NOISE REQUIREMENTS FROM A MILITARY POINT OF VIEW

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SUMMARY

Little effort has been expended by the military to establish external noise standards for helicopters. Prior to UTTAS/AAH, specific requirements were nonexistent. Recent requirements which have been used for these designs generally have not been met. The military must cooperate with the Federal Aviation Administration (FAA) in establishing such requirements to minimize public annoyance; however, the FAA should use simple criteria which do not excessively impact overall design. Military internal noise requirements, while not generally met in the past, must be stiffened and enforced if realistic acoustical treatment, good speech intelligibility, and hearing conservation are to be achieved. Without significant additional research, an aggressive attack on external noise will significantly impact cost and flight performance; therefore, jeopardizing performance margins needed for overall helicopter reliability improvements.

INTRODUCTION

Establishing realistic external noise requirements for military helicopters is an extremely difficult task. This results in a diverse range of needs, for example, the battlefield is an extremely noisy environment. During peacetime operation, military helicopters are frequently criticized because of the noise they generate. The task of avoiding public annoyance is extremely important in order to attain support of the public, particularly in the face of our all-volunteer fighting forces. Some specific missions require the helicopter to operate as far as possible behind enemy lines without detection. Most of us are aware of operating features developed by Hughes Helicopters for a prototype OH-6A to make this type of mission possible; however, the Army prefers to avoid dedicated mission aircraft as much as possible to minimize our total logistical support problem.

On the technical side of the issue, the range of noise sources significantly complicates the problem. The predominant source of external noise from the main and tail rotor are drastically affected by the number of blades, blade design, and operating tip speeds of the rotors. Fundamental gear meshing frequencies for present day transmission gearboxes range from 40 to 22 000 Hz. Engine noise at its relatively high frequency (5000 Hz and above) can also be an important factor. The impulse noise from aircraft ordinance, blade slap phenomenon, and other wake vortices effects are also important.

The military is hard-pressed to meet current design-to-cost requirements; therefore, a significant amount of money is not available to apply to noise reduction during the full-scale engineering development effort. Currently, only those techniques may be used that do not adversely effect operating cost.

EXTERNAL NOISE DISCUSSION

It is first important to consider the noise levels of our current helicopters. A summary of sound exposure levels using A-weighted averaging techniques for a large range of Army helicopters from the two place TH-55 trainer to the CH-54B crane are contained in Table I. The dispersion in this noise is shown at distances of 30.5, 305 and 3050 meters (100, 1000 and 10000 feet). The data are taken from Ref. 1 which is a summary of noise measurements obtained during helicopter operation at our Aviation Center, Ft. Rucker, AL. Eight manuevers, which include level flight at 91.4 meters (300 feet), turns over the middle of the runway, ascent and descent to the runway, takeoff and landings, and hover in and out of ground effort are averaged from an array of microphones positioned at 61 meters (200 feet), intervals perpendicular to the aircraft's flight path. As you can see, the noise levels are quite high, ranging from 97 to 107 SELdB(A) at 30.5 meters (100 feet), reducing to only 86 to 97 SELdB(A) at 305 meters (1000 feet). None of the aircraft listed in this table were required to meet specific external noise requirements during their design.

Our first quantitative noise requirements were initiated with the UTTAS airframe and engine development programs. Figures 1(a) and 1(b) show the original airframe requirements which were crudely based on noise measurements made using the Lockheed XH-51 experimental helicopter. The noise levels of the winning prototype are shown to significantly exceed these requirements. It should be pointed out that there were no significant noise differences between the two competing prototypes relative to this requirement. With some improvement in the production configuration, production specification values taken from Ref. 2 still exceed the requirement; therefore, the objective of keeping the detectability of this larger helicopter down to the levels of the XH-51 could not be met without a significant additional expenditure. Aircraft development costs and schedule trade-offs negated achievement of the noise level objectives. A similar picture exists for the Advanced Attack Helicopter as shown in Figure 2. Specification values are from Ref. 3.

PROPOSED COMMERCIAL STANDARDS

Much work has been done by the FAA and working parties of the International Civil Aviation Organization (ICAO) in preparing standards that would be a prerequisite for civil type certification. An Effect Perceived Noise level range of 88 to 105 EPNdB for a fly-over at 150 meters and for takeoffs and approaches at the same height is envisioned. This does not include the 3 EPNdB correction for rotor impulse noise. For the fly-over case, the speed of 90% of the maximum speed in level flight or 90% of the Never Exceed Speed, whichever is less, would be used. The familiar flight profile for these test conditions are shown in Figure 3. It is the Army's understanding that the flight elevations and other test conditions remain open for negotiation and may not necessarily be 150 meters for all conditions.

The concept of an external noise requirement to prevent public annoyance is certainly valid; however, the demonstration technique appears unduly complicated. Variations in pilot techniques should not be allowed to meet ultimate external noise requirements. The Army has consistently held to this position in the demonstration of flight performance which has kept such demonstrations relatively straight forward. For example, hover, maximum speed and manuever commitments must all have been demonstrated at 100% rotor rotational speed because a combat flight crew may well forget to adjust main rotor speed for a critical manuever, thus losing performance when it is most important.

The Army does not believe that any of its current helicopters could meet the new proposed requirements; and even with current technology, the natural tendency would be to lower design tip speed in order to reduce noise. This approach has many disadvantages in that high speed retreating blade stall will result at lower forward speeds, high speed manueverability will be reduced and entry into autorotation will be compromised by rotor decay from a lower potential energy condition.

Scout and Attack helicopters during tactical operations will spend a predominant amount of time in hover or near hover flight; therefore, external noise under these conditions is also important to the military to minimize detectability in combat environment.

Any attempt to make existing helicopters, or those designs currently in development, conform to existing FAA thinking will divert funds needed for long-range research to insure that our next generation of helicopters will probably be optimized for detectability and performance at an affordable cost.

INTERNAL NOISE REQUIREMENTS

Most of our current helicopters do not meet the internal noise requirements of Ref. 4. Hearing damage risk criteria is being determined for personnel who operate our aircraft for long periods of time. Aircraft internal aided and unaided communications are less than optimum. As a result, the Army has established a working group to develop the helicopter requirements for MIL-A-8806A, under the chairmanship of the U.S. Army Aviation Research and Development Command (AVRADCOM). Government membership includes representatives from U.S. Army Health Services Command, U.S. Army Avionics Research and Development Activity, U.S. Army Aeromedical Research Laboratory, U.S. Army Human

Engineering Laboratory, U.S. Army Training and Doctrine Command (TRADOC), U.S. Army Troop Support and Aviation Materiel Readiness Command (TSARCOM), Department of the Army--Office of the Surgeon General, U.S. Army Environmental Hygiene Agency, as well as four major U.S. helicopter manufacturers (Bell Helicopter Textron, Boeing Vertol, Hughes Helicopters, and Sikorsky Aircraft). This working group will emphasize requirements for crew hearing conservation in terms of mission times, duty cycles, ground exposure time and troop temporary threshold shifts resulting during helicopter transit to the assault area. Speech intelligibility, both aided and unaided, with emphasis on reduced background noise in avionic equipment will be addressed. Impulse noise requirements of weapons as well as impulsive rotor near field noise will be considered during revision of the specification. The working group is chartered to have a draft revised specification by mid-1979.

The seriousness of the current situation is well illustrated by reviewing Figure 4 (obtained from Ref. 5). The sound pressure levels between 250 and 8000 Hz, which covers the normal hearing range, are largely above the specification requirements in the cabins of our current helicopters. Figures 5 and 6 (also from Ref. 5) show the reductions that must be necessary for effective communication at speech intelligible levels of 50% and 80% respectively. To date, the working group is projecting an adjustment to the military specification as shown in Figure 7 for unaided communication with a significant relaxation where aided communication is available. Peak pressure levels for impulse noise currently presented in MIL-STD-1474 (Ref. 6) appear acceptable. These are illustrated in Figure 8 for no ear protection and for various combinations of ear plugs and muffs, depending upon the daily exposures rate. In developing such criteria, the exposure duration to steady noise is quite important. Standards obtained from Ref. 7 are shown in Table II.

TRADE-OFF IMPACTS RE NOISE REDUCTION

If specification external noise requirements exist, new designs will be based on significant margins due to relatively poor prediction techniques. For example, analysis by others has shown that for a small 1361 kilogram (3000 pound) class helicopter, a 3 to 4 dB margin will require a 45 kilogram (100 pound) margin in weight, as well as a 20 knot decrement in forward speed. If the inability to achieve specific requirements will block the production of a design, industry is forced to take such conservatisms due to the poor accuracy of noise predictions. Although vehicle flight performance can be predicted quite accurately, most organizations use a 5% conservatism to insure achieving flight performance objectives.

The most significant technique in reducing rotor noise is reduction of tip speed, as previously discussed. This has been quantified to show (see Figure 9) that a reduction in tip speed of 230 m/sec (750 ft/sec) to 200 m/sec (650 ft/sec) results in an increase in design gross weight of approximately 160 kg (350 lb) (5%) for an Advanced Scout Helicopter of a 3402 kg (7500 lb) class with all other performance requirements remaining fixed. This 5% increase in helicopter size will also represent a 5% increase in helicopter cost.

CONCLUDING REMARKS

Establishing realistic external noise requirements for military aircraft is an extremely difficult task. Cooperating with the FAA to generate and enforce such requirements is extremely important to minimize public annoyance; however, a cautious path must be followed to insure that unnecessary payload penalties and cost impacts, which are built into the basic design are minimized. High performance margins are needed for combat effectiveness and weight allowance for innovative reliability improvements. Reliability improvements are the key to reducing life cycle operating costs. The demonstration of compliance with extreme noise requirements should be kept extremely simple, and avoid gimmicks in piloting techniques. Before such requirements become regulatory, much research is needed to develop innovative techniques for noise reductions without unduly affecting performance and cost.

REFERENCES

1. Rotary Wing Operational Noise Data. Report TRN #38, U.S. Army Construction Engineering Research Laboratory, Champaign, IL, February 1978.

2. UH-60A Utility Tactical Transport Aircraft System Prime Item Development Specification. AMC-CP-2222-S1000B, Sikorsky Aircraft, Division of United Technologies, Stratford, CT, 1 November 1976.

