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THE INFORMATIVENESS OF ROUTINE MONITORING OF MINE ATMOSPHERE COMPOSITION WHEN THE DIESEL FACTOR IS DOMINANT IN CALCULATING AIR CONSUMPTION

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ABSTRACT

This article discusses how the required air volume for ventilating a mine that operates self-propelled diesel equipment is determined by calculating the installed engine power, and how the adequacy of the actual air supply is verified by monitoring the composition of the mine atmosphere. If the list of monitored components does not correspond to the list of substances for which the air is supplied for dilution, the verification of the calculation becomes a mere formality. The study aimed to evaluate the informative value of routine monitoring of the mine atmosphere composition as it relates to the task of diluting diesel engine exhaust products and to determine under what conditions the monitored components are capable of detecting concentrations exceeding the limit values. Actual air composition records from 24 measurement points in two ventilation shafts were used during the course of the research. A two-parameter model of the mixing of undiluted exhaust gases with mine air was developed, linking the decrease in the volume fraction of oxygen to the

concentrations of carbon monoxide and nitrogen dioxide. The model was parameterized using documented limit values for undiluted exhaust gases and for the air in the working area; an analysis was performed to assess the robustness of the conclusions with respect to the ratio of these values. At all 24 measurement points, the same value of the oxygen volume fraction was recorded—20%; the sample standard deviation is zero for an air flow rate range from 0.2 to 122.4 m³/s. It is shown that when the maximum concentration of carbon monoxide is reached, the oxygen depletion is 0.16–0.66 percentage points, depending on the composition of the exhaust gases, and does not exceed 0.87 percentage points for any composition; for nitrogen dioxide, the oxygen depletion is 0.20–0.80 and 1.05 percentage points, respectively.

KEYWORDS Mine atmosphere; air composition; self-propelled diesel equipment; carbon monoxide; nitrogen dioxide; oxygen volume fraction; measurement resolution; air-depression survey.

Introduction

Calculating the amount of air required to ventilate a mine operating self-propelled diesel equipment is essentially a forecast: it answers the question of how much air must be supplied to ensure that the concentrations of combustion products do not exceed the maximum permissible limits. Like any forecast, it must be verified against actual conditions. This verification is carried out by monitoring the composition of the mine atmosphere [1].

The logical connection between the calculation and the monitoring is direct: the components that the calculation was intended to dilute must be monitored. If this condition is not met, the monitoring ceases to be a verification of the calculation and becomes an independent procedure, the results of which say nothing about the correctness of the assumptions made in the calculation.

The relevance of this issue is determined by two factors. First, the diesel factor is dominant in calculating the air demand for mines of the type under consideration. Second, the list of regulated components of diesel exhaust has expanded significantly over the past decade: following the classification of diesel particulate matter as a hazardous substance in 2012 [4], several jurisdictions have introduced limit values for elemental and total carbon—160 μg/m³ of total carbon in U.S. underground mines [7] and 0.12 mg/m³ of elemental carbon in Ontario‘s underground mines [5]. At the same time, requirements have been established for undiluted mine exhaust gas: its composition must contain less than 600 ppm of carbon monoxide and less than 60 ppm of nitrogen dioxide [5].

Meanwhile, the scope of routine monitoring in air-depression surveying remains unchanged and focuses on oxygen and carbon dioxide. The question of whether these two parameters can detect atmospheric pollution from diesel combustion products has not been quantitatively addressed in the existing literature.

The purpose of this study is to evaluate the informational value of routine monitoring of mine atmosphere composition as it relates to the dilution of diesel engine combustion products and to determine under what conditions the monitored components can detect concentrations exceeding the threshold limits.

Objectives:

To evaluate the informational content of the obtained data set.

Establish a quantitative relationship between the decrease in the volume fraction of oxygen and the concentrations of toxic components in diesel exhaust.

Determine the sequence in which limit values are reached for different components during the dilution of exhaust gases.

Assess the robustness of the conclusions drawn with respect to the adopted limit concentration values.

Compare the list of monitored components with the list of components used in the calculation.

