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# EMISSION OF HYDROCARBON GASES DURING PROCESSING AND DISPOSAL OF OIL AND GAS WASTE

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*This article presents an analysis of main sources of harmful gases are hydrocarbon emissions, which are discussed in this article, which is dedicated to environmental management and harmful emissions of harmful gases into the environment of enterprises in the oil and gas industry of Kazakhstan. Gas production, transportation, and processing, carry the risk of negative environmental impacts.*

*The installation is designed environmental assessment systems for planned activities are used in virtually every country and in many international organizations as a proactive tool in environmental policy. Thus, environmental assessment focuses on a comprehensive analysis of the potential impact of a proposed activity on the environment and the use of the results of this analysis to prevent or mitigate environmental damage.*

*The results showed that approach is becoming especially relevant as the concept of sustainable development spreads, since it allows environmental factors to be taken into account, along with economic ones, planning and making decisions about the implementation of certain activities. One physical properties of oil petroleum products, accordingly at my Uzen field. Quantitative losses are distributed approximately as follows: losses fields – 2.5%; at oil refineries – 2.5%; during transportation and storage of oil and oil products – 2%.*

*In this regard, the issues of atmospheric and environmental pollution from hydrocarbon gases during the processing and disposal of oil and gas waste are of serious concern. Therefore, this article comprehensively examines the fight against hydrocarbon gas emissions during the processing and disposal of oil and gas waste at oil and gas fields in Kazakhstan.*

***KEYWORDS:*** *emissions, hydrocarbon gases, waste processing and disposal, oil and gas, environment, ecology.*

# ВЫБРОС УГЛЕВОДОРОДНЫХ ГАЗОВ ПРИ ПЕРЕРАБОТКЕ И УТИЛИЗАЦИИ ОТХОДОВ НЕФТИ И ГАЗА

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*В статье представлены теоретические основы выбросов углеводородных газов при переработке и утилизации нефтегазовых отходов, наносящих вред окружающей среде и экологии. Основными источниками вредных газов являются выбросы углеводородов, которые рассматриваются в данной статье, посвященной управлению природоохранной деятельностью и вредным выбросам вредных газов в окружающую среду предприятий нефтегазовой отрасли Казахстана.*

*Экспериментально установлена, что экологическая оценка сосредоточена на всестороннем анализе возможного воздействия планируемой деятельности на окружающую среду и использование результатов этого анализа для предотвращения или смягчения экологического ущерба. Такой подход становится особенно актуальным по мере распространения концепции устойчивого развития, поскольку он позволяет учитывать экологические факторы, наряду с экономическими, уже на стадии формулировки целей, планирования и принятия решений об осуществлении той или иной деятельности.*

*Результаты показали, что одним из физических свойств нефти и нефтепродуктов, соответственно и на моем месторождении Узень, является испаряемость, то есть пе-*

*реход легких фракций в газовое состояние, которая определяет потери нефти. Количественные потери распределяются примерно следующим образом: потери на нефтепромыслах – 2,5%; на нефтеперерабатывающих заводах – 2.5%, при транспорте и хранении нефти и нефтепродуктов – 2%.*

*В этой связи серьезную обеспокоенность вызывают проблемы загрязнения атмосферы и экологии углеводородных газов при переработке и утилизации нефтегазовых отходов. Поэтому в статье комплексно рассматривается борьба с выбросами углеводородных газов при переработке и утилизации нефтегазовых отходов нефтегазовых месторождений Казахстана.*

***КЛЮЧЕВЫЕ СЛОВА:*** *выбросы, углеводородные газы, при переработке и утилизации отходов, нефть и газ, окружающая среда, экология.*

## МҰНАЙ ЖӘНЕ ГАЗ ҚАЛДЫҚТАРЫН ӨҢДЕУ КЕЗІНДЕГІ КӨМІРСУТЕК ГАЗДАРЫНЫҢ ШЫҒАРЫНДЫЛАРЫ

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*Бұл мақалада мұнай және газ қалдықтарын өңдеу және көміркөтек газдарының шығарылуы қоршаған орта мен экологияға зиянын тигізетіндігі айтылған. Зиянды газдардың негізгі көздері көмірсутек шығарындылары болып табылады, олар Қазақстанның мұнай-газ өнеркәсібі кәсіпорындарының қоршаған ортаны қорғау және зиянды газдардың қоршаған ортаға зиянды шығарындыларын басқаруға арналған осы мақалада талқыланады.*

*Тәжірибеде нақтыланғандай, газды өндіру, тасымалдау және өңдеу кез келген технологиялық қызмет сияқты қоршаған ортаға теріс әсер ету қаупін тудырады. Жоспарланған іс-шараларға арналған экологиялық бағалау жүйелері іс жүзінде әрбір елде және көптеген халықаралық ұйымдарда экологиялық саясаттың белсенді құралы ретінде қолданылады. Осылайша, экологиялық бағалау жоспарланған қызметтің қоршаған ортаға ықтимал әсерін жан-жақты талдауға және осы талдау нәтижелерін қоршаған ортаға келтірілген залалды болдырмау немесе азайту үшін пайдалануға бағытталған.*

*Зерттеу нәтижелерінде, бұл тәсіл тұрақты даму тұжырымдамасы кеңейген сайын өзекті бола түсуде, өйткені ол мақсаттарды тұжырымдау, жоспарлау және белгілі бір қызмет түрлерін жүзеге асыру туралы шешім қабылдау кезеңінде экономикалық факторлармен қатар экологиялық факторларды да ескеруге мүмкіндік береді. Өзен кен орнындағы мұнай мен газдың физикалық қасиеттерінің бірі – мұнайдың шығынын анықтайтын жеңіл фракциялардың газ тәрізді күйге айналуы белгілі. Сандық шығындар шамамен келесідей бөлінеді: мұнай кен орындарында 2,5%; 2,5% мұнай өңдеу зауыттарында; және мұнай мен мұнай өнімдерін тасымалдау және сақтау кезінде 2% құрайды.*

*Осыған байланысты мұнай және газ қалдықтарын өңдеу және көму кезінде көмірсутекті газдардан атмосфералық және қоршаған ортаны ластау мәселелері елеулі алаңдаушылық туғызуда. Сондықтан бұл мақалада Қазақстандағы мұнай және газ кен орындарында мұнай және газ қалдықтарын өңдеу және көму кезінде көмірсутек газдарының шығарындыларымен күрес жан-жақты қарастырылған.*

***ТҮЙІН СӨЗДЕР:*** *шығарындылары, көмірсутек газдары, қалдықтарды өңдеу және көму, мұнай және газ, қоршаған орта, экология.*

**Introduction.** The main reason for the significant deterioration of the environmental situation in our country is the lack of a sustainable mechanism for recording the level of excess of maximum permissible concentrations (MPCs) and maximum permissible emissions (MPEs). This impacts polluters, as well as basic environmental and economic standards that determine the types of economic and moral penalties or incentives. Consequently, the disposal of oil and gas waste in Kazakhstan results in large volumes of hydrocarbon gas emissions. For example, significant volumes of harmful gas emissions associated with oil and gas production have been detected at many oil and gas fields, including those within the Zhetybai-Uzen stage of the South Mangyshlak system.

Within the Zhetybai-Uzen tectonic step, confined to the northern edge of the South Mangyshlak trough system, a significant number of local structures have been identified, including associated oil and gas fields. These include Uzen, Zhetybai, Karamandybas, Tenge, Tasbulat, Asar, Yuzhny-Zhetybai, Turkmenoy, Aktas, and Vostochny Zhetybai [1, 2].

The Uzen structure borders the southeastern anticline zone in the north, from which it is separated by the narrow Kyzylsay trough, where the rock dip angles on the northern flank are 3°. The southern part of the fold, where the rock dip angles are 5-6°, is separated from the middle Tengin uplift by the same narrow trough. In the western part of the area is the northwestern pericline of the Uzen fold. It connects with the Karamandybas structure through a small saddle. In the eastern part of the area, near the eastern end of the Tungraksha Basin, the Uzen uplift plunges steeply. The Uzen deposit is confined to a large rachyanticlinal fold, measuring 39 x 9 km. The fold is significantly asymmetrical. Its crest is offset to the east, resulting in the eastern pericline being shorter than the highly elongated northwestern one. The southern limb is relatively steeper. The dip angles here along the top of horizon XIV are 6-8°. The northern limb of the fold is significantly gentler. Dip angles in the western half of the northern limb vary across the top of Horizon XII from 10° to 30°. In the western part of the structure, domes containing oil deposits are distinguished: the Northwest and Parsumurun domes.

The productive deposits of the Uzen deposit belong to a distinct class of polymictic reservoirs, characterized by their unique properties. The main characteristics of this reservoir are the high percentage of minerals in the rocks, their instability to chemical and mechanical influences, and their ability to undergo energy transformation.

Oil produced from these wells accounted for 64% of the total oil produced at the field. The average daily flow rate of a single production well at the field across horizons ranges from 3.1 to 5.4 tons per day of oil and from 6.7 to 15.8 tons per day of liquid. Horizons XIII and XIV are divided by rows of injection wells into 64 independently developed blocks. The horizon blocks differ in their recoverable reservoir reserves and productive formation properties, their degree of drilling, and their oil and gas production over a wide range. Oil and gas production characteristics for recent years: the majority of oil production (97%) is achieved by deep-well pumping (SRP) and gas lift. Gas-lift wells account for only 9.2% of the total production capacity, while liquid production accounts for 24% of the field's total production. This is because the average oil and liquid flow rates from gas-lift wells are 3-3.5 times higher than from wells equipped with deep-well pumps, which account for 92.7% of the total production capacity [1, 2, 3 - 6].

The gases of the Uzenskoye field are methane gases, with a slight increase in ethane with depth. The gas-bearing horizons contain predominantly "dry" methane gas with traces of nitrogen and carbon dioxide. The gas density is low, ranging from 0.562 to 0.622 kg/m$^3$. The distribution of reservoir layers across the area is determined using maps of effective oil-saturated thicknesses of layers, development targets, and horizons as a whole. While quartz sandstones comprise approximately 95% quartz, the polymictic reservoirs of the Uzen field contain approximately 30% quartz, with the remaining 70% being unstable minerals. Rock transformation, which primarily involves compaction and cementation, results in the formation of large micropore volumes. As a result, porosity values for individual samples reach 30% or more. These micropore volumes also result in high water saturation values with relatively low permeability values [1, 4, 7].

**Research materials and methods**

Gas production, transportation, and processing, like any man-made activity, carry the risk of negative environmental impacts. Environmental performance assessment systems are used in virtually all countries worldwide as a proactive tool of environmental policy. Environmental assessment is based on identifying and preventing negative environmental impacts at the planning stage rather than addressing them during implementation. Environmental assessment focuses on a comprehensive analysis of the planned environmental impact of an activity and the use of the results to prevent environmental damage. This approach is becoming especially relevant as the concept of sustainable development spreads, since it allows environmental factors to be taken into account, along with economic ones, already at the stage of formulating goals, planning and making decisions about the implementation of certain activities [3, 8].

Violating environmental protection laws entails legal liability in accordance with the law on the Constitution of the Republic of Kazakhstan. Preserving nature and maintaining a clean air basin is only possible through careful management and strict compliance with laws and all other regulations aimed at their protection. Unfortunately, there are cases in life where individual leaders, officials, and others, as well as citizens, behave poorly toward nature and violate environmental laws. This causes irreparable damage to the environment and the national economy, adversely affects human health, and ultimately comes at a high cost to the state.

Calculation of annual emissions of harmful substances from boiler flue gases. When fuel oil is burned in boilers, sulfur, carbon, and nitrogen oxides, as well as particulate matter (soot when burning coal), are released into the atmosphere with the flue gases.

Calculation of particulate matter emissions. Particulate matter emissions from fly ash and unburned fuel (t/yr) are calculated using the formula [1, 3, 9]:

$$M=B*A^{r}*f(1-ŋ),$$
$$M=25*0,1*0,01(1-0) = 0,025$$

where B is the fuel consumption, t/yr; for the calculation, B = 25 t/yr. Ar is the ash content of the fuel per working mass, %. Determined based on the fuel burned, for the calculation, Ar = 0.1; f is a coefficient depending on the type of furnace and fuel, for the calculation, f = 0.01; ŋ is the proportion of solid particles captured in the ash collector, for the calculation, ŋ = 0.

Sulfur oxide emissions are calculated using the formula:

$$M_{so2}=0,02*B*S^{r}(1-ŋ'_{so2})(1-ŋ''_{so2}),$$
$$M_{so2}=0,02*25*1,9(1-0,02)(1-0) = 0,931$$

where B is the fuel consumption, t/yr; for the calculation, B = 25 t/yr. Sr is the sulfur content in the fuel per working mass, %, determined by the nature of solid fuels; for the calculation, Sr = 1.9; ŋ,so2 is the proportion of sulfur oxides in the fly ash of the fuel; for the calculation, ŋ,so2 = 0.02; ŋ,,so2 is the proportion of sulfur oxides in the ash collector; for the calculation, ŋ,,so2 = 0.

Calculation of carbon monoxide emissions. Emissions are calculated using the formula:

$$M_{CO}= 0,001C_{CO}*B(1-q_{h}/100)$$
$$M_{CO}= 0,001*11,375*25(1-0,5/100) = 0,283$$

where B is the fuel consumption, in t/year; for calculations, B = 25 t/year. CCO is the carbon monoxide yield during fuel combustion, in kg/t or kg/thousand m3.

Calculated using the formula:

$$C_{CO}=q_{3}*R*Q^{K}_{Д}$$
$$C_{CO}=0,5*0,65*35 = 11,375$$

where q3 is the heat loss due to chemical incomplete combustion of fuel, %; determined by the boiler furnace, for the calculation q3 = 0.5; R is the heat loss coefficient due to chemical incomplete combustion of fuel, for the calculation R = 0.65; QKD is the net calorific value of natural fuel, MJ/kg, MJ/m3; qh is the heat loss of fuel combustion, % (determined by the boiler furnace, for the calculation q4 = 0.5).

The amount of nitrogen oxides emitted per unit of time is calculated using the formula:

$$M_{so2}=0,01*B*Q^{r}*k_{NO2}(1 - \beta),$$
$$M_{so2}=0,01*25*40,3*0,09(1 - 0) = 0,907$$

where B is the consumption of natural fuel, t/year, for the calculation B – 25 t/year. Qr is the heat of combustion of natural fuel, MJ/kg (for fuel oil Qr=40.3 MJ/kg); kNO2 is the parameter of the amount of nitrogen oxides formed per 1 GJ/heat, kg/GJ. For calculations kNO2=0.09; β is a coefficient taking into account the degree of reduction of nitrogen oxide emissions as a result of the application of technical solutions. For calculations β=0.

The structure of damage to environmental components in the event of oil and gas spills onto the earth's surface and into a surface water body in the event of a fire spill [1, 3, 9].

As is well known, one of the physical properties of oil, particularly at the Uzen field, is evaporation – that is, the transition of light fractions to a gaseous state—which determines oil losses. Quantitative losses are distributed as follows: 2.5% at oil fields; 2.5% at refineries; and 2.5% during transportation and storage – 2%.