3. Advanced Attack Helicopter System Specification. AMC-SS-AAH-H10000A, Hughes Helicopters, Culver City, CA, 23 November 1976.

4. Military Specification: Acoustical Noise Level in Aircraft, General Specification For. MIL-A-8806A, Department of Defense, 11 July 1966.

5. Doyle, L. Bukowski; Sternfeld, H.: Evaluation of Current Helicopter Internal Noise Level Design Criteria. Contract DAAJ01-74-C-10544, The Boeing Vertol Company, Philadelphia, PA, December 1976.

6. Military Standard: Noise Limits for Army Materiel. MIL-STD-1474(MI), Department of Defense, 1 March 1973.

7. Noise and Conservation of Hearing. Technical Bulletin MED 251, U.S. Army, 7 March 1972.

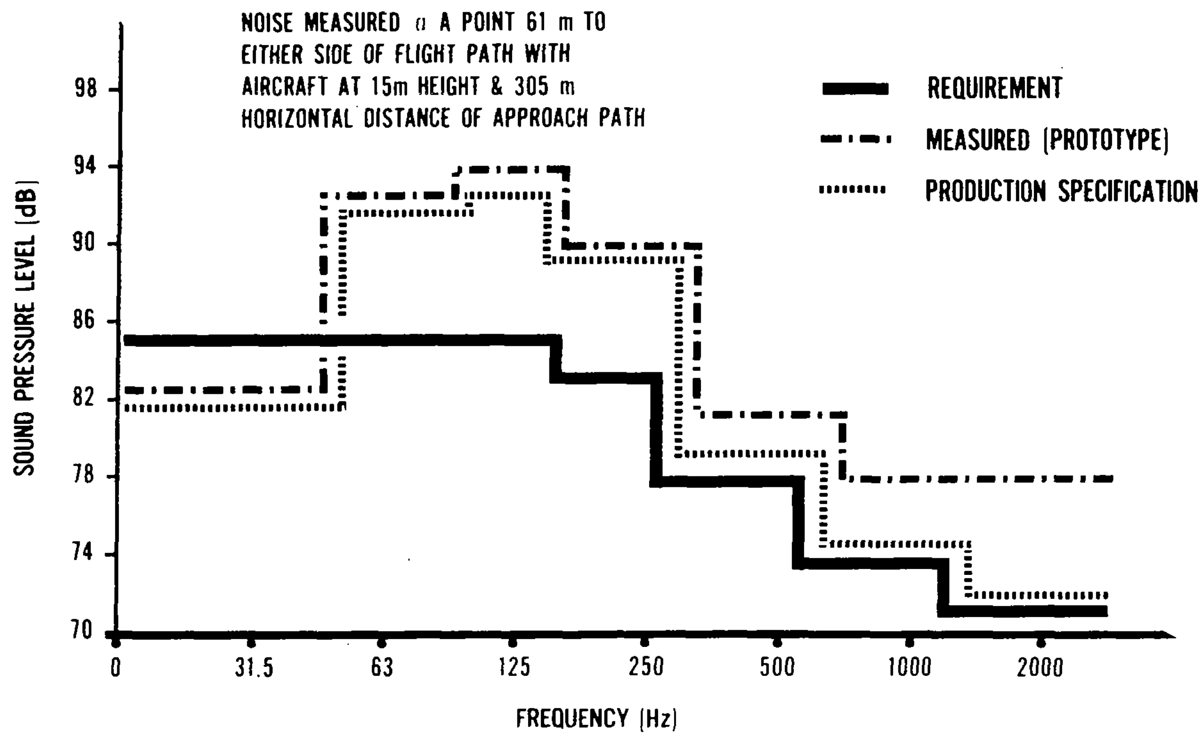
TABLE I.- HOW NOISY ARE OUR CURRENT HELICOPTERS

		SOUND EXPOSURE LEVEL dB(A) AT		
HELICOPTER	LOADING	30.5 m	305 m	3050 m
OH-58A	NORMAL MISSION	97	86	69
UH-1H	MAX WT	106	94	79
UH-IB	MAX WT	101	90	73
AH-IG	NORMAL MISSION	105	93	76
CH-47C	MAX WT	107	97	82
CH-54B	MAX WT	106	95	78
TH-55	PILOT/STUDENT	99	87	67

