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Setting the thresholds for selected components of air in filling the cylinders of autonomous breathing apparatus

This paper deals with the determination of the number of engine hours needed to reach the limits set by the standard STN EN 12021 for clean air in the autonomous breathing apparatus used by the Fire and Rescue Corps in the Slovak Republic.[1] The purity of air sucked in affects the life of the filter cartridge P-21 TRIPLEX and its effective use in the filling of the cylinders of the autonomous breathing apparatus using compressor Bauer Mariner II.The determination of thresholds of CO, CO_2, H_2O and oil at the outlet of the compressor was performed by the air tester Auer Airtester HP, which is used to measure the quality and purity of the air supplied to the compressor cylinders.
Keywords: autonomous breathing equipment, compressor, air tester, air, Bauer Mariner II, Auer Airtester HP

Introduction

Protection and rescue of people and property is the main mission of the Fire and Rescue Corps SR (FRC SR). [17] In an environment with the assumption of non-breathing atmosphere is very important to ensure the maximum degree of protection for the respiratory tract of intervening fire-fighters. The respiratory protection of intervening fire-fighters is addressed by the anti-gas service in the FRC. One of its tasks is to supply air in unhealthy or non-breathing conditions [8] [18]. The fire-fighters at various interventions, especially in fires and anywhere where it is not possible to breathe pure air, or where a damage to the respiratory tract is suspected, use autonomous breathing apparatus (hereinafter ABA) [1]. [16]

The use of ABA entails risks and incidences of occupational accidents, occupational diseases and other health damage, and therefore the Act no. 124/2006 Coll. on Safety and health at work and its amendments governs the general principles of prevention and basic conditions to ensure and eliminate these risks and factors [15].

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Under the conditions of the FRC for the compression of air and filling the compression cylinders of the autonomous breathing apparatus a gas compressor is used, therefore the purity of air at the outlet of the compressor is very important.

Rentka (2006) dealt with the air quality issues for fire-fighters, who further states that the composition of air is common and is often influenced by local sources of emissions with a large variety of substances with harmful effects. Therefore, there is a rule that high-pressure compressor filling reservoirs of the autonomous breathing apparatus must be positioned so that it sucks the cleanest air without undesirable air pollutants [7]. Martinka (2011) in his work states that it is very important to know the different parameters of the burning materials, because nitrogen oxides are one of the most important toxicological combustion gases with which the fire-fighters may come into contact in extinguishing fires [5]. Mózer solved the issue of modelling the formation of smoke in burning buildings and especially its toxic products [6]. Janásek et al. (2004) point out the adverse impact of combustion products on the respiratory tract and the necessity to protect the respiratory by personal protective equipment, namely by the autonomous breathing apparatus [2].

Air

Atmospheric air is a colourless gas with no taste, which consists mainly of various gaseous chemical elements. This composition remains largely still up to the height of about 25 km. Air always contains water vapour, and solid particles, e.g. dust, sand, soot, salt crystals, etc. [4]. Atmospheric air in an industrial environment contains approximately 140 million m^3 of dirt particles in the air, 80% of these particles are smaller than 2 microns. In general and for the general public only the highest % ingredients represented in the air are given. Air composition is as follows: 20.96% oxygen, 78.00% nitrogen, 1.00% inerts and 0.04% carbon dioxide [3].

International standard ISO 8573 defines several classes for the quality of compressed air in terms of content of water, oil, solids etc., which may be included in the compressed air. Class 1 is the highest air quality. Compressed air is assigned to Class 2, where the temperature does not exceed the dew point of - 40 °C, or in terms of absolute humidity of 0.12 g per m^3 of water vapour and 18 ppmV (parts per million by volume) [14].

In the standard STN EN 12021, which establishes the requirements for compressed air quality, the threshold values of measured substances are the following: content of lubricating substances (droplets or mist) must not exceed 0.5 $mg.m^{-3}$, carbon dioxide content shall not exceed 500 $mg.m^{-3}$ (500 ppm), carbon monoxide content shall be as low as possible, not exceeding 15 $mg.m^{-3}$ (15 ppm). At atmospheric pressure, the maximum water content can be in the liquid state 50 $mg.m^{-3}$ at a nominal pressure up to 200 bar, 35 $mg.m^{-3}$ at a nominal pressure of more than 200 bar. The water content in the compressed

air supplied by compressor for filling tanks of compressed gas for 200 or 300 bar tanks, shall not exceed 25 $mg.m^{-3}$ [10]. The air purity at the outlet of compressors is measured with devices specified to control the purity of air, so. FRC uses air testers from the companies Auer and Dräger.

