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OCCUPATIONAL NOISE AND SUBMARINE CONSTRUCTION

S J Clampton

Noise & Vibration Engineering Department (NAVED)
VSEL, Barrow-in-Furness, Cumbria, LA14 1AF
Tel 01229 874473, Fax 01229 874818

ABSTRACT

Noise is an important factor in the life of a submarine. From a military point of view, the control of noise within an operational submarine is essential for its safe and efficient operation. Occupational noise generated during its construction, however, also needs to be controlled so that hearing loss of construction workers can be minimised. This paper discusses aspects of the noise control programme used in the submarine construction industry and how compliance is achieved with noise at work legislation.

1. INTRODUCTION

Although the existence of noise induced hearing loss has been known since the early 18th century, and that shipbuilding was one of the first industries where hearing damage was officially recognised, detailed relationships between hearing loss and the amount of noise exposure to produce this loss only became established relatively recently. By the 1960s it was accepted that long term exposure to noise levels at or above 85 dBA caused permanent loss of hearing in addition to losses due to age related loss, presbycusis.

Many studies of note on this subject have been carried out over the years. Those, for example, by Passchier-Vermeer [1] on people exposed to a range of noise levels for 8 hours a day, for at least 5 days a week, over 10 to 40 years showed how hearing damage increases with increased noise levels for a constant exposure time. Using Figure 1 one can see, for example, that the hearing threshold level at 3k Hz for personnel exposed to a level of 90 dBA over 40 years, is 10 dBA poorer than those exposed to a level of 85 dBA over the same time span.

Other studies by Burns and Robinson [2,3] have shown how hearing thresholds for a given level and exposure time are related to a person's age and susceptibility to hearing loss.

The way in which hearing loss increases with time for a constant level of noise exposure is shown in Figure 2 which is drawn from data by Taylor and Pearson [4,5]. This clearly shows that hearing loss initially occurs in the 4k to 6k Hz frequency range. As the exposure time is increased, so too does the hearing loss which spreads both to higher and lower frequencies. The first handicap that occurs due to hearing loss is usually the inability to hear high pitched sounds.

As hearing loss becomes more acute, then the ability to understand speech becomes affected. Ultimately, the methods to determine hearing loss for occupational exposure have been embodied in international standards [6].

As a result of the investigations just mentioned and other surveys, many countries have proposed that daily (8 hour) exposure levels of 85 to 90 dBA will be the action level for noise control measures to be considered and the wearing of hearing protection recommended [7]. Occupational noise exposure limits in the UK are set out in the Noise at Work Regulations [8].

2. SHIPYARD NOISE SURVEY PROCEDURES AT VSEL

In order to identify which personnel in the shipyard were exposed to high noise levels, a preliminary survey was carried out involving the taking of sound pressure level measurements at selected locations in each work area. Using these levels, and with knowledge of the items of machinery contained within the work areas, a priority list of workshops requiring further surveys was made. As a result, the workshops were placed into three distinct groups: construction areas in which metal working and other noisy activities were carried out for a large proportion of the day, maintenance areas in which noisy activities occasionally took place, and other areas where noisy activities were infrequent or unlikely.

Following the preliminary surveys, a more in-depth investigation was carried out for each area on the priority list which involved taking personal noise dosimetry measurements and further sound pressure measurements at selected locations. Similar surveys were carried out in each type of area, differing only in the number of measurements taken. Examples of a survey in each of the three types of workshop, and a presentation of the results and the acoustic treatments proposed are discussed in the following sections.

3. NOISE SURVEY IN A CONSTRUCTION AREA

The first area considered in this paper is a large assembly workshop where submarine hull units are constructed. A shift system is in operation in this area, and work is carried out 24 hours a day. Seventy two personnel representing 15 different trades had their LEPds monitored using personal noise dosemeters which they wore during their working period. The LEPds of individuals ranged from 76 dBA to 108 dBA and a summary of the results are shown in Table 1. This shows that 14 personnel were exposed to an LEPd below 85 dBA (First Action Level [8]). Of these, 4 were exposed to peak levels at or above 140 dB (Peak Action Level of 200 Pa [8]). As shown 58 personnel were exposed to an LEPd of 85 dBA or above of which 37 were exposed to an LEPd at or in excess of 90 dBA (Second Action Level [8]). Of these 58, thirty three were exposed to peak levels at or above 140 dB.

Each person was also given a form to fill in to give details of which tools/machines they used during the monitoring period, and area of the workshop in which they worked. Overall sound pressure levels were also measured using a hand held sound level meter at 90 locations within the workshop, at different times during the survey and the results are shown in Figures 3 and 4.

The results of the survey showed that the majority of personnel, whose duties required them to be on the shop floor of the workshop, could be exposed to high noise levels. Information from the forms and the sound pressure levels in Figures 3 and 4 identified those personnel who were engaged in noisy activities and received high LEPds or who were regularly exposed to high peak levels (eg. those using grinders, drills, rotary files, and welding and gouging equipment or a combination of these), those who were present in areas of high steady state or peak noise levels at certain times of the day but were not directly involved in noise generating activities (supervisors, cleaners, quality inspectors, etc.), and those who spent most of their time in quiet areas (storekeepers, etc.). As Figure 3 shows, high noise levels occurred even in the absence of intermittent noise sources such as grinding, welding, gouging and hammering. These levels were identified as emanating from extraction fans which were run continually.

As a result of the survey, most of the workshop was formally designated as an Ear Protection Zone according to the Noise at Work Regulations. Appropriate personal hearing protection for everyone in the workshop (shop floor and management) was selected to ensure that assumed protection for the operators of the noisiest tools (in this case high cycle grinders) would be below 90 dBA (Table 2). Similar ear protection was also made available at the entrances to the workshop for visitors to this area.

In addition to providing hearing protection, a training programme involving off the job instruction was also instigated, in accordance with the Noise at Work Regulations, to remind/inform the relevant personnel of the hazards associated with high noise levels, the steps they could take to minimise risk and of the correct use and availability of hearing protection. Routine safety audits to check on the wearing rate of hearing protection have shown that over 90% of personnel in this area are wearing the appropriate protection.

Following the survey, a noise control programme was instigated to carry out the following: to investigate methods to reduce noise from specific tools/machines at source and to ensure that noise emission was considered when purchasing items, investigating fitting silencers and lagging to the extraction fans and to identify those which were not required, fitting localised areas of the workshop with acoustic absorbent material, relocating certain machines and to relocate personnel who had no need to be in areas of high noise levels.

As a result of the noise control programme, various unwanted extraction fans were identified and switched off producing localised reductions in overall noise levels of up to 18 dBA. Trials of cutting metal plate submerged in water rather than in air using plasma arc have resulted in a

localised overall reduction of 20 dBA in the contribution due to this process. Also trials with acoustic screens positioned around some of the larger machines have resulted in localised reductions of 10 dBA.

Although the noise exposure of certain personnel not directly involved in noise generating activities have been reduced, it has proved difficult to reduce the exposure of tools such as grinders, and drills and discussions have been proposed with the tool manufacturers on this subject. In the meantime, machine suppliers are now being asked to provide noise data before items are purchased.

4. NOISE SURVEY IN A MAINTENANCE AREA

The second area considered here is a workshop in which maintenance of various items of plant used in the shipyard was carried out. Thirty three personnel representing 9 different trades had their LEPds monitored and these ranged from 73 dBA to 99 dBA. A summary of the results are shown in Table 3. This shows that 19 personnel were exposed to an LEPd below 85 dBA. Of these 19, five were exposed to peak levels at or above 140 dB. As shown 14 personnel were exposed to LEPds at or above 85 dBA of which 7 were exposed to LEPd at or in excess of 90 dBA. Of these 14, twelve were exposed to peak levels at or above 140 dB.

Overall sound pressure levels were measured at 11 locations within the workshop at different times during the survey. These indicated that levels were generally below 85 dBA except when certain localised items of machinery were operated. From the forms issued to each person at the beginning of the survey, it was found that most personnel who had high LEPds actually spent most of their monitoring period carrying out activities in areas other than the maintenance workshop itself. Of the personnel who remained in the workshop during their monitoring period, only 6 received high LEPds or were exposed to high peak levels. It was found that these persons were occasionally involved in grinding, drilling, or sawing operations or were in the vicinity of such activities during their monitoring period.

At the completion of the survey it was decided that the results did not warrant the workshop being designated as an Ear Protection Zone. It was recommended, however, that personnel should wear appropriate hearing protection when involved in, or located nearby to, processes involving grinding, drilling or sawing. Again, a training and awareness programme was instigated and kit for the job cards (including the use of hearing protection) were issued to the relevant personnel.

The noise control programme for this workshop was concentrated on screening off or enclosing the noisy tools/machines, tagging them to remind the user that hearing protection should be

worn when they were operated, and to investigate the eventual replacement of the machines with quieter units.

5. NOISE SURVEY IN A STORE AREA

The final area considered in this paper is an electrical store area. Six personnel representing 4 different trades had their LEPds monitored and these ranged from 73 dBA to 81 dBA. Overall sound pressure levels were measured at 3 locations in the store at different times during the survey and were all found to be well below 85 dBA.

From the forms given to each person, as expected, no one was engaged in any noise generating tasks of any note since they were involved in storekeeping and general labouring activities and only occasionally used hand tools.

In the light of the results obtained, no noise control treatments were required in this area.

6. CONCLUSIONS

This paper has shown how areas of high noise levels in the shipyard were identified and how noise exposure of the workforce was determined. By identifying the dominant noise sources, appropriate noise control programmes have been instigated, where practical, with the aim of providing relevant acoustic treatments to reduce levels to within limits set by noise at work legislation.