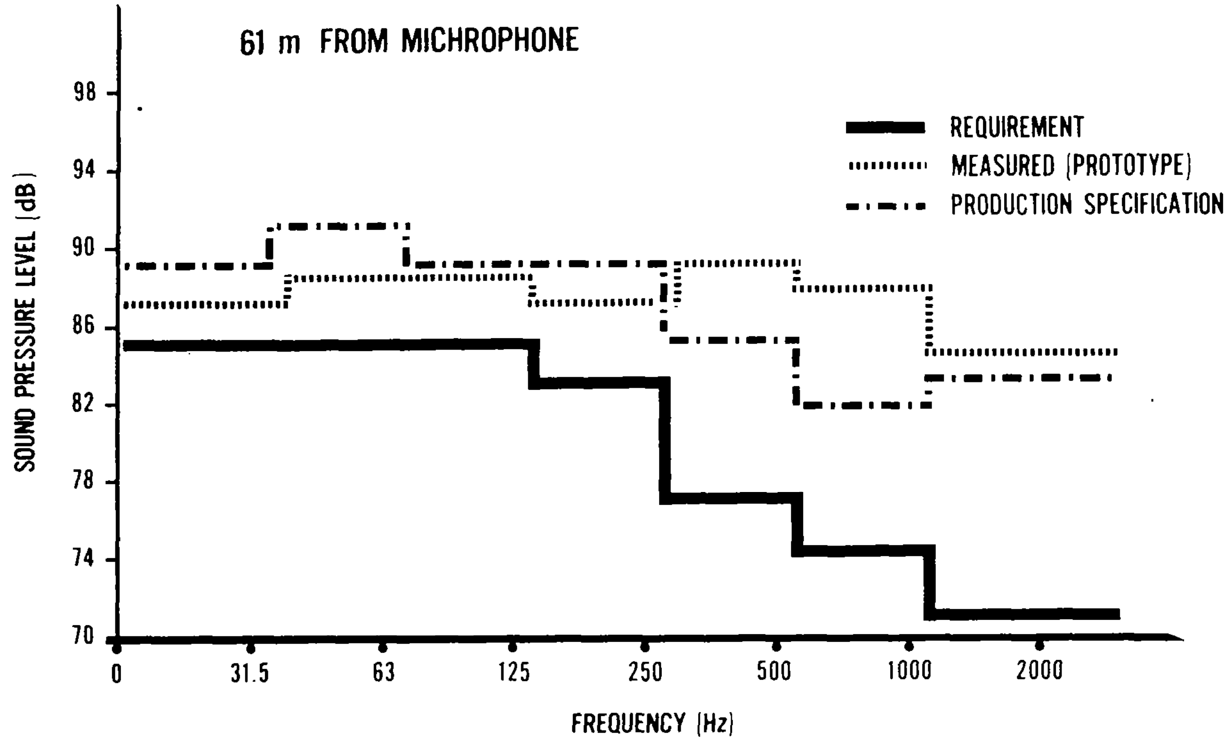
DATA AVERAGE FROM 8 SPECIFIC MANEUVERS & 6 PICKUPS AT FORT RUCKER BY US ARMY CONSTRUCTION ENGINEERING RESEARCH LAB (RPT TRN-38)

TABLE II.- MAXIMUM RECOMMENDED SOUND LEVEL EXPOSURE

	MAXIMUM STEADY NOISE dB(A)	
EXPOSURE DURATION PER DAY IN HOURS	TB MED 251 7 MARCH 1972	WALSH-HEALY CRITERIA
8	85	90
6	87	92
4	90	95
3	92	97
2	95	100
1-1/2	97	102
1	100	105
1/2	105	110
1/4 OR LESS	110 (CEILING)	115 (CEILING)



(a) Black Hawk in out-of-ground-effect hover.



(b) Black Hawk in cruise at true airspeed of 150 knots.

Figure 1.- External noise.

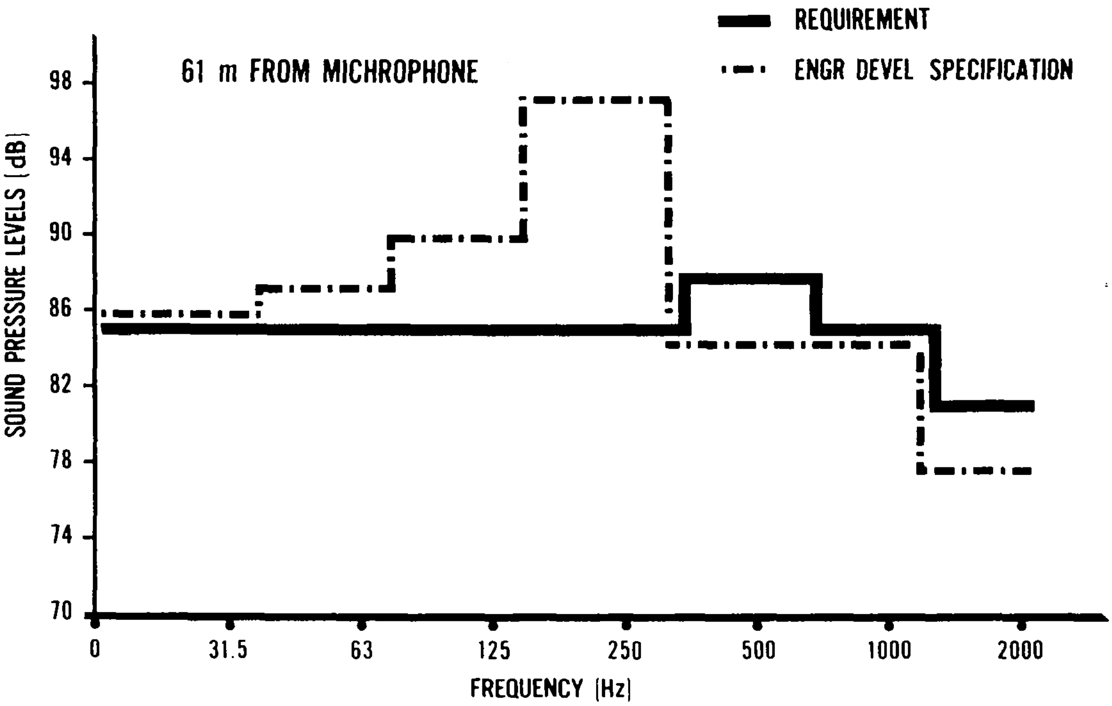


Figure 2.- External noise for advanced attack helicopter in out-of-ground-effect hover.

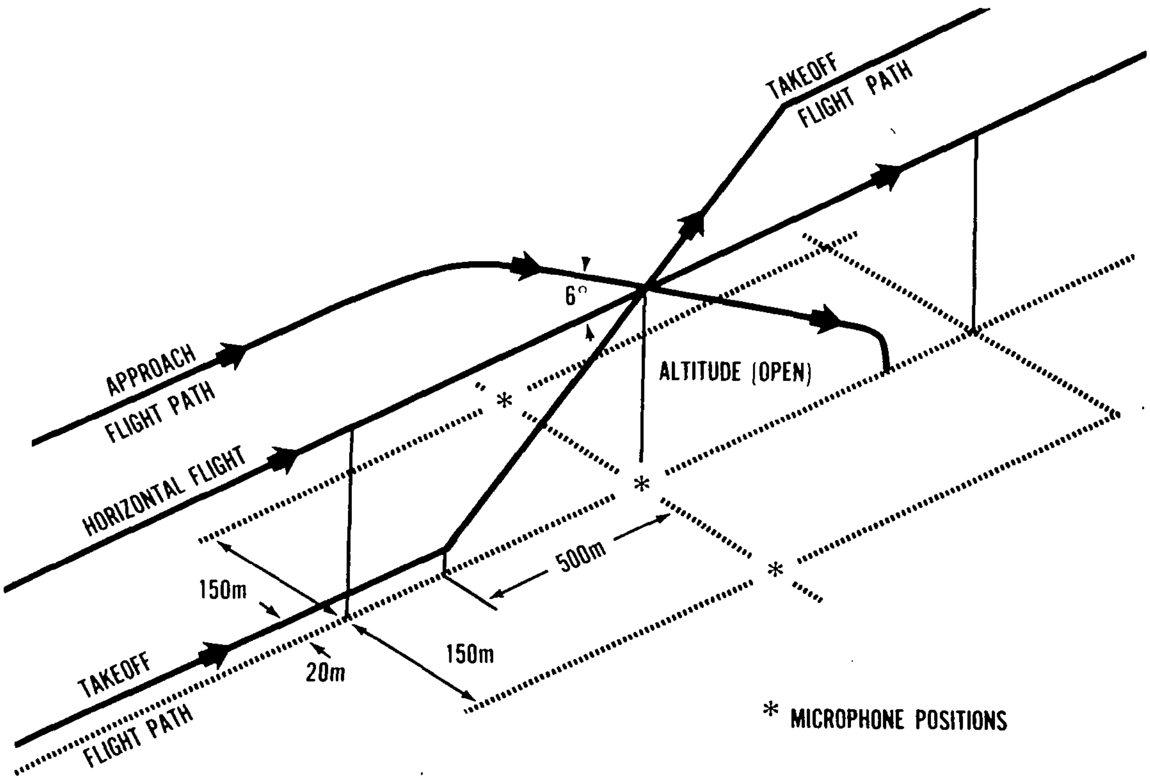


Figure 3.- Proposed helicopter noise tests.

