MASTER THESIS

(EXPLANATORY NOTE)

SPECIALTY 101 «ECOLOGY»
Training Professional Program “ECOLOGY AND ENVIRONMENTAL PROTECTION”

Theme: «Estimation of modern motor gasoline properties, which determine its environmental safety »

Done by: student of the EK – 202m group, Nataliia O. Herasymenko

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KYIV 2020
ДИПЛОМНА РОБОТА
(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТЬНОГО СТУПЕНЯ МАГІСТРА

ЗА СПЕЦІАЛЬНІСТЮ 101 «ЕКОЛОГІЯ»
ОПІ «ЕКОЛОГІЯ ТА ОХОРОНА НАВКОЛИШНЬОГО СЕРЕДОВИЩА»

Тема: «Оцінка властивостей сучасного автомобільного бензину, що визначають його екологічну безпеку»

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КИЇВ 2020
1. Theme: «Estimation of modern motor gasoline properties, which determine its environmental safety» approved by the Rector on September 29, 2017, № 2484/ст.


3. Output work (project): main characteristics of modern petrol, different types of gasoline.


5. The list of mandatory graphic (illustrated materials): tables, figures, charts, graphs.
6. Schedule of thesis fulfillment

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<td>Labor Precaution</td>
<td>Viktoria V. Kovalenko, Ph.D., Assoc. Prof. of the Civil and Engineering Safety Department</td>
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8. Date of task issue: «___» ___ 2020__

Diploma (project) advisor: ___________________ Larysa M. Cherniak
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Task is taken to perform: ___________________ Nataliia O. Herasymenko
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спеціалізація «Екологія та охорона навколишнього середовища»

(шифр, найменування)

ЗАТВЕРДЖУЮ
Завідувач кафедри
__________Фролов В.Ф.
«____» _________ 2019 р.

ЗАВДАННЯ
на виконання дипломної роботи
Герасименко Наталії Олександрівни

1. Тема роботи «Оцінка властивостей сучасного автомобільного бензину, що визначають його екологічну безпеку» затверджена наказом ректора від «29» вересня 2016 р. №2484/ст.


3. Вихідні дані роботи: основні характеристики палив.

4. Зміст пояснювальної записки: аналітичний огляд літератури за темою диплому. Аналітичний огляд проблеми емісії транспортних засобів. Розрахунок викидів відпрацьованих газів в атмосферу, аналіз отриманих результатів.

5. Перелік обов’язкового графічного (ілюстративного) матеріалу: таблиці, рисунки, діаграми.
6. Календарний план-графік

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<tr>
<td>Охорона праці</td>
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Керівник дипломної роботи (проекту): ___________________ Черняк Л.М.

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Завдання прийняв до виконання: _______________ ___________ Герасименко Н.О.

(підпис випускника) (П.І.Б.)
РЕФЕРАТ

Пояснювальна записка до дипломної роботи на тему «Оцінка властивостей сучасного автомобільного бензину, що визначають його екологічну безпеку» містить: 57 с., 12 рис., 2 табл., 29 літературних джерела.

Об’єкт дослідження: взаємозв’язок між вмістом різних вуглеводнів у складі бензину та його екологічною безпекою.

Предмет дослідження: автомобільні палива.

Мета роботи: оцінка та вивчення взаємозв’язку між вмістом різних вуглеводнів у складі бензину та його екологічною безпекою.

Методи дослідження: аналітичний метод, який включає в себе аналіз і узагальнення інформації для визначення загальної тенденції екологічності моторного бензину, методи аналізу отриманих даних в результаті розрахунків.

ЕКОЛОГІЧНІ ВЛАСТИВОСТІ, АВТОМОБІЛЬНИ БЕНЗИНИ, ЕКОЛОГІЧНА БЕЗПЕКА, СТАТИСТИЧНИЙ АНАЛІЗ.
ABSTRACT

Explanatory note to thesis «Estimation of modern motor gasoline properties, which determine its environmental safety» contains: 57 pages, 12 figures, 2 tables, 29 references.

Object of research: the relationship between the content of different hydrocarbons in gasoline and its environmental properties.

Subject of research: automotive fuels.

Aim of work: assessment of environmental safety of automotive gasoline level.

Methods of research: an analytical method, which includes analysis and generalization of information for determining the general tendency of environmental friendliness of motor gasoline, methods of statistical analysis of data received from calculation.

ENVIRONMENTAL PROPERTIES, AUTOMOBILE EMISSIONS, ENVIRONMENTAL SAFETY, STATISTICAL ANALYSIS.

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LIST OF SYMBOLIC NOTATIONS, ABBREVIATIONS AND NOTIONS

CO - Carbon Monoxide
NOx - Oxides of Nitrogen
HC - Hydrocarbons
PM - Particulate matter
MS - Member States
FQD - Fuel Quality Directive
AAQDs - Ambient Air Quality Directives
CAA - Clean Air Act
EPA - Environmental Protection Agency

INTRODUCTION
The exhaust of the world's oil reserves and the rise in prices for traditional automotive fuels and the ever-increasing requirements for the toxicity of the exhaust gases of internal combustion engines require measures to be taken to reduce the consumption of these petroleum products and improve their environmental properties.

The environmental properties of fuels characterize the level of their environmental impact during their operation or use. The main environmental properties of hydrocarbon fuels include: toxicity, carcinogenicity, bioaccumulation, evaporation, as well as properties related to the immediate danger to living organisms and the environment (fire and explosion, transport and storage).

**Relevance of topic.** Nowadays reduction of air pollution of hazardous substances released by motor transport is one of the most important environmental problem of transport ecology. Environmental exhaust gas toxicity standards for vehicles are a system that monitors the flue gas toxicity levels of automobile engines and sets the toxicity standards that vehicles and other vehicles must comply with.

**Aim of work.** Therefore, the aim is an assessment of environmental safety of automotive gasoline level.

To achieve this aim the following tasks are solved in the work:
- study the main sources of automobile emissions;
- analysis of modern ways to improve the environmental properties of motor gasoline;
- analysis and comparable of standard for fuel quality in the world;
- analysis of main characteristics of gasoline that determine the level of environmental safety;
- analysis of relationship between implementation of standards for fuel quality and decreasing of exhaust gas emissions.

**The object of research** is the relationship between different standards and ecological properties of modern gasoline.

**The subject of research** is automobile gasoline and standards for its quality.

The various methods were used in the study to achieve the goal, including
the following:
- analytical method which involves analysis and synthesis of information to determine the general trend of ecological aspects of motor gasoline;
- statistic method.

Scientific novelty:

Practical application:

Personal contribution of graduate. In term of work performance were done such actions as conducting the analytical work, collection and estimation of statistical data.

Approbation of results:

Publications:
CHAPTER 1
INFLUENCE OF VEHICLE OPERATION ON ATMOSPHERIC AIR IN CITIES

1.1. Characteristics of car emissions in the total level of air pollution in metropolitan areas.

Concerns about cars as a source of air pollution have been expressed periodically, but national concern was first identified in the 1960s when California first set new emission standards for cars. The scientific basis of this effort is the groundbreaking studies of atmospheric chemistry by AJHaägen-Smit, which have shown that photochemical reactions among hydrocarbons (HC) and oxides of nitrogen (NO \textit{x}) form many secondary pollutants that reduce visibility and cause eye and nose irritation Angeles [1].

Cars emit a number of pollutants. Perhaps the most damaging are solids, a combination of organic material and inorganic substances. Dust, soil, acids, metals, and organic chemicals are all components of solids. Most materials are extremely scarce, and the smaller the proportion, the greater the harm; particles less than 10 micrometers in diameter are able to enter the lungs. Once in the lungs, the particles can also cause serious problems for the heart. Nitrogen dioxide produced by burning fuel at high temperature can also cause trouble; in high concentration it can damage the lungs and cause chest pain.

Volatile organic compounds (better known as VOCs) are also found in air pollution and are as dangerous as the name. Unlike solids and some other known pollutants, VOCs have no taste, odor or color. They are known as "volatiles" because of how easily they evaporate at room temperature. Some VOCs, such as benzene, are known carcinogens. Although VOCs are manufactured mainly by industrial means, vehicles release them during fuel combustion. Even car interiors produce VOCs.

But how much pollution do machines produce? The answer is more complicated than you might expect. For starters, air pollution is not constant all over the world or even across the country. Densely populated areas - or, more precisely, areas where large quantities of fossil fuels are burned - have significantly higher levels of air pollution
than low-occupied areas. Densely populated cities such as Los Angeles, Mexico City and Beijing are known for their air pollution. Weather conditions also affect air quality, leading to daily fluctuations in air permeability. Thus, the level of pollution does not simply change from one geographical to another; they also change from day to day.

1.1.1. United States

And yet, with all these variables, scientists can still give us an approximate percentage of the air pollution produced by cars in the United States. According to the Environmental Protection Agency, motor vehicles produce about half of such pollutants as VOCs, nitrous oxide and particulate matter. Seventy-five percent of carbon monoxide emissions come from cars. In cities, harmful emissions of cars cause up to 50 percent of air pollution. Everyone is told that this is a lot of air pollution coming from our vehicles [2].

The United States Clean Air Act (CAA) is a great basis on which to judge the environmental safety of fuels and fuel additives (F / FA) that are marketed. The U.S. Environmental Protection Agency (EPA) administers the law and provided recommendations that new fuels and additives may meet CAA requirements. The instructions make it clear that only additives and fuels that "contain no elements other than carbon, hydrogen, oxygen, nitrogen and / or sulfur (CHONS)" are considered safe to register without further testing according to existing fuel data. Any other items are considered "atypical". Additives containing atypical elements must be thoroughly tested to ensure that they do not have a detrimental effect on the environment, and the law specifies the type of test and the method of approval of such other additives [14].

