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Correlation Between Effective-Equivalent Kilometres and Average Fuel - Lubricant Consumption of Road Motor Vehicles: Correction Coefficients and their Application

[1] Gheorghe Neamțu, [2] Marinela Ință, [3] Ioan Țincu

[1] Ph. D. Engineer, Associate Professor at "Lucian Blaga" University of Sibiu, 10 Victoriei Street, Sibiu, Romania
[2] Ph. D. Engineer, Lecturer at "Lucian Blaga" University of Sibiu, 10 Victoriei Street, Sibiu, Romania
[3] Ph. D. Mathematician, Lecturer at "Lucian Blaga" University of Sibiu, 10 Victoriei Street, Sibiu, Romania

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Abstract

The monitoring of the standardised consumption of motor fuels and lubricants for each car and driver is obligatory for all units having their own fleet of road vehicles. In order to comply with the standardised consumption of motor fuels and lubricants, it is necessary to continuously monitor them at all levels and to deal with any deviations of any kind that lead to excessive consumption with the maximum exigency. The scientific paper presents in a concrete and elegant way a point of view of the authors, presented with the aim of highlighting the documents and devices that manage the effective, real kilometres travelled, but also the correlation between the effective-equivalent kilometres travelled and the average fuel - lubricant consumption of road vehicles. The most important correction coefficients (surcharges) are presented here, and in the case study we provide concrete, relevant examples of how the mathematical calculation of fuel consumption for passenger cars, trucks, lorries, special car and crawler construction machines. At the end of the scientific article, the conclusions in the field are presented.

Keywords: Roadmap, Tachograph, Tachograph Card, Effective Distance Travelled, Equivalent Distance Travelled, Kilometres, Standard Fuel Consumption

1. Introduction

For the most judicious management and the most efficient use of engine fuels and lubricants, it is necessary to standardise their consumption, taking into account all the factors influencing consumption and to establish some maximum limits for their level. Among the most important factors to be taken into account when normalising fuel and oil consumption are: for each type of engine 3 measurements should be carried out, as far as possible with different engines of the same type; the time for one measurement: 50 minutes (1 teaching hour); the engine speed and operating regime should be that normally used in workshop practice. The resulting average fuel consumption "Cmd" is calculated as the arithmetic average of the three measurements. In order to monitor the daily consumption and to determine the remainder in the tanks, when new cars are put into service or when they come out of repair, as well as at the beginning of the decade, refuelling shall be carried out until the tank is full. The approval for fuelling of motor vehicles with fuel and engine lubricants shall be given on the waybill by the person designated by the head of the unit by written decision. As a rule, this person must be the head of the motor pool (transport formation) or the employee in charge of monitoring fuel and oil consumption in the motor vehicles belonging to the motor pool in question. But in order to ensure that the vehicle's actual distance travelled (effective kilometres) is in line with the regulations, the vehicle's actual distance travelled (equivalent kilometres) must be corrected by the appropriate correction coefficients to obtain the equivalent distance travelled (equivalent kilometres). Fuel distributors shall dispense motor fuel or lubricants only within the limits of the quantities and assortments approved on the waybill and only if the approval is given by persons designated by decision of the head of the unit. For this purpose it is necessary to provide the fuel distributor with a table of specimen signatures of the persons authorised to approve the fuel and oil supplies. In the case of cars where the capacity of the fuel tank does not ensure the journey to the destination and back (usually intercity transport), the refuelling approvals are granted as follows: the standard fuel consumption for the journey to be made is calculated, taking into account a 10% safety margin required for unforeseen situations; the “full” approval is given on the waybill, which represents the right to fill the car's tank to capacity; the difference in quantity between the total journey requirements (including the safety margin) and the tank capacity is approved in fixed quantity tickets (BCF). In the case of cars carrying out transport operations for which the consumption requirements, on a waybill, do not exceed the capacity of the tank (as a rule for local transport), the approval for refuelling is granted, depending on the activity carried out with the last waybill. At the decade (10th, 20th) and at the end of the month (30th or 31st), in order to accurately determine the amount of fuel left in the tank, the cars are refuelled by filling the tank and the approval ‘full’ is given on the waybill for the above dates. Engine oil fuelling approvals for combustion shall be granted on the basis of the equivalent journey since the last fuelling and the specific normalised consumption for combustion, after prior checking of the level in the crankcase or in the engine oil tank. Fuel supply approvals for the replacement of used oil in the engine lubrication system are granted according to the replacement intervals stipulated in the vehicle maintenance and repair regulations, the approved quantity being determined on the basis of the capacity of the lubrication system as stipulated in Table 2.1 of the Automotive Fuel and Oil Consumption Normative [7], as well as in the technical books of the cars concerned. In the case of motor oil or gasoline with an octane number higher than CO/R 75, the quantity approved on the road log shall be accompanied by the specification of the assortment. The analysis of fuel consumption is carried out on a decadal and monthly basis with the aim of detecting cases of exceeding the normalised consumption or unjustified savings, establishing the causes and eliminating them, while taking legal measures against the possible guilty parties.

Company data:				Issuing unit stamp Date of issue...............			
Car category used vehicle		No. of immatriculare	Fuel Tip	Own consumption norm (litres/100 km)		Driver first and last name	
A B C D		....	Diesel/ Gasoline	....		....	
ROAD MAP							
Series....No......							
Initial date and km		Route		Place of displacement	Purpose of the displacement	No. and km traveled	Consumption
Date	Initial km	Departure	Arrival				
Total liters consumed			Total km traveled:				
Costs/l			Total costs:				
Initial Km beginning of the month 0			Initial km end of the month:				
Month:							
Edit, Driver:							

Fig 1: Model Roadmap (journey form) in Romania for vehicles (trucks, lorries, special trucks) [2]

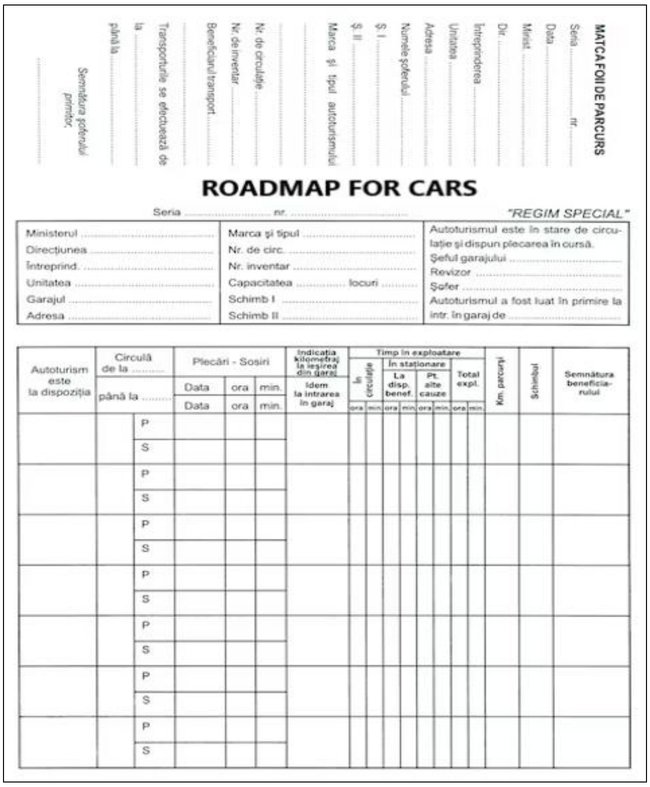

Fig 2: Model Roadmap (journey form) in Romania for cars [2]

2. Documents and devices managing the effective - equivalent kilometres for the normalised consumption of fuel and lubricants at the road motor vehicles

2.1 The roadmap (journey form)

It is a document can be described as a necessary and obligatory act in the field of transport. If there are road police checks, this document will be checked.

According to Art. 27, paragraph 2, letter b of the Regulation implementing the Emergency Ordinance of the Government of Romania no 195/2002 on traffic on public roads of October 4, 2006 [1], vehicle owners or transport operators are obliged to issue a waybill or service order for vehicles in transit. Fig 1 shows a model of the roadmap used by Romanian transporters.

