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Hygienic Assessment of Harmful Factors and Prevention of Occupational Respiratory Diseases in Livestock Workers

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Annotation: The article considers the main factors of occupational risk of respiratory diseases in livestock workers (cattle breeding, pig breeding), analyses the dynamics and structure of occupational morbidity, scientifically substantiates hygienic principles of occupational health risk management for this category of workers, and recommends primary and secondary prevention of occupational respiratory diseases.

Keywords: livestock workers, occupational health risk factors.

INTRODUCTION

Respiratory diseases (RBD) caused by exposure to environmental factors, including occupational factors, have become more and more relevant and medically important worldwide in recent decades. According to WHO experts' forecasts, in 2020, 11.9 million (17.5%) out of 68 million deaths will be caused by respiratory diseases (4.7 million - chronic obstructive pulmonary disease, 2.5 million - pneumonia, 2.4 million - tuberculosis, 2.3 million - lung cancer) [3, 20].

In the structure of primary occupational morbidity registered on the territory of Russia, OSA consistently occupies one of the first rank places (25-30%), being the main cause of disablement of the working population. According to different years of observation, up to 70% of deaths from chronic occupational diseases were caused by severe respiratory pathology 11,12+.

The largest share of the types of economic activity, whose employees were registered with occupational diseases for the first time in 2014, is represented by enterprises engaged in mining, manufacturing and agriculture. Workers in the livestock sector are the most vulnerable occupational group with regard to the risk of occupational diseases (OD) development of the respiratory system.

Despite the diversity of sectors (beef and dairy cattle breeding, pig breeding, sheep breeding, horse breeding, poultry farming, etc.), labour conditions in animal husbandry have much in common and are associated with close contact with a large number of animals, causing air pollution of the working zone and, as a consequence, the formation of RBD. Thus, domestic and foreign studies on some sectors of animal husbandry revealed that in economically developed regions up to 25% of livestock workers suffer from one or another nosological form of respiratory system diseases associated with working conditions[2, 4, 6, 17].

MATERIALS AND METHODS

Nowadays the technology of livestock products production provides for mechanisation and partial automation of the main technological processes - feeding and watering of animals, manure removal, milking, veterinary treatment, cleaning and disinfection of premises and equipment. As a rule, fodder preparation is carried out in fodder shops, and its distribution is carried out with the help of pipelines, belt conveyors or mobile dispensers. Hydraulic systems (gravity, hydroflush, etc.) or mechanical conveyors are used for manure removal in litter-free housing.

Most farms use machine milking with the use of milking machines of various types. To maintain favourable air environment and microclimate parameters, pig breeding facilities are equipped with supply and exhaust ventilation, ventilation and heating devices and constant air extraction from manure channels. In cattle housing facilities, only natural ventilation (exhaust shafts) is used[15,16].

Investigations of livestock complex laboratory. Determination of ammonia in the main shops of the livestock complex by the method of Nesler (1982.)

Discussion of materials

The results of research have shown that the labour process in animal husbandry is characterized by high intensity. Operational workload in the performance of the main types of work is 93-95% of the shift time, which often leads to irrational modes of labour and rest without observance of regulated breaks. The labour of livestock breeders is characterised by significant nervous and emotional tension associated with the risk of

injury, the constant need for strict supervision of animal care routines (drinking, feeding, milking, etc.), high responsibility for their health and productivity 6,10+.

The severity of the labour process in animal husbandry is characterised by high total dynamic load when moving loads over various distances (up to 40000 and more kg-m), load when lifting and moving loads with a mass from 5 to 30 kg and static efforts when holding them. A significant part of working operations (animal care, cleaning of premises) are performed in uncomfortable and forced body positions with deep inclinations of the body. It is characteristic of long (more than 80% of the shift) standing posture and significant transitions due to the technological process. To a great extent high physical loads are determined by irrational organisation of workplaces and ergonomic imperfection of equipment and workplaces. According to the Guidelines R 2.2.2006-05, the severity of labour of livestock workers according to the current hygienic criteria is classified as harmful working conditions of 2 and 3 degrees (classes 3.2 and 3.3),[13, 17].

