COMMUNICATIONS IN VERY HIGH NOISE ENVIRONMENTS

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Abstract

Sometimes while working in a very high, continuous noise environment regular voice communication may be necessary. One example of such an environment is the run-up area used to test recently serviced, jet aircraft engines before the aircraft is returned to active service. It is typical for the continuous noise in the immediate work area surrounding the aircraft to exceed an A-weighted, continuous sound pressure level, L_{Aeq}, of around 132 dB. Voice communication is unrealistic if not impossible and normal radio communication is limited and difficult. This project addressed this issue with successful results.

Introduction

Attempting to communicate in noise is difficult. More so if the communication is to contain any complexity or to have any meaning greater than the most simple of messages. The difficulty compounds when some form of hearing protectors are required to be worn in order to reduce the noise exposure of affected individuals.

There has been a lot of discussion concerning difficulties with communication in continuous A-weighted noise levels up to around 95 to 100 dB while wearing hearing protectors. There seems to be general agreement that verbal communication is possible, and in many cases enhanced in lower noise levels (< 95 dB) while warning signals are certainly audible and effective [1- 4].

However, great difficulties arise when communication must be intelligible while operators work in very high noise backgrounds, for example greater than a continuous A-weighted level of 110 dB. The need for intelligible and reliable communication has been seriously addressed, for obvious reasons, by the military where background A-weighted continuous noise can easily exceed 120 dB [5,6] and in some cases 150 dB [7].

The US army successfully overcame communication problems in continuous A-weighted noise levels of up to 110 dB [6] through the use of Communications Earplugs (CEPs) and the, relatively poor, attenuation provided by a Combat Vehicle Crewman's (CVC) helmet for both the M1A2 Abrams battle tank and the M2A3 Bradley Fighting Vehicle. The Communication Radio volume could be turned down; there were less communications problems; and speech intelligibility increased significantly.

The current difficulty

In the standard operating procedure for aircraft servicing, before an aircraft can be returned to the flight line after engine maintenance, the engine, while fitted to the aircraft, must be run in a test area to ensure that all systems operate satisfactorily. This entails service personnel working in and around the aircraft with engines operating at full (military, MIL) power and in the case of jet aircraft with the afterburner (AB) operating.

Noise can reach particularly high levels and, in the case of the F-111C, continuous A-weighted levels of over 138 dB have been measured at full AB in the vicinity of the rear of the aircraft. Noise levels at the front of BAe HAWK 127 LIF aircraft are typically 132 dB during MIL power runs which can last up to ten minutes. Typical maximum L_{Aeq}s are shown in *Figure 1.*

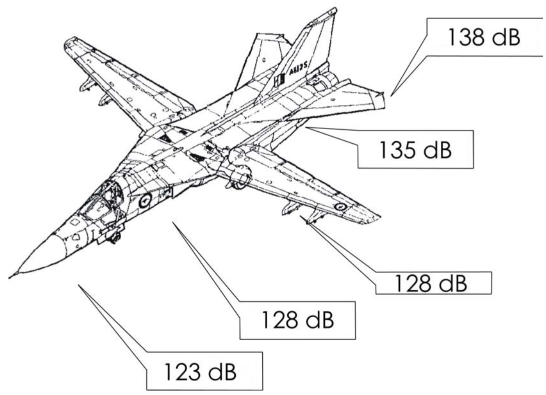

Figure 1
Typical maximum noise levels around an F 111

During this time service personnel are required to move about the aircraft, sometimes into areas sufficiently close to the engines to observe the workings of mechanical linkages. At the same time they are expected to be able to communicate with other ground staff and operation controllers in a reliable and intelligible manner. They must do this while also using hearing protectors in an attempt to keep noise exposure levels below that required by good OHS policy [8], *viz* $L_{Aeq,8h}$ less than 85 dB.

Any solution to the communications problems must occur within the many restrictions that arise when working with and/or around military aircraft. For example, if you wish to communicate with the individual in the cockpit who is operating the controls any equipment that is used must be physically, electrically and electronically compatible with the aircraft and all equipment must be sufficiently secure so that no part can be drawn into the engine or any operating parts.

A solution

The current solution to the communication problem comes in two stages. The first stage is to provide noise excluding communication headsets. Say, that an absolute maximum, these headsets can provide an optimistic 30 dB of reduction of the external noise. Then during times of operation when the external noise is at 120 dB, the operator experiences an equivalent at ear noise level of 90 dB.

For reliable intelligibility the signal-to-noise ratio (S/N) of the communication signal should be at least 5 dB preferably 10 dB, thus the level produced by the earphone, mounted inside the ear cup of the hearing protector must produce a level in the order of 95 dB minimum. This is well above the level recommended by OHS policy [8] of 85 dB. Now the operator is then supplied with earplugs to further reduce the noise level, and so on. With a good set of earplugs offering, say 20 dB of attenuation, this may result in an equivalent at ear level of about 75 dB.

Consider the outside noise that still reaches the ear via bone conduction. This will be attenuated on average by around 40 dB so the external noise that started at 120 dB is reduced to an equivalent at ear level of around 80 dB. This results in an S/N of -5 dB for the operator which is not good for speech intelligibility or communications. Even if we adjust the level of the earphone to the maximum that the 19ohm H-143 military earphone generates this still can only produce an S/N of 2 dB.

The solution is to use the CEP that places the required signal on the inside of the earplug. Then with a plug-muff combination of around 35 dB maximum attenuation the equivalent level of the outside noise at the ear is about 85 dB. The CEP ear piece needs to deliver an equivalent at ear level of 90 dB for reasonable speech intelligibility. For short periods this level of signal should not be damaging.

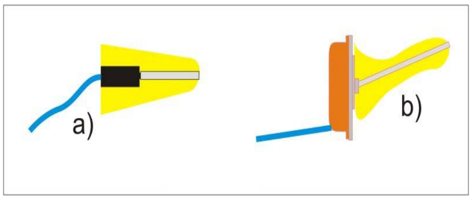

Figure 2

Figure 2 illustrates a CEP with (a) a small sound source within the plug or (b) a magnetic button earpiece.

Figure 3 shows the typical CEP devices with replaceable foam ear plugs.

Figure 3

A typical CEP device with NATO plug and replaceable foam earplugs

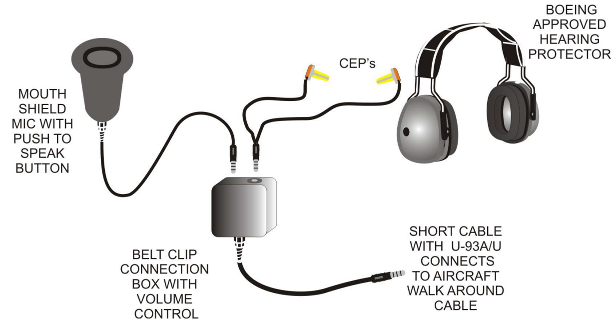

Figure 4

"Kit" for CEP communications with aircraft in engine run-up area

Figure 4 shows the typical communications "kit" for use in an aircraft engine run-up area. The use of personally moulded ear plugs for individual users of the CEP kit is not favored as there are difficulties ensuring that a particular user has their personally moulded plugs with them at the time they are required as the engine run-up area is conventionally located at some distance from normal work areas because of noise problems.

It will be noted that *Figure 4* shows the use of a microphone with a mouth shield rather than the sometimes suggested throat microphone. This is because it was found that a throat microphone has the disadvantage of allowing external noise into the mouth and throat cavity when the mouth is opened to speak. This noise then gets into the microphone and causes noise in the system.

Results

Tests of the proposed CEP communication system were carried out at the engine run-up facilities at RAAF Williamtown, NSW and RAAF Amberly, Qld, during 2003/'04. Operators used the CEPs in conjunction with the RAAF approved ear muffs and carried out a complete test regime in accordance with recognized procedures.

As it would be very difficult if not impossible to carry out an objective test of the new communications we are reliant on subjective measures and the experience of the crew. In most respects this subjective measure is more relevant than objective measures as it encompasses the users and their scale of values.

Comments from the operators indicated that the use of the CEPs under conventional ear muffs allowed for a greater degree of communication as compared to that previously experienced. While background noise was not entirely eliminated, particularly when the afterburner was in use, communications were intelligible and useful. Importantly the operator who must work in the limited area between the two engines when operating at full AB, could communicate with the event controller, hence every one knew what was happening at all times.

Conclusions

The use of a CEP communication system in the particularly noisy process of jet engine aircraft run-up reliability testing has proven to be very successful. It is to be hoped that this successful outcome can be adopted into other areas where communication in extreme noise areas is essential.

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