1.1.2. EU

According to the fifth report of the Intergovernmental Panel on Climate Change (IPCC), it is highly likely that human activity has warmed our planet in the last 50 years. These include, for example, burning coal, oil and gas, deforestation and agriculture.
Energy accounts for 80.7% of greenhouse gas emissions in 2017, with transport accounting for about a third. Agricultural greenhouse gas emissions contribute from 8.72%, production processes and product use - from 7.82% and waste management - 2.75%.

Transport is responsible for almost 30% of total CO2 emissions in the EU, of which 72% is from road transport. As part of its efforts to reduce CO2 emissions, the EU aims to reduce transport emissions by 60% by 2050 compared to 1990 levels. It will be difficult to reduce CO2 emissions from transport significantly as the rate of emission reductions has slowed. Other sectors have been reducing emissions since 1990, but as more people become more mobile, CO2 emissions from transport are increasing. Efforts to improve fuel efficiency of new cars are also slowing. After a steady downturn, recently registered cars emitted an average of 0.4 grams of CO2 per kilometer more than in 2017. To suppress the trend, the EU is introducing new CO2 emission targets aimed at reducing harmful emissions from new cars and vans. MEPs adopted new rules during the March 27 plenary session. On April 18, MEPs also approved a proposal to reduce CO2 emissions from new trucks by 30% by 2030 compared to 2019 levels.

CO2 emissions from passenger transport vary considerably depending on the mode of transport. Passenger cars are the major pollutant, accounting for 60.7% of Europe's total CO2 emissions from road transport. However, modern cars could be one of the cleanest modes of transport, if shared, rather than alone. In Europe, on average, 1.7 people per car, other modes of transport, such as buses, are now a cleaner alternative.

Under the Paris Agreement on Climate Change, the EU has committed itself to reducing greenhouse gas emissions by at least 40% in all sectors of the economy by 2030 compared to 1990 levels. In addition to setting targets for car emissions, MEPs have taken the following steps to help the EU fulfill this obligation:

- European Emissions Trading Scheme for industry emissions;
- Binding national targets for reducing greenhouse gas emissions from non-industrial sectors;
- Use of forests to offset carbon emissions [3].
1.1.3. In the world

The charts above list total greenhouse gas (GHG) emissions in 2017. The EU is the third largest emitter behind China and the United States, followed by India and Russia.

Greenhouse gases remain in the atmosphere for periods of several years to thousands of years. As such, they have a worldwide impact, regardless of where they were first thrown [4].

Because Australian fuel performance is broadly in line with CEN standards, they are substantially different from US, Japan and South Korea standards. However, for test methods, the ASTM test methods are mainly used as benchmarks in Australian specifications for gasoline, diesel and E85. Autogas and biodiesel specifications use not only ASTM but also CEN test methods, the International Organization for Standardization (ISO), the Institute of Petroleum Products1 (IP) and the Japanese LP LP Association (JLPGA) as a reference [13].
1.2. Characteristics of the exhaust gas composition.

Exhaust gases from internal combustion engines are complex mixtures consisting mainly of complete combustion products, small amounts of sulfur and nitrogen oxidation products and compounds derived from fuel and lubricants.

NOx. Mono-nitrogen oxides NO and NO2 (NOx) (obtained in this way or naturally by lightning) react with ammonia, moisture and other compounds to form nitric acid vapors and related particles. Small particles can penetrate deeply into the sensitive tissue of the lungs and damage it, causing premature death in extreme cases. Inhalation of NO species increases the risk of lung and colorectal cancer, and inhalation of such particles can cause or worsen respiratory diseases such as emphysema and bronchitis and heart disease.

In the US EPA 2005 study, the largest NOx emissions came from road vehicles, the second largest contributor is non-road equipment, which is mainly gasoline and diesel stations.

The resulting nitric acid can be washed into the soil, where it will turn into nitrate, which is useful for growing plants.

Volatile organic compounds. When nitrogen oxides (NOx) and volatile organic compounds (VOCs) react to the presence of sunlight, ozone is generated at the soil level, the main ingredient in smog. In the 2005 US EPA report, Road Vehicles is the second largest source of VOCs in the US at 26% and 19%, respectively, of non-road equipment, which is predominantly gasoline and diesel. 27% of VOC emissions are from solvents used in the production of paints and dyes, solvents and other uses.
a) 
Fig. 1.2. Examples of composition of the exhaust gas from "diesel" combustion using excess air and stoichiometric spark-ignited "gasoline" combustion. [7]

Carbon monoxide (CO). Carbon monoxide poisoning is the most common type of lethal air poisoning in many countries. Carbon monoxide is colorless, odorless and tasteless, but highly toxic. It is combined with hemoglobin to produce carboxyhemoglobin, which blocks the transport of oxygen. At a concentration above 1000 ppm, this is considered to be immediately dangerous and is the most immediate health hazard when the engine is running in a poorly ventilated area. In 2011, 52% of carbon monoxide emissions were generated by mobile vehicles in the United States.

Dangerous air pollutants (toxicants). Chronic (prolonged) exposure to benzene (C6H6) damages the bone marrow. It can also cause excessive bleeding and inhibit the immune system, increasing the likelihood of infection. Benzene causes leukemia and is associated with other blood cancers and precancerous blood diseases.

Particles (PM10 and PM2.5). The effects of inhalation of air into the air are contained in the air, widely studied in humans and animals and include asthma, lung cancer, cardiovascular problems, premature death. Due to the particle size, they can penetrate into the deepest parts of the lungs. A UK study of 2011 estimates 90 deaths a year through passenger transport PM. In a 2006 publication, the Federal Highway Administration (FHWA) states that in 2002, about 1 percent of all PM10 emissions and
2 percent of all PM2.5 emissions came from road vehicle exhausts (mainly from diesel engines).

Carbon dioxide (CO2). Carbon dioxide is a greenhouse gas. Car CO2 emissions are part of the anthropogenic contribution to increasing CO2 concentrations in the atmosphere, which, according to the vast majority of the scientific community, causes climate change. Automobile vehicles are designed to generate about 20% of CO2 emissions by man-made emissions, and passenger cars - about 12%. European emission standards limit the CO2 emissions of new passenger cars and light vehicles. The average CO2 emission of new cars in the European Union in the year to the first quarter of 2010 decreased by 5.4%, decreasing to 145.6 g / km.

Hydrocarbon emissions consist of unburnt fuel due to insufficient temperature that occurs near the cylinder wall. At this point, the temperature of the air-fuel mixture is much lower than the central part of the cylinder. Hydrocarbons are made up of thousands of species, such as alkanes, alkenes and aromatic substances. They are usually found in equivalent CH4 content [9].

1.2.1. Emission Standards

The change in emission standards has led to three levels of rigidity and, in turn, three types of control technology. It also shows the percentage reduction of HC, carbon monoxide (CO) and NO x emissions. The air / fuel ratio (A / F), which is controlled by the carburetor or the fuel injection system, is the most important variable in the determination of emissions and the application of catalyst technology.

Tab. 1.1. is a graph of NO x, HC and CO concentrations in the ratio of exhaust systems against A / F for a typical gasoline engine. It is not possible to achieve the low emissions required by federal standards only by adjusting the A / F ratio, since the concentration of the three pollutants is not minimal with one A / F ratio.
Fig. 1.3. Major phases in the reduction of automotive emissions [5]

In fact, when CO and HC concentrations are a minimum, at an A/F ratio of around 16:1, NO\textsubscript{x} production is close to a maximum. Also shown is the A/F ratio for maximum power (13.5:1) and maximum fuel economy (17:1). The region where A/F ratio exceeds 17.5:1 is the lean burn region where misfires can occur along with slow flame speeds, causing increased HC concentration.

Fig. 1.4. Concentrations of HC, CO, and NO\textsubscript{x} emissions as a function of air/fuel ratio in a typical gasoline engine [6]

Exploring the lean burn region is an important area of research and development because of the potential of improved fuel economy and adequate emission control with only an oxidation catalyst [5].
The A/F ratio effects are used in all phases of control. The stoichiometric ratio of 14.7:1 is necessary in the Phase III control using three-way catalysts since the A/F ratio must be in a narrow window within ± 0.05 of the stoichiometric ratio to achieve high HC, CO, and NO \textsubscript{x} control efficiencies simultaneously.

Europe. The European Economic Community, an inter-European regulatory body, has announced future standard standards for passenger cars based on three engine categories (drainage). Large car standards (> 2 liter engine capacity) are roughly equivalent to current US standards, although there is no clear correlation between individual US and European emission test cycles. Standards for Medium Cars. (1.4-2.0 liters) is considered to be in the phase I / II phase range. The requirements for the level of a small car (<1.4 liters) can be compared to the requirements of phase I. The standards include diesels; however, large diesel cars are only needed to meet the midrange levels.

Japan. Compulsory catalyst standards currently applicable to passenger cars - 0.25 HC / 2.1 CO / 0.25 NO xg / km for a unique 10-mode hot start and 7.0 HC / 60 CO / 4.4 NO xg / test for 11-mode cold start test procedures. Usually, these standards are considered equivalent to current levels in California in the United States [5].

1.3. Conclusions to Chapter 1

Concern about the automobile as a source of air pollution has been expressed periodically, but national concern was first evidenced in the 1960s when California established the first new car emission standards. Motor vehicles emit a number of pollutants. Perhaps the most damaging is particulate matter, a combination of organic material and inorganic substances. Unlike particulate matter and some of the other well-known pollutants, VOCs have no taste, smell or color. They're known as "volatile" because of how easily they evaporate at room temperature. Some VOCs, such as benzene, are known carcinogens. Though VOCs are primarily produced through
industrial means, vehicles do release them as they burn fuel. Even car interiors release VOCs.

The other main and dangerous emission from vehicles are CO2 gases. As we can see on the diagram, the amount of emissions is the most high from transport industry. Transport is responsible for nearly 30 percent of the EU’s total CO2 emissions, of which 72% comes from road transportation.