This requirement makes the roadmap (journey form) necessary for several important reasons [2]:

- respond to any checks carried out by the traffic police;
- organize accounting and fiscal records of actual fuel consumption (based on distance travelled);
- demonstrate that the vehicle is used exclusively for commercial purposes.

It is the responsibility of the roadmap firm or company operating in this field to fill in the road transport operators' waybill.

The roadmap (journey form) can also create effects in:

- *labor protection* – the roadmap (journey form) form shall contain details of the technical condition of the vehicles used to carry out a transport operation;
- *taxation* – roadmaps (journey forms) are documents that can be used to obtain deductions of up to 50% or even 100% of the cost of the vehicle used for transportation;
- *movement of road vehicles or persons* – the roadmap (journey form) may be used as an alternative to the travel order. The driver may present it to traffic officers in such a way that he cannot be penalized for the transport activity carried out;

- *justice* – they are documents that can be used as evidence in court, should the company become involved in lawsuits;
- *accounting* – the roadmap (journey form) is a supporting document, useful for drawing up the compulsory accounting reports.

The Romanian Tax Code obliges transport operators to have this document. The document justifies the expenses and the value added tax related to the expenses directly attributed to the vehicles. In addition, it indicates the exact route of the vehicles and in this way it can be compared with fuel consumption.

This document contains relevant information about the journey on which the driver is starting and the car in which he is leaving.

Some examples of past information are:

- company name;
- vehicle registration number, make;
- vehicle category;
- date and time of dispatch and arrival/departure, date/time;
- period to which it refers;
- kilometers at departure and arrival;
- the period the vehicle was on the move, etc..

For passenger cars, in Romania, the model of the roadmap (journey form) shown in Fig 2 can also be used.

2.2 The tachograph

The tachograph is a device about the size of an ordinary radio intended to be mounted on a motor vehicle for the purpose of automatically displaying and writing down data relating to the journey and working time of each driver. As of January 1, 2007, the fitting installation of digital tachographs became mandatory for all vehicles registered for the first time.

The tachograph stores the following data:

- date and registration number of the vehicle;
- vehicle speed in kilometers per hour (for the last 24 hours of driving);
- a single or co-driver;
- how frequently a driver card is inserted each day;
- distance traveled by the driver in kilometers - reads the vehicle odometer when the card is inserted and removed;
- driver activity - driving, rest, breaks, other activities, periods of availability;
- date and time of change of activity;
- events (e.g. driving without a driver card, speeding, attempted fraud, etc.);
- achograph system malfunctions;
- egality checks;
- details about tachograph calibration;
- fraudulent manipulation of the system.

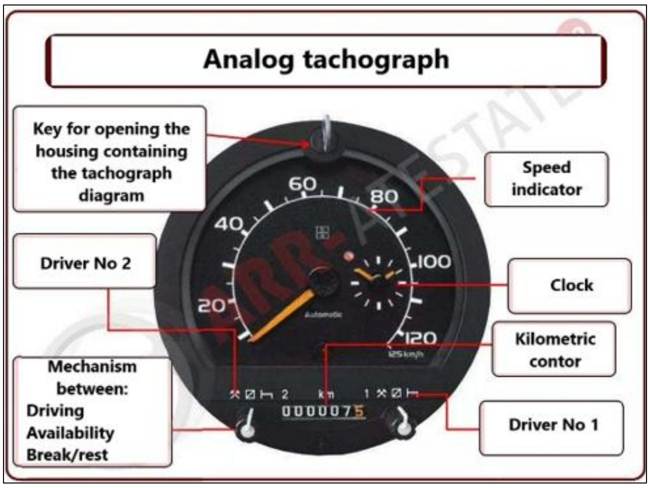

Fig 3: Mechanical or analog tachograph

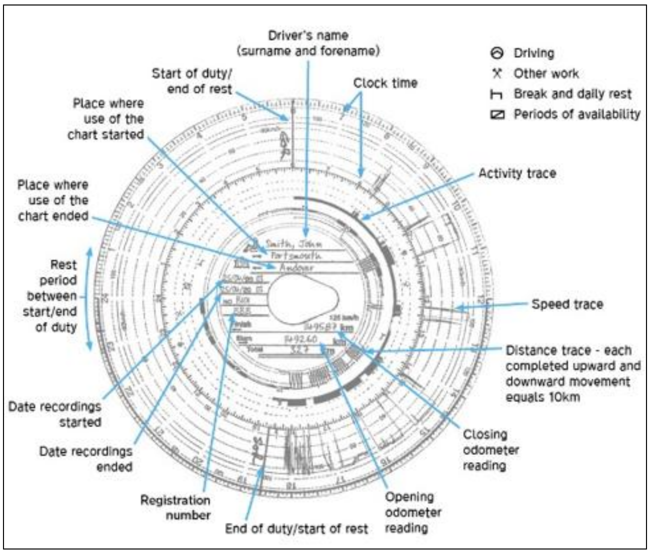

Fig 4: Analog tachograph diagram [8]

Types of tachographs:

a) Mechanical or analog tachographs (Fig 3) which uses a mechanical gear system to transfer information from the gearbox. Uses paper disks (Fig 4) to record information, where activities are marked by mechanical writing on them. These types of tachographs first went into production in the 1970s and 1980s and were gradually replaced by electronic tachographs and then by digital tachographs due to the fact that speed limitation systems cannot be fitted to the electronic and analog models.

b) Electronic tachograph (Fig 5) which make the transfer from the pulser to the tachograph via an electrical cable. The pulser generates regular pulses which are translated by the machine's motherboard and transformed into data. The analog tachographs to be fitted on motor vehicles is the model 1311, the digital ones used since 1984 are the model 1314 and have a similar design to the analog ones. At the present time, the most common tachograph with working time recording is the 1318 tachograph.

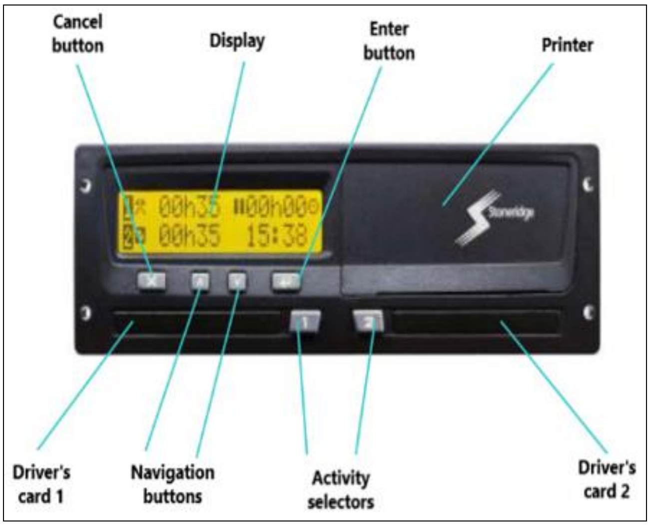

Fig 6: Digital tachograph [2]

c) Digital tachograph (Fig 6) which combines the characteristics of a clock with those of a speedometer and is connected to the engine to record speed and determine whether the vehicle is stationary or moving. This type of tachograph allows important information to be stored in the internal memory for driver safety and to prevent long periods of driving without rest. The information stored in the tachograph's internal memory has to be downloaded periodically by drivers so that the data can be analyzed to determine whether the regulations in force have been complied with. Detailed reports are issued after data analysis. For data management, the digital tachograph requires special software and special devices are also needed for downloading. In addition, the tachograph can also be used to read information stored on the driver card.
Although it is not mandatory to retrofit vehicles equipped with an analog tachograph with a digital tachograph, those registered for the first time must, according to European Regulations, be equipped with a digital tachograph model.
Romanian Road Authority [3] is the only one in a position to regulate the use of tachographs in Romania and to determine the type of tachograph suitable for replacing analog tachographs that do not work properly.

