

THE EVALUATION OF SANITARY-EPIDEMIOLOGICAL SERVICE CONDITIONS ON A SUBMARINE

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ABSTRACT

Service on a submarine is the most stressful and psychologically challenging form of military service. It is characterised by specific living and sanitary-epidemiological conditions which are far from typical.

This work is based on the analyses of reports formulated from research conducted by a working environment laboratory, and on the control protocols of the sanitary supervision and control team (WOMP) Gdynia, from the Kobben submersible vessels in the years 2014 and 2015. Military Centres of Preventive Medicine hold supervision over Military Units pursuant to generally applicable regulations in the civil environment and standardised NATO norms. Measurements concern the level of noise, mechanical vibrations, chemical agents, electromagnetic radiation, physiochemical and biological water and kitchenware tests. The objective of the research is to evaluate the service conditions on a submersible vessel with regard to sanitary-epidemiological aspects such as exposure to infectious and occupational diseases.

In selected stations, the conducted measurements indicate an increased level of noise, electromagnetic radiation and excess quantities of bacteria colonies on kitchenware.

Keywords: working environment, submarine, electromagnetic radiation, noise, vibrations, chemical agents.

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INTRODUCTION

Seafarers, serving in atypical conditions, are exposed to different hygiene and epidemiological hazards as compared to a regular environment. This is connected with the risk of an occurrence of infectious or occupational diseases in the course of service or upon its completion. Service on a submersible vessel is one of the most stressful and psychologically challenging forms of military service. A submarine constitutes an enclosed, ventilated space with variable temperature and humidity. The temperature inside the hull varies from 15-27 degrees Celsius, whereas humidity from 40 to 70% [1].

Such service involves certain sacrifices, namely: a small social and working area, disruption of circadian rhythm, overpopulation, a lack of the possibility to escape, isolation from the external world and an incapability to contact relatives. These factors are further extended by stress connected with working on costly equipment, in conditions which are far from 'normal'.

Military Centres of Preventive Medicine conduct sanitary-epidemiological supervision over units' subordinate to the Minister of National Defence. Military Units in the Pomeranian and West-Pomeranian provinces, including units of the Navy, fall under the jurisdiction of the Gdynia Centre.

Military Centres of Preventive Medicine hold supervision over Military Units pursuant to generally applicable regulations in the civil environment, and standardised NATO norms. The documents in question are the Regulation of the Minister of Labour and Social Policy as of 18 December 2002 (with regard to detailed principles on permanent or long-term bodily harm, procedure of determination of such a harm and procedure concerning payment of a one-off compensation) and the Regulation of the Minister of Labour and Social Policy as of 29 November 2002 (with regard to the highest permissible zones and levels of harmful agents in working environments).

NATO norms STANAG 1379 and STANAG 2345 regulate the provisions concerning electromagnetic radiation, measurement methods and their norms. Whereas the directive 2004/40/EC as of 29 April 2004 on minimum requirements is concerned with the security and health protection of workers subjected to an exposure to electromagnetic fields. The Polish Central Office of Measures has generated a group of PN ISO documents containing norms regarding harmful working environments and hygiene conditions and defining what constitutes excessive levels. Sanitary factors are specified by art. 20a of the act of 14 March 1985 of National Sanitary Inspection (i.e. Journal of Laws of 2011 No. 212, it. 1263, as amended) and the regulation of the Minister of National Defence as of 14 June 2002 (with regard to organisation and methods of performing tasks by Military Sanitary Inspection (JL.02.97.872)).

HAZARDS

The examination of harmful conditions of a working environment encompasses the control of the level of exposure to:

- noise,
- electromagnetic radiation,
- mechanical vibrations,
- chemical agents.

Noise: with low sound A levels (solmization) - above ca. 55 dB we observe: complaints about noise occurring in intellectual work stations, increased nervous excitability, constant irritation, as well as intellectual difficulties expressed in memory problems, an inability to focus attention, and an impeded ability to assimilate fresh information; in the case of higher sound A levels (up to ca. 75 dB) noise works mainly as a stressor, which may cause violation of the system of biological balance, moreover this type of noise hinders sound reception and identification (e.g. communication), prolonged exposure to high levels of sound A (above 80 dB) may cause hearing impairment. In the case of very high levels of sound A (above 115 dB), noise may lead to hearing impairment even with very short exposure times [2,3].

In the initial period of exposure, high-intensity noise induces a permanent loss of ability to hear quieter sounds, and in later periods occupational deafness manifested as an inability to hear loud sounds, e.g. speech. Initial symptoms of an excessive exposure to noise include fatigue, difficulty in focusing attention, orientation disturbances, irritability, increased blood pressure, headache and vertigo, temporary or permanent hearing impairment, and tinnitus.

