

Analysis of regulative documents in the field of human vibration safety

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Abstract. A number of medical research has demonstrated the negative impacts of vibration on human health, therefore, the development of regulatory documents in the field of vibration is a topical issue for the protection of employees' health. The analysis of the cancelled regulatory documents in the Republic of Kazakhstan and are currently in force setting the maximum available levels of vibration characteristics has been carried out. The legislative frameworks governing the sanitary regulation of industrial vibration in a few nearby and distant nations were investigated. This document includes conclusions about Republic of Kazakhstan's current state of affairs on the hygienic regulations pertaining to human vibration safety are concluded and given.

Keywords: general and local vibration, vehicle, neurovegetative, separate, hygienic laws, epidemiological requirements.

1. Introduction

It was proven that vibration has a negative impact on human health. Depending on the nature of the worker's contact with vibrating equipment, there are general vibration, transmitted through supporting surfaces to the body of a sitting or standing person and local vibration transmitted through the limbs of the arms and legs.

The functional changes in the central and peripheral nervous system are noted under the general vibration impact, they are manifested in the form of unsystematized dizziness, rapid motion sickness, and nausea. Vibration easily spreads through the bones of the skeleton. The vibration energy is extinguished in ligaments and cartilaginous structures, causing dystrophic changes in the joints of the limbs resulting in osteochondrosis of the lumbosacral region of the spine. This disease is frequent among tractor drivers and heavy vehicle drivers. General and jerky vibration negatively affects the female genital area [1].

High-intensity vibration with a vibration velocity of more than 1 m/s is a traumatic factor. Due to its action, injuries are possible even ruptures of muscles and internal organs. Prolonged exposure to lower intensity vibration results in pathological alterations in the brain regions that control pain and tactile sensitivity, which can cause a range of neurovegetative and dystrophic changes in internal organs. Vibration in the range of 100-250 Hz affects the rheological properties of blood, reducing its characteristic viscosity; this applies to a greater extent to local vibration [2].

The vibration diseases classification was made based on the effects of both general and local vibration, based on a number of research. It is proven that vibration illness results in internal organ pathology and can harm the chewing mechanism. Then can develop such major dental diseases, such as carious processes, inflammatory periodontal diseases, and disorders of the tongue, lips, and oral cavity's mucous membranes [3, 4].

Regarding the aforementioned, one of the most pressing concerns for worker health protection is the prevention of vibration's harmful effects. This is achieved mainly through the creation of regulatory documents that set acceptable values and techniques for assessing vibration

characteristics, such as the unique GOST SSBT (System of Occupational Safety Standards).

The work aims to conduct a comparative analysis of different nations' methods to general vibration regulation and the current status of the Republic of Kazakhstan's vibration regulatory framework.

2. Methods

GOST 12.1.012 – 78 “Vibration” and later the interstate standard GOST 12.1.012 – 90 “Vibration safety. General requirements” [5, 6] set the categorization and hygiene standards of vibration during the USSR's existence. According to these guidelines, the general vibration is separated into three groups based on where it originates:

1) Transport vibration affecting operators of mobile machines and vehicles when they move across terrain, agricultural backgrounds and roads (including during their construction).

2) Transport and technological vibration affecting operators of machines with limited movement only on specially prepared surfaces of production premises, industrial sites and mine workings.

3a) Technological vibration affecting operators of stationary machines or transmitted to workplaces that do not have sources of vibration.

The standard [6] added the following category:

3b) Vibration in the workplaces of mental workers and personnel not engaged in physical labor.

These standards also provide standardized parameters and methods for hygienic assessment of vibration using the frequency and integral method for local vibration and all categories of general vibration.

The interstate standard “Vibration safety” GOST 12.1.012-2004 is currently in effect in the territory of the Russian Federation, Belarus, Kyrgyzstan, Moldova, Tajikistan, Armenia, and Uzbekistan in addition to the Republic of Kazakhstan. “General requirements,” which reflects the vibration safety concept embraced by the European Union (EU) and other developed nations, state that the machine's manufacturer is in charge of disclosing any features that directly affect the circumstances surrounding the machine's safe use [7].

This is included in the terminology of GOST 12.1.012-2004, wherein generic and local vibration definitions are provided, and instead of the classification of general vibration, the following definitions are given:

– Type 1 machine: A machine can transfer vibration to the human body while in use. (Grinding machine, excavator).

– Type 2 machine: A machine can cause vibration to the human body through mechanical connections and/or other sorts of connections, even when it is not in contact with the body during regular operation. (Compressor for supplying compressed air in a trolleybus, turbogenerator in the engine room).

– Vibration-isolating product of type 1: A product that is not a source of vibration but is used in accordance with its intended purpose in such a way that vibration from machines of type 1 is transmitted through them directly to the human body (seat in the cabin of an electric train, vibration-isolating gloves).

– Vibration-isolating product of type 2: A product that is not a source of vibration and is not in contact with the human body under normal conditions of use but is intended to attenuate vibration from machines of type 2 (elastic fan supports, flexible inserts in the pipeline).

Operational documentation provides details regarding the vibration properties of a machine or vibration-isolating equipment. If, under all operating modes and typical use conditions, the maximum total root-mean-square value of the corrected vibration acceleration does not exceed 0.5 m/s^2 for local vibration and 0.1 m/s^2 for general vibration, then the machine is not considered vibration-hazardous. It's possible that the vibration characteristics of these equipment are not declared or verified.

Stated differently, GOST 12.1.012 regulated “hygienic vibration standards” prior to 2004. These standards consider the intensity and severity of labor when evaluating human health when exposed to vibration, and they rule out the possibility of vibration disease. Currently, this GOST regulates “Technical Vibration Standards”, that set acceptable vibration characteristics values for different types and groups of machines based on the current vibration level that this type of equipment can achieve [8]. Many interstate norms that are in effect in Kazakhstan, such as GOST 12.1.049-86 “System of Occupational Safety Standards”, support this standard. Vibration. Techniques for measuring self-propelled wheeled road construction machines during work, GOST 12.4.095-80 “Occupational Safety Standards System”. Self-moving farm vehicles. Methods for determining vibration and noise characteristics, GOST 16519-2006 “Vibration. Determination of parameters of vibration characteristics of manual and manually operated machines. General requirements”, etc.

It is necessary to point out that the classification of general vibration and sanitary vibration standards for all categories were given in the Sanitary Standards of Workplace Vibration *No. 1.02.012-94 signed by the Chief State Sanitary Doctor of the Republic of Kazakhstan A.G. Dernov dated 08/22/1994. Moreover, the general vibration of category 3 – technological was divided into the following types according to the place of action:

- a) At the permanent locations of businesses’ industrial buildings.
- b) In areas used for work in warehouses, canteens, duty rooms, service rooms, and other industrial buildings without any vibrating machinery.
- c) At offices, design bureaus, training facilities, computer centers, health facilities, plant administration buildings, workrooms, and other locations for mental health professionals [9].

Table 1. Sanitary standards for vibration category 3 - technological type “b” in accordance with SN *No. 1.02.012-94

Geometric mean frequencies of bands, Hz	Acceptable values for axes X_0, Y_0, Z_0							
	Vibration acceleration				Vibration velocity			
	m/s (2)		dB		m/s 10^{-2}		dB	
	1/3 Oct.	1/1 Oct.	1/3 Oct.	1/1 Oct.	1/3 Oct.	1/1 Oct.	1/3 Oct.	1/1 Oct.
1.6	0.0125		82		0.13		88	
2.0	0.0112	0.02	81	86	0.089	0.18	85	91
2.5	0.01		80		0.063		82	
3.15	0.009		79		0.0445		79	
4.0	0.008	0.014	78	83	0.032	0.063	76	82
5.0	0.008		78		0.025		74	
6.3	0.008		78		0.02		72	
8.0	0.008	0.014	78	83	0.016	0.032	70	76
10.0	0.01		80		0.016		70	
12.5	0.0125		82		0.016		70	
16.0	0.016	0.028	84	89	0.016	0.028	70	75
20.0	0.0196		86		0.016		70	
25.0	0.025		88		0.016		70	
31.5	0.0315	0.056	90	95	0.016	0.028	70	75
40.0	0.04		92		0.016		70	
50.0	0.05		94		0.016		70	
63.0	0.063	0.112	96	101	0.016	0.028	70	75
80.0	0.08		98		0.016		70	
Adjusted and equivalent adjusted values and their levels		0.014		83		0.028		75

The Decree of the Government of the Republic of Kazakhstan No. 168, dated January 25, 2012, signed by the Prime Minister of the Republic of Kazakhstan, K. Masimov, also provided the norms of spectral indicators of the vibration load on the worker, depending on the duration of

vibration exposure for all categories of general vibration [10]. The normalized values of vibration acceleration were given depending on the duration of vibration exposure with a time step of 5-30 minutes for an eight-hour workday, making this Resolution the most progressive in the field of normalization of spectral parameters of vibration load, it should be noted. In contrast, CH*No. 1.02.012-94 set the maximum permissible values of the normalized parameters. The highest acceptable values for the normalized vibration parameters in places of employment where workers have been exposed to vibration for 480 minutes (8 hours).