7. REFERENCES

[1] W Passchier-Vermeer, "Hearing Loss due to Exposure to Steady State Broadband Noise" IG-TNO Report 35, Research Institute for Public health Engineering, TNO Delft The Netherlands, 1968

[2] D W Robinson "The Relationship Between Hearing Loss and Noise Exposure" NPL Aero Report AC 32 Teddington, 1968

[3] W Burns, D W Robinson "Hearing and Noise in Industry", HMSO, 1970

[4] W Taylor, J C G Pearson, A Mair, W Burns, "A Study of Noise and Hearing in Jute Weaving", J Acoust Soc Am Vol 38 p113-120, 1965

[5] J C G Pearson, "Prediction of Presbycusis", J Soc Occup Med Vol 27 p125-133, 1977

[6] ISO 1999 "Assessment of Occupational Noise Exposure for Hearing Conservation Purposes", 1975

[7] J R Hassall, K Zaveri, "Acoustic Noise Measurements", Bruel & Kjaer, 1988
[8] Noise at Work Regulations, HMSO, 1989

TABLE 1 CONSTRUCTION AREA RESULTS

	LEPd <85 dBA	LEPd 85-89 dBA	LEPd 90+ dBA
Number of personnel in LEPd range	14	21	37
Number of personnel exposed to peak levels of 140+ dB	4	13	20

TABLE 2 EXPOSURE DUE TO HIGH CYCLE GRINDER

	Sound Pressure Levels dBA								
	Overall	63	125	250	500	1k	2k	4k	8k
Measured level	114	67	79	93	96	108	109	113	104
Assumed protection due to ear plugs	-	21	24	26	29	27	33	41	40
Assumed protected level	83	46	55	67	67	81	76	71	64

TABLE 3 MAINTENANCE AREA RESULTS

	LEPd <85 dBA	LEPd 85-89 dBA	LEPd 90+ dBA
Number of personnel in LEPd range	19	7	7
Number of personnel exposed to peak levels of 140+ dB	5	6	6

FIGURE 1 MEDIAN NOISE INDUCED HEARING LOSS AFTER 40 YEARS AS A FUNCTION OF NOISE LEVEL NR (500-2K Hz) [1]

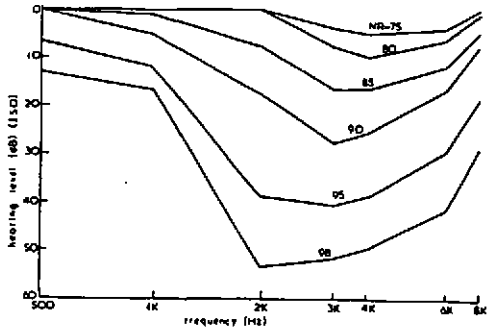

FIGURE 2 DEVELOPMENT OF NOISE INDUCED HEARING LOSS WITH TIME (EXPOSURE LEVEL OF 101 dBA INCLUDING PRESBYCUSIS) [4,5]

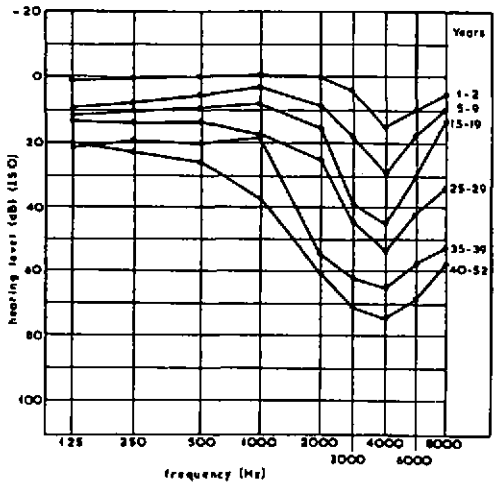

FIGURE 3 SOUND PRESSURE LEVELS IN WORKSHOP WITHOUT INTERMITTENT NOISE

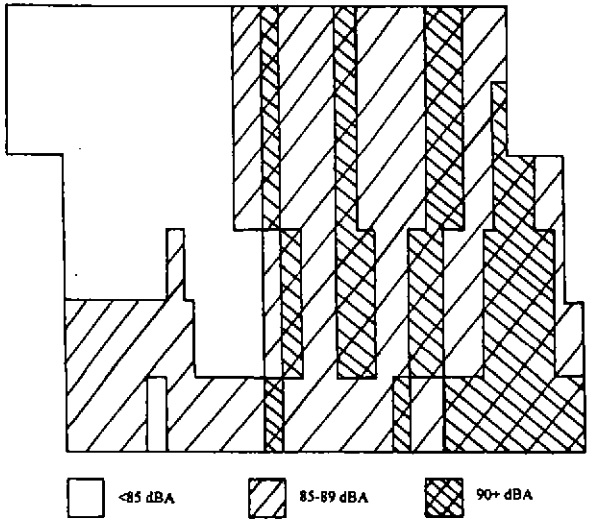

FIGURE 4 SOUND PRESSURE LEVELS IN WORKSHOP WITH INTERMITTENT NOISE