Objective

The aim of this paper is to determine the maximum lifetime of use of the filter cartridge, by comparing the measured data with thresholds set in the standard for air purity STN EN 12021. So we compare the measured maximum period of use of the filter cartridge P-21 TRIPLEX on the compressor Bauer Mariner II used in FRC and the manufacturer specified time to replenish the filter cartridge, in our conditions.

Methodology

Concentration limits of individual substances provided by STN EN 12021 were taken to be the thresholds. Exceeding the threshold value of even a single parameter meant the necessary replacement of the filter cartridge. Measurement was carried out with high pressure compressor Bauer Mariner II, which is the device used by FRC to fill the diving bottles and bottles of autonomous breathing apparatus. Technical parameters of the compressor Bauer Mariner II are listed in Table. 1

This type of compressor uses a filter system with P-21 with TRIPLEX filter cartridge which serves as a final filter in the compressor. It influences the quality and purity of the air compressed by the compressor to a significant extent. To replenish the filter cartridge, there are very strict conditions provided by the manufacturers of compressors [11].

When measuring with the compressor Bauer Mariner II, at the air output terminal (300 bar), a measuring device was joined to the pressure valve to measure air purity. The Auer Airtester HP device is used to measure the quality and purity of the air supplied to the compressor cylinders, according to STN EN 12021.

Using Auer Airtester HP, it is possible to accurately measure the content of oil, carbon dioxide, carbon monoxide and water vapour in the compressed air [12]. The tester's disadvantage is that each measured parameter must be measured separately. It is not possible to measure simultaneously all four measured parameters. A rubber adapter is adapted just to be connected to one detector tube.

Complete equipment		Compressor	
medium	air	degrees number	3
input pressure	atmospheric	cylinders number	3
power output [l.min^{-1}]	200	cavil of the 1. / 2. / 3. degree [mm]	88/36/14
max. operating pressure [MPa]	PN 300	piston lift [mm]	40
safety valves-settings [MPa]	22.5/33.0	turns [U.min^{-1}]	1270
loudness [dB]	83	refrigeration	air
weight [kg]	93	volume of oil tank [l]	2.8
Electro engine		inter-degree pressures [MPa]	0.65/4.7/33.0
engine type	380 V/ 50 Hz	oil pressure [bar]	3.6
engine power [kW]	4	max. ambient temperature [°C]	+5 až +45
at turns [U.min^{-1}]	2815	max. compressor inclination [°]	10

Tab. 1: Technical parameters of Bauer Mariner II compressor [12]

Results and discussion

The measurements were conducted under very specific conditions, in accordance with the proper use of the compressor, measuring instruments, and also under conditions which allow the measurement of each parameter of air according to STN EN 12021. All measurements were conducted at a constant temperature of 20 °C + - 2 °C, measured with certified thermometer and the humidity of atmospheric air was 30% + - 10%, measured by a hygrometer VL 305016.

Measurements were initiated when a new filter cartridge P-21 Triplex was applied. The first values were read immediately after inserting a new filter cartridge and then we took measurements after each operating hour of the compressor, up to the 22nd operating hour.

Table 2 shows the measured values of CO, CO_2, H_2O and oil content, and the individual values modified with measurement deviations, measured with airtester Auer Airtester HP.

Meas.	Operating hrs. of compressor	State of compressor operat. hrs.	Parameters				Parameters completed with measurement deviations		
			CO ($ml.m^{-3}$)	CO_2 ($ml.m^{-3}$)	H_2O ($mg.m^{-3}$)	Oil ($mg.m^{-3}$)	CO +25% ($ml.m^{-3}$)	CO_2 +25% ($ml.m^{-3}$)	H2O +15% resp. +25% (mg. m-3)
1	0	163.5	0	100	5	0.1	0.0	125.0	6.25
2	3	166.5	0	100	5	0.1	0.0	125.0	6.25
3	6	169.5	0	200	10	0.1	0.0	250.0	12.50
4	9	172.5	0	220	12	0.1	0.0	275.0	15.00
5	12	175.5	0	240	17	0.1	0.0	300.0	21.25
6	15	178.5	0	280	20	0.1	0.0	350.0	23.00
7	18	181.5	0	320	30	0.3	0.0	400.0	34.50
8	21	184.5	1	350	45	0.3	1.25	437.5	51.75

