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Investigation of occupational noise exposure in a ship recycling yard

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ABSTRACT

The ship recycling industry is often criticised for unacceptable occupational health and safety practices. In order to support the development of technical solutions and new regulatory norms, there is an urgent need for quantitative data explaining the impacts of ship recycling practices on health and safety. Therefore, this study investigated hazardous noise exposure in ship recycling yards by identifying the sources of noise, quantifying their potential impacts on workers and making recommendations for improvement. A noise exposure investigation in an operational ship recycling yard was conducted, which comprised a general noise survey, a personal noise exposure measurement for workers and comparison of the results with the exposure limits and action values defined by the European Union's Physical Agents (Noise) Directive (EC 2003b). The results of this study show that ship recycling workers are at risk of experiencing occupational noise induced hearing loss as a result of being exposed to hazardous noise levels for prolonged periods of time. This study explains that those working with torch cutting equipment, in particular, are most at risk. The study also shows that there is currently a lack of appropriate hearing protection being used in ship recycling yards.

1. Introduction

Ship recycling is a heavy industry that is primarily performed in developing countries where a demand for scrap metal and second hand equipment is prevalent. In the past, countries such as Taiwan and South Korea were the dominant nations within the industry; at present, India, Pakistan, Bangladesh, China and Turkey possess 98% of the total market share (Mikelis, 2013).

Typical ship recycling operations in the countries mentioned above are labour intensive, and workers have been observed being exposed to a variety of occupational hazards (ILO, 2004; OSHA, 2010) which have unfortunately led to accidents, illness and even death (Wu et al., 2015). Legislative efforts, in the form of the International Maritime Organisation's (IMO) Hong Kong convention (IMO, 2009) (International Convention for the Safe and Environmentally Sound Recycling of Ships) and the European Commission's Ship Recycling Regulation (EC, 2013), are in the process of establishing a framework of improvement. However, a lack of quantified data underpinning the true extent of the unique occupational health and safety challenges within a ship recycling context are hampering efforts.

Through an initial literature review of ship recycling related research, one specific occupational health issue which was identified as requiring attention was the risk of occupational noise induced hearing loss (ONIHL). Exposure to noise can be considered as one of the most common occupational hazard in the world (Bogardus Jr et al., 2003; Ferrite and Santana, 2005; Koh and Jeyaratnam, 1998; Yueh et al., 2003). According to Nelson et al. (2005) occupational noise exposure is considered as a cause for 16% of disabling hearing loss in adults. In a similar study Tak and Calvert (2008) analysed more than 130,000 responses given to National Health Interview Survey in U.S. and concluded that 11.4% of the population experience hearing difficulty, 24% of which is attributable to occupational noise. In the E.U., one study has suggested that 28% of the workers experience high noise levels at work at least one fourth of the time (EASHW, 2000). Many workers engaged in heavy industry, factories, forge hammering, coal and ore mining, construction, cement plants, the gas processing industry and mechanical engineering, as well as mill and stationary machine device operators and workers at oil refineries have been identified as being at risk of ONIHL (Azizi, 2010). Furthermore, besides its direct health effects, there are many studies (Cohen, 1974; Melamed et al., 2004) which show that noise exposure coupled with hearing loss interfere with safety, as 12.2% of accidents can be related to noise exposure (Picard et al., 2008). Ship recycling is a heavy industry and it is suspected that ship recycling workers are being exposed to intermittent or continuous hazardous noise levels (> 85 dB(A)) in their working environments and are subsequently at risk from ONIHL.

At the beginning of this study, it became apparent that no previous studies of noise exposure or ONIHL had been conducted specifically for ship recycling operations. Therefore, studies conducted in other sectors

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as well as shipbuilding and ship repair yards were used as an initial reference point for activities where the use of heavy plant machinery, moving steel plates, and cutting and welding using torches were judged to be of a similar nature to the core ship recycling activities.

Chute (2012) conducted personal noise dosimetry and noise level surveys during selected tasks in four shipyards. The findings showed that out of 30 full shift dosimetry results 43% exceeded the Occupational Safety and Health Administration's (OSHA) Permissible Exposure Limit (PEL) Criteria of 90 dB(A), 73% exceeded the OSHA's Hearing Conservation trigger level of 85 dB(A), and 90% exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) criteria of 85 dB(A).

A study by Toppila et al. (2005) reported that the average noise level observed in a shipyard ranged between 93–95 dB(A). Similarly, research conducted by Kihlman et al. (1976) showed that the average noise level experienced by a welder in a shipyard was 96 dB(A), while a plater was exposed to 100 dB(A) noise level on average. Furthermore, analysis revealed that 41% of the workers had already experienced a slight loss of hearing and 15% had experienced a serious loss of hearing.

Nilsson et al. (1977) conducted a study of 1492 workers in a shipyard which showed that 58.1% of the workers had some level of hearing problem, with 20.4% of the workers being diagnosed as having severe ONIHL. In addition, hearing tests conducted by Ross (1978) on 926 British welders with heavy engineering and shipyard experience showed that in 40–49 year old welders, 70% had a hearing loss at 4 kHz of over 40 dB in the left ear, 60% had the same hearing loss in the right ear, and over 20% had a hearing loss greater than 60 dB.

Finally, more recent research confirms that ONIHL continues to be a problem in shipbuilding and repair related environments. Alexopoulos and Tsouvaltzidou (2015) reported that 27.1% of the employees were hearing handicapped in a study conducted in a shipyard in Greece. A similar study revealed that 6% of the employees of a shipbuilding yard in India had ONIHL (Bhumika et al., 2013).

In summary, the review of literature from analogous industries suggested that the issue of ONIHL was going to be applicable to ship recycling workers and that further investigation was required. Due to commercial and political restrictions, it was not possible to conduct hearing tests to identify the actual impacts on a typical ship recycling workforce's hearing. However, we were able to investigate potential noise exposure generated during realistic ship recycling operations through a dedicated measurement campaign.

2. Material and methods

In order to implement a measurement campaign, access to an operational ship recycling yard was negotiated on the terms that the details of the yard would remain confidential. The yard chosen and its working practices were representative of a typical ship recycling yard. Additionally, the country in which the measurements were made has officially adopted EU's Physical Agents (Noise) Directive (EC, 2003b).

This study was conducted in a manner as close as practicable to the measurement method defined by ISO (9612–2009) Acoustics Determination of Occupational Noise Exposure: Engineering method (ISO, 2009). Fig. 1 presents an overview of the experimental procedure followed within this investigation.

Initially, an overall noise survey of the yard was conducted to identify zones in the yard where occupational noise problems may be present. This survey was carried out using a sound level meter (Bruel Kjaer Hand Held Analyser Type 2250). The sound level meter used was

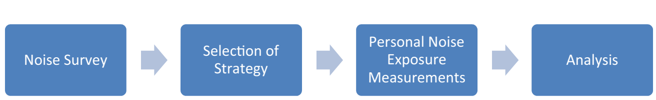

Fig. 1. Experiment methodology overview.

in full compliance with IEC (2003b) 200361672:2003 Type 2, certified as being recently calibrated in accordance with ISO (2005) EN ISO/IEC 17,025 and checked using an acoustical calibrator compliant with IEC (2003a) 200360942:2003 before and after the measurements. The device had an acoustic measuring range of 50 dB(A) to 120 dB(A) Root Mean Square (RMS) with an estimated accuracy of ±2 dB(A). The measuring approach involved taking instantaneous noise measurements at various locations throughout the yard. As far as possible, the device was held at arm's length and at a height which was considered close to an average workers' hearing zone (i.e. 1.6–1.7 m). A wind-shield was used to avoid the effect of the wind. After 30 s of data acquisition, the obtained data were averaged automatically by the device. The values recorded were then mapped onto the ship recycling yard plan in order to visualise the locations where noise levels are close to or exceeding L_{Aeq}. 80 dB(A): The level at which a worker will reach or exceed the lower exposure action value, as defined by the EU's Physical Agents (Noise) Directive (EC, 2003b), if spending up to 8 h in the location of the source of noise.

Following the scanning survey of the field, daily noise exposure of individuals will be conducted by using the most suitable measurement strategy for the ship recycling yard being investigated in this paper. A number of measurement strategies for occupational exposure assessment are listed in ISO 9612-2009 Acoustics Determination of Occupational Noise Exposure: Engineering method (ISO, 2009). These strategies are explained below.

Task-based measurement: This strategy recommends to conduct noise measurements for the tasks which expose a worker to noise, which in turn reduces the measurement time (ISO, 2009). Therefore, before these measurements work should be analysed in order to understand the tasks involved. Task based measurement is appropriate when the worker conduct the tasks, which are well-defined and the noise conditions are well defined (ISO, 2009).

Job-based measurement: In this strategy, a number of random samples of noise exposure is taken during the job. Job-based measurements are relevant when typical work patterns and tasks are difficult to define or not practical to perform a detailed work analysis. While Job-based measurements may lead to less effort for work analysis, actual measurement time for the samples is longer (ISO, 2009).

Full-day measurement: This strategy is recommended when work patterns are not well defined and noise levels, which workers are exposed to, are varying. Full day measurement strategy is useful as it takes into account all the noise contributions within the work environment however the measurement time required is longer than previous strategies (ISO, 2009).

Ship recycling workers investigated in this study have a fairly well-defined singular task, which makes 'task based measurement' strategy a good candidate for this study. However, due to safety concerns the ship recycling yard requested from authors to keep interaction with the worker at a minimum level in order to avoid any potential distraction. By also considering the difficulty to conduct these kind of measurement studies in an operational ship recycling yard, "Full Day Measurement" strategy was selected which is referred as a simpler but longer measurement strategy by Arezes et al. (2012).

For the measurement of exposure, three different worker types were chosen as a target group to cover those roles considered most at risk based on the initial investigation. Three torch cutters, one polygrab operator and one foreman were selected to conduct exposure measurements. More detailed information about selected trades and their job descriptions are provided below.

Torch cutters: In the ship recycling yard torch cutters are the workers who operate oxy-fuel torches to cut the ship's steel into smaller pieces for easy handling and transport (Fig. 6), Torch cutters are generally located in a fixed location and they conduct cutting almost continuously during their 8 h-shift. They are either located on board to cut blocks from the ship or they are located in the secondary zone to cut the steel from the blocks into smaller pieces. The main noise source