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COMPARATIVE ANALYSIS OF NOX EMISSIONS OF TWO VEHICLES

R. BOIBOREAN[1], Ana (CARCUȘ) LAUKO[1], Casiana MIHUȚ[1], Anișoara DUMA-COPCEA[1], M. STROIA[1]

[1] University of Life Sciences "King Mihai I" from Timisoara, 300645, 119 Calea Aradului, Romania, Phone: +40256277001, Fax:+40256200296

Corresponding author: casiana_mihut@usvt.ro

Abstract. *The purpose of this work is to evaluate and compare the emissions of two vehicles, to determine the differences in environmental performance and identify the possible causes of the variations. The current state of the art in the field of reducing vehicle emissions is marked by rapid evolution, mainly imposed by increasingly strict regulations, such as the Euro 6 and the upcoming Euro 7 standards. These regulations specifically aim to reduce emissions of carbon monoxide (CO), nitrogen oxides (NOx), unburned hydrocarbons (HC) and fine particles (PM). The materials used in the comparative study on the emissions of two vehicles are: the vehicles studied, the emission measurement equipment. The methods used are: vehicle preparation, test procedure, data collection and analysis. The Volkswagen Passat E6 is superior in terms of emissions compared to the Volkswagen Golf E4. The Golf E4, on the other hand, could be a more economical option, but with a greater impact on the environment. Automakers use a range of advanced technologies to meet pollution standards: -Exhaust gas after-treatment systems; -Exhaust gas recirculation (EGR): a system that recirculates part of the exhaust gases to reduce the combustion temperature in the engine, which reduces the formation of NOx; -Electronic control systems (ECU): these are the "brains" of the engine. The ECU constantly monitors and optimizes operating parameters, such as fuel injection and ignition timing, to ensure the most efficient combustion and minimize emissions.; -Hybridization and electrification: The shift to hybrid vehicles and, in particular, fully electric vehicles (EVs) is a major direction, as EVs have no direct tailpipe emissions. For any driver, the operating condition of the car is important, and of all the testing and checking actions of a vehicle, the most important is the Periodic Technical Inspection, which we all know by the abbreviated name ITP.*

Keywords*: comparative analysis, vehicles, emissions*

INTRODUCTION

According to the law, in order to be kept in circulation, registered or registered vehicles must undergo periodic technical inspection. Exceptions to this obligation are self-propelled vehicles with a maximum design speed not exceeding 25 km/h, tracked vehicles, trams and animal-drawn vehicles. (AKINBAMI J.A.F.K., 2001) The Periodic Technical Inspection (ITP) is mandatory for all drivers driving in Romania, and failure to carry it out brings sanctions for drivers. In other words, the car must receive approval from a center authorized by the Romanian Auto Registry - RAR or from an authorized service, according to the legislation in force, where the ITP is carried out. (DUMA-COPCEA ANISOARA CLAUDIA, ET AL, 2024). Through this periodic technical inspection, the authorities want to ensure that all cars driving on public roads in Romania are technically safe (NEGREA, V.D., ET AL, 2003).

The Volkswagen Passat and Volkswagen Golf are important pillars in the history of the German manufacturer Volkswagen and have dominated the automotive markets in their respective segments. They represent two different design and engineering philosophies, adapted to the varying needs of consumers (PETRESCU ET.AL. 2011).

Volkswagen Golf E4

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The Volkswagen Golf is undoubtedly one of the most popular and influential passenger cars in the world. Since its launch in 1974, it has defined the compact class (hatchback) and set benchmarks for reliability, functionality and handling (Gheorghe Frățilă, ET AL, 2007).

Golf E4 (fourth generation) was produced between 1997 and 2003. This generation was praised for its superior build quality, modern yet conservative design, and a wide range of engines. It was a transitional model, bringing significant innovations over previous generations, but which, with the Euro 4 pollution standard, lags behind newer technologies in terms of emissions (NEGREA, V.D., ET AL, 2004).

Volkswagen Passat E6

The Volkswagen Passat is an upper-middle-class (family) model, recognized for its comfort, generous interior space and quality finishes. It served as a more affordable alternative to premium brands, offering a refined driving experience and an imposing presence. (https://ptc-auto.ro/blogs/masina-mea/istoria-volkswagen-o-poveste-de-succes)

Passat E6 (sixth generation, also known as the B6) was launched in 2005 and brought a completely new design, advanced safety systems and a modern engine range. (http://www.volkswagen.de.) By complying with the Euro 6 pollution standard, this model integrated state-of-the-art technologies for reducing emissions, reflecting the manufacturer's commitment to stricter environmental regulations. In short, the two vehicles are representative of Volkswagen's strategies from different periods. The Golf E4 symbolizes the evolution of the compact model, while the Passat E6 illustrates technological progress and a step towards more environmentally responsible mobility (URICANU, N., ET AL., 2011)

The technical inspection is performed only on road vehicles that are presented with: - the registration certificate or replacement proof of the registration certificate, issued by the police (duly completed with the necessary identification data); - the vehicle's identity card. (URICANU, N., 2011, ET AL).

The order of execution of the specified operations will be established by each station according to its own technological flow, except for identification, which will be the first operation performed. For each road vehicle presented for technical inspection, a technical inspection report is completed, corresponding to the category of the road vehicle. (PETRESCU ET.AL. 2012) The technical inspection report is recorded in the computer and in the Technical Inspection Records Register (until the date established by the Romanian Motor Registry). Road vehicles presented for technical inspection must be clean, especially the body, chassis, assemblies and subassemblies to be checked. They must be presented with tires inflated to the nominal pressure (VASILESCU, A.C., 1975).

Operations carried out within the ITP

1. Identification

Identification represents the verification of the identification number, engine code and series, as well as their comparison with those recorded in the vehicle's identity card. The identification number, or VIN (Vehicle Identification Number) code, is a combination of numbers and letters, and is stamped on the body or chassis of each vehicle (VIOREL CAZAN, ET AL, 2007). The area around the identification number must be clean, must not show traces of welding, rust, etc.(https://catalog-web.ro/de-ce-este-necesare-efectuarea-inspectiei-tehnice-periodice-ITP; https://promotortm.ro/service-auto/statie-ITP/). If the identification establishes the need for rejection for the reasons specified in the "Defects found" section, group code 200, it is prohibited to continue the technical inspection, the person who presented the road vehicle being directed to the Romanian Motor Registry office in the county in which the road vehicle is registered or to other legally authorized bodies. In this case, a new technical inspection is not accepted until after

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the problems that led to the rejection have been resolved for the reasons specified in code group 200 (AdBlue - Sistemul de tratare a emisiilor de NOx (SCR). Available on: http://www.eautomobile.ro/categorie-motor/19-diesel/140- adblue-motor-diesel-uree-scr.html).

The Periodic Technical Inspection (PTI) should not be the moment when you discover problems with your car, but only an official confirmation that the vehicle is in good working order. Car owners have a legal obligation to maintain their car properly between two visits to the PTI, so that there are no unpleasant surprises on the day of the inspection. Representatives of the Romanian Auto Registry (R.A.R.) have published a list of the main defects that can lead to a vehicle being rejected for inspection, many of which are easy to notice and without special equipment. "The Periodic Technical Inspection (PTI) is not an opportunity to find out if the vehicle is operating within parameters, but should only be an official confirmation of this fact. Starting from this idea, we remind you that the owner of a car has a legal obligation to maintain it in optimal working order between two visits to the PTI (WARNATZ, J.; ET AL, 2006).

We would like to give you some examples of possible non-conformities that you can observe yourself, without the need for professional equipment or much technical knowledge: - failure of certain components of the electrical lighting and signaling system; - failure of the horn; - visible smoke; - tire wear beyond the permitted limits; - failure of the wipers; - significant and repeated losses of fluids: oil, brake fluid, coolant, etc.; - increased wear of the brake pads and discs; - malfunctioning of the DPF; - the existence of illuminated warning lights on the dashboard; - the appearance of vibrations in the steering wheel at higher speeds; - decreased efficiency of the braking and steering systems; - cracks in the windshield, side mirrors, etc.; - failure of the handbrake; - general condition of the bodywork, degradation of some bodywork elements; - fluid leakage from the shock absorbers (https://www.lyonservice.ro/car-services/statie-ITP).

Needless to say, simply finding non-conformities is not enough to be sure that you are not putting yourself in danger when driving your vehicle. The defects must be remedied before the I.T.P. is carried out. In addition, if between two periodic technical checks you have replaced the engine, installed an LPG installation on the vehicle or changed its color, it is necessary to first go to a R.A.R. dealership, in order to make the necessary entries in the CIV", write the representatives of the Romