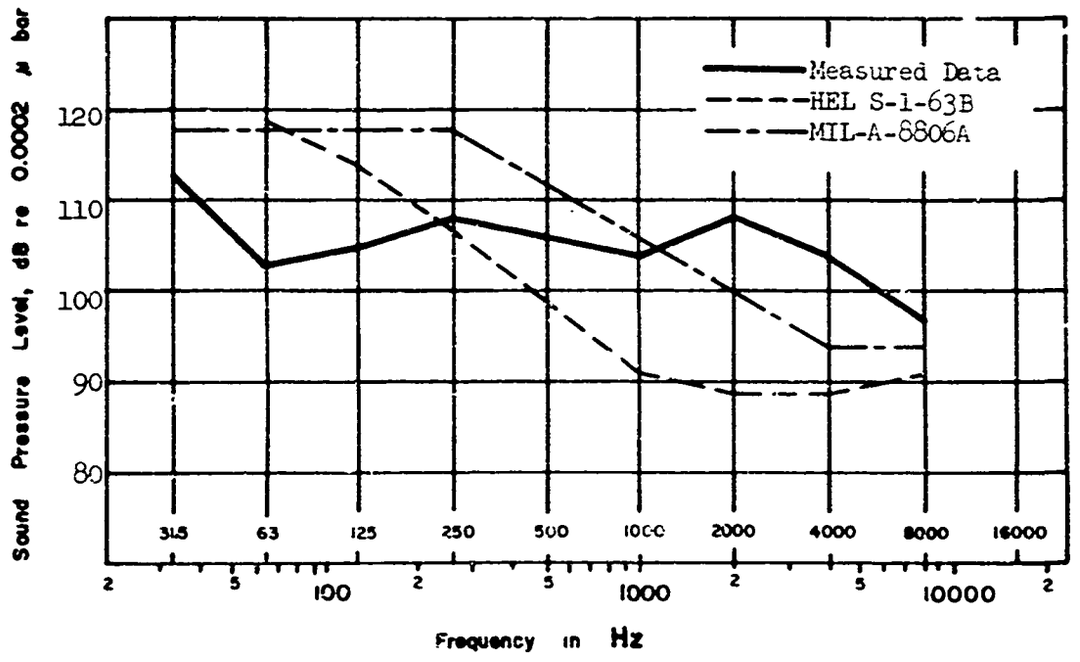


Fig. 30A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 60 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)
(All panels aft of Station 486 removed.)

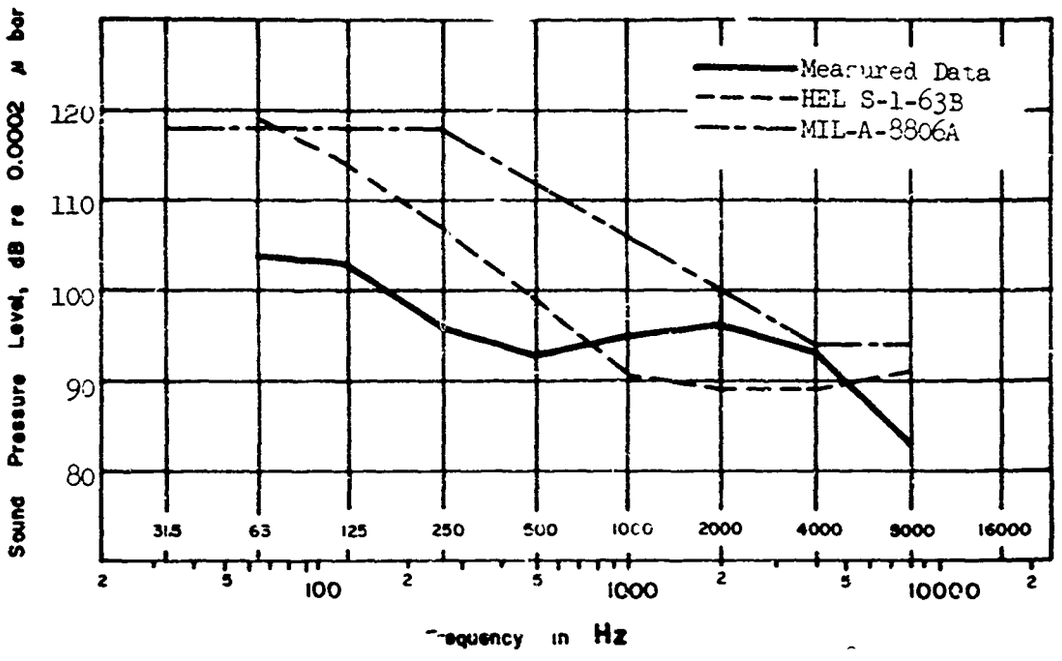


Fig. 31A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT
AT 80 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 95.)

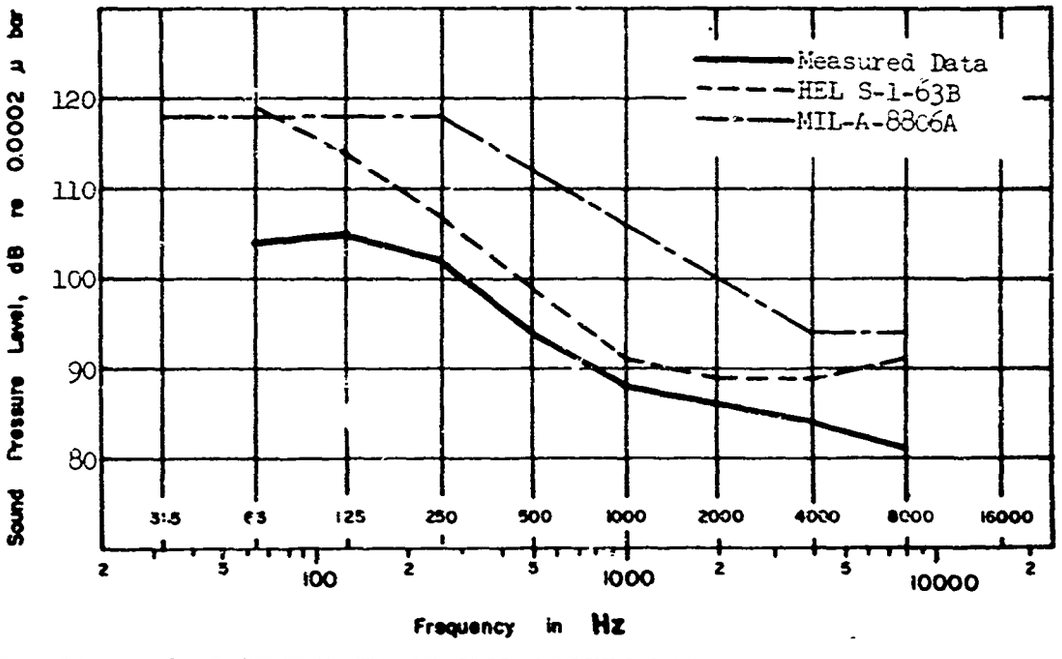


Fig. 32A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT
AT 80 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 320.)

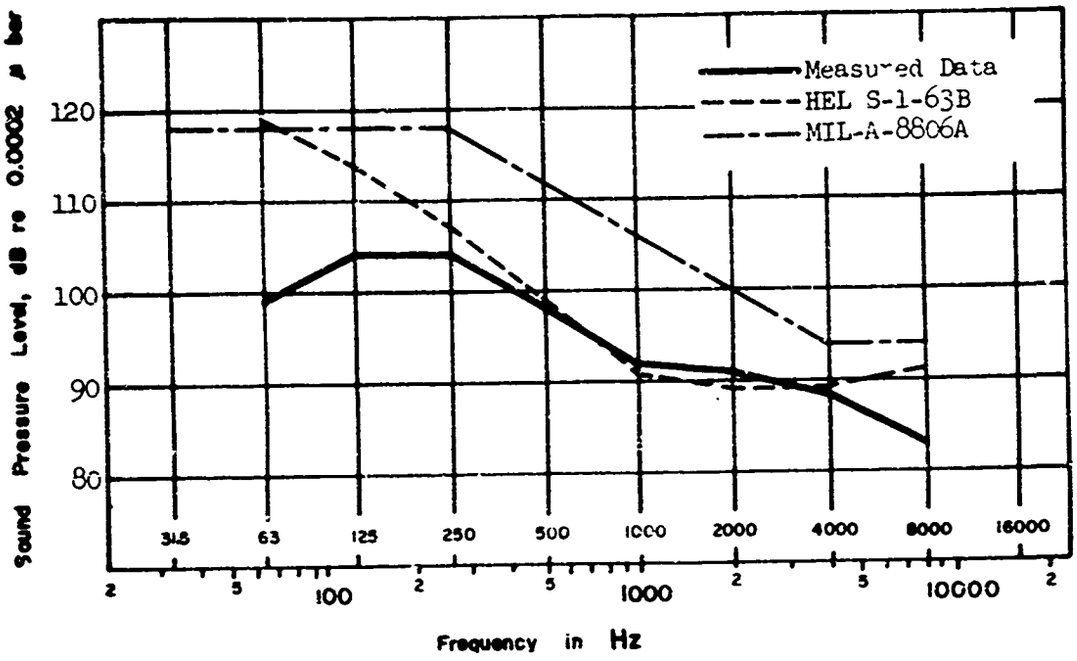


Fig. 33A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 80 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 480.)

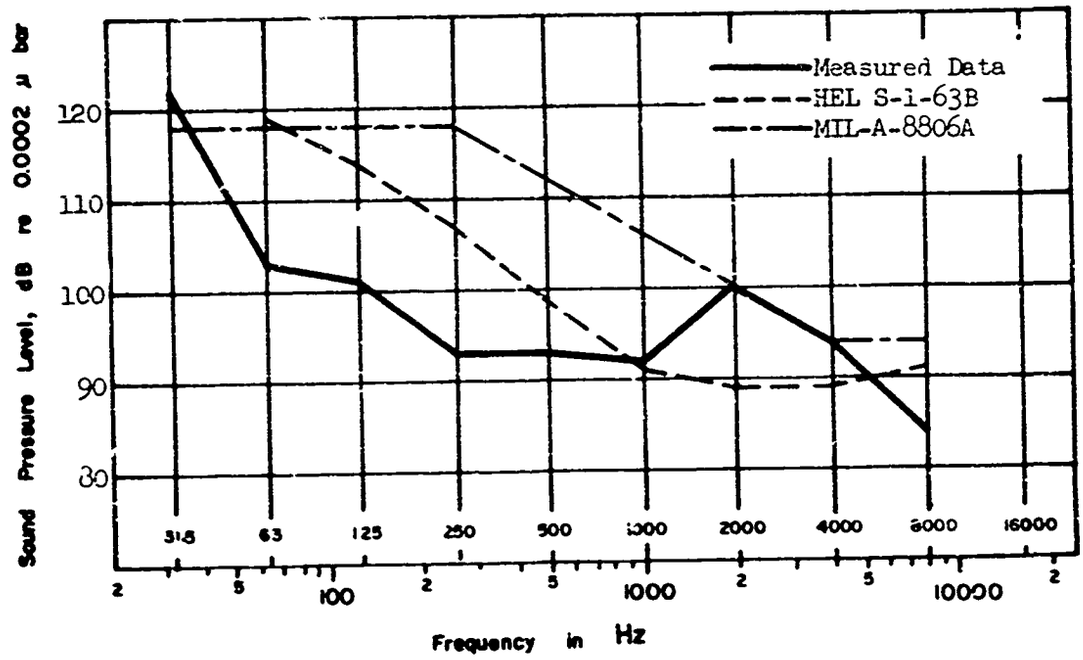


Fig. 34A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 80 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

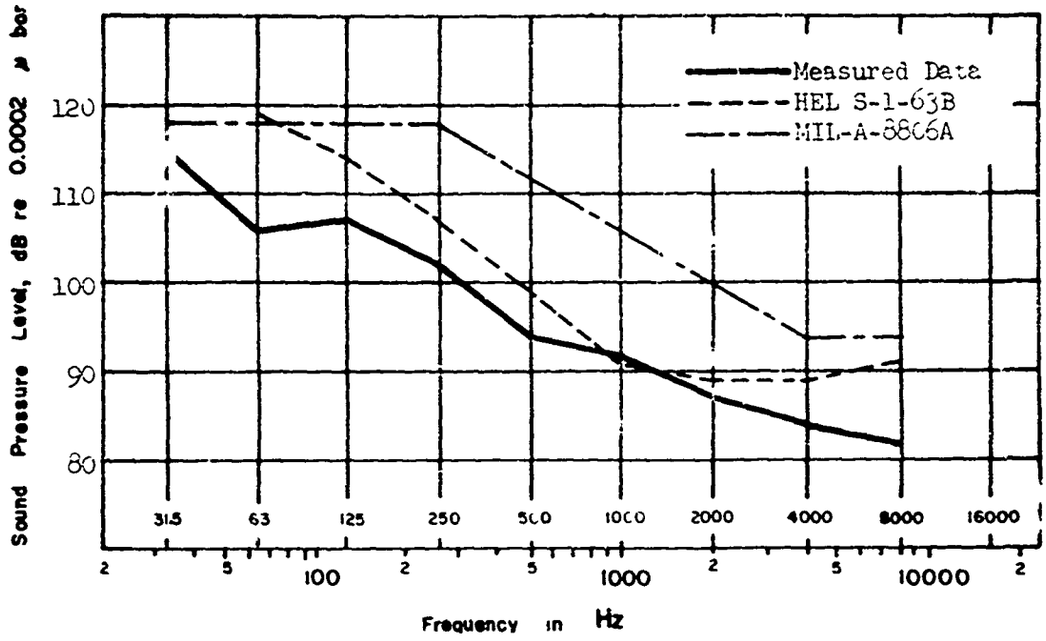


Fig. 35A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 80 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

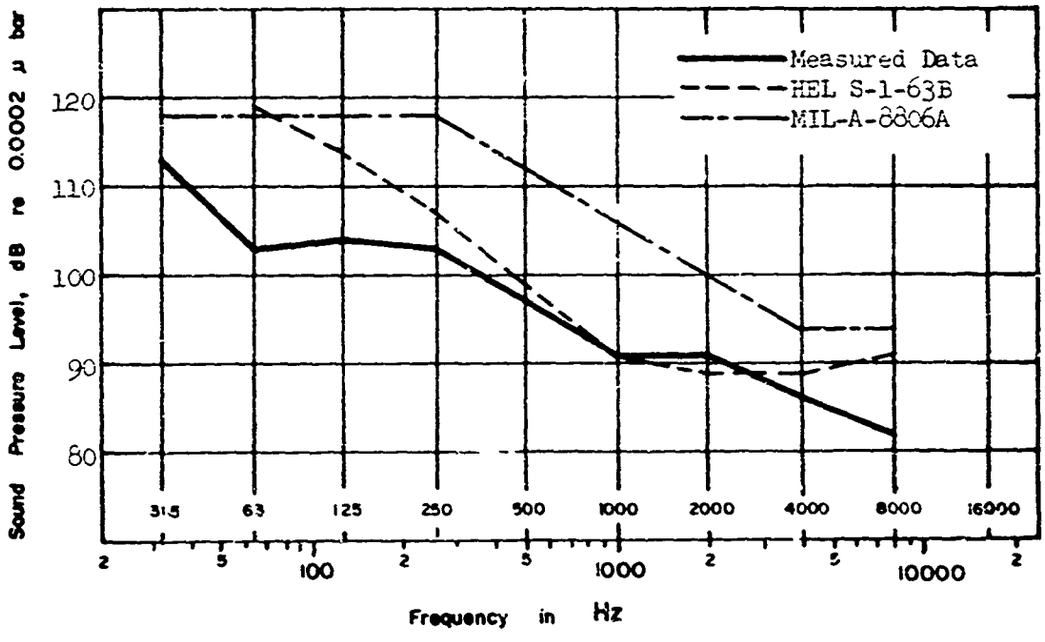


Fig. 36A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 80 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)

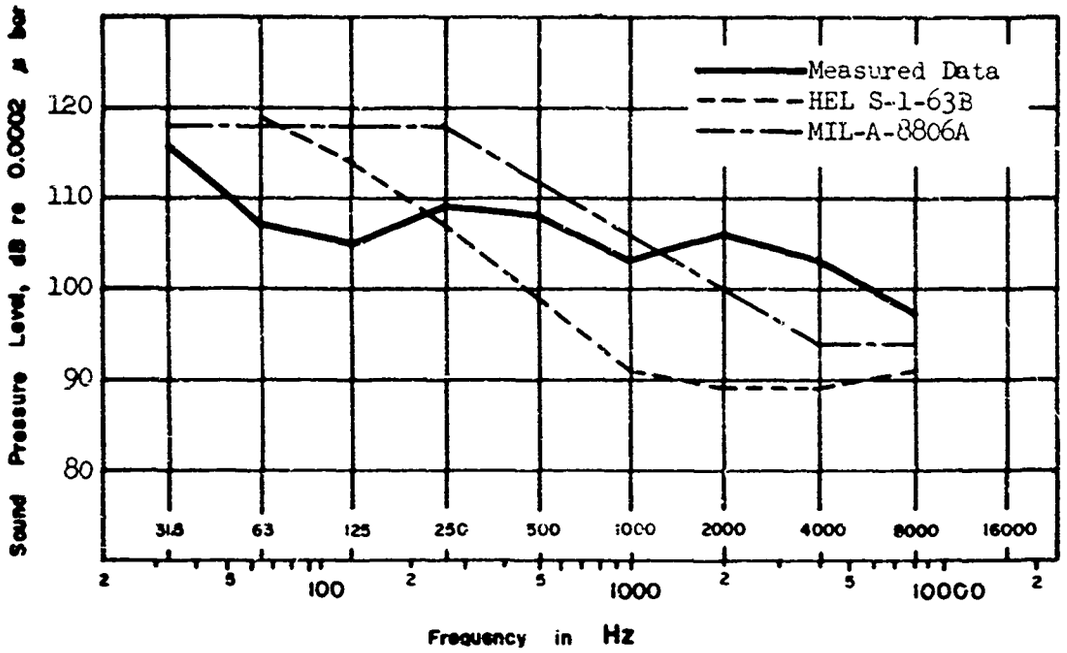


Fig. 37A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 80 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)
(All panels aft of Station 486 removed.)

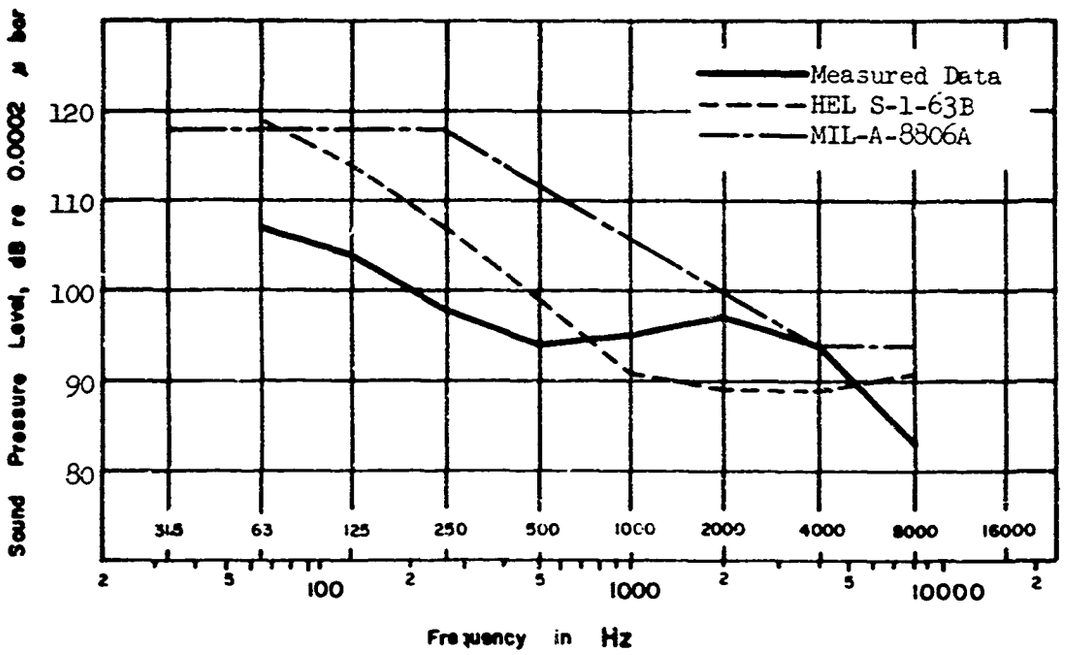


Fig. 38A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 95.)

