MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ENVIRONMENTAL SAFETY,
ENGINEERING, AND TECHNOLOGY
DEPARTMENT OF ECOLOGY

APPROVED TO DEFENCE
Head of the Graduate Department
_____________ V.F. Frolov
«_____» ____________ 20__

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
(student, group, surname, name, patronymic)

Scientific Supervisor: Ph. D. in Engineering Sc., Associate Professor of the Ecology Department, Larysa M. Cherniak
(academic degree, academic rank, surname, name, patronymic)

Consultant of the chapter "Labor Precaution": _____________ Viktoria V. Kovalenko
(signature) (S.N.P)

Standards Inspector: _____________ Andrian A. Iavniuk
(signature) (S.N.P)

KYIV 2020

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ ЕКОЛОГІЧНОЇ БЕЗПЕКИ,
ІНЖЕНЕРІЇ ТА ТЕХНОЛОГІЙ
КАФЕДРА ЕКОЛОГІЇ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_____________ В.Ф. Фролов
«_____» ____________ 20__ р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ МАГІСТРА

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

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

Виконавець: студентка групи ЕК-202м Герасименко Наталія Олександрівна
(студент, група, прізвище, ім'я, по батькові)

Керівник: канд.техн.наук, доцент кафедри екології Черняк Лариса Миколаївна
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Консультант розділу «Охорона праці»: _______________ Коваленко В.В. п
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Нормоконтролер: _______________ Явнюк А. А. п
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КИЇВ 2020

NATIONAL AVIATION UNIVERSITY

Faculty of Environmental Safety, Engineering, and Technology

Ecology Department

Direction (speciality, major): specialty 101 “Ecology”, TPP “Ecology a Environmental Protection”

(code, name)

APPROVED
Head of the Department
__________ Frolov V.F.
«____» _________ 20__

MASTER THESIS ASSIGNMENT

Nataliia O. Herasymenko

1. Theme: « Estimation of modern motor gasoline properties, which determine its environmental safety » approved by the Rector on October 11, 2019, № 2364/ст.

2. Duration of work: from 14.10.2019 to 02.02.2020.

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

4. Content of explanatory note: (list of issues): Analytical review of the literature on the topic of the diploma. Analytical review of automobile emissions problem, calculation of the exhaust gases emissions, analyzing of the results.

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

6. Schedule of thesis fulfillment

№ з/п	Task	Term	Advisor's signature
1	Receiving of topic assignment, search of the literature and methodology development	18.10.2019 – 20.10.2019	
2	Preparation of the main part	21.10.2019 – 10.11.2019	
3	Comparative description of the properties of petrol. The assessment of gasoline ecological safety	10.11.2019 – 17.11.2019	
4	Preparation of the main part (Chapter III) and drafting explanatory note for the first preliminary presentation	17.11.2019 – 10.12.2019	
5	First preliminary presentation of the diploma work	16.12.2019	
6	Preparation of the main part (Chapter IV)	12.12.2019 – 28.12.2019	
7	Drafting explanatory note for the second preliminary presentation	10.01.2019 – 21.01.2019	
8	Second preliminary presentation of the diploma work	23.01.2019	
9	Formulation of the conclusions and recommendations of the diploma work, editing, consultation with standard's incpector, remarks and recommendations consideration	23.01.2019 – 26.01.2019	
10	Finalizing, signatures receiving, plagiarism verification, preparation to the final presentation	27.01.2019 – 04.02.2020	
11	Presentation of the final version of the diploma work at the department	06.02.2020	

7. Consultant(s) of certain chapter(s):

Chapter	Consultant (academic rank, S.N.P)	Date, signature	
		Given by	Accepted by
Labor Precaution	Viktoria V. Kovalenko, Ph.D., Assoc. Prof. of the Civil and Engineering Safety Department		

8. Date of task issue: «___»   _ 2020__

Diploma (project) advisor: _______________ Larysa M. Cherniak

(advisor's signature)   (S.N.P.)

Task is taken to perform: _______________ Nataliia O.Herasymenko

(graduate's signature)   (S.N.P.)

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет екологічної безпеки, інженерії та технологій

Кафедра екології

Напрям (спеціальність, спеціалізація): спеціальність 101м «Екологія», ОПП «Екологія та охорона навколишнього середовища»

(шифр, найменування)

ЗАТВЕРДЖУЮ
Завідувач кафедри
__________Фролов В.Ф.
«____» _________ 20__ 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 «11» жовтня 2019 р. №2364/ст.

2. Термін виконання роботи: з 14.10.2019 р. по 02.02.2020 р.

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

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Отримання завдання, пошук літературних джерел по темі, напрацювання методології роботи	18.10.2019 – 20.10.2019	
2	Підготовка основної частини	21.10.2019 – 10.11.2019	
3	Підготовка основної частини (Розділ III) та підготовка до першого попереднього захисту	10.11.2019 – 17.11.2019	
4	Оцінка перспектив використання оксигенованих бензинів в Україні	17.11.2019 – 10.12.2019	
5	Перше попереднє представлення роботи на кафедрі	16.12.2019	
6	Підготовка основної частини (Розділ V)	12.12.2019 – 28.12.2019	
7	Підготовка основної частини та підготовка до другого попереднього захисту	10.01.2019 – 21.01.2019	
8	Друге попереднє представлення роботи на кафедр	23.01.2019	
9	Формулювання висновків та рекомендацій, косметичні правки, консультація з нормоконтролером, урахування зауважень	23.01.2019 – 26.01.2019	
10	Дооформлення, отримання підписів, перевірка на плагіат, підготовка до захисту	27.01.2019 – 04.02.2020	
11	Захист готової роботи на кафедрі	06.02.2020	

7. Консультація з окремого(мих) розділу(ів):

Розділ	Консультант (посада, П.І.Б.)	Дата, підпис	
		Завдання видав	Завдання прийняв
Охорона праці	Коваленко В. В., к.б.н., доцент каф. цивільної та промислової безпеки		

8. Дата видачі завдання: «___» ______ 2020 р.

Керівник дипломної роботи (проекту): ________________ ___Черняк Л.М.__ф

(підпис керівника) (П.І.Б.)

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: 83 с., 10 рис., 16 табл., 9 формул, 33 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 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, АВТОМОБІЛЬНІ БЕНЗИНИ, ЕКОЛОГІЧНА БЕЗПЕКА, СТАТИСТИЧНИЙ АНАЛІЗ.

ABSTRACT

Explanatory note to thesis «Estimation of modern motor gasoline properties, which determine its environmental safety» contains: 83 pages, 10 figures, 16 tables, 9 formulas, 33 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.

CONTENT

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;

VOCs – Volatile Organic Compounds;

AAQDs – Ambient Air Quality Directives;

CAA – Clean Air Act;

EPA – Environmental Protection Agency;

MPC – Maximum Permissible Concentration.

INTRODUCTION

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.

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).

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: the advantages and disadvantages of the use of different types of motor fuel in the aspect of environmental safety are substantiated.

Practical application: the results of the work can be useful for the study and scientific progress in the fields of transport ecology.

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: VIII All-Ukrainian Scientific-Practical Internet Conference «Technogenic and ecological safety of Ukraine: state and prospects of development».

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

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. The scientific basis of this effort is the pioneering atmospheric chemistry research of A.J.Haägen-Smit, who showed that photochemical reactions among hydrocarbons (HC) and nitrogen oxides (NO_x) produce the many secondary pollutants that reduce visibility and cause eye and nose irritation in the Los Angeles area [1].

Motor vehicles emit a number of pollutants. Perhaps the most damaging is particulate matter, a combination of organic material and inorganic substances. Dust, soil, acids, metals, and organic chemicals are some of the components of particulate matter. Most of the stuff is extremely small, and the smaller the particle, the more damaging; particles less than 10 micrometers in diameter are capable of entering the lungs. Once in the lungs, the particulate matter can also cause serious problems for the heart. Nitrogen dioxide, produced when fuel is burned at high temperatures, can also spell trouble; in high concentrations, it can damage your lungs and cause chest pains.

Volatile organic compounds (better known as VOCs) are also found in air pollution, and they're just as dangerous as the name would suggest. 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.

But just how much pollution do cars produce? The answer is more complicated than you might expect. For starters, air pollution isn't consistent around the world or even around the country. Areas of dense populations -- or, more specifically, areas where large quantities of fossil fuels are burned -- have much higher levels of air pollution than sparsely-occupied regions. Heavily-populated cities such as Los Angeles, Mexico City and Beijing are all famous for their air pollution. Weather conditions also impact air quality, resulting in daily fluctuations in the breathability of the air. So, pollution levels don't just vary from one geographic area to another; they also vary from one day to the next.

1.1.1. United States

And yet with all those 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 roughly one-half of pollutants like VOCs, nitrogen oxide and particulate matter. Seventy-five percent of carbon monoxide emissions come from automobiles. In urban areas, harmful automotive emissions are responsible for up to 50 percent of air pollution. All told, that's quite a lot of air pollution coming from our vehicles [2].

The United States Clean Air Act (CAA) provides an excellent basis on which to judge the environmental safety of fuels and fuel additives (F/FA) brought to market. The United States Environmental Protection Agency (EPA) administers the law and has provided the guidelines by which new fuels and additives can comply with the CAA. The guidelines are quite clear that only additives and fuels that “Contain no elements other than carbon, hydrogen, oxygen, nitrogen, and/or sulfur (CHONS)” are to be considered safe for registration without further testing in accordance with existing fuel data. Any other elements are considered “atypical.” Additives containing atypical elements should undergo rigorous testing to ensure they have no detrimental environmental impact, and the law lays out the type of testing and a process to get such other additives approved [14].

1.1.2. EU

According to the fifth assessment report by the Intergovernmental Panel on Climate Change (IPCC), it is extremely likely that human activities over the past 50 years have warmed our planet. These activities include for example the burning of coal, oil and gas, deforestation and farming.

Energy is responsible for 80.7% of greenhouse gas emissions in 2017, of which transport accounts for about a third. Greenhouse gas emissions from agriculture contribute with 8.72%, industrial processes and product use with 7.82% and the management of waste with 2.75%.

Transport is responsible for nearly 30 percent of the EU's total CO_2 emissions, of which 72% comes from road transportation. As part of efforts to reduce CO_2 emissions, the EU has set a goal of reducing emissions from transport by 60% by 2050 compared to 1990 levels. Significantly reducing CO_2 emissions from transport will not be easy, as the rate of emission reductions has slowed. Other sectors have cut emissions since 1990, but as more people become more mobile, CO_2 emissions from transport are increasing. Efforts to improve the fuel efficiency of new cars are also slowing. After a steady decline, newly registered cars emitted on average 0.4 grammes of CO_2 per kilometre more in 2017 than the year before. To curb the trend, the EU is introducing new CO_2 emission targets, which aim to cut harmful emissions from new cars and vans. MEPs adopted the new rules during the plenary session on 27 March. On 18 April, MEPs also approved a proposal to cut CO_2 emissions from new trucks by 30% by 2030 compared to 2019 emission levels.

CO_2 emissions from passenger transport vary significantly depending on the transport mode. Passenger cars are a major polluter, accounting for 60.7% of total CO_2 emissions from road transport in Europe. However, modern cars could be among the cleanest modes of transport if shared, rather being driven alone. With an average of 1.7 people per car in Europe, other modes of transport, such as buses, are currently a cleaner alternative.

Under the Paris agreement on climate change, the EU committed to cut greenhouse gas emissions by at least 40% in all economic sectors by 2030 compared to 1990 levels. In addition to setting targets for car emissions, MEPs have adopted the following measures to help the EU meet this commitment:

- The European Emissions Trade Scheme for the industry's emissions;
- Binding national targets to cut greenhouse gas emissions from non-industrial sectors;
- The use of forests to offset carbon emissions [3].

1.1.3. In the world

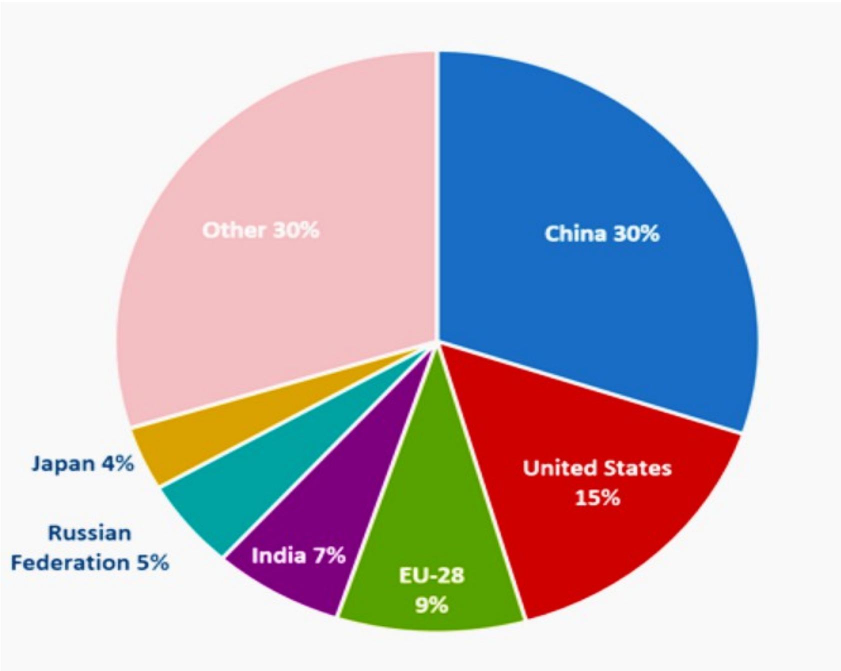


Fig. 1.1. Countries emitting the most greenhouse gases in the world [12]

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

Greenhouse gases remain in the atmosphere for periods ranging from a few years to thousands of years. As such, they have a worldwide impact, no matter where they were first emitted [4].

Since the Australian fuel specifications primarily follow that of the CEN standards, they are largely different from those of the U.S., Japan and South Korea.

However, for test methods, ASTM test methods are primarily used as reference in the Australian specifications for gasoline, diesel and E85. The specifications for autogas and biodiesel use not only ASTM but also test methods from CEN, International Organization for Standardization (ISO), Institute of Petroleum1 (IP) and Japan LP Gas Association (JLPGA) as reference [13].

1.1.4. Euro 1-6 Standards

European emission standards define the acceptable limits for exhaust emissions of new vehicles sold in the European Union and EEA member states. The emission standards are defined in a series of European Union directives staging the progressive introduction of increasingly stringent standards.

The EU has said that "the air pollutant emissions from transport are a significant contribution to the overall state of air quality in Europe", with industry and power generation being the other major sources.

The aim of Euro emissions standards is to reduce the levels of harmful exhaust emissions, chiefly:

- Nitrogen oxides (NO_x);
- Carbon monoxide (CO);
- Hydrocarbons (HC);
- Particulate matter (PM).

These standards are having a positive effect, with the SMMT (Society of Motor Manufacturers and Traders), claiming: "It would take 50 new cars today to produce the same amount of pollutant emissions as one vehicle built in the 1970s."

In 2017, the SMMT quoted the following figures in support:

- Carbon monoxide (CO): petrol down 63%, diesel down 82% since 1993
- Hydrocarbons (HC): petrol down 50% since 2001
- Nitrogen oxide (NO_x): down 84% since 2001
- Particulate matter (PM): diesel down 96% since 1993

Because petrol and diesel engines produce different types of emissions they are subject to different standards. Diesel, for example, produces more particulate matter – or soot – leading to the introduction of diesel particulate filters (DPFs).

The EU has pointed out, however, that NO_x emissions from road transport "have not been reduced as much as expected because emissions in 'real-world' driving conditions are often higher than those measured during the approval test (in particular for diesel vehicles)".

According to Department for Business, Energy & Industrial Strategy (BEIS) stats from 2018, transport still accounted for 33% of all carbon dioxide emissions, with most of this coming from road transport.

However, BEIS estimates current emissions from road transport have fallen back by around 8.5% over the last decade to levels last seen in 1990, having previously peaked in 2007.

In 2018, the government announced its new strategy – called the Road to Zero – to support the transition to zero emission road transport, which includes a ban on the sale of new petrol and diesel cars by 2040 and a complete ban by 2050.

As part of this, some authorities across the UK are considering implementing low-emission zones, following the example of London, which increased emissions restrictions by establishing the Ultra-Low Emission Zone (ULEZ) in April 2019.

Euro 6 and Euro 6 diesel. Implementation date (new approvals): 1 September 2014. The sixth and current incarnation of the Euro emissions standard was introduced on most new registrations in September 2015. For diesels, the permitted level of NO_x has been slashed from 0.18g/km in Euro 5 to 0.08g/km.

A focus on diesel NO_x was the direct result of studies connecting these emissions with respiratory problems.

To meet the new targets, some carmakers have introduced Selective Catalytic Reduction (SCR), in which a liquid-reductant agent is injected through a catalyst into the exhaust of a diesel vehicle. A chemical reaction converts the nitrogen oxide into harmless water and nitrogen, which are expelled through the exhaust pipe.

The alternative method of meeting Euro 6 standards is Exhaust Gas Recirculation (EGR). A portion of the exhaust gas is mixed with intake air to lower the burning temperature. The vehicle's ECU controls the EGR in accordance with the engine load or speed.

Euro 6 emissions standards (petrol):

- CO: 1.0g/km;
- THC: 0.10g/km;
- NMHC: 0.068g/km;
- NO_x: 0.06g/km;
- PM: 0.005g/km (direct injection only).

Euro 6 emissions standards (diesel):

- CO: 0.50g/km;
- HC + NO_x: 0.17g/km;
- NO_x: 0.08g/km;
- PM: 0.005g/km.

Euro 5. Implementation date (new approvals): 1 September 2009. The big news for Euro 5 was the introduction of particulate filters (DPFs) for diesel vehicles, along with lower limits across the board. For type approvals from September 2011 and new cars from January 2013, diesel vehicles were subject to a new limit on particulate numbers. DPFs capture 99% of all particulate matter and are fitted to every new diesel car. Cars meeting Euro 5 standards emit the equivalent of one grain of sand per kilometre driven [31].

Euro 4 introduced in the European Union in 2005. In 2009, replaced by a new standard - Euro-5. From January 1, 2013, all cars produced and imported into Russia must comply with Euro-4 class, however, it is possible to use chassis and base vehicles with Euro-3 certificates issued before December 31, 2012. This standard tightened previous standards by 65-70%.

Euro 3. It was introduced in the European Union in 1999 and replaced by the Euro-4 standard in 2005. All vehicles manufactured or imported into Russia from January 1, 2008 must meet the requirements of the Euro-3 standard.

Compared to Euro-2 - a reduction in emissions compared with 30-40 percent. In Euro-3, indicators such as carbon monoxide (CO), nitric oxide, and hydrocarbons that promote carcinogenicity are standardized. For diesel engines, these are solid particles that form in the fuel and cause cancer. It corresponds to all new cars produced in European countries since 1999.

Euro 2 was introduced in the European Union as a replacement for Euro-1, in 1995 (adopted in Russia in the fall of 2005). In Euro-2, almost 3 times tightened (0.29 versus 0.72) standards for the content of hydrocarbons in the exhaust.

Replaced by Euro-3 standard in 1999.

Euro 1. It was introduced in the European Union in 1992. Provides emission by gasoline engines:

- carbon monoxide (CO) - not more than 2.72 g / km (grams per kilometer)
- hydrocarbon (CH) - not more than 0.72 g / km
- nitrogen oxides (NO) - not more than 0.27 g / km

Replaced by Euro-2 standard in 1995.

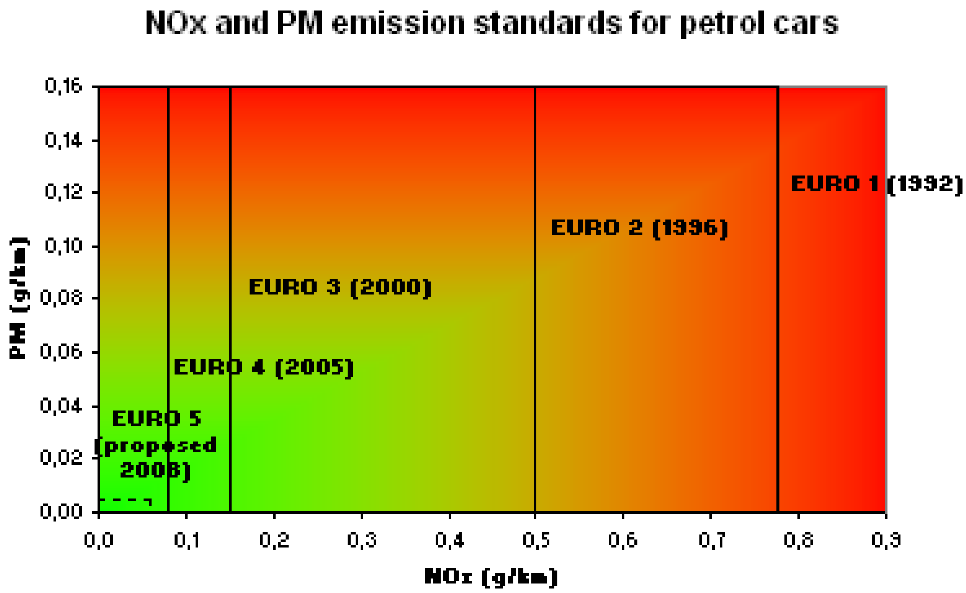


Fig. 1.2. Euro standards for gasoline engines [32]

For the emission standards to deliver actual emission reductions it is crucial to use a test cycle that reflects real-world driving conditions. It was discovered that vehicle manufacturers would optimize emissions performance only for the test cycle, whilst emissions from typical driving conditions proved to be much higher than when tested. Some manufacturers were also found to use so-called defeat devices where the engine control system would recognize that the vehicle was being tested, and would automatically switch to a mode optimized for emissions performance. The use of a defeat device is expressly forbidden in EU law.

An independent study in 2014 used portable emissions measurement systems to measure NO_x emissions during real world driving from fifteen Euro 6 compliant diesel passenger cars. The results showed that NO_x emissions were on average about seven times higher than the Euro 6 limit. However, some of the vehicles did show reduced emissions, suggesting that real world NO_x emission control is possible. In one particular instance, research in diesel car emissions by two German technology institutes found that zero 'real' NO_x reductions in public health risk had been achieved despite 13 years of stricter standards (2006 report).

In 2015, the Volkswagen emissions scandal involved revelations that Volkswagen AG had deliberately falsified emission reports by programming engine management unit firmware to detect test conditions, and change emissions controls when under test. The cars thus passed the test, but in real world conditions, emitted up to forty times more NO_x emissions than allowed by law. An independent report in September 2015 warned that this extended to "every major car manufacturer", with BMW, and Opel named alongside Volkswagen and its sister company Audi as "the worst culprits", and that approximately 90% of diesel cars "breach emissions regulations". Overlooking the direct responsibility of the companies involved, the authors blamed the violations on a number of factors, including "unrealistic test conditions, a lack of transparency and a number of loopholes in testing protocols".

In 2017, the European Union will introduce testing in real-world conditions called Real Driving Emissions, using portable emissions measurement systems in addition to laboratory tests. The actual limits will use 110% (CF=2.1) "conformity factor" (the difference between the laboratory test and real-world conditions) in 2017, and 50% (CF=1.5) in 2021 for NO_x, conformity factor for particles number P being left for further study. Environment organizations criticized the decision as insufficient, while ACEA mentions it will be extremely difficult for automobile manufacturers to reach such a limit in such short period of time. In 2015 an ADAC study (ordered by ICCT) of 32 Euro 6 cars showed that few complied with on-road emission limits, and LNT/NOx adsorber cars (with about half the market) had the highest emissions. At the end of this study, ICCT was expecting a 100% conformity factor. NEDC Euro 6b not to exceed limit of 80 mg/km NO_x will then continue to apply for the WLTC Euro 6c tests performed on a dynomometer while WLTC-RDE will be performed in the middle of the traffic with a PEMS attached at the rear of the car. RDE testing is then far more difficult than the dynomometer tests. RDE not to exceed limits have then been updated to take into account different test conditions such as PEMS weight (305–533 kg in various ICCT testing), driving in the middle of the traffic, road gradient, etc.

