NOISE AND ITS IMPLICATIONS WITH THE INDIAN AIR FORCE

By

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Abstract

Noise survey of the Jet Fighter/Bomber aircraft in I.A.F. have been carried out. Overall sound pressure levels and frequency analysis during ground running for distances upto 100' for different angles were measured. Speech interference levels, Perceived noise levels and Noise rating numbers for crew positions have been caleulated. The maximum safe duration of noise exposure along with the maximum permissible ground running cycles in the case of different aircraft are also given from the point of view of hearing damage. Noise rating numbers with ear defenders have been worked out. The requirements of ear defenders for different types of aircraft have been indicated. Guidelines for the location of briefing rooms and lecture rooms are submitted on the basis of limiting speech interference.

Introduction

In the past one or two decades noise has attained high intensities and has turned out to be a very serious problem especially in aviation, compelling attention.

It is accepted that noise affects human beings in many ways such as

(*a*) Damage to hearing mechanism
(*b*) Effects on communication
(*c*) Physiological effects
(*d*) Effects on efficiency at work and work output
(*e*) Psychological effects such as annoyance and irritation
(*f*) Disturbance of sleep and rest contributing to fatigue.

Noise levels above 130 dB are usually accepted as very intense sound. High noise field can set up resonance. The body and the sensory receptors for touch, pressure and joint movement may be stimulated. Excessive fatigue, nausea and disorientation due to the stimulation of the Labyrinthine mechanisms may be caused. There may be facial pain due to resonance of the nasal and upper respiratory cavities. There may be disturbance of vision and feeling of exaggerated movement of the head and a feeling of giddiness.[1-3]

U.S.A.F. regulation 160-3 states that the body should not be exposed to overall S.P.L. of 150 dB and above. This limit, though appears arbitratry, due to lack of enough experience of such nose levels, is still considered a reasonable level at which to prohibit exposure.

Damage to Hearing Mechanism

It is universally accepted that exposure to noise levels of 85 dB and above are likely to cause damage to hearing, when it is prolonged and repeated.[4, 5]

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This damage can be a temporary threshold shift, a permanent threshold shift or acoustic trauma. Temporary threshold shift as the name implies is a short term effect, and hearing loss is reversible. If a person is exposed to longer duration exceeding this limit recovery from the hearing loss is not complete but some degree of threshold shift remains. This residue is known as permanent threshold shift.

There is no treatment at present available for noise induced deafness and hence the importance of prevention. It is therefore, necessary to assess the noise environment and to see whether it falls within maximum permissible limits at least as far as hearing damage is concerned.

A survey of noise environment of any flying establishment would reveal that the environment is largely made up of the noises caused by

(*a*) Ground running aircraft

(*b*) Aircraft flying overhead

(*c*) Engine test-beds

(*d*) Workshop and repair hangars

(*e*) Ground power equipments such as starter trolley, etc.

(*f*) Traffic, machinery and people

(*g*) Sonic boom.

Out of the noise environment, ground running of aircraft contributes the major share and thus constitutes the greatest hazard to personnel in the vicinity. A project was, therefore, undertaken and the noise analysis on ground running of all the Jet-fighter, bomber and trainer aircraft of the I.A.F. has been completed. [6, 7, 8, 9, 10, 11, 12, 13, 14]

Method

Noise measurements were carried out by using General Radio Company Type 1551-B Sound level Meter and Type 1550-A Octave band analyser. Rochelle salt crystal microphone supplied with the above sound level meter was used.

Calibration checks on the noise measuring equipment were carried out as prescribed [16] at the beginning and at the end of each day's operation. All the equipment was operated on dry batteries and the voltage of the batteries were checked daily before commencement of noise measurement.

The aircraft was positioned on the open tarmac and distances were marked in the axes of 0°, 45°, 90° and 135° at intervals of 20', 40', 60', 80' and 100' commencing from the tip of the Jet exhaust pipe. Overall sound pressure levels (S.P.L.) were measured at these points. Measurements of S.P.L. were carried out with all the three weightings (A, B & C) of the sound level meter at various R.P.M. settings. In addition, measurements were also made at the crew positions, that is where maintenance personnel usually stand while ground engine running of the aircraft is in progress. All measurements were carried out by positioning the microphone approximately at the head-level of personnel occupying the area.

The temperature of the atmosphere at the time of measurements was well below the safe operating limit prescribed for Rochelle salt crystal microphone. The humidity was also well below the safe limit. The Rochelle salt crystal unit in the microphone is protected by a coating so that it is relatively unaffected by high humidity (less than 84%). [16]

As far as possible, other sources likely to give rise to electrical interference such as transformer, motor, etc., were excluded from the field of measurement. The aircraft was positioned completely away from any other noise source, such as other running aircraft. All measurements were carried out on open tarmac. The possibility of error due to wind velocity was taken into consideration. Measurements were carried out when the wind velocity was less than 5 knots.