Storing and downloading data: The information recorded on the tachograph must be kept on the internal memory or in copies of the data for a period of at least one year, which is necessary in case of inspection by the control authorities.
The data recorded by the tachograph is used to check compliance with DHL, which stands for Driver's Hours Law, or Driving and Rest Time. They must comply with the Working Time Directive or WTD (Working Time Directive) in force throughout the European Union (Directive 92/104/EC, amended by Directive 2000/34/EC) [4, pp. 41-45] and which contains a collection of regulations on working time, i.e. the period during which drivers can drive continuously without affecting their health or safety.
According to it, the maximum length of a working week is at 48 hours in 7 days and the minimum rest period at 24 hours is 11 hours. The system warns 15 minutes before reaching the legal uninterrupted driving time of 4.5 hours. It also warns of a system malfunction, a power supply problem or abnormal operation detected by the equipment, which may be the result of a fraud attempt. Warnings are visual (flashing light). Some systems may also have audible warnings. The display shows you the cause of the warning until you acknowledge it. Visual warnings are clearly visible day and night. Visual warnings will remain pending on the display until acknowledged by the driver (normally by pressing the ”OK” or “Return” button, depending on the type of tachograph fitted to the vehicle. Each warning or error message must be acknowledged individually.
According to Council Regulation No 2135/98 of September 24, 1998 amending Regulation 3821/85 it is compulsory, in the European Union, to use digital tachographs digital tachographs whose technical specifications are specified in Regulation (EC) No 1360/2002 [5, pp. 1-252].
The legislation in force obliges drivers to provide the data recorded by the tachograph and stored on the driver card to be read once every 28 days. Even after reading, data must be kept for at least one year in case of inspection. The data on the digital tachograph must be fully downloaded every three months. Digital tachographs are designed to store approximately 365 days of data, and when its memory is full, the oldest data is overwritten.
Transport companies are obliged to make copies of the data stored on the digital tachographs of each vehicle, and the tachographs themselves must be checked every 2 years by specialized service authorized for this type of activity. It is forbidden to operate the tachograph while the vehicle is moving.

The tachograph cards: The tachograph card is the card issued in Romania and recognized in all EU countries. The card is issued by Romanian Road Authority (ARR) and can be of several types: control, driver, service or company. These cards function as a complementary part of the tachograph and contain more information such as personal data of the driver and the car, data on the car's operation and the driver's activity.

They can be [5, pp. 1-252]:

- ***Driver tachograph card,*** (Figure 7 a), is a white card, valid for 5 years, which is the property of the driver and is not transferable. The data on this card is loaded manually by the driver using the tachograph. This type of card can store information for 28 days of activity, with up to 93 activity changes per day;

Fig. 7 a) **Fig. 7 b)** **Fig. 7 c)** **Fig. 7 d)**

Fig 7

- ***Service tachograph card,*** (Figure 7 b), is a red colored card, valid for one year, used by workshop specialists, each set with a PIN that locks the card if it is inserted incorrectly 5 consecutive times. This type of card is used for activation, mounting or saving data;
- ***Tachograph card of the transport operator (company),*** (Figure 7 c), is a yellow color card valid for 5 years

which allows blocking and downloading of carrier specific data;

- ***Tachograph card control authority,*** (Figure 7 d), is the card of the control authority which has a blue color, is valid for 2 years and is issued to the authorized control bodies for the purpose of reading and verifying the data recorded by the tachograph.

3. Main factors influencing average fuel consumption of road motor vehicles

Among the most important factors to be taken into account when standardizing the consumption of fuel and lubricants for engines are:

- technical consumer characteristics of cars;
- the category and condition of the road they are traveling on;
- difficulties of the route/itinerary (ramps, curves or narrow road surface);
- he size of the journey and the conditions in which it is carried out (road category, towing trailers, traffic in urban areas, use of special equipment in cars, etc.);
- the degree to which the cars are loaded with goods or material goods;
- seasonal conditions (cold, frost, snow and/or ice);
- the operating conditions of the vehicle (technical condition of the vehicle, state of maintenance of the vehicle, how the vehicle is used, how the vehicle is driven, variable engine operating regime, operation in the presence of vibrations and vibrations, operation in environments with mechanical impurities leading to clogging of air filters, variation in ambient temperature, etc.);
- frequent use of air conditioning;
- the aerodynamic coefficient of the vehicle (Ra), determined by the air friction of the outside of the cab and bodywork of road vehicles in their dynamics.

4. Standard fuel consumption of road motor vehicles

By definition, fuel consumption is the maximum permissible amount of petrol, diesel, liquefied petroleum gas (LPG) or biofuel that can be consumed by a vehicle propelled by a heat engine over a specified distance (usually 1,000 m) on a given route, taking into account the specific operating conditions, road category and environmental conditions. A vehicle's fuel consumption is conditioned by its technical characteristics, equipment and the environment in which it is used. The requirements for the type-approval of road vehicles have gradually become more delimiting, with the incorporation and subsequent revision of the Euro pollution standards [6, p. 189].

When calculating the standard consumption of fuels and lubricants for the engines of road motor vehicles and for stationary power-driven equipment (generating sets, motor pumps, cranes, excavators, motor mowers, motor hoes, snow chains, engines driving various machines, etc.), the average standard consumption of fuels and lubricants for each type of vehicle or equipment, corrected by additional factors (correction coefficients for actual mileage) specific to the actual operating conditions, shall be used.

Under a different definition, according to the literature, the standard fuel consumption, ***CC***, is the maximum amount of fuel allowed to be consumed by a road motor vehicle, a machine, a heat engine-driven unit, or a piece of equipment for the journey and/or type of operation, depending on the specific operating conditions. This quantity of motor fuels is determined at the expiry of the validity or exhaustion of the headings under which the journeys (runs) made by motor vehicles are recorded, or at the end of the journey on a route, and represents the product of the distance travelled, expressed in kilometers, the average fuel consumption, ***Cm*** and, where appropriate, its correction coefficients.

For equipment, aggregates or machinery for which the average normalized average fuel consumption of engines is expressed in operating hours (as a rule for heat engines fitted to static vehicles/gear/aggregates, which do not have a journey path and which operate on the spot), the normalized fuel consumption of fuels consumed in operation shall be the product of this, the operating time expressed in hours and, where appropriate, the correction factors.

- The normalized fuel consumption of a road motor vehicle/equipment/tracked combination is calculated with the mathematical relationship:

$$CC = \frac{Pef}{100} * Cm1 * Z + t * z * Cm2 \quad \text{[Liters]} \qquad (1)$$

Where,

CC is the standard fuel consumption;

Pef – the actual distance traveled in kilometers. This is the actual distance over which a tracked vehicle travels to complete a journey (travel route);

C_{m1} – average fuel consumption in liters per 100 km;

Z – the product of the average fuel consumption correction coefficients to be applied in relation to the operating conditions of crawler vehicles;

t running time, expressed in hours, of the heat engine when stationary, of the tracked motor vehicle under special conditions, of the craft, aggregates or other devices with auxiliary heat engine (for heat engines or auxiliary heat engines driving other installations fitted to this type of vehicle);

C_{m2} – the average standard fuel consumption expressed in liters per hour of operation of the heat engine of the tracked towed vehicle for the towing of attachments and auxiliaries.

- The normalized fuel consumption of a road motor vehicle/equipment/gear/unit or motorcycles on wheels is calculated with the mathematical relationship:

$$CC = Cm1 * Z * (\frac{Pef}{100} * Ke * t) + t * Z * Cm2 \quad \text{[Liters]} \qquad (2)$$

Where,

CC is the standard fuel consumption;

Pef – the actual journey of the vehicle in kilometers;

C_{m1} average fuel consumption in liters per 100 km;

Z – the product of the average fuel consumption correction coefficients to be applied in relation to the operating conditions of motor vehicles;

t operating time, expressed in hours, of the heat engine when stationary, of the road motor vehicle under special conditions, of the craft, aggregates or other devices with auxiliary heat engine;

Ke – the engine operating equivalence coefficient for driving special equipment fitted to motor vehicles;

C_{m2} – the average standard fuel consumption expressed in liters per hour of operation of the heat engine of the road motor vehicle for the gearing of aggregates and auxiliaries.