ADAC also performed NO_x emission tests with a cycle representative of the real driving environment in the laboratory. Among the 69 cars tested:

- 17 cars emit less than 80 mg/km i-e do not emit more NO_x on this more demanding cycle than on the NEDC cycle;
- 22 additional cars fall below the 110% conformity factor. In total: 57% of cars have then a good chance to be compatible with WLTC-RDE;
- 30 cars fall above the 110% conformity factor and have then to be improved to satisfy the WLTC-RDE test.

Since 2012, ADAC performs regular pollutant emission tests on a specific cycle in the laboratory duly representing a real driving environment and gives a global notation independent from the type of engine used (petrol, diesel, natural gas, LPG, hybrid, etc.). To get the maximum 50/50 note on this cycle, the car shall emit less than the minimum limit applicable to either petrol or diesel car, that is to say 100 mg HC, 500 mg CO, 60 mg NO_x, 3 mg PM and 6×1010 PN. Unlike ambient discourse dirty diesel versus clean petrol cars, the results are much more nuanced and subtle. Some Euro 6 diesel cars perform as well as the best hybrid petrol cars; some other recent

Euro 6 petrol indirect injection cars perform as the worst Euro 5 diesel cars; finally some petrol hybrid cars are at the same level as the best Euro 5 diesel cars [33].

1.2. Characteristics of the exhaust gas composition.

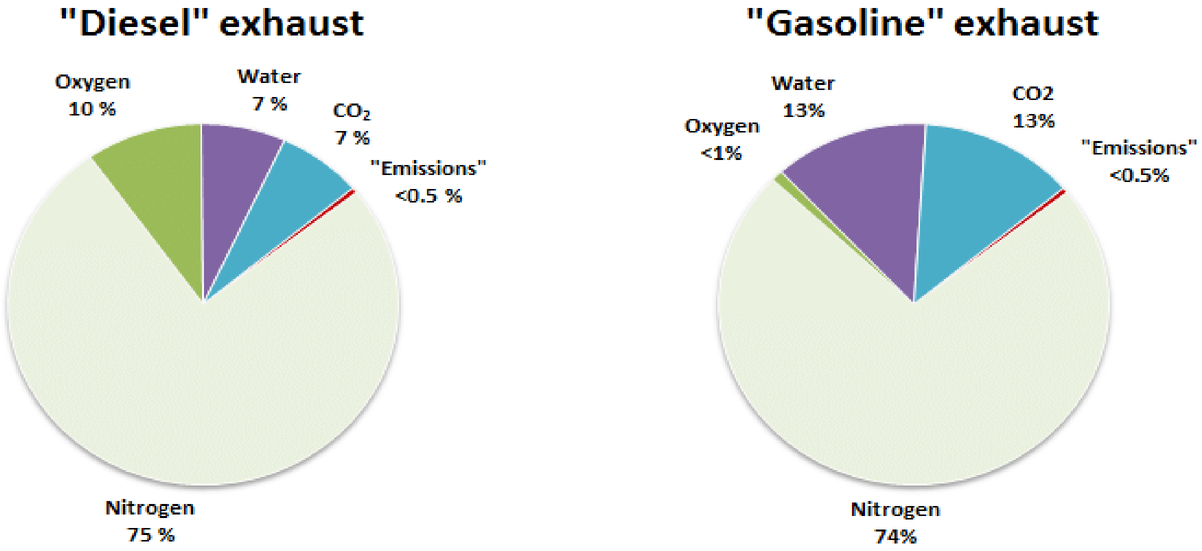
The exhaust gases from internal combustion engines are complex mixtures consisting principally of the products of complete combustion, small amounts of the oxidation products of sulfur and nitrogen, and compounds derived from the fuel and lubricant.

NO_x. Mono-nitrogen oxides NO and NO_2 (NO_x) (whether produced this way or naturally by lightning) react with ammonia, moisture, and other compounds to form nitric acid vapor and related particles. Small particles can penetrate deeply into sensitive lung tissue and damage it, causing premature death in extreme cases. Inhalation of NO species increases the risk of lung cancer and colorectal cancer and inhalation of such particles may cause or worsen respiratory diseases such as emphysema and bronchitis and heart disease.

In a 2005 U.S. EPA study the largest emissions of NO_x came from on road motor vehicles, with the second largest contributor being non-road equipment which is mostly gasoline and diesel stations.

The resulting nitric acid may be washed into soil, where it becomes nitrate, which is useful to growing plants.

Volatile organic compounds. When oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) react in the presence of sunlight, ground level ozone is formed, a primary ingredient in smog. A 2005 U.S. EPA report gives road vehicles as the second largest source of VOCs in the U.S. at 26% and 19% are from non road equipment which is mostly gasoline and diesel stations. 27% of VOC emissions are from solvents which are used in the manufacturer of paints and paint thinners and other uses.



a) b)

Fig. 1.3. Examples of composition of the exhaust gas from "diesel"(a) combustion using excess air and stoichiometric spark-ignited "gasoline"(b) combustion [7]

Carbon monoxide (CO). Carbon monoxide poisoning is the most common type of fatal air poisoning in many countries. Carbon monoxide is colorless, odorless and tasteless, but highly toxic. It combines with hemoglobin to produce carboxyhemoglobin, which blocks the transport of oxygen. At concentrations above 1000 ppm it is considered immediately dangerous and is the most immediate health hazard from running engines in a poorly ventilated space. In 2011, 52% of carbon monoxide emissions were created by mobile vehicles in the U.S.

Hazardous air pollutants (toxics). Chronic (long-term) exposure to benzene (C_6H_6) damages bone marrow. It can also cause excessive bleeding and depress the immune system, increasing the chance of infection. Benzene causes leukemia and is associated with other blood cancers and pre-cancers of the blood.

Particulate matter (PM_{10} and $PM_{2.5}$). The health effects of inhaling airborne particulate matter have been widely studied in humans and animals and include asthma, lung cancer, cardiovascular issues, premature death. Because of the size of the particles, they can penetrate the deepest part of the lungs. A 2011 UK study estimates 90 deaths per year due to passenger vehicle PM. In a 2006 publication, the

U.S. Federal Highway Administration (FHWA) state that in 2002 about 1 percent of all PM_{10} and 2 percent of all $PM_{2.5}$ emissions came from the exhaust of on-road motor vehicles (mostly from diesel engines).

Carbon dioxide (CO_2). Carbon dioxide is a greenhouse gas. Motor vehicle CO_2 emissions are part of the anthropogenic contribution to the growth of CO_2 concentrations in the atmosphere which according to the vast majority of the scientific community is causing climate change. Motor vehicles are calculated to generate about 20% of the European Union's man-made CO_2 emissions, with passenger cars contributing about 12%. European emission standards limit the CO_2 emissions of new passenger cars and light vehicles. The European Union average new car CO_2 emissions figure dropped by 5.4% in the year to the first quarter of 2010, down to 145.6 g/km.

Hydrocarbon emissions are composed of unburned fuels as a result of insufficient temperature which occurs near the cylinder wall. At this point, the air–fuel mixture temperature is significantly less than the center of the cylinder. Hydrocarbons consist of thousands of species, such as alkanes, alkenes, and aromatics. They are normally stated in terms of equivalent CH_4 content [9].

1.2.1. Emission Standards

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_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.

Fig. 1.4. is a plot of NO_x, HC, and CO concentrations in the exhaust versus A/F ratio for a typical gasoline engine. It is impossible to achieve the low emissions demanded by federal standards by A/F ratio control alone since the concentrations of the three pollutants are not minimums at the same A/F ratio.

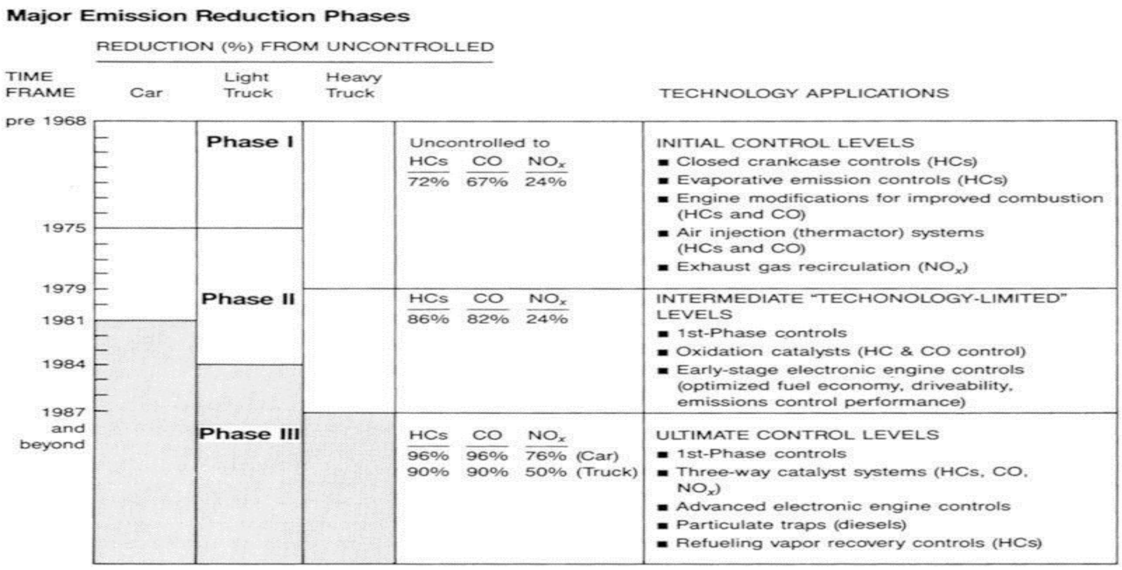


Fig. 1.4. Major phases in the reduction of automotive emissions [5]

In fact, when CO and HC concentrations are a minimum, at an A/F ratio of around 16:1, NO $_x$ 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.

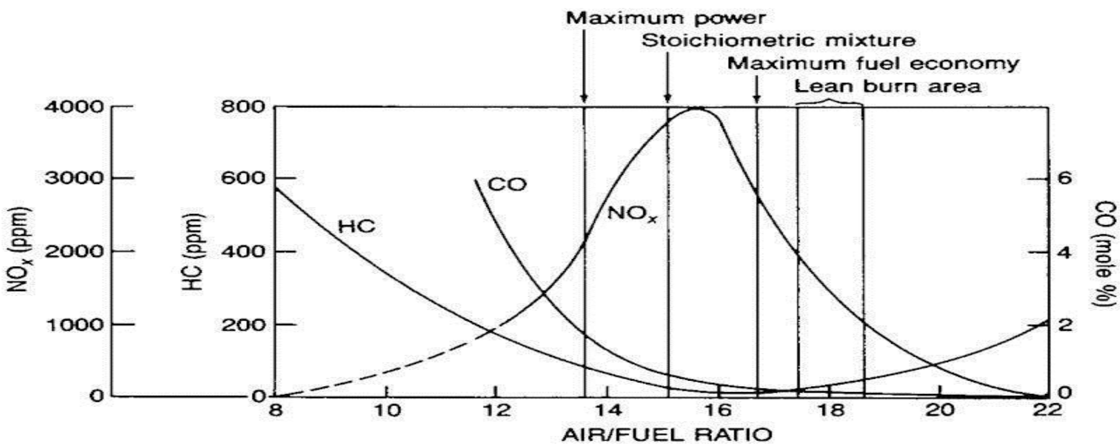


Fig. 1.4. Concentrations of HC, CO, and NO $_x$ emissions as a function of air/fuel ratio in a typical gasoline engine [6]

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_x control efficiencies simultaneously.

Europe. The European Economic Community, an inter-Europe regulatory body, has announced future model standards for passenger cars based on three engine size (displacement) categories. Large-car (>2-liter engine displacement) standards are roughly equivalent to current U.S. standards although there is no valid correlation between the distinct U.S. and European emission test cycles. Standards for medium cars. (1.4–2.0 liters) are considered to fall in the Phase I/Phase II range. Requirements for small-car levels (<1.4 liters) are comparable to Phase I requirements. The standards include diesels; however, large diesel cars are only required to meet medium-car levels.

Japan. Catalyst forcing standards currently in effect for passenger cars are 0.25 HC/2.1 CO/0.25 NO *x* g/km for the unique 10-mode hot start and 7.0 HC/60 CO/4.4 NO *x* g/test for the 11-mode cold-start test procedures. These standards are generally considered to be equivalent to current U.S. California levels [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 CO_2 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 CO_2 emissions, of which 72% comes from road transportation.

To curb the trend, the EU is introducing new CO_2 emission targets, which aim to cut harmful emissions from new cars and vans. CO_2 emissions from passenger transport vary significantly depending on the transport mode. Passenger cars are a major polluter, accounting for 60.7% of total CO_2 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_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 practices, policies, and procedures that ensure the safety and well-being of anyone in the immediate area. This can include safety in terms of proper waste disposal, containment and storage of potentially toxic chemicals and much more.

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 (depending on the area where fuels were used–in environmentally sensitive zones where the sulfur limits must be lower than in other areas). Fig.2.1. depicts the evolution of the European fuel quality specifications as a result of the decades of development described above [11].

A few years later, the lead content of gasoline was addressed for the first time by the European legislation. The allowable limit has been reduced from 0.40 g/l to 0.005 g/l in a step-by-step process. In both cases, the main driver for reductions in permissible limits of lead and sulfur was concern over their impact on human health and the environment. Since the early 1970s, in the numerous action programs on the environment, the European Community has addressed the need to protect the European population and natural environment from the hazardous influence of polluting substances present in the atmosphere. Exhaust pollutants, in particular those resulting from the combustion of fuels' sulfur and lead, were addressed by these programs.

Another factor that influenced the introduction of fuel quality parameters at the EU level was the proper functioning of the internal market. Any disparities in the national laws concerning the composition of fuels (sulfur and lead at the beginning of the process) could negatively affect free trade among the 282 Member States (MS) and competitiveness of some European oil companies against others. These two factors remain the main drivers of any further changes in the fuel quality.

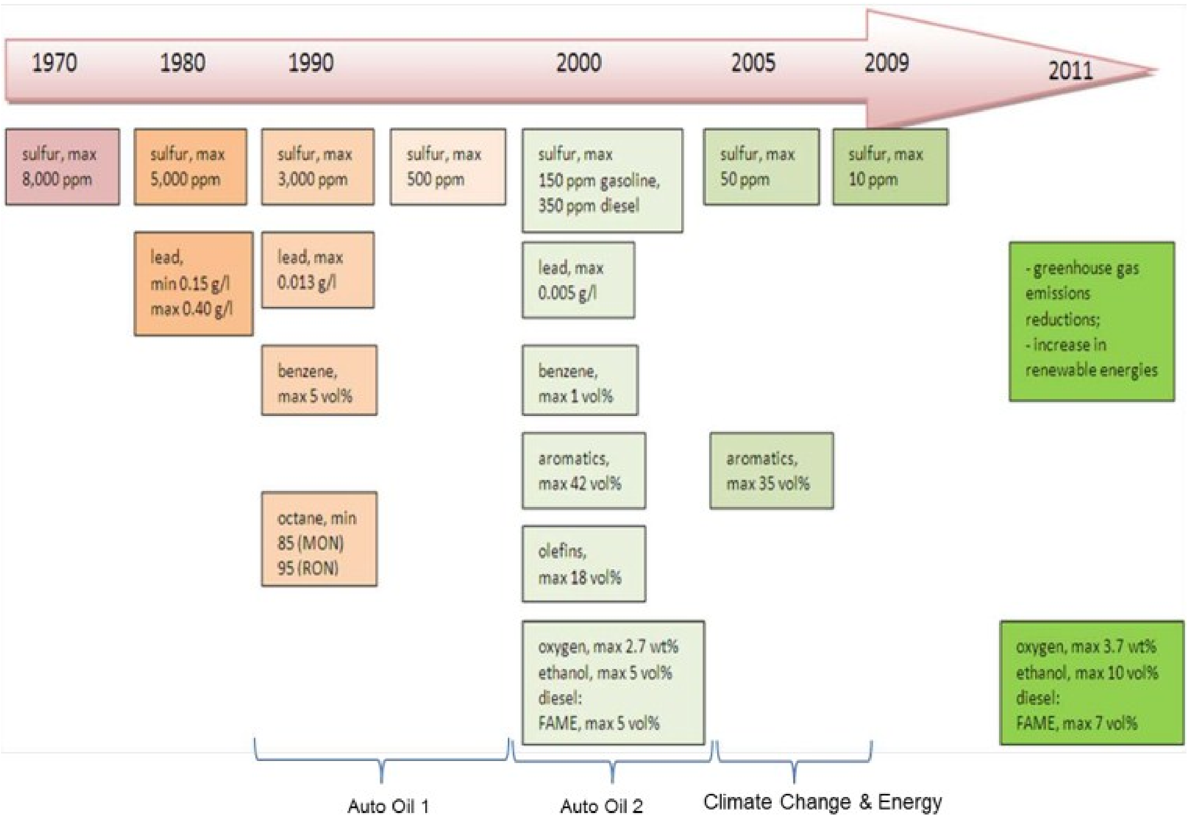


Fig. 2.1. Evolution of the European Fuel Quality Specifications [11]

Automotive fuel quality specifications in the EU are addressed at two levels: binding legislation and nonmandatory technical specifications. This dualism often creates confusion as to which parameters must be obeyed by fuel suppliers and the requirements that are obligatory in each of the 28 MS.

The United States Clean Air Act (CCA) Section 211(a) requires that EPA designate particular fuel/fuel additive (F/FA) that must be registered, and prohibits any sale or distribution in commerce of designated fuels and additives unless they are registered. CAA Section 211(b) states, inter alia, that EPA must require registrants of fuels and additives to "conduct tests to determine potential health and environmental effects of the fuel or additive," and to determine "the emissions resulting from the use of the fuel or additive" and "the extent to which such emissions affect the public health or welfare." CAA Section 211(e) required EPA to promulgate regulations by August 7, 1978, to implement the testing requirements in CAA Section 211(b). The EPA issued regulations establishing testing requirements for registered F/FAs in 1994.4 In the 1994 final rule, EPA adopted which created a grouping system for registered F/FAs. Although this grouping system does not always operate this way in practice, it was designed and intended by EPA to make the required testing of emissions and their effects less burdensome.

The basic premise underlying this new grouping system was stated by EPA as follows: EPA expects F/FAs within each group to have similar emission characteristics and thus essentially the same general effects on the public health and welfare. Therefore, chemical or toxicologic information associated with individual members of a given group can reasonably be generalized to all F/FAs in the group. EPA wanted to make the groups inclusive enough to prevent unnecessary testing, but not so broad that meaningful differences in emissions and their effects between different groups of F/FAs would be missed.

EPA stated: In establishing the F/FA categories (and the groups within them), EPA has sought to avoid overly narrow definitions which would result in unnecessary and duplicative testing by manufacturers, as well as overly broad definitions which would cause potentially important toxicologic differences between F/FAs to be obscured.6 The grouping system for motor vehicle fuels (gasoline and diesel) consists of three general categories: baseline, non-baseline, and atypical. Baseline and non-baseline gasolines, diesels, and the associated additives must "Contain no elements other than carbon, hydrogen, oxygen, nitrogen, and/or sulfur". Non-baseline gasolines and the associated additives must meet all of the requirements for baseline gasoline "except that they contain 1.5 percent or more oxygen by weight and/or may be derived from sources other than those listed in [baseline criterion 5]." Non-baseline diesel fuels and the associated additives must meet all of the requirements for baseline diesel fuels "except that they contain 1.0 percent or more oxygen by weight and/or may be derived from sources other than those listed in [baseline criterion 5]."

Atypical gasolines are "gasoline fuels and associated additives which contain one or more elements other than carbon, hydrogen, oxygen, nitrogen, and sulfur." Atypical diesel fuels are "diesel fuels and associated additives which contain one or more elements other than carbon, hydrogen, oxygen, nitrogen, and sulfur." Within these gasoline and diesel categories, EPA has established discrete F/FA groups. F/FA registrants may meet testing requirements either on an individual or group basis if the product in question meets the criteria for enrollment in a group. All baseline gasolines and the associated additives are in one group. All baseline diesel fuels and the associated additives are also in a single group. Non-baseline gasolines and non-baseline diesel fuels are registered in separate groups, depending on the oxygenate(s) used and the source materials from which the fuel is made.

Applying all of these grouping rules and policies, a taggant additive product may be enrolled in a baseline gasoline group and/or a baseline diesel group when it contains no elements other than CHONS. If a taggant additive contains a deliberately added element other than CHONS, it may only be enrolled in an atypical gasoline group or an atypical diesel group with other fuels and additives containing the same element. If a taggant additive contains more than one deliberately added element other than CHONS, it may only be enrolled in an atypical gasoline or an atypical diesel group with other fuels and additives containing the same combination of atypical elements [14].

2.2. Main Differences between the Fuel Quality Directive and European Standards on Fuel Quality

Reforms of the energy markets have occurred through the sequence of three energy legislative developments. These started during the mid-1990s with the First Energy Package in 1996 until the Third (and latest) Energy Package (2020 Climate and Energy Package) of 2009, as illustrated in Fig. 2.2.

The First Directive aimed at introducing competition, with the objective of separating or unbundling former energy monopolies and ensuring the distinction between regulated and nonregulated activities.

The Second Electricity Directive, adopted in June 2003, reinforced procedures whereby energy transmission networks had to be run independently from the production and supply of energy. This was in conformity with the unbundling principle, aimed at limiting risks of systemic conflict of interest deemed inherent in the vertical integration of production, networks, and supply activities.

The integration of the electricity and gas markets progressed further with the Third Energy Package, which currently forms the legal basis of the electricity market. It detailed further the role of transmission and distribution system operators, and the separation requirements of generation and supply. European regulation created the Agency for Cooperation of Energy Regulators (ACER), and the European Network of Transmission System Operators (ENTSO), acting together in the creation and adoption of framework guidelines and in the definition of network codes for electricity and gas. ACER issues framework guidelines, while ENTSO (in electricity) and ENTSO (in gas) develop network codes based on these guidelines. Network codes become legally binding upon a specific legislative procedure called comitology.

While EU legislation painted a new operating landscape for networks, assets in use today have been inherited from former integrated utility companies. European legislation, however, was not passed without some form of cultural and political resistance to the creation of unbundled operating models, in which networks began their “own lives” within separate entities.

Through the new governance role of ENTSO, electricity transmission network operators were able to regain some form of political foothold that they may have lost in the process of unbundling former integrated monopolies.

The promotion of renewables was enhanced with the Renewables Directive of the Third Package, which included a priority dispatch for renewables and the definition of short- to mid-term electricity market models for electricity. This directive was designed with the aim of creating a market-based framework and providing transparent price signals for all technologies including renewables [15].

This process of reform led to a complete transformation of the energy policy landscape allowing the European Union to advance towards the objective of supplying 20% of the final energy consumption by renewables in 2020.

It also led to important transformations at industry sector (utilities) level through the unbundling process, the creation of power electricity exchanges and gas hubs, as well as the phasing out of regulated supply tariffs.

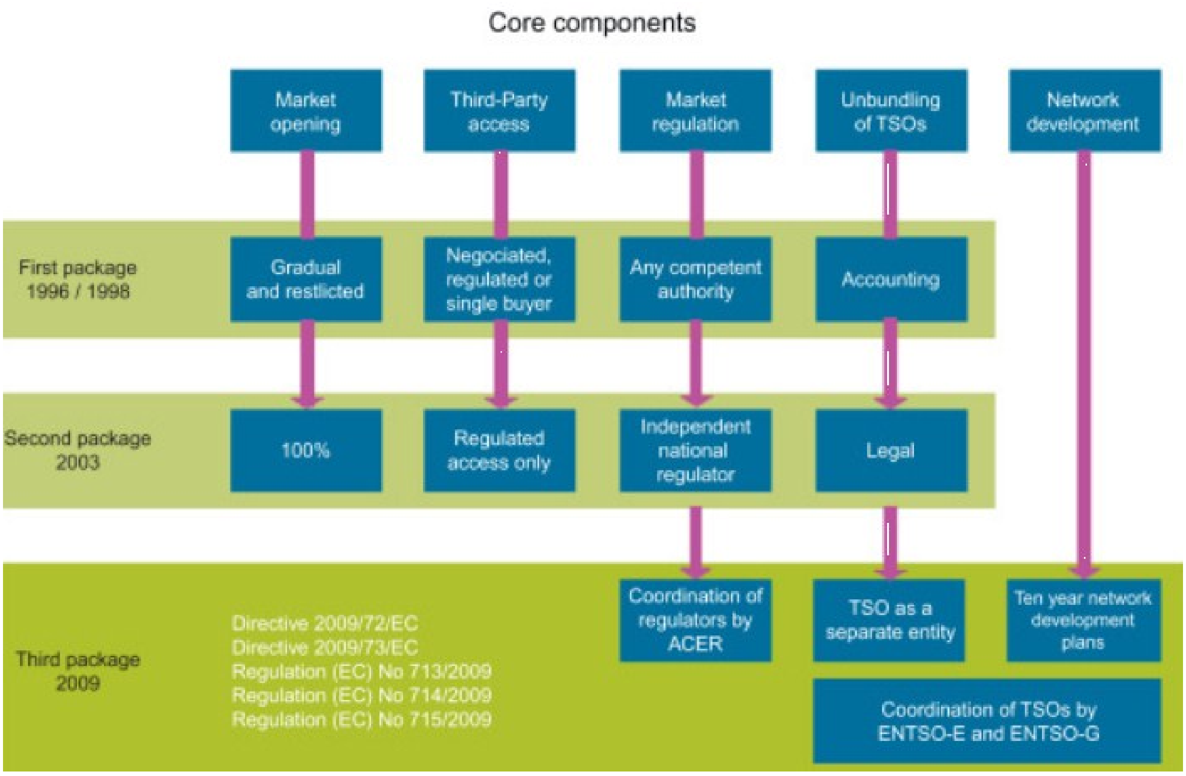


Fig. 2.2. Development of energy packages [15]

Fuel Quality Directive or FQD (Directive 98/70/EC as amended) sets mandatory environmental and health requirements for automotive gasoline and diesel. The directive binds MS as to its parameters, i.e., the quality of fuels placed on European markets must be in compliance with the directive and no MS can refuse access to the market if the fuel meets quality requirements from the directive.

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.

The content of the directive is an outcome of the consultation process with all stakeholders (auto and petroleum industries, NGOs, experts, etc.) as well as negotiations between decision makers in the EU, i.e., the European Commission (which is the initiator), the European Parliament and the Council of the European Union representing the MS [18].

Tab.2.1.

Main Differences between the Fuel Quality Directive and European Standards on Fuel Quality [11]

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

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.

Quality standards (referred to as ENs) are technical specifications with which compliance is not compulsory. 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 that are as negligible as possible, and at the same time ensure the best possible performance of the vehicle.

Standards are elaborated by experts in the field of fuel quality – those working in the fuel production sector and those representing the vehicle industry, as well as experts from fuel laboratories and research institutes with extensive and thorough knowledge and experience in fuel-quality-related research and science.

Experts are representatives of the standardization bodies of 31 states that are currently members of CEN. Gasoline quality properties are established by the most recent version of gasoline standard EN 228:2012, "Automotive fuels – Unleaded petrol – Requirements and test methods."

Diesel quality properties are established by the most recent version of diesel standard EN 590:2013 "Automotive fuels – Diesel – Requirements and test methods." It is accepted in the EU (and the majority of other European countries) that the industry follows and respects the widest range of quality parameters for fuels.

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.

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.

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.

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.

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%.

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.

Tab.2.2.

Main Gasoline Quality Parameters Addressed by the EU Legislation

Fuel Specification	Function	Effect on Pollutants	Current Status of the Specifications
Lead	Good octane component; Poisonous for vehicle emissions control systems; Adverse health effects	Reduction in lead emissions	Regulated at 0.005 gl/l
Aromatics	Good octane components; Increases engine deposits and tailpipe emissions - e.g., benzene emissions	Reduction in HC, CO, CO_2 and benzene emissions Increase NO_x emissions over full European driving cycle for constant E100	Regulated at 35 vol%
Vapor pressure	Affects cold-start and warm-up performance; Sensitive to oxygenates and gasoline blending with ethanol or methanol	Reduction in PM LDVs and NO_x from HDVs; Reduction in VOC emissions	Regulated max vapor pressure and distillation parameters; vapor pressure waiver per ethanol content
Sulfur	Corrosive; Source of sulfur emissions; Sulfur reduction enables application on new emission capture technologies	Reduction in HC, CO_2 and NOx emissions	From 2009, limited to 10 ppm EU wide
Olefins	Good octane component; Can lead to deposit formation and increased emissions of reactive (ozone forming) hydrocarbons and toxic compounds	Reduction of evaporation, which contributes to ozone formation and toxic dienes	Limited to 18 vol%
Benzene	Produces high-octane gasoline streams; Human carcinogen	Reduction of benzene emissions	Limited to 1 vol%
Bio-components and oxygenates	Reduces life cycle GHG emissions of fuels; Octane enhancers, affects vapor pressure	Reduction in GHG emissions from fuel life cycle	From 2009, oxygen content increased to 3.7 wt%, ethanol content to 10 vol%

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.

Tab.2.3.

Main Diesel Quality Parameters Addressed by the EU Legislation

Fuel Specification	Function	Effect on Pollutants	Current Status of the Specifications
Lower Density	Affects injection timing of mechanically controlled injection equipment, emission and fuel combustion; Sensitive to increasing FAME content of diesel	Reduces NC, CO and PM from LDV and NO_x from HDVs.	Regulated at 820-860 min-max at 15 °C, kg/m3
Lower Polyaromatics	The fuel aromatic content affects combustion and formation of particulate and PAH emissions	Reduces NOx and PM from LDVs and HC, NOx and PM from HDVs	Regulated at 8%
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 NO_x	Reduces SO_x, 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 refers to all the activities a regulatory authority undertakes to help protect human health and the environment from the harmful effects of air pollution. The process of managing air quality can be illustrated as a cycle of inter-related elements.

The cycle is a dynamic process. There is a continuous review and assessment of goals and strategies based on their effectiveness. All parts of this process are informed by scientific research that provides air quality managers with essential understanding of how pollutants are emitted, transported and transformed in the air and their effects on human health and the environment.

In the EU, Directive 98/70/EC requires Member States to establish a fuel quality monitoring system (FQMS) at national level, perform fuel quality monitoring and report to the European Commission on the results. If a MS does not implement EU law (including Directive 98/70/EC) or does not implement it properly, the infringement procedure might be launched against this country. This procedure is complicated and very long. It starts with an informal proceeding where the European Commission, together with the MS concerned, looks to bring the case to a conclusion. If it is not possible, the Commission brings the MS to the Court of Justice. The Court gives its ruling, and if it decides that the country breached EU law, it forces the country to implement this law. If the country still does not implement the law, the Court may impose financial penalties. According to Directive 98/70/EC as amended, Member States should monitor compliance with the requirements of the Directive's rulings on gasoline and diesel specifications on the basis of the analytical methods referred to in European Standard EN 228 for gasoline and EN 590 for diesel.

The EU Ambient Air Quality Directives (AAQDs) oblige EU Member States to divide their territories in zones and agglomerations for the purposes of air quality assessment and management. This is the information reported by Member States according to the rules of Commission Implementing Decision 2011/850/EU.

Air quality assessment and air quality management should be carried out in all zones and agglomerations, and each zone and agglomeration should be classified in relation to the assessment thresholds for the ambient concentrations of sulphur dioxide (SO_2), nitrogen dioxide (NO_2) or nitorgen oxides (NO_x), particulate matter (PM10, PM2.5), lead, benzene or carbon monoxide as specified in the AAQDs.

The AAQDs also require Member States to take appropriate measures to ensure compliance with the limit and target values within a specified deadline and/or to maintain compliance once the limit and target values have been met. Therefore, air quality plans are required in polluted zones and agglomerations where air quality standards are exceeded and/or in zones and agglomerations where there is a risk of exceedances.

These plans aim to reduce concentrations of air pollutants to below the legislative limit and target values specified in the Directives in the shortest possible time. Details of the plans must be reported by Member States to the European Commission via the European Environment Agency (EEA). This is the information reported by Member States according to the rules of Commission Implementing Decision 2011/850/EU [16].

When and where concentrations of pollutants in ambient air exceed the relevant target values or limit values, the AAQ Directives require Member States to develop air quality plans and/or take appropriate measures (depending on the pollutant), so that the related target values or limit values are achieved in the respective zones and agglomerations, and that exceedance periods are kept as short as possible.

In many Member States, responsibility for developing and implementing air quality plans has been devolved by national authorities to local governments.

Air quality plans typically include a series of measures based on an assessment of air quality and trend forecasts for the future, and detailed analysis of the high level of concentrations, including the sources responsible. Understanding the reasons for high levels of air pollution is crucial for decision-making on urban air quality management.

2.3. Conclusion to Chapter 2

To curb the trend, the EU is introducing new CO_2 emission targets, which aim to cut harmful emissions from new cars and vans. CO_2 emissions from passenger transport vary significantly depending on the transport mode. Passenger cars are a major polluter, accounting for 60.7% of total CO_2 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 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_x), hydrocarbons (C_nH_m), sulfur dioxide (SO_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:

$$B_{jk}^{i} = M_{k}^{i} \cdot \text{КПв}_{jk}^{i} \cdot \text{КТс}_{jk}^{i}, \quad (1)$$

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; КТс_{jk}^{i} - average specific emissions of j-th pollutant per unit of fuel and type (except lead) by vehicles of economic entities; КПв_{jk}^{i} - 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 and KTC are used.

The values of and 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:

$$M_{k}^{i} = Q_{k}^{i} \cdot K^{i}, \quad (2)$$

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 m3); K^i - coefficient (specific gravity) of fuel of the i-th type (kg /l, kg /m3).

Tab. 3.1.

Values of average specific emissions of pollutants by cars during urban transport (KPV)

Groups of cars	Type of fuel	CO	C_nH_m	NO_x	solid impurities	SO_2	Pb
Freight cars	gasoline	225,7	54,8	17.46	-	0.6	0.23
	diesel fuel	40,4	6,8	30	3.85	5	-
	gas is liquefied	225,7	54,8	17.46	-	0.6	-
	gas compressed	91,1	29.13	24,07	-	-	-
Passenger buses	gasoline	233	56,9	16,37	-	0.6	0.23
	diesel fuel	41.5	6.93	29.6	3.85	5	-
	gas is liquefied	233	56,9	16,37	-	0.6	-
	gas compressed	92	30,8	23,2	-	-	-
Passenger cars	gasoline	225,7	32.3	17.46	-	0.6	0.5
	diesel fuel	40,4	6,8	30	3.85	5	-
	gas is liquefied	225,7	32.3	17.46	-	0.6	-
	gas compressed	91,1	29.13	24,07	-	-	-
Special cars	gasoline	225,7	32.3	17.46	-	0.6	0.5
	diesel fuel	40,4	6,8	30	3.85	5	-
	gas is liquefied	225,7	32.3	17.46	-	0.6	-
	gas compressed	91,1	29.13	24,07	-	-	-
Special	gasoline	225,7	54,8	17.46	-	0.6	0.23

trucks	diesel fuel	40,4	6,8	30	3.85	5	-
	gas is liquefied	225,7	54,8	17.46	-	0.6	-
	gas compressed	91,1	29.13	24,07	-	-	-

The value of the coefficient K^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:

$$B_k^{Pb} = М_k^{пал-ет} \bullet КПВ_{jk}^i \bullet КТС_{jk}^i, \tag{3}$$

where B_k^{Pb} – quantity of lead emissions from gasoline consumed by the k-th group of motor transport of business entities; $М_k^{пал-ет}$ - 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

Groups of cars	Type of fuel	CO	C_nH_m	NO_x	solid impurities	SO_2	Pb
Freight cars	gasoline	169,8	39,2	25,8	-	0.6	0.23
	diesel fuel	32	5.65	32,8	3.85	5	-

	gas is liquefied	169,8	39,2	25,8	-	0.6	-
	gas compressed	84,2	16,29	30,8	-	-	-
Passenger buses	gasoline	177.92	42.45	24.6	-	0.6	0.23
	diesel fuel	33.2	18.15	32.38	3.85	5	-
	gas is liquefied	177.92	24,42	24.6	-	0.6	-
	gas compressed	85,2	16,29	29.86	-	-	-
Passenger cars	gasoline	177.92	24,42	24,62	-	0.6	0.5
	diesel fuel	32	5.65	32,8	3.85	5	-
	gas is liquefied	177.92	24,42	24,62	-	0.6	-
	gas compressed	84,2	16,29	30,8	-	-	-
Special cars	gasoline	177.92	39,2	24,62	-	0.6	0.5
	diesel fuel	32	5.65	32.8	3.85	5	-
	gas is liquefied	177.92	24,42	24,62	-	0.6	-
	gas compressed	84,2	16,29	30.8	-	-	-
Special cars trucks	gasoline	169,8	39,2	25,8	-	0.6	0.23
	diesel fuel	32	5.65	32.8	3.85	5	-
	gas is liquefied	169,8	39,2	25,8	-	0.6	-
	gas compressed	84,2	16,29	30.8	-	-	-

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

$$M_k^{пал-ет} = Q_k^i \cdot K_{ет}, \tag{4}$$

where

Q_k^i - total volume of gasoline used by the k-th group of motor transport of business entities, kg; $K_{ет}$ - 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

Groups of cars	Type of fuel	CO	C_nH_m	NO_x	solid impurities	SO_2	Pb
Freight cars	gasoline	1.7	1.8	0.9	-	1.0	1.0
	diesel fuel	1.5	1.4	0.95	1.8	1.0	1.0
	gas is liquefied	1.7	1.8	0.9	-	1.0	1.0
	gas compressed	1.7	1.8	0.9	-	1.0	1.0
Passenger buses	gasoline	1.7	1.8	0.9	-	1.0	1.0
	diesel fuel	1.5	1.4	0.95	1.8	1.0	1.0
	gas is liquefied	1.7	1.8	0.9	-	1.0	1.0
	gas compressed	1.7	1.8	0.9	-	1.0	1.0
Passenger cars	gasoline	1.5	1.5	0.9	-	1.0	1.0
	diesel fuel	1.5	1.4	0.95	1.8	1.0	1.0
	gas is liquefied	1.5	1.5	0.9	-	1.0	1.0
	gas compressed	1.7	1.8	0.9	-	1.0	1.0
Special cars	gasoline	1.5	1.5	0.9	-	1.0	1.0
	diesel fuel	1.5	1.4	0.95	1.8	1.0	1.0
	gas is liquefied	1.5	1.5	0.9	-	1.0	1.0

	gas compressed	1.7	1.8	0.9	-	1.0	1.0
Special trucks	gasoline	1.7	1.8	0.9	-	1.0	1.0
	diesel fuel	1.5	1.4	0.95	1.8	1.0	1.0
	gas is liquefied	1.7	1.8	0.9	-	1.0	1.0
	gas compressed	1.7	1.8	0.9	-	1.0	1.0

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:

$$Bj = Б \cdot Кj \cdot Kmj \quad , \tag{5}$$

where

B_j is the amount of emission of the j-th pollutant (except lead); Б - the volume of gasoline consumed (leaded and unleaded); $К_j$ is the average specific emission of the j-th pollutant (other than lead) for cars of individual owners with gasoline-powered internal combustion engines; $К_{mj}$ is the coefficient of influence of the technical condition of cars on the specific emissions of the j-th pollutant.

The values of $К_j$ and $К_{mj}$ are presented in Tab.3.4.

Lead emissions are determined by the formula:

$$Bj = Б \cdot Кj \cdot Kmj \cdot K_j^3 \quad , \tag{6}$$

where

B_j is the amount of lead emission; $К_{mj}$ - volume of consumed ethylated gasoline; K_j^3 - the proportion of leaded gasoline in the total amount of gasoline consumed.

Tab.3.4.

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

Name of indicators	CO	NO_x	C_nH_m	SO_2	Pb
Individual owners' cars with internal combustion engines running on gasoline in urban areas (kg / ton of fuel)	202.22	20.98	28.43	0.6	0.5
Individual owners' cars with internal combustion engines running on gasoline in the countryside (kg / ton of fuel)	177.92	22.91	24.42	0.6	0.5
Coefficient of influence of the technical condition of cars on the specific emissions of pollutants (Kt)	1.5	0.9	1.5	-	-

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:

$$Б = К_а \cdot Б_{авт} \cdot К_{ГМ} \cdot К_м, \qquad (7)$$

where

B is the annual consumption of gasoline by private transport owned by citizens in cities, towns and cities; $К_а$ - the number of privately owned cars in cities, towns and villages; $Б_{авт}$ - 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); $К_{ГМ}$- 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; $К_М$- 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, $К_а$ is made by the formula:

$$К_а = \frac{N_i \cdot K_{CA}}{1000}, \qquad (8)$$

where

K_a - the number of privately owned cars in cities, towns and villages; N_i - average annual population in cities (N_{city}), urban settlements (N_{settl}) and rural areas ($N_{village}$) according to Form No. A-1; 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_{CKA}, use the formula:

$$K_{CKA} = \frac{K_{ПА}}{N_{region}} \cdot 1000, \qquad (9)$$

where

K_{CKA} - the average number of private vehicles, per 1,000 people of the district, city of regional or republican subordination; $K_{ПА}$ - the number of private vehicles in the region, city of regional or republican subordination according to GAI; N_{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:

$$B_{заг} = \sum_{j=1}^{4} B_j, \qquad (10)$$

where $B_{заг}$ - the amount of emissions of all pollutants from motor transport, which is privately owned by the population in cities, towns and cities; 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 Q_k^i (l, ths m 3) is presented in Tab.3.5.

Tab.3.5.

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

	Q_k^i value (l, thousand m^3) by fuel type			
Type of car	gasoline	diesel fuel	liquefied petroleum gas	natural compressed gas
Passenger buses	7.83	-	-	-
Trucks	-	60.72	-	-
Passenger cars	14.92	-	8.26	37.33
Special cars	6.31	-	15.39	46.24
Special cars	-	23.61	9.94	-

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 M_k^i (kg) by the formula (2):

$$M_{\text{ПА}}^{\text{Б}} = Q_{\text{ПА}}^{\text{Б}} \cdot K^{\text{Б}} = 7{,}83 \cdot 0{,}74 = 5{,}79 \text{ кг}$$
$$M_{\text{ПЛА}}^{\text{Б}} = Q_{\text{ПЛА}}^{\text{Б}} \cdot K^{\text{Б}} = 14{,}92 \cdot 0{,}74 = 11{,}04 \text{ кг}$$
$$M_{\text{СЛА}}^{\text{Б}} = Q_{\text{СЛА}}^{\text{Б}} \cdot K^{\text{Б}} = 6{,}31 \cdot 0{,}74 = 4{,}67 \text{ кг}$$
$$M_{\text{ВА}}^{\text{ДП}} = Q_{\text{ВА}}^{\text{ДП}} \cdot K^{\text{ДП}} = 60{,}72 \cdot 0{,}85 = 51{,}61$$
$$M_{\text{СНА}}^{\text{ДП}} = Q_{\text{СНА}}^{\text{ДП}} \cdot K^{\text{ДП}} = 23{,}61 \cdot 0{,}85 = 20{,}07 \text{ кг}$$
$$M_{\text{ПЛА}}^{\text{ЗНГ}} = Q_{\text{ПЛА}}^{\text{ЗНГ}} \cdot K^{\text{ЗНГ}} = 8{,}26 \cdot 0{,}55 = 4{,}54 \text{ кг}$$
$$M_{\text{СЛА}}^{\text{ЗНГ}} = Q_{\text{СЛА}}^{\text{ЗНГ}} \cdot K^{\text{ЗНГ}} = 15{,}39 \cdot 0{,}55 = 8{,}47 \text{ кг}$$
$$M_{\text{СНА}}^{\text{ЗНГ}} = Q_{\text{СНА}}^{\text{ЗНГ}} \cdot K^{\text{ЗНГ}} = 9{,}94 \cdot 0{,}55 = 5{,}47 \text{ кг}$$
$$M_{\text{ПЛА}}^{\text{ПСГ}} = Q_{\text{ПЛА}}^{\text{ПСГ}} \cdot K^{\text{ПСГ}} = 37{,}33 \cdot 0{,}59 = 22{,}03 \text{ кг}$$
$$M_{\text{СЛА}}^{\text{ПСГ}} = Q_{\text{С ЛА}}^{\text{ПСГ}} \cdot K^{\text{ПСГ}} = 46{,}24 \cdot 0{,}59 = 27{,}28 \text{ кг}$$

The results of the calculation are presented in Tab.3.6.

Tab.3.6.

Volume of fuel consumed by groups of cars

	Quantity (kg) by fuel type			
Type of car	gasoline	diesel fuel	liquefied petroleum gas	natural gas
Passenger buses	5.79	-	-	-
Trucks	-	51.61	-	-
Passenger Cars	11.04	-	4.54	22.03
Special trucks	4.67	-	8.47	27.28
Special cars	-	20.07	5.47	-

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

$$B_{CO}^{Б} = M_{ПА}^{Б} \cdot КПВ_{CO}^{Б} \cdot КТС_{CO}^{Б} = (5,79 \cdot 233,0 \cdot 1,7) \cdot 10^{-3} = 2,29 \ tons;$$

$$B_{C_nH_m}^{Б} = M_{ПА}^{Б} \cdot КПВ_{C_nH_m}^{Б} \cdot КТС_{C_nH_m}^{Б} = (5,79 \cdot 56,9 \cdot 1,8) \cdot 10^{-3} = 0,593 \ tons;$$

$$B_{NO_x}^{Б} = M_{NO_x}^{Б} \cdot КПВ_{NO_x}^{Б} \cdot КТС_{NO_x}^{Б} = (5,79 \cdot 16,37 \cdot 0,9) \cdot 10^{-3} = 0,085 \ tons;$$

$$B_{SO_x}^{Б} = M_{SO_x}^{Б} \cdot КПВ_{SO_x}^{Б} \cdot КТС_{SO_x}^{Б} = (5,79 \cdot 0,6 \cdot 1,0) \cdot 10^{-3} = 0,004 \ tons.$$

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

Tab.3.7.

Emissions of pollutants by fuel type

Type of fuel	The amount of pollutant released into the atmosphere (tons)				
	CO	CnHm	NOx	solid impurities	SO2
gasoline	7,611	1,354	0,332	-	0,014
diesel fuel	4,346	0,682	2,042	0,497	0,358
liquefied petroleum gas	6,504	1,17	0,29	-	0,011

natural gas	7,637	2,585	1,068	-	-

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.