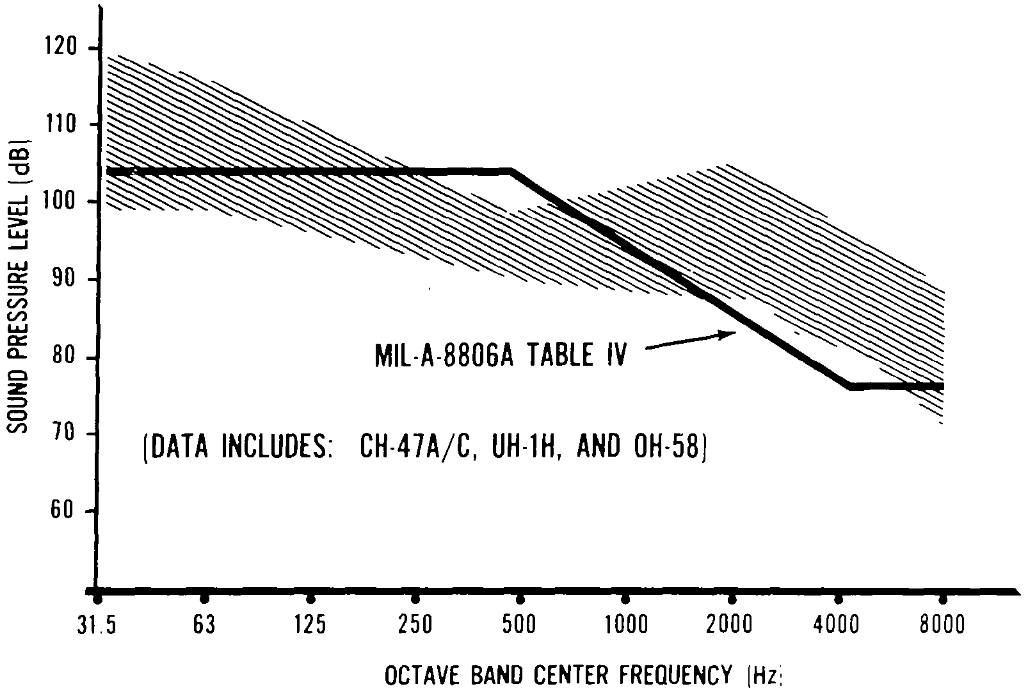


Figure 4.- Scatter of center cabin noise data in army helicopters during cruise flight.

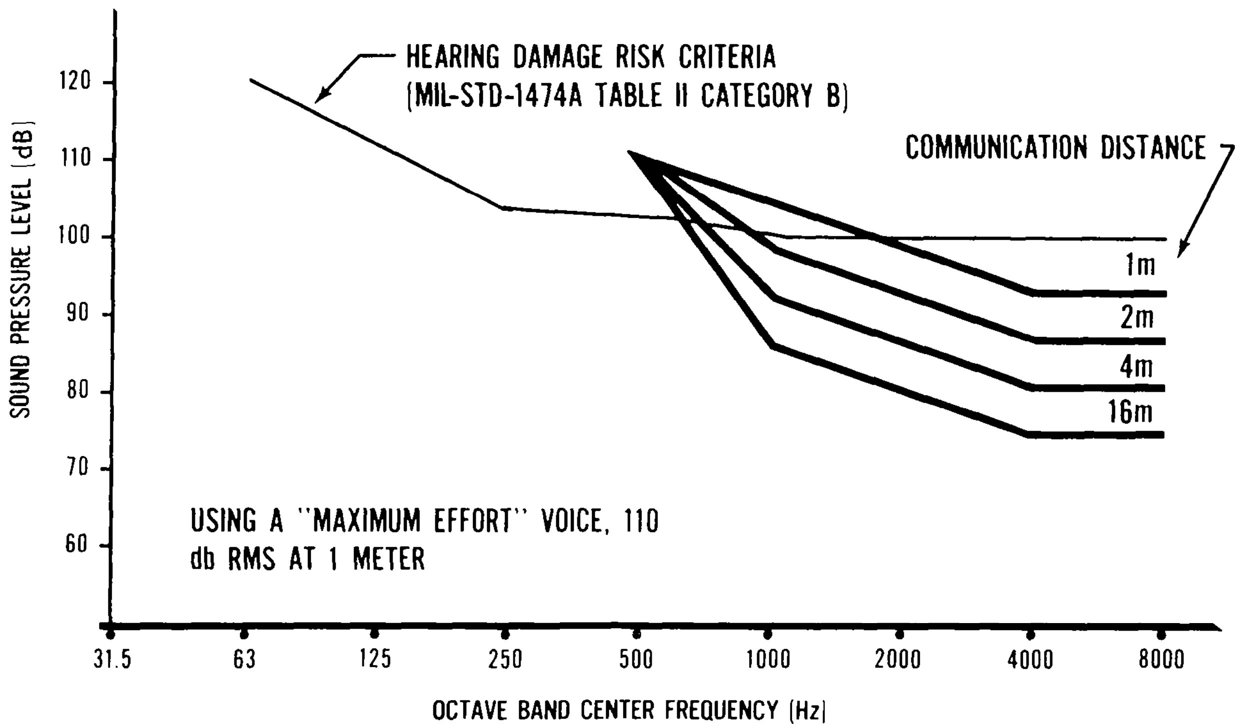


Figure 5.- Helicopter interior noise levels required for emergency commands. 50% speech intelligibility.

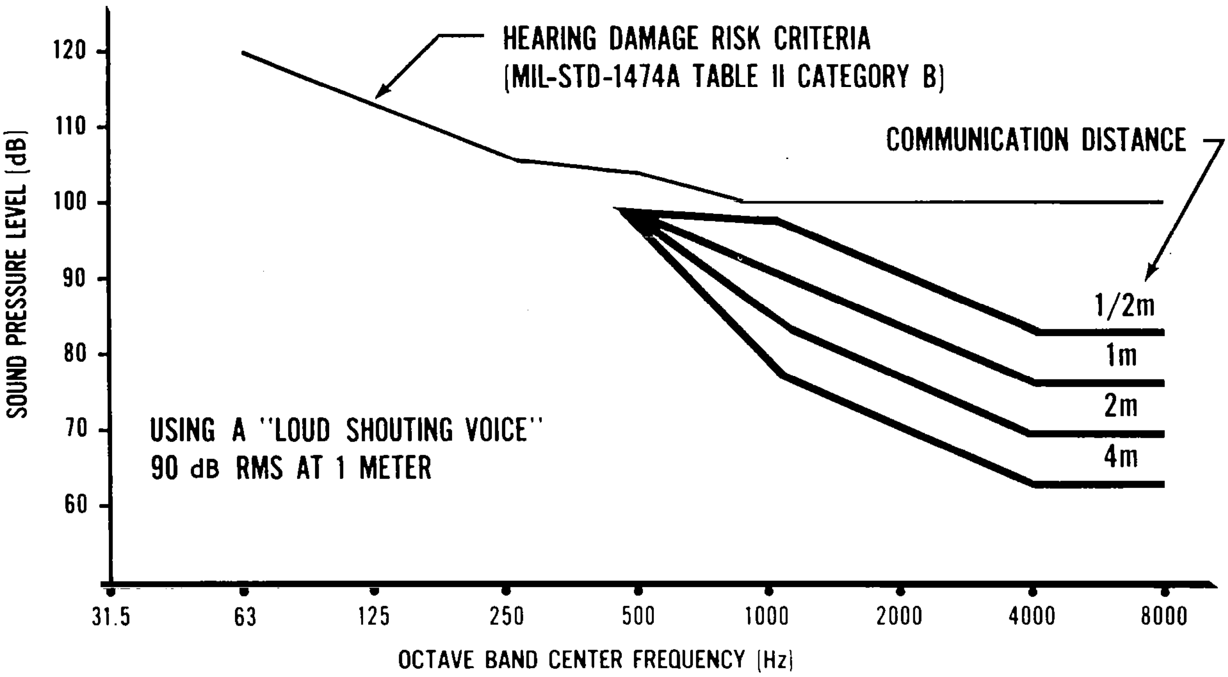


Figure 6.- Helicopter interior noise levels required for instructing troops. 80% speech intelligibility.

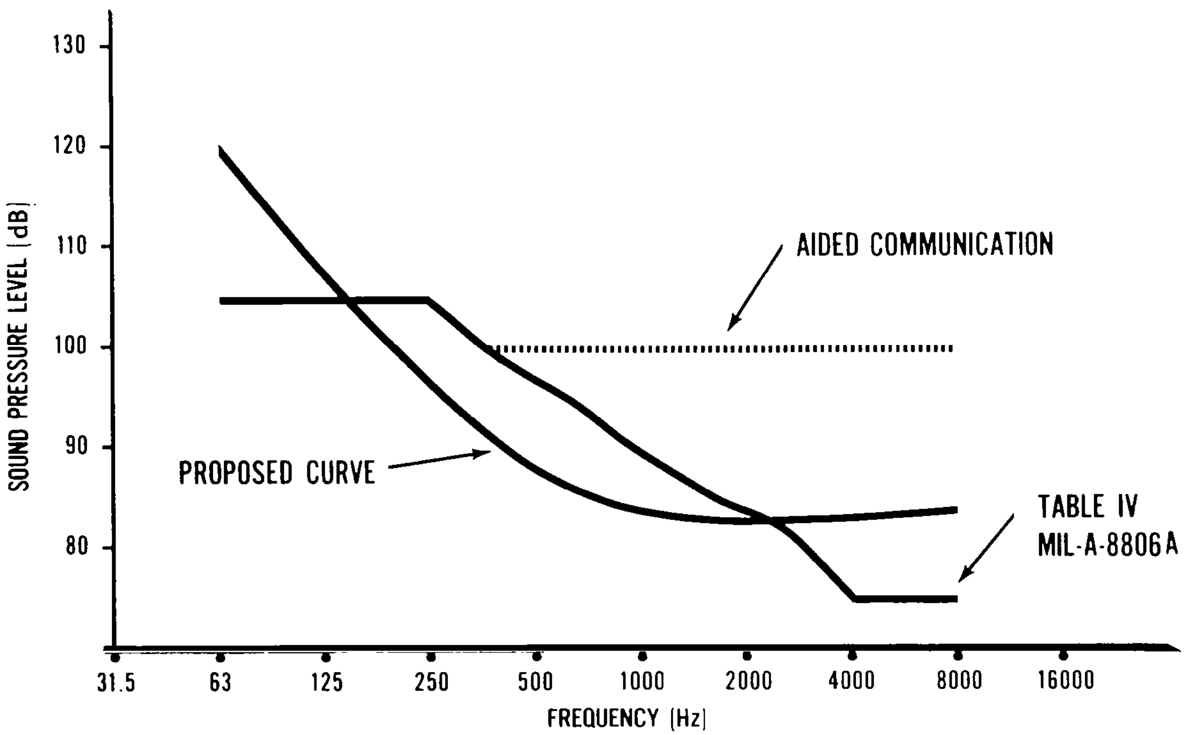


Figure 7.- Working group proposed design curve for noise levels.