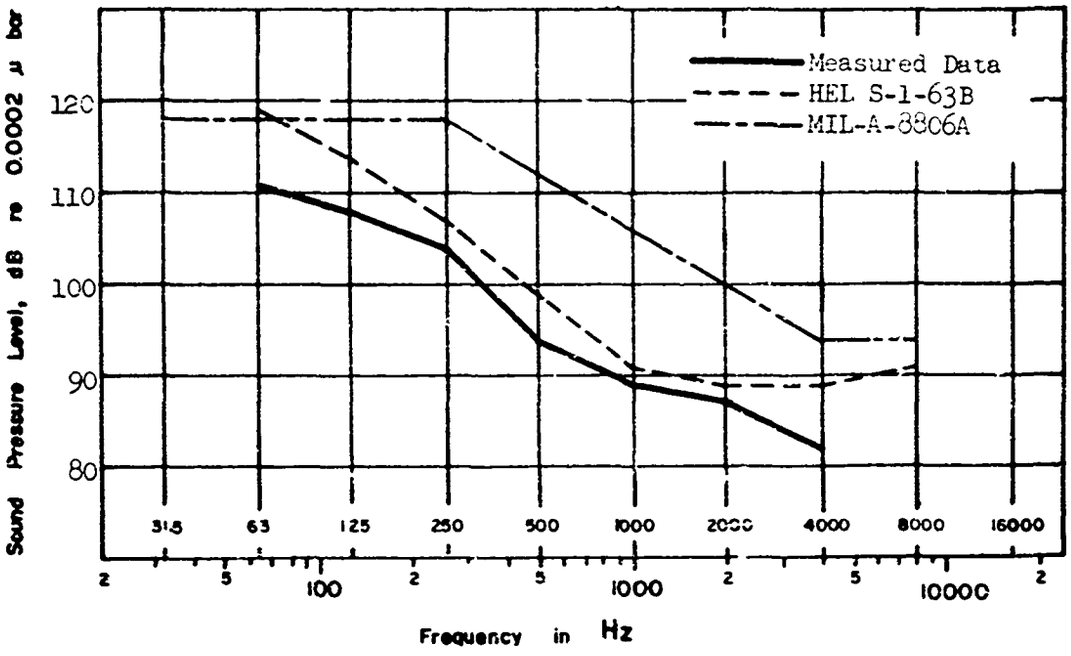


Fig. 39A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 320.)

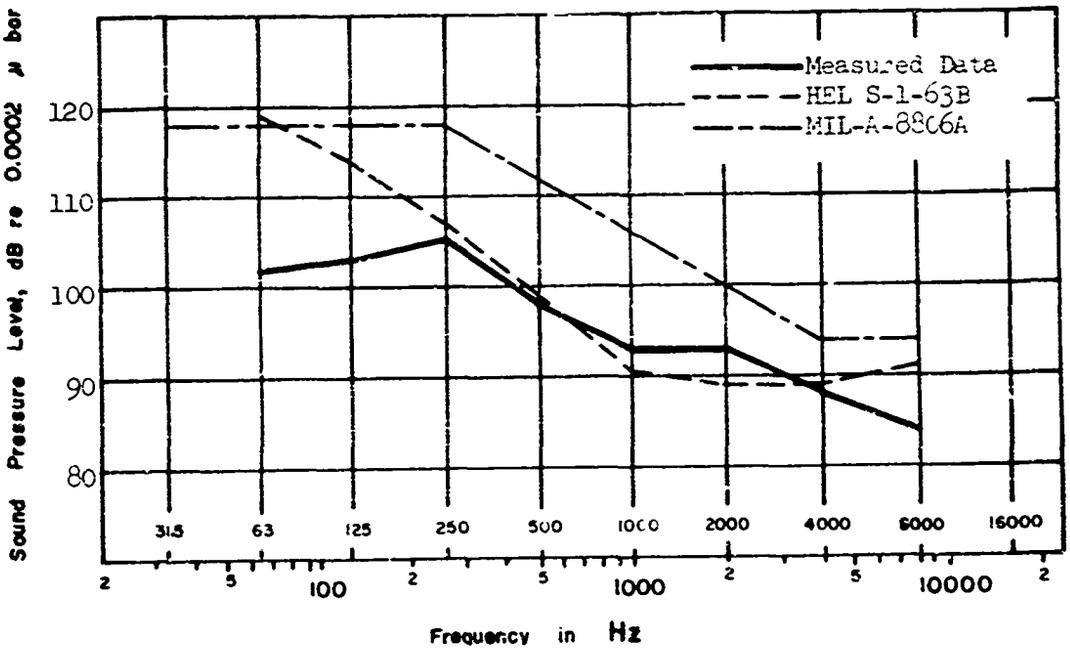


Fig. 40A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 480.)

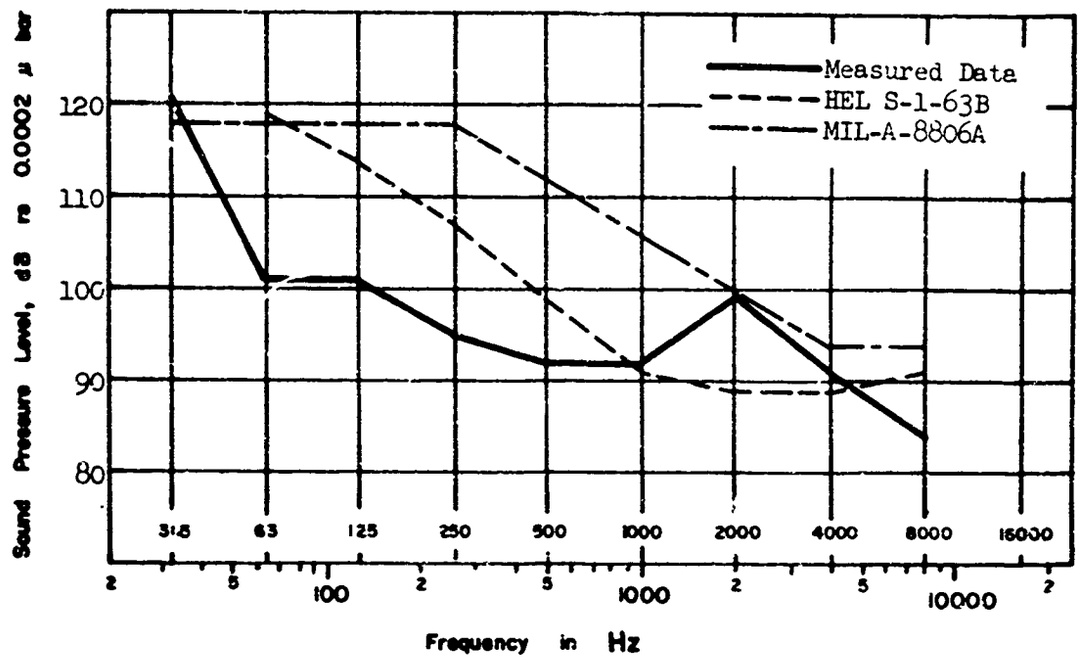


Fig. 41A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

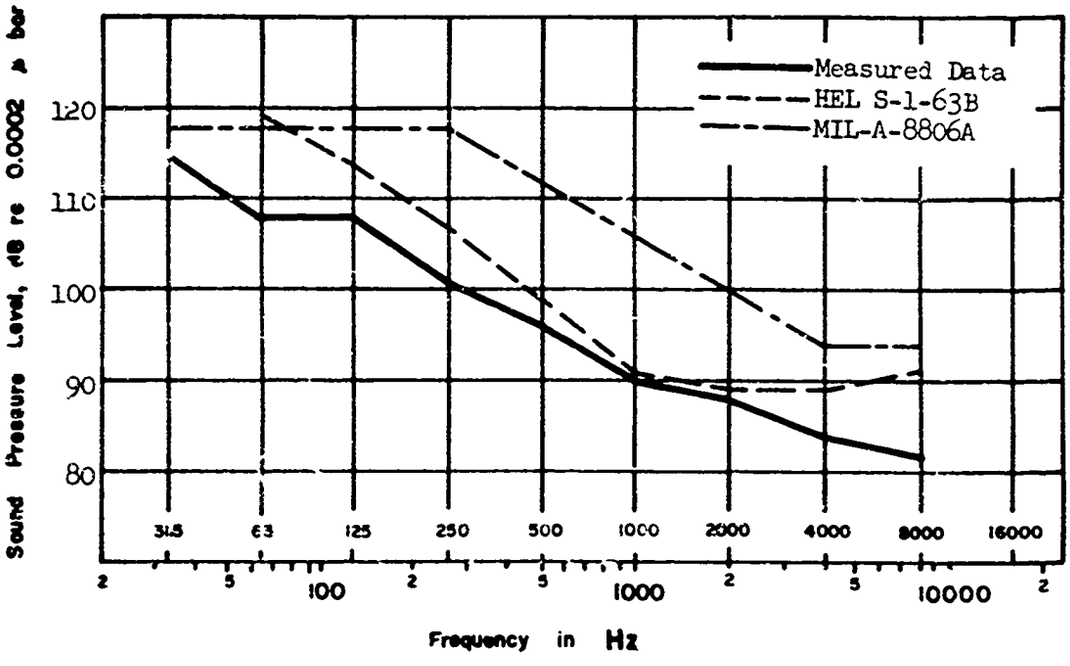


Fig. 42A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

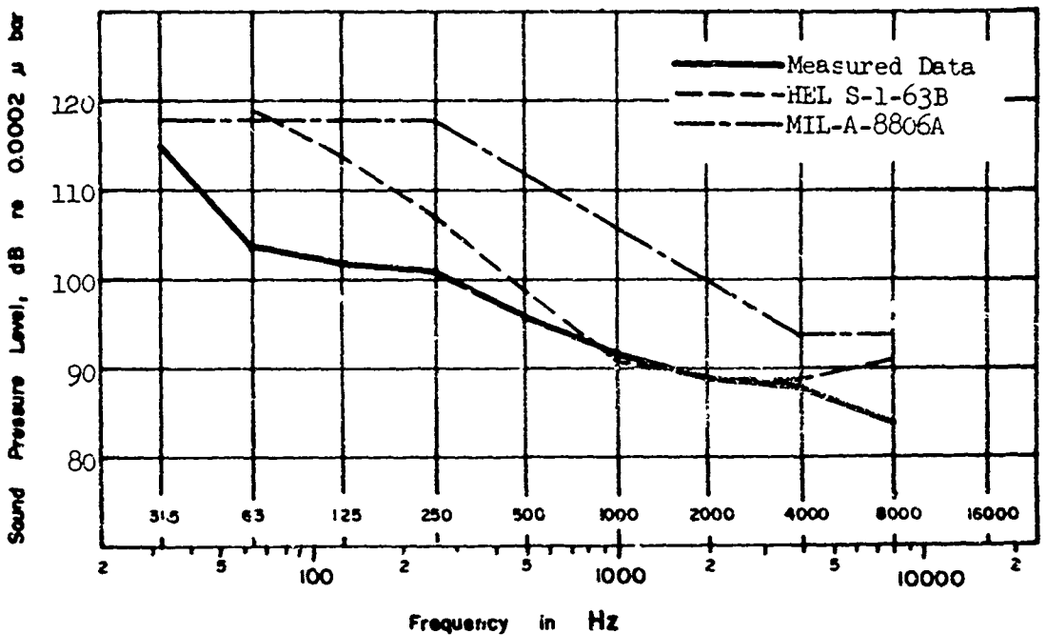


Fig. 43A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT
AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)

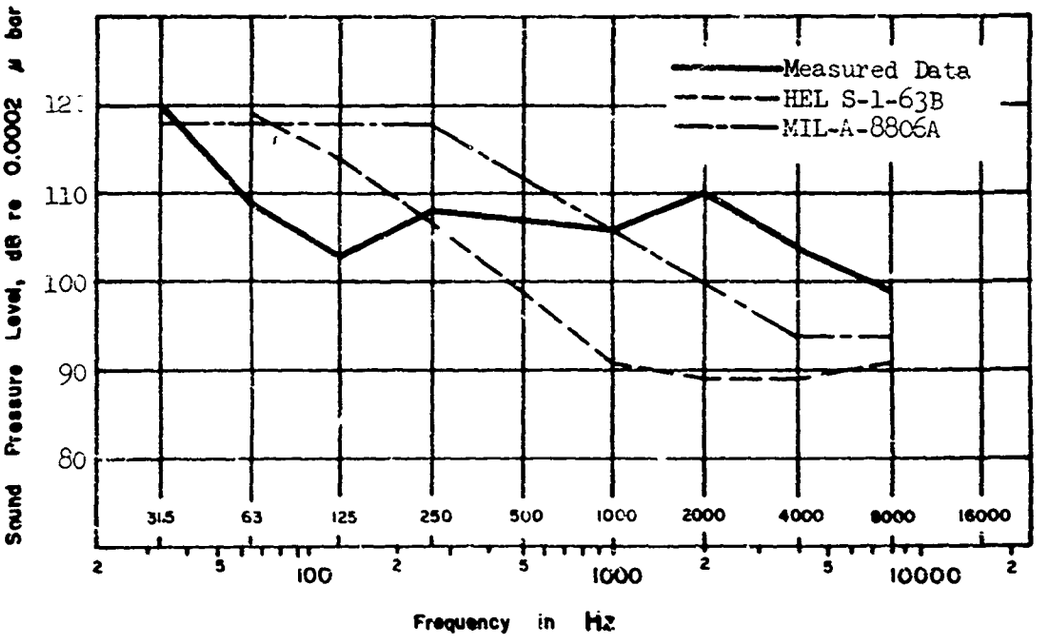


Fig. 44A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT
AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)
(All panels aft of Station 486 removed.)

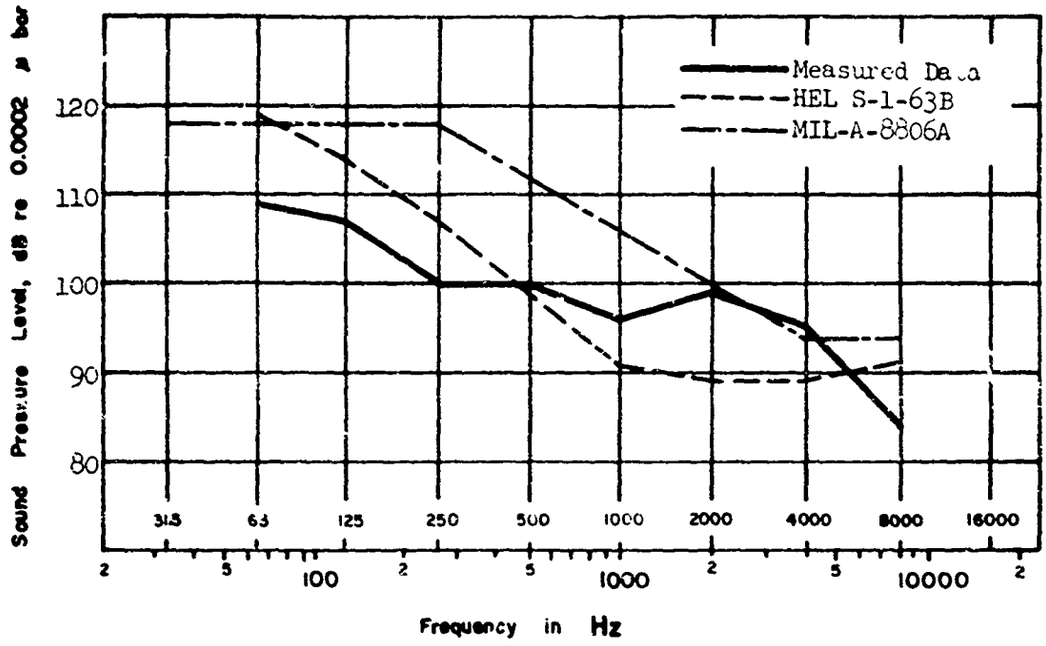


Fig. 45A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 120 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 95.)

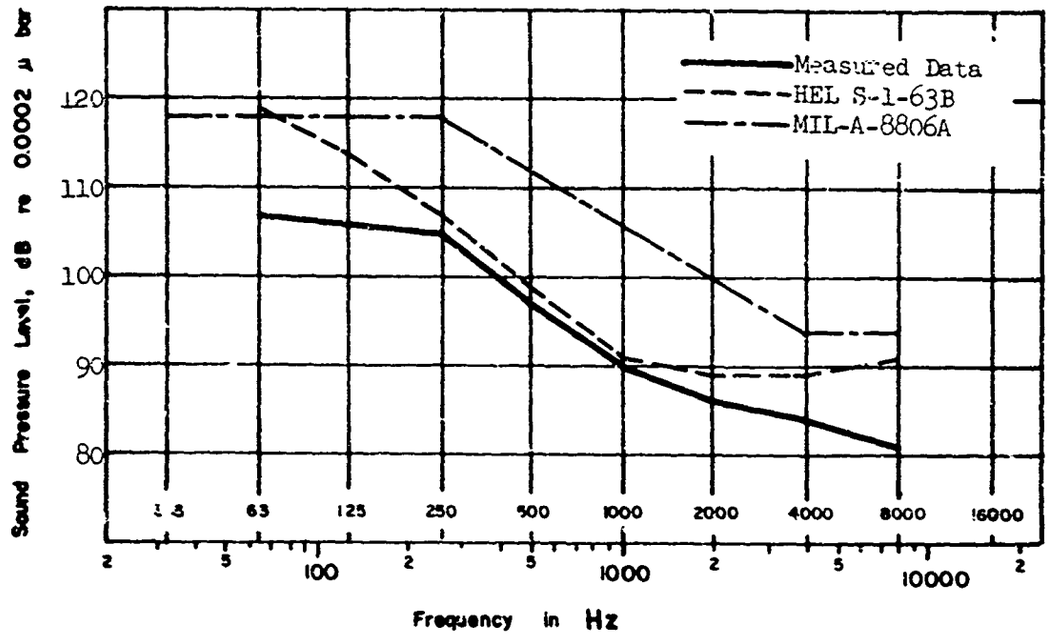


Fig. 46A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 120 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 320.)

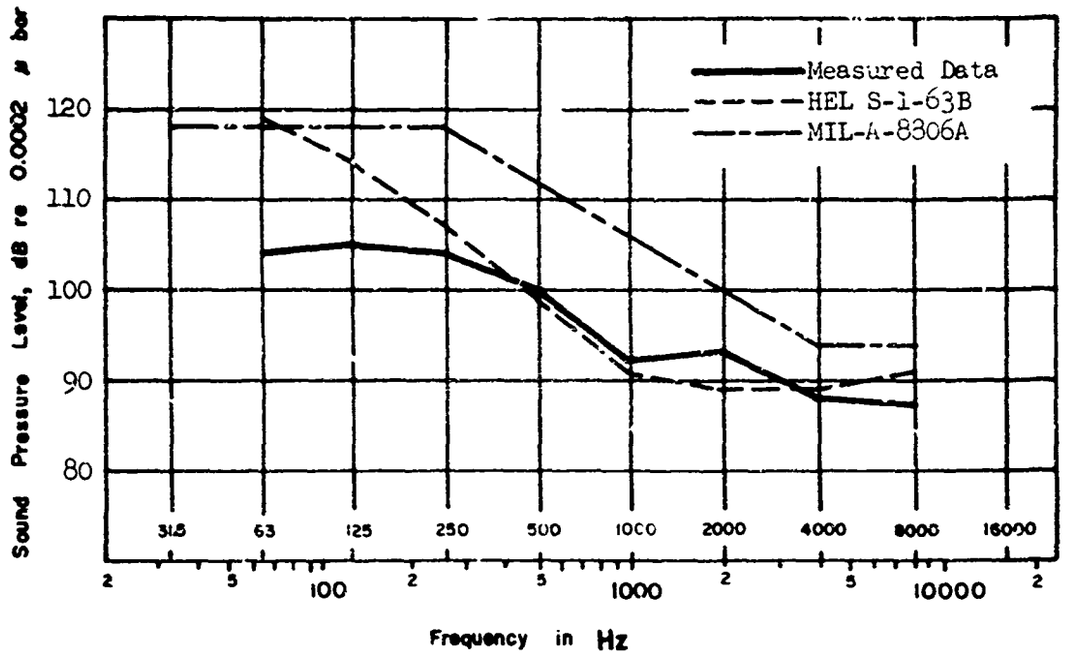


Fig. 47A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 120 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 480.)

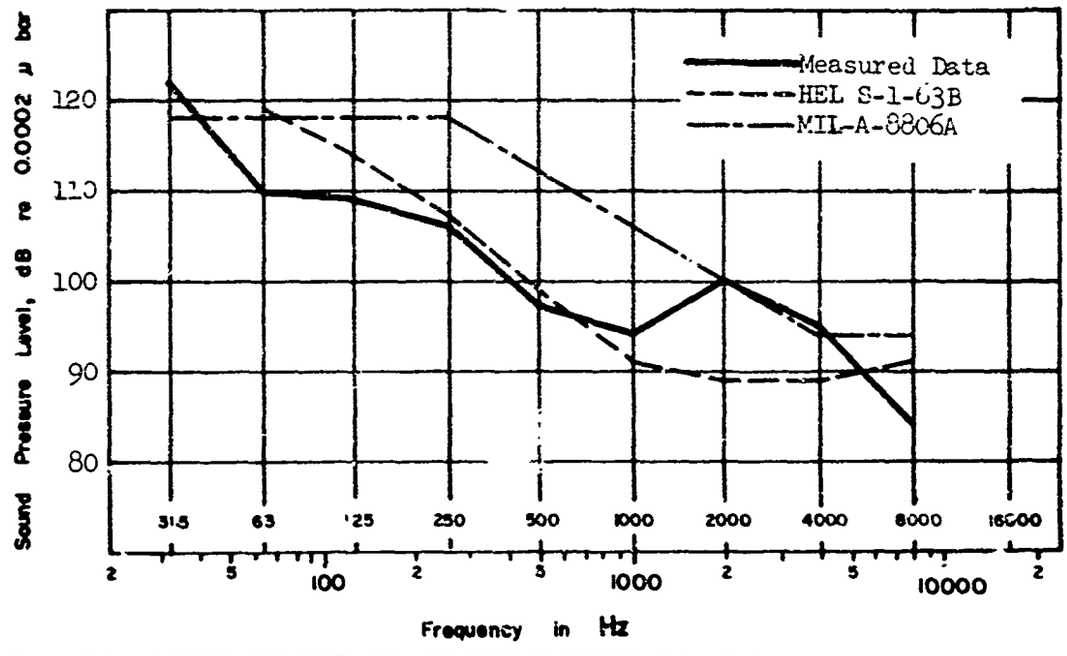


Fig. 48A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 120 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

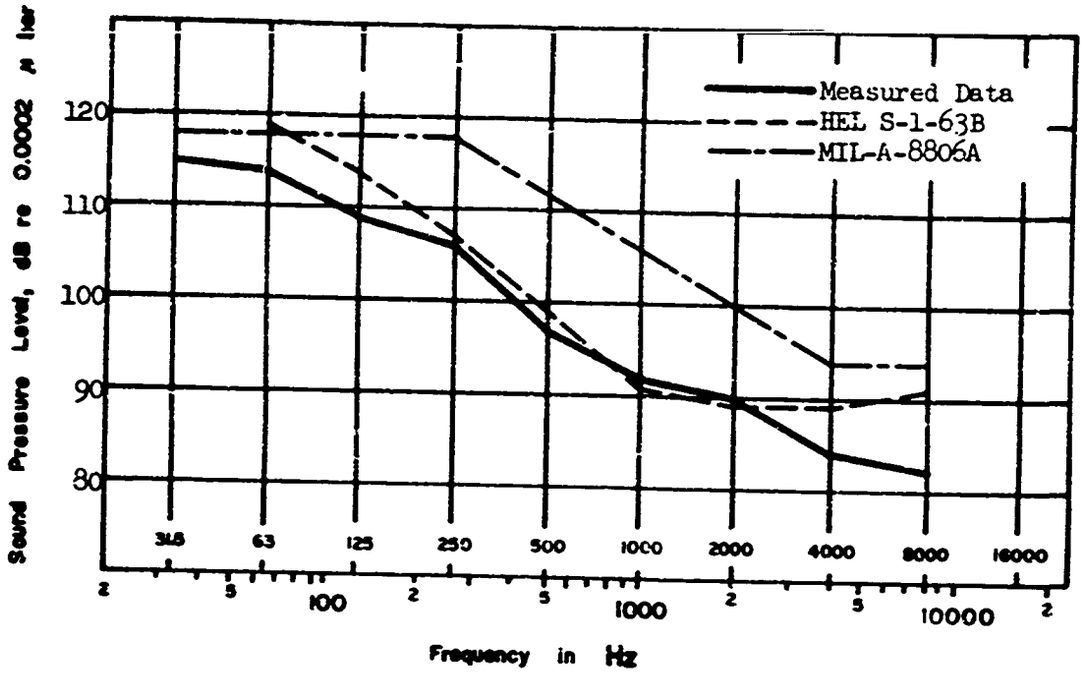


Fig. 49A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 120 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

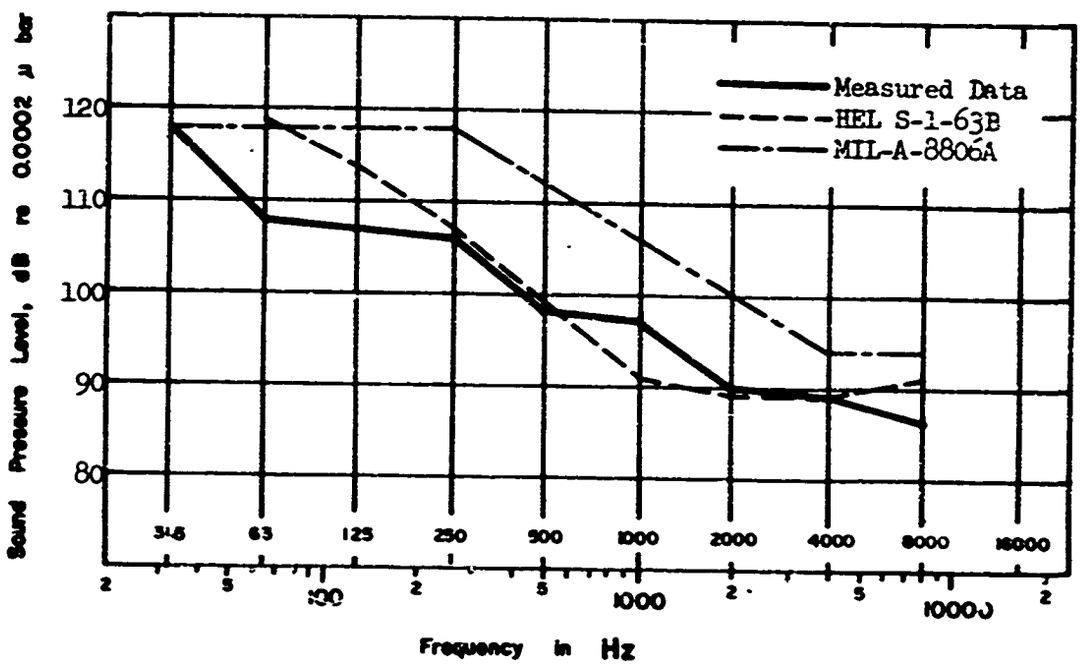


Fig. 50A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 120 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)

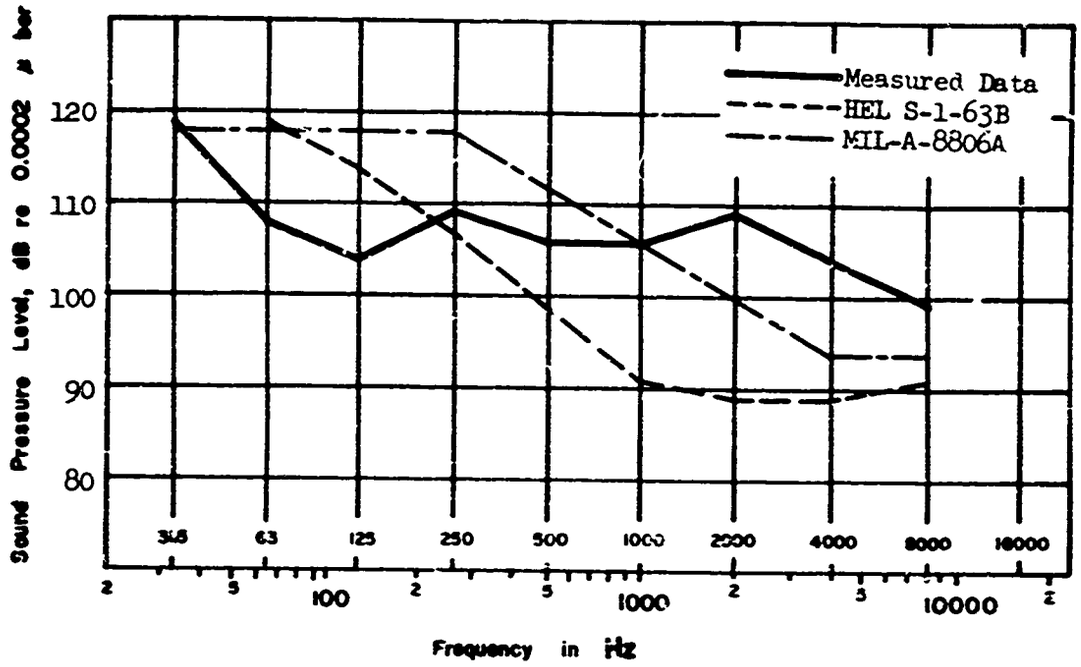


Fig. 51A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 120 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)
(All panels aft of Station 486 removed.)

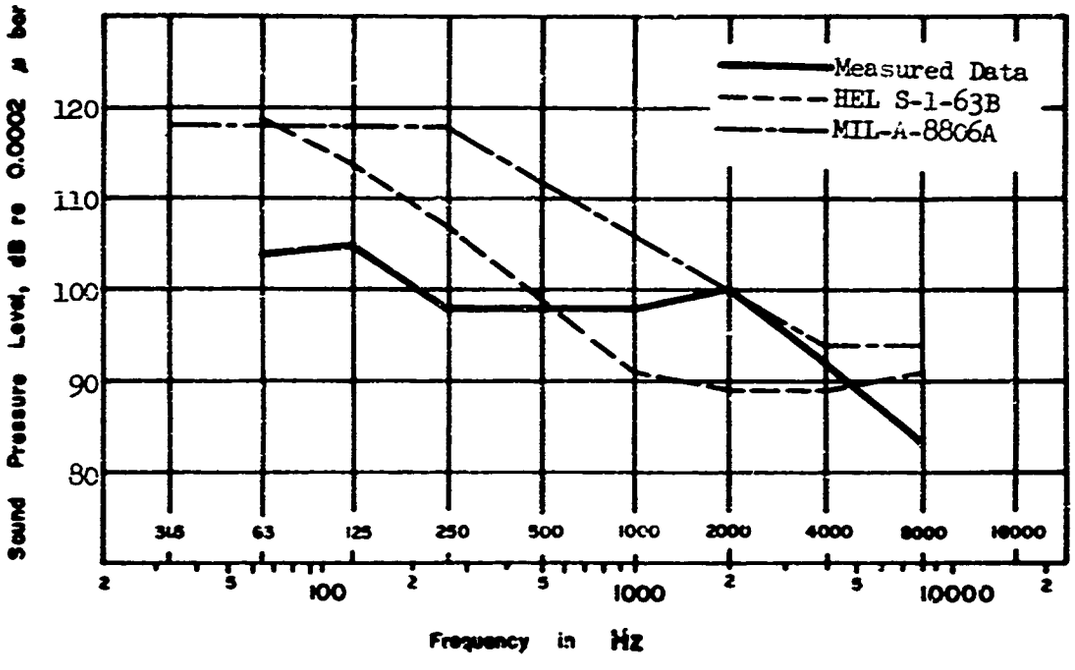


Fig. 52A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 140 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

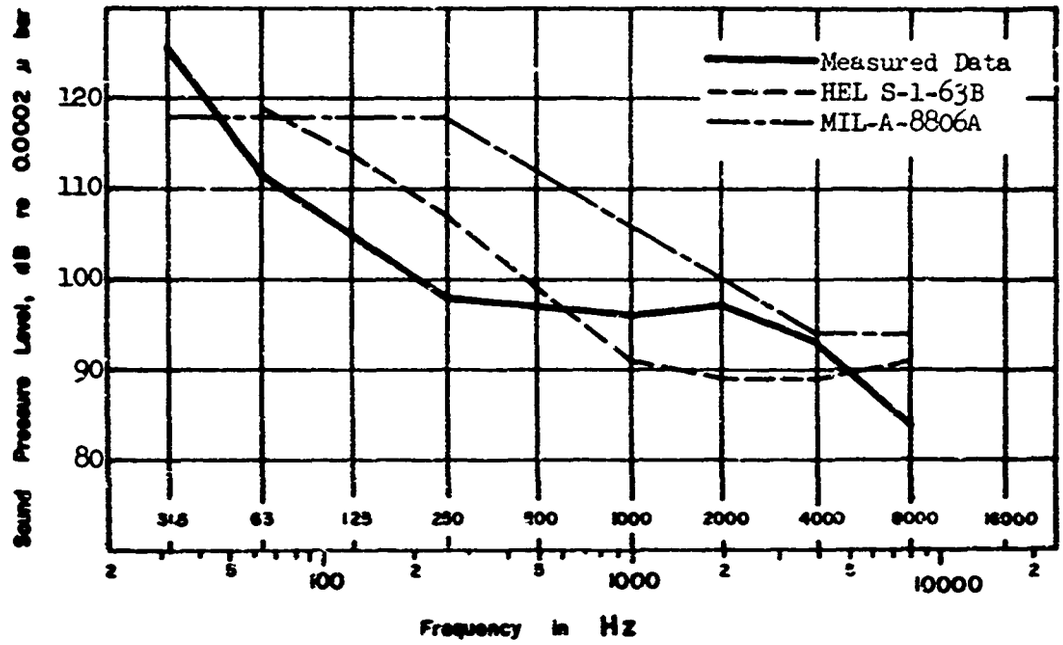


Fig. 53A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 140 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

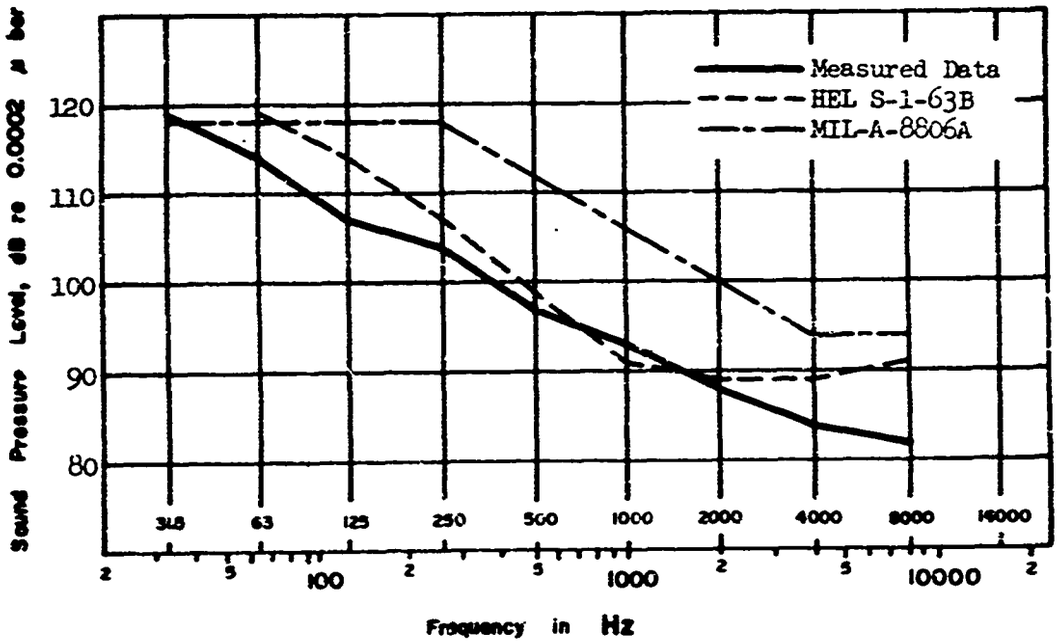


Fig. 54A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 140 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

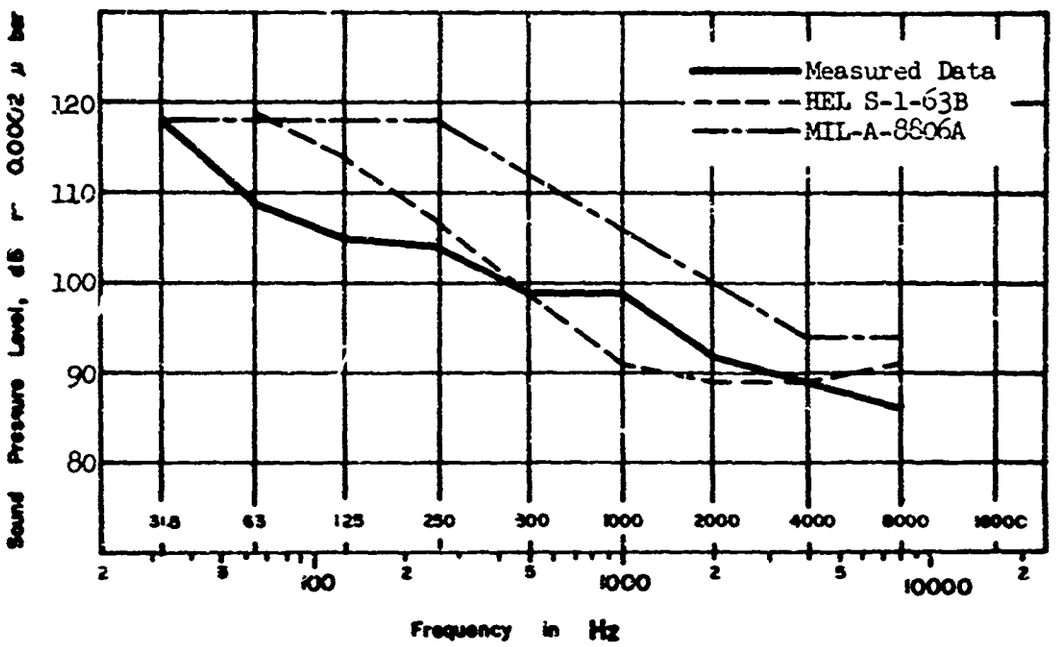


Fig. 55A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 140 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)