Specificity of microclimatic conditions in livestock buildings is determined by zoohygienic standards of animal housing and peculiarities of the technological process. In the conditions of stall housing, the optimal temperature for animals should be within the range of 18-25°C, humidity should not exceed 75%, air velocity should be no more than 0.25 m/sec. However, their actual values can fluctuate within a wide enough range, not corresponding to the permissible values. Thus, according to the results of our own research, the air temperature in the premises of pig breeding complexes due to the work of supply and exhaust ventilation was 16-20ºC, relative humidity 70-75%, air velocity 0.15-0.3 m/s. In cattle keeping and fattening premises microclimatic conditions are subject to even greater fluctuations: in the warm period of the year air temperature can rise up to 35◎C, and in the cold period not to exceed 8ºC at relative humidity 80-90%, which is much lower than sanitary norms. We have found that air humidity in animal housing facilities depends on the efficiency of ventilation systems, type of building, ambient air parameters, number of animals kept, and production operations performed. In cold and transitional periods of the year, hydro harvesting and distribution of liquid fodder was accompanied by an increase in air humidity to levels exceeding hygienic standards by 5-10%. According to the microclimate parameters, the labour conditions of cattle breeders in the warm period of the year were assessed as harmful 2 and 3 degrees (classes 3.2 and 3.3); in the cold period - as harmful 4 degrees (class.3.4) [10, 13].

The air environment of livestock buildings is polluted with gaseous impurities, the presence of which is caused by animal activity, decomposition products of excrement and feed residues. Concentration of harmful gaseous impurities (ammonia, hydrogen sulphide, mercaptans, aldehydes) depends on planning decisions, methods of animal housing and manure removal, type of feeding, ventilation system and other reasons. At violation of ventilation regime and untimely manure removal the content of ammonia can

exceed MAC in 1-3 times, hydrogen sulphide - in 22,5 times, that corresponds to harmful labour conditions of 2 degree (class 3.2),[13, 19].

Chemical compounds used for disinfection and disinsection of premises (formalin, chlorine, chloro-betta-naphthol, lysol, chlorophos, etc.) may be present in the air of the working zone. For example, in the first hours after treatment of premises formaldehyde is detected in concentrations exceeding MPC from 2 to 10 times, forming harmful labour conditions of the 4th degree (class 3.4),[7, 19].

Gaseous impurities contained in the air of the working zone have irritating effect. At their increased concentrations or prolonged exposure to concentrations not exceeding MPC, workers may experience catarrhal phenomena of the upper respiratory tract, irritation of the mucous membranes of the pharynx and larynx, headaches, nausea, and subsequently, subatrophic and atrophic lesions of the upper respiratory tract. Formaldehyde is also a substance dangerous for human reproductive health and a moderately dangerous allergen with sensitising effect.

During the research of microbiological contamination of the working zone air, a large number of bacteria, micro-mycetes (fungi), actinomycetes, viruses, which are part of dust aerosols, falling into the breathing zone of the working personnel and causing a fairly high biological hazard to their health[7].

Aerogenic bacterial flora is mainly represented by saprophytic and opportunistic microorganisms, mainly white and golden staphylococci, haemolytic streptococcus, as well as representatives of the intestinal group: Salmonella, Escherichia coli, Proteus, the sources of which are animals and their products. The most frequently detected micromycetes are Aspergillus, Recnicillium, Mucor, Rhizopus, Alterparia, Fusarium, as well as yeast-like fungi p. Candida. Candida, the main source of which is dry mixed fodder. The level of microbial contamination of the air of the working zone of livestock buildings can vary from 6.0 × 104 to 2.56 × 105 colony-forming units (CFU) in 1 m^3 in the warm period of the year and from 4.2 × 104 to 2.3 × 105 CFU/m3 - in the cold period. The highest microbial contamination of the air environment, reaching 2.5 × 106 CFU/m^3, is characteristic of large pig farms [18].

Microbial contamination of the air environment of production facilities of livestock farms and complexes, which is biologically dangerous, is one of the leading hygienic risk factors for the formation of general and occupational morbidity of livestock breeders (brucellosis.) Micromycetes play a major role in the allergic alteration of the organism and the development of exogenous alveolitis. Saprophytic microflora is one of the factors contributing to the development of polyvalent sensitisation and the formation of allergic diseases (allergic rhinitis).