Noise measurements as described above have been carried out in the case of following aircraft:[6,14]

(*a*) Mystere
(*b*) Hunter
(*c*) HF-24
(*d*) Gnat
(*e*) Canberra
(*f*) HJT-16
(*g*) S-22
(*h*) Type-74
(*j*) Type-76
(*k*) Vampire.

Results and Discussion

The sound pressure levels in decibles with reference to 0.0002 dynes/sq.cm. measured at different points around the aircraft are presented for idling R.P.M. of the engine and higher R.P.M. usually employed for ground running. The present data are with 'C' weighting. Since noise levels measured are all above 85 dB, other weightings are not valid.

Since the highest damage risk is experienced by the technical personnel working in the vicinity of the aircraft, noise levels at two typical crew positions I (45° 20′) and II (45° 40′) are given for all aircraft in Table I, with Speech Interference Levels (SIL), Perceived Noise Levels (PNdB) and Noise Rating Numbers. Noise rating number, which is a single index of overall noise level and the composition of the noise, is an accepted measure of the risk of impairment of hearing.

It may be seen from Table I that at crew positions, the sound pressure levels are above the accepted safe limit based on conservation of hearing. Table II gives the maximum admissible time for daily exposure or the maximum number of engine running cycles which can be undertaken daily by the personnel without risk to hearing.

Protection

It is evident that personnel protective devices such as Ear Defenders are required in all the cases. The protection offered by these devices depends on their attenuation characteristics with respect to the noise environment. The attenuation characteristics of the insert type of ear defenders are given in Fig. 1 while those of the muff type are given in Fig. 2. The altered values of noise rating numbers with insert or muff are given in Table III for various aircraft.

It may be seen from Table III that the protection offered by insert type of ear defender is not adequate for most of the aircraft. The ear muffs give higher degree of protection, and noise rating numbers are kept within safe limits from the view point of permanent hearing-damage. However, in the case of S-22 and Type-76 aircraft, where 100% engine r.p.m. is built up and after burners are applied, the noise levels are increased to higher values. The degree of increase in noise levels for crew position I (45° 20′) are as follows:

S-22, +2 db, Type-76, +12 db, Type-74, +23 db.

TABLE I

Aircraft	CREW POSITION I—45° 20'				CREW POSITION II—45° 40'			
	Sound pressure level (dB)	Speech interference level (dB)	Perceived Noise level (PNdB)	Noise rating number (N)	Sound Pressure level (Db)	Speech Interference level (dB)	Perceived Noise level (PNdB)	Noise rating number (N)
MYSTERE ..	112	95	119.5	96	106	89	113.5	90
HUNTER ..	115	100	122.5	105	110	97.6	117.5	102
HF-24 ..	121	112	128.5	115	116	107	127	110
GNAT ..	120	110	127.5	115	114	107	121.5	108
CANBERRA ..	130	121	137.5	122	126	118	133.5	118
HJT-16 ..	116	109	127	113	113	105	120.5	108
S-22 ..	123	114	130.5	120	118	107	128	116
TYPE-74 ..	117	105	127.5	111	112	103	119.5	105
TYPE-76 ..	118	111	126	112	113	106	120.5	105
VAMPIRE ..	118	109.6	127	119	115	102	122.5	113

Since the frequency characteristics of the jet noise produced by various types of aircraft are different, ear muffs with matching attenuation characteristics will give optimum results. Table IV gives the frequency wise noise rating numbers for different aircraft at the crew position I (45° 20') which could be compared with attenuation characteristics of the ear muff currently in use. The ear muffs have the frequency characteristics which match with the frequency spectrum of Hunter, Vampire, Gnat and Canberra.

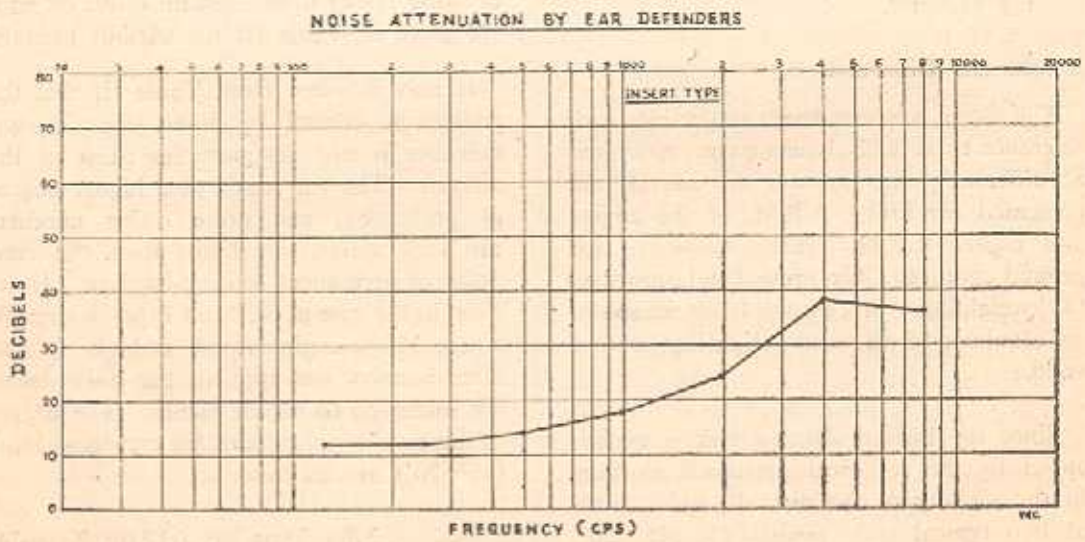

Fig. 1

TABLE II

Aircraft	CREW POSITION I—45° 20′				CREW POSITION II—45° 40′			
	Nature of exposure	*On time in minutes*	*Off time in minutes*	*No. of exposure cycles per working day of 6 hours*	*Nature of exposure*	*On time in minutes*	*Off time in minutes*	*No. of exposure cycles per working day of 5 hours*
MYSTERE ..	Continuous	Less than 25			Continuous	Less than 50		
	Intermittent	15	20	12	Intermittent	25	20	12
HUNTER ..	Continuous	Less than 16			Continuous	Less than 20		
	Intermittent	9	37	8	Intermittent	13	32	8
HF-24 ..	Continuous	Less than 8			Continuous	Less than 12		
	Intermittent	3	42	8	Intermittent	6	40	8
GNAT ..	Continuous	Less than 8			Continuous	Less than 13		
	Intermittent	3	40	8	Intermittent	7	40	8
CANBERRA ..	Continuous	Less than 4			Continuous	Less than 6		
	Intermittent	1	45	8	Intermittent	2	38	8
HJT-16 ..	Continuous	Less than 9			Continuous	Less than 13		
	Intermittent	4	40	8	Intermittent	7	40	8
S-22 ..	Continuous	Less than 5			Continuous	Less than 7		
	Intermittent	1.5	42	8	Intermittent	3	40	8
TYPE-74 ..	Continuous	Less than 12			Continuous	Less than 16		
	Intermittent	16	40	6	Intermittent	9	37	8
TYPE-76 ..	Continuous	Less than 12			Continuous	Less than 16		
	Intermittent	3	45	7	Intermittent	9	37	8
VAMPIRE ..	Continuous	Less than 5			Continuous	Less than 10		
	Intermittent	2	40	8	Intermittent	6	40	8

TABLE III

Aircraft	CREW POSITION I—45° 20'		CREW POSITION II—45° 40'	
	Noise Rating Number with Ear Insert	Noise Rating Number with Ear Muff	Noise Rating Number with Ear Insert	Noise Rating Number with Ear Muff
MYSTERE ..	85	75	77	67
HUNTER ..	80	69	76	65
HF-24 ..	100	88	95	83
GNAT ..	95	83	89	77
CANBERRA ..	105	93	102	90
HJT-16 ..	94	83	90	79
S-22 ..	103	90	100	87
TYPE-74 ..	95	84	90	79
TYPE-76 ..	96	84	92	80
VAMPIRE ..	95	80	90	75

However, in the case of Canberra aircraft the protection offered by the ear muffs is not adequate as far as the total noise attenuation is concerned. It can also be concluded that ear muff with low frequency attenuation properties are required for the following aircraft:

Mystere
S-22
Type-74
Type-76
HF-24
HJT-16.