In order to reduce the volume of emissions and decrease their ground-level concentrations during the development of the Uzen deposit, a set of planning, technical, technological and organizational measures must be provided for both during the construction and operation of the designed facilities. In this regard, the implementation of modern technologies, the use of highly sealed and reliable equipment, and strict adherence to process regulations are mandatory and a top priority.

The main measures to reduce the formation of pollutants and protect the atmosphere during field development are [1, 3, 5, 10]:

- use of modern technologies, as well as state-of-the-art oil equipment and machinery with minimal emissions;
- automation of the emergency protection system to prevent the formation of explosive atmospheres and other emergency situations, as well as ensuring safe shutdown or transition of the process to a safe state;
- timely implementation of scheduled preventive maintenance and repairs of process equipment and pipelines;
- research and monitoring of parameters at controlled points in process processes.

Measures to regulate emissions during adverse weather conditions have been developed in accordance with and provide for a short-term reduction in emissions into the atmosphere during periods of unfavorable meteorological conditions.

Emission regulation should be carried out taking into account the forecast of adverse meteorological conditions based on warnings from the Hydrometeorological Center about a possible dangerous increase in the concentration of impurities in the air of harmful chemicals due to the formation of unfavorable conditions.

Forecasting the onset of adverse weather conditions and regulating emissions are integral parts of a comprehensive program to ensure clean air. The State Hydrometeorological Committee of the Mangystau Region carries out operational forecasting of high air pollution levels. The regional ecology department monitors the implementation of emission reduction measures during adverse weather conditions. The effectiveness of pollutant emission reductions is monitored using instrumental monitoring, balance sheets, and other methods [1, 3, 5, 11].

**Results and discussion.** It should be noted that one of the main sources of air pollution in oil processing is storage tanks, which experience the greatest loss of light hydrocarbons from evaporation.

To reduce harmful emissions from the storage tank at my field, the following effective measures have been developed:

- installation of pontoons and floating roofs;
- installation of a gas equalization system;
- installation of non-freezing breather valves;
- installation of air flow deflector disks in the tank.

To reduce hydrocarbon losses at oil treatment facilities before delivering commercial oil to the tanks, separation units are used. Separation is recommended to be carried out under heating and some vacuum. When separating under vacuum, the oil vapor pressure drops below atmospheric pressure, resulting in minimal oil losses in storage tanks and reduced atmospheric pollution [1, 3, 5 - 7].

Light hydrocarbons (methane and pentane) are the most frequently emitted into the atmosphere, with concentrations often exceeding established maximum permissible concentrations. It has been established that the majority of emitted hydrocarbons (75%) enter the atmosphere, 20% enter water, and 5% enter the soil.

The sources of pollutant emissions are: process equipment, fire alarm systems, control valves, systems and structures of primary and auxiliary production, necessary for the extraction, collection and transportation of products and hydrocarbon raw materials.

Permanent emissions include organized emissions from oil and water heating furnaces, emergency flares, diesel generators, boiler houses, separators, drainage tanks, purge candles, reservoirs, etc. These include leaks at flange connections, shut-off and control valves, warehouses, landfills, wells, gas welding stations, and metalworking machines.

Periodic emissions include those that occur when safety valves are activated. One-time emissions include those occurring during repair and maintenance work, hydraulic testing, and other process operations.

The primary air pollution at OzenMunaiGas will result from emissions [1, 3, 11 - 13]:

- combustion products of petroleum gas in furnaces; process losses of oil and gas during evaporation, storage tanks, and oilfield equipment during gas system purging;
- from areas and during accidental oil spills; hydrocarbons from oil wells, separators, pumps, during gas bleeds at flares, drainage tanks, and buffer tanks;
- gas combustion products in boiler rooms;
- pollutants from diesel generator operation;
- abrasive dust and iron oxide from machine tool operation;

- iron oxides, nitrogen, carbon, manganese and its compounds, gaseous fluoride compounds, gaseous fluoride compounds, and dust from welding and gas welding stations.

Atmospheric air pollution will occur with 29 types of ingredients, including: saturated hydrocarbons C1-C5, C6-C10, C12-C19, black carbon (soot), nitrogen oxides, sulfur dioxide, carbon monoxide, methane, inorganic dust, manganese and its compounds, etc [1, 3, 5]

Existing atmospheric pollution at the Uzen field is caused by emissions from operating wells containing hydrocarbons. A complete list of pollutants emitted into the field's atmosphere is provided in *Table 1*, along with maximum permissible concentrations, the amount of emitted substances (M) t/year, and the hazard categories of the substances [1, 2, 7-10].

*Table 1* – **List of pollutants emitted into the atmosphere**

| № | Name of pollutants | Hazard class MAC | maximum one-time mg/m3 | MAC average daily mg/m3 | Emissions of harmful substances per year, tons |
|---|---|---|---|---|---|
| 1. | Nitrogen oxides | 3 | 0,4 | 0,06 | 0,546 |
| 2 | Nitrogen dioxide | 2 | 0,085 | 0,04 | 0,150 |
| 3. | Carbon monoxide | 4 | 5,0 | 3,0 | 1,159 |
| 4. | Sulfur dioxide | 3 | 0,5 | 0,05 | 0,050 |
| 5. | Hydrocarbons | 4 | 1,0 | 1,5 | 7,094 |
| 6. | Soot | 3 | 0,15 | 0,05 | 0,035 |
| 7. | Acrolein | 2 | 0,03 | 0,01 | 0,006 |
| Total: | | | | | 9,04 |

In terms of their impact on the atmosphere, these sources are characterized by direct impact. Pollutants are generally released continuously throughout the year. The above measures to reduce the harmful impact of the oil production facility are sufficient, according to the calculated indicators of air pollution under normal operating conditions, since they ensure sanitary requirements for air quality.

**Conclusions and findings.** The main pollutants in the atmospheric air of oil production areas are hydrocarbons, sulfur oxides, nitrogen oxides, carbon oxides, and others. In terms of damage to environmental components from oil spills on the land surface and water bodies, the area of land surface contamination is equal to the area of water body contamination.

The system for regulating harmful emissions into the atmosphere considers substances generated as a result of industrial activities. The main pollutants are carbon oxides and hydrocarbons, which account for 91% of total gross emissions. The formation of carbon monoxide and hydrocarbons is associated with the combustion process. The substantiation of pollutant emissions data from emission sources is based on current methods and equipment specifications, as well as raw material and material consumption data.

Based on their impact on the human body, emitted substances are classified into four hazard classes according to sanitary standards. There are no Class 1 emissions from the deposit's facilities, while the following Class 2 emissions are emitted into the atmosphere: nitrogen dioxides - 0.150 tons, acrolein - 0.006 tons. The total emitted substances of hazard class 2 are 0.156 tons. Of the substances of hazard class 3, nitrogen oxides are emitted in the amount of 0.546 tons, sulfur dioxide - 0.05 tons. The total emitted substances of hazard class 3 are 0.596 tons. Gaseous pollutants account for 99% of emissions, while particulate pollutants account for 1%. Hydrocarbon emissions account for the bulk of gaseous emissions, at 78%, and carbon monoxide emissions for 13%. The most toxic pollutants, nitrogen dioxide and acrolein (hazard class 2), account for 1.7% [1, 3, 11 - 16].

As noted in the article, the oil and gas industry will bring significant economic benefits to the country, but harmful gas emissions will have a negative impact on the environment and ecology. Finally, it should be noted that Kazakhstan has a complex system in place to combat hydrocarbon gas emissions from oil and gas field waste.

Measures to prevent environmental pollution from industrial waste:

- Incorporate a dedicated oil sludge processing unit into the process flow, implement methods for maximizing oil recovery from oil sludge, and utilize it in road construction.
- Organization of storage and disposal of oil and gas waste.
- To prevent the formation of hydrogen sulfide in deposits during their development, provide for the injection of bactericides.

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