In the case of operation of engines to drive special installations, the average fuel consumption may be influenced only by operation in cold weather - correction factor ***A***, or by operation at altitudes above 1,000 m - correction factor ***V***.

- The normalized fuel consumption of a wheeled road tractor is calculated with the mathematical relationship:

$$CC = t * C_m * A * R_9 \quad \text{[Liters]} \quad (3)$$

Where,

CC is the standard fuel consumption;

t – operating time in hours;

C_m – verage fuel consumption in liters per 100 km;

A – winter fuel correction coefficient;

R_9 – the fuel consumption correction coefficient for road tractors towing trailers.

5. Standard consumption of engine lubricant by combustion in road motor vehicles

The consumption of engine oil by combustion in road motor vehicles is the maximum permissible quantity of engine oil to be consumed by an engine of a road motor vehicle equipment or appliance for operation over a given period of time or for a given journey/trip itinerary and consists of:

a) engine oil consumption by combustion, ***CUa***;

b) oil consumption for oil change, ***CUs***.

Oil consumption by combustion (***Cua)*** is the maximum normalized quantity for replenishing consumption during engine operation and is calculated with the mathematical relationship:

- For motor vehicles and crawlers machinery:

$$CUa = \frac{Ce}{100} * Ca \quad \text{[Liters]} \quad (4)$$

Where,

CUa is the combustion engine lubricant consumption in liters;

Ce – the amount of fuel effectively consumed, expressed in liters;

Ca – specific consumption of engine lubricant by combustion per 100 liters of fuel, in accordance with the consumption set by regulations or manufacturer's recommendations.

- For motor vehicles, motorcycles and ATVs:

$$CUa = \frac{(Pef + t + Ke)}{100} * Ca \quad \text{[Liters]} \quad (5)$$

Where,

CUa is the combustion engine lubricant consumption in liters;

Pef – effective distance of the vehicle in kilometers;

t - the operating time, expressed in hours, of the engine at standstill, of the motor vehicle under special conditions, of aggregates and auxiliaries;

Ke – he engine operating equivalence coefficient for driving special equipment installed in motor vehicles;

Ca – specific combustion engine lubricant consumption expressed in hours per 100 km.

- For road tractors:

$$CUa = t * Ca \quad \text{[Liters]} \quad (6)$$

Where,

CUa is the combustion engine lubricant consumption in liters;

t – tractor running time in hours;

Ca – specific combustion engine lubricant consumption expressed in liters of lubricant per hour of operation.

The determination of the need for engine lubricant, transmission lubricant and special fluids (brake fluid for vehicle braking systems, antifreeze fluid for engine cooling systems, hydraulic oil in pressure systems, etc.) for the replacement of used lubricant ***(CUs)*** is carried out as follows:

1. In the case of meeting the rolling standard:

a) For crawler machinery:

$$CUs = \frac{Pef}{Ps} * (Cb + Cc) \quad \text{[Liters]} \quad (7)$$

b) For wheeled motor vehicles and road tractors:

$$CUs = \frac{Pef(N0)}{Ps} * (Cb + \frac{Cb}{2} \text{ or } \frac{Cb}{2}) \quad \text{[Liters]} \quad (8)$$

Where,

CUs s the consumption of lubricant or special fluids expressed in liters;

Pef – effective travel during the period for which consumption is calculated;

Ps – standard time for lubricant change;

Cb - capacity of the lubrication system;

Cc - the quantity of lubricant set for washing the lubrication system;

N_0 – the number of operating hours in the period for which consumption is made.

2. If the replacement of the lubricant is carried out at the end of the period of use:

a) For crawler machinery:

$$Cs = Ns * (Cb + Cc) \quad \text{[Liters]} \quad (9)$$

b) For wheeled motor vehicles and road tractors:

$$Cs = Ns * (Cb + Cb \text{ or } Cc) \quad \text{[Liters]} \quad (10)$$

Where

Cs is the consumption of lubricant or special fluids for gearbox, expressed in liters;

Ns - the number of changes to be made following the end of service life in years;

The change of lubricant in thermal engines and transmissions shall be recorded in the technical books of the motor vehicles and engines, including those carried out during repairs.

During the running-in period, the change of lubricants and special fluids shall be carried out in accordance with the running-in conditions laid down by the manufacturer for each motor vehicle.

If the lubricant in the lubricating system of the engine or other parts of the motor vehicle has been altered due to the penetration of the oil into the lubricating system, the engine shall be run in with the lubricant in the engine.
of the lubricant, coolant and mechanical impurities or water (specific for heat engines or transmission components), after operating the machinery or motor vehicle in various conditions (driving through water, swamps, washed-out ground, etc.), it shall be replaced as necessary. If the alteration of engine or transmission lubricant or special fluids has been caused by faulty operation, measures will be taken to recover the material damage following an administrative inquiry.

6. The value of the correction coefficients applied to the average consumption of fuels - lubricants in the case of operation of motor vehicles, machinery and equipment in conditions other than those for which the average consumption was determined

Fuel consumption standards for motor vehicles, machinery or other equipment with heat engines are directly influenced by the specific conditions of the operating environment. In order to correct for this influence, the average fuel consumption shall be corrected by appropriate correction factors.
These correction factors are:

a) The seasonal correction coefficient "A".

It is a correction coefficient which is taken into account for the correction of fuel consumption when the engines of road motor vehicles are operated in the cold season (period) of the calendar year, i.e. from November 1st to April 1st and has the value A =1.10.

b) The correction coefficient for the movement of road motor vehicles in adverse weather conditions, on heavy terrain, off-road or in special operating conditions "B".

It is a correction coefficient that is applied to the correction of fuel consumption for engines of road motor vehicles that are operated irrespective of weather and terrain conditions and has the value B =1.5.

c) The correction coefficient for the movement of road motor vehicles in single columns "C".

It is a correction coefficient to be applied for the correction of the fuel consumption of the engines of road motor vehicles which are operated during journeys in organized columns of more than three vehicles. Depending on the conditions under which the journeys are made, the coefficient shall have the following values:

- cars driving in columns during the day $C_1 = 1.1$;
- cars driving in a columns night or in a mixed column of the day $C_2 = 1.3$;
- cars driving in mixed columns at night $C_3 = 1.4$.

Mixed columns of vehicles are defined by their heterogeneity, i.e. their composition. The composition of a column of motor vehicles can be composed of only cars, trucks or buses reaching and moving at the same speed (homogeneous column), or a mix of motor vehicles (e.g. cars, trucks, vans, trucks with trailer, buses, etc.), reaching and moving at different speeds (heterogeneous column).
Where the movement of vehicles is made in a column and one of the above-mentioned coefficients is applied, the following shall be entered by the driver of the column on the roadmap (journey form): "the journey from............to................ was made in a car/mixed column".

The C_1 and C_2 column coefficients may be applied, as appropriate, to all road vehicles circulating in isolation in fog, slush, ice, snow, carrying slightly flammable, explosive, oversized loads, inside buses or institutions, and in other situations where reduced speed is required. In the event of bad weather, the approval of the column coefficients may also be given at the end of the journey, if this is necessary. Approval shall be given by the head/director of the bus or coach or by the head/director of the institution to which the vehicle belongs.

d) Fuel consumption correction coefficient for road motor vehicles operating at high altitudes "V".

It is a correction coefficient that is applied to correct the fuel consumption of engines of road motor vehicles operating at altitudes above 1,000 meters and has the value V = 1.1. For the application of this coefficient, also the head/director of the bus or coach or the institution to which the vehicle belongs shall give his approval on the roadmap (journey form), where the following text shall be entered on the return from the race: "Over the distance from .... to .... the vehicle has traveled at an altitude of .... meters".

e) The average fuel consumption correction coefficient for road motor vehicles used for learning and improvement of driving practice "S".