Tab. 2: Volume of particular air components

As can be seen in Table 2, CO values ranged from 0 $ml.m^{-3}$, at the beginning of the measurement, up to the value of 1 $ml.m^{-3}$ in the 22nd operating hour of the compressor. CO_2 values ranged from 100 $ml.m^{-3}$ up to 350 $ml.m^{-3}$ in the 22nd operating hour of the compressor. The water content of compressed air ranged from 5 $ml.m^{-3}$to 45 $ml.m^{-3}$, oil content ranged from 0.1 $ml.m^{-3}$ to 0.3 $ml.m^{-3}$. This value was measured in the 22nd hour of operation of the Bauer Mariner II compressor. Even after adding the specified measurement deviation to the individual measured parameters, they didn't exceed the thresholds of air quality set in the STN EN 12021, up to c.a. 17th hour of compressor operation.

The compressor manufacturer sets the time for the P-21 Triplex filter cartridge replacement after 13 hours of operation, with the condition that the thresholds set by standard STN EN 12021 are not exceeded. In the operational instructions for compressor BAUER Mariner II it is stated that the Triplex P-21filter cartridge replacement is after c.a. 10 operating hours of compressor operation in our conditions.

In Fig. 1, we can see how the CO content of the air at the outlet of a compressor is related to the passing of operation time, up to the 22nd operating hour.

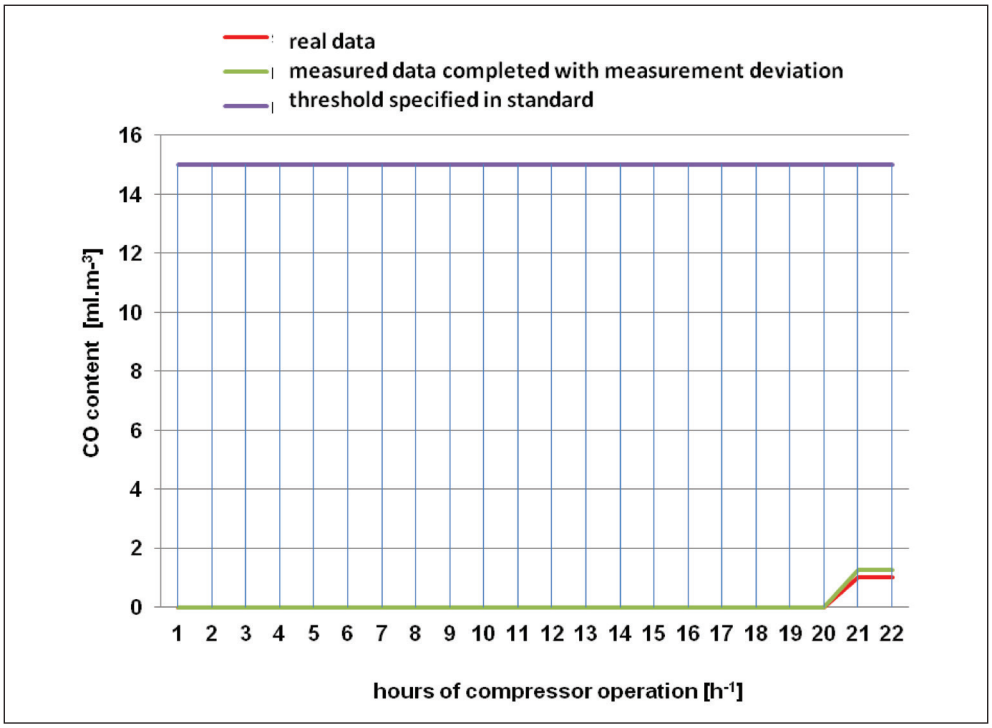

Fig. 1: Dependency of CO content on operating hours

The graph (Fig. 1) shows that the measured value of the CO component of air (measured with device Auer) were zero up to the 19th operating hour. We did not observe any coloration on the detector tube. At the 20th operating hour the tube began to be coloured, but the measured value was minimal, even with the addition of deviations (measurement uncertainty); the measured value was below the 150 $ml.m^{-3}$ threshold specified in STN EN. It follows from the graph (Fig. 1) that after 13 operating hours it is not necessary to replace the filter cartridge of the compressor. The values of the measured component are under the prescribed threshold value during the entire measurement (up to the 22nd operating hour) and the purity of air does not endanger the health of users of the compressed air from the compressor.