(allergic rhinitis, asthmatic bronchitis, bronchial asthma) 1, 17+. For production facilities, air pollution with antibacterial preparations (levomecitin, tetracycline, streptomycin, penicillin, gentamicin, grisin, bacitrocin, etc.) is characteristic, the use of

which in animal feed is based on their antibacterial action and biological effect, which is expressed in the increase of animal body weight. The content of antibiotics in 1 kg of mixed fodders can reach, according to different formulations, up to 100 mg and get into the breathing zone of livestock breeders during preparation of fodders and feeding of animals. Prolonged industrial contact with antibiotics even at low working concentrations can lead to general sensitisation of the organism of livestock workers and alteration of various organs and systems, as well as the development of mycoses [5].

Dustiness of the working zone air is the leading pathogenetic risk factor for the development of occupational IBD in livestock workers. Dust contained in the air of livestock buildings has a complex composition and consists of mineral and organic components. The predominant is the organic component, which includes products of animal activity (wool, bristles, skin scales, dried faeces), residues of plant matter and mixed fodder. The mineral component is represented by soil dust brought in with fodder and mobile machinery, particles of concrete floors, dry lime, which is sprinkled on passages [19]. Dust present in the air of the working zone of cattle breeders belongs to low-fibrogenic aerosols (content of free silicon dioxide, as a rule, does not exceed 7-8%). The highest concentrations of dust in the respiratory zone of cattle breeders are determined during loading and distribution of dry fodder (up to 700 mg/m², exceeding MPC 40 and more times) and during dry cleaning of premises (up to 40-45 mg/m², exceeding MPC up to 10 times). Exceedances of average daily dust concentration in the air of the working zone of cattle breeders, taking into account the time of exposure, are from 3 to 10 times, which corresponds to harmful labour conditions of 2-3 degrees (classes 3.2-3.3) [13].

Dust of plant and animal origin is a pronounced allergen, and its chronic inhalation exposure can lead to dystrophic and allergic diseases of the upper and lower respiratory tract. It is also an ideal reservoir and substrate for the development of a wide range of microorganisms. When polluted dust is inhaled, synergistic effect of chemical and biological agents contained in it is possible [17] .

Thus, the analysis of hygienic characteristics of working conditions in animal husbandry (cattle breeding, pig breeding) allows us to identify, in accordance with the current regulations, the following harmful production factors that affect the respiratory system of workers and can lead to the development of occupational diseases.

(Table 1). Individual sensitivity of the worker's organism, allergic reactions to organic dust and microflora, as well as irritating chemical and mechanical components of dust and its fibrogenic effect, are of great importance in the aetiology of cattle breeders' morbidity due to dust factor, the complex composition of the working zone air and microclimatic discomfort.

In the structure of general morbidity with temporary loss of working capacity (LTC), the share of LTC detected in cattle breeders is subject to significant fluctuations depending on the working conditions and professional experience of workers. In workers

at different agricultural enterprises (dairy farms, cattle-breeding, pig-breeding complex, etc.) respiratory diseases with TSS account for 26.3% to 52.4% of all cases and 15.7 to 35.6% of days of incapacity for work [5].

Table 1

Harmful production factors leading to the development of occupational pathology of respiratory organs in livestock workers

according to the List of harmful factors, Order of the Ministry of Health of RU. of 2012 No. 200

No. n/a	Name of harmful production factor		Mechanism of action organism
	1. chemical factors		
1.2.	Chemicals and compounds containing:		
1.2.32.2.	dihydrosulphide (hydrogen sulphide)	OH, R	O, P
1.2.32.4.	mercaptans	OH, R	O, P
	ammonia	P	P
1.2.2.	formaldehyde	O, A, Rz	O, A, P3
1.2.8.1.	chlorine	OH, R	O, P
1.2.43.	chloro-betta-naphthol	A, R	A, P
1.3	Complex chemical mixtures, compositions, substances for a specific purpose: chemical		
1.3.2.1.	chlorophos	R, A, O	P, A, O
1.3.9.1.	antibiotics	A	A
2.1.	Fungi producers, protein-vitamin fodder yeasts, feed concentrates,	A	A

		Ф
2.2.	Enzymatic preparations, biostimulants	А
2.7.	Dust of animal and plant origin	Ф
3.8.	Lower air temperature in production facilities and outdoor areas (in cold season)	
3.9.	Increased air temperature in production facilities and outdoor areas (in hot season).	
4.1.	Physical overload	

Notes: Substances marked with 'O' are substances with acutely directed mechanism of action, 'P' - irritants, 'A' - allergens, 'F' - fibrogenic effect, 'Rz' - dangerous for human reproductive health according to R 2.2.2006-05].