Only the maximum allowable values of the normalized parameters of technological vibration type “b” in compliance with CH*No. 1.02.012-94 and the Decree of the Government of the Republic of Kazakhstan No. 168, dated January 25, 2012, are provided in Tables 1 and 2 for comparison.

In 2015 Resolution of the Government of the Republic of Kazakhstan No. 168 became invalid in connection with the release of Order No. 169 signed by the Minister of National Economy of the Republic of Kazakhstan E. Dosaev [11], wherein not only no definitions but even mentions in the field of vibration, in addition, this order is not without, in our opinion, unjustified increases in normative equivalent sound levels for train drivers and contains outright blunders [12, 13]. Unfortunately, we have to state that the current order of the Minister of Health of the Republic of Kazakhstan dated February 16, 2022, No. KR DSM-15 [14], duplicates Order No. 169 of the Minister of National Economy of the Republic of Kazakhstan with all these shortcomings. Sanitary standards for workplace vibration *No.1.02.012-94 also became invalid by Order No. 1 of the Chief State Sanitary Doctor of the Republic of Kazakhstan dated May 12, 2017.

As a result, the Republic of Kazakhstan does not currently have a single regulatory document that would define and classify the categories of general vibration or provide acceptable values of characteristics for different categories of vibration.

A review of the hygienic laws governing industrial vibration in China, the USA, the EU, and Russia can be found in [15]. Simultaneously, it is demonstrated that the level of advancement in hygienic management of the vibration component in the workplace differs greatly between nations. Despite the fact that Directive 2002/44/EC establishing minimum requirements for vibration safety is in force in the EU countries, it does not restrict the States that have ratified it in setting their own stricter maximum permissible vibration levels (MPD). For example, in Finland, the Decree of the State Council on the Protection of Workers from the harmful effects of Vibration of February 27, 2005 VNa 48/2005 is in force, and in Germany VDI 2057 of September 2001, Part 1. The effect of mechanical vibration on humans. General vibration.

The impacts of industrial vibration are not regulated by standards in the United States, unlike in Europe. However, the Association of State Industrial Hygienists (ACGIH), a non-legislative group, has established several standards that are merely advisory.

The regulatory values of remote control in non-CIS countries are presented in Table 2.

3. Results

It turns out that the differences in overall vibration based on the source of the vibration are not taken into consideration by the vibration regulations in the EU, USA, and China. It can be assumed that the classification of general vibration is no longer relevant with the introduction of the interstate standard GOST 12.1.012-2004 “Vibration safety. General requirements”, which reflects the concept of vibration safety adopted in the EU countries. However, SanPiN 2.2.4.3359-16 is in effect in the Russian Federation, and the Republic of Belarus has a hygienic standard “Indicators of safety and harmlessness of vibration exposure to humans”, which gives acceptable values of characteristics for various categories of general vibration as well as all necessary terms and definitions [16, 17]. It should be mentioned that workers' psychophysiological and functional states are more affected by the combined effects of categories 1 and 2 general vibration. According to data from the source [18], there are discernible differences between the indicators of driver-operators who are exposed to both transport and transport-technological vibration and drivers of

freight transport who are only exposed to transport vibration. These differences include the following:

- The level of simple visual-motor reaction of driver-operators after a work shift is significantly higher ($p = 0.04$) than that of truck drivers.
- The level of functionality after a work shift among truck drivers is higher ($p = 0.04$) than among operator drivers.
- Driver-operators have more advanced reactions in response to a moving object both before the work shift ($p = 0.02$) and after the work shift ($p < 0.01$) than truck drivers.
- Delayed reactions after a work shift are greater ($p < 0.01$) among truck drivers, compared to this indicator among driver-operators after a work shift.
- The average reaction time according to the “noise immunity” method for driver-operators before ($p = 0.03$) and after ($p = 0.04$) a work shift is lower than this indicator for truck drivers.

Table 2. Standard values of MPL in non-CIS countries [15]

Country	General vibration			Local vibration		
	Exposure time	Standard equivalent adjusted values and vibration acceleration levels		Exposure time	Standard equivalent adjusted values and vibration acceleration levels	
		m/s ²	dB		m/s ²	dB
Directive 2002/44/EC Belgium, France, Spain	8 hours	1.15	121	8 hours	5.0	134
	Warning threshold	0.5	114	Warning threshold	2.5	128
Finland	8 hours	1.15	121	8 hours	5.0	134
	Warning threshold	0.5	114	Warning threshold	2.5	128
	Temporary maximum values	7.0	137	Temporary maximum values	35	151
Germany	8 hours	0.8	118	8 hours	5.0	134
	Warning threshold	0.5	114	Warning threshold	2.5	128
	No more than 30 days per year	0.8-1.15	118-121	–		
USA	8 hours	0.315	110	0t 4 to 8 hours	4.0	132
	4 hours	0.53	114	0t 2 to 4 hours	6.0	136
	1 hour	1.18	121	0t 1 to 2 hours	8.0	138
	16 minutes	2.12	126	Less than an hour	12.0	141
China	Not standardized (GBZ 2/2-2007)			8 hours	5	134

As previously said, there isn't a single regulatory document in the Republic of Kazakhstan that specifies the categorization and upper limit of general vibration. However, the permissible values of general vibration parameters are given in the following regulatory documents for certain types of transport: interstate standards GOST 31428-2011 “Shunting diesel locomotives with electric transmission”, GOST 31187-2011 “Line-line diesel locomotives”, as well as the Order of the Minister of Health of the Republic of Kazakhstan dated January 11, 2021 No. KR DSM-5. “Sanitary and epidemiological requirements for vehicles for transporting passengers and cargo,” which provides permissible values of vibration parameters in the cabins of various types of transport [19].

It should be mentioned that Order of the Minister of Health of the Republic of Kazakhstan dated January 11, 2021 No. KR DSM-5 has several problems because it lacks fundamental

technical literacy and terminology in the field of vibration. For instance, Table 1 of Appendix 16 shows “Vibration parameters in the cabin of trucks”, where the permissible values of vibration velocity 1/3 octaves are measured in m/s^2 , while 1/1 octaves are not measured at all, in Fig. 2. Appendix 9 of this order shows the “Maximum permissible values of vibration acceleration in the locomotive cabin”, which are measured in m/s , in Fig. 1. While vibration acceleration, like acceleration, is measured in m/s^2 , vibration velocity, like simply speed, is measured in m/s . This list of general vibration categories is not mentioned.

Appendix 16 to the Sanitary Rules
 "Sanitary And Epidemiological
 Requirements For Vehicles For The
 Transportation of Passengers And Goods"

Vibration parameters in the cab of trucks

Average geometric frequency bands, Hz	Vibroacceleration values, m/s		
	Floor in utility room, workplace in equipment room		Shelves for lying and sitting
	Vertical direction	Horizontal direction	Vertical and horizontal direction
1	2	3	4
1,6	0,50	0,224	0,18

Fig. 1. Maximum vibration acceleration values that are allowed by Republic of Kazakhstan Health Minister Order No. KR DSM-5, issued January 11, 2021

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 Transportation of Passengers And Goods"

Vibration parameters in the cab of trucks

#	Average geometric frequency bands, Hz	Acceptable vibration velocity values						
		m/s^2		In1/1oct.		DB		
		In1/3 oct.				In1/3 oct.		In1/1 oct.
		Z0	X0Y0	Z0	X0Y0	Z0	X0Y0	Z0
1	2	3	4	5	6	7	8	9
1.	0,8	0,71	0,224			6575		
2.	1,0	0,63	0,224	1,12	0,4	6657	71	6

Fig. 2. Permissible values of vibration velocity in accordance with Order of the Minister of Health of the Republic of Kazakhstan No. KR DSM-5

4. Conclusions

The Republic of Kazakhstan's interstate standards, according to a review of them, are primarily concerned with the “technical standardization” of vibration safety criteria. Internal regulations govern “hygienic vibration standards” in post-Soviet nations. Global experience demonstrates that domestic regulations are typically far more stringent than widely recognized interstate regulations, especially when it comes to worker protection and vibration. This is because one of the most significant tools of state policy for labor protection and the health of the working population is the implementation of hygienic standards.

It should be noted that until 2015, Kazakhstan had a fairly strong and advanced regulatory framework in the field of vibration safety, but currently the Republic of Kazakhstan has a very weak internal regulatory framework in the field of vibration. Due to the lack of clear terminology and a unified regulatory document in the field of vibration, the System of Occupational Safety Standards in the Republic of Kazakhstan suffers.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of interest

The authors declare that they have no conflict of interest.

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