In Fig. 2, we can see how the CO_2 content in the air at the outlet of the compressor is related to the passing of operation time, up to the 22nd operating hour.

The graph (Fig. 2) shows that the values of the CO_2 component of air (measured with device Auer) increased with every operating hour. The detection tube got coloured immediately after inserting a new filter cartridge Triplex P-21 and with each operating hour the coloured part of the tube expanded, indicating that the values of the measured component of air was increasing. During the measurement, i.e. after 22 hours of compressor the thresholds of CO_2 standard specified by standard STN EN 12021 (500 $ml.m^{-3}$) was not exceeded.

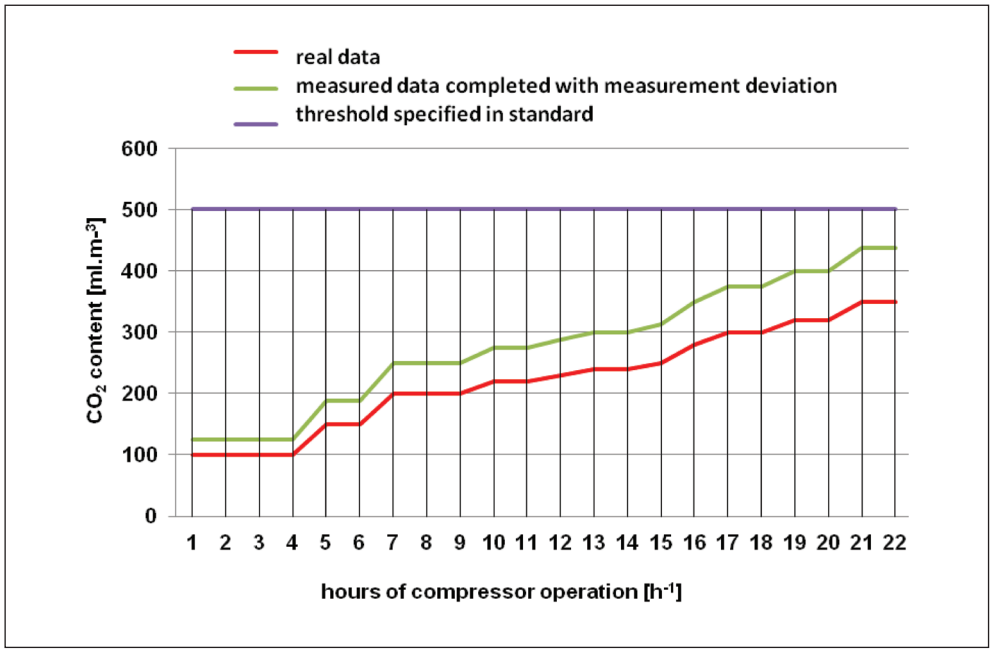

Fig. 2: Dependency of CO_2 content on operating hours

The graph (Fig. 2) shows that after the 13th hour of compressor operation it is not necessary to replace the filter cartridge. The values of the measured component during the measurement (up to 22nd operating hour) are under the prescribed threshold value and purity of the air does not endanger the health of users of compressed air from the compressor.

In Fig. 3, we can see how the H_2O content in the air at the outlet of the compressor is related to the passing of operation time, up to the 22nd operating hour.

The graph (Fig. 3) shows that the values of H_2O in the air (measured with device Auer) increased with every operating hour of the compressor. The detection tube got coloured immediately after inserting a new filter cartridge Triplex P-21 and with every operating hour the coloured part slightly increased, which meant that the values of the measured component were increasing. After 17 hours of compressor operation the water vapour content increased substantially and the values were rapidly increasing, the threshold limits of water vapour content, set in the standard STN EN 12021 to 25 $mg.m^{-3}$, were exceeded. Our measurements showed that after 16 operating hours of compressor operation the measured component of air (water vapour content) exceeded the threshold.