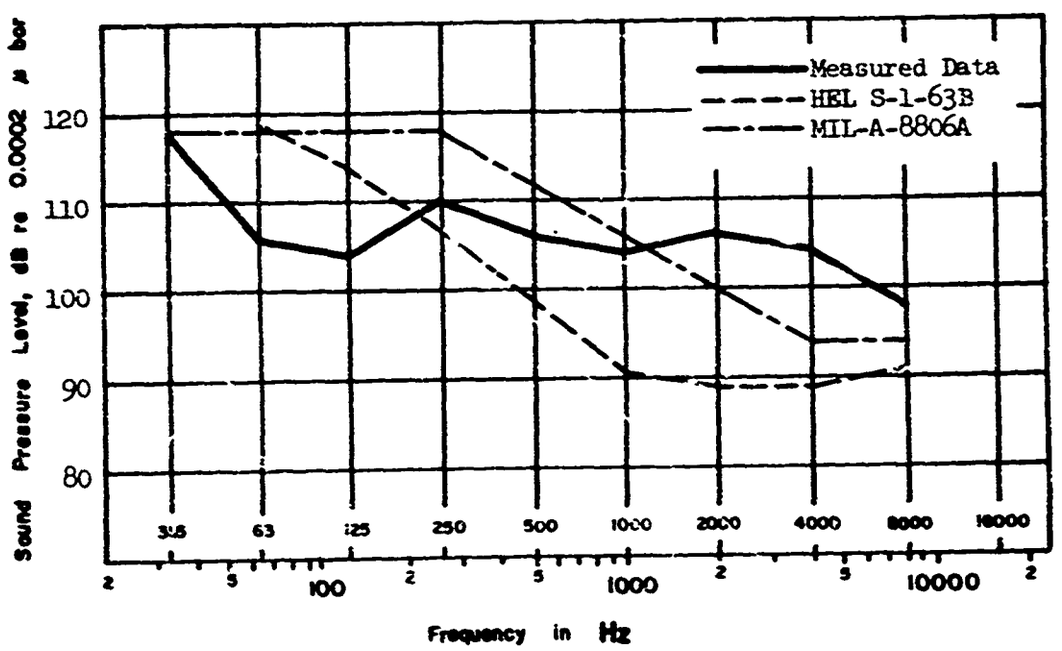


Fig. 56A. NOISE OF THE CH-47B HELICOPTER IN LEVEL FLIGHT AT 140 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 480.)
(All panels aft of Station 486 removed.)

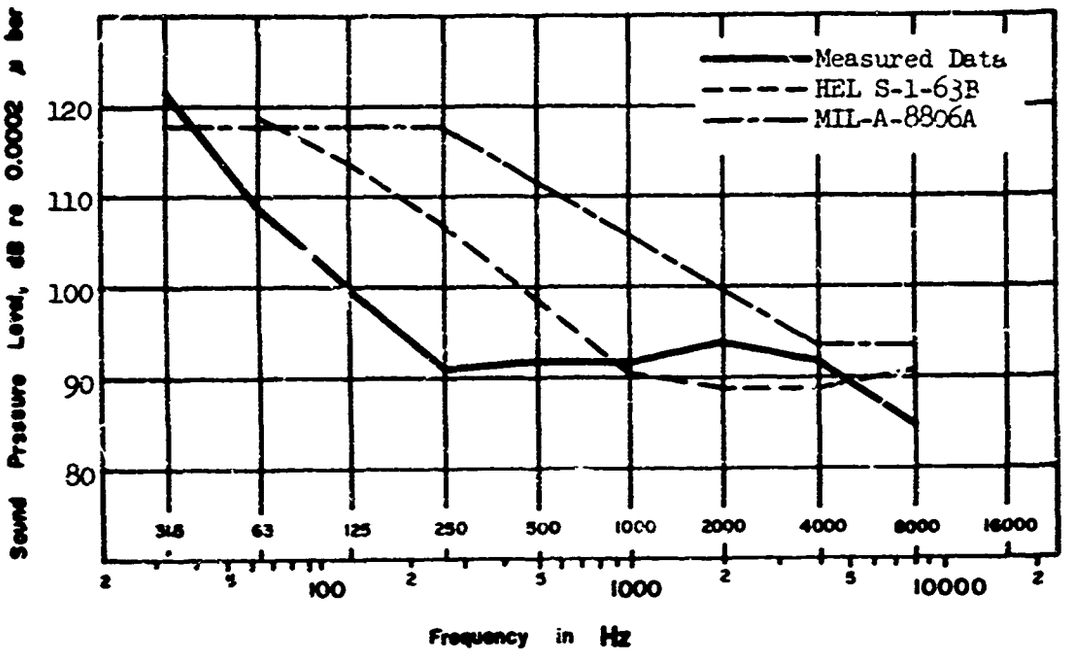


Fig. 57A. NOISE OF THE CH-47B HELICOPTER WHILE HOVERING OUT OF GROUND EFFECT
(Rotor speed is 225 rpm. Measuring position is at Station 95.)

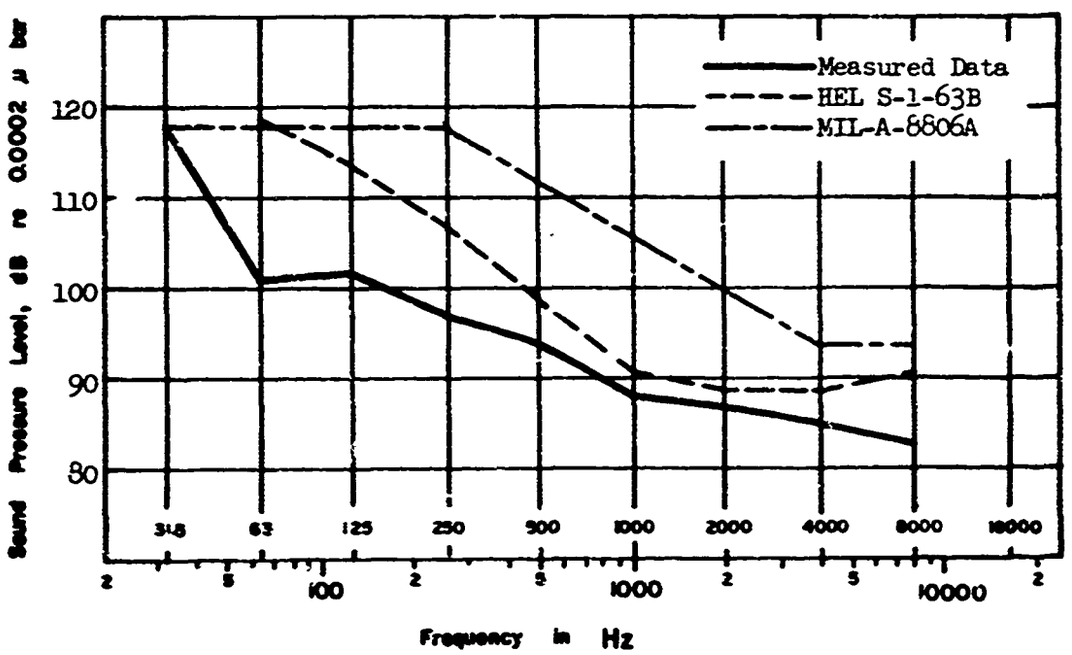


Fig. 58A. NOISE OF THE CH-47B HELICOPTER WHILE HOVERING OUT OF GROUND EFFECT
(Rotor speed is 225 rpm. Measuring position is at Station 320.)

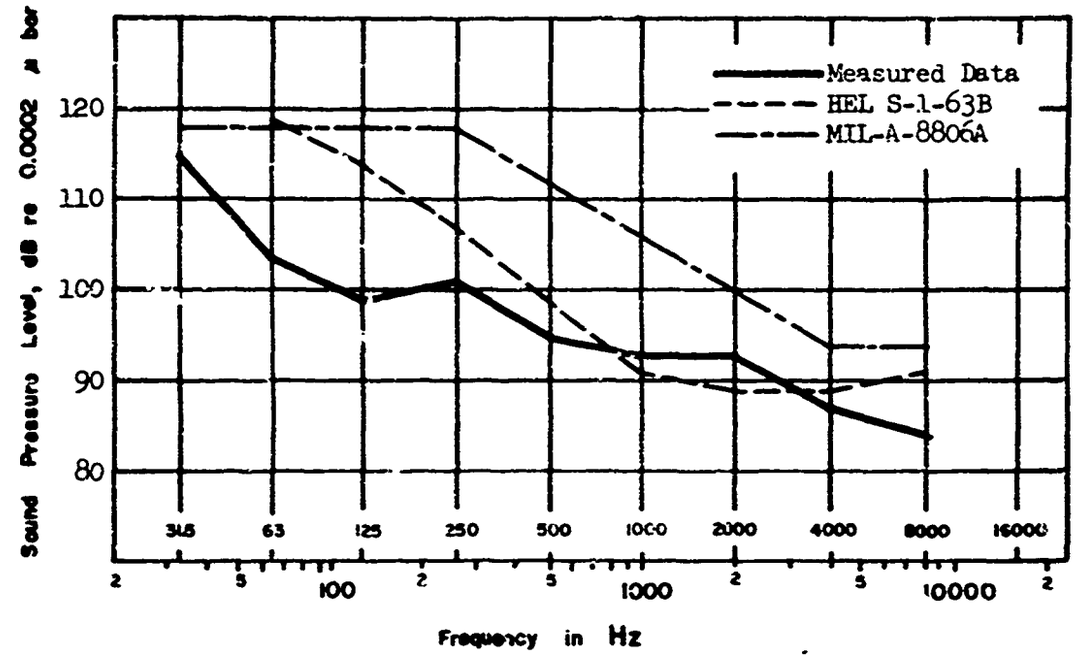


Fig. 59A. NOISE OF THE CH-47B HELICOPTER WHILE HOVERING OUT OF GROUND EFFECT
(Rotor speed is 225 rpm. Measuring position is at Station 480.)

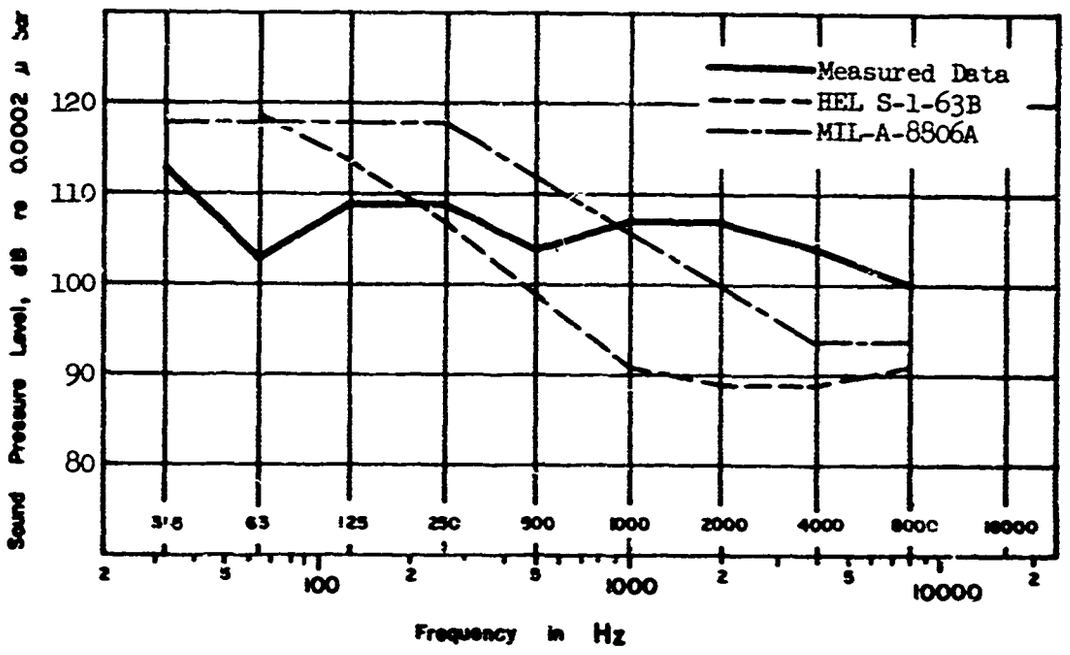


Fig. 60A. NOISE OF THE CH-47B HELICOPTER WHILE HOVERING OUT OF GROUND EFFECT
(Rotor speed is 225 rpm. Measuring position is at Station 480.)
(All panels aft of Station 486 removed.)

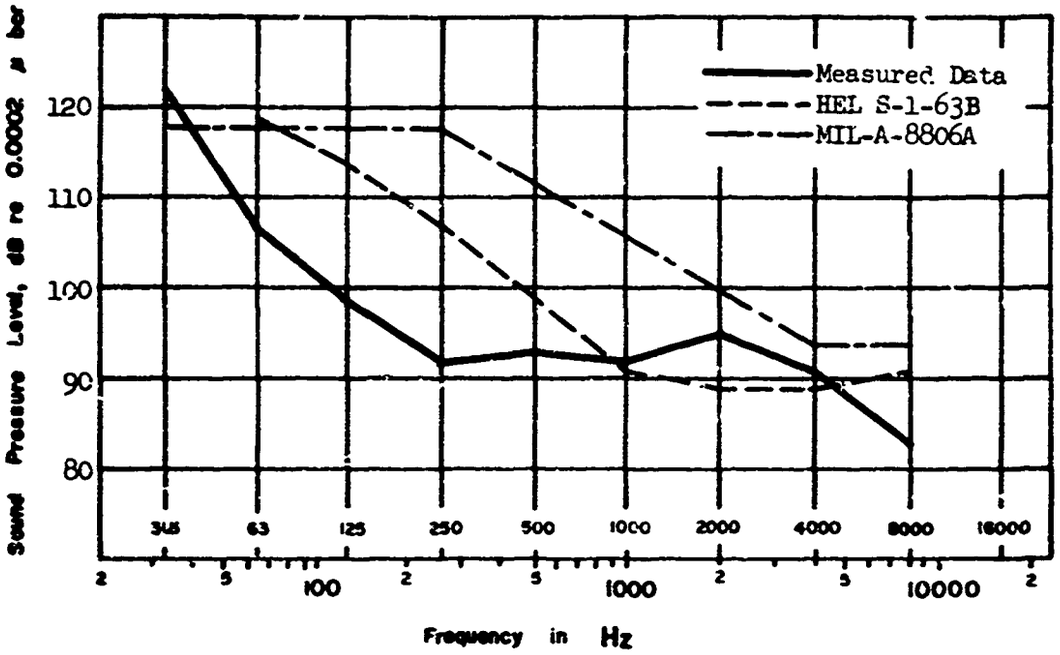


Fig. 61A. NOISE OF THE CH-47B HELICOPTER WHILE HOVERING OUT OF GROUND EFFECT
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

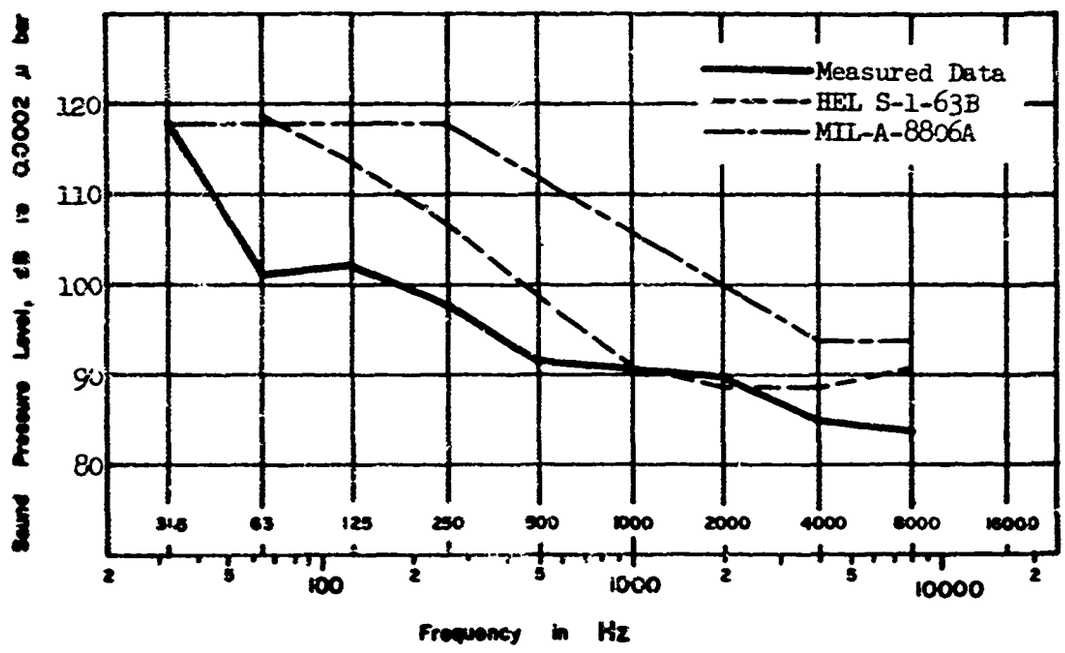


Fig. 62A. NOISE OF THE CH-47B HELICOPTER WHILE HOVERING OUT OF GROUND EFFECT
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

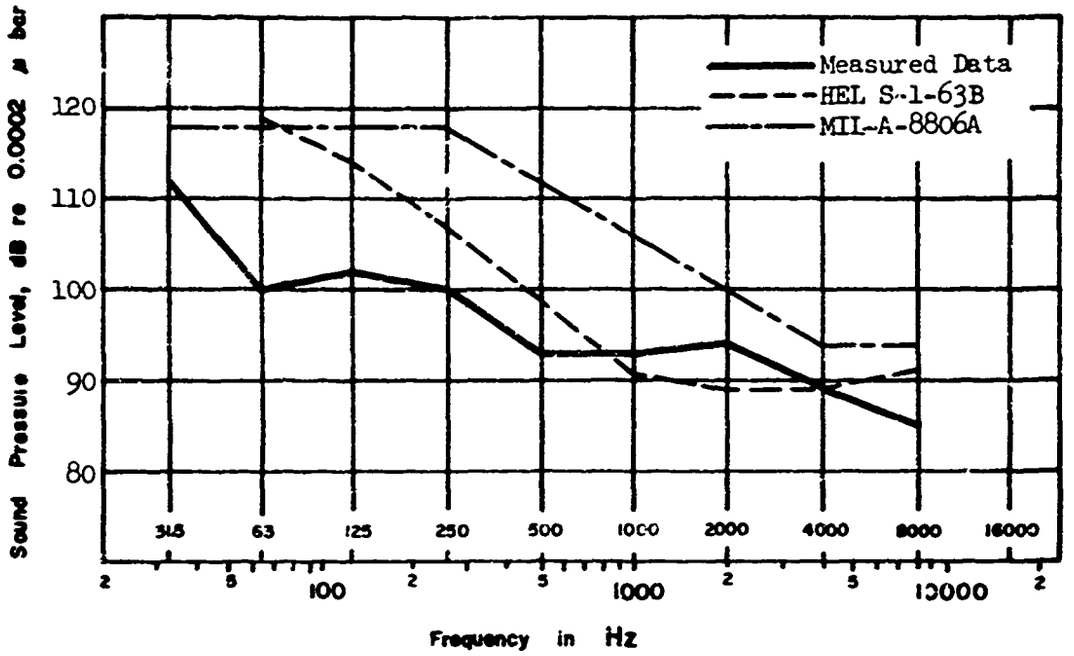


Fig. 63A. NOISE OF THE CH-47B HELICOPTER WHILE HOVERING OUT OF GROUND EFFECT
(Rotor speed is 230 rpm. Measuring position is at Station 480.)

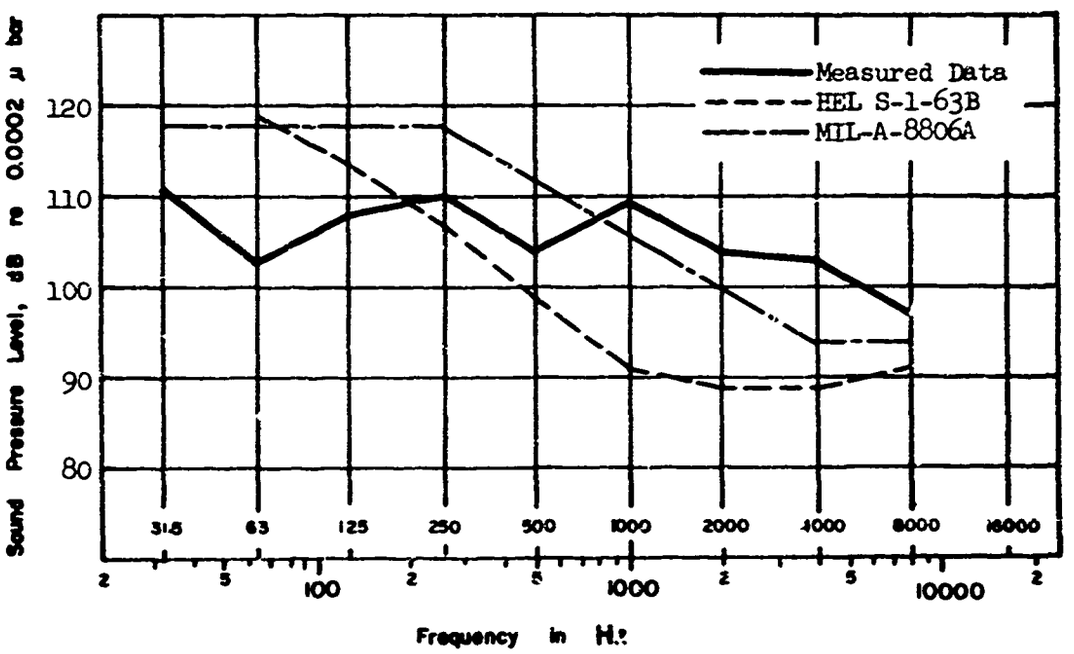


Fig. 64A. NOISE OF THE CH-47B HELICOPTER WHILE HOVERING OUT OF GROUND EFFECT
(Rotor speed is 230 rpm. Measuring position is at Station 480.)
(All panels aft of Station 486 removed.)

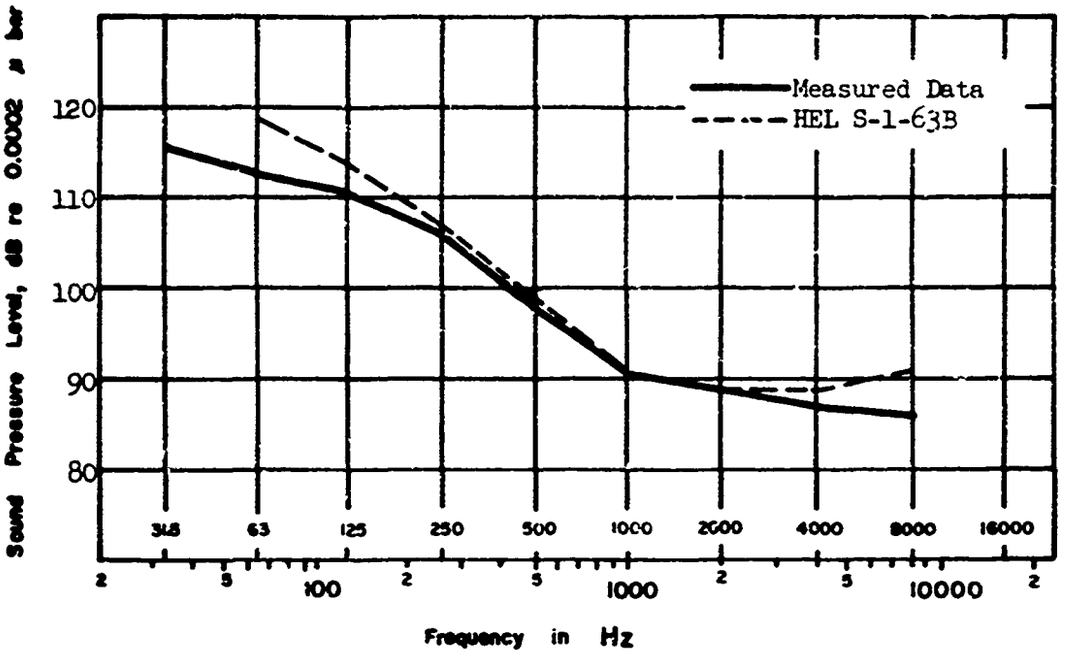


Fig. 65A. NOISE OUTSIDE THE CH-47B HELICOPTER WHILE HOVERING (IN GROUND EFFECT) AT 10 FEET ALTITUDE (Rotor speed is 230 rpm. Measuring position is 20 meters in front of the aircraft; $0^{\circ}$ with the axis.)

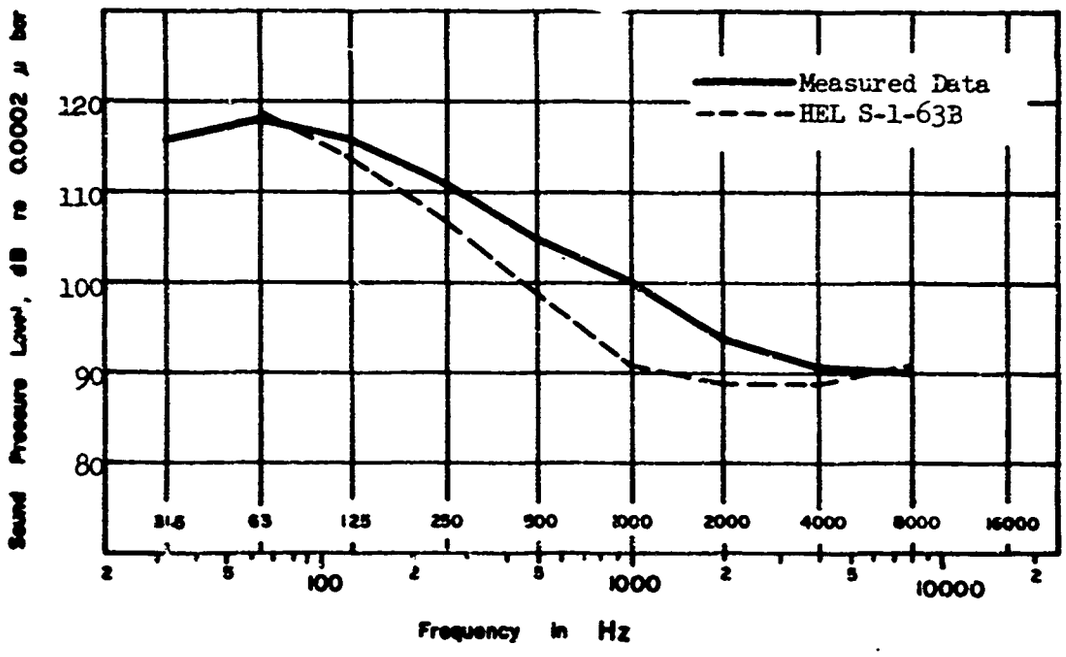


Fig. 66A. NOISE OUTSIDE THE CH-47B HELICOPTER WHILE HOVERING (IN GROUND EFFECT) AT 10 FEET ALTITUDE (Rotor speed is 230 rpm. Measuring position is 20 meters starboard of the aircraft; $90^{\circ}$ with the axis.)

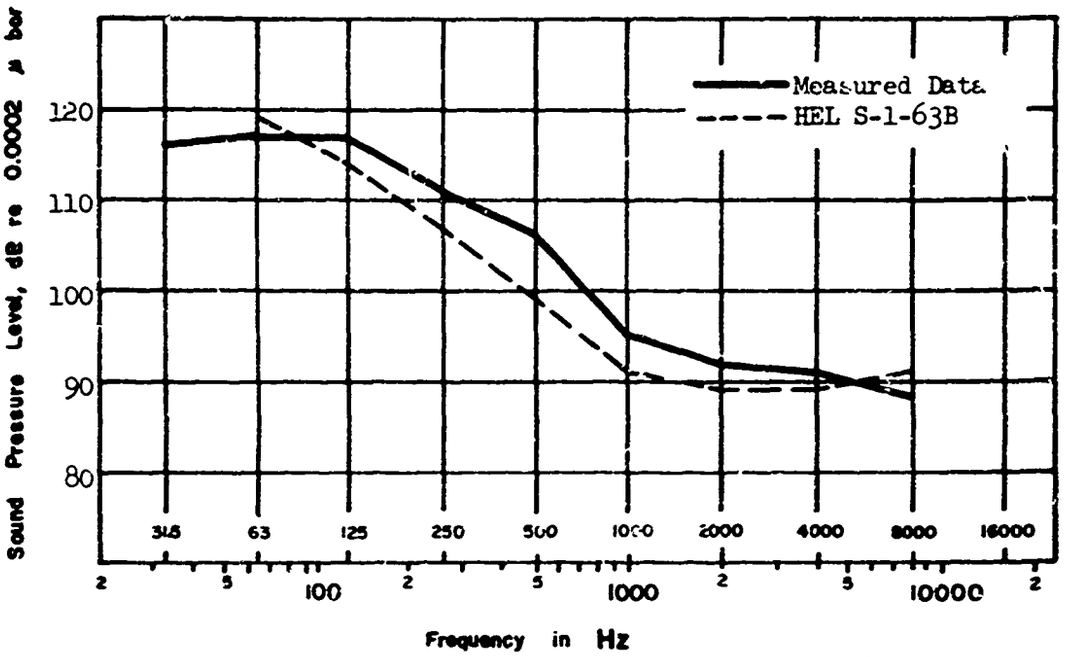


Fig. 67A. NOISE OUTSIDE THE CH-47B HELICOPTER WHILE HOVERING (IN GROUND EFFECT) AT 10 FEET ALTITUDE (Rotor speed is 230 rpm. Measuring position is 20 meters behind the aircraft; $180^{o}$ with the axis.)

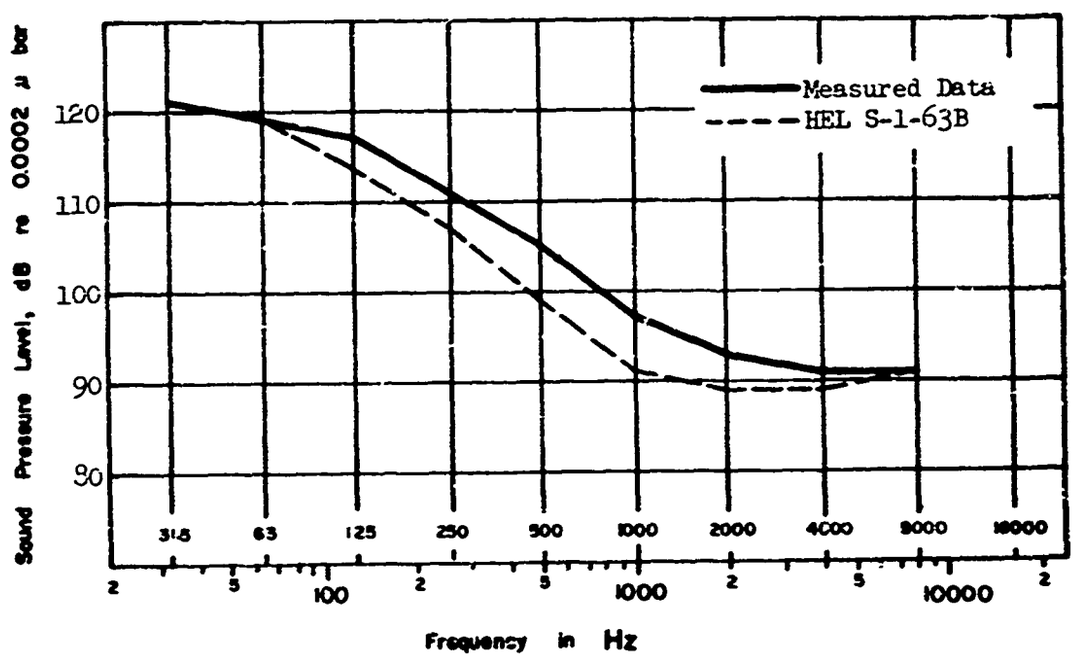


Fig. 68A. NOISE OUTSIDE THE CH-47B HELICOPTER WHILE HOVERING (IN GROUND EFFECT) AT 10 FEET ALTITUDE (Rotor speed is 230 rpm. Measuring position is 20 meters port of the aircraft; $270^{o}$ with the axis.)

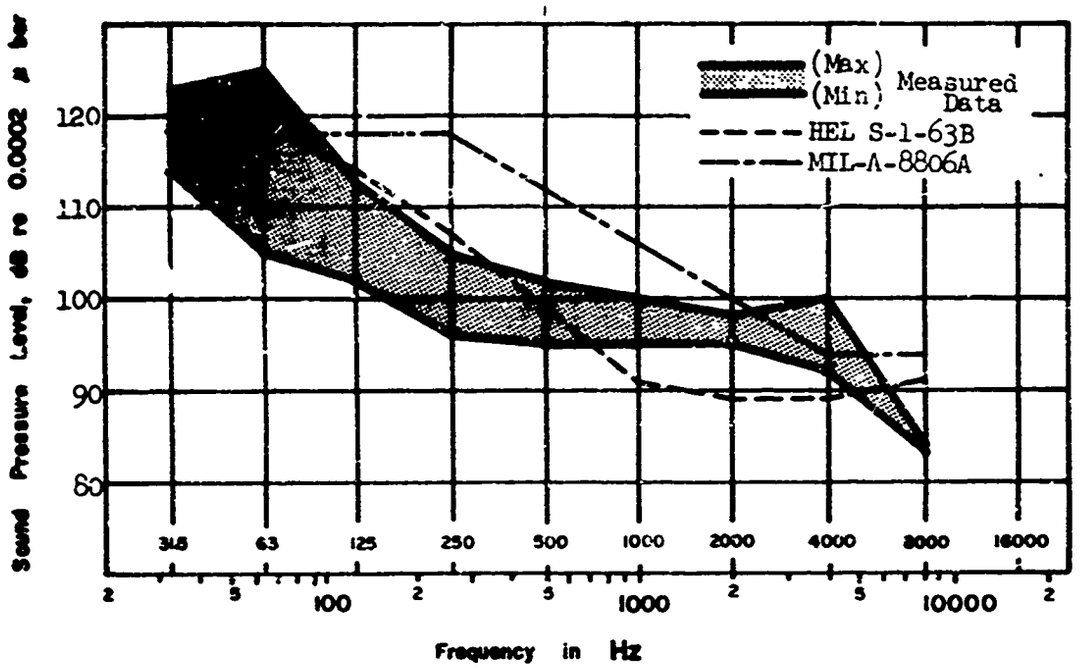


Fig. 69A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A LEVEL ACCELERATION FROM 40 KNOTS TRUE AIR SPEED TO 140 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 95.)

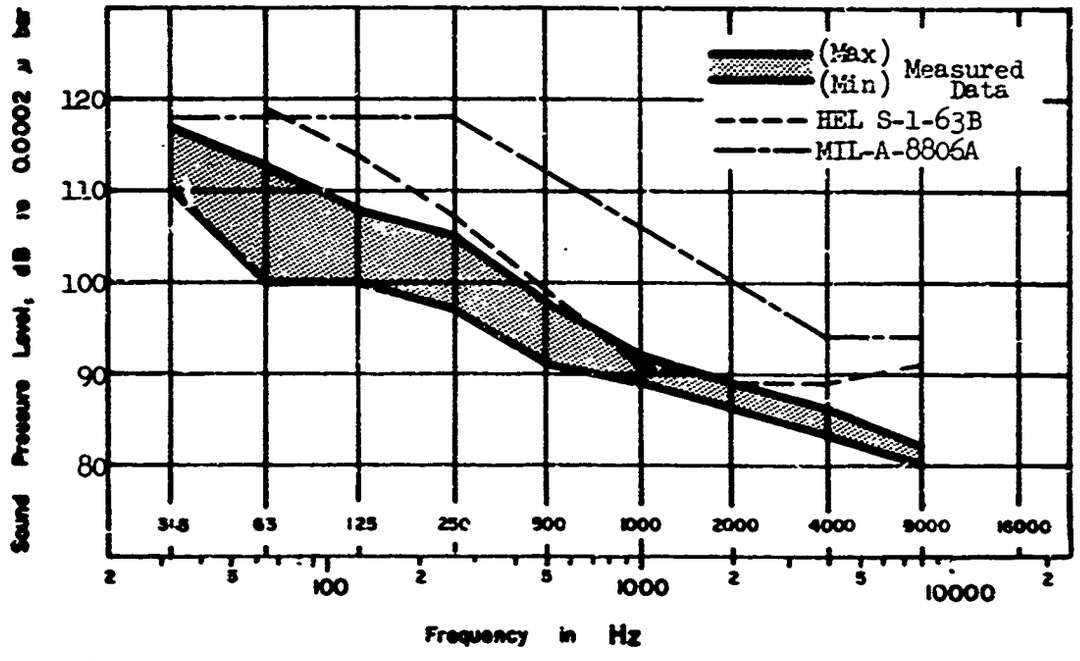


Fig. 70A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A LEVEL ACCELERATION FROM 40 KNOTS TRUE AIR SPEED TO 140 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 320.)