To curb the trend, the EU is introducing new CO2 emission targets, which aim to cut harmful emissions from new cars and vans. CO2 emissions from passenger transport vary significantly depending on the transport mode. Passenger cars are a major polluter, accounting for 60.7% of total CO2 emissions from road transport in Europe.

Evolving emission standards have resulted in three levels of stringency, and in turn, three types of control technology. The percent reduction in the HC, carbon monoxide (CO), and NO\textsubscript{x} emissions are also shown. Air/fuel (A/F) ratio, which is controlled by the carburetor or fuel injection system, is the most important variable in determining emissions and in applying catalyst technology.
CHAPTER 2
THE CONCEPT OF "ENVIRONMENTAL SAFETY"

2.1. A list of petrol quality indicators that determine its level of environmental safety due to European Standards.

The most common definition of environmental safety is the practices, policies and procedures that ensure the safety and well-being of anyone in the immediate area. This includes security regarding the proper disposal of waste, the retention and storage of potentially toxic chemicals, and more.

Fuel quality in the EU began to adjust in the mid-1970s, when sulfur limits in all fuels were lowered to levels between 8,000 ppm and 3,000 ppm (depending on the area where the fuel is used - in environmentally sensitive areas where sulfur limits should be lower than in other areas). Figure 2.1. depicts the evolution of European fuel quality specifications as a result of the decades of development described above [11].

A few years later, the content of lead in gasoline was first considered by European law. The limit is lowered from 0.40 g / l to 0.005 g / l in a phased process. In both cases, the major driver of reducing lead and sulfur is concern over their effects on human health and the environment. Since the early 1970s, the European Community has, in numerous environmental action programs, addressed the need to protect the European population and the environment from the harmful effects of pollutants in the atmosphere. These programs concerned exhaust pollutants, in particular those resulting from the combustion of fuel sulfur and lead.

Another factor that influenced the implementation of fuel quality parameters at EU level was the proper functioning of the internal market. Any differences in national laws on fuel composition (sulfur and lead at the start of the process) could adversely affect the free trade between 282 Member States (FMUs) and the competitiveness of some European oil companies against others. These two factors remain the main drivers of any further changes in fuel quality.
The quality of car fuel in the EU is considered at two levels: mandatory legislation and optional specifications. This dualism often creates confusion as to what fuel suppliers are required to meet and the requirements required in each of the 28 Member States.

Section 211 (a) of the United States Clean Air Act (CCA) requires the EPA to designate a specific fuel / fuel additive (F / FA) to be registered and prohibit any sale or distribution of designated fuels and additives if they are not registered. CAA section 211 (b) states, inter alia, that the EPA must require fuel registrars and additives to "conduct tests to determine the potential effects of fuel or additives on health and the environment" and to determine "emissions from the use of fuel whether additives "and" the degree of impact of such emissions on health and well-being. " Section 211 (e) of the CAA required EPA to adopt rules to meet the requirements of the tests in section 211 (b) of the CAA by April 7, 1978. The EPA issued regulations establishing testing requirements for registered F / FAs in 1994.4. In the final rule of 1994, the EPA adopted
a grouping system for registered F / FAs. Although this grouping system does not always work in practice, it has been designed and designed by the EPA to make the necessary emissions and impact tests less burdensome.

The basic premise underlying this new grouping system was stated by the EPA as follows: EPA expects the F / FA in each group to have the same emission characteristics and thus substantially the same overall health effects and welfare. Therefore, chemical or toxicological information associated with individual members of this group may be reasonably generalized to all F / FAs in the group. EPA wanted to make the groups sufficiently inclusive to prevent unnecessary testing, but not so wide that significant differences in emissions and their impacts between the different P / JI groups were not overlooked.

EPA states: By establishing F / FA categories (and groups within them), the EPA is trying to avoid too narrow definitions that lead to unnecessary and duplicate testing by manufacturers, and too broad definitions that can cause potentially important toxicological differences between F / FA that should be overshadowed. The grouping of motor vehicle fuels (gasoline and diesel) consists of three general categories: basic, non-standard and atypical. Base and non-base gasoline, diesel and related additives should "contain no elements other than carbon, hydrogen, oxygen, nitrogen and / or sulfur". Non-basic gasoline and related additives must meet all of the basic gasoline requirements "except that they contain 1.5 percent or more oxygen by weight and / or may be obtained from sources other than those listed in [baseline criterion 5]." - diesel fuel and related additives must meet all requirements for basic diesel fuel, "except that they contain 1.0 percent or more by weight of oxygen and / or may be obtained from sources other than those are listed in [Baseline Criterion 5]."

Atypical gasoline is "gasoline and related additives containing one or more elements other than carbon, hydrogen, oxygen, nitrogen and sulfur". Within these gasoline and diesel categories, EPA has created separate F / FA groups. F / FA registrars may satisfy the testing requirements on an individual or group basis, if the relevant product meets the criteria for admission to the group. All base gasoline and related additives are in the same group. All the basic diesel fuels and
related additives are also in the same group. Non-basic gasoline and non-baseline diesel fuel are recorded in separate groups, depending on the oxygenates used and the starting materials used to make the fuel.

By applying all of these rules and grouping rules, a product that adds additives can be included in the base gasoline group and / or the base diesel group when it contains no elements other than CHONS. If the accomplished additive contains a deliberately added element other than CHONS, it may only be counted toward an atypical gasoline group or a non-typical diesel group with other fuels and additives containing the same element. If the accomplished additive contains more than one intentionally added element other than CHONS, it may only be counted against atypical gasoline or atypical diesel groups with other fuels and additives containing the same combination of atypical elements [14].


Reforms in the energy markets have taken place through a series of three energy legislative developments. They began in the mid-1990s with the First Energy Package in 1996 to the third (and last) Energy Package (Climate and Energy Package 2020) in 2009, as shown in Figure 2.2.

The first Directive aimed to introduce competition in order to separate or demarcate former energy monopolies and to distinguish between regulated and non-regulated activities.

The second Electricity Directive, adopted in June 2003, reinforced the procedures under which energy transmission networks were to operate independently of energy production and supply. This was in line with the principle of unbundling aimed at limiting the risks of systemic conflict of interest, which is considered to be inherent in the vertical integration of production, networks and supply activities.
The integration of the electricity and gas markets has further progressed with the third energy package, which is currently the legal basis of the electricity market. It details the role of transmission and distribution system operators, as well as the requirements for the separation of production and supply. European Regulations have established the Agency for the Cooperation of Energy Regulators (ACER) and the European Network of Transmission System Operators (ENTSO), which work together to create and adopt framework guidelines and to define network codes for electricity and gas. ACER issues framework recommendations, while ENTSO (in electricity) and ENTSO (in gas) develop network codes based on these guidelines. Network codes become legally binding following a specific legislative process called comitology.

While EU law has been drawing a new landscape for the operation of networks, the assets used today are inherited from former integrated utilities. However, European legislation was not adopted without some form of cultural and political resistance to the creation of unbundled operating models in which networks began their "own lives" within individual structures. Thanks to ENTSO's new management role, transmission system operators have been able to regain some of the political support they may have lost in the process of dismantling former integrated monopolies.

The promotion of renewable energy sources was reinforced by the Renewable Energy Directive of the Third Package, which included the priority of sending to renewable energy sources and defining short- and medium-term models of the electricity market. This directive was designed to create a market base and to provide transparent price signals for all technologies, including renewable energy sources [15].

This reform process has led to a complete transformation of the energy policy landscape, which will allow the European Union to move towards the goal of delivering 20% of final energy consumption to renewable energy by 2020. This has also led to important transformations at the industry (utility) level through the process of disconnection, the creation of energy exchanges for electricity and gas units, as well as the phased termination of regulated tariffs for supply.
The Fuel Quality Directive or FQD (Directive 98/70 / EC, as amended) sets out mandatory environmental and hygiene requirements for motor gasoline and diesel. The Directive binds the MS to its parameters, ie the quality of fuels placed on European markets must comply with the Directive, and no Member State can refuse access to the market if the fuel meets the quality requirements of the Directive. FQD covers parameters that are environmentally important and require restrictions to protect human health. Another important objective of the directive is to harmonize the EU market and avoid the negative consequences for fuel suppliers in all 28 countries, which could be provoked if each country had its own fuel quality requirements. The content of the directive is the result of consultations with all stakeholders (automotive and oil industry, NGOs, experts, etc.) as well as negotiations between decision makers in the EU, ie the European Commission (initiator), the European Parliament and the Council of the European Union. representing Member States [18].

European standards are set by the European Committee for Standardization (CEN), the only recognized organization in the EU authorized to develop and adopt standards for fuel quality requirements. Quality standards (called ENs) are specifications
that are not compulsory. These specifications are those required for safety, engine and vehicle performance, mobility, mitigation of atmospheric air pollution, health and the environment, and the like. Therefore, the lists of parameters included in the European fuel standards are longer than those covered by the Directive. The purpose of the standard is to ensure that the fuel produced in accordance with the standard creates a risk to the environment that is minimally insignificant, while at the same time providing the best possible performance of the vehicle. The standards are developed by fuel quality experts - those working in the fuel industry and the automotive industry, as well as experts from fuel laboratories and research institutes with extensive and thorough knowledge and experience in fuel quality research and science.

The experts are representative of the standardization bodies of the 31 states that are currently members of CEN. Petrol quality properties are established by the latest version of the EN 228: 2012 petrol standard, "Automotive fuel - unleaded gasoline - requirements and test methods". Diesel quality properties are set out in the latest version of Diesel EN 590: 2013 "Automobile fuel - Diesel - Requirements and test methods. It is accepted in the EU (and in most other European countries) that the industry adheres to and adheres to the widest range of fuel quality parameters. Manufacturers and fuel distributors use EN 228 and EN 590 as reference documents in their trading operations, and recognition of these standards is reflected in the quality of the products they distribute and in their response for this quality.