The measurement showed that after the 16th operating hour it is necessary to replace the filter cartridge according to the threshold specified in the standard. However, the compressor manufacturer recommends the replacement of the filter cartridge after 13 hours of compressor operation. Our measurements showed that after 13 hours of compressor

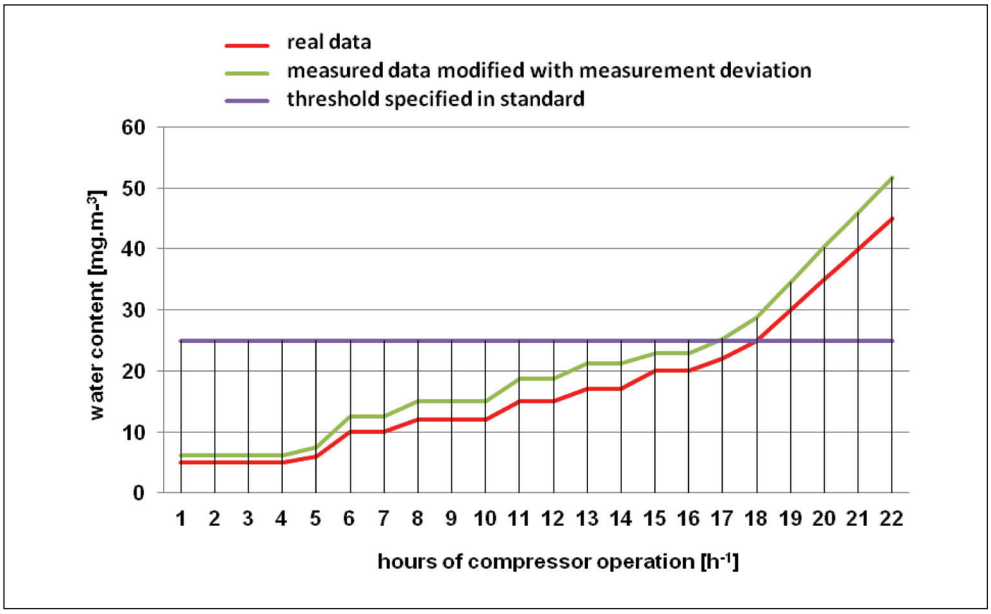

Fig. 3: Dependency of water content on operating hour number

operation the value of H_2O content, modified with measurement deviation (uncertainty), was 21.25 mg.m^{-3}. At that level, however, it is not necessary to replace the filter cartridge as indicated by the compressor manufacturer in the operating instructions. It is necessary only after 16 operating hours according to the STN EN 12021.

In Fig. 4, we can see how the oil content in the air at the outlet of the compressor is related to the passing of operation time, up to the 22nd operating hour.

The graph (Fig. 4) shows that the values of the measured oil content component of the air (measured with the airtester Auer Airtester HP) were constant up to 18th operating hour of the compressor. The detection tube did not get coloured for the set threshold. Only after the 18th hour of compressor operation did the value of the oil content slightly increase. During the entire measurement, the thresholds for oil content, provided by STN EN 12021, were not exceeded, and therefore the fact was confirmed, that it is not necessary to replace the filter cartridge after 13 operating hours. In this measurement it was not possible to calculate the error of measurement (uncertainty), as in the instructions for use of the measuring device Auer it is emphasized that the values of oil content are for informational purposes only and the chemical composition of the compressor oil influences the results. Another reason was that the detector tubes are not marked with measuring ranges.

