Assessment of Working Conditions in a Modern Russian Milk Processing Plant from the Aspect of Occupational Medicine

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Aim. Assessment of harmful industrial factors caused by work conditions in a modern milk processing plant.

Methods. Work conditions, rest, nutrition, medical service, and subjective health indices among the employees in a new milk processing plant were studied. We used a specially formed questionnaire; instrumental measurements of microclimate parameters, noise, and illumination at workplace; laboratory physical and chemical evaluation of air pollution with aerosols and gases in the plant premises; chronometric studies determining the workers' activity during the working day, location, and physical and psychological body exertion at the time of industrial activities; and assessment of design and operating documents of the plant. Laboratory studies included 157 workers, 1,724 tests, 26 chronometric studies, and analysis of 11 plant's documents.

Results. Unfavorable microclimatic conditions, noise, inadequate illumination, air pollution with dust and toxic substances, physical workload, increased demand for concentration, and monotony of labor in mass production professions were found. A great proportion of workers was dissatisfied with their working conditions and many suffered from occupational diseases and work-related diseases.

Conclusion. The conditions of work in the studied milk processing plant may be classified as harmful and dangerous. The flaws in technological process, omissions in design and construction of the plant, as well as its improper exploitation aggravated industrial harmful factors. In combination with unsatisfactory organization of rest, nutrition, and medical services in the plant these factors may affect the workers' health and cause general and occupational diseases.

Key words: employee health; milk; noise, occupational; nutrition assessment; occupational diseases; Russia; social conditions; workplace

Milk processing industry is one of the leading food industries in Russia. Dairy plants are situated in almost all parts of the country; their broad network is due to short periods of storage of raw material and ready products. Many new domestic and foreign equipment has recently been introduced into the dairy industry with simultaneous preservation of traditional forms of technical equipment and labor organization.

Industrial environment in modern milk processing plants may influence the employees' health (1-3). There are insufficient reports on this problem in literature, but the available data show the harmful effects of some occupational factors on the workers' health (1-5). However, prophylactic measures against unfavorable working conditions, and social-hygienic factors were inadequately treated in normative and operative documents (6,7). They were not included into the report forms, and thus have been beyond the competence of the sanitary-epidemiologic service, preventive-medical institutions, and milk processing plants in Russia. All the above described facts were the basis for the complex hygienic studies aimed at the assessment of workers' exposure to harmful industrial factors and development of medical measures of primary prophylaxis against diseases which are at present directly or indirectly caused by the work conditions in a milk processing plant (5-7).

Subjects and Methods
We studied working conditions in one of the milk processing plants in Saint-Petersburg. It was built in 1989 as a cooperative venture of Russian and West European companies. Approximately 400 people were employed, half of the operating staff working in five mass production professions, servicing main industrial divisions. More than a half of the studied subjects were women aged 18 to 65 years. Duration of their employment in the dairy plant varied from several months to three years. As a starting point of our medical analysis we examined materials describing design and construction of the dairy plant. We also examined service forms and records of the used technology, material, production, equipment, sanitary and technical instruments, industrial and everyday premises, list of
the staff, regime of work, rest, nutrition, and medical services. The total of 11 documents were examined.

The investigated plant produces drinking milk, cream, sour dairy products, sour-cream, curds, and dietary products. Daily milk supplied by the farms and dry milk received from different suppliers constitute the basic raw materials for the industry. Technological process in milk production consists of six industrial stages corresponding to the six main shops of the milk plant (Table 1). Technological equipment of the shops included numerous capacities, pumps, pipelines, electric cars, equipment for milk processing, and appliances for automatic control and regulation. Technical servicing of the equipment was performed by the representatives of six mass production professions (Table 2).