Tab.3.8.

Emissions of contaminants by groups cars

Type of car	Type of fuel	The magnitude of the emission of the j-th pollutant and B_{jk} (tons) into the air				
Passenger buses	gasoline	CO	C_nH_m	NO_x	solid impurities	SO_2
Passenger buses	gasoline	2,29	0,593	0,085	-	0,004
Trucks	diesel fuel	3,13	0,491	1,47	0,358	0,258
Passenger Cars	gasoline	3,74	0,535	0,174	-	0,007
	liquefied petroleum gas	1,537	0,22	0,071	-	0,003
	natural gas	3,412	1,155	0,477	-	-
Special trucks	gasoline	1,581	0,226	0,073	-	0,003
	liquefied petroleum gas	2,868	0,41	0,133	-	0,005
	natural gas	4,225	0,191	0,591	-	-
Special cars	diesel fuel	1,216	0,54	0,572	0,139	0,1
	liquefied petroleum gas	2,099	0,36	0,086	-	0,003
All across car groups and types of fuel		26,1	5,791	3,732	0,497	0,383

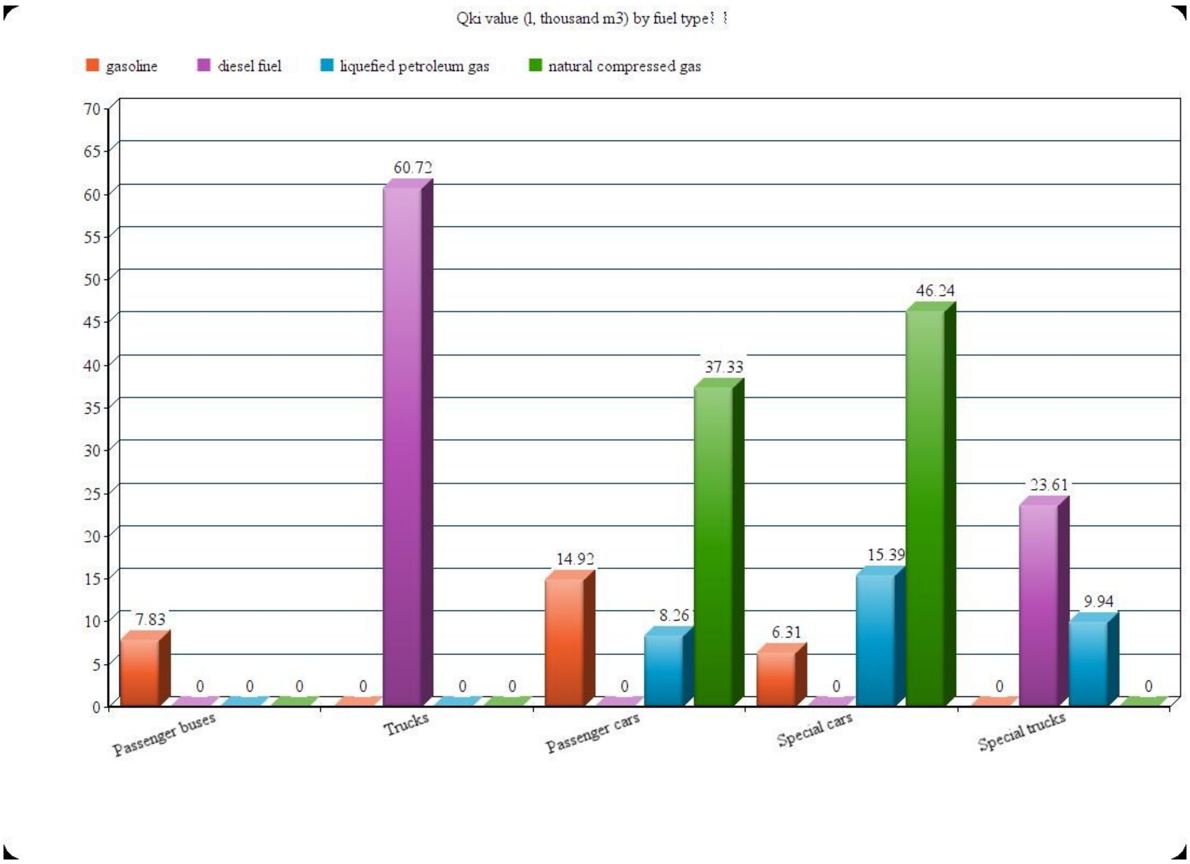


Fig. 3.1. The amount of fuel consumed by the transport group

On the fig.3.1. we can see what volume of fuels were used by different types of transport.

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).

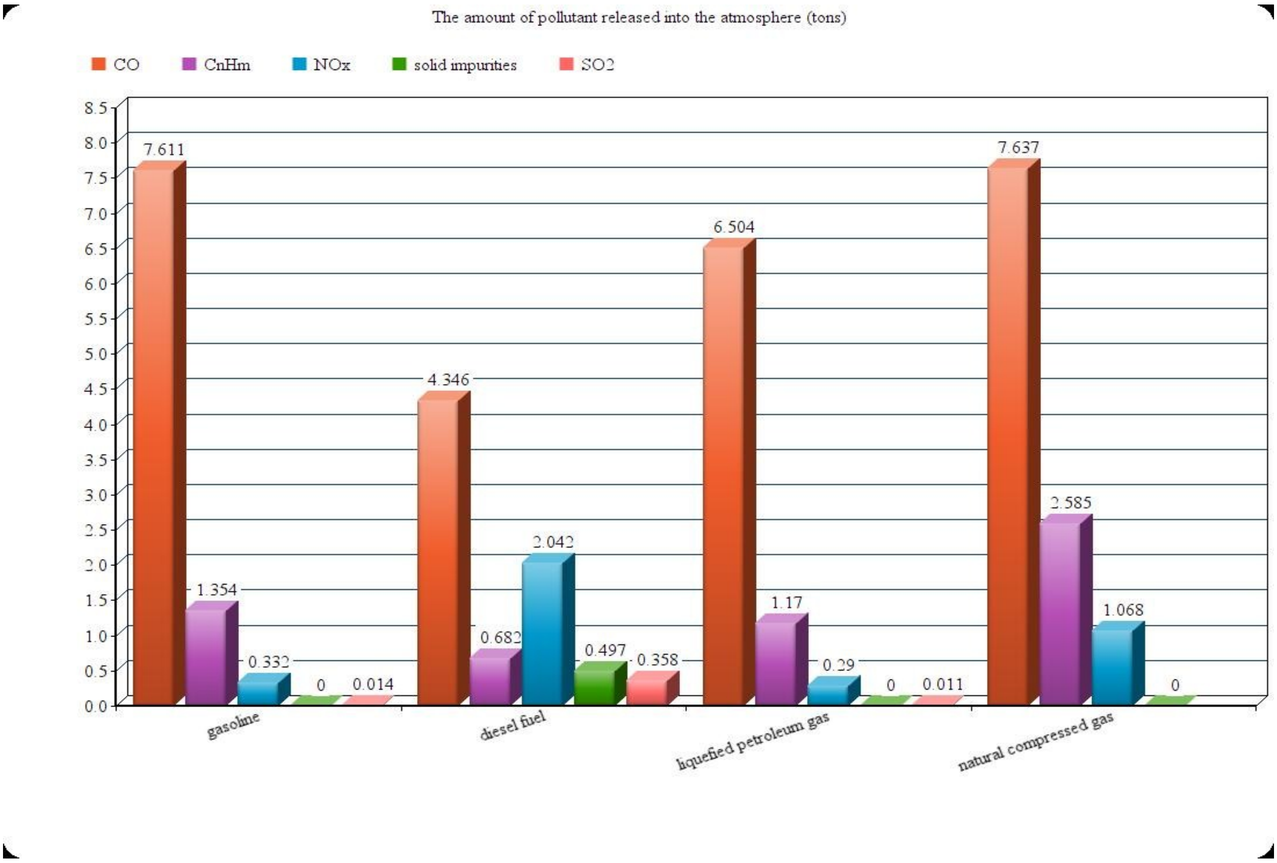


Fig. 3.2. Emissions of pollutants by fuel type

3.2. Improvement of operational ecological characteristics of vehicle gasolins by using surface-active additives and antioxidants

Today, a number of additives are used to improve the environmental performance of gasoline different functional purpose. All modern gasoline contains a package of additives, the content of which ranges from 0.01 to 1.0%. The largest manufacturers of additives are: BASF, Lubrizol, Infineum (controlled by Shell / Exxon), Oronite (controlled by Chevron) and Ethyl (now Afton). In total they owns more than 90% of the global additive market.

Today, several types of additives are commonly used in fuels:

- anti-knock additives;
- detergents (detergents);
- dispersants (dispersants);
- anti-wear additives;

• oxidation inhibitors (antioxidant additives);
• corrosion inhibitors;
• modifiers of combustion processes;
• multifunctional additives.

It is known that engine oils when the engine is running internal combustion are exposed to high temperatures and pressure, contact with oxygen of air and with various metals; resulting in hydrocarbon fuels undergoing oxidation, condensation and decomposition processes.

This creates carbonate deposits, asphalt-resinous substances, carbenes and carbides, acids and more. Settling on engine parts in the form of deposits, varnish and sludge, they change initial fuel characteristics and worsening conditions of the engine. The main purpose of dispersing agents additives are to prevent the deposition of these substances, to ensure the mobility of the piston rings and normal engine operation [8].

The analysis of the literature showed the feasibility of developing a multifunctional additive for hydrocarbon fuels, the use of which is not would impair their physico-chemical characteristics, as well as positively affect the environmental friendliness of vehicles (reducing CO, CO2, CxNu and NOx emissions).

In this work we estimated how such surface-active component as 4,4′-Dioctyl diphenylamine ($C_{28}H_{43}N$) and antioxidant as Nonylphenol ($C_{15}H_{24}O$) works as fuel additives and how they change fuel properties.

It is known that low-octane gasoline has a short reaction time and is more oxidized under such conditions, giving a high temperature and amount of heat, while high-octane gas, on the contrary, has a longer reaction time and a lower temperature.

But the use of additives 1 and 2, as shown in the Tab.3.9, slightly increases the octane number of gasoline, as evidenced by increasing the reaction time of cold flame oxidation and reducing the maximum reaction temperature allowing them to be used in commercial gasoline.

Tab.3.9.

Comparative data of thermostability of different antioxidants chemical classes

№	Name of compound	Temperatures at which relative weight loss occurs, ° C	
		10% loss	50% loss
1	4,4´-Dioctyl diphenylamine	110	140
2	Nonylphenol	205	290

Also we can see that there is a relationship between the induction period and the thermal stability of the antioxidant used. The greatest period of induction and reduction of the temperature of the reaction of cold flame oxidation (and reduction of the amount of heat released during oxidation) was achieved when used as an antioxidant 4,4′-Dioctyl diphenylamine, which is a common industrial product and is successfully used, in particular, for improvement properties of motor oils.

Ionol is a colorless, crystalline substance that is easily distillable. It is readily soluble in acetone, and ethanol, hydrocarbons, benzene, esters, non-toxic.

Since the developed detergent-additive contains in its composition Oxygen, it is important to study its effect on knock resistance of fuel. The results of determining the octane number of gasoline A-80 when it contains different concentrations of additives are given in tab.3.10.

Tab.3.10.

The results of determining the octane number of gasoline when it contains different concentrations of additives

Contamination of additive	Octane number
0	77.4
0.01	78.1
0.05	78.9
0.1	79.2
0.15	79.3

This additive improves the anti-knock properties of gasoline. Increasing the octane number indicates an improvement in technical and economic performance engine and increase its power.

Tab.3.11.

