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Short Communication

New Powered Air Respirator

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Abstract

The analysis of respiratory protective device use efficiency has shown the substantial limitations of quality assessment for respirators. This results in potential hazard of excessive influence of harmful particulate pollutants on employees. To prevent occupational diseases development it is extremely important that employers are motivated to improve labour conditions. Not least important is development of requirements to the biomonitoring procedure and conditions, as well as selection, testing and users training for individual respiratory protective devices use as based on the modern science development. The elimination of hazard class based only in providing the employees with individual respiratory protective devices is not scientifically substantiated and inadmissible way.

Keywords: Dust mask; Protection factor; Dust load; Pneumoconiosis

Introduction

The filtering respirator with forced air supply is an effective means of individual protection of respiratory organs (RPD) of users in especially dangerous conditions saturated with harmful substances in which it is impossible to use other types of protective equipment [1-3]. The main disadvantages of the known designs of filtering respirators with forced air supply include inefficient operation of the fan due to the significant resistance of the air flow inhaled by the user. This is due to the shortcomings of the existing fan speed control system in the event of a sharp increase in air flow due to increased physical activity of the user or contamination of the filter elements [4,5]. This leads to the suction of polluted air along the obturation strip into the submask space, which can cause poisoning or death of the user [6].

Description of the Design and Operating Modes of the Filtering Respirator with Forced Air Supply

This problem is solved by equipping a filtering respirator with forced air supply by the air flow control unit, which provides the relationship between air flow and the intensity of physical activity of the user, considering the air flow passing through the filter elements while maintaining the appropriate level of protective properties (Figure 1). The filtering respirator with forced air supply has several operating modes (Table 1):

a. Automatic, based on the output signals of sensors for monitoring air parameters, the information from which comes to the controller, where they are processed and controlled: fan speed, purified air heater, indication and alarm, which is illuminated on the display of the air purification unit.

b. Turbo mode, which is activated in case of heavy contamination of the filtering elements to increase the speed of the fan, which is regulated by the controller in case of receipt of the corresponding signals from the control sensors.

c. Emergency mode, which is activated when the battery is minimally charged, or when the critical value of the pressure drop across the contaminated filter elements is reached, for the user to quickly leave the danger zone.

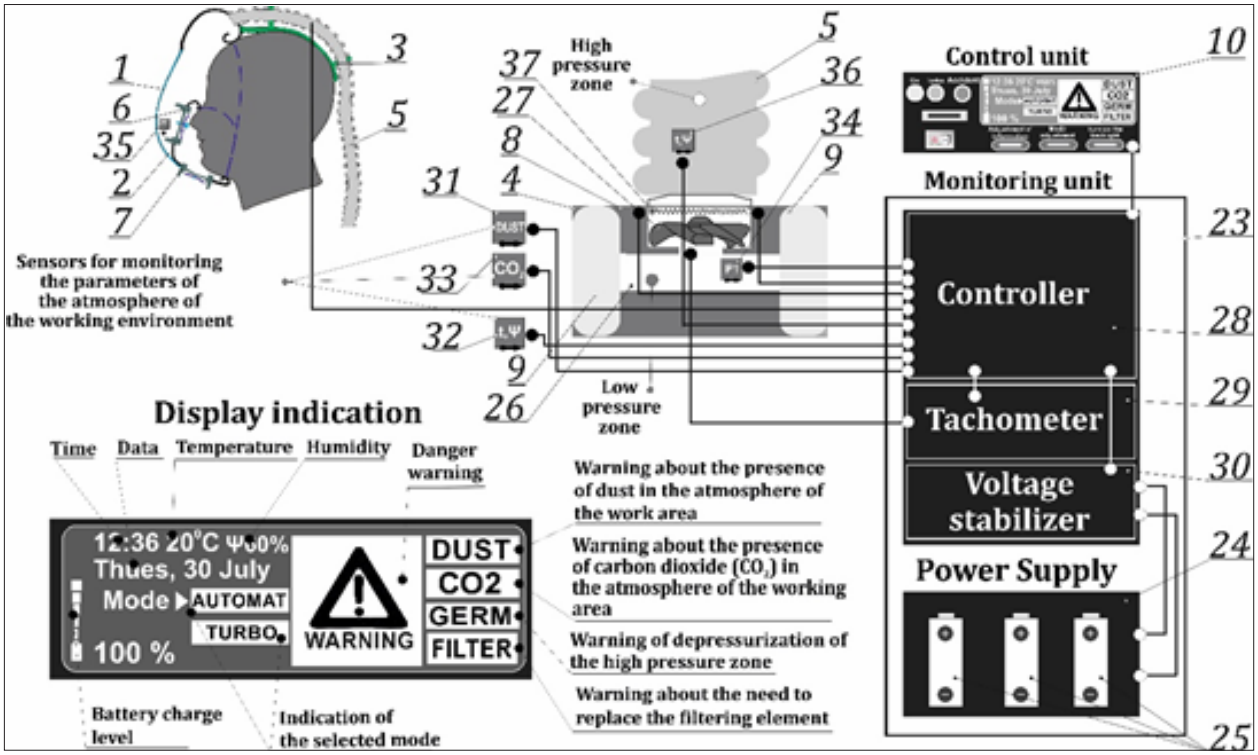
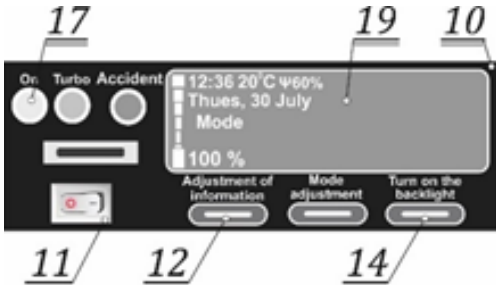
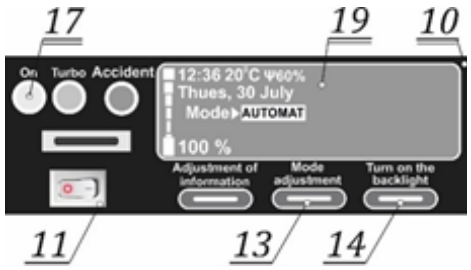