Table 1: Technological and equipment characteristics of the main stages of production in the milk processing plant. [view this table]

Table 2: Characteristics and application of mass production occupation activities in the milk processing plant. [view this table]

The factual duration of the working day of the workers was up to 12 or 16 hours with alternating days off. One fixed interval was set for the workers' meals and recreation. Everyday premises of the workers were furnished in accordance with the standards determined for the dairy industry, approved by the Russian (USSR) Ministry of Health (6,7). There was a canteen open for three hours a day, where workers could have their meals. First medical aid and prophylactic supervisions of the workers were carried out at the plant's Medical Office.

The studies had a complex structure and included examination of documents on the construction and exploitation of the industrial plant, employees' questionnaire, measurement of the levels and exposure influence of the industrial environmental factors.

Subjects

The examination of workers was performed using a specially developed questionnaire that included four groups of questions. The first group was related to the characteristics of the interrogated employee (sex, age, duration of employment, place of work); the second group included questions about the effects of harmful industrial factors, organization of work and rest, living conditions, attitude to the work performance, and relations within the working team; the third group of questions was related to the organization of the workers' rest and nutrition; the fourth group included questions about the employees' health problems in the last three years.

All the employees in mass production occupations (N=192) were asked to take part in this study, but only 157 (82%) questionnaires were suitable for analysis. Age of the examined workers enrolled in the study ranged from 20 to 60 years, duration of their employment was at least a year, and all production stages were taken into account. Half of the employees had previous working experience in dairy or other industries.

Measurements

Our study included examination of the documents of the dairy plant, workers' examination, laboratory studies, assessments of harmful industrial factors, and chronometric studies. Assessment of harmful industrial factors included temperature measurements, identification of relative humidity and air flow in the working zone, noise parameters, and illumination at workplace at all stages of the technological process. Measurements of microclimatic conditions were made both in cold and warm seasons. Chronometric studies of the activities of workers were performed during their working day. They recorded the workers' engagement, location, distance that they passed, body movements and their character, body bending at an angle of more than 30°, periods of concentration, density of the received signal, frequency of the repeated signals and duration of operation performance. The total of 25 chronometric studies were made.

Air samples from the working zones were taken, their weight and chemical analysis for determination of air pollution with dust, oil aerosols, ammonia, alkali, and chlorine were carried out in the divisions where air pollution was expected because of the used technology. In total, 1,250 measurements of microclimatic parameters, 48 measurements of noise levels, and 198 measurements of illumination were performed, and 228 air samples were taken and analyzed. The applied instrumental measurements and analyses corresponded to the requirements of the state standards, normative and methodical acts approved by the Russian Ministry of Health (6,7).

Results

Hygienically Unfavorable Characteristics in Industrial Organization

The analysis of the technical documentation in the plant revealed some hygienically significant
The chosen technological process was associated with air temperature below the permitted level for the workers in reception premises with raw materials and in long-term storage of ready products. The technology used for milk production is inevitably associated with the use of a great number of pumps, pipe-lines and other equipment generating noise in the immediate proximity of the workplaces. The design of the dairy plant envisaged workplaces to be in the open air in cold and warm seasons during raw materials reception and ready products transportation. There was also open sewage outflow near workplaces in the majority of industrial premises. The design lacked local ventilation during open transportation of such loose materials as dry milk.

In the construction of the dairy plant, several deviations from the design were made. The most important among them included realization of the automatic control and regulation of technological process in the engine room, as well as the installation of both domestic and foreign equipment with dimensions inadequate to the design in the bottling shop. Untimely repair, change and regulation of technological equipment, ventilation, pipe-lines, sources of artificial hot liquids, and open transport openings in the proximity of the workplaces were observed during the operation of the dairy plant.

**Questionnaire**

Due to a relatively small number of the analyzed questionnaires (N=157) we did not divide the sample into smaller groups.

Seventy-six percent of the employees were not satisfied with the working conditions. Among the harmful industrial factors listed in the questionnaire, increased air flow was reported by 74%, high humidity by 54%, and poor illumination by 50% of the workers.