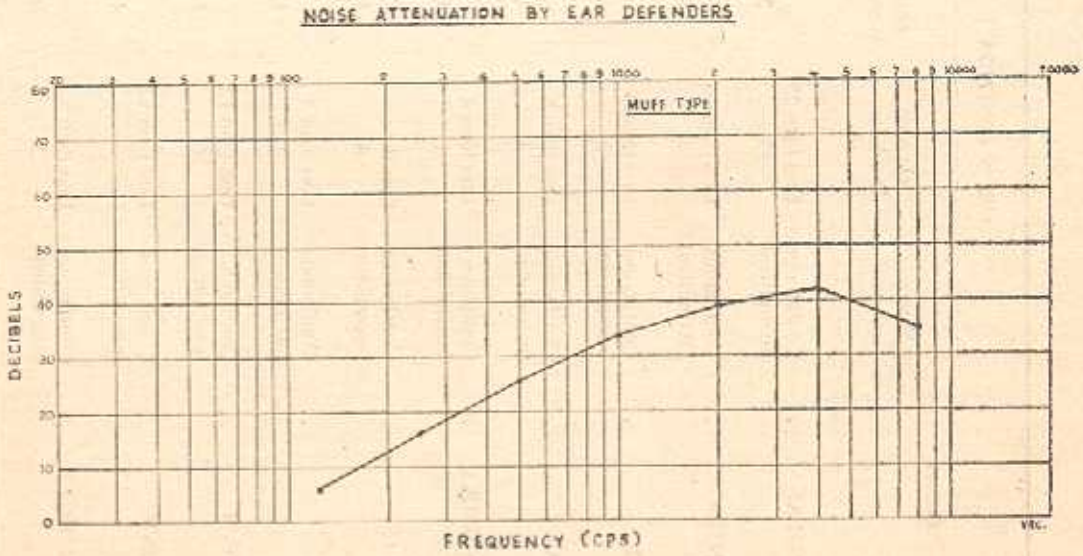

Fig. 2

TABLE IV

Noise Rating Numbers for Different Frequencies

Aircraft	NOISE RATING NUMBERS			
	500 CPs	1,000 CPs	2,000 CPs	4,000 CPs
MYSTERE ..	99	92	94	93
HUNTER ..	95	100	105	118
HF-24 ..	115	115	115	110
GNAT ..	110	114	115	112
CANBERRA ..	118	120	122	124
HJT-16 ..	109	106	113	109
S-22 ..	120	118	114	112
TYPE-74 ..	111	109	106	105
TYPE-76 ..	110	112	110	111
VAMPIRE ..	100	105	119	112

If the maintenance personnel are exposed to noise levels higher than the permissible values as described earlier this can give rise to hearing damage. It is necessary to detect early symptoms of deafness in these individuals. It is a well established fact that the first evidence of noise induced deafness is seen in the Pure Tone Audiometry as a 'dip' at 4,000 cps. At this stage, tests such as whispered voice and conversational voice tests cannot reveal the presence of hearing loss. If the noise exposure is contined the 'dip' will extend to the adjacent frequencies and in course of time, the hearing loss can be detected by voice tests. If noise induced hearing loss is detected early and the person taken off from the noisy environment, there are chances of recovery and the degree of permanent damage is likely to be less; hence the need for a periodic monitoring of hearing of the personnel exposed to noise by pure tone audiometry. However, to be able to recognise the deterioration in hearing due to employment, a base line audiogram is an absolute necessity. Individuals who have suffered damage to their hearing should be moved away from the noise enviornment at least for a period of three months and reassessed as to the degree of recovery. When the recovery occurs, the man is returned to his employment adequately protected and checked periodically to assess his progress. When recovery fails to occur the choice is between remustering or return to work adequately protected. The latter course is justified only in skilled, highly trained personnel and must be accompanied by close and regular supervision to detect further deterioration in hearing. In case of further deterioration he should be remustered in order to preserve him from severe perceptive deafness.

Effect on intelligibility and speech Communication

Maximum noise rating numbers for intelligibility of speech communication are laid down by International Standards Organisation (I.S.O.)[4] for different distances between the speaker and the listener. Maximum noise rating number for a distance of 14 ft. with raised voice level, which should be considered the minimum requirement for briefing rooms and lecture rooms, is 50. A simple method of finding out the noise rating number for this purpose is to subtract 4 dB from the sound level meter reading in the 'A' weighting.

In determining the location of the briefing and lecture rooms, the noise survey data can be used. The sound pressure level (S.P.L.) at a distance of "r" feet from the source is dependent on the power level of the source PWL and the direction factor "Q". This may be represented as

$$SPL = PWL + 10 \log Q - 20 \log r - 10.5 \text{ dB}.$$

The data of the noise survey can be used to find out the direction factor and power level and distances at which the location of briefing/lecture rooms are to be constructed to keep the noise rating number below permissible levels, how the aircraft has to be oriented, where the engines are to be run up so that minimum interference is produced in existing briefing/lecture rooms. However, if the briefing/lecture rooms are situated with noise contours above the accepted values, acoustic treatment of the rooms will be necessary and the degree of noise attenuation required can be easily calculated. The type of acoustic treatment required is dependent on the frequency characteristics of the aircraft noise and is available for the aircraft from the data collected.

Conclusions

(*a*) The survey of noise environment of various types of aircraft with I.A.F. reveals that the maintenance personnel working in the vicinity of the aircraft are exposed to noise levels which are above the maximum permissible limits from the point of view of noise induced deafness.

(*b*) Ear defenders are essential for prevention of noise induced deafness.

(*c*) Ear muff type of ear defenders (at present authorised for jet maintenance personnel) are considered superior to the insert type.

(*d*) It is necessary to develop ear defenders with high degree of low frequency attenuation properties for use in the case of following aircraft:

Mystere
S-22
Type-74
Type-76
HF-24
HJT-16

The data obtained can be used in the location of briefing/lecture rooms and crew rooms.

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