Literature Review

Changes to the List of Regulated Components

Historically, the regulation of mine air quality during the operation of diesel equipment focused on toxic gases. As shown in the review [4], all air supply regulations in effect at the time of its preparation were issued prior to 2012 and were specifically designed to dilute gases; diesel particulate matter was not officially classified as a hazardous substance until 2012. An international review of regulations from the earlier period is provided in [16].

After 2012, a number of jurisdictions introduced limit values for the dispersed phase: in the United States—160 μg/m³ of total carbon over an eight-hour shift [7], determined using the NIOSH 5040 method [8]; in Ontario, effective in 2023—0.12 mg/m³ of elemental carbon as a time-weighted average [5, 17]. At the same time, Ontario has established requirements for the undiluted exhaust emissions from diesel equipment: carbon monoxide content must be less than 600 ppm, and nitrogen dioxide content must be less than 60 ppm [5]. The limit values for workplace air in the same jurisdiction are 25 ppm for carbon monoxide and 3 ppm for nitrogen dioxide [17], with a minimum oxygen content of 19.5% by volume [5].

The Role of Individual Components in Diesel Exhaust

The special case of nitrogen dioxide is noted in [9]: the use of oxidation catalysts and particulate filters can increase the proportion of nitrogen dioxide in the total amount of nitrogen oxides, as a result of which a reduction in the dispersed phase may be accompanied by an increase in the concentration of precisely that component for which the limit value is the most stringent. The same source describes the procedure used in the United States to determine an engine's rated ventilation ratio: based on the results of engine dynamometer tests conducted according to the ISO 8178 C1 cycle, the amount of air required to dilute the undiluted emissions of a given engine to the corresponding threshold values is calculated; periodic monitoring of raw emissions is performed based on carbon monoxide while the engine is operating under load [9].

The characteristics of aerosols formed during the operation of diesel equipment in underground conditions are studied in [10]; the contribution of machines of various categories is separated using the isolated zone method.

It is important to note that in all of the approaches listed, the controlled variables are either the concentrations of the combustion products themselves or the characteristics of the dispersed phase. The volume fraction of oxygen is not used in the reviewed literature as an indicator of pollution by diesel combustion products.

Emissions-Based Approaches

Methods are being developed to calculate the required air volume based directly on the emissions from a specific fleet of vehicles, rather than on installed capacity: The Air Quantity Estimator software tool estimates the amount of air required to dilute diesel particulate matter to regulatory levels based on projected emissions [12], and its latest version additionally allows for identifying the vehicles with the largest emissions contributions and accounting for engine operating time [11]. In Ontario, starting in 2023, the recommended air-to-fuel ratio from the type approval certificate [5] applies to vehicles certified to the CSA M424.2 standard [13].

A common feature of these approaches is the closed-loop nature of the "calculation–control" cycle: both calculation and verification operate on the same substances.

Regulatory Practice

The importance of ensuring that actual emissions match calculated values is confirmed by regulatory practice. The New South Wales (Australia) Resources Regulator has identified ventilation as a critical measure for controlling diesel emissions [16]; during inspections, diesel equipment has repeatedly been found operating in workings with air volumes below the prescribed minimum, leading to the issuance of cease-and-desist orders [14]. Such situations can only be identified by measuring parameters directly related to emissions.

Materials and methods.

Source of Factual Data

The primary source of factual data on air composition is research conducted as part of an air-depression survey of a gold mine—inspection reports on the operation of the main ventilation fan units in reverse airflow mode, prepared with the participation of representatives from the State Inspectorate for Geological and Industrial Safety Supervision and the militarized emergency rescue unit. The reports contain tables showing the distribution of air flow by level, with columns detailing air composition (carbon dioxide and oxygen) when the system operates in normal mode and in reverse mode.

Mixing Model

The contamination of mine air by combustion products is described by a single-parameter mixing model. Let f be the volume fraction of undiluted exhaust gases in the mine air, y_0=20.9% be the volume fraction of oxygen in dry atmospheric air, ye be the volume fraction of oxygen in the undiluted exhaust gases, and Ce be the concentration of the toxic component in question in the undiluted exhaust gases. Then

$$y = y_0 - f\,(y_0 - y_e), \qquad C = f\,C_e, \qquad (1)$$

The decrease in the volume fraction of oxygen when the maximum concentration C_{max} is reached is

$$\Delta y|_{C=C_{\max}} = \frac{C_{\max}}{C_e}\,(y_0 - y_e) = \frac{y_0 - y_e}{R}, R = \frac{C_e}{C_{\max}}, \qquad (2)$$

The inverse problem is the concentration of the toxic component at the moment when the oxygen threshold value y_{min} is reached:

$$C|_{y=y_{min}} = C_e\,\frac{y_0 - y_{\min}}{y_0 - y_e}, \qquad (3)$$

The condition under which the limit value for the toxic component is reached before that for oxygen follows from (2) and (3):

$$R > R_{\text{ox}} = \frac{y_0 - y_e}{y_0 - y_{\min}}, \qquad (4)$$

The volume fraction of oxygen in the undiluted exhaust gases of a diesel engine is estimated, as a first approximation, using the air excess coefficient λ as $y_e \approx y_0(1-1/\lambda)$. The calculation was performed for the range y_e=0…18%, corresponding to a change in λ from the stoichiometric value to idle conditions; The values y_e=5% (λ≈1.3, full load), 10% (λ≈1.9, partial load), and 14% (λ≈3, idle) are noted separately. Equations (1)–(3) for y_e=0 provide upper bounds that hold regardless of the accuracy of this approximation.

Adopted Limit Values and Stability Analysis

The calculation was performed using documented values [5, 17]: for undiluted exhaust gases, C_e=600 ppm for carbon monoxide and 60 ppm for nitrogen dioxide; for work zone air, C_{max}=25 ppm and 3 ppm, respectively; minimum oxygen content y_{min}=19.5%.

Since national limit values may vary, a stability analysis of the result was performed with respect to the

ratio $R=C_e/C_{max}$ in the range from 10 to 50. As follows from (1), the result depends only on this ratio, not on the absolute values, which makes the conclusions transferable when substituting different limit values.

Assessment of the Information Content of the Actual Data

For the array of oxygen volume fraction records, the sample standard deviation and the number of distinct values were calculated. The resolution of the measuring instrument used is not specified in the report; it is estimated indirectly based on the data format.

The calculations were performed in Python 3 (NumPy); the calculation script is attached to the article.

Results and discussions.

Actual Composition of Monitored Parameters

The results of the report analysis are presented in Table 1.

Table 1.

Records of the Mine Atmosphere Composition

Indicator	Shaft "1"	Shaft "2"	Total
Number of measurement points	15	9	24
Air flow rate range by station, m^3/s	0,2–122,4	2,6–65,6	0,2–122,4
The number of different values for the volume fraction of oxygen	1	1	1
Recorded value, % by volume	20	20	20
Sample standard deviation	0,000	0,000	0,000
Carbon dioxide column filling	a dash in all items	a dash in all items	—
Column filling during reversal	not filled in	not filled in	—

The measurement points cover ventilation ducts, surface buildings, and levels ranging from +420 to +900 m, including field drifts in which self-propelled equipment is operated based on calculated air demand.

A dataset of 24 records, obtained from various workings across nine levels and at air consumption rates varying by two and a half orders of magnitude, contains a single value. The sample standard deviation is zero, the number of distinct values is one; therefore, the information content of the data set regarding the spatial distribution of oxygen is zero.

Physically, such a result cannot reflect the true concentration field: the air in a ventilation duct and the air in a working level drift cannot have exactly the same composition. The observed pattern is entirely explained by the resolution of the measuring instrument: if the device reports the result as a whole number percentage, then any true value in the range of approximately 19.5 to 20.5% will be displayed as "20."

Sensitivity of Oxygen as an Indicator of Pollution

The results of the calculation based on Equation (2) are presented in Table 2 and Figure 1.

Table 2.

Decrease in the volume fraction of oxygen upon reaching the maximum concentration

Volume fraction of oxygen in undiluted exhaust gases, %	λ (assessment)	Engine Mode	Δy at CO=25 ppm	Δy at NO_2=3 ppm,
5	1,31	full load	0,662	0,795
8	1,62	—	0,537	0,645
10	1,92	partial load	0,454	0,545
12	2,35	—	0,371	0,445
14	3,03	idling	0,287	0,345
17	5,36	—	0,162	0,195
0	1,00	theoretical limit	0,871	1,045

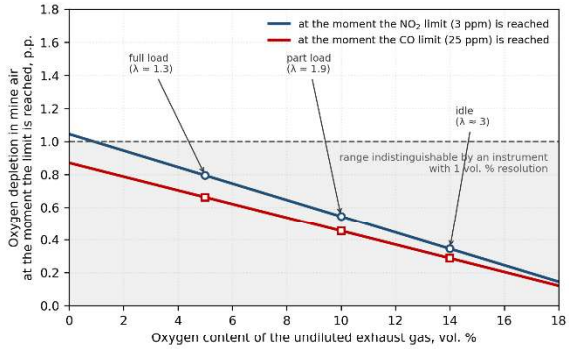


Figure 1 — Decrease in the volume fraction of oxygen in mine air when the maximum concentration of carbon monoxide and nitrogen dioxide is reached, as a function of the composition of the undiluted exhaust gases

The result obtained is of fundamental importance. When the concentration of carbon monoxide reaches a threshold value, the oxygen volume fraction decreases by 0.16–0.66 percentage points under actual engine operating conditions and by no more than 0.87 percentage points for any conceivable exhaust gas composition, including the physically impossible case of a complete absence of oxygen in the exhaust. For nitrogen dioxide, the corresponding values are 0.20–0.80 and 1.05 percentage points.

In other words, the entire diagnostically significant range of variation in the oxygen volume fraction falls within one percentage point—that is, within the least significant digit of the entry contained in the reports.

Sequence of Reaching Limit Values

The results of the calculation using equation (3) are presented in Table 3, and the overall dilution pattern is shown in Figure 2.

Table 3.

Concentrations of toxic components at the moment the oxygen limit value (19.5%) is reached

Volume fraction of oxygen in undiluted exhaust gases, %	EG f percentage, %	CO, ppm	Proportion of the limit	NO_2, ppm	Proportion of the limit
5	8,81	52,8	2,1	5,28	1,8
8	10,85	65,1	2,6	6,51	2,2
10	12,84	77,1	3,1	7,71	2,6
12	15,73	94,4	3,8	9,44	3,1
14	20,29	121,7	4,9	12,17	4,1
17	35,90	215,4	8,6	21,54	7,2

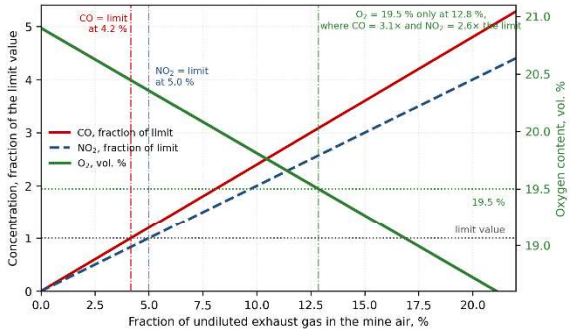


Figure 2 — Changes in the concentrations of carbon monoxide, nitrogen dioxide, and the volume fraction of oxygen when exhaust gases are diluted with mine air (the volume fraction of oxygen in the undiluted exhaust gases is assumed to be 10%)

Oxygen reaches its limit value significantly later than the toxic components: at partial engine load at this point, carbon monoxide is at 3.1 times the limit concentration, and nitrogen dioxide is at 2.6 times the limit concentration.

Condition (4) defines the limits of applicability of this conclusion: the limit for a toxic component is reached earlier if the ratio R exceeds a critical value of 14.9 at zero oxygen content in the exhaust gases, 7.8 at 10%, and 4.9 at 14%. The actual ratio based on documented regulatory values is 24 for carbon monoxide and 20 for nitrogen dioxide [5, 17]; that is, the condition is satisfied with a threefold margin even in the most unfavorable case. The conclusion regarding the lagging nature of oxygen as an indicator is thus robust.

