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<https://doi.org/10.26641/2307-0404.2019.1.162315>**U.B. Lototska-Dudyk****HARMFUL OCCUPATIONAL FACTORS
OF SHOE PRODUCTIONS:
NOISE AND VIBRATION**

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Ключевые слова: обувное производство, производственные факторы, условия труда, шум, вибрация

Abstract. Harmful occupational factors of shoe productions: noise and vibration. Lototska-Dudyk U.B. *Shoe production is an important and promising industry of light industry in Ukraine. More than 15 thousand people work at almost 300 enterprises. Improvement of technologies and equipment, intensification of production processes on the background of their incomplete mechanization and automation cause production noise and vibration at the workplaces, in particular, in cutting, clicking and closing workshops. Levels of manufacturing noise and production vibration in the workplaces of workers of the main occupations: cutters, clicking details, shoe markers, seamstresses, striking operatives, cementing operators, fitters and lasters, trimers and bottom scourers were analyzed. According to noise level, working conditions of cutters on the cutting machines Gerber, seamstresses, skivers, stitchers of upper, casters, fitters and lasters, cementing operators belong to the 2nd class (permissible). The working conditions of cutters on the cutting presses, shoe markers, fitters of upper on the heavy-class sewing machines, bottom scourers, trimers and striking operatives are classified as harmful ones (class 3.1), on separate workplaces of clicking details (press PVH-8) and bottom scourers – class 3.2 degree of danger. Equivalent correction levels of local and general vibration don't exceed permissible levels. The presence of related unfavorable industrial factors necessitates the study of both combined and jointed action of noise and vibration with the subsequent assessment of the risks to the health of workers in the light industry.*

Реферат. Вредные производственные факторы обувных производств: шум и вибрация. Лотоцька-Дудик У.Б. *Производство обуви является важной и перспективной отраслью легкой промышленности Украины. Почти на 300 предприятиях работает более 15 тыс. человек. Совершенствование технологий и оборудования, интенсификация производственных процессов на фоне их неполной механизации и автоматизации обуславливают наличие производственного шума и вибрации на рабочих местах, в частности в раскройных, вырубочных и сборочных цехах. Были проанализированы уровни производственного шума и производственной вибрации на рабочих местах работников основных профессий: раскройщиков, вырубщиков деталей, литейщиков, клеймовщиков, бросовиц, швей, обработчиков деталей верха и низа обуви, намазчиков клея, затяжчиков, сборщиков обуви, шершевальщиков, фрезеровщиков. Условия труда раскройщиков на раскройных машинах Gerber, швей, бросовиц, заготовителей верха, литейщиков, сборщиков и затяжчиков обуви, намазчиков клея по шумовым нагрузкам относятся ко 2-му классу (допустимые). Условия труда раскройщиков на раскройных прессах, клеймовщиков, сборщиков верха обуви на швейных машинах тяжелого класса, шершевальщиков, фрезеровщиков и обработчиков низа обуви - к вредным (класс 3.1), на отдельных рабочих местах вырубщиков деталей (пресс ПВГ-8) и шершевальщиков – к вредным (класс 3.2). Эквивалентные скорректированные уровни локальной и общей вибрации не превышают допустимых уровней. Наличие сопутствующих неблагоприятных производственных факторов обуславливает необходимость изучения как комбинированного, так и сочетанного действия шума и вибрации с последующей оценкой рисков для здоровья работающих в легкой промышленности.*

Footwear manufacture is an important and promising branch of the consumer goods industry in Ukraine. Over 15 thousand people work at almost 300 enterprises. Improvement of technology and

equipment, intensification of manufacturing processes against their incomplete mechanization and automation, in some cases, cause the presence of working noise and vibration at the workplaces. At footwear factories in Ukraine, 5.4-4.7% of the workplaces of main workshops are characterized by excessive noise levels and 5.1-3.4% by vibration [3].

The combined effect of noise and vibration is one of the harmful factors in cutting and assembling shops of footwear manufacture [4]. The high noise level is recorded on streams where the veldtschoen cement shoe construction method is used – 88% of workplaces; the strip cement shoe construction method – 84.6%; welt cement shoe construction method – 52.6% and welt shoe construction method – 52.7%. There are somewhat less noisy shops where footwear is assembled by the cement shoe construction method – 40.8% and 15.5%, and moulding – 51.7% and 18.2% of workplaces [1]. A number of manufacturing processes are accompanied by total and local vibration. The levels of total vibration in the cutting shops reach significant values (108-112 dB) exceeding the permissible vibration velocity parameters for all axes (X, Y, Z) [5].

The problem of preventing the negative effects of noise and vibration remains an urgent problem in the occupational medicine, since professional diminished hearing and vibration disease are among the most common occupational diseases in modern conditions [2, 9]. In addition, a number of studies [6] show that the development of occupational diseases is possible with a small and medium intensity of productive factors under conditions of their combined or joined action. Taking into account the above, the purpose of the paper was to study and evaluate the working conditions at the enterprises manufacturing the footwear by levels of noise and vibration.

MATERIALS AND METHODS OF RESEARCH

The research has been performed at the footwear enterprises of the Western region of Ukraine, which are engaged in the manufacture of children's, men's and women's footwear. The indicated enterprises are typical for the footwear industry in terms of ownership, number of employees, production conditions and processing equipment, fully consistent with national indicators, which allows using the obtained results for extrapolation on the hygienic assessment of footwear manufacture in general.

To achieve the goal, 143 measurements of industrial noise and 126 measurements of production vibration at the workplace of the workers of the main occupations have been analysed: cutters, parts

cutters, markers, sewing operators, top and bottom footwear parts processors, gluers, lasters, footwear assemblers, polishers, millers have been made by the Laboratory of Industrial Toxicology of the Lviv National Medical University named after Danylo Halytsky (LNMU) and sanitary and hygienic laboratories of the Laboratory Centres under the Ministry of Health of Ukraine located in the Western region.

Noise and vibration have been measured with the use of VShV 003-M2 device, which has a certificate of verification in accordance with GOST 12.1.05.86 “Methods for Measuring Noise at the Workplace”, and a hygienic noise has been estimated according to DSN 3.3.6.037-99 “State Sanitary Norms for Production Noise, Ultrasound and Infrasound”. Vibration has been measured, calculated and estimated according to GOST 12.1.034-81 “Occupational Safety Standards System. Vibration. Methods of Measurement at the Workplaces in Industrial Premises”, DSTU/GOST 12.1.012:2008 “Occupational Safety Standards System. Vibration Security. General requirements” and DSN 3.3.6.039-99” State Sanitary Norms of Production General and Local Vibration”.

The assessment of noise and vibration loads at the workplaces has been carried out at the equivalent levels of these factors in accordance with the criteria established by the Hygienic Classification of Labour (Order of the Ministry of Health No.248 of April 8, 2014).

Material systematization and primary mathematical processing have been performed according to Microsoft EXCEL 2013 tables. Statistical processing has been performed using the STATISTICA 7.0. licensed package.

RESULTS AND DISCUSSION

The footwear manufacture process consists of a sufficiently large number of separate operations, the number of which, depending on the footwear design, may amount to 300 and more. However, the main stages of technology do not differ fundamentally.

There are footwear-cutting (part cutting: to make the footwear bottom: heels, soles, insoles, etc.; cutting to make the footwear top); upper production (parts of the footwear top are glued or stitched) and assembling shops where the bottom of the footwear is attached to the upper.

The parts of the footwear bottom are manufactured by the method of cutting down using the press equipment, mainly on the cross-bar presses PVG-8-2-0, PG-18-2-0. Today, footwear soles made by the method of moulding from various polymer materials are also widely used (Desma machine).

Leather, fur, fabrics are cut on the swan neck presses PKP-10, PKP-16, Compart, Gerber cutting machines or cutting knives for the parts of the footwear top.

Kamoga machines for duplication and alignment of the footwear top parts, Fortuna and ANKAI skiving machines, ASG-13 machines for cutting the edges of the footwear top parts, smoothing the back seam, applying the brand and gluing the parts are used in the upper production shop. The footwear uppers are assembled on sewing machines of various types: flat (for non-volume uppers), post-type (for volume uppers), of "zigzag" type (for sewing through lining), of heavy-duty (for sewing trough collars, decorative stitches).

At the stage of footwear assembly, the bottom is attached to the upper and the footwear is processed. The uppers are formed using the machines for lasting the forepart (ZNK-3-0, Cherim K-68), the heel seat (ZPK-4-0, Zeus 71A) and the calf (ZKG-0) parts of footwear. The soles are attached to the uppers and processed using the Strobels machines, bottom-gluing presses (PPG), moulding machines, machines for processing and milling of the edge.

The indicated equipment is a source of production noise, local and total vibration at the workplace of workers engaged in the footwear manufacture. The analysis of technologies used at the indicated enterprises testifies to the application of the same type of equipment at most workplaces.

Noise load at the workplaces during the main footwear manufacturing processes is given in Table 1.

The noise factor at the cutting and marking workplaces is of the greatest significance. It is mechanical noise by origin, and inconsistent intermittent according to the time characteristic. It is broadband noise, with the predominance of medium and high frequencies, by spectral composition.

The immediate duration of noise from the basic operations of cutting and parts cutting varied from 385 to 420 minutes, which amounted to 80.2-87.5% of the working time. The equivalent level of noise at the workplace of parts cutting operators at some workplaces exceeded the permissible limit up to 6 dB A.

Production noise is volatile, fluctuating over time at the workplaces of sewing operators of the cutting shops, and volatile intermittent at the workplaces of upper production operators, skiving operators.

The noise levels created by the sewing equipment at the stage of footwear upper construction vary within a range of 73-83 dB A. The use of modern sewing machines ensures compliance with hygiene norms, limit-exceeding levels (above 80 dB A) are

generated by heavy-duty sewing machines and sewing machines of old modifications. The timekeeping of working time shows that duration of the noise load during basic operations of footwear upper construction is 375-420 minutes. (79.0-87.5% of duration of the work shift). Equivalent levels of production noise at the workplaces of footwear skiving and upper production operators did not exceed the standard values.

The production noise is volatile, varying over time at the workplaces of moulding operators, millers and polishers in the assembling shops. The equivalent levels of noise in assembling shops vary within the range of 65-87 dB A. The lowest levels have been recorded at the workplace of lasters, footwear construction operators, moulding operators, gluers, while levels in excesses have been recorded at the workplace of polishers (up to 7 dB A) and footwear bottom processing operator (up to 3 dB A). The permanent noise caused by the ventilation equipment is recorded manually at the workplace of the gluer. The duration of the noise effect at the workplace of the moulding operators on average is 400 minutes (83.33%), construction operators – 395 minutes (82.89%), lasters – 375 minutes (79%), mechanical gluers – 350 minutes (72.9%). Noise is broadband with predominance of medium and high frequencies at the upper production and assembling shops.

Maximum noise levels at all workplaces have not exceeded the regulated levels.

According to other researchers [8], noise intensity of noise in the footwear manufacture at some workplaces is 76-68 dB A (upper production shops), 90-92 dB A (assembling shops), 96-108 dB A (cutting shops) with prevalence of permissible limits by all octave bands of average geometric frequencies of 125 to 8,000 Hz.

The working conditions of cutters operating the cutting machines Gerber, sewing operators (except for those operating the heavy-duty sewing machines), skiving operators, upper production operators, moulding operators, assemblers and lasters of footwear, gluers belong to Class 2 and are characterized as permissible. The working conditions of cutters operating the cutting presses, markers, footwear upper production operators using the heavy-duty sewing machines, polishers, millers and footwear bottom processing operators are harmful (Class 3.1), and at some workplaces of the parts cutters (press PVG-8) and polishers are harmful (Class 3.2).

Table 1

Levels of Noise at Workplaces of Workers Engaged in the Footwear Manufacture

Workplace	Equivalent level of noise, dB A <u>min-max</u> M±m	Maximum level of noise, dB A <u>min-max</u> M±m	Equipment
Cutting Shops			
Upper cutter	<u>74-79</u> 77.0±1.6	<u>80-85</u> 82.5±1.77	Cutting machine Gerber
Upper cutter	<u>80-85</u> 82.0±1.61	<u>86-90</u> 87.4±1.36	Cutting presses PKP-10, PKP-16
Part cutter	<u>80-83</u> 81.28±1.25	<u>85-90</u> 87.29±1.79	Cutting press Compart
Part cutter	<u>80-86</u> 83.33±2.5	<u>86-92</u> 88.66±2.44	Cutting press PVG-8
Marking machine operator	<u>80-82</u> 80.88±0.83	<u>85-88</u> 86.50±0.93	Marking machine
Upper Production Shops			
Upper assembler (sewing operator)	<u>73-78</u> 74.96±1.39	<u>78-84</u> 80.88±1.56	Sewing machines PFAFF, Singer, Durcopp, Brother
Upper assembler (sewing operator)	<u>77-81</u> 79.36±1.21	<u>83-89</u> 85.27±1.79	Sewing machine Podolsk
Upper assembler (sewing operator)	<u>79-81</u> 79.7±0.67	<u>84-88</u> 86.2±1.23	Sewing machine MINERVA
Upper assembler (sewing operator)	<u>79-83</u> 81.25±1.28	<u>86-90</u> 86.88±1.36	Sewing machine cl. 330, 34-24-10
Upper assembler (sewing operator)	<u>75-77</u> 76.0±0.89	<u>81-83</u> 82.17±0.75	Strobel machine Strobel
Skiving operators	<u>76-80</u> 78.72±1.49	<u>82-87</u> 85.14±1.77	Skiving machine Fortuna
Upper production operators	<u>73-77</u> 74.33±1.51	<u>79-83</u> 80.67±1.51	Stitch smoothing machine
Assembling Shops			
Moulding operator	<u>70-79</u> 75.87±2.89	<u>77-85</u> 81.46±2.95	Moulding injection machines Ottogalli, Ottirgen, Inotec
Sole polishers	<u>82-87</u> 83.33 ±1.97	<u>87-94</u> 89.33±2.50	Roller polishing machine
Footwear assembler	<u>74-78</u> 76.0±1.64	<u>79-85</u> 82.29±2.14	Footwear counter forming machine
Footwear laster	<u>65-70</u> 67.4±1.72	<u>72-76</u> 73.8±1.39	Lasting machine
Footwear bottom processing operator	<u>79-83</u> 80.86±1.35	<u>85-89</u> 86.86±1.35	Footwear bottom processing machine
Footwear bottom parts gluer	<u>68-72</u> 70.14±1.68	<u>73-78</u> 76.0±1.83	Gluing machine
Gluer		<u>70-75 *</u> 73.0±1.56	Noise from the exhaust ventilation
Miller	<u>80-83</u> 80.88±0.99	<u>86-89</u> 87.25±1.16	Sole edge milling machine

Note: * – constant noise, permissible limit – 75 dB A.



Our data coincide with the research results of the noise factor at the footwear enterprises of the Dnipropetrovsk region, where workplaces for parts cutting, sewing, and polishing operations are also characterized as harmful [5].