It is a correction factor to be applied to correct the fuel consumption of engines of road motor vehicles which are used in the training of learners in driving instruction in driving instruction for road motor vehicle driving skills and has a value S = 1.2. The application of this coefficient does not preclude the use, where appropriate, of all the fuel consumption correction coefficients mentioned above.

f) The average fuel consumption correction coefficient for road motor vehicles used for the transportation of children to and from schools, nurseries or kindergartens and for the delivery of mail to institutions "O".

It is a correction coefficient to be applied to correct the fuel consumption of the engines of road motor vehicles used for the transportation of children to and from schools, kindergartens or crèches and for the collection or delivery of mail, having a value of O = 1.1.

7. Determination of equivalent mileage (equivelent kilometers) for road motor vehicles. Coefficients/correction factors

The actual distance is the distance traveled by a vehicle, established on the basis of the on-board equipment recordings or, in case of its failure during a journey, on the basis of the confirmations given by the beneficiaries of the transport, compared with the geographical distance indicators or with the decisions issued by the county road and bridge directorates regarding the road classification and the distances between localities.
In the course of their operation, cars are subject to different traffic and transportation conditions, which means that the actual journey does not always reflect the degree of demand placed on them.
In order to calculate the standard fuel and oil consumption and to carry out maintenance and repair work in relation to the actual operating conditions, it is necessary to calculate the equivalent mileage.
Equivalent mileage is the distance traveled by a vehicle, corrected by the coefficients and increases corresponding to

the various operating conditions (road conditions, towing trailers, traffic in urban areas, operation of special equipment and aerodynamic factors).

The equivalent distance traveled (Pe) of road vehicles is calculated with the mathematical relationship [7]:

$$Pe = Ped + T + U + I +/- Ra \text{ [Equivalent kilometers]} \quad (11)$$

Where,

Pe is the equivalent journey of the road vehicle (km);
Ped - equivalent road distance (km);
T - towing increment;
U – coefficient for traffic in urban areas;
I - coefficien for the operation of special installations;
Ra - coefficient (reduction) for air resistance.

Note: The values of the above-mentioned bonuses are regulated in Romania by the Normative on fuel and oil consumption for cars [7], of January 7, 1982, elaborated by the Ministry of Transport. The text of this regulation was published in the Official Bulletin of Romania no. 2 of January 7, 1982, the date on which it came into force.

The equivalent road travel *(Ped)* is calculated for cars and trailers with the mathematical relationship [7]:

P_{ed} = *Sum from i = 1 until the 6 Pi * Di* [Equivalent kilometers] (12)

Where:

P is the effective distance of the car (km);
D – road coefficient (see Table 1);
i - road category (i = 1,.....,6), (see Table 1).

a) Road coefficient (D)

In relation to their influence on cars (wear and tear, fuel and oil consumption, etc.) due to their rolling resistance, the steepness of slopes and ramps, as well as due to factors that require frequent changes in speed, public roads in Romania are classified into asphalt, gravel and gravel roads. The ***"D"*** road coefficients apply to all motorcycles, ATVs, road motor vehicles and trailers towed by them, traveling on public roads, both inside and outside the localities, and have the symbol and coefficient values shown in Table 1.

Table 1: Symbols and values of road coefficients for existing road categories in Romania [7]

Road category Symbol	Road Coefficient	Value	Description of road stands
I (M)	D_1	0.9	Asphalt roads in good condition (asphalt concrete, asphalt macadam, macadam with double treatment, bituminized ballast, cement concrete).
II (K)	D_2	1.0	Paved roads (paved roads with normal or abnormal pavers) in good condition. Paved and paved roads in good condition.
III (T)	D_3	1.1	Asphalt roads, paved, macadamized and paved in mediocre condition, requiring speed changes on approx. 20% of the route. Earth roads and earthworks in good condition. Roads paved with rough stone, river boulders and sand in good condition.
IV (L)	D_4	1.2	Roads paved with crushed stone, gravel or macadamized and paved with stone and river boulders, in mediocre condition. Category K and T roads with gradients requiring speed changes on approx. 40% of the route.
V (E)	D_5	1.4	Roads whose condition requires speed changes on approx. 70% of the route. Dirt roads and earthworks, in mediocre condition. Roads paved with river boulders or stone, in a bad condition.
VI (H)	D_6	1.6	All other roads in a state of viability or with gradients that do not allow speeds above 15 km/hour along their entire length.

Note: 1. The classification of public roads in Romania into one of the road categories presented in Table 1 will be done by consulting the website of the National Road Infrastructure Administration Company (CNAIR), sections highways/national roads, for the roads under its administration, or by requesting annually to the County Councils (C.C.), the data on road construction for the roads under their administration.

2. Public roads within the territorial limits of urban localities (municipalities and cities) are included in category (K), except for degraded roads, roads under construction, etc, for which the people's councils of the respective localities may temporarily establish other categories.

3. For the purpose of equalizing the distance covered by buses for urban passenger transport, public roads within the territorial limits of urban localities, which have gradients of more than 2%, shall be classified in road category III (T).

4. Roads within the precincts of construction sites, quarries, etc. shall be framed by a committee made up of:

- the person responsible for consumer standards in the motor transport unit concerned;
- director/head of the autogarage/coach (transport formation);
- delegated by the unit owning the road.

5. The note signed for the classification of these roads will be signed both by the management of the interested road transport unit and by the road owning unit, having temporary validity, i.e. until the road condition changes, when it is necessary to update their classification. The classification of forest roads under the exclusive administration of the Ministry of Industrialization of Wood and Building Materials (roads closed to public traffic), is made by the bodies designated by this ministry

b) Coefficient for towing (T) or (R)

It is determined for the route over which the automobile tows trailers, semi-trailers, trailers or other motor vehicles with the mathematical relationship [7]:

$$T = \frac{Pt}{100} * \text{t} \quad \text{[Equivalent kilometers]} \quad (13)$$

Where,

Pt is the effective distance towed (km);
T - the specific coefficient/specific towing ratio (equivalent km/100 km), the values of which are given in

the Fuel and Oil Consumption Standard for Cars, Table 1.2 [7].

In the literature the traction coefficient can also be found as ***"R"***.

In Table 2 we present the values of the correction coefficient for towing trailers ***"R"***, interpreted in a different way than in the fuel and oil consumption norms for cars Table 1.2

Table 2: Correction coefficient for towing car trailers

Towed trailer category	Towed trailer weight
$R_1 = 1.1$	For trailers weighing 500 – 1,500 kg
$R_2 = 1.2$	For trailers weighing 1,501 - 3,000 kg
$R_3 = 1.3$	For trailers weighing 3,001 - 5,000 kg
$R_4 = 1.4$	For trailers weighing 5,001 - 7,000 kg
$R_5 = 1.5$	For trailers weighing 7,001 – 10,000 kg
$R_6 = 1.6$	For trailers weighing 10,001 – 15,000 kg
$R_7 = 1.8$	For trailers over 15,000 kg

Note: 1. In the case of a tractor-trailer with a saddle, the coefficient R8 = 1.1 is applied and in the case of towing a stranded (defective) vehicle, the coefficient corresponding to the weight of the towed vehicle is applied to the towing car;
2. For road tractors, for which the standard fuel consumption is expressed in liters/hour, if towing trailers, the increment/coefficient shall be applied $R_9 = 1.15$;

c) Coefficient for traffic in urban localities (U)

It is granted exclusively for journeys made on public roads within urban localities (intra-urban) and is determined by the mathematical relationship [7]:

$$U = \frac{Pu}{100} * u \quad \text{[Equivalent kilometers]} \qquad (14)$$

Where,

Pu is the effective driving distance of the car in urban areas (km);

U – specific coefficients for road motor vehicle traffic in urban areas (km) equiv/100 km), the values of which are given in Table 3.