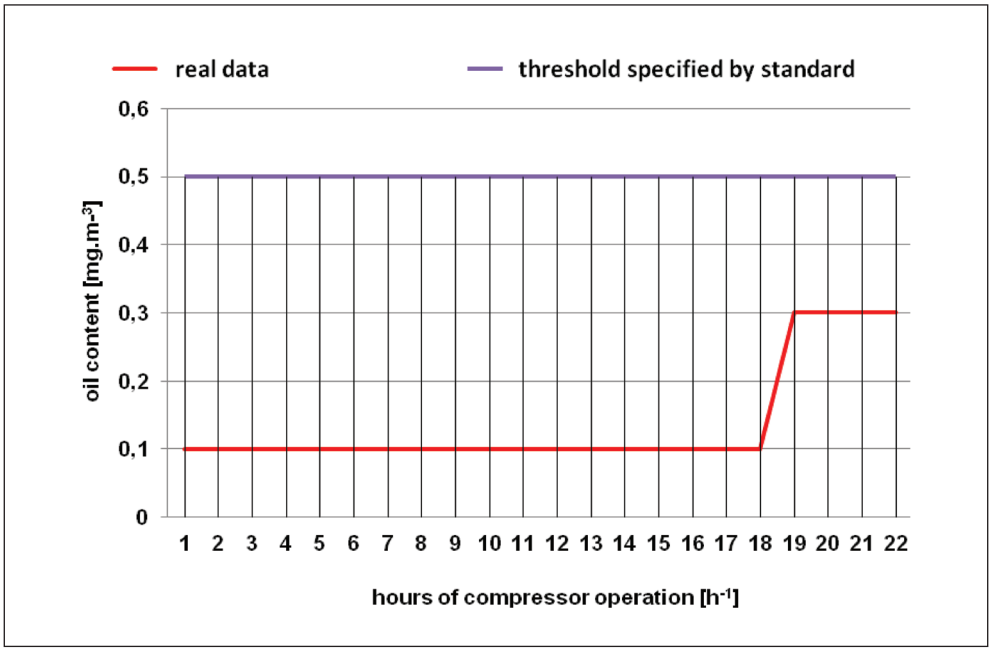

Fig. 4: Dependency of oil content on operating hours

Conclusions

Based on our measurements, we found that the replacement of the filter cartridge Three P-21 is not necessary after 13 operating hours, as specified by the manufacturer, because the threshold limits of the particular components of the air measured, set in the standard STN EN 12021, were not exceeded. Out of these STN EN 12021 limits in the first 22 operating hours only the water vapours (H_2O) content (measured with Auer Airtester HP) exceeded the prescribed threshold in the 16th hour of compressor operation. Only at this operating hour is the replacement of filter cartridge Three P-21 required. Up to the 15th hour of compressor operation the air purity complies with the prescribed standard and the health of intervening fire-fighters is not at risk of inhalation of polluted air from the compressor.

Based on our measurements, the efficiency of the filter cartridge Triplex P-21 usage can be enhanced. When measuring with the device Auer Airtester HP, the lifespan of the filter cartridge reached a 100% (end) at the 15th hour of compressor operation, from which we can deduce that the replacement of the cartridge after the 13th operating hour happens at the 86.67% of the lifespan.

If it were possible to extend the life of the filter cartridge TRIPLEX P-21 of the high pressure compressor Bauer Mariner II by 2 hours, it would mean a 13.33% longer use of the filter cartridge, which would ultimately help to save considerable funds for the FRC.

It should be noted that the measurements were carried out in the spring, and it is likely that the measured values were influenced by the weather conditions, thus they may vary depending on the weather. Especially in humid weather conditions, the water content in the compressed air might be increased therefore the surpassing of the threshold value mightd occur sooner. Apparently, the manufacturer provides a shorter filter cartridge replacement interval to emphasize the strict requirements for air used in the anti-gas service in FRC SR.

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A levegő választott összetevőinek küszöbérték-beállítása a légzőkészülék palackjainak töltésekor

Martin Zachar – Pántya Péter – Radoslav Veliký – Andrea Majlingová

Jelen írás ismerteti annak meghatározását, hogy mennyi működési órával lehet elérni az STN EN 12021 készülék szabvány szerinti működési idejének felső határát, mellyel a Szlovák Köztársaság tűzoltási és mentési szervezetének légzőkészülékeit töltik tiszta levegővel. A Bauer Mariner II kompresszorral használt P-21 TRIPLEX szűrőbetét a levegő szennyeződéseit nyeli el légzőpalackok töltésekor. Annak meghatározására, hogy a kompresszor kimeneti oldalán mennyi a CO-, CO_2-, H_2O- és olajtartalom, az Auer Airtester HP készüléket használtuk, így vizsgálva a betöltésre kerülő levegő minőségét és tisztaságát.

Kulcsszavak: légzőkészülék, kompresszor, levegő, levegőelemző, Bauer Mariner II, Auer Airtester HP