Figure 1: Schematic and structural scheme of the filtering respirator with forced air supply: helmet-mask (1), obturator (2), head straps (3), air purification device (4), flexible corrugated air duct (5), inhalation valve (6), exhalation valve (7), air cleaner housing (8), filter elements (9), control unit (10), on/off switch (11), button №1 (12), "Information correction" (time, day of the week, month, ambient temperature, humidity); button №2 (13), "Mode adjustment" (automatic mode, turbo mode, emergency mode); button №3 (14), "Display backlight"; indicator lights: - red indicator light (15), "Accident", blue indicator light (16), "Turbo", green indicator light (17), memory card (18), display (19), loudspeaker (20), connector for charging batteries (21), USB connector for connection to a PC for setting up and adjusting the software of the air cleaning device (22), monitoring unit (23), power supply unit (24), which includes three batteries (25), channel (26), power supply (27), controller (28), tachometer (29), voltage stabilizer (30), sensor for monitoring the presence of dust in the atmosphere of the working area (31), temperature and humidity control sensor in the working zone atmosphere (32), carbon dioxide concentration control sensor in the working zone atmosphere (33), low pressure zone pressure control sensor (34), high pressure zone pressure control sensors (35), control sensor temperature and humidity in the high pressure zone (36), purified air heater (37).

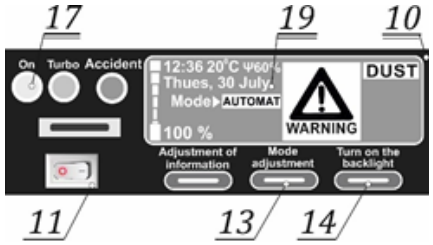
Table 1: Operating modes of the filtering respirator with forced air supply.

Image of the Display Information of the Control Unit Depending on the Operating Mode	Algorithm for Switching on the Device in the Appropriate Mode
1	2
1. Preparing the device for operation	
	To prepare the device for operation, it is necessary to press the "On/Off" switch (11), and the green "On" LED on the display (19) of the control unit (10) will light up. (17). Then the information displayed on the device is adjusted using the "Information correction" button (12): day of the week, date, month, time (hours, minutes). The control of temperature and humidity of air space of a working zone is checked. The backlight of the display (19) is checked by pressing the "Switch on backlight" button (14). The degree of charge of the power supply unit (24) is checked. The indication of the state of the batteries (25) is carried out by means of a signal indication, which flashes at the residual capacity of the batteries (25) not less than 25-30%; when the voltage on the battery stack is reduced to 2.8-3 V, the fan (27) is switched off.
2. Purge of the air purifier	

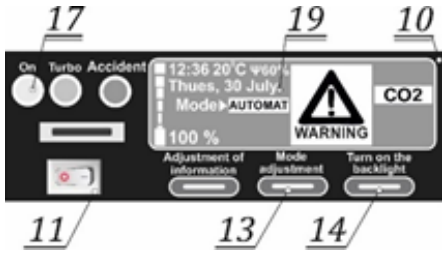


To purge the device, it is necessary to press the “On/Off” switch (11) and the green LED “On” (17). will light up on the display (19) of the control unit (10). Press the “Switch on backlight” button (14) and the “Mode adjustment” button (13). Use the “Mode adjustment” button (13) to set the “automatic” mode. At the same time the fan (27) begins to rotate and to inject air from the external environment in a helmet mask (1). The fan (27) rotates at a constant speed.