Resolution and Practical Detection Threshold

If the measuring instrument can distinguish a change in the volumetric fraction of oxygen of at least 1 percentage point, then at an oxygen content in the exhaust gases of 10%, the smallest distinguishable change corresponds to an exhaust gas fraction of 9.17%, at which the carbon monoxide concentration is 55 ppm (2.2 times the limit value), and the nitrogen dioxide concentration is 5.50 ppm (1.8 times the limit value). Even under the optimistic assumption that half a unit of the least significant digit (0.5 percentage points) can be distinguished, the corresponding values are 27.5 ppm (1.1 times the limit) and 2.75 ppm (0.9 times the limit).

Practical conclusion: routine oxygen monitoring with a resolution of 1% is incapable of detecting atmospheric pollution from diesel combustion products before the concentrations of carbon monoxide and nitrogen dioxide exceed the limit values by approximately a factor of two. A formally satisfactory monitoring result (“20% at all points”) is compatible

with both a completely clean atmosphere and a twofold exceedance of the limit concentrations for toxic components; it is impossible to distinguish between these conditions based on the available data.

Stability of the Result with Respect to the Accepted Threshold Values

As follows from (1), the decrease in oxygen at the moment the threshold is reached depends only on the ratio $R = C_e/Cmax$. The results of the stability analysis are presented in Table 4.

Table 4. Decrease in the volume fraction of oxygen at the moment the threshold is reached as a function of the ratio R

$R=C_e/C_{max}$	Δy when $y_e=10\%$	Δy when $y_e=0$ (maximum)
10	1,090	2,090
15	0,727	1,393
20 (corresponds to NO_2)	0,545	1,045
24 (complies with CO)	0,454	0,871
30	0,363	0,697
40	0,272	0,522
50	0,218	0,418

When the ratio $R \geq 20$—corresponding to documented regulatory values—the oxygen depletion upon reaching the limit concentration remains below one percentage point under actual exhaust gas composition conditions. This conclusion holds when other national limit values are substituted, provided that the order of the R ratio remains the same. At significantly lower values of R (less than 15), the oxygen signal becomes potentially distinguishable; however, the conclusion regarding the delayed response of oxygen, as derived from (4), remains valid in this case as well.

Comparison of Monitored and Calculated Values

A comparison of the list of components used to calculate air demand with the list of actually monitored variables is presented in Table 5.

Table 5.

Components Involved in Calculating Air Demand and Monitoring Atmospheric Composition

Component	Role in Calculation and Standardization
Carbon monoxide	is standardized in the air of the work area and in undiluted exhaust gases [5, 17]; determines the calculation based on the blasting factor
Nitrogen oxide	a product of diesel combustion, a precursor to NO_2
Nitrogen dioxide	the most strictly regulated gaseous component; levels may increase when neutralizers are used [9]
Diesel particulate matter (elemental or total carbon)	carcinogen; regulated separately [7, 8, 5]
Carbon dioxide	combustion completeness index
Volume percentage of oxygen	an indicator of the atmosphere's suitability for breathing

Data on Gas Conditions During Reverse Operation

Dynamics of Gas Conditions: the time it takes for the concentration of harmful gases in the underground strata to reach the threshold level when the ventilation system is operating in reverse mode. The recorded values are shown in Table 6.

Table 6.

Time to reach the threshold level of harmful gases during ventilation reversal

Shaft	Survey Station	Time to reach the maximum level, min	Duration of mode, min	Percentage, %
«1»	Level +480, crosscut 13, 13a	10	16	62
«1»	Level +420, eastern drift	9	16	56
«2»	Level +600, 3rd eastern drift	9	12	75
«2»	Level +540, crosscut 26b	11	12	92

In all four documented cases, the limit level is reached before the end of the reverse-flow mode; that is, the duration allocated for the test exceeds the time during which the atmosphere in these workings remains within acceptable limits. Additionally, we note that switching the systems from normal mode to reverse mode takes 7 and 5 minutes, respectively—that is, a time comparable to the time it takes to reach the threshold level.

Limitations of the Study

The mixing model is idealized. Equations (1)–(3) describe uniform mixing of undiluted exhaust gases

with fresh air. Real-world processes include non-uniform distribution, secondary conversion of nitrogen oxide to nitrogen dioxide along the jet path, and dispersion-phase deposition. The model provides an order-of-magnitude estimate and boundaries, rather than a precise prediction of concentrations.

The composition of the undiluted exhaust gases was not measured. The C_e values are taken from regulatory limit values [5], rather than from actual measurements on the mine's vehicles. The impact of this assumption has been assessed via a stability analysis but has not been eliminated. Measuring the undiluted exhaust emissions from the fleet's machines is a top priority for future work.

The estimate of the oxygen content in the exhaust gases is approximate. The ratio $y_e \approx y_0(1 - 1/\lambda)$ does not account for changes in the number of moles during combustion or the water vapor content. All main conclusions are presented in a form that holds true even when $y_e = 0$, making them independent of the accuracy of this estimate.

The limit values are taken from documented foreign sources. The values of 25 ppm for carbon monoxide, 3 ppm for nitrogen dioxide, and 19.5% for oxygen apply to the jurisdiction of Ontario [5, 17]. When applying the results in a different jurisdiction, national values must be substituted into equations (1)–(3); the stability analysis methodology is designed for this purpose.

Conclusion

It was found that the same oxygen volume fraction—20%—was recorded at all 24 measurement points in the two ventilation shafts. The sample standard deviation of the data set is zero despite differences in air flow rates; therefore, the information content of the data set regarding the spatial distribution of atmospheric composition is zero.

Equation (1) was derived, relating the decrease in the oxygen volume fraction to the concentration of the toxic component via a single parameter—the ratio of the concentration in undiluted exhaust gases to the limit concentration. It was found that when the carbon monoxide concentration reaches its limit value, the decrease in oxygen is 0.16–0.66 percentage points under actual engine operating conditions and does not exceed 0.87 percentage points for any exhaust gas composition; for nitrogen dioxide, the figures are 0.20–0.80 and 1.05 percentage points, respectively.

It has been established that the oxygen volume fraction is a lagging indicator: it reaches its limit value of 19.5% at a dilution ratio where carbon monoxide accounts for 2.1–8.6 times the limit concentration and nitrogen dioxide accounts for 1.8–7.2 times the limit concentration. The lag condition (4) is satisfied when the ratio R is greater than 4.9–14.9 depending on the composition of the exhaust gases, whereas the actual ratio based on documented regulatory values is 20–24; that is, the condition is satisfied with a margin of at least three times.

It has been shown that, with a measurement resolution of 1 percentage point, the smallest detectable change in the volume fraction of oxygen corresponds to concentrations of 2.2 times the limit value for carbon monoxide and 1.8 times the limit value for nitrogen dioxide. Consequently, a test result of the form "20% at all points" is compatible with both a clean atmosphere and a twofold excess of the limit concentrations, and it is impossible to distinguish between these conditions based on the available data.

A stability analysis showed that conclusions 3–5 are determined by the ratio of concentrations rather than their absolute values, and remain valid when substituting different national limit values, provided that the order of this ratio is maintained.

HAVO EHTIYOJINI HISOBLASHDA DIZEL OMILI USTUNLIK QILGANDA KON ATMOSFERASI TARKIBINI SHTATLI NAZORAT QILISHNING MA'LUMOTLILIGI

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ANNOTATSIYA Maqolada o'ziyurar dizel uskunalarini ishlatadigan konni shamollatish uchun zarur bo'lgan havo miqdori dvigatellarning o'rnatilgan quvvati bo'yicha hisoblash orqali aniqlanishi, haqiqiy berilgan havoning yetarliligi esa kon atmosferasi tarkibini nazorat qilish orqali tekshirilishi ko'rib chiqilgan. Agar nazorat qilinadigan komponentlar ro'yxati aralashtirish uchun havo beriladigan moddalar ro'yxatiga mos kelmasa, hisob-kitobni tekshirish shunchaki rasmiyatchilik bo'lib qoladi. Dizel dvigatellarining yonish mahsulotlarini aralashtirish masalasiga nisbatan kon atmosferasi tarkibini shtatli nazorat qilishning ma'lumotliligini baholash va nazorat qilinadigan komponentlar qaysi sharoitlarda chegaraviy konsentratsiyalardan oshib ketishini aniqlay olishini aniqlash. Ilmiy-tadqiqot ishlarini olib borishda ikkita ventilyatsiya stvolining 24 ta o'lchov punkti bo'yicha havo tarkibining haqiqiy yozuvlaridan foydalanilgan. Aralashmagan chiqindi gazlarning kon havosi bilan aralashishining kislorod hajmiy ulushining pasayishini uglerod oksidi va azot dioksidi