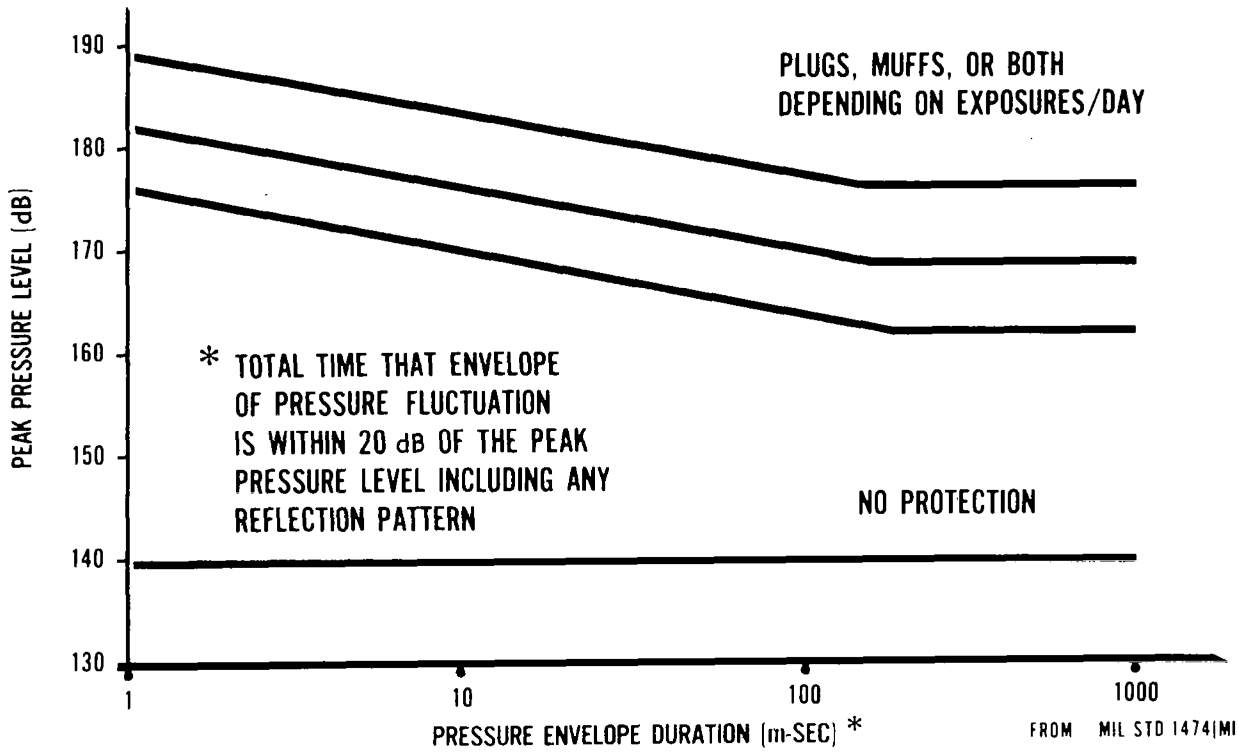


Figure 8.- Peak pressure level and B-duration limits for impulse noise.

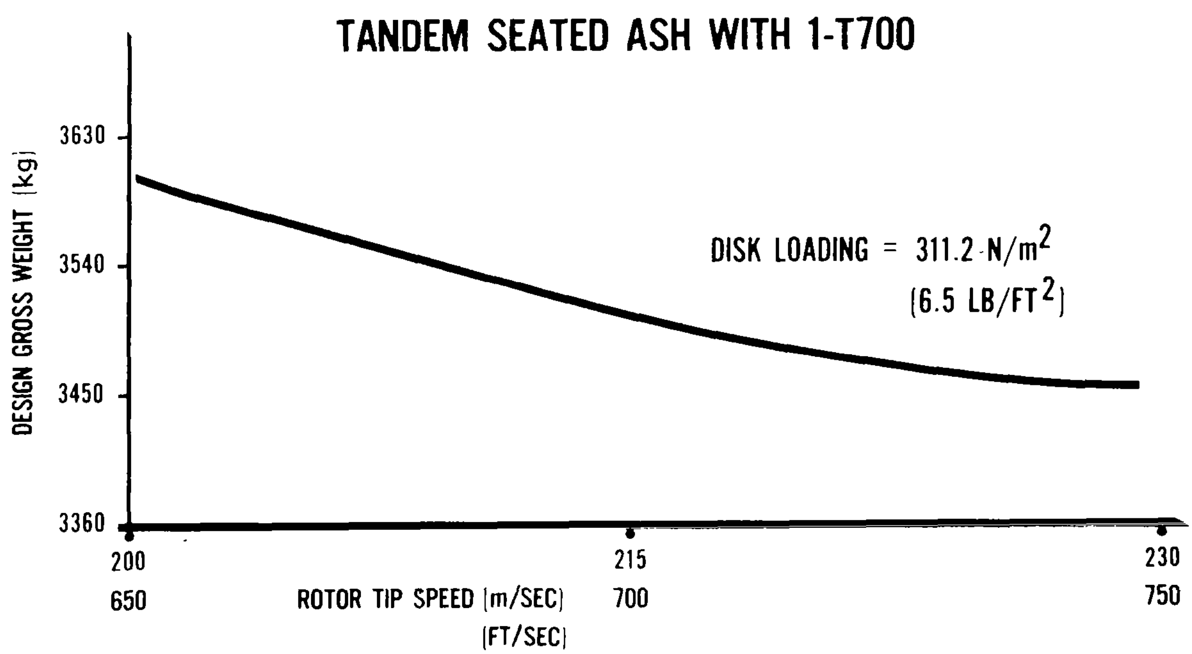


Figure 9.- Design gross weight impact of tip speed.