The results test of gasoline engine when working on gasoline A-80 with and without additive

Parameter	Contamination of additive in gasoline		
	0%	0.01%	0.05%
CO, %	4,12	3,96	3,82
CO_2, %	15,83	15,45	15,31
C_xH_y, pm	620	602	596
NO_x, ppm	2576	2 307	1960

The results of our measurements in the table confirm the prospect of using this impurity to reduce the toxicity of the flue gas. Depending on the test mode, the concentration of CO decreases in on average by 4-10% and CO_2 by 1.5 - 3%. In turn, total hydrocarbon emissions are also reduced by 3-6%. Such an effect can be explained by the increase in the completeness of combustion of gasoline when used detergent-dispersing additives. Also installed, that the NO_x content is reduced by 8-24%, with the maximum effect achieved when testing the engine at partial load and impurity concentration of 0.05% by volume.

3.3. Estimation of oxygenated gasoline properties

The use of various oxygen-containing additives (alcohols, ethers) as anti-detonators has several advantages. Of the various anti-knock detergents, the most effective, affordable and environmentally friendly are alcohols, in particular ethyl alcohol. Ethanol additives can reduce the amount of carbon monoxide and nitrogen emissions and carcinogenic compounds several times. That is, in order to improve environmental and energy security in Ukraine, the problem of transferring vehicles to use ethanol motor fuel from their own renewable raw materials is urgent.

1. Corrosive activity of ethanol-containing fuel

Ethanol aggressively affects zinc, brass, lead, aluminium, steel, lead and tin alloy, lead-based solder. The corrosive effect of gasoline leads not only to the rapid deterioration of pipelines, tanks, fuel tanks, but also to the contamination of gasoline by corrosion products in the form of mechanical impurities.

Corrosion can be slowed down or virtually stopped by the introduction of inhibitors into the environment. Protective inhibitory films may occur with the introduction of amines, amino alcohols, certain acids and nitro compounds into gasoline.

2. Phase instability of ethanol-containing fuel

Ethanol is mixed with water in any ratio, but the presence of the latter in alcohol-containing gasoline is the cause of phase separation. The problem of phase separation of gasoline-alcohol mixtures is not eliminated even when using absolute ethyl alcohols. Under real conditions of storage and transportation of gasoline-alcohol fuel, its inevitably watering through the ingress of water into the fuel during storage, transportation and operation. As stabilizers of gasoline-alcohol mixtures it is proposed to use aliphatic alcohols C3-C12 of normal and isobody, alkyl acetates, ethers and esters and their alkyl carbonates, carboxylic acids and mixtures of the above compounds. Another solution to the problem of destabilization of gasoline-alcohol mixtures is the use of 2-furylcarbinol as a stabilizer. The advantages of this substance are that it is made from furfural, which, in turn, is obtained from vegetable raw materials - corn cobs or sugar cane processing waste.

The study of the stabilizing properties of 2-furylcarbinol was carried out on ethyl alcohol at a concentration of ω = 89,02% wt. From the data shown in Fig. 1 we can conclude that when using 2-furylcarbinol as a stabilizer there is no need to carry out the absolutization of ethyl alcohol when used as a fuel.

3. Higher heat of evaporation of ethanol-containing fuel

High evaporation heat creates great difficulty when starting the engine. For ethanol, the lower evaporation limit is minus 15 ° C. Below this temperature, the vapour of the fuel is not sufficient to form an easily flammable mixture. Petrol, unlike alcohols, have sufficient evaporation to allow the engine to start at relatively low temperatures (minus 22 ° C). Improvement of cold start is possible due to structural changes of installation of "block of heating", and also use of fuels of the appropriate quality and special starting substances. The simplest and most economical for improving cold start is the introduction of volatile components into the fuel: butane, isopentane, gas gasoline, saturated vapour pressure is 350, 125 and 152 kPa respectively. However, from an environmental point of view, this method is undesirable even in winter, because at any time it can lead to the formation of steam plugs in the fuel system. The practical benefits of starting the engine quickly can be given by starting mixtures injected into the fuel line by means of special instruments or by aerosol cans on the air filter.

As we can see on fig.3.3., the environmental properties of gasoline depends not only on fuel additive but also on engine type.

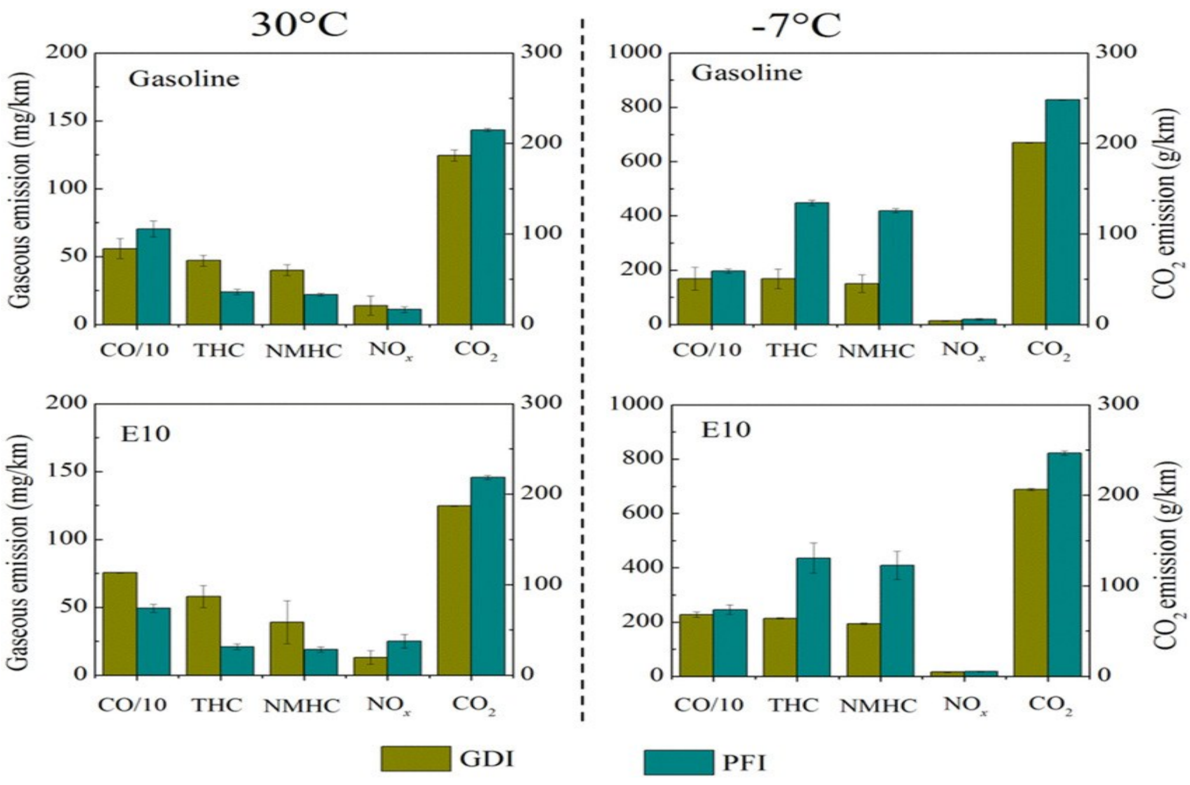


Fig. 3.3. Gaseous emissions from the GDI and PFI vehicles with gasoline and E10 in the cold-start tests

3.4. 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).

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.

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.

The results of theoretical and experimental studies confirm the feasibility development and application of multifunctional additives for gasoline based on surface-active additives and antioxidants. In the course of the work the influence was investigated different oxidation inhibitors in the composition of additives to fuels and revealed the maximum positive effect on fuel performance when applied 4,4′-Dioctyl diphenylamine as an antioxidant.

It is hypothesized that the effect of an antioxidant on the process of combustion of gasoline depends on its thermostability and have been found to be more effective antioxidants that remain stable at temperatures above 250 °C.

While consider Nonylphenol on the test mode, the concentration of CO decreases in on average by 4-10% and CO_2 by 1.5 - 3%. In turn, total hydrocarbon emissions are also reduced by 3-6%. Such an effect can be explained by the increase in the completeness of combustion of gasoline when used detergent-dispersing additives. Also installed, that the NO_x content is reduced by 8-24%, with the maximum effect achieved when testing the engine at partial load and impurity concentration of 0.05% by volume.

As we can see, the environmental properties of gasoline depends not only on fuel additive but also on engine type.

CHAPTER 4
LABOR PRECAUTION

4.1. Introduction

As the topic of the diploma thesis is devoted to the issues of the working in laboratory with hazardous substances as gasoline, therefore, in the chapter on labor precaution it is necessary to investigate the impact of dangerous factors on a petrochemical expert during laboratory research.

4.2. Analysis of working conditions of petrochemical expert

4.2.1. Organization of the working place of 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 [23], 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, Order 'On approval of the Rules of labor protection during work in chemical laboratories" provides the norms according to the Code of Civil Protection of Ukraine [27] 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 [24]
- 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.

4.2.2. Hazardous and harmful production factors on the working place

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 [23]. 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.

4.2.3. Analysis of harmful and dangerous factors

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» [26]. According to maximum permissible concentration (MPC) classification [28], laboratory work of expert may be deemed harmful of the IV category due to the possible contact with cancerogenic substance as gasoline.

Tab.4.1.

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

№	Name of substances	MPC mg/3	Class of danger	Aggregate state	Peculiarities of influence on human
1	Gasoline	100	V	Vapor	Carcinogen

Still, in case of adherence to the set of working place chemical safety rules, the working conditions may be complying 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).

4.2.4. The microclimate and ventilation of working area

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 4.2 [23].

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 [25] 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.

Tab.4.2.

Optimal and permissible microclimate parameters values for category IIb premises

Season	**Microclimate parameters**	**Optimal value**	**Permissible value**	**Actual value**
Cold	Room temperature	19-21 ^oC	15-23 ^oC	13-18 ^oC
	Relative humidity	60-40 %	Up to 75 %	55%
	Room's air velocity	0.2 m/s	<0.3 m/s	–
Warm	Room temperature	21-23 ^oC	17-27 ^oC	22-27 ^oC
	Relative humidity	60-40 %	65 if t=26 ^oC	60%

	Room’s air velocity	0.3 m/s	0.4-0.2 m/s	–

4.3. 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.

4.4. Fire safety

The category of the laboratory room is B “Explosive fire hazard” in accordance with State Standard DSTU B V.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 the Model Standards for the use of fire extinguishers, approved by the order of the Ministry of Emergencies and Affairs of Population General technical requirements, 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 (NAPB Б.01.008-2018), and their maintenance - in accordance with the requirements of DSTU 4297: 2004 "Fire Engineering. Maintenance of fire extinguishers. General technical requirements ".

4.5. Conclusions to Chapter 4

Therefore, after the completion of labor precaution chapter of diploma, we can conclude that the working place of the 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 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.

CONCLUSION

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). 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.

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.

To curb the trend, the EU is introducing new CO_2 emission targets, which aim to cut harmful emissions from new cars and vans. CO_2 emissions from passenger transport vary significantly depending on the transport mode. Passenger cars are a major polluter, accounting for 60.7% of total CO_2 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_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.

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 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.

The results of theoretical and experimental studies confirm the feasibility development and application of multifunctional additives for gasoline based on surface-active additives and antioxidants. In the course of the work the influence was investigated different oxidation inhibitors in the composition of additives to fuels and revealed the maximum positive effect on fuel performance when applied 4,4′-Dioctyl diphenylamine as an antioxidant.

It is hypothesized that the effect of an antioxidant on the process of combustion of gasoline depends on its thermostability and have been found to be more effective antioxidants that remain stable at temperatures above 250 °C.

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As we can see, ecological properties of fuel depend not only on fuel type but also on different factors, such as:

1. How it is regulated on government level, by standards accepted in country.
2. Air\Fuel ration that determines vehicle capacity. Because different types of emissions produces during different phases of burning and load.
3. Also important place takes engine type. As it was estimated, Gasoline Direct Injection engines are more economic and ecologically safe but needs more qualitive fuels.
4. The other component that determines fuel ecological properties and its quality is the contamination of different gasoline additives.
5. Also, according to calculation, the contamination of burned gases depends on vehicle technical condition.

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