Apart from that, 48% of the workers described their work as monotonous movements during the shift, and 68% of them reported that their work required increased attention. More than half considered their work uninteresting, and nearly every third person described the relations within the working team as bad. Many workers (86%) were not satisfied with the provided rest during the shift. All these drawbacks were attributed to the poor organization of industrial process by 84% of the workers.

Almost 90% of the examined workers expressed their dissatisfaction with the service of the canteen. Insufficient variety of meals was reported by 88%, inadequate choice of products in the refreshment room by 87% of the workers, and 82% of them complained of the quality of the food. Most of the workers reported non-coordinated working regime of the canteen. Since they were not satisfied with the nutrition, more than half of the employees refused to use the canteen and eat meals brought from home or products produced in the plant, such as cream, fatty yogurt, sour cream, and curds. They consumed the meal in the production areas or service rooms. There was a lack of dietary nutrition, although 39% of the examined workers required special diets due to their health problems.

More than half of the examined workers complained of health problems. Half of them reported subjective health disorders of neurologic character, abnormalities of vision, and the so-called cold symptoms. Somewhat less than half of the employees suffered form the disorders of the locomotor system and digestive organs; about every fourth examinee had cardiovascular system disorders; every fifth woman complained of gynecological disorders; and, finally, 10% of the examinees suffered from skin disorders.

**Harmful Industrial Factors**

The analysis of microclimate, noise, and illumination parameters at the workplaces of mass production workers from milk industry revealed a number of violations of the sanitary norms (Table 3).

| Table 3: Variations of air, noise, and illumination parameters at the workplaces in the milk processing planta. [view this table] |

Temperature in cold seasons was significantly lower than that permitted by the sanitary standards (17-23°C) in the majority of industrial areas. The lowest (below or equal to 0°C) temperature was registered at the permanent workplace of loading workers in packing shops, in the shop of ready products, and in cooler shops. In the last two shops, low temperature was constantly registered during warm seasons of the year (18°−27°C is permissible). At the same time, increased temperature (up to 28.7°C) was recorded in the shop for dry milk production and compressor shop in different seasons. Relative humidity of the surrounding air was high (above 75%) in most of the shops during the whole year.

In bottling and packing shops, as well as in the department of milk approval and engine room, increased air flow was registered (up to 1.6 m/s; the allowed speed is 0.1-0.3 m/s).

The analysis of the obtained data showed that unfavorable microclimatic conditions resulted from different causes, including specificity of technological schedule, work in the open air, open transport systems during the whole shift, open sewage discharge in manual washing of the equipment, frequent disorders in compression pipe-lines and their tardy repair, presence of open air tanks with hot fluid,
improper work of washing machines, and unsatisfactory ventilation.

Noise in the plant was constant and its level in all the departments was above the allowed limit (80 dB). The most intensive noise (10-20 dB above maximally allowed level) was registered in the compressor, bottling, curds, and ready product shops, as well as in the operation control room, engine room, and the washing station. The source of the noise was technological and ventilation equipment, pipe-lines, compressors, pumps, conveyers, storage-battery trucks, operating in the immediate proximity of the workplaces.

There were workplaces in nearly all the divisions with the illumination 130-192 lk, below the permissible level (200 lk). This was due to the poor maintenance of light sources.

Air pollution with aerosols and gases was assessed with respect to the physical and chemical conditions of the used substances, technical characteristics of the equipment and use of manual operations. Intensive air pollution of the working environment with the dry milk dust was registered at the section of its dissolution, in the reception shop, where dust concentrations ranged from 266.3 to 2,634.8 mg/m³ (maximum permissible value is 4 mg/m³). This high level of pollution was due to the manual work with loose material and lack of local ventilation. This dust is a mixture of proteins, fats, and other substances of animal origin. Air pollution with oil aerosols was found in the engine room, in the area of separators, and in the compressor shop, but oil aerosol content in the atmosphere was rather low (from 2.6 to 5.5 mg/m³, at maximum permissible values of 5 mg/m³) and was the result of inadequate regulation of technological equipment.

Chemical analysis of air samples taken in the plant showed air pollution with toxic substances. Thus, in the manual tank washing in the engine room, in the area of bottle washing, at the automatized lines in the shop of milk and sour-milk products, as well as in the washing station, alkali in the concentrations of 0.5-1.5 mg/m³ (at maximum permissible values of 0.5 mg/m³) of the equipment were constantly found. Chlorine was periodically registered at the washing station and its maximal concentrations were also 2-3 times higher than permitted (1.0 mg/m³). In the process of manual washing of the internal surfaces of the tanks, performed in the restricted area, higher chlorine content in the air was suspected by the workers; however, special character of this work and methods of study adopted in the hygienic practice did not allow us to obtain objective data. Nevertheless, the obtained results showed that in the case of manual and automatized washing and sanitary treatment of the equipment, the working atmosphere may be polluted by washing and disinfectant substances, which is a consequence of the insufficient localization of the excreting harmful compounds and the use of manual labor. These findings are rather important since washing processes and sanitary treatment of the equipment proceed during the whole working day.

Air pollution by ammonia in the compressor shop was particularly important: its concentration in the working area ranged from 5 to 93.3 mg/m³ at maximum permissible values of 20 mg/m³. This was the result of design and exploitation drawbacks of the used technological equipment.

Chronometric Studies

Analysis of chronometric studies allowed us to separate sections and professions in milk processing industry connected with harmful psychophysiologic factors resulting from the character of work. The workers from the apparatus department (operators) and operators of the automatized lines in the bottling shop were in these categories. Employees engaged in this profession were required to work in standing position. The operators in bottling shops were in the standing position for 57.3-95.3% of their working day. In performance of their occupational tasks, some workers could occasionally take a sitting position, but their workplace was not provided with necessary equipment. Apparatus workers and operators have to move about the shop in performing their tasks. The apparatus workers made more than 20 km during their working day, which was significantly above the permissible level of up to 10 km. For the operators, this figure ranged between 4.5 and 5.2 km. The increased distance passed by the apparatus workers during the working day was caused by the lack of distant communication (telephone, connection with other sections, inadequate equipment installation, long distance required to pass in performing the operation).

In the bottling shop, the obligatory bending for more than 30 degrees was registered. In servicing of the bottling line at the section of container loading, for example, the number of bendings during the working day ranged from 700 to 2,000, whereas the permissible number is 100. This was caused by numerous manual operations accompanying the work of automatized equipment, and discrepancy in dimensions between domestic conveyers and foreign equipment.

Servicing of the bottling lines required constant attention. Analysis of the detailed chronometric studies showed that the period of concentration during the working day in some operations in bottling lines exceeded the permissible upper limit (26-50% of the working day) by 12-48%, and the frequency of signals per 1 hour in servicing all lines of the bottling shop ranged from 3,000 to 12,000, which was significantly higher than maximal permissible values (75-125 signals/hour). These data show the
increased concentration of workers in the bottling and sour-milk products shops. Monotony is an accompanying factor in automatized bottling lines. The results of the study showed that the number of frequently repeated operations in some sections of bottling lines was decreased to 3-2 (9-6 permitted), and the time for the operation realization equaled to 18-10 s (100-25 s permitted). Harmful psychophysiological factors were recorded in the majority of sections abundant with modern equipment (apparatus section, bottling shop) and were caused by the combination of automatized processes requiring visual control and many manual operations necessary for washing of the equipment, regulation of milk movement and process of loading and unloading.

Chronometric studies allowed us (a) to determine the influence of exposure to the revealed harmful physical and chemical industrial factors; and (b) to define professions characterized by the harmful influence of psychophysiologic factors. Chronometric studies were performed in all the divisions of the plant in order to evaluate the influence of exposure to the above mentioned industrial factors. Analysis of the obtained data showed the time of work under unfavorable microclimatic conditions, increased noise levels, and inadequate illumination from 66% to 94% of the shift period at all the stages of the technological process, which was connected with the work in the main industrial areas. The period of air pollution by aerosols and toxic substances varied to a great extent (from 6% to 92%) and depended on the time required to perform certain operations.

Discussion

The results of the study confirmed the presence of occupational risk factors. Unsatisfactory social conditions in the analyzed dairy plant increased their adverse effects. These factors should be considered as hazards for the employees' health, requiring adequate measures of primary medical prevention.

The data obtained from our study allowed us to give a medical assessment of a modern dairy plant. The technology used in dairy industry, omissions in the design of the plant, deviations from the design in plant construction and violation of rules and regulations in exploitation of both technological and sanitary-technical equipment, and labor orientation during the operation of the plant resulted in harmful physical, chemical, and psychosocial industrial factors. Occupations involved in mass production in dairy industry were also constantly exposed to the influence of unfavorable microclimate (reduced or increased air temperature, and increased relative air movement in the working zone), intensive noise, and inadequate illumination at all the stages of industrial process during a prolonged factual working day. In addition, at some industrial stages, some workers performed their tasks in conditions of air pollution by aerosols and gases together with milk dust in its dissolution, components of washing and disinfecting substances (alkali and chlorine) during their preparation and equipment cleaning (both manual and automatic). These workers were also exposed to the influences of oil aerosols while servicing compressors in the engine room and to ammonium hydrate in the refrigerators.

Concentrations of all the enumerated substances, except oil aerosol, exceeded the established regulations for the working zone. However, air pollution with dry milk dust, ammonium hydrate and chlorine during extensive hand washing presents the highest risk for the workers (7). Some workers were exposed to the influences of physical overloading during more than half of the working day. The physical overexertion of the employees of the engine room was caused by the compulsory standing position and increased distance passed during the working day. The work of the operators at the automatized lines in the bottling shop was also accompanied by a forced standing position, bending of their bodies at an angle greater than 30 degrees, sensory exertion, and monotonous work (6,7).

The effect of harmful industrial factors was aggravated by unsatisfactory organization of rest and nutrition in the industrial environment. Unsatisfactory taste of food, inadequate variety of dishes, and noncoordinated regime of the canteen work seem to be some of the serious reasons of the employees' reluctance to use the canteen. The majority of workers thus consumed the food brought from home or produced in the plant at their workplace or in production areas not equipped for food consumption. The established custom of having meals unfavorably affects the regime and character of nutrition during the whole day, promotes the reduction of meals (especially cooked ones), rescheduling the main meal from lunch to supper, etc. The irregular nutrition leads to metabolic body changes and may present a risk factor for the development of some diseases (8,9).

The above described disadvantages of the social labor conditions in industry may form a negative attitude towards the task performance on the part of some workers. The negative influence on health, causing general, work-related and occupational diseases in the employees was confirmed to a great extent by the examination of workers showing that more than a half of them were not satisfied with their health condition. The short period of the employment of the examined workers in the plant (the plant is considered a new one, since it was built in 1989) allowed
us to reliably associate subjective health disorders of the employees with the labor conditions. According to the data presented by the trade unions of dairy industry at our request, the statistical index of disease incidence with temporary disability as the number of absences for 100 workers at the time of our study amounted to 1,286 and was estimated as high by the Notkin classification (10). According to the data by Latishhevskaya (4), increased indices of disease incidence with temporary disability in women employed in dairy industry are reliably higher compared to the mean values of food industry in Russia. Therefore, the indices of disease incidence with temporary disability in employees in dairy industry are significantly high. In view of the obtained data, harmful industrial factors can be considered one of the main reasons of high incidence of diseases among workers. On the basis of these studies, the labor condition requirements were for the first time included into the hygienic-sanitary regulations for dairy industry and approved by the Russian Ministry of Health. Methodical instructions on the control system of labor conditions in the dairy plants of Saint-Petersburg were for the first time developed and approved by the Public Health City Committee.

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