A long-term exposure to noise may also manifest itself in system and organ disorders. Possible side-effects include arterial hypertension, cardiac dysrhythmia, moderate anaemia, elevated OB and eosinophilia, increased gastric secretion, hyperactivity of adrenal glands, hyperthyroidism, increase in intracranial pressure, changes in EEG curve, weariness, irritation, quarrelsomeness, anxiety and fear, attention impairment, disturbances and difficulties to have a complete and peaceful rest and sleep. Problems with sleep also seem logical [2,3,4,5,6].

In people exposed to general vibration we observe changes in the motion system, central and peripheral nervous system, impairment of sensory organs (balance, hearing, sight), as well as disturbances of the alimentary tract and, in females, in the reproductive system.

Mechanical vibrations are low-frequency acoustic vibrations spreading through solids and transmitted to a worker's organism through a part of his body that remains in direct contact with a vibrating object (source of vibration). In other words, vibration is a physical phenomenon characterised by oscillations of material points depending on their acceleration and frequency.

Vibration white finger is a syndrome encompassing non-specific changes in the vascular, nervous, and osteo-articular systems caused by the impact of mechanical vibrations on a human organism. The source of vibration may be general or local. Local sources are related to working with power tools such as a drill or a pneumatic hammer, whereas general sources include different means of transport. The period which needs to elapse from an occurrence of initial symptoms to the diagnosis of vibration white finger extends from 1 to 3 years [7,8].

The chemical agents examined by WOMP as a hazard to a working environment are gasoline and carbon dioxide. Inhalation of dangerous chemical substances constitutes the most common type of an exposure in occupational conditions [9].

The symptoms of gasoline poisoning resemble typical toxicological symptoms. These include gastro-

intestinal, vascular symptoms, damage to skin, and mucous membranes. Inhalation of dangerous chemical substances constitutes the most common type of an exposure in occupational conditions [10,11].

Onboard a vessel, the radio transmitters and receivers are the main source of electromagnetic radiation. An elevated risk of leukaemia is observed in both radio amateurs and military personnel involved in operating radio communication equipment. It is also suspected that magnetic field networks don't just act as carcinogens to the human organism, but may cause other forms of harm e.g. on the central nervous system – amyotrophic lateral sclerosis and Alzheimer disease, whilst from the cardiovascular system we see increased risk of death due to arrhythmia or myocardial infarction, an increase in the percentage of individuals with an elevated arterial pressure and disturbed day-night blood pressure regulation, and an increase in the risk of a disturbance of heart rhythm disorders or reproductive functions. Dermatological symptoms include skin redness, tingling sensation on the surface of the skin, and a localised sensation of warmth or overheating [12].

Others factors which are undoubtedly present in the environment of a submersible vessel are micro-organisms. Among them there are such bacteria as *Legionella*, *Pseudomonas* and *E. coli*. The bacteria species examined by WOMP colonise ventilation shafts, water pipelines and lavatories. A closed-circulation system transmits droplets carrying bacteria which go on to colonise the airways and skin; bacteria from the group of streptococci and staphylococci. These bacteria mainly colonise the airways. Some of them may produce skin inflammation or be the cause of complications after an injury.

Preventive measures include the testing of water intended for consumption on board. Seafarers are ensured an unrestricted access to running water due to desalinating systems, however, the requirement to maintain silence in the course of the submarine's movement imposes bathing prohibitions. Due to hygiene reasons, the only person that is allowed to shower on a daily basis is the cook.

Water tests are performed with regard to its physiochemical and biological properties.

The most important part of water purity tests, from the diagnostic point of view, is the test for *Escherichia Coli*. In sanitary water and food examinations, it is treated as bacteria indicative of faecal contamination, and the possible presence of pathogenic micro-organisms. The presence of at just one single bacteria in potable water is perceived as an indicator of faecal contamination and water is deemed unfit for consumption. *Escherichia Coli* is an ubiquitous micro-organism. It is chronically present in the large intestine of a healthy person. Its pathogenic strains are enterotoxins (ETEC) responsible for travellers' diarrhoea, the enterohaemolytic strain (EHEC) causing haemorrhagic diarrhoea and haemolytic uraemic syndrome, and the enteropathogenic strains (EPEC) being responsible for diarrhoea. Gram-positive enterococcus bacteria belonging to the group of Streptococci (*E. Faecalis* and *E. Faecium* subspecies) are natural constituents of the bacterial flora of the intestines and oral cavity. These bacteria are characterised by low pathogenicity and are responsible for inducing opportunistic infections, urinary infections and endocarditis [13,14].

Pseudomonas aeruginosa is a gram-negative

bacillus capable of pigment production, primarily aerobic but capable of growing in anaerobic conditions. The risk of infection in the case of seafarers of a submersible vessel occurs during immunity disturbances following injuries such as burns, whereas for the general population those enduring tumours, neutropenia, diabetes, or the insertion of catheters and endotracheal tubes are at risk. The bacteria causes inflammation of airways, skin, soft tissues, urinary tract and the outer ear [13,14].

PREVENTIVE MEASURES

Sanitary supervision is responsible for physiochemical and biological water testing, control of vaccination and medical care of seafarers, equipment and medical supplies storage, condition and access to lavatories and food storage facilities.

Noise emission measurement methods in working stations are specified by PN-N-01307:1994. The quantities which define noise with regard to hearing protection include: – noise exposure levels referring to an 8-hour working time and the corresponding daily exposure, or a noise emission level referring to weekly working times and their corresponding exposure, – maximum sound A level, – sound C peak level (solmization) [13].

In this case, the following levels are determined for each activity occurring during the time of work: – weighted sound A level, – maximum A sound level, – peak C sound level during a 30-minute exposure. The assessment of noise exposure is conducted by comparing values, which define the noise level at a working station, with allowable values provided in the aforementioned regulations (tab.1) [13,14].

Onboard a vessel, along with an intensification of a chronic acoustic injury we observe the synergistic action of harmful chemical compounds (organic solvents, heavy metals, gases, pesticides) [6].

Noise level was evaluated with the use of a Svan 945 analyser by measuring the maximum sound A level – norm of 115dB; Maximum sound A level in the period of 8 hours LA max – norm up to 80 dB/8h; Peak sound C level C Lc peak up to 135dB.

Tab. 1

Noise level in particular working stations.

Position	Lex8h	Lamax	Lcpeak
Commander	56.5	63.2	91.9
Deputy commander	56.5	63.2	91.9
Chief petty officer	56.5	63.2	91.9
Operational sector commander	56.5	63.2	91.9
Navigation division commander	56.5	63.2	91.9
Junior technician of the navigation department	56.5	63.2	91.9
Underwater weapons division commander	56.5	63.2	91.9
Junior technician of underwater weapons division	56.5	63.2	91.9
Communications division commander	56.5	63.2	91.9
Senior operator of hydroacoustic group	56.5	63.2	91.9
Junior operator of hydroacoustic group	56.5	63.2	91.9
Consumables division commander	99.5	118.3	134.4
Senior technician of main propulsion division	99.5	118.3	134.4
Independent operator of main propulsion division	99.5	118.3	134.4
Electromagnetic division commander	99.5	118.3	134.4
Electromagnetic division technician	78.1	85.3	105.3
Independently operator of electromagnetic division	78.1	85.3	105.3
Senior operator of electromagnetic division	78.1	85.3	105.3

Exceeded limits were noted in the case of the working stations of consumables division commander, senior technician of main propulsion division, independent operator of main propulsion division, electromagnetic division commander.

Mechanical vibrations were estimated with the use of mechanical vibration meter SVAN SV 106 with SV

38V vibration transducer. The corrected values of vibration acceleration in x, y, z directions are the basis in the determination of sums of vector vibration acceleration (fig. 1). The measurements are contained in table 2.

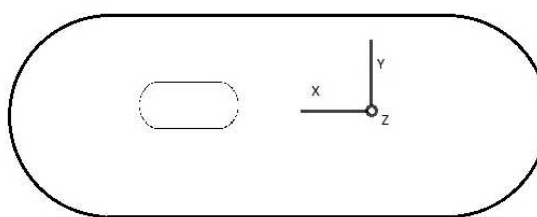


Fig. 1. Mechanical vibration deflection curve with regard to the vessel's directions.

In a 30-minute exposure the intensity of mechanical vibrations should not exceed 3.2 m/s^2 . Thus, mechanical vibrations do not pose a health hazards for seafarers.

Tab. 2.

Acceleration of material points in different directions in relation to the vessel (with reference to figure 1).

Commander	x	0.0044
	y	0.0066
	z	0.0126
Deputy commander	x	0.0044
	y	0.0066
	z	0.0126
Chief petty officer	x	0.0044
	y	0.0066
	z	0.0126
Operational sector commander	x	0.0044
	y	0.0066
	z	0.0126
Navigation division commander	x	0.0044
	y	0.0066
	z	0.0126
Junior technician of the navigation department	x	0.0044
	y	0.0066
	z	0.0126
Underwater weapons division commander	x	0.0044
	y	0.0066
	z	0.0126
Junior technician of underwater weapons division	x	0.0044
	y	0.0066
	z	0.0126
Communications division commander	x	0.0044
	y	0.0066
	z	0.0126
Senior operator of hydroacoustic group	x	0.0044
	y	0.0066
	z	0.0126
Junior operator of group e	x	0.0044
	y	0.0066
	z	0.0126
Consumables division commander	x	0.0044
	y	0.0066
	z	0.0126
Senior technician of main propulsion division	x	0.0044
	y	0.0066
	z	0.0126
Independent operator of main propulsion division	x	0.0044
	y	0.0066
	z	0.0126

Tab. 2. cont.

Acceleration of material points in different directions in relation to the vessel (with reference to figure 1).

Electromagnetic division commander	x	0.0044
	y	0.0066
	z	0.0126
Electromagnetic division technician	x	0.0044
	y	0.0066
	z	0.0126
Independent operator of electromagnetic division	x	0.0044
	y	0.0066
	z	0.0126
Senior operator of electromagnetic division	x	0.0044
	y	0.0066
	z	0.0126

Chemical agent measurements were performed with the use of a Two-met Dräger device with CMS aspirator. It examined gasoline and carbon monoxide levels in the atmosphere. Measurement results are presented in table 3.

Tab. 3

The concentration of chemical agents in vessel' atmosphere NDS - highest allowable concentration.

	NDS	Temporary NDS	Measurement
gasoline	300	900	20.3
CO	23	117	1.43
mg/m ³			

Electromagnetic radiation measurements indicate a hazard zone up to 25 cm from XK-2100L and RT1217 V5 radio station masts – ca. 25 (A/m)²h, 0.25 (V/m)²h with allowable doses (results are presented in table 4.):

Allowable emission dose for magnetic radiation
[E] 20.48 (A/m)²h.

Allowable emission dose for electric radiation
[H] 0.053 (V/m)²h.

Tab. 4

Electromagnetic radiation level in particular working stations.

Measurement line	E	H
Operator	3	0.008
Helmsman	3	0.008
Radar operator	3	0.008
Engineer Officer	3	0.008
Navigator	2	0.0053
Operator	3	0.008
Electrician	2	0.0053
Motorman	4	0.0107
Watch Officer	16	0.042
Mess	1	0.0026

Tab. 4. cont.

Head office bow	2	0.0053
Head office stern	2	0.0053
Power plant	3	0.008
15cm from XK-2100L/I antenna mast	20	0.053
15cm from XK-2100L/II antenna mast	25	0.066
15cm from RT-1217V antenna mast	98	0.26
25cm from RT 1217V antenna mast	65	0.017
Deck bow	20	0.053

The watch officer's position is characterised by the highest radiation dose; however it does not exceed the specified limit. Bacteriological water testing allows determination of total bacteria count as well as quantities of particular bacteria species. These include Coli, E. Coli, Enterococci and Pseudomonas aeruginosa. (tab. 5).

Tab. 5

Bacteria colonies count in water sample.

Water quality index	bacteria count
total bacteria count (36° C, 48h)	27
Coliform bacteria	0
E. coli	0
Enterococci	0
Pseudomonas Aeruginosa	0
colony count (22° C, 72h)	>300

Additionally, tests are conducted with regard to bacteria colonies present on kitchenware (tab. 6).

Tab. 6.

Bacterial colonies on kitchenware (norm up to 100 cfu).

Tested element	Total number of micro-organisms
soup plate	4 cfu
dinner plate	5 cfu
red knife	> 100cfu
green knife	3 cfu
dessert plate	1 cfu
dinner plate	2 cfu
yellow knife	2 cfu
consomme dish	2 cfu
brown knife	>100 cfu
dessert plate	7 cfu

DISCUSSION OF RESULTS

A submersible vessel is an environment of an increased risk of an occurrence of infectious and occupational diseases.

The conducted tests, with regard to occupational exposure, define noise emission as the most harmful condition in this working environment. The risk of an occurrence of occupational diseases in particular working

stations is reduced by the use of hearing protection. There exists an elevated level of exposure to electromagnetic radiation. Mechanical vibrations constitute a factor which does not pose a threat to seafarers with regard to their health.

What is worth considering is a colony growth test. Improper disinfection may lead to the spread of infectious diseases in the alimentary tract, resulting from the growth of other colonies than those tested, which

should convince seafarers of submersible vessels to strictly observe hygiene regulations.

It is necessary to conduct distant tests concerning the effect of the conditions of the working environment and hygiene on seafarers' health status upon service completion, as well as concerning the seafarers' attitude to service and its effect on them. It is a fact that seafarers' state of health requires systematic monitoring.

CONCLUSIONS

The exceeding of noise emission limits were noted in the working stations of the consumables division commander, senior technician of main propulsion division, independent operator of main propulsion division and electromagnetic division commander.

The highest radiation level, on the other hand, was observed in the watch officer's station located nearest to the radio station masts. Along with distance reduction, the level of exposure grows.

With consideration to the health status of seafarers, submersible vessels create a moderately high risk. It is necessary to regularly examine seafarers and implement long-term preventive and treatment programmes evaluating their health conditions upon service completion.

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