In addition to noise, both local and general processing vibration can affect workers in the footwear manufacture, when performing a number of processing operations. Table 2-3 shows the measurement results of local and total vibration in the inter-perpendicular planes along the X, Y, Z axes. Mid-frequency vibration with maximum vibration velocity levels at 31.5 Hz at the workplace of the footwear parts cutter and high-frequency at the

workplace of the sewing operator are recorded by frequency composition.

The total vibration load at the workplaces of footwear upper production operators was 240-420 minutes (50.0-87.5% of the duration of a working shift) (sewing machines PFAFF, Singer, Durcopp, Brother), 360-420 minutes (75.0-87.5%) (sewing machines Podolsk, Class 330, 34-24-10), 360-400 minutes (75.0-83.3%) (sewing machines MINERVA), 420 minutes (87.5%) (Strobel machine), markers – 240-300 minutes (50.0-62.5%), skiving operator – 360-380 minutes (75.0-79.2%), polishers – 165-180 minutes (34.4-37.5%), millers – 140-180 minutes (29.16-37.5%) and lasters – 265-300 minutes (55.0-62.5%).

Table 2

Levels of Local Vibration at Workplaces of Workers in the Footwear Manufacture

Workplace, equipment	Equivalent adjusted level by vibration velocity, dB <u>min-max</u> M±m		
	X	Y	Z
Upper assembler (sewing operator) (sewing machines PFAFF, Singer, Durcopp, Brother)	<u>80-110</u> 93.16±9.86	<u>79-107</u> 91.68±9.38	<u>81-110</u> 92.44±8.94
Upper assembler (sewing machine Podolsk)	<u>100-109</u> 105.46±2.91	<u>98-106</u> 102.09±2.57	<u>100-106</u> 102.64±1.75
Upper assembler (sewing machine MINERVA)	<u>102-110</u> 106.5±3.44	<u>99-109</u> 106.0±3.06	<u>100-110</u> 104.20±3.12
Upper assembler (sewing machine Class 330, 34-24-10)	<u>106-110</u> 108.0±1.60	<u>105-110</u> 108.25±1.58	<u>104-112</u> 107.75±3.06
Operator (marking machine)	<u>92-98</u> 96.5±2.27	<u>90-96</u> 94.38±2.20	<u>92-96</u> 94.0±1.77
Skiving operator (skiving machine Fortuna)	<u>98-102</u> 100.57±1.51	<u>96-102</u> 99.71±2.14	<u>96-100</u> 97.86±1.21
Upper assembler (Strobel machine)	<u>98-107</u> 102.0±3.52	<u>96-106</u> 100.33±3.93	<u>96-104</u> 99.17±3.71
Sole polisher (roller polishing machine)	<u>106-110</u> 107.83±1.47	<u>105-112</u> 108.0±2.61	<u>103-108</u> 105.33±2.16
Miller (sole edge milling machine)	<u>97-105</u> 100.50±2.56	<u>96-102</u> 99.25±2.05	<u>95-100</u> 97.51±1.93
Laster (lasing machine)	<u>95-102</u> 98.60±2.71	<u>94-103</u> 99.80±3.01	<u>94-102</u> 97.40±3.37

According to Table 2, it is obvious that equivalent levels of local vibration at vibration velocity in the upper production and assembling shops do not

exceed the permissible limit of 112 dB, and there are no significant differences in the directions of vibration effect.