konsentratsiyalari bilan bog‘laydigan ikki parametrli modeli tuzildi. Model aralashmagan chiqindi gazlar va ish zonasi havosi uchun hujjatlashtirilgan chegaraviy qiymatlar bilan parametrlangan; ushbu kattaliklar nisbatiga nisbatan xulosalarning barqarorligi tahlili amalga oshirilgan. Barcha 24 ta punktda kislorod hajmiy ulushining bir xil qiymati - 20% qayd etilgan; havo sarfi 0,2 dan 122,4 m3/s gacha bo‘lgan oraliqda tanlanma standart og‘ish nolga teng. Uglerod oksidi bo‘yicha chegaraviy konsentratsiyaga erishish paytida kislorodning kamayishi chiqindi gazlar tarkibiga qarab 0,16–0,66 foiz punktni tashkil etishi va hech qanday tarkibda 0,87 foiz punktdan oshmasligi; azot dioksidi bo‘yicha esa mos ravishda 0,20–0,80 va 1,05 foiz punktni tashkil etishi ko‘rsatilgan.

KALIT SO‘ZLAR Kon atmosferasi; havo tarkibi; o‘ziyurar dizel uskunalari; uglerod oksidi; azot dioksidi; kislorodning hajmiy ulushi; o‘lchashning ajrata olish qobiliyati; havo-depressiya syomkasi.

ИНФОРМАТИВНОСТЬ ШТАТНОГО КОНТРОЛЯ СОСТАВА РУДНИЧНОЙ АТМОСФЕРЫ ПРИ ДОМИНИРОВАНИИ ДИЗЕЛЬНОГО ФАКТОРА В РАСЧЁТЕ ВОЗДУХОПОТРЕБНОСТИ

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АННОТАЦИЯ В статье рассмотрено, как потребное количество воздуха для проветривания рудника, эксплуатирующего самоходное дизельное оборудование, определяется расчётом по установленной мощности двигателей, а достаточность фактически поданного воздуха проверяется контролем состава рудничной атмосферы. Если перечень контролируемых компонентов не соответствует перечню веществ, ради разбавления которых воздух подаётся, проверка расчёта оказывается формальной. Цель работы — оценить информативность штатного контроля состава рудничной атмосферы применительно к задаче разбавления продуктов сгорания дизельных двигателей и определить, при каких условиях контролируемые компоненты способны выявить превышение предельных концентраций. При проведении исследований использованы фактические записи состава воздуха по 24 замерным пунктам двух вентиляционных стволов. Построена двухпараметрическая модель смешения неразбавленных отработавших газов с рудничным воздухом, связывающая убыль объёмной доли кислорода с концентрациями оксида углерода и диоксида азота. Модель параметризована документированными предельными значениями для неразбавленных отработавших газов и для воздуха рабочей зоны; выполнен анализ устойчивости выводов к отношению этих величин. Во всех 24 пунктах зафиксировано одно и то же значение объёмной доли кислорода — 20 %; выборочное стандартное отклонение равно нулю при диапазоне расходов воздуха от 0,2 до 122,4 м³/с. Показано, что в момент достижения предельной концентрации по оксиду углерода убыль кислорода составляет 0,16–0,66 процентного пункта в зависимости от состава отработавших газов и не превышает 0,87 процентного пункта ни при каком составе; по диоксиду азота — соответственно 0,20–0,80 и 1,05 процентного пункта.

КЛЮЧЕВЫЕ СЛОВА Рудничная атмосфера; состав воздуха; самоходное дизельное оборудование; оксид углерода; диоксид азота; объёмная доля кислорода; разрешающая способность измерения; воздушно-депрессионная съёмка.

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