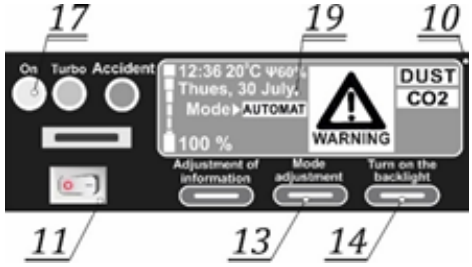
Display indication in the presence of dust in the atmosphere.



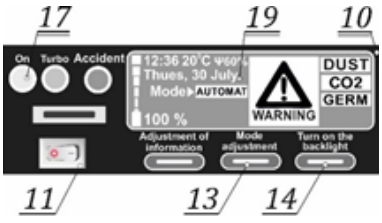
Display indication in the presence of CO_2 in the atmosphere.



Display indication in the presence of dust and CO_2 in the atmosphere.



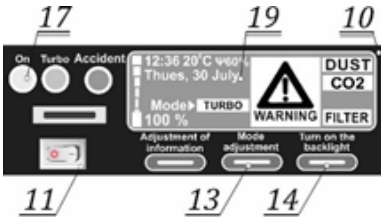
Display indication in case of loss of sealing of the device.



Switching on the device for operation in the automatic mode the switch “On / off” (11) is pressed at the same time on the display (19) of the control unit (10) the light-emitting diode of green color “On” will light up. (17). Press the “Switch on backlight” button (14) and the “Mode adjustment” button (13). Use the “Mode adjustment” button (13) to set the “automatic” mode. At the same time the fan (27) begins to rotate and to inject air from the external environment in space of a helmet mask (1). The user puts on a helmet mask (1) on the face and with the help of the head straps adjusts the tight pressing of the helmet mask (1) to the head and carefully checks the comfortable pressing of the shutter to the face. The user also checks the tightness of the connection of the filter elements (9) with the housing (8) of the air purifier (4), the connection of the housing (8) of the air purifier (4) with the corrugated duct (5) and the connection of the corrugated duct (5) with a helmet mask (1). After checking the air purifier, the user puts on a helmet-mask (1), fastens the air purifier (4) on the belt behind the back for convenience.

3. The device working in Turbo mode

Display indication in the presence of dust and CO_2 in the atmosphere



To turn on the device for operation in Turbo mode, press the switch "On/Off" (11) while the display (19) of the control unit (10) lights up the green LED "On" (17). Press the "Switch on backlight" button (14) and the "Mode adjustment" button (13). Use the "Mode adjustment" button (13) to set the "Turbo" mode, and at the same time the blue "Turbo" LED (16) is switched on and the warning" WARNING!", "FILTER" lights up on the display (19). At the same time, the fan (27) starts to rotate at the maximum possible speed and injects air from the external environment into the space of the helmet-mask (1) to the respiratory organs of the user.

Laboratory studies have established a relationship between the volume of air flow that enters the submask space to the user's respiratory system and the fan speed (Figure 2). The critical pressure drop on the filtering elements, which change the parameters of the air flow, is determined and the changes of the air flow modes from the intensity of the user 's physical activity are investigated. As a result of substantiation of design parameters and modes of operation of the fan on the basis of processing of input signals from sensors of control of technological parameters and comparison with existing analogues RPD of the corresponding class, efficiency of the offered design of the dust respirator with forced air supply inhaled taking into account the frequency and depth of breathing of the user during exercise.

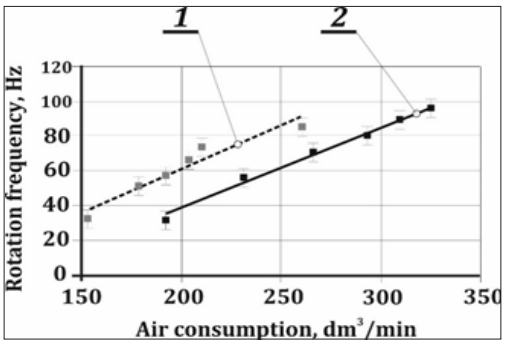


Figure 2: Graphs of air flow dependences on fan speed "HA4010V4" unmodernized (1) and modernized with replacement of stator excitation windings by resistors (2).

Conclusion

The design of a filtering respirator with forced air supply in which a new element is introduced - the control unit of air flow parameters (volume, speed, temperature, humidity), which enters the submask space. This allows not only to provide the required volume of air in the submask space of the filtering respirator, by controlling the fan speed in a given range, taking into account the frequency and depth of breathing of the user depending on physical activity.

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