Table 3

Levels of Total Vibration at Workplaces of Workers in the Footwear Manufacture

Workplace, equipment	Equivalent adjusted level of total vibration of category 3 (processing type "a") by vibration velocity, dB $\frac{\text{min-max}}{M\pm m}$		
	X	Y	Z
Upper cutter (cutting machine Gerber)	$\frac{86-90}{88.0\pm 1.60}$	$\frac{84-92}{86.50\pm 2.78}$	$\frac{84-92}{86.38\pm 3.02}$
Upper cutter (cutting presses PKP-10, PKP-16)	$\frac{85-92}{89.18\pm 2.36}$	$\frac{86-92}{89.73\pm 1.84}$	$\frac{85-92}{88.73\pm 2.28}$
Parts cutter (parts cutting press Compart)	$\frac{87-91}{89.0\pm 1.41}$	$\frac{89-92}{90.71\pm 1.11}$	$\frac{87-90}{88.57\pm 1.27}$
Parts cutter (parts cutting press PVG-8)	$\frac{84-88}{86.22\pm 1.20}$	$\frac{83-88}{85.89\pm 1.45}$	$\frac{82-85}{83.44\pm 0.88}$
Upper production operator (stitches smoothing machine)	$\frac{78-83}{80.50\pm 1.64}$	$\frac{77-82}{79.33\pm 1.97}$	$\frac{77-84}{80.67\pm 2.73}$
Footwear assembling operator (footwear counter forming machine)	$\frac{81-85}{83.00\pm 1.73}$	$\frac{80-83}{81.00\pm 1.29}$	$\frac{83-88}{84.71\pm 1.60}$
Moulding operator (moulding injection machines Ottogalli, Ottirgen, Intec)	$\frac{85-90}{87.93\pm 1.87}$	$\frac{82-92}{87.93\pm 3.19}$	$\frac{81-91}{86.07\pm 3.01}$
Bottom parts gluer (gluing machine)	$\frac{75-80}{77.57\pm 1.99}$	$\frac{73-79}{75.57\pm 2.37}$	$\frac{74-83}{77.14\pm 3.23}$
Bottom parts processing operator (bottom parts processing machine)	$\frac{80-84}{81.00\pm 1.53}$	$\frac{77-82}{78.86\pm 1.68}$	$\frac{77-80}{78.43\pm 1.27}$

The timekeeping of working time shows that duration of the vibration load during the footwear cutting operations is 240-420 minutes (50.0-87.5% of duration of the work shift). The duration of the total vibration in assembly shops is as follows: 360 minutes (75.0%) at the workplaces of the upper production operators and footwear construction operators, gluers, 300-420 minutes (62.5-87.5%) at the workplaces of moulding operators, 240-300 minutes (50.0-62.5%) at the workplace of footwear bottom processing operators.

Equivalent adjusted levels of total vibration of category 3 (processing of type "a") did not exceed the standard value (92 dB), but were more significant along the Y and Z axes at the workplaces of cutters and footwear assemblers.

The working conditions are characterized as permissible and belong to class 2.

However, there are other production factors at the workplaces of the main shops of the footwear industry, along with noise and vibration, which necessitates an in-depth study of the combined and

joined effects of these physical factors, with subsequent assessment of the health risks of workers.

CONCLUSIONS

1. In footwear manufacture, the combined effect of noise and vibration is one of the harmful factors in cutting, parts cutting and assembling shops.

2. Excessive levels of noise at the workplaces of cutters, parts cutters, markers, sewing operators, assemblers, upper processing operators are 2-7 dB A. The working conditions of cutters operating the Gerber machines, upper construction operators (except those operating the heavy-duty sewing machines), skiving operators, upper production operators, moulding operators, footwear assemblers and lasters, gluers belong to class 2 and are characterized as permissible according to the noise load. The working conditions of cutters operating the cutting presses, markers, upper construction operators operating the heavy-duty sewing machines, polishers, millers and footwear bottom processing operators are harmful (class 3.1), separate work places of parts cutters (presses PVG-8) and polishers are harmful (class 3.2).

3. Equivalent adjusted levels of local and total vibration in cutting, upper production and assembling shops do not exceed permissible levels. The working conditions in footwear manufacture are characterized as permissible and belong to class 2 by this factor.

4. The availability of associated adverse production factors necessitates the study of both combined and joined noise and vibration effect, with subsequent assessment of the health risks of workers engaged in the consumer goods industry.

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