Catarrhal inflammatory processes in the mucosa of the nasopharynx are characteristic of low-stage persons working in animal husbandry for less than 5 years, which subsequently turn into sub- and atrophic states. At present, occupational diseases of the upper respiratory tract (allergic rhinitis, pharyngitis, laryngitis, sinusitis) are quite rare [4].

Occupational pathology of the bronchopulmonary system in livestock workers develops predominantly with 10 or more years of work experience in the profession and can be represented by occupational bronchial asthma, chronic dusty nonobstructive bronchitis, chronic obstructive pulmonary disease, much less often - exogenous allergic alveolitis (Table 2).

Table 2

List of occupational respiratory diseases of livestock workers under the Order of the Ministry of Health of the Russian Federation of 2012 No. 200

№ п/п	List of diseases associated with exposure to harmful and (or) dangerous production factors	ICD-10 disease code	Name of harmful and (or) hazardous
1.61.2.	occupational factors	J41.0	(or) hazardous production factor
1.61.4.	Chronic dust	J44.8	
1.67.2.	non-obstructive bronchitis	J67.0 J67.2	Chemical substances with toxic effect, except for the substances specified in clauses
3.6.	Chronic obstructive pulmonary disease	J45.0	1.1-1.51
3.7.	Hypersensitive pneumonitis (exogenous allergic alveolitis).	J68.2	

From 2000 to 2020 in Bukhara oblast, occupational respiratory diseases were diagnosed in 36 livestock workers, of which the majority (71%) served cattle (milkmaids, machine milking operators, calves).

The analysis of occupational morbidity of workers taking into account the duration of work in harmful labour conditions showed that respiratory diseases caused by production factors were registered mainly in persons aged 30-45 years with an average work experience in the profession of 15.3 ± 2.6 years. In 14.2% of cases, occupational respiratory pathology developed in livestock breeders working in contact with animals for no more than 5 years. Allergic bronchial asthma (BA) - 85.7%, chronic obstructive pulmonary disease (COPD) - 28.6%, chronic dusty non-obstructive bronchitis (CNOB) - 14.3% occupied the first rank places in the nosological spectrum of occupational respiratory diseases. Atopic bronchial asthma was combined with COPD or PNOB in a number of cases (28.6%) (Fig. 1).

Diseases associated with physical overload and functional overstrain of individual organs and systems - lumbosacral radiculopathy (LSR) and brachial-femoral periarthrosis (SFP) - were diagnosed as concomitant diseases.

Frequency of detection of nosologies (%)

Figure 1: Frequency of disease detection depending on nosological form.

A significant decrease in the frequency of detection of occupational respiratory pathology among livestock workers in comparison with the 80-90 years of the last century, in our opinion, was due to the reduction of production (mainly) and its modernisation (in some cases), which led to a decrease in the number of livestock breeders working in harmful and hazardous working conditions 6+.

Based on the sanitary and hygienic assessment of working conditions in livestock breeding, the priority in reducing the risk of occupational respiratory diseases among livestock workers is sanitary, hygienic and epidemic measures aimed at reducing air pollution in the working zone, ensuring favourable microclimatic working conditions, optimisation of workplaces and labour processes.

Priority is given to mechanisation and automation of such production processes as fodder preparation and distribution, animal watering, pneumatic cleaning, mechanised and automated cleaning, and manure removal. The process of fodder preparation is preferable from raw materials in the form of pellets and briquettes. Conveyors, dosers, crushing and grinding devices used for fodder preparation should be sealed, and working places in rooms for fodder preparation should be equipped with local exhaust devices. Transporting dust-forming materials (fodder, premixes) by vacuum-pneumatic systems or using closed-type conveyors equipped with local exhaust ventilation is advisable.