Table 3: Equivalent path correction coefficients in urban localities (cities, county towns)

Nr. crt.	Group of road motor vehicles	Correction coefficients for urban traffic "U"		
		Bucharest	Municipalities and county towns	Municipalities and county towns
1	Passenger cars and trucks built on their chassis with conventional or automatic transmission	$U_1 = 1.53$	$U_2 = 1.28$	$U_3 = 1.15$
2	Buses running inside cities	$U_4 = 1.44$	$U_5 = 1.42$	$U_6 = 1.38$
3	ther cars, trailers, ATVs and motorcycles	$U_7 = 1.43$	$U_8 = 1.26$	$U_9 = 1.19$

Note: Another interpretation of the equivalent distance correction coefficient in urban areas, other than the one presented in Table 1 can be found in the Fuel and Oil Consumption Standard for Cars Table 1.3 [7].

During peak traffic periods, the ***"U"*** surcharge may be increased by up to 25% for cars engaged in urban passenger transport. The periods for which the increase may be applied shall be determined by the people's councils of the localities concerned, so that the increase does not exceed 6 hours per working day [7].

***d) Coefficients for the circulation of passenger cars in special conditions (W)**, Table 4.*

Table 4: Coefficients for the circulation of passenger cars/autospecial vehicles in other conditions (W)

Nr. crt.	Type of correction coefficient	Vehicle/equipment to which it applies	Conditions under which it applies	Value of the correction coefficient
1	Representation coefficient, W_1	Special vehicles (protocol, police, gendarmerie, ambulances)	In accordance with the provisions of the immediate superior body (ministries, directorates, other higher echelons), the entity to which the motor vehicle/ special vehicle	1.2
2	Coefficient of speed correction for city and off-road passenger cars at the legal speed on the highway, W_2	City and off-road cars	Driving on the highway at the legal speed of 130 km/h	1.3

e) Coefficient for the operation of special installations (I)

It applies in the case of motor vehicles whose engines drive the special installations which equip the means of transport and is determined by the mathematical relationship:

$$I = np * i \quad \text{[Equivalent kilometers]} \qquad (15)$$

Where,

np is the number of special benefits made;

I - the specific coefficient/specific performance (equ equiv. km/1 special performance), the values of which are given in Table 1.4 of the Fuel and Oil Consumption Standard for Cars [7].

In the literature this coefficient is also denoted by the letter ***"Q"*** and has the following values:

- for motor cars and trailers fitted with special permanent installations, having a mass approximately equal to the total mass $Q_1 = 1.2$;
- for motor cars and trailers fitted with permanently installed special equipment, with a mass approximately equal to the total mass - for motor cars and trailers fitted with permanently installed special equipment, but the total mass of which exceeds the useful mass of a laden motor vehicle of that type and make by at least 10% of the total mass $Q_2 = 1.4$.

Note: 1. Coefficients Q_1 and Q_2 will apply at all times, irrespective of the conditions in which the vehicles are operated;

2. In the case of trailers fitted with special equipment powered by the towing vehicle's engine, the specific bonus for the whole trailer is calculated by adding the bonus for the towing vehicle to that of the towed trailers. For each special service carried out with the equipment fitted to the trailers, the corresponding value of the specific bonus in Table 1.4 must be given [7].

f) Coefficient (reduction) for air resistance (Ra)

It applies to journeys made in interurban and international traffic by cars equipped with a tail and tarpaulin, those equipped with deflectors and in the case of towing van trailers or those equipped with a tail and tarpaulin and is determined by the mathematical relationship:

$$\mathrm{Ra} = \frac{\mathrm{Pa}}{100} * ra \quad \text{[Equivalent kilometers]} \quad (16)$$

Where,

Pa is the effective distance (km) driven outside urban areas;

Ra – the specific coefficient (reduction) for air resistance (equivalent km/100 km), the values of which are given in Table 1.5 of the Fuel and Oil Consumption Standard for Cars [7].

Note: In the case of lorries with one or more van trailers or fitted with a cowl and tarpaulin, the specific "Ra" increment will be increased by 2 km equivalent/100 km for each trailer towed [7].

g) Equivalent distance coefficients (Pe) for driving practice cars

The equivalent driving distance is determined according to the type of car, the schooling cycle and the number of hours of driving instruction, with the mathematical relationship:

$$Pe = Ph * hd + T + U \quad \text{[Equivalent kilometers]} \quad (17)$$

Where,

Ph is the normalized equivalent time for one teaching hour of driving (50 minutes), whose values are shown in Table 1.6;

hd - number of hours of driving instruction;

T si *U* - have the meanings given in point 2.1 of the Regulation on fuel and oil consumption of motor vehicles [7], and is determined by the following mathematical relationships:

$$\mathrm{T} = \frac{\mathrm{Ph-hd}}{100} * t \quad \text{[Equivalent kilometers]} \quad (18)$$

$$\mathrm{U} = \frac{\mathrm{Ph-hd}}{100} * u \quad \text{[Equivalent kilometers]} \quad (19)$$

Note: 1. Cycles I and II of schooling represent respectively the first and the second half of the total number of teaching hours, per series, dedicated to leadership practice;

2. In case the kilometers recorded by the sealed mileage meter exceed the values provided in Table 1.6 (on a day of activity), the equivalent mileage will be determined on the basis of the data provided by the on-board equipment of the cars (the vehicle odometer), according to the methodology indicated in point 2.1 of the Regulation on Fuel and Oil consumption for cars [7].

h) Ratings given for the operation of workshop practice engines

The equivalent path *(Pe)* is determined with the mathematical relationship:

$$Pe = phm * hdm \quad \text{[Equivalent kilometers]} \quad (20)$$

Where,

phm, is the standard equivalent distance for one teaching hour of engine operation and has a value of 10 km equivalent/1 teaching hour of operation;

hdm - number of teaching hours of engine operation.

In the Fuel and Oil Consumption Standard for Cars [7], other road vehicle mileage and fuel consumption correction coefficients are also presented. In this scientific paper we have presented those of particular importance (relevance). Readers interested in other mileage (km) and fuel consumption (liters/100 km, or liters/hour) coefficients/calculation factors/increments can consult this Standard on the website: https://lege5.ro/Gratuit/he3dqnjt/normativul-privind-consumul-de-combustibil-si-ulei-pentru-automobile-din-07011982?pid=19991000#p-19991000

At the same time, this regulation also describes in a logical and detailed manner the methodology for type-approving the fuel and lubricant consumption of road vehicle engines.

8. Calculation of standard fuel consumption (CC) of cars, road tractors and motorcycles. Cases study

The mathematical calculation relationship used for fuel consumption ***(CC)*** is as follows:

$$CC = Cm1 * Z * (\frac{Pef}{100} * Ke * t) + t * Z * Cm2 \quad \text{[Liters]} \quad (21)$$

where,

CC is the standard fuel consumption;

P_{ef} – the effective distance traveled in kilometers. This is the actual distance over which a crawler vehicle travels to complete a route (journey itinerary);

C_{m1} – average fuel consumption in liters per 100 km;

Z – the product of the average fuel consumption correction coefficients to be applied in relation to the operating conditions of crawler machinery;

Ke – the engine operating equivalence coefficient for driving special equipment fitted to motor vehicles;

t – running time, expressed in hours, of the heat engine when stationary, of the tracked motor vehicle under special conditions, of the craft, aggregates or other devices with auxiliary heat engine (for heat engines or auxiliary heat engines driving other installations fitted to this type of vehicle);

C_{m2} – the average standard fuel consumption expressed in liters per hour of operation of the heat engine of the crawler vehicle for the gearing of aggregates and auxiliaries.

In the following, we will present in this case study some examples of mathematical calculation of normalized fuel consumption for passenger cars, off-road cars, trucks, special trucks, crawler tracked construction machines and road tractors, applying the most used and relevant correction coefficients.

Calculation example 1. A DAF XF truck, is transporting materials in winter, A = 1.1, between two locations (A and B) 240 km apart, of which 120 km on a paved road, D_1 = 1.0 and 120 km on a gravel road, D_2 = 1.2.
Applying the data presented in the mathematical relationship (21) for case study 1, we have:

CC = standard fuel consumption;
C_{m1} = 38,5 liters/100 km;
P_{ef} = 120 km on an asphalt road, D_1 = 1.0 and 120 km on a paved road, D_2 = 1,.;
Z = A * D = 1,.1 * 1.0 = 1.1 for driving on a paved road and 1.1 *1.2 = 1.32 or driving on a gravel road.

It results:

$$CC = 38.5 * 1.1 * \frac{120}{100} + 38.5 * 1.32 * \frac{120}{100}\ 111.8\ liters \quad (22)$$

Calculation example 2. A DAF XF truck, driving in a convoy at night, C_2 = 1.30, in summer, transporting materials between two locations (A and B), towing a 3,000 kg trailer, R_2 = 1.20, over a distance of 300 km, of which 100 km on a paved road, D_1 = 1.0 and 200 km on a gravel road, D_2 = 1.2.
Applying the data presented in the mathematical relationship (21) to case study 2, we have:

CC = standard fuel consumption;
C_{m1} = 38.5 liters/100 km;
Z = 1.3 * 1.2 * 1.0 = 1.56 for driving in a column with a trailer on a paved road;
Z = 1.3 * 1.2 * 1.2 = 1.87 for driving in a column with a trailer on a gravel road.

It results:

$$CC = 38.5 * 1.56 * \frac{100}{100} + 38.5 * 1.87 * \frac{200}{100} = 60.06 + 143.99 = 204.06\ liters \quad (23)$$

Calculation example 3. A Ford Ranger van, transporting construction materials in winter, A = 1.1 in the city of Sibiu, U_8 = 1.26 traveling a total of 250 km.
Applying the data presented in the mathematical relationship (21) to case study 3, we have:

CC = standard fuel consumption;
Z = A * U_8 = 1.1 * 1.26 = 1.38
C_{m1} = 6.7 liters/100 km

It results:

$$CC = 6.7 * 1.38 * \frac{250}{100} = 23,1\ liters \quad (24)$$

Calculation example 4. A Ford F-MAX tipper truck, in the summer, carries out transportation for road improvement work over a distance of 100 km on unpaved B = 1.5 km and 200 km on a paved road, D_2 = 1.20 km. For unloading the earth, 20 tippings were carried out, K_e = 0.05 for one tipping.
Applying the data presented in the mathematical relationship (21) for case study 4, we have:

CC = standard fuel consumption;
C_{m1} = 31 liters/100 km;
For driving on the unpaved road: Z = B = 1.5;
For driving on the paved road: Z = D_2 = 1.20;
Z = 1.3 * 1.2 * 1.0 = 1.56 for driving in a column with a trailer on a asphalt road;
Z = 1.3 * 1.2 * 1.2 = 1.87 for driving in a column with a trailer on a gravel road.

It results:

$$CC = 31 * 1.5 * \frac{100}{100} + 31 * 1.2 * \frac{200}{100} + 31 * 20 * 0,005 = 124\ liters \quad (25)$$

Calculation example 5. A car DACIA DUSTER, type SD/HSDAC/HSDACN travels in summer 50 km in Bucharest, U_1 = 1.53 and 120 km on the highway, at a speed of 130 km/h W_2 = 1.30. During the trip the air conditioning was functioning for 2 hours.
Applying the data presented in the mathematical relationship (21) to case study 5, we have:

CC = standard fuel consumption;
C_{m1} = 7.60 liters/100 km;
C_{m2} = 0,80 liters /h;
For traveling to Bucharest: Z = U1 = 1.53;
For highway travel: Z = W_2 = 1.30;
Z = 1.3 * 1.2 * 1.0 = 1.56 for driving in a column with a trailer on a asphalt road;
Z = 1.3 * 1.2 * 1.2 = 1.87 for driving in a column with a trailer on a gravel road.

It results:

$$CC = 7.60 * 1.53 * \frac{50}{100} + 7.60 * 1.30 * \frac{120}{100} + 2 * 20 * 0,80 = 19.26\ liters \quad (26)$$

Calculation example 6. A DAF XF truck is used in winter, A = 1.10 for learning driving practice in order to obtain the driving license, S_1 = 1.5 over a distance of 250 km in Targoviste U_8 = 1.26.
Applying the data presented in the mathematical relationship (21) to case study 6, we have:

CC = standard fuel consumption;
C_{m1} = 38.5 liters /100 km;
Z = A * S_1 * U_8 =1.1 * 1.5 * 1.26 = 2.08

It results:

$$CC = 38.5 * 2.08 * \frac{250}{100} = 200.20\ liters \quad (27)$$

Calculation example 7. An IVECO S-WAY vacuum pumper truck is used in winter, A = 1.10 for vacuuming work. During the work, it travels 50 km inside the city of Pitești U_8 = 1.26 and 20 km on a paved road D_2 = 1.20 and for driving the loading-unloading installation, the engine has been working for 4 hours, K_e = 0.30.
Applying the data presented in the mathematical relationship (21) to case study 7, we have:

CC = standard fuel consumption;
C_{m1} = 44 liters/100 km;
For travel in the locality: Z = A * U_8 = 1.1 * 1.26 = 1.38;
For driving on gravel roads: Z = A * D_2 = 1.1 * 1.2 = 1.32;

It results:

$$CC = 44 * 1.38 * \frac{50}{100} + 44 * 1.32 * \frac{20}{100} + 44 * 0.30 * 4 = 94.77\ liters \quad (28)$$

Calculation example 8. A refrigerated IVECO DAILY van exceeding by more than 10% the weight of the vehicle on whose chassis it was manufactured, loaded to the rated capacity Q_2 = 1.40, is driven in winter A = 1.10, 100 km on a national road, D_1 = 1.0, 20 km on a gravel road, D_2 = 1.2 and 3 km on dry hard ground, off categorized roads, B = 1.5.
Applying the data presented in the mathematical relationship (21) to case study 8, we have:

CC = standard fuel consumption;

C_{m1} = 11 liters/100 km;

For national road travel: $Z = A * D_1 * Q_2 = 1.1 * 1.0 * 1.4 = 1.54$;

For driving on gravel roads: $Z = A * D_2 * Q_2 = 1.1 * 1.2 * 1.4 = 1.85$;

For traveling on uncategorized roads: $Z = A * B * Q_2 = 1.1 * 1.5 * 1.4 = 2.31$;

It results:

$$CC = 11 * 1.54 * \frac{100}{100} + 11 * 1.85 * \frac{20}{100} + 11 * 2,31 * \frac{30}{100} = 28.63\ liters \quad (29)$$

Calculation example 9. On an IVECO IG190EL2CA/MAGZAR RIE/190EL tanker truck, K_e = 0.15, adjustments are made at the exit of the tanker truck, after which it travels with a full load 50 km inside Sibiu, U_8 = 1.26, after which it carries out fueling works for 1 hour.
Applying the data presented in the mathematical relationship (21) for case study 9, we have:

CC = standard fuel consumption;

C_{m1} = 20.60 liters/100 km;

C_{m2} = 17.50 liters/h;

For travel within the locality: $Z = U_8 = 1.26$;
It results:

$$CC = 17.50 * 0.15 * \frac{10}{60} + 20.6 * 1.26 * \frac{50}{100} + 6 * 1 = 19.41\ liters \quad (30)$$

Calculation example 10. A Tym T700 road tractor is used in the winter, A = 1.10, to transport electrical materials with a trailer, operating for 6 hours.

$$CC = t * (C_m * Z) \quad [\text{Liters}] \quad (31)$$

Applying the data presented in the mathematical relationship (31) to case study 10, we have:
For the given case: CC = to calculate;

T = 6 ore;

C_m = 7.5 liters/ hour;

Z = A = 1.10;

It results:

$$CC = 6 * (7.5 * 1.10) = 49.5\ liters \quad (32)$$

Calculation example 11. A Caterpillar bulldozer - CAT travels 100 km in winter, A = 1.1 on a road with heavy snow in heavy weather conditions, B = 1.5, without trailer, to tow a broken down truck. In the field performs for one hour with the blade, and 30 minutes the engine runs for warm-up. On the return, the bulldozer runs in the same conditions, another 100 km, towing the defective truck. Before going out in the field, the water and oil heater ran for 30 minutes.

$$CC = \frac{Pef}{100} * Cm1 * Z + t * Z * Cm2 \quad [\text{Liters}] \quad (33)$$

Applying the data presented in the mathematical relationship (33) for case study 11, we have:

CC = CC = standard fuel consumption;

Pef = 100 km without trailer and 100 km with trailer;

C_{m1} = 150 liters/100 km for travel without trailer;

C_{m1} = 200 liters/100 km for trailer travel;

Z = A * B = 1.1 * 1.5 = 1.65;

T = 1 hour for bulldozer blade work;

T = 0.5 hours for heating engine operation;

T = 0.5 hours for oil and water heater operation;

C_{m2} = 15 liters/h for working with a bulldozer blade;

C_{m2} = 3 liters/h r oil and water heater operation;

It results:

$$CC = \frac{100}{100} * 150 * 1.1 * 1.5 + \frac{100}{100} * 200 * 1.1 * 1.5 + 1 * 15 * 1.1 + 0.5 * 8 * 1.1 + 0.5 * 3 = 599.9\ liters$$
(34)

Calculation example 12. A Tatra T815 Collos 8x8 transporter with a HYAB type crane, travels from the truck 50 km on a paved road and 80 km in terrain with a snow cover of more than 30 cm, in heavy weather conditions B = 1.5 in winter A = 1.1. During field operation, it idles for 30 minutes to warm up the engine, after which it works for one hour with the HYAB crane, self-loading construction materials into its body. On departure from the site, due to the weight of the loaded materials, the transporter is lowered into the soft ground of the construction site and uses the winch for the self-loading excavator for 30 minutes. Before setting off, it uses the oil and water heater for 20 minutes.

$$CC = \frac{Pef}{100} * Cm1 * Z + t * Z * Cm2 \quad [\text{Liters}] \quad (35)$$

Applying the data presented in the mathematical relationship (35) to case study 12, we have:
CC = standard fuel consumption;
Pef = 50 km on an asphalt road and 80 km on snow-covered ground with more than 30 cm of snow, in heavy weather conditions;
C_{m1} = 50 liters/100 km for driving on an asphalt road;
C_{m1} = 90 liters/100 km for travel in the field;
Z = A = 1.1 for all situations except driving in heavy terrain, 80 km, for which the coefficient B = 1.5 is applied, and for the operation of the water and oil heater, for which no coefficient is applied;
T = 0,5 hours field running time for heating;
T = 1 hour working with HYAB type crane for self-loading;
T = 0.5 hours for the operation of the winch for self-propelled mud scrapers;
T = 0.33 hours for oil and water heater operation;
C_{m2} = 10 liters/hour for heating;
C_{m2} = 24 liters/hour for working with HYAB type crane on self-loading;
C_{m2} = 8 liters/hour for winch operation;
C_{m2} = 2 liters/hour for oil and water heater operation;
It results:

$$CC = \frac{50}{100} * 50 * 1.1 + \frac{80}{100} * 90 * 1.1 * 1.5 + 0.5 * 10 * 1.1 + 1 * 24 * 1.1 + 0.5 * 8 * 1.1 + 0,33 * 2 = 177.76\ liters$$
(36)

9. Conclusions

The roadmap (journey form) is a mandatory and basic document. It must be present when each vehicle sets off on its journey. It records such things as fuel consumption, the number of runs at which roadworthiness checks are carried out, the route and the number of runs made, and the hours of operation.

In short, the roadmap (journey form) characterizes the specifics of each route. From an administrative point of view, in the field of transport, it is mandatory to have this document because it justifies the actions of the vehicles in the fleet.

To make it easier for you to make your roadmaps, GPS tracking systems with a download function can be used.

Especially if you consider that the whole process can be made easier by using GPS monitoring equipment that has this function. With such equipment, the creation of the roadmap becomes an automated process, and you can download the document with a single click.

Specific combustion lubricant consumption is the maximum normalized quantity for engine operation at:

(a) 100 liters of fuel consumed by motor vehicles and tracked machines;

(b) 100 kilometers for wheeled road motor vehicles, motorcycles and ATVs;

c) one operating hour for road tractors.

The consumption of combustion lubricant for internal combustion engines shall be estimated by the specialists who manage the fleets of road motor vehicles in their own fleets before each means of transport is taken on the road and, if the supply provided by the engine sump (engine oil sump) is exceeded, an appropriate quantity shall be provided in advance as a reserve for topping up the lubricant in the engine sump by the driver during the journey.

Consumption of lubricant for replacement is the quantity of lubricant required to replace worn lubricants in the crankcases of heat engines, transmission, steering and suspension components within the prescribed time limits and to wash the lubrication system of engines and some aggregates of specialized motor vehicles (bulldozers, excavators, crawler cranes).

For motor vehicles and equipment whose lubricant changes are not nominated in normative acts established by legal entities (ministries, carcolors, tank trucks), the changes of used lubricants shall be carried out according to the terms established by the manufacturer of each motor vehicle, machine or unit with thermal engine.

At each change of lubricant, the lubrication system shall be flushed with lubricant of the type and quality prescribed for lubrication so that, in the case of road machinery, motor vehicles and tractors: ½ of the capacity of the lubrication system for spark ignition engines, Cb/2 and 1/3 of the capacity of the lubrication system for compression ignition engines, Cb/3.

In the calculation of the normalized fuel consumption on the journey data sheets, the actual kilometers will be corrected first by means of coefficients/scores to become equivalent kilometers, then the normalized fuel consumption for this distance will be calculated on the basis of the distance of equivalent kilometers.

In the calculation of the normalized fuel consumption on the journey timesheets, the operating hours will first be corrected by means of coefficients/weights, which will thus become corrected hours, and on the basis of these corrected hours the normalized fuel consumption will be calculated for the operating time in hours.

With this scientific work, the managers/managers of buses/coaches have at their disposal a number of methods for assessing the consumption of fuel, lubricants and spare parts for the cars in their own fleet over specific periods (daily, weekly, monthly, annually), in order to make objective, pragmatic assessments of their operating process.

These methods include:

- checking the accuracy of the data entered in the waybills, with reference to the engines consumed, the categories of roads traveled, the quantity of materials transported, etc;
- checking the full tanks of fuel-lubricants for each individual vehicle in the vehicle fleet and the way in which the operational records are kept;
- inter-operational and final control of preventive maintenance work carried out during technical maintenance (Daily Technical Maintenance - ITZ, Level 1 Technical Maintenance - IT1, Level 2 Technical Maintenance - IT2);
- ensuring that the supporting documents for the specific materials consumed in the preventive maintenance process are drawn up correctly and on time, that they comply with the consumption rules and that they are used as intended;
- checking the specific materials consumed during maintenance work carried out by the maintenance group or workshop when taking delivery of vehicles on the basis of the document ordering the document - supporting document;
- ensuring that the consumption of engines is within the rights allocated by the annual maintenance and repair plan and that current repairs are carried out.

The daily monitoring of fuel-lubricant consumption is carried out at the level of the vehicle or of the transport group, for each vehicle and driver, with the aim of detecting any possible deviations from the standard fuel consumption, establishing and eliminating the causes that have generated them.

The average fuel consumptions provided in the mentioned annexes are established under the conditions of equipping the cars with tires of the dimensions indicated by the manufacturer. In very exceptional cases, when some cars are fitted with other sized tires (on the drive axles), the average fuel consumption is corrected as follow:

- by an increase of 10%, if smaller tires are used;
- by decreasing by 10% if tires of a larger size are used.

The above corrections are only applicable to cars for which the correction coefficient of the odometer has not been updated.

The calculation examples presented in the case study can be successfully used in real-life calculation of fuel consumption on the journey log for motorcycles, ATVs, passenger cars, trucks, trailers with engines and construction machines.

10. References

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