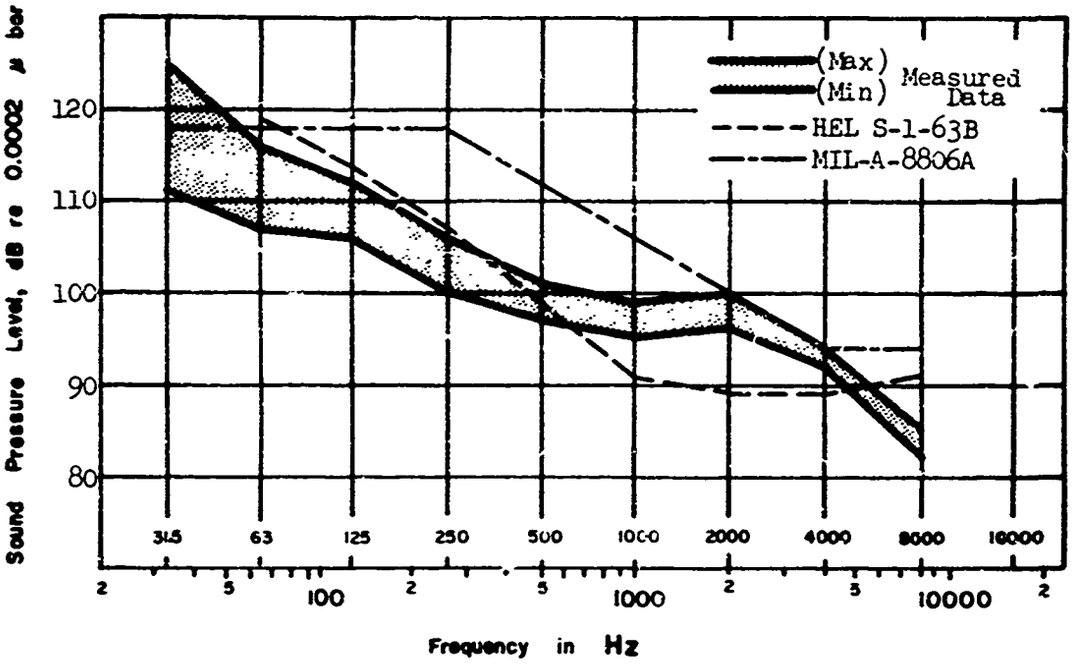


Fig. 71A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A LEVEL ACCELERATION FROM 40 KNOTS TRUE AIR SPEED TO 140 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

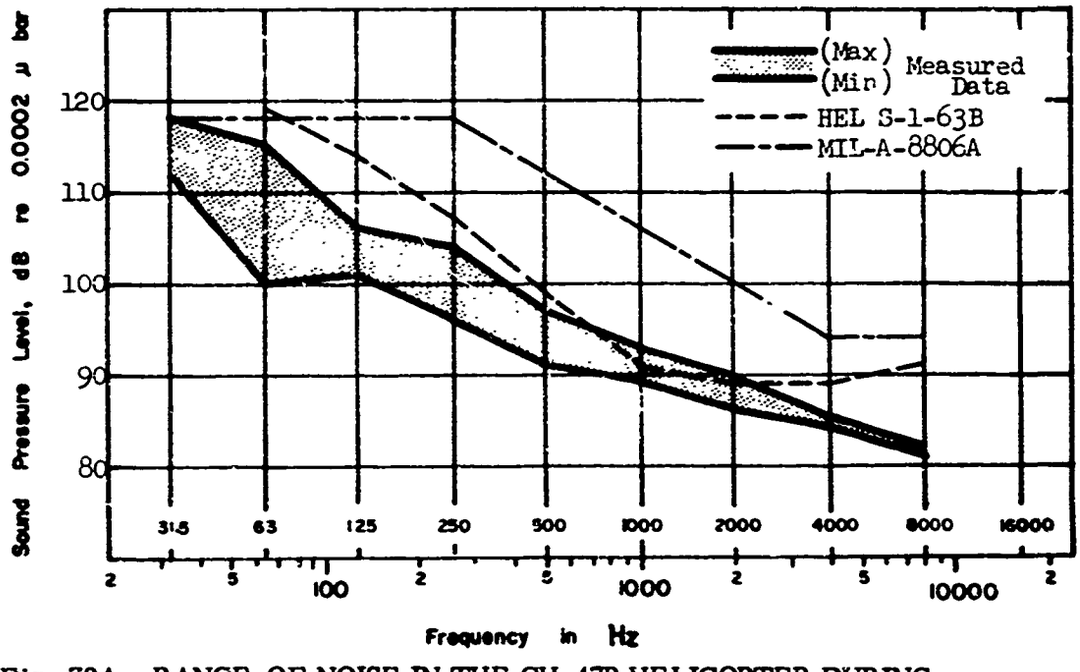


Fig. 72A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A LEVEL ACCELERATION FROM 40 KNOTS TRUE AIR SPEED TO 140 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

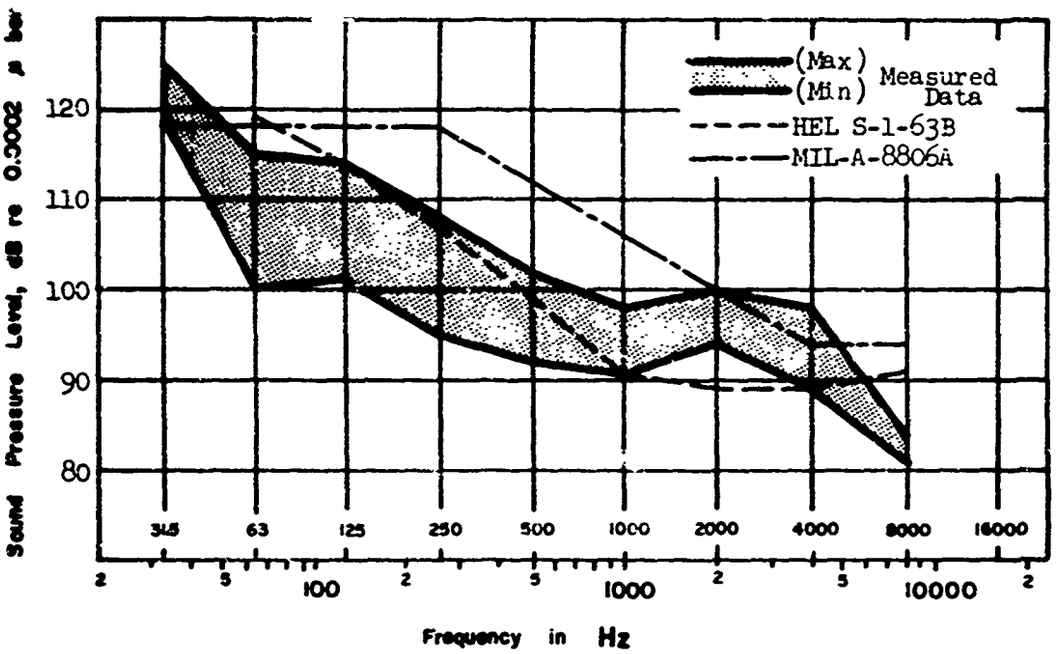


Fig. 73A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A LEVEL DECELERATION FROM 140 KNOTS TRUE AIR SPEED TO 40 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 95.)

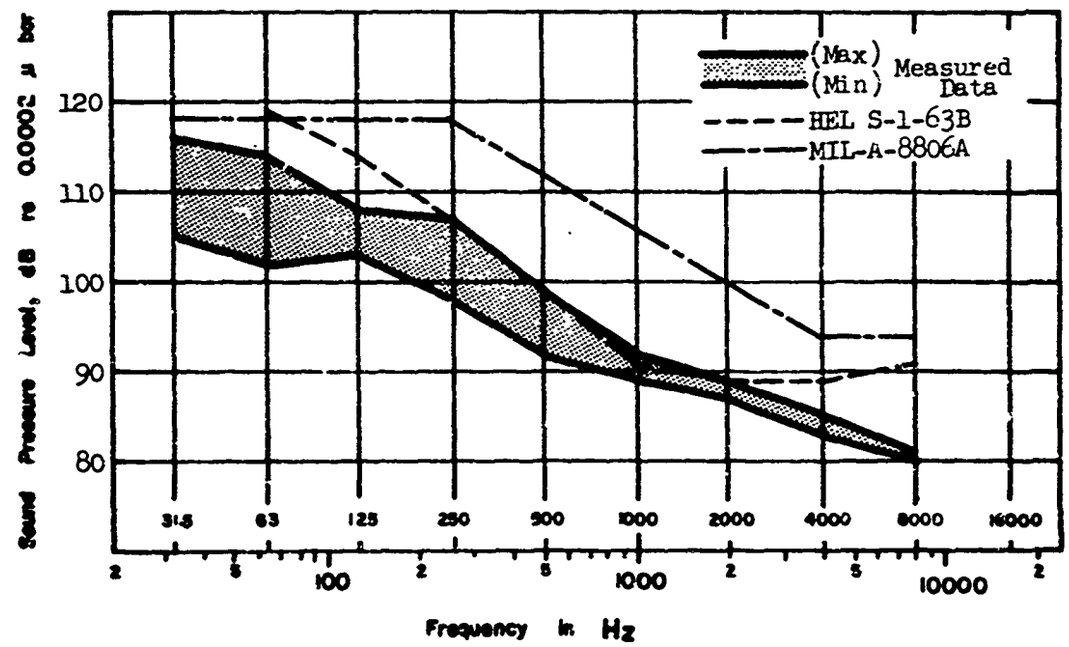


Fig. 74A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A LEVEL DECELERATION FROM 140 KNOTS TRUE AIR SPEED TO 40 KNOTS TRUE AIR SPEED
(Rotor speed is 225 rpm. Measuring position is at Station 320.)

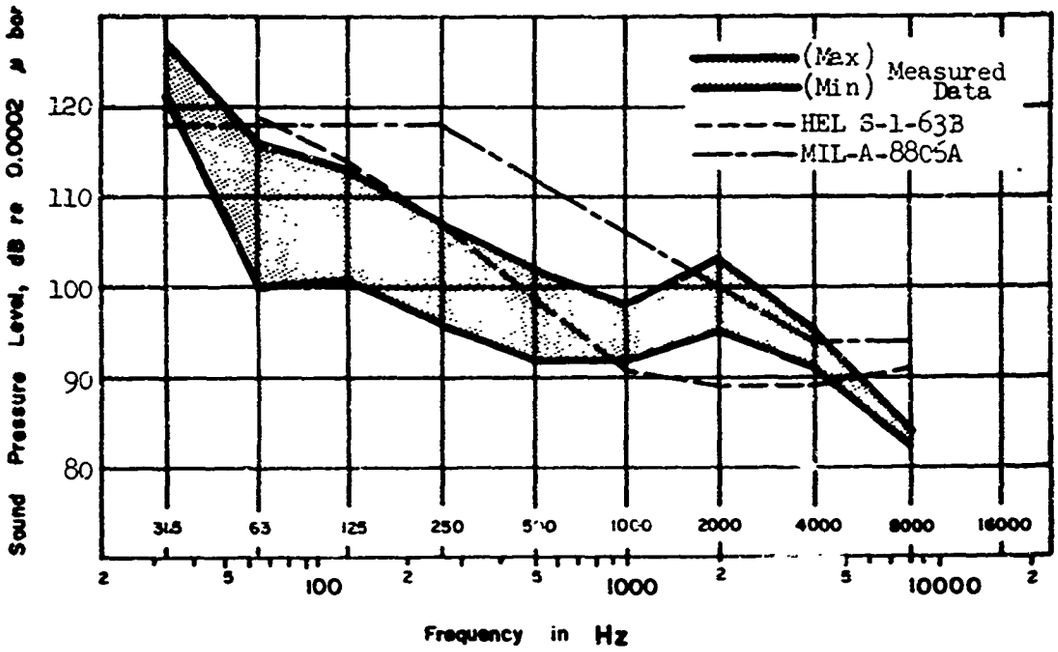


Fig. 75A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A LEVEL DECELERATION FROM 140 KNOTS TRUE AIR SPEED TO 40 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

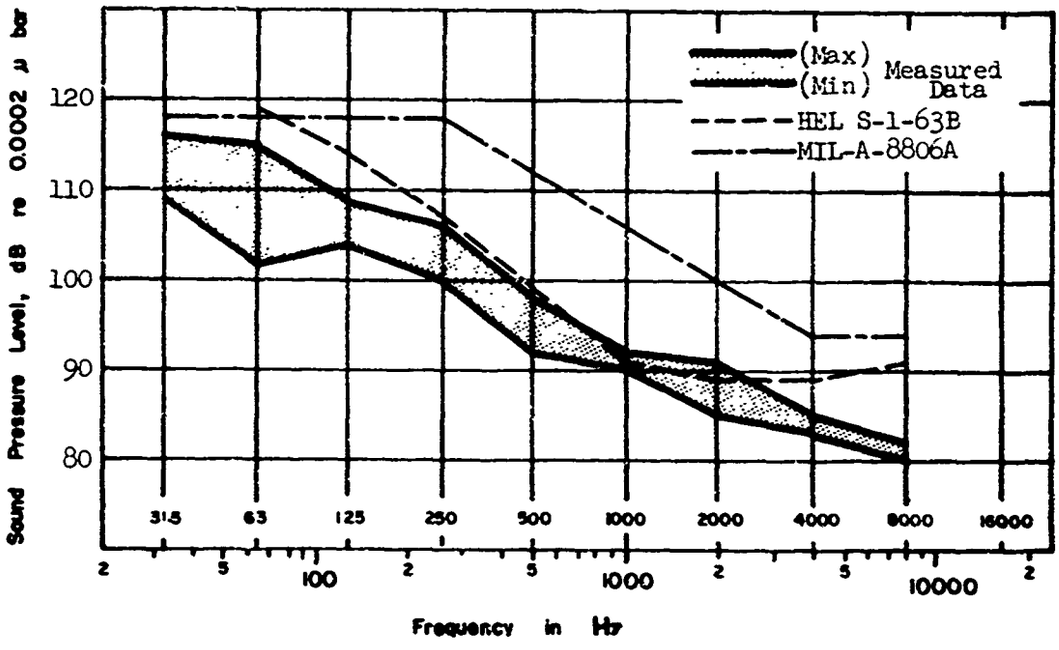


Fig. 76A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A LEVEL DECELERATION FROM 140 KNOTS TRUE AIR SPEED TO 40 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

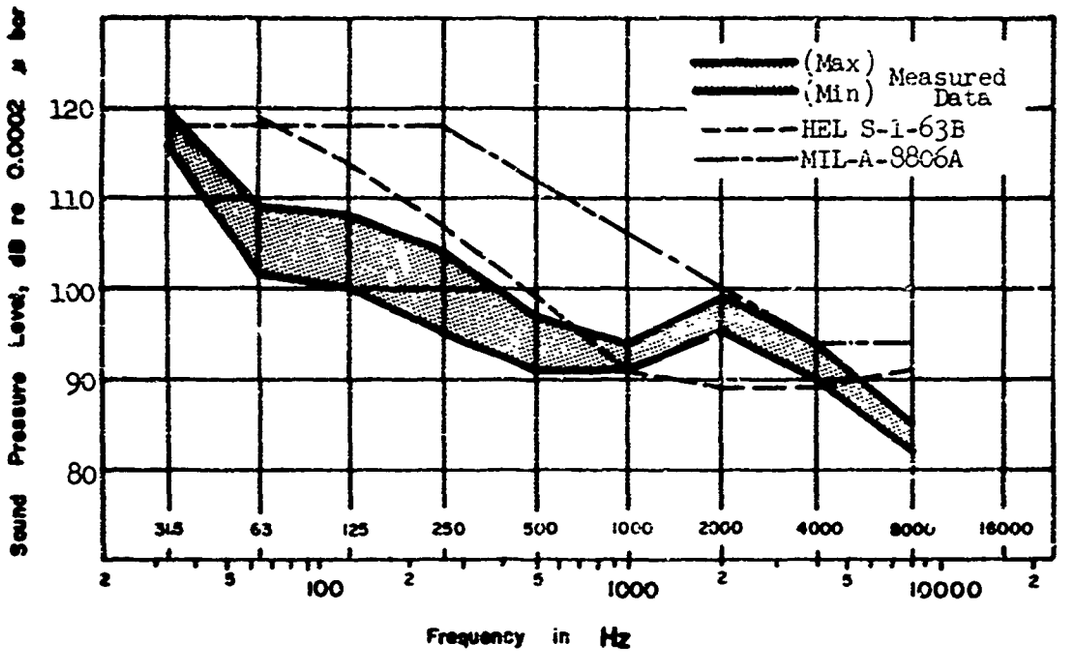


Fig. 77A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A PARTIAL POWER DESCENT OF 500 FEET PER MINUTE AT 60 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

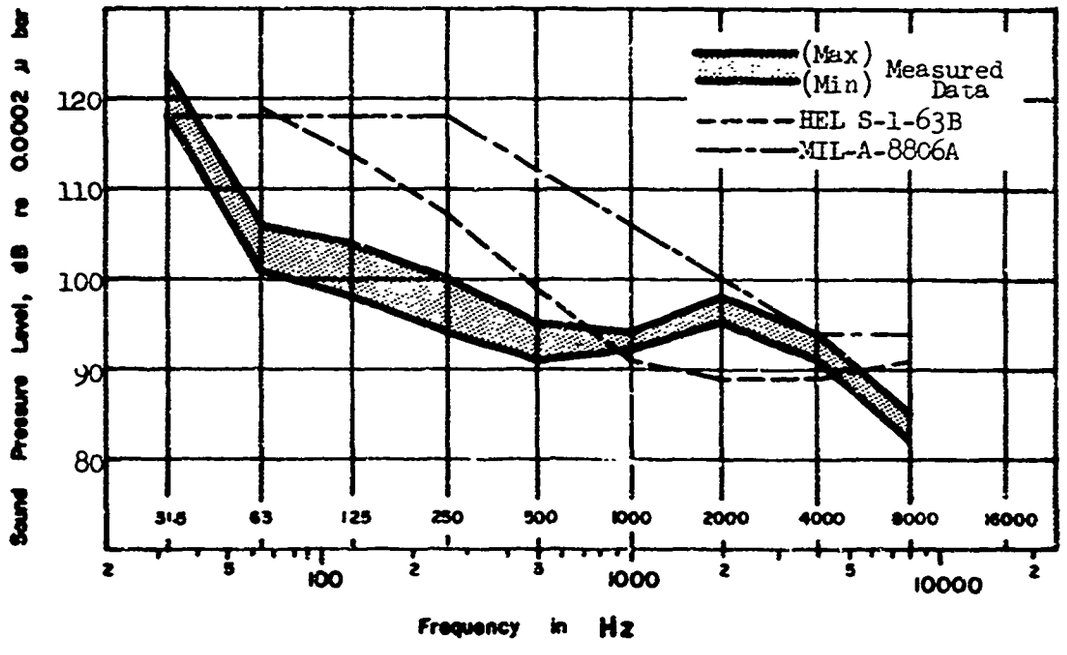


Fig. 78A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A PARTIAL POWER DESCENT OF 1000 FEET PER MINUTE AT 60 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

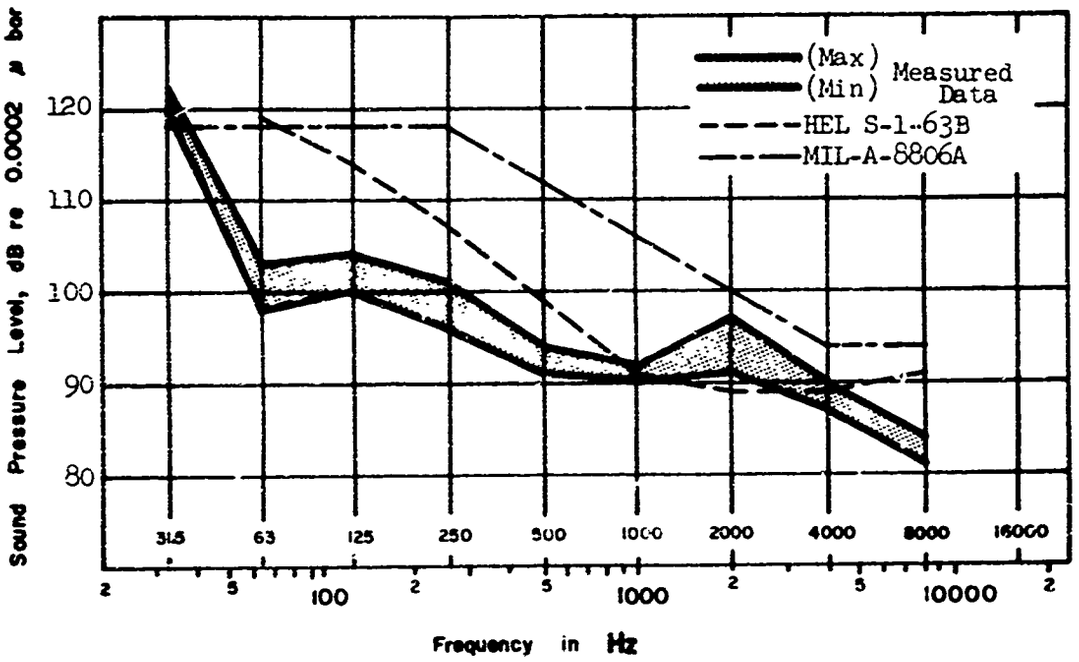


Fig. 79A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A PARTIAL POWER DESCENT OF 1500 FEET PER MINUTE AT 60 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

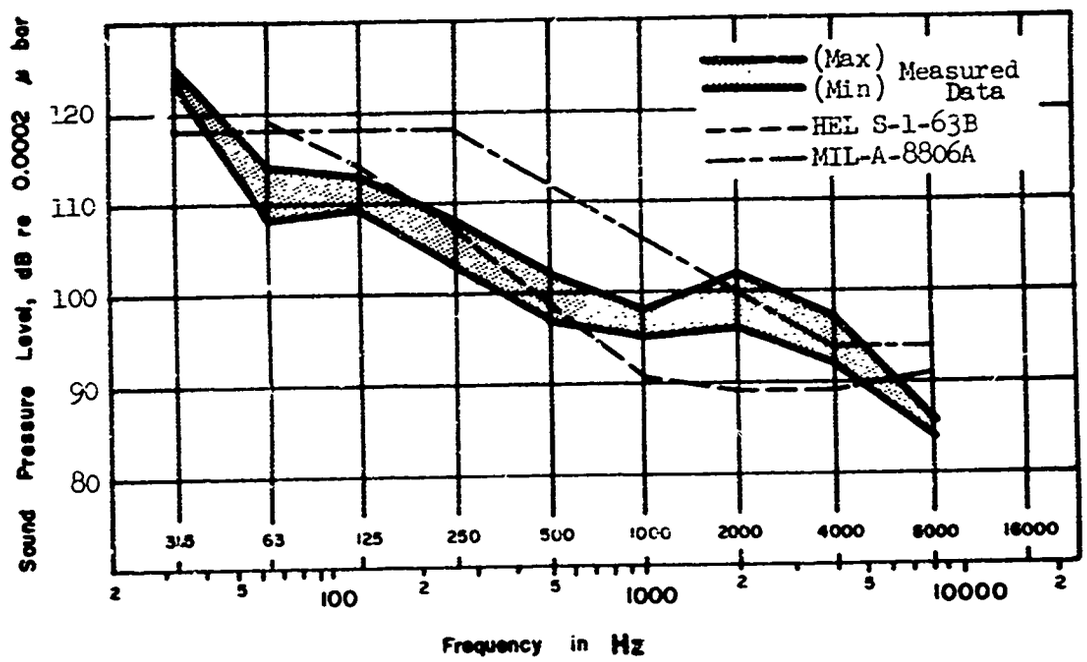


Fig. 80A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A PARTIAL POWER DESCENT OF 500 FEET PER MINUTE AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

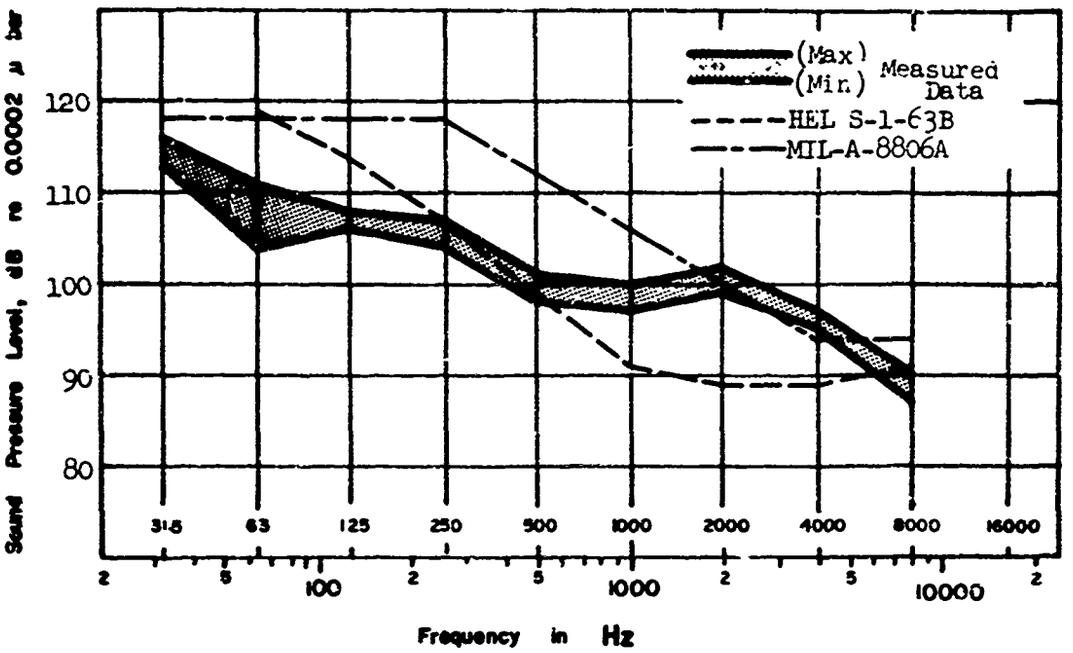


Fig. 81A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A PARTIAL POWER DESCENT OF 500 FEET PER MINUTE AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

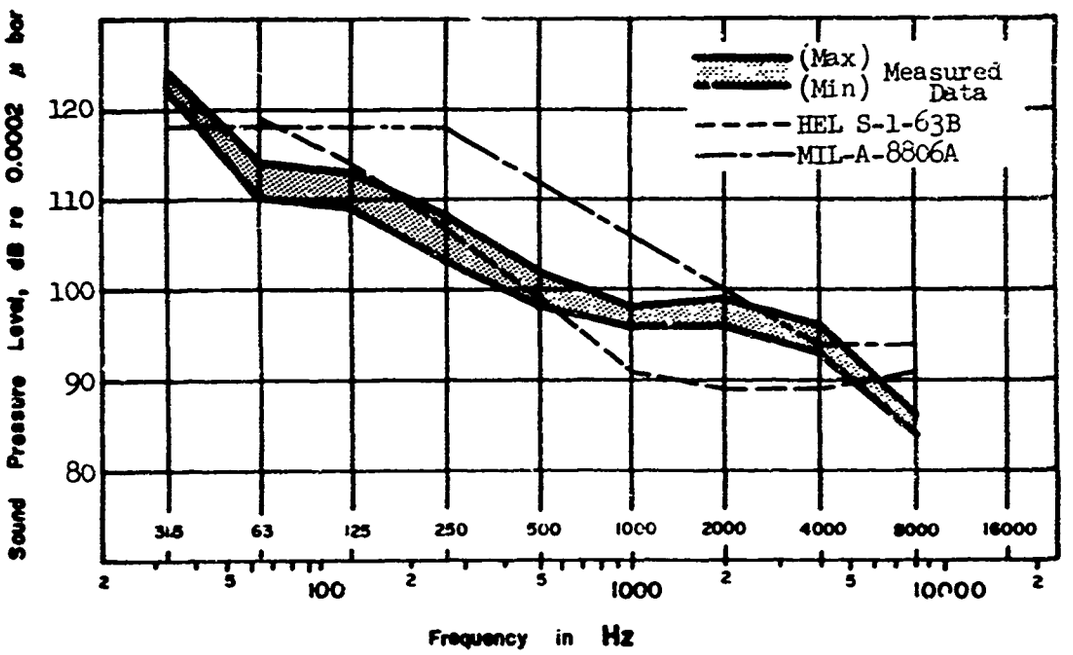


Fig. 82A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A PARTIAL POWER DESCENT OF 1000 FEET PER MINUTE AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

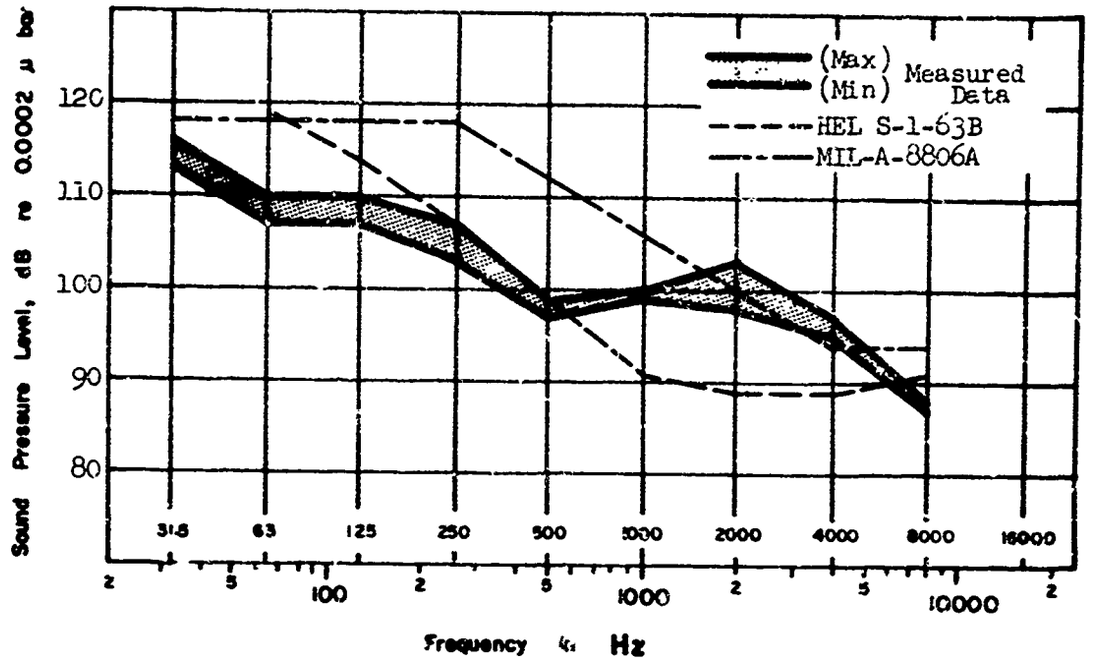


Fig. 83A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A PARTIAL POWER DESCENT OF 1000 FEET PER MINUTE AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

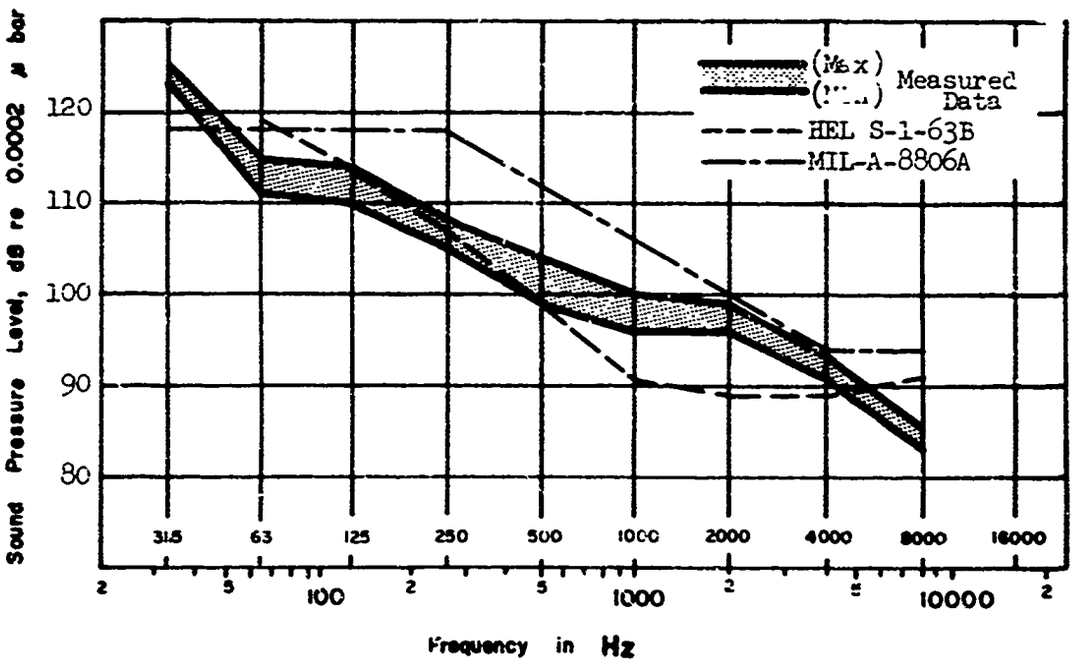


Fig. 84A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A PARTIAL POWER DESCENT OF 1500 FEET PER MINUTE AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 95.)

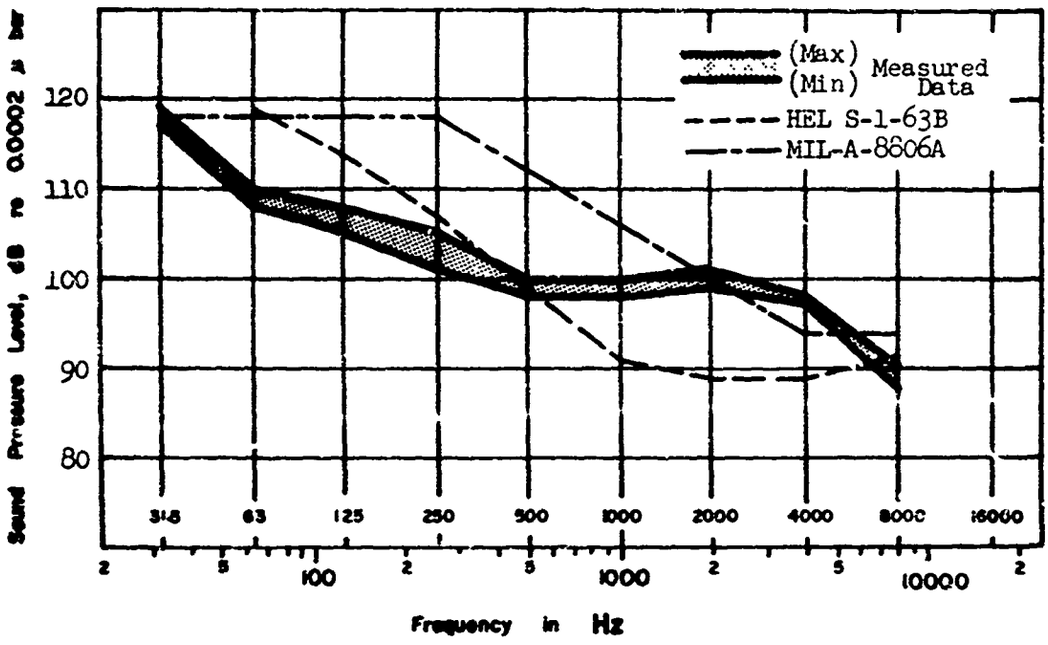


Fig. 85A. RANGE OF NOISE IN THE CH-47B HELICOPTER DURING A PARTIAL POWER DESCENT OF 1500 FEET PER MINUTE AT 100 KNOTS TRUE AIR SPEED
(Rotor speed is 230 rpm. Measuring position is at Station 320.)

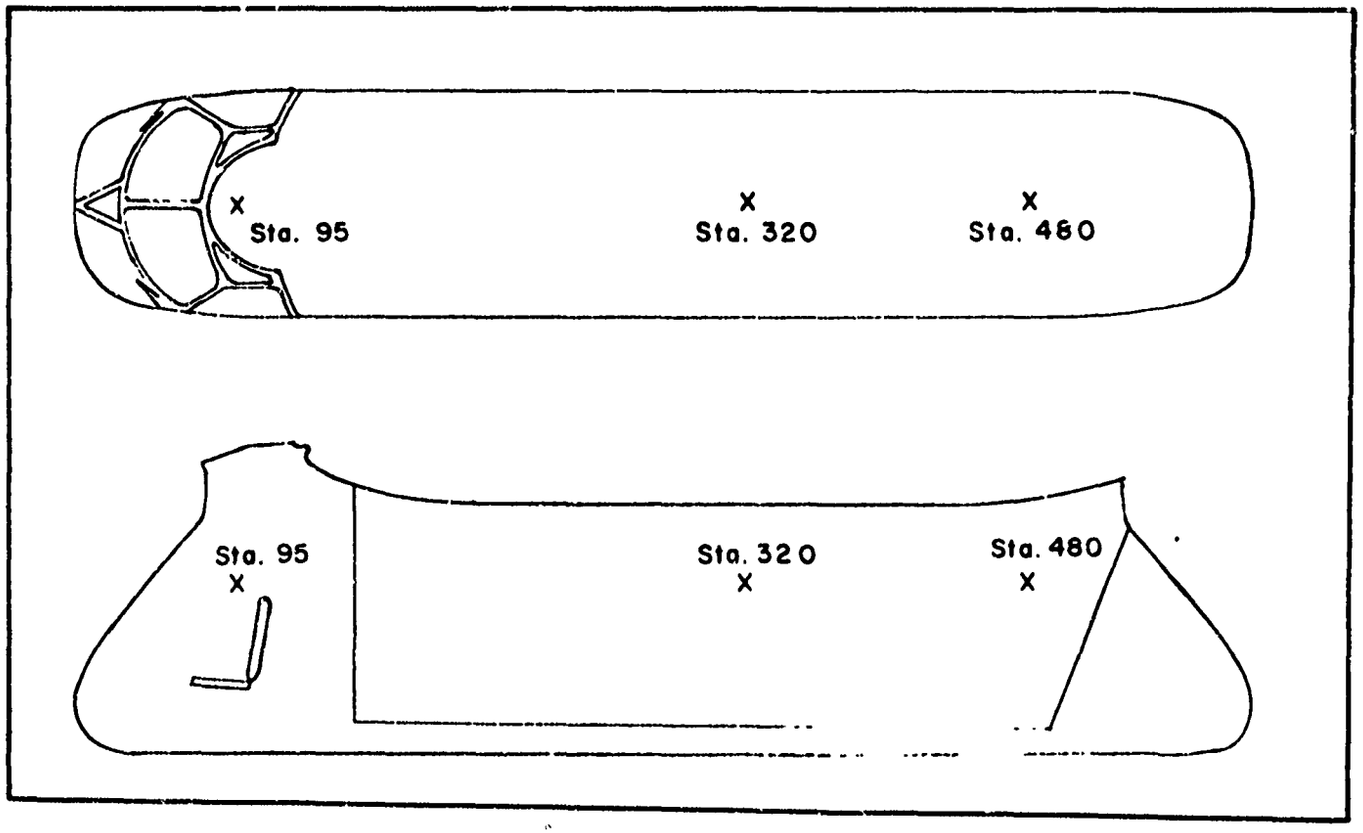


Fig. 86A. MICROPHONE POSITIONS USED TO OBTAIN DATA INSIDE THE CH-47B HELICOPTER

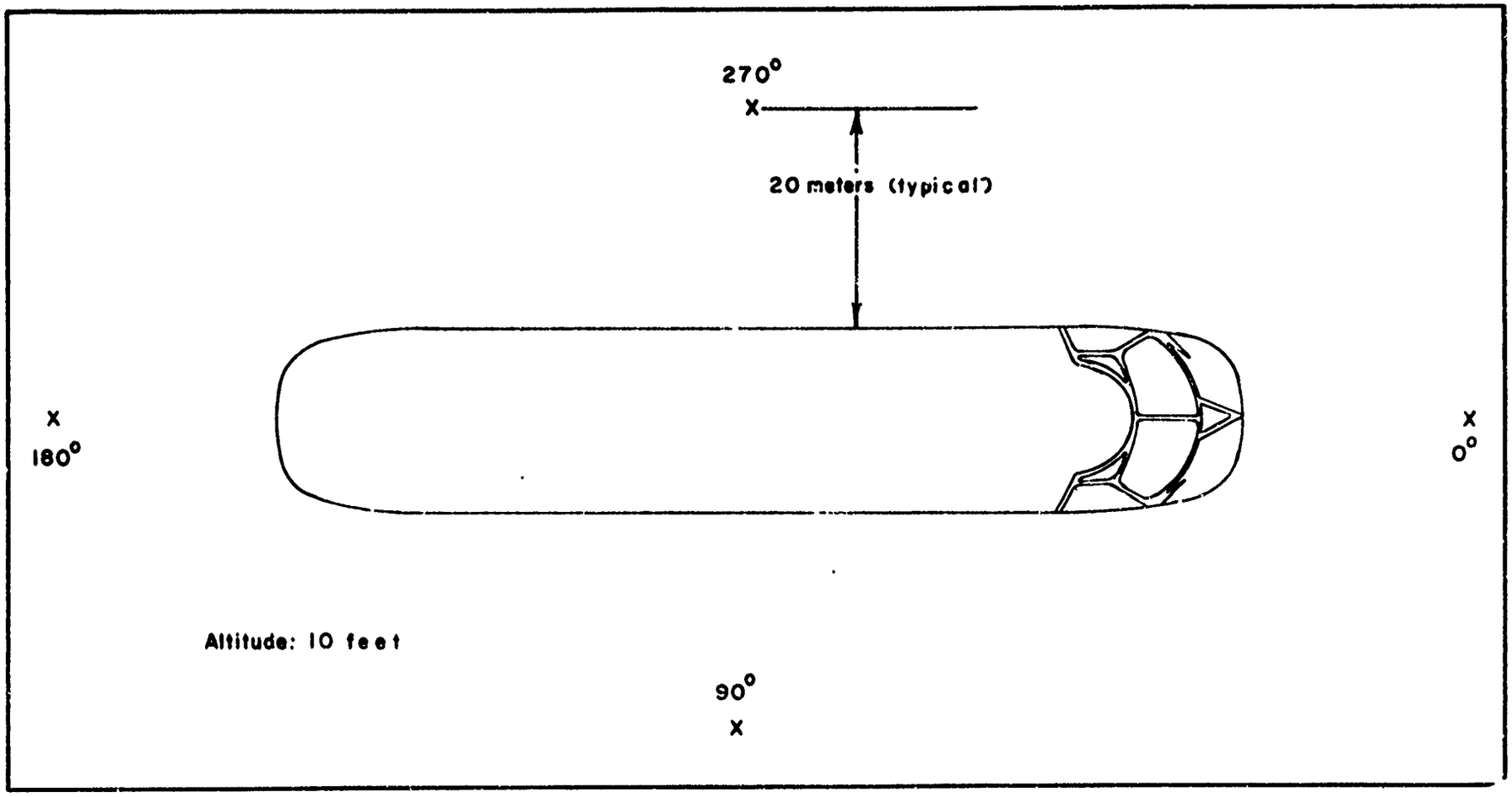


Fig. 87A. MICROPHONE POSITIONS USED TO OBTAIN DATA OUTSIDE THE CH-47B HELICOPTER

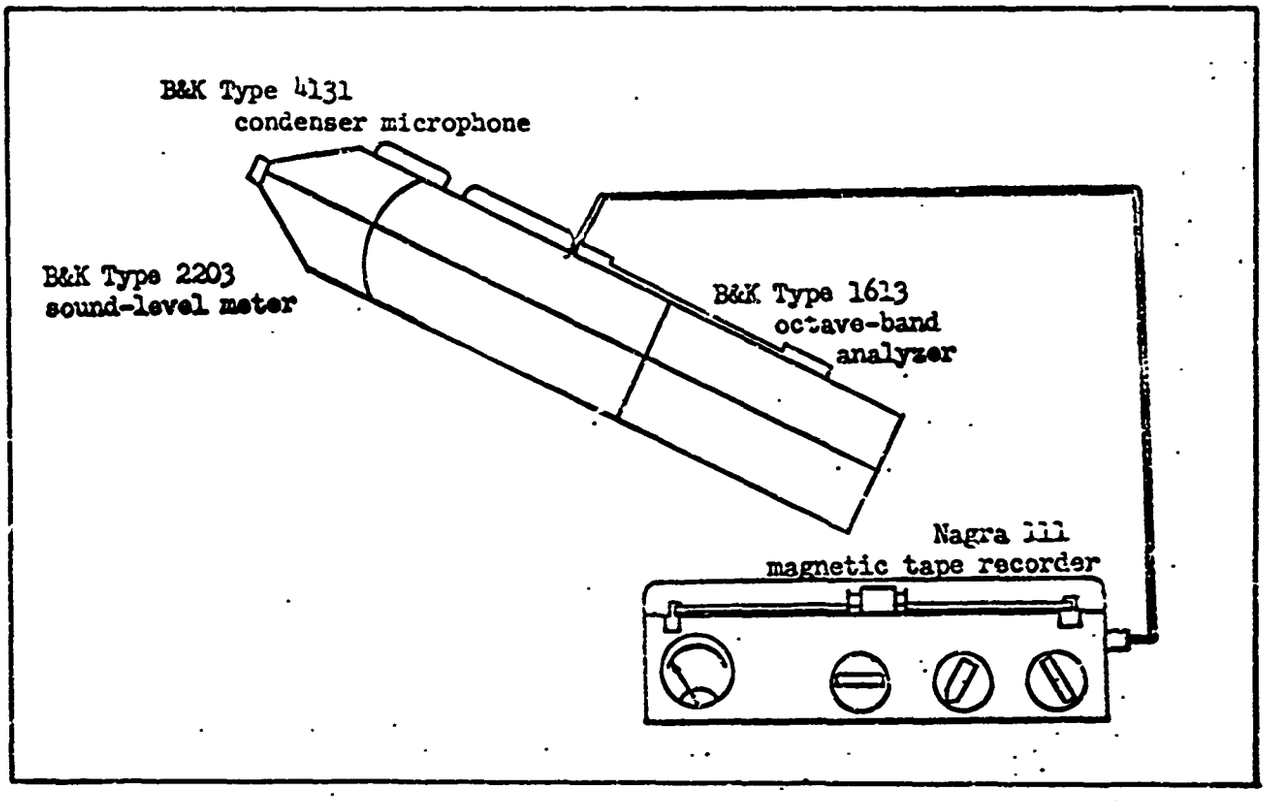


Fig. 88A. EQUIPMENT USED TO OBTAIN AND RECORD DATA IN THE CH-47B HELICOPTER

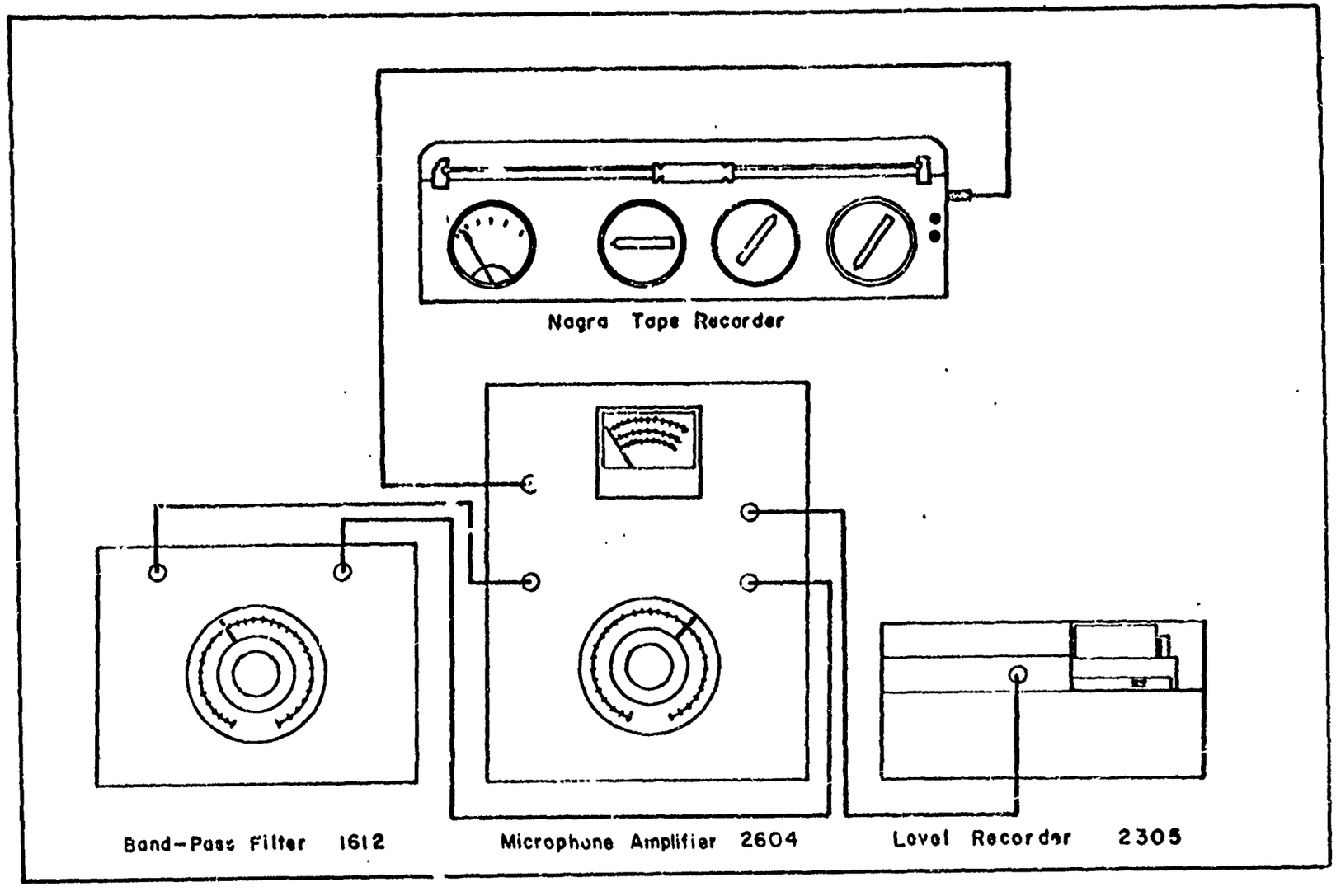


Fig. 89A. EQUIPMENT USED TO ANALYZE TAPE RECORDED CH-47B HELICOPTER DATA

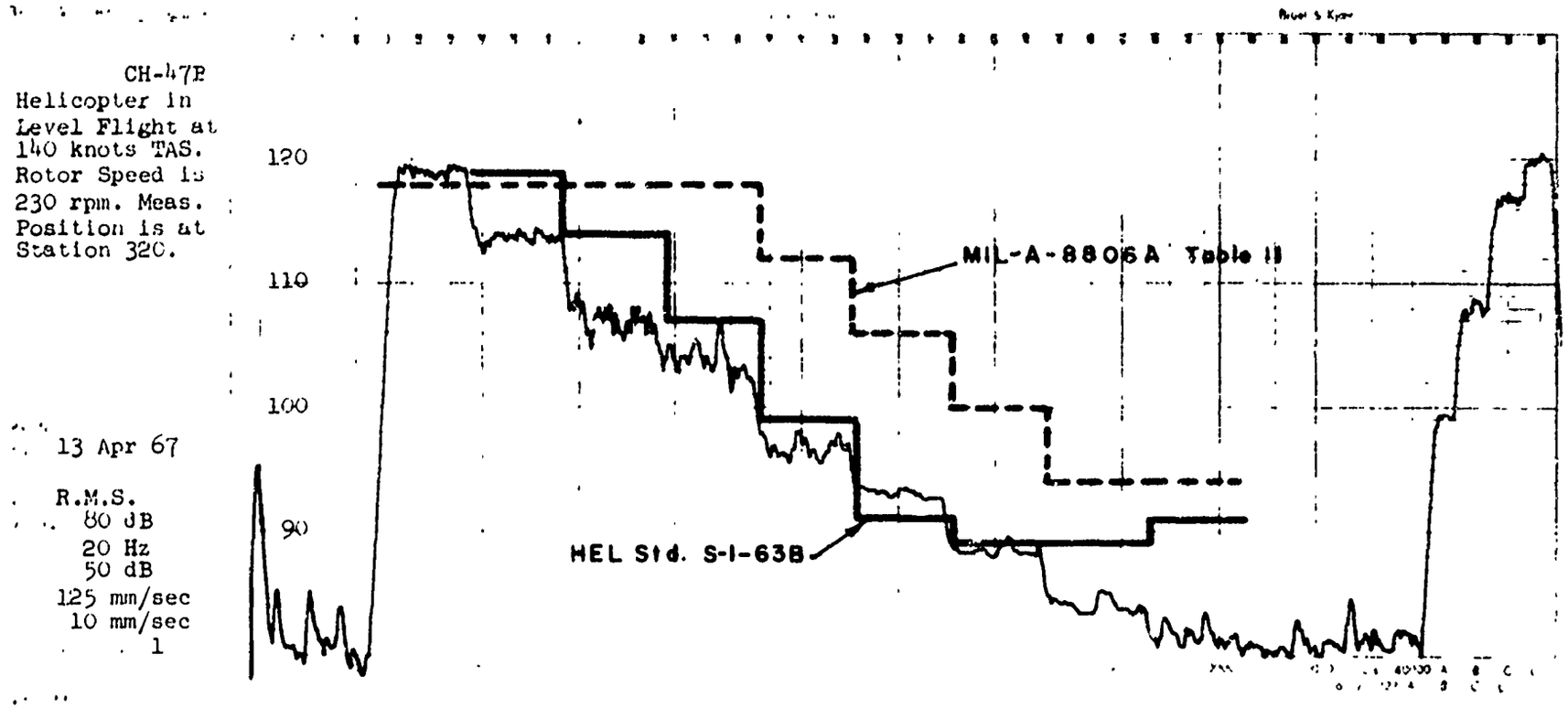


Fig. 90A. TYPICAL OCTAVE BAND RECORD USED IN ANALYSIS OF DATA FOR THE CH-47B HELICOPTER

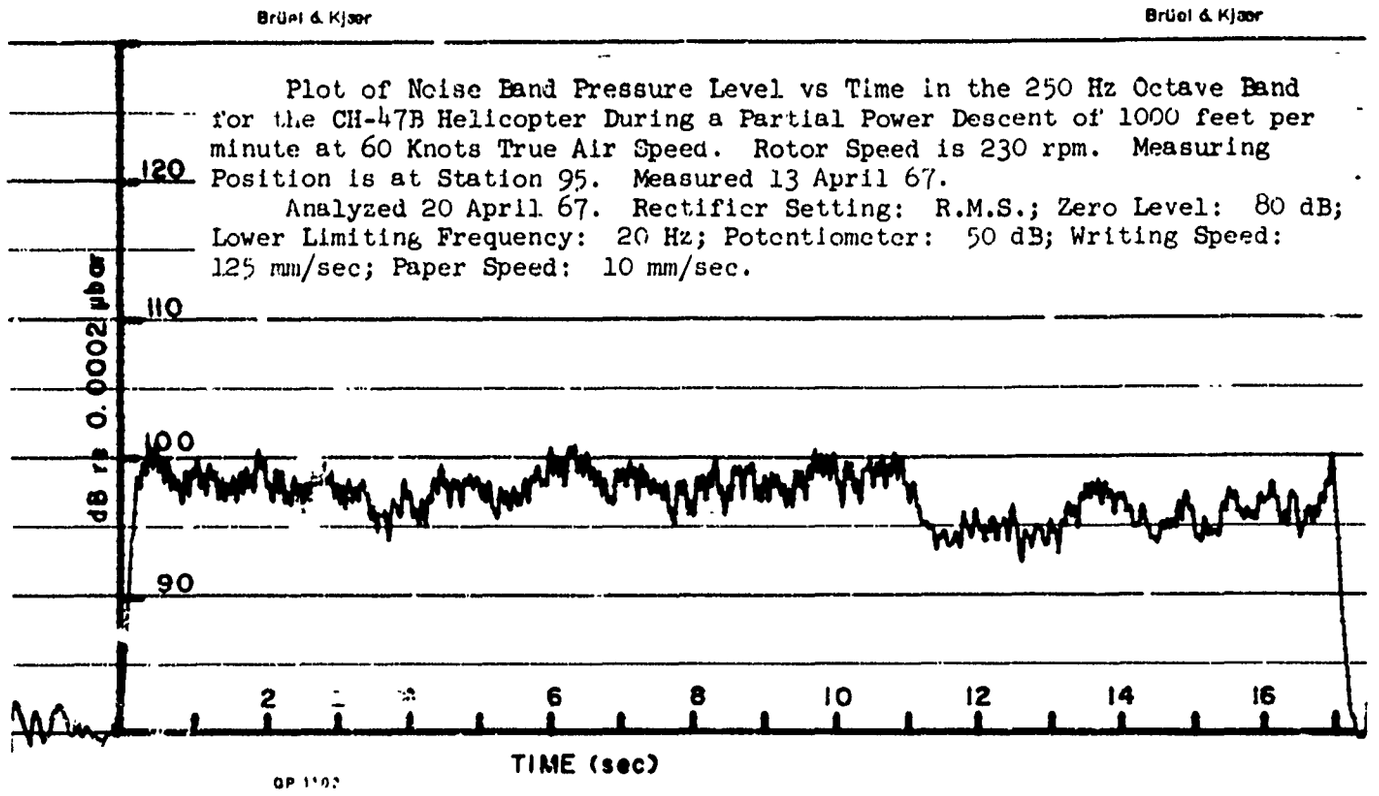


Fig. 91A. TYPICAL GRAPHIC LEVEL RECORD OF A TIME-VARYING NOISE IN THE CH-47B HELICOPTER

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13. ABSTRACT

Sound measurements were conducted in the CH-47B (Chinook) Helicopter under conditions of normal cruise, maximum continuous power, level flight at various air speeds, hover, level acceleration and deceleration, and partial-power descent. Results are presented and compared with applicable parts of Military Specification MIL-A-8806 and U. S. Army Human Engineering Laboratories Standard S-1-63B. Variations of the noise from that specified in these documents are discussed, and it is recommended that the noise be reduced to conform to the specified levels.

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