Ventilation and air conditioning systems of cattle-breeding premises should provide effective air exchange, and regulated parameters of microclimate and air environment. Per technical requirements, supply and exhaust ventilation should provide air exchange at 50-60 m3 per hour per 100 kg of live weight of animals in the room. The use of air recirculation in ventilation and air heating systems of livestock buildings is not allowed. When removing air from the lower zone of the premises, it is necessary to provide for the removal of air from the underground manure channels, which prevents the spread of toxicants, microorganisms and unpleasant odours.

Along with automated ventilation systems, natural air exchange can be used.

The creation of special remote posts (consoles) equipped with monitoring devices and remote control of the technological process allows to reduce the time of personnel stay in areas with increased dust formation and reduces physical stress.

Walls, equipment elements, window surfaces, and lighting fittings of livestock buildings are subject to wet cleaning. Moistening of floors along the whole way cattle move contributes to the reduction of the dustiness of the working area air. To minimise

unpleasant odours it is recommended to use electric and chemical air ozonators, as well as chlorine lime, ammonium sulphate and other means.

Reduction of microbial contamination of the air should be ensured, first of all, by compliance with the regulated requirements for sanitary and hygienic animal housing. This is achieved by using good quality bedding, good condition and trouble-free operation of sewerage and ventilation systems, timely manure removal, use of bactericidal lamps and chemical means, including electrochemically activated sodium chloride solutions with bacteriostatic and bactericidal properties. Integrated plans of health improvement measures must necessarily include preventive and focal disinfection, disinsection and derivatisation.

To prevent the negative impact on workers of toxic substances used for sanitary treatment of livestock premises and territory of livestock facility, it is necessary to strictly observe exposure and frequency of treatment, norms of consumption and concentration of working disinfectant solutions and waiting periods. To prevent the toxic-allergic effect of antibacterial agents should be established strict control over the dosage and methods of application of antibiotics in animals. During disinfection and vaccination using aerosol generators, personal protective equipment should be used.

To prevent acute respiratory diseases in cattle-breeding premises, where cows work, it is necessary to maintain acceptable microclimate parameters, avoiding high and low temperatures, draughts, and high air humidity. To maintain acceptable microclimate parameters in the cold season, it is recommended to equip the supply and exhaust ventilation with devices for heating the supply air, and entrances to the premises with vestibules and air-heat curtains. When designing the heating system of livestock buildings, heating installations that do not cause air pollution by fuel combustion products should be used. The most promising is the use of infrared irradiators for heating the premises.

For those who work outdoors and in humid environment there should be provided rooms and

Livestock breeders working outdoors or in unheated premises during the cold season must be provided with special regulated breaks for heating and rest, which are included in working hours.

Livestock workers must be provided with personal protective equipment (protective masks, respirators, gas masks, etc.), protective clothing and footwear in accordance with the established norms and taking into account the climatic region (belt).

An important role in the prevention of professional morbidity of cattle breeders should be given to sanitary-educational work, realised by means of preventive talks, sanitary bulletins, reading lectures, distribution of individual leaflets on existing production and additional risks. Course training of livestock breeders within the framework of sanitary minimum should be carried out according to the programme established by the requirements of labour protection, taking into account local conditions.

Among medical measures of primary prevention of respiratory diseases in livestock workers, the leading place should be taken by differentiated professional selection among those entering the workplace, taking into account individual characteristics of potential employees, and the presence of general and additional contraindications for work in the profession.

Preliminary medical examination (as well as periodic medical examinations) of livestock workers should be carried out by medical organisations of any form of ownership that have a licence for this type of activity (in common practice, a central district hospital) by Order.

Ministry of Health and Social Development of the Russian Federation No. 302n of 12.04.11.

The employer is obliged to provide the medical organisation, with which the contract for compulsory medical examinations is concluded, with a complete list of workplaces and occupations related to the employee's exposure to harmful production factors and an indication, based on the results of attestation of workplaces and special assessment of working conditions, of the whole complex of these harmful factors for each occupation. The assessment of production factors and working conditions may also use the data of laboratory studies and tests obtained as part of control and supervisory activities, industrial laboratory control, as well as operational, technological and other documentation used in the implementation of production activities.

