

A History of Respiratory Protection in Yugoslavia

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The nations of Yugoslavia started the process of industrialization later than did many other European countries. Industrial development, as well as working conditions in factories, were under various foreign influences.

The first works on occupational medicine in the Serbo-Croatian language were published by A. Giacic (1855), K. Pejic (1862–1882), and M. Nikolic (1862). The first accident insurance laws in Slovenia, Croatia, and Serbia were introduced at the beginning of the 20th century. These laws regulated the employer's obligations regarding safety measures including some measures regarding respiratory protection.

The use of poison gas in World War I had had a major influence on the development of respiratory protection in Yugoslavia. By the end of the war, the Serbian Royal Forces were equipped with French gas masks. At the end of World War I, all Yugoslav nations were unified in the Kingdom of Serbs, Croats, and Slovenes, which became known soon afterward as the Kingdom of Yugoslavia.

The founder of modern occupational medicine in our country was Dr. Zeljko Hahn (1876–1941), who was the director of the Health Division of the Institution for Workers' Insurance, established by the Law of Social Insurance in 1921. He made the first programs for workers' protection against occupational diseases and tuberculosis. In 1925 Dr. G. Bogie published a book on the subject of safety in Yugoslav mines, including some aspects of respiratory diseases. Dr. Sekulic and Dr. Milosevic wrote articles on silicosis in 1936, and in 1939 Dr. B. Kesic published a book, *Occupational Hygiene and Occupational Diseases of Miners*. Between the two World Wars, the journal *Workers' Protection* had an important role in publishing many articles on health protection at work.

The first steps in the actual production of respiratory-protective devices were taken in 1925 by

the Military and Technical Enterprise Obilicevo, located in Krusevac. At that time, Obilicevo was the largest military and chemical corporation in the Balkans. It consisted of ten plants that produced gunpowder, explosives, and various chemicals. Three engineers—Kostic, Vukadinovic, and Cekic—who would be the Yugoslav pioneers in the field of gas-mask production, were appointed by the Ministry of the Armed Forces to work on this new project. After their studies in France, Kostic, Vukadinovic, and Cekic spent about two years on the development of the first Yugoslav military gas mask, M-27, based on French design. The original feature of the mask was the filter canister filled with activated carbon made from plum pit shells and impregnated with zinc chloride.

By 1933, succeeding designs of gas mask met the new performance specifications and were in production. These were the M-33 military mask and the M-34 civil mask (Figure 1). Both masks had the same type of facepiece made of leather, with a built-in inner flange, nosecup, and two air-distribution tubes behind the eyelenses. The basic versions of these masks were air-purifying with the canister attached to the facepiece by a corrugated hose. In addition, the M-34 mask was produced in a design that had the canister attached directly to the facepiece. The special-purpose military mask was made as an SCBA, which was equipped with a Draeger unit consisting of a small cylinder of compressed oxygen, chemical container, bag, and regulating valves.

Until 1939, the Technical Department of Obilicevo made rapid progress in research and development of new materials and mask designs, as well as in new methods of testing and inspection. The Technical Department had a chemical laboratory and a prototype workshop, including a large gas chamber used for fit testing and animal exposures (Figure 2). In 1939 they produced a new mask, Nebojsa (Figure 3), with a facepiece made of natural rubber. The canister was improved by a circular-type particulate filter.



Figure 1. Military gas mask M33 (left) and civil gas mask M 34 (right).

Figure 2. Gas chamber for mask testing.



In that year, the beginning of World War II, the Military and Technical Enterprise Obilicevo was bombed and almost completely demolished. After the war, great efforts were made to restore production. The repaired plants continued production under the name Miloje Zakic Combine, named after a war hero who had been a former cadet at the technical school.

Protection for workers was declared by the Constitution of the Federal People's Republic of Yugoslavia in 1946. The first Federal regulations concerning hygienic and technical protective measures in the workplace were established in 1947. At the same time, the institutes for occupational hygiene in Belgrade and Zagreb were founded. The first list of threshold limit values (TLV) was issued by the Yugoslav Standard Institution in 1957. The standards concerning respiratory-protective devices were adopted in 1956 and 1957. These standards

covered dust respirators, gas masks, hose masks, hose masks with hood or helmet, and self-contained breathing apparatus (SCBA). Standardization of the design, quality, testing methods, and use of respirators generated a significant impact on the development of respiratory protection in Yugoslavia. Industry Miloje Zakic increased the assortment of products by the dust respirator model "Z," gas respirator model "P," different types of gas-mask filters, and the hose mask.

Two years after the production of activated carbon was restored in 1950, new gas masks appeared. Over the next four decades, the development of respiratory protection has been influenced by two overlapping areas: military protection and industrial protection.

Gas mask model M-52 (Figure 4) was designed to provide combat units of the armed forces with



Figure 3. Gas mask Nebojsa.

protection against particulate and gaseous chemical-warfare agents. The facepiece was made of natural rubber. Two eyepiece assemblies, each consisting of a flat triplex glass lens, provided a wide field of vision. The expiratory valve diaphragm was similar to the poppet-type valve. The large-capacity gas and particulate canister was connected to the facepiece by a corrugated hose.

The first industrial gas mask was model M-53. This mask consisted of a rubber facepiece, two flat triplex glass lenses, a flap-type expiratory valve, six head harnesses, and a canister directly attached to the facepiece.

In the 1960s a great deal of research was done, improving standards, writing new regulations, conducting physiological studies and workplace exposure studies, investigating new materials, and developing products.

Old standards were updated in 1963. In 1965, the Basic Law on Protection at Work was passed, which promoted an increased use of powers in mak-



Figure 4. Gas mask M 52.

ing detailed regulations and orders. It defined many details of safety at work, including advocating the use of personal protective equipment. In 1969, the Federal Council of Work issued the Rules on Personal Protection at Work and Personal Protective Equipment. The rules prescribed eight types of respiratory-protective devices and some limitations on their use. These rules were also the basis for further improvement of the existing standards.

Of special importance during this decade were several research projects carried out in the Institute of technical and Medical Protection, the Institute for Occupational Medicine, and in the Military Medical Academy. A study on the physiological reactions to wearing respirators was conducted by Z. Stojiljkovic. Anthropometric measurement of male faces was the basis for mask design was carried out by V. Radmili. A study on protection factors with half-mask respirators worn by workers exposed to carbon disulfide in the chemical plant was made by D. Djuric.

During this period, Industry Miloje **Zakic** developed several new respirators, including:

- New military protective mask model **M-1**, similar to the U.S. military mask **M9**;
- Civil RBC protective mask MC 1;
- Full facepiece industrial mask M 65;
- Half facepiece dust and vapour respirator **FA M65**;
- Half facepiece dust respirator **FF M68**;
- Half facepiece with corrugated hose and canister;
- Quarter facepiece dust respirator **FF M62**;
- Mouthpiece filtering self-rescuer for miners M 67.

All these types of facepieces were made of natural rubber. The full-facepiece masks were produced in three sizes. Eleven types of gas and **gas**/particulate canisters were in production.

The next decade (1970-1980) was marked by the strong development of the worker's self-management in Yugoslavia. By the Law of Associated Labor, the legislation on protection in the workplace was simplified to provide a minimum administrative framework. According to this law, workers were responsible for their own personal protection at work, and the workers' council at the company could propose the rules on the use of personal protective devices, including respirators. This idea was very good in theory, but in reality it did not contribute to better protection of workers. Yugoslav standards on respiratory protective devices were updated in 1975, modeled after German (DIN) standards.

During this period the Yugoslav market of protective equipment was enriched by the import of respiratory protective devices, mainly from West Germany and the Soviet Union. Responding to the competition, the domestic manufacturer Industry Miloje **Zakic** improved the quality of its own products and developed two new respirators: the filtering particulate half-mask model **FM 73** and the full-facepiece model **Panorama B 2**. The **FM 73** respirator consists of a half facepiece made of large-pore polyurethane foam and polymeric film lining provided with inhalation and exhalation valves, nose clip, and head straps. The **Panorama B2** is similar to the **3S** mask from Auer (MSA branch in West Germany). This mask has a facepiece made of natural rubber with a one-flap face seal, nose cup, and five adjustable straps.

By the end of this decade, an unusual type of protective mask was designed to protect horses from

inhaling radiological, biological, and chemical warfare agents. The mask for horses (Figure 5) consists of a facepiece provided with integrated hood, two canisters, and an exhalation valve. The unique feature of this mask is its two-size facepiece, each with three separated inner flaps, assuring an adequate protection factor for horses of various breeds. Another specific feature of the mask is the dual position of the exhalation valve diaphragm in the valve assembly. It has a free-air position that enables breathing and bypassing the valve diaphragm, and a protective position with the usual exhalation valve operation.

The last decade has seen a certain stagnation in Yugoslavian legislation and standardization. But, on the other hand, there have been many activities in research, development, and production. Particular attention has been devoted to the following research areas:

- Development of **anthropometric** panels for mask design and fit testing;
- Development of the methodology for mask fit testing;
- Studies on respirator impedance;
- Use of the **CAD/CAM** (computer aided) system for mask design;
- Studies on particulate filtration;
- Development of new materials for vapor adsorption;
- Studies on powered air-purifying respiratory devices;
- Studies on respirator use in the industry.

The research work has been carried out in several institutes and facilities: the Military Technical Institute, the Military Medical Academy, the **Boris Kidric** Institute, the School for Protection at Work,

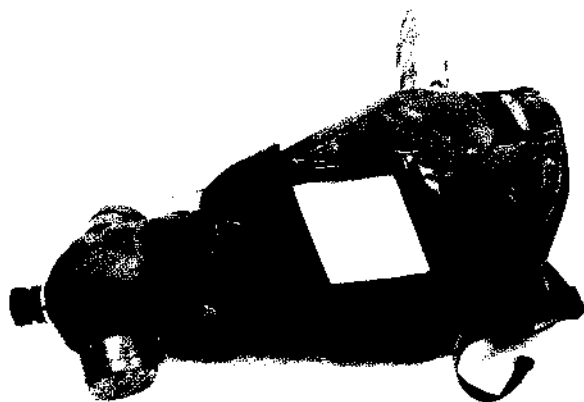


Figure 5. Gas mask for horses.

the Institute for Safety and Protection at Work, the School of Mechanical Engineering, and at several Institutes of Occupational Medicine.

During this period, Industry Miloje **Zakic** has introduced several new respirators:

- New military protective mask model **M2**;
- Panorama **mask B2/G** with a speaking diaphragm;
- Powered air-purifying hood for victims of head injuries;
- Protective mask for children, **MD-1**;
- New universal gas and vapour respirators, **UR2/UR4**;
- Respirator with integrated hood.

Responding to today's diversified needs for industrial safety equipment, new Yugoslavian manufacturers have entered the domestic market. The Djuro Djakovic Corporation has produced a positive-pressure SCBA. Company Konus has developed a disposable dust respirator, and the first private manufacturer, **Akrapovic** entered the market with **half-facepiece** respirators.

After almost seventy years of development of respiratory protection in Yugoslavia, it is reasonable to expect its further progress in the future by adoption of European standards and by international cooperation in the production and marketing of respiratory protective equipment.