<table>
<thead>
<tr>
<th>Directive 98/70 as amended (Fuel Quality directive)</th>
<th>CEN Standards on Fuel Quality (EN 228 - Gasoline; EN 590 - Diesel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adopted by the EU bodies</td>
<td>Established the European Committee for Standardization (a stakeholders’ platform; industries’ consensus)</td>
</tr>
<tr>
<td>Valid for the EU territory</td>
<td>Valid for the countries that are members of CEN (or have similar status) - the geographical coverage is wider than in EU</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fuel quality specifications regulated on the grounds of their impact on environment and human health; and also to harmonize &quot;product requirements&quot; due to MS</td>
<td>Fuel quality specifications established for technical reasons - proper vehicle running; therefore the gamut of parameters is wider than in directive</td>
</tr>
</tbody>
</table>

The development of specifications for gasoline and diesel is controlled by a committee known as CEN Technical Committee (TC) 19. This committee has the wider responsibility for petroleum products, lubricants and related products. Of the 13 different working groups that come under the jurisdiction of TC 19, two have the specific responsibilities for gasoline and diesel, WG 21 and WG 24, respectively, and these groups developed EN 228 and EN 590 specifications. The TC 19 working groups are very active, are responsible for publishing 159 standards and are in the process of developing another 40.

The mission of CEN TC 19 is to:

- Support EU policies on environment, transportation, energy and open market;
- Complement them with consumer safety, including trouble-free operation;
- Incorporate industry needs to guarantee fuels production and distribution reliability, vehicle safety and life span, and compatible fuel-vehicle combinations.

For their analytical test requirements, CEN generally adopts test methods defined by ISO. ASTM methods are adapted only when there are neither suitable ISO nor EN methods available.

### 2.2.1. Gasoline

The EU regulates automotive gasoline parameters through Directive 98/70/EC as amended (mandatory) and EN 228:2012. Within the limits of Directive 98/70/EC, the EN 228 standard indicates parameters for two gasoline grades:

- Gasoline blended with 5 vol% of ethanol max, provided that oxygen content is 2.7 wt%;
• Gasoline blended with 10 vol% of ethanol, provided that oxygen content is 3.7 wt%.

Tab.2.2. Main Gasoline Quality Parameters Addressed by the EU Legislation

<table>
<thead>
<tr>
<th>Fuel Specification</th>
<th>Function</th>
<th>Effect on Pollutants</th>
<th>Current Status of the Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>Good octane component; Poisonous for vehicle emissions control systems;</td>
<td>Reduction in lead emissions</td>
<td>Regulated at 0.005 gl/l</td>
</tr>
<tr>
<td></td>
<td>Adverse health effects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aromatics</td>
<td>Good octane components; Increases engine deposits and tailpipe</td>
<td>Reduction in HC, CO, CO₂ and benzene emissions</td>
<td>Regulated at 35 vol%</td>
</tr>
<tr>
<td></td>
<td>emissions - e.g., benzene emissions</td>
<td>Increase NOx emissions over full European driving cycle for constant E100</td>
<td></td>
</tr>
<tr>
<td>Vapor pressure</td>
<td>Affects cold-start and warm-up performance; Sensitive to oxygenates and</td>
<td>Reduction in PM LDVs and NOx from HDVs; Reduction in VOC emissions</td>
<td>Regulated max vapor pressure and</td>
</tr>
<tr>
<td></td>
<td>gasoline blending with ethanol or methanol</td>
<td></td>
<td>distillation parameters; vapor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>pressure waiver per ethanol content</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Corrosive; Source of sulfur emissions; Sulfur reduction enables</td>
<td>Reduction in HC, CO₂ and NOx emissions</td>
<td>From 2009, limited to 10 ppm EU wide</td>
</tr>
<tr>
<td></td>
<td>application on new emission capture technologies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olefins</td>
<td>Good octane component; Can lead to deposit formation and increased</td>
<td>Reduction of evaporation, which contributes to ozone formation and toxic dienes</td>
<td>Limited to 18 vol%</td>
</tr>
<tr>
<td></td>
<td>emissions of reactive (ozone forming) hydrocarbons and toxic compounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>Produces high-octane gasoline streams; Human carcinogen</td>
<td>Reduction of benzene emissions</td>
<td>Limited to 1 vol%</td>
</tr>
<tr>
<td>Bio-components and</td>
<td>Reduces life cycle GHG emissions of fuels; Octane enhancers, affects</td>
<td>Reduction in GHG emissions from fuel life cycle</td>
<td>From 2009, oxygen content increased</td>
</tr>
<tr>
<td>oxygenates</td>
<td>vapor pressure</td>
<td></td>
<td>to 3.7 wt%, ethanol content to 10 vol%</td>
</tr>
</tbody>
</table>
According to Directive 89/70/EC, from 2009 gasoline containing max 2.7 wt% of oxygen and max 5 vol% of ethanol (known as “E5” grade) was required to be distributed in the EU markets until at least 2013. EU Member States were obliged to implement this requirement on their national markets. In addition, they may decide to mandate a longer period of E5 distribution and are responsible for determining who may distribute E5 and how it should be distributed.

2.2.2. Diesel Fuel

Tab.2.3. reflects on the major automotive diesel parameters regulated by the EU (EN 590) and their implications for emissions and vehicle performance. The trend in diesel fuel is to reduce aromatics and sulfur content, lower density and distillate curve control, and increase cetane number.

<table>
<thead>
<tr>
<th>Fuel Specification</th>
<th>Function</th>
<th>Effect on Pollutants</th>
<th>Current Status of the Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Density</td>
<td>Affects injection timing of mechanically controlled injection equipment, emission and fuel combustion; Sensitive to increasing FAME content of diesel</td>
<td>Reduces NC, CO and PM from LDV and NOx from HDVs.</td>
<td>Regulated at 820-860 min-max at 15 °C, kg/m3</td>
</tr>
<tr>
<td><strong>Lower Polyaromatics</strong></td>
<td>The fuel aromatic content affects combustion and formation of particulate and PAH emissions</td>
<td>Reduces NOx and PM from LDVs and HC, NOx and PM from HDVs</td>
<td>Regulated at 8%</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>----------------</td>
</tr>
</tbody>
</table>
| **Higher Cetane**       | Measure of compression ignition behavior of diesel fuel; Higher cetane levels enable quicker ignition; Cetane affects cold startability exhaust emissions and combustion noise | Decreases HC and CO from LDVs and HDVs | Cetane number: 51.0 min  
Cetane index 46.0 min (can not be used for fuels containing FAME) |
| **Lower Sulfur**        | Corrosive; Can lead to wear of engine systems; Reduction enabled application of after-treatment systems to remove NOx | Reduces SOx, PM | Regulated at 10 ppm max |
| **Higher Biodiesel (FAME)** | Reduces life cycle GHG emissions from fuels; Has characteristics of lubricant | Reduces life cycle GHG emissions of fuels | Regulated at 7 vol% |

2.2.3. Fuel Quality Monitoring

Air quality management applies to all activities that the regulatory body does to protect human health and the environment from the harmful effects of air pollution. The process of air quality management can be illustrated as a cycle of interrelated elements.

A cycle is a dynamic process. There is ongoing review and evaluation of goals and strategies based on their effectiveness. All parts of this process are informed by scientific research that gives air quality managers an essential understanding of how pollutants are emitted, transported and converted into air and their impact on human health and the environment.

In the EU, Directive 98/70 / EC requires Member States to establish a national fuel quality monitoring system (FQMS), to monitor fuel quality and to notify the European Commission of the results. If a Member State does not apply EU law (including Directive 98/70 / EC) or does not apply it properly, infringement proceedings can be
initiated against that country. This procedure is complicated and very lengthy. It begins with informal proceedings when the European Commission, together with the Member States concerned, seeks to complete the case. If this is not possible, the Commission shall submit the ICJ to the Court. The court makes its decision, and if it decides that a country has violated EU law, it forces the country to comply with the law. If the country still does not comply with the law, the Court may impose financial penalties. In accordance with Directive 98/70 / EC as amended, Member States should monitor compliance with the requirements of the Directive on petrol and diesel specifications on the basis of the analytical methods specified in European Standard EN 228 for petrol and EN 590 for diesel.

The EU Air Quality Directives (AAQD) oblige EU Member States to divide their territories into zones and agglomerations for air quality assessment and management. This is information communicated by Member States in accordance with the rules of Commission Implementing Decision 2011/850 / EC.

Air quality assessment and air quality management should be performed in all zones and agglomerations, and each zone and agglomeration should be classified according to the thresholds for assessing the content of sulfur dioxide (SO2), nitrogen dioxide (NO2) or nitrogen. (NOx), solids (PM10, PM2.5), lead, benzene, or carbon monoxide as indicated in AAQD.

AAQDs also require Member States to take appropriate measures to ensure that thresholds and targets are met for a specified period and / or maintain compliance once the thresholds and targets have been reached. Therefore, air quality plans are required in contaminated sites and agglomerations where the air quality standards are exceeded, and / or in areas and agglomerations where there is a risk of excess. These plans aim at reducing the concentration of air pollutants to the lower regulatory standards and targets set by the Directives in the shortest possible time. The details of the plans shall be communicated by the Member States to the European Commission through the European Environment Agency (EEA). This is information communicated by Member States in accordance with the rules of Commission Implementing Decision 2011/850 / EC [16].
When and where concentrations of pollutants in the air exceed the relevant target values or limit values, AAQ Directives require Member States to develop air quality plans and/or take appropriate measures (depending on the pollutant) in order to achieve the relevant target values or limit values at areas and agglomerations, and excess periods are kept as short as possible.

In many Member States, local governments are responsible for developing and implementing air quality plans.

Air quality plans typically include a number of activities based on air quality assessment and future trend forecasts and a detailed analysis of high concentrations, including relevant sources. Understanding the causes of high levels of air pollution is critical to making urban quality management decisions.

2.3. Conclusion to Chapter 2

To curb the trend, the EU is introducing new CO₂ emission targets, which aim to cut harmful emissions from new cars and vans. CO₂ emissions from passenger transport vary significantly depending on the transport mode. Passenger cars are a major polluter, accounting for 60.7% of total CO₂ emissions from road transport in Europe.

The environmental properties of fuels characterize the level of their environmental impact during their operation or use. Fuel quality in the EU started to be regulated in the mid-1970s, when sulfur limits in all types of fuel had been reduced to the levels between 8,000 ppm and 3,000 ppm parts per million (depending on the area where fuels were used).

Eleven countries have already exceeded the EU’s targets to obtain reduction of emissions. It is aiming to increase this to 32% by 2030.

Fuel Quality Directive or FQD (Directive 98/70/EC as amended) sets mandatory environmental and health requirements for automotive gasoline and diesel. The FQD covers parameters that are important from an environmental point of view and require limitations for the protection of human health. Another important aim of the directive is
to harmonize the EU market and avoid negative consequences for fuel suppliers in all 28 MS, which could be provoked if each state had its own quality requirement for fuels.

European Standards are established by the European Committee for Standardization (CEN), the only recognized organization in the EU empowered to elaborate and adopt standards with fuel quality requirements. These technical specifications are characteristics required of a product for reasons of safety, engine and vehicle performance, drivability, air pollution mitigation, health and environmental protection, etc. This is why the lists of parameters included in European standards for fuels are longer than those covered by the directive. The aim of the standard is to ensure that fuels produced in accordance with it pose environmental threats. Fuel producers and distributors use EN 228 and EN 590 as reference documents in their trade transactions. Acknowledging these standards reflects on the quality of products they distribute and that they take responsibility for this quality.

CHAPTER 3
CALCULATION OF MODERN VEHICLE EMISSIONS

3.1. Calculation of pollution emissions in atmospheric air by transport used as economic subjects activities and private ownership people

The aim of the following calculation is to determine the volume of emissions of harmful substances into the atmospheric air by motor transport operated by economic entities, as well as the amount of pollutant emissions from vehicles, which are privately owned by the population.

Method of calculation: Gas, diesel, liquefied petroleum gas and compressed natural gas are used to operate vehicles operated by business entities.
The main pollutants to be calculated are carbon monoxide (CO), nitrogen oxides (NO\textsubscript{x}), hydrocarbons (C\textsubscript{n}H\textsubscript{m}), sulfur dioxide (SO\textsubscript{2}), lead and impurities.  
The calculation of pollutant emissions into the atmospheric air from certain fuels by economic entities is carried out by by the formula:

\[
B_{jk}^i = M_k^i \cdot \text{КПБ}_{jk}^i \cdot \text{КТС}_{jk}^i B_{jk}^i = M_k^i \cdot \text{КПБ}_{jk}^i \cdot \text{КТС}_{jk}^i,
\]

(1)

where

- \(B_{jk}^i\) - the amount of emission of the j-th pollutant from the consumed fuel and of the k-th type by the motor vehicle group (except lead);
- \(M_k^i\) - volume of consumed fuel of the i-th type by the k-th group of vehicles;
- average specific emissions of j-th pollutant per unit of fuel and type (except lead) by vehicles of economic entities;
- coefficient of influence of the technical condition on the specific emissions of the j-th pollutant by the k-th group of vehicles.

Fuel costs for mileage and transport work are given per unit volume. For their translation into weight units, coefficients such as \(\text{KTC}\) are used.

The values of and \(\text{KTC}\) are presented in Table. 1, 2 and 3.

The calculation of the volume of fuel consumed by groups of cars in weight units is made by the formula:

\[
M_k^i = Q_k^i \cdot \text{K}^i M_k^i = Q_k^i \cdot \text{K}^i,
\]

(2)

where

- \(M_k^i\) - the volume of fuel consumed by the i-th type of the k-th group of vehicles business entities in weight units (kg, tons);
- \(Q_k^i\) - quantity of consumed fuel of the i-th type by the k-th group of motor transport of subjects of economic activity in units of volume (l, ths m\textsuperscript{3});
- \(\text{K}^i\) - coefficient (specific gravity) of fuel of the i-th type (kg / l, kg / m\textsuperscript{3}).
### Tab. 3.1. - Values of average specific emissions of pollutants by cars during urban transport (KPV)

<table>
<thead>
<tr>
<th>Groups of cars</th>
<th>Type of fuel</th>
<th>CO</th>
<th>CnHm</th>
<th>NOx</th>
<th>solid impurities</th>
<th>SO2</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight cars</td>
<td>gasoline</td>
<td>225,7</td>
<td>54,8</td>
<td>17,46</td>
<td>-</td>
<td>0,6</td>
<td>0,23</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>40,4</td>
<td>6,8</td>
<td>30</td>
<td>3,85</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas is liquefied</td>
<td>225,7</td>
<td>54,8</td>
<td>17,46</td>
<td>-</td>
<td>0,6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas compressed</td>
<td>91,1</td>
<td>29,13</td>
<td>24,07</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Passenger buses</td>
<td>gasoline</td>
<td>233</td>
<td>56,9</td>
<td>16,37</td>
<td>-</td>
<td>0,6</td>
<td>0,23</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>41,5</td>
<td>6,93</td>
<td>29,6</td>
<td>3,85</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas is liquefied</td>
<td>233</td>
<td>56,9</td>
<td>16,37</td>
<td>-</td>
<td>0,6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas compressed</td>
<td>92</td>
<td>30,8</td>
<td>23,2</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Passenger cars</td>
<td>gasoline</td>
<td>225,7</td>
<td>32,3</td>
<td>17,46</td>
<td>-</td>
<td>0,6</td>
<td>0,5</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>40,4</td>
<td>6,8</td>
<td>30</td>
<td>3,85</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas is liquefied</td>
<td>225,7</td>
<td>32,3</td>
<td>17,46</td>
<td>-</td>
<td>0,6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas compressed</td>
<td>91,1</td>
<td>29,13</td>
<td>24,07</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Special cars</td>
<td>gasoline</td>
<td>225,7</td>
<td>54,8</td>
<td>17,46</td>
<td>-</td>
<td>0,6</td>
<td>0,23</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>40,4</td>
<td>6,8</td>
<td>30</td>
<td>3,85</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas is liquefied</td>
<td>225,7</td>
<td>54,8</td>
<td>17,46</td>
<td>-</td>
<td>0,6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas compressed</td>
<td>91,1</td>
<td>29,13</td>
<td>24,07</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Special trucks</td>
<td>gasoline</td>
<td>225,7</td>
<td>54,8</td>
<td>17,46</td>
<td>-</td>
<td>0,6</td>
<td>0,23</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>40,4</td>
<td>6,8</td>
<td>30</td>
<td>3,85</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas is liquefied</td>
<td>225,7</td>
<td>54,8</td>
<td>17,46</td>
<td>-</td>
<td>0,6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas compressed</td>
<td>91,1</td>
<td>29,13</td>
<td>24,07</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
The value of the coefficient $K^iK^i$:
- for gasoline - 0.74 kg / l;
- for diesel fuel - 0.85 kg / l;
- for liquefied gas - 0.55 kg / l;
- for compressed gas - 0.59 kg / m³.

Lead emissions are determined only for leaded gasoline. Lead emissions (for leaded gasoline) are determined by the formula:

$$B^Pb_k = M_{k_{\text{ет-ет}}} \cdot KPB_{j_k} \cdot KTC_{j_k},$$

where $B^Pb_k$ - quantity of lead emissions from gasoline consumed by the k-th group of motor transport of business entities; $M_{k_{\text{ет-ет}}}$ - the volume of consumption of leaded gasoline by the k-th group of motor transport of business entities.

Lead emissions are determined only for leaded gasoline. The share of leaded gas (Ket) from the total amount of gasoline consumed is provided annually to the regional statistics offices of the State Statistics Committee of Ukraine.

Tab.3.2. - Values of the average of specific emissions of pollutants by vehicles during rural transport

<table>
<thead>
<tr>
<th>Groups of cars</th>
<th>Type of fuel</th>
<th>CO</th>
<th>CnHm</th>
<th>NOx</th>
<th>solid impurities</th>
<th>SO2</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight cars</td>
<td>gasoline</td>
<td>169,8</td>
<td>39,2</td>
<td>25,8</td>
<td>-</td>
<td>0.6</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>32</td>
<td>5.65</td>
<td>32,8</td>
<td>3.85</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas is liquefied</td>
<td>169,8</td>
<td>39,2</td>
<td>25,8</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>gas compressed</td>
<td>84,2</td>
<td>16,29</td>
<td>30,8</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Passenger</td>
<td>gasoline</td>
<td>177.92</td>
<td>42.45</td>
<td>24.6</td>
<td>-</td>
<td>0.6</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>33.2</td>
<td>18.15</td>
<td>32.38</td>
<td>3.85</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
<td>------</td>
<td>-------</td>
<td>-------</td>
<td>------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>buses gas is liquefied</td>
<td>177.92</td>
<td>24.42</td>
<td>24.6</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>gas compressed</td>
<td>85.2</td>
<td>16.29</td>
<td>29.86</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Passenger cars gasoline</td>
<td>177.92</td>
<td>24.42</td>
<td>24.62</td>
<td>-</td>
<td>0.6</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>diesel fuel</td>
<td>32</td>
<td>5.65</td>
<td>32.8</td>
<td>3.85</td>
<td>5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>gas is liquefied</td>
<td>177.92</td>
<td>24.42</td>
<td>24.62</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>gas compressed</td>
<td>84.2</td>
<td>16.29</td>
<td>30.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Special cars gasoline</td>
<td>177.92</td>
<td>39.2</td>
<td>24.62</td>
<td>-</td>
<td>0.6</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>diesel fuel</td>
<td>32</td>
<td>5.65</td>
<td>32.8</td>
<td>3.85</td>
<td>5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>gas is liquefied</td>
<td>177.92</td>
<td>24.42</td>
<td>24.62</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>gas compressed</td>
<td>84.2</td>
<td>16.29</td>
<td>30.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Special cars trucks gasoline</td>
<td>169.8</td>
<td>39.2</td>
<td>25.8</td>
<td>-</td>
<td>0.6</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>diesel fuel</td>
<td>32</td>
<td>5.65</td>
<td>32.8</td>
<td>3.85</td>
<td>5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>gas is liquefied</td>
<td>169.8</td>
<td>39.2</td>
<td>25.8</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>gas compressed</td>
<td>84.2</td>
<td>16.29</td>
<td>30.8</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Consumption of ethylated gasoline by economic entities is determined by the formula:

\[
M_{k}^{\text{man-er}} = Q_{k}^{i} \cdot K_{\text{er}} \tag{4}
\]

where

- \(Q_{k}^{i}\) - total volume of gasoline used by the k-th group of motor transport of business entities, kg;
- \(K_{\text{er}}\) - the share of leaded gasoline according to the State Statistics Committee of Ukraine.
The total amount of emissions of the j-th pollutant by cars of business entities is defined as the sum of the emissions of the j-th pollutant from the consumption of all fuels by all groups of vehicles.

The main type of fuel used in privately owned motor vehicles is gasoline. The consumption of compressed natural gas and diesel is negligible. Therefore, when calculating emissions of pollutants from private vehicles emissions of harmful substances from combustion of gasoline are taken into account.

Tab.3.3. - Values of coefficients of influence of technical condition of cars on specific emissions of pollutants

<table>
<thead>
<tr>
<th>Groups of cars</th>
<th>Type of fuel</th>
<th>CO</th>
<th>CnHm</th>
<th>NOx</th>
<th>solid impurities</th>
<th>SO2</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight cars</td>
<td>gasoline</td>
<td>1.7</td>
<td>1.8</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>1.5</td>
<td>1.4</td>
<td>0.95</td>
<td>1.8</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>gas is liquefied</td>
<td>1.7</td>
<td>1.8</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>gas compressed</td>
<td>1.7</td>
<td>1.8</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Passenger buses</td>
<td>gasoline</td>
<td>1.7</td>
<td>1.8</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>1.5</td>
<td>1.4</td>
<td>0.95</td>
<td>1.8</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>gas is liquefied</td>
<td>1.7</td>
<td>1.8</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>gas compressed</td>
<td>1.7</td>
<td>1.8</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Passenger cars</td>
<td>gasoline</td>
<td>1.5</td>
<td>1.5</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>1.5</td>
<td>1.4</td>
<td>0.95</td>
<td>1.8</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>gas is liquefied</td>
<td>1.5</td>
<td>1.5</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>gas compressed</td>
<td>1.7</td>
<td>1.8</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Special cars</td>
<td>gasoline</td>
<td>1.5</td>
<td>1.5</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>diesel fuel</td>
<td>1.5</td>
<td>1.4</td>
<td>0.95</td>
<td>1.8</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>gas is liquefied</td>
<td>1.5</td>
<td>1.5</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>gas compressed</td>
<td>1.7</td>
<td>1.8</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Special</td>
<td>gasoline</td>
<td>1.7</td>
<td>1.8</td>
<td>0.9</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Emissions of carbon monoxide, hydrocarbons, nitrogen oxides, sulfur dioxide into the atmospheric air of cities, urban and rural settlements by vehicles owned by citizens are calculated by the formula:

\[ B_j = B \cdot K_j \cdot K_{mj} \]  

(5)

where \( B_j \) is the amount of emission of the \( j \)-th pollutant (except lead);

\( B \) - the volume of gasoline consumed (leaded and unleaded);

\( K_j \) is the average specific emission of the \( j \)-th pollutant (other than lead) for cars of individual owners with gasoline-powered internal combustion engines;

\( K_{mj} \) is the coefficient of influence of the technical condition of cars on the specific emissions of the \( j \)-th pollutant.

The values of \( K_j \) and \( K_{mj} \) are presented in Table 4.

Lead emissions are determined by the formula:

\[ B_j = B \cdot K_j \cdot K_{mj} \cdot K_j^3 \]  

(6)

where \( B_j \) is the amount of lead emission; - volume of consumed ethylated gasoline;

\( K_j^3 K_j^3 \) - the proportion of leaded gasoline in the total amount of gasoline consumed.

Table 4 - Values of average specific emissions of pollutants and coefficients of influence of technical condition of cars

<table>
<thead>
<tr>
<th>Name of indicators</th>
<th>CO</th>
<th>NOx</th>
<th>CnHm</th>
<th>SO2</th>
<th>Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual owners' cars with internal combustion engines running on gasoline in urban areas (kg/ton of fuel)</td>
<td>202.22</td>
<td>20.98</td>
<td>28.43</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Individual owners' cars with internal combustion engines running on gasoline in the countryside (kg / ton of fuel)</td>
<td>177.92</td>
<td>22.91</td>
<td>24.42</td>
<td>0.6</td>
<td>0.5</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>------</td>
<td>------</td>
<td>------</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Coefficient of influence of the technical condition of cars on the specific emissions of pollutants (Kt)</td>
<td>1.5</td>
<td>0.9</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Calculation of the volume of gasoline consumed by motor vehicles located in property of citizens in cities, towns and villages is performed by the formula:

$$B = K_a \cdot B_{avt} \cdot K_{GM} \cdot K_M,$$

(7)

where \(B\) is the annual consumption of gasoline by private transport owned by citizens in cities, towns and cities;

\(K_a\) - the number of privately owned cars in cities, towns and villages;

\(B_{avt}\) - fuel consumption by one car, which is privately owned by citizens during the year (for urban areas, urban settlements, this figure equals 626 kg, for rural areas - 411 kg);

\(K_{GM}\) - coefficient of loss of fuel for work in mountainous conditions: at altitude from 500 to 1500 m - 1.05, and from 1501 to 2000 m - 1.1;

\(K_M\) - coefficient of fuel loss for work in city conditions: with a population of 0.5 to 1.0 million people. - 1,1, and with a population of more than 1 million people. - 1,5.

Determination of the number of private vehicles in cities, towns and villages, \(K_a\) is made by the formula:

$$K_a = \frac{N \cdot K_{GM}}{1000},$$

(8)
where \( K_a \) - the number of privately owned cars in cities, towns and villages;
\( N_t N_{t\text{r}} \) - average annual population in cities (\( N_{\text{city}} N_{\text{city}} \)), urban settlements (\( N_{\text{setti}} N_{\text{setti}} \)) and rural areas (\( N_{\text{village}} N_{\text{village}} \)) according to Form No. A-1;
\( K_{CA} K_{CA} \) - the average number of private vehicles, per 1,000 people in the area.

The \( K_a \) figure is rounded to an integer.

To determine the average number of privately owned cars per 1,000 inhabitants of a district, city of a regional or republican subordination \( K_{CA} K_{CA} \), use the formula:

\[
K_{CA} = \frac{K_{III}}{N_{\text{region}}} \cdot 1000, \tag{9}
\]

where \( K_{CA} K_{CA} \) - the average number of private vehicles, per 1,000 people of the district, city of regional or republican subordination;
\( K_{III} K_{III} \) - the number of private vehicles in the region, city of regional or republican subordination according to GAI;
\( N_{\text{region}} N_{\text{region}} \) - average annual number of population in the area according to the form № A-1.

Calculation of emissions of all pollutants into the atmospheric air urban, urban and rural settlements are carried out by by the formula:

\[
B_{3ar} = \sum_{j=1}^{4} B_j B_{3ar} = \sum_{j=1}^{4} B_j, \tag{10}
\]

where \( B_{3ar} B_{3ar} \) - the amount of emissions of all pollutants from motor transport, which is privately owned by the population in cities, towns and cities;
\( B_j B_j \) - the amount of emission of the j-th pollutant from motor vehicles, which is privately owned by the population in cities, towns and cities.
The task is to determine the amount of pollutant emissions into the air by road transport operated by economic entities. Baseline: The amount of fuel consumed by the i-th type of k-th group of vehicles of economic entities in units of volume $i \mathbf{Q}_k^i \mathbf{Q}_k^l$ (l, ths m3) is presented in Table 5.

Tab.3.5. - Quantity of consumed fuel of the i-th type by the kth group of motor transport of business entities

<table>
<thead>
<tr>
<th>Type of car</th>
<th>gasoline</th>
<th>diesel fuel</th>
<th>liquefied petroleum gas</th>
<th>natural compressed gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger buses</td>
<td>7.83</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Trucks</td>
<td>-</td>
<td>60.72</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Passenger cars</td>
<td>14.92</td>
<td>-</td>
<td>8.26</td>
<td>37.33</td>
</tr>
<tr>
<td>Special cars</td>
<td>6.31</td>
<td>-</td>
<td>15.39</td>
<td>46.24</td>
</tr>
<tr>
<td>Special cars</td>
<td>-</td>
<td>23.61</td>
<td>9.94</td>
<td>-</td>
</tr>
</tbody>
</table>

Note. Cars are transported within the city (city transportation).

1. Determine the volume of consumed fuel of the i-th type by the kth group of vehicles of economic entities in weight units $i \mathbf{M}_k^i \mathbf{M}_k^l$ (kg) by the formula (2):

\[
\begin{align*}
\mathbf{M}_{\text{ПА}} &= \mathbf{Q}_{\text{ПА}}^i \cdot K = 7,83 \cdot 0,74 = 5,79 \text{ кг} \\
\mathbf{M}_{\text{ПЛ}} &= \mathbf{Q}_{\text{ПЛ}}^i \cdot K = 14,92 \cdot 0,74 = 11,04 \text{ кг} \\
\mathbf{M}_{\text{СЛ}} &= \mathbf{Q}_{\text{СЛ}}^i \cdot K = 6,31 \cdot 0,74 = 4,67 \text{ кг} \\
\mathbf{M}_{\text{ВА}} &= \mathbf{Q}_{\text{ВА}}^i \cdot K = 60,72 \cdot 0,85 = 51,61 \text{ кг} \\
\mathbf{M}_{\text{СНА}} &= \mathbf{Q}_{\text{СНА}}^i \cdot K = 23,61 \cdot 0,85 = 20,07 \text{ кг} \\
\mathbf{M}_{\text{НГ}} &= \mathbf{Q}_{\text{НГ}}^i \cdot K = 8,26 \cdot 0,55 = 4,54 \text{ кг} \\
\mathbf{M}_{\text{СНА}} &= \mathbf{Q}_{\text{СНА}}^i \cdot K = 15,39 \cdot 0,55 = 8,47 \text{ кг} \\
\mathbf{M}_{\text{НГ}} &= \mathbf{Q}_{\text{НГ}}^i \cdot K = 9,94 \cdot 0,55 = 5,47 \text{ кг} \\
\mathbf{M}_{\text{ПСГ}} &= \mathbf{Q}_{\text{ПСГ}}^i \cdot K = 37,33 \cdot 0,59 = 22,03 \text{ кг}
\end{align*}
\]
The results of the calculation are presented in Tab.3.6.

Tab.3.6. - Volume of fuel consumed by groups of cars

<table>
<thead>
<tr>
<th>Type of car</th>
<th>gasoline</th>
<th>diesel fuel</th>
<th>liquefied petroleum gas</th>
<th>natural gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger buses</td>
<td>5.79</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Trucks</td>
<td>-</td>
<td>51.61</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Passenger Cars</td>
<td>11.04</td>
<td>-</td>
<td>4.54</td>
<td>22.03</td>
</tr>
<tr>
<td>Special trucks</td>
<td>4.67</td>
<td>-</td>
<td>8.47</td>
<td>27.28</td>
</tr>
<tr>
<td>Special cars</td>
<td>-</td>
<td>20.07</td>
<td>5.47</td>
<td>-</td>
</tr>
</tbody>
</table>

2. Determine the number \( B_{jk}^j \) (tons) of the emission of the j-th pollutant into the atmospheric air from the consumed fuel and of the k-th type by the motor vehicle group according to the formula (1):

- by buses

\[
B_{CO}^{5} = M_{HA}^{5} \cdot \text{KPIB}_{CO}^{5} \cdot \text{KTC}_{CO}^{5} = (5, 79 \cdot 233, 0 \cdot 1, 7) \cdot 10^{-3} = 2.29 \text{ tons};
\]

\[
B_{C_{sH_{m}}}^{5} = M_{HA}^{5} \cdot \text{KPIB}_{C_{sH_{m}}}^{5} \cdot \text{KTC}_{C_{sH_{m}}}^{5} = (5, 79 \cdot 56, 9 \cdot 1, 8) \cdot 10^{-3} = 0.593 \text{ tons};
\]

\[
B_{NO_x}^{5} = M_{NO_x}^{5} \cdot \text{KPIB}_{NO_x}^{5} \cdot \text{KTC}_{NO_x}^{5} = (5, 79 \cdot 16, 37 \cdot 0, 9) \cdot 10^{-3} = 0.085 \text{ tons};
\]

\[
B_{SO_x}^{5} = M_{SO_x}^{5} \cdot \text{KPIB}_{SO_x}^{5} \cdot \text{KTC}_{SO_x}^{5} = (5, 79 \cdot 0, 6 \cdot 1, 0) \cdot 10^{-3} = 0.004 \text{ tons}.
\]

The amount of emission of the i-th pollutant into the atmospheric air by vehicles used by economic entities by fuel is presented in Table.3.7.

Tab.3.7. Emissions of pollutants by fuel type

<table>
<thead>
<tr>
<th>Type of fuel</th>
<th>CO</th>
<th>CnHm</th>
<th>NOx</th>
<th>solid impurities</th>
<th>SO2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CnHm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOx</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>solid impurities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Similarly emissions of pollutants into the atmospheric air from consumed fuel and other types of other economic entities are calculated. The results of the calculation are presented in tab.3.8.

<table>
<thead>
<tr>
<th>Type of car</th>
<th>Type of fuel</th>
<th>The magnitude of the emission of the j-th pollutant and $B_{jk}$ (tons) into the air</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CO</td>
</tr>
<tr>
<td>Passenger buses</td>
<td>gasoline</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,29</td>
</tr>
<tr>
<td>Passenger buses</td>
<td>gasoline</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,13</td>
</tr>
<tr>
<td>Trucks</td>
<td>diesel fuel</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,74</td>
</tr>
<tr>
<td>Passenger Cars</td>
<td>liquefied petroleum gas</td>
<td>1,537</td>
</tr>
<tr>
<td></td>
<td>natural gas</td>
<td></td>
</tr>
<tr>
<td>Special trucks</td>
<td>gasoline</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,581</td>
</tr>
<tr>
<td></td>
<td>liquefied petroleum gas</td>
<td>2,868</td>
</tr>
<tr>
<td></td>
<td>natural gas</td>
<td></td>
</tr>
<tr>
<td>Special cars</td>
<td>diesel fuel</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,216</td>
</tr>
<tr>
<td></td>
<td>liquefied petroleum gas</td>
<td>2,099</td>
</tr>
</tbody>
</table>
3.2. Conclusion to Chapter 3

The analysis of the calculations shows that the most pollutants are carbon monoxide (26.1 tonnes), hydrocarbons (5.791 tonnes) and nitrogen oxide (3.732 tonnes). On the fig.3.1. we can see what volume of fuels were used by different types of transport.

![Fig.3.1. The amount of fuel consumed by the transport group](image)

According to this data we can see that the major consumers of gasoline are passenger busses and cars. Also passengers and special cars consume the natural gas in high volumes. And the most of diesel fuel is using by trucks. Diesel-powered trucks, unlike all other motor vehicles, emit solid impurities and the highest amount of sulfur dioxide into the atmosphere.
Fig. 3.2. shows the emissions of pollutants by fuel type. Analyzing the estimated amount of pollutant emissions into the atmosphere by fuel, it can be noted that the largest amount of carbon monoxide is released into the atmosphere when compressed natural gas (7,637 tonnes), gasoline (7,611 tonnes) and liquefied petroleum are used as fuel. gas (6,504 tons). The largest amount of hydrocarbons enters the atmosphere when compressed natural gas (2,585 tons), nitrogen oxide and sulfur dioxide - diesel (2,042 and 0,358 tons respectively) are used as fuel.

Thus, compressed natural gas is a major source of pollution atmospheric air by hydrocarbons, diesel fuel by nitric oxide, sulfur dioxide and solid impurities, and all fuels are to a greater or lesser extent sources of air pollution by carbon monoxide.
CHAPTER 4
ORGANIZATION OF THE WORKING PLACE OF IBCP OF NASU PETROCHEMICAL EXPERT

4.1. Organization of the working place of IBCP of NASU petrochemical expert

Working place of a petrochemical expert is composed of laboratory of homogeneous catalysis and additives for petroleum products where expert has work with the next devices: gasoline purge unit, chromatograph device and computer for processing and results analysis.

In its turn, organization of the work in the laboratory is regulated by the LU «On Labor Precaution», the Order of Ministry of Social Policy of Ukraine «On Approval of Requirements for the Safety and Health of Workers during Work with On-Screen Devices» and the accompanying set of requirements [1], as well as Regulation of the Cabinet of Ministers of Ukraine «Hygienic Classification of Labor (by Indicators of Hazard and Danger of Factors of the Production Environment, Severity and Intensity of the Labor Process)» and the Sanitary and Hygienic Norms [2, 3], Order ‘On approval of the Rules of labor protection during work in chemical laboratories” provides the norms according to the Law of Ukraine "About fire safety" as we had worked with flammable substance.

Requirements for premises and equipment of chemical laboratories are listed below:

- Premises of chemical laboratories are equipped with forced ventilation, and places of possible accumulation of harmful chemicals - local suction cups.
- All work with chemicals should be carried out only in the exhaust cabinets. Exhaust cabinets must be equipped with suction cups.
• The floors of premises of chemical laboratories should have an even, and surface-friendly surface, also its should be resistant to mechanical loads, moisture and aggressive environments.

• Tables and exhaust cabinets intended for work with fire and explosive substances must have protective bands and be covered with non-combusting material, and for work with acids, alkalis and other inorganic and organic chemically active materials - substances resistant to their influence.

• Pliability with the fire-prevention regime and equipping premises of chemical laboratories with primary means of fire-fighting.

• All electrical equipment, a power tool with a voltage over 36 V, as well as equipment and mechanisms that can be energized, are reliably grounded.

• The level of noise in chemical laboratories should not exceed the norms (60 dBA), established by the State sanitary norms of industrial noise, ultrasound and infrasound.

• The premises of chemical laboratories are provided with natural, artificial and combined lighting, depending on the characteristics of the work due to requirements of DBN V.2.5-28:2018 "Natural and artificial lighting".

• The microclimate in the working area of the chemical laboratories must meet the requirements of the State Sanitary norms of the microclimate of industrial premises.

4.3. Development of safety measures.

Consider the hazardous and harmful production factors that affect a person according to the classification that is given in State Sanitary Standards And Rules "Hygienic classification of labor on the indicators of harmfulness and danger factors of the production environment, the severity and intensity of the labor process", 08.04.2014
No. 248. The workplace is placed in chemical laboratory. According the following dangerous and harmful production factors affect the worker:

Physical:
- the increased value of the voltage in the electric circuit, the closure of which can occur in human body;
- elevated level of electromagnetic radiation;
- laboratory utensils that can break through during work (eg glassware);
- deficient lighting of the workplace.

Chemical:
- chemicals that penetrate the human body through the respiratory system, mucous membranes and gastrointestinal tract.

Psychophysiological:
- neuropsychic overload (over-voltage analyzers, monotony of labor, visual discomfort).
- Nervous-psychological overload (over-voltage analyzers, monotony of labor, visual discomfort). Source - work on the computer.

4.3.1. The microclimate and ventilation

Microclimate is a complex of meteorological conditions at the working places: temperature, relative humidity, number of air ions, air exchange, air movement rate, the content of particulate matter (dust) in the air, the presence of pleasant odors (aromatherapy), etc. Microclimate is highly important for working premises, as workers spend much time there and require comfortable conditions for been more productive. The specifications are given in Table 4.1 [4].
Tab. 4.1. Optimal and permissible microclimate parameters values for category IIb premises

<table>
<thead>
<tr>
<th>Season</th>
<th>Microclimate parameters</th>
<th>Optimal value</th>
<th>Permissible value</th>
<th>Actual value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold</td>
<td>Room temperature</td>
<td>19-21 °C</td>
<td>15-23 °C</td>
<td>13-18 °C</td>
</tr>
<tr>
<td></td>
<td>Relative humidity</td>
<td>60-40 %</td>
<td>Up to 75 %</td>
<td>55%</td>
</tr>
<tr>
<td></td>
<td>Room’s air velocity</td>
<td>0.2 m/s</td>
<td>&lt;0.3 m/s</td>
<td>–</td>
</tr>
<tr>
<td>Warm</td>
<td>Room temperature</td>
<td>21-23 °C</td>
<td>17-27 °C</td>
<td>22-27 °C</td>
</tr>
<tr>
<td></td>
<td>Relative humidity</td>
<td>60-40 %</td>
<td>65 if t=26 °C</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>Room’s air velocity</td>
<td>0.3 m/s</td>
<td>0.4-0.2 m/s</td>
<td>–</td>
</tr>
</tbody>
</table>

For the case of our laboratory, in warm seasons all microclimatic values are contained within permissible values, as general exchange ventilation system is installed in the premises in accordance with the state building standards [5] and the room has access to the natural air and cooling sources through two windows.

The situation with the heating in cold season is more complicated, as the general heating system and radiators were installed in accordance with older standards and are significantly outdated causing temperature drop up to five degrees below permissible level.

4.3.2. Chemical hazards and safety

Risk of chemical exposure of workers is possible exclusively in the laboratory condition during conduction of experimental acting. Regulation in the field of chemical safety in labor precaution provided by the State Sanitary Norms and Rules «Hygienic Classification of Labor by Hazard and Danger of Factors of the Production Environment, the Severity and Intensity of the Labor Process» and by Law of Ukraine «On the Provision of Sanitary and Epidemiological Welfare of the Population» [9] and
Interstate Standard GOST 12.1.007-76 SSBT. Harmful substances. Classification and general safety requirements.

According to MPC classification, laboratory work of expert may be deemed harmful of the IV category due to the possible contact with cancerogenic substance as gasoline.

Tab.4.2. MPC of harmful substances in the air of the working area (gasoline)

<table>
<thead>
<tr>
<th>№</th>
<th>Name of substances</th>
<th>MPC mg/3</th>
<th>Class of danger</th>
<th>Aggregate state</th>
<th>Peculiarities of influence on human</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gasoline</td>
<td>100</td>
<td>V</td>
<td>Vapor</td>
<td>Cancerogen</td>
</tr>
</tbody>
</table>

Still, in case of adherence to the set of working place chemical safety rules, the working conditions may be comply with the requirements. Those include: good ventilation system, exhaust cabinets, avoidance of close work with dangerous chemicals or work with the special protective equipment (e.g. masks and respirators) and clothing items (e.g. rubber gloves and boots).

4.4. Fire safety

The category of the laboratory room is В “Explosive fire hazard” in accordance with State Standard ДСТУ Б В.1.1-36:2016 «Definition of Category of Premises, Buildings and External Facilities According to Explosion and Fire Hazard». According to this it’s a rooms which contain flammable dust and / or fibers, flammable liquids with a flash point higher than 28 ° C, combustible liquids in such quantities that they can form explosive dust, steam-air mixtures, in the case of which a projected excessive explosion pressure in the room develops that exceeds 5 kPa.
Compliance with the fire-prevention regime and equipping the premises of chemical laboratories with primary means of fire-fighting is carried out in accordance with the requirements of NAPB A.01.001-2004 and the Model Standards for the use of fire extinguishers, approved by the order of the Ministry of Emergencies and Affairs of Population Protection from the Consequences of the Chernobyl Disaster of April 2, 2004 No. 151, registered with the Ministry of Justice of Ukraine on April 29, 2004 under No. 554/9153 (NAPB B.03.001-2004). For the localization and liquidation of fires in their initial stage of development it is necessary to use fire extinguishers in accordance with the requirements of DSTU 3675-98 "Fire Engineering. Fire extinguishers are portable. General Technical Requirements and Test Methods "(hereinafter - DSTU 3675-98) and DSTU 3734-98 (GOST 30612-99)" Fire Engineering. Fire extinguishers are mobile. General technical requirements "(hereinafter - DSTU 3734-98), as well as internal fire water pipelines, coverings of non-combustible heat-insulating material, sand and other primary means of fire-fighting.

Exploitation of fire extinguishers shall be carried out in accordance with the requirements of the Rules of operation of fire extinguishers approved by the order of the Ministry of Ukraine on Emergencies and Protection of the Population from the Consequences of the Chernobyl Catastrophe of April 2, 2004 No. 152, registered with the Ministry of Justice of Ukraine on April 29, 2004, No. 555/9154 (NAPB B.01.008-2004), and their maintenance - in accordance with the requirements of DSTU 4297: 2004 "Fire Engineering. Maintenance of fire extinguishers. General technical requirements ".

4.5. Labor protection issues for detailed elaboration. Organizational and technical measures of harmful and dangerous factors mitigation

Workplace safety is a system of organizational measures and technical means, which prevent the working of hazardous industrial factors, and each organization and enterprise to follow these measures to ensure safe working conditions, which are divided into the following varieties:
1. Technical measures - technical means providing safe and harmless working conditions, and related to introduction of new equipment, devices and devices of safety and safe operation of means of production.

2. Regulatory and methodical measures:
   - development of manuals and recommendations;
   - development of the regulatory framework for labor protection at the enterprise;
   - providing necessary legal documentation of functional services, separate structural subdivisions and workplaces;
   - provision of programs and development of training methods on labor protection issues;

3. Organizational events:
   - control over the technical state of equipment, tools, buildings and structures;
   - control over observance of requirements of normative documents on labor protection;
   - supervision of equipment of high danger;
   - organization of training, examination of knowledge on labor protection and training of employees of the enterprise;
   - control over the implementation of the technological process in accordance with the requirements of labor protection;
   - organization of proper conditions for fares and passages in accordance with the requirements of occupational safety;
   - provision of employees with means of individual and collective protection;
   - Providing appropriate security signs, posters.
   - development of sections of labor protection in job descriptions, instructions on professions;

4. Sanitary-hygiene measures:
   - control over the influence of production factors on the health of workers;
   - provision of sanitary conditions in accordance with the applicable norms;
- certification of workplaces in accordance with their normative acts on occupational safety;
- planning of measures to improve sanitary and hygienic working conditions;
- certification of the sanitary and technical condition of working conditions.

5. Socio-economic measures:
- provision of benefits and compensations to workers who work with harmful and hazardous working conditions;
- creation of conditions for the economic interest of the employer and the employee in improving the conditions and improving the safety of work;
- social insurance of employees by the employer;
- financing of occupational safety measures;
- compensation by the employer to the employee in case of injury.

6. Therapeutic and preventive measures:
- provision of medical assistance to victims of accidents at work;
- control over the health of workers during their work;
- medical and prophylactic feeding of workers who work on work with harmful and dangerous working conditions;
- medical examinations of employees (preliminary and periodic);
- observance of labor protection of women, minors and invalids;
- reimbursement to the injured employee of expenses for treatment, prosthetics, purchase of vehicles and other kinds of medical care.

7. Scientific events:
- forecasting of social and economic consequences of accidents and accidents;
- simulation of emergency situations and development of measures to prevent them;
- plans for localization and liquidation of the accident;
- assessment of the effectiveness of the management of labor protection;
- preparation of scientifically grounded technical solutions aimed at increasing safety and improving working conditions.

4.6. Conclusion to Chapter 5

Therefore, after the completion of labor precaution chapter of diploma, we can conclude that the working place of the IBCP of NASU petrochemical expert is in sufficient satisfactory condition, though some adjustments are necessary.

After the analysis of workplace conditions certain minor drawbacks of occupational safety system were detected on the part of microclimate provision during cold seasons and insufficiently good equipment and protective clothing for the worker. Considering mainly non-profit character of IBCP of NASU work as well as big and costly scale of full-on repairs of the whole building, I would suggest the following solutions:

- Purchase new protective clothing for the worker. renovate technical equipment of working places
- Use organizational measures to come with microclimate flaws during cold seasons: cover gaps and cracks in windows and doors with styrofoam and tape; introduce increased breaks working mode and use local heating devices allowed by standards.

Hopefully, those relatively simple and cheap measures will allow adjustment of the situation. As for other factors and fire safety the considered working place was complacent with legislation and current standards and standards.
References

2. https://auto.howstuffworks.com/percentage-of-air-pollution-due-to-cars.htm - What percentage of air pollution is due to cars?
23. 