When analysing actual working conditions at livestock enterprises, special attention should be paid to allergens, carcinogens and substances affecting the respiratory system and reproductive function of workers, microclimate characteristics and labour severity. When conducting preliminary and periodic medical examinations (PME) of livestock workers, the medical commission, in addition to a general practitioner, a psychiatrist and a narcologist, must include an otorhinolaryngologist, a neurologist, a dermatovenerologist, and a surgeon. Allergist, oncologist, ophthalmologist, dentist, ophthalmologist, and allergist, if indicated (recommendations of the above-mentioned medical specialists).

On the indications (recommendations of medical specialists) - sputum microscopy, mycological studies, determination of bilirubin level, AST, ALT, GGTP, 'cold' test, rheovasography (or ultrasound) of peripheral vessels, examination of the anterior segment of the eye. All female workers should be examined by an obstetrician-gynaecologist with bacteriological (for flora) and cytological (for atypical cells) examination at least once a year. Women over 40 years of age are required to undergo mammography or breast ultrasound once every 2 years.

The medical organisation conducting compulsory medical examinations must have full information on the health status of the future employee (medical card of an outpatient

or an extract from it with the results of periodic examinations at the place of previous work).

In the presence of additional risk factors for respiratory diseases, which are not direct contraindications to work in livestock enterprises, it is necessary to conduct an explanatory conversation about the possibility of risk of respiratory diseases at the proposed workplace. If such a significant additional risk factor for the development of dust lung pathology as smoking is detected, a preventive conversation should be held to encourage the abandonment of this harmful habit. Also the occupational pathologist participating in the preliminary (or periodic) medical examination is obliged to inform the potential employee about the nature of long-term occupational health risks when working in contact with animals, to familiarise him with early manifestations of occupational DOD, measures of individual protection from negative health effects of harmful production factors.

Thus, the main task of primary medical prevention of the risk of development of occupational CVD in livestock workers is a strict selection into the profession, carried out in the process of preliminary medical examinations.

At the stage of secondary medical prevention of occupational respiratory diseases in livestock workers, the main role is given to PMO. Regardless of profession and length of service in animal husbandry, all workers in the risk group should be examined at least once a year, and in case of deterioration of health and appearance of symptoms of occupational pathology of the respiratory system - 2-3 times a year (depending on the state of health). For all persons under dispensary supervision, individual plans of therapeutic and prophylactic measures are developed on a mandatory basis, an important place among which should be taken by individual smoking cessation programmes, especially in case of high risk of chronic bronchitis and chronic obstructive pulmonary disease.

Trainee cattle breeders employed in jobs with harmful and (or) hazardous working conditions for 10 or more years should undergo PMO in occupational pathology centres at least once every five years.

At the same time, information about low levels of harmful production factors according to the results of the last workplace certification carried out by the employer cannot be a reason for refusal to carry out mandatory medical examinations in CPs, since in modern conditions, as a rule, there is their complex, combined effect on the organism, increasing the health risk of the worker.

In addition, it should be taken into account that recently, occupational diseases have been detected in trainee workers, the duration of development of which is counted in decades, and the formation of occupational pathology is due to the hygienic characteristics of the previous harmful working conditions, which cannot be covered by the current results of workplace certification.

Employees with symptoms of occupational disease detected in the course of the MOT should be duly referred by the medical organisation that carried out the MOT, or, in the case of self-referral, by the attending physician (occupational pathologist), to the occupational pathology centre for consultation, in-depth examination and in-patient treatment, as well as expert assessment of the relationship between the disease and the occupation.

Thus, the labour activity of livestock workers takes place in conditions of uncomfortable temperature regime, increased levels of relative humidity and air velocity, with constant contact with opportunistic and pathogenic microflora. The air of the working zone is constantly polluted with gaseous impurities - products of animal activity, decomposition of plant residues of fodder and excrement, organic dust of animal and plant origin, which may include antibacterial, enzyme and protein preparations, growth stimulants, microorganisms and disinfectants. Labour activity of cattle breeders is characterised by emotional tension, excessive physical and static loads when performing manual work, performing work operations in uncomfortable forced body positions with prolonged orthostasis and transitions.

In this regard, timely comprehensive prevention (organisational-technical, administrative-legal, medical and preventive measures) of occupational respiratory diseases and adequate medical and social rehabilitation of livestock workers, based on the principles of continuity, continuity and stages of medical supervision and provision of primary and specialised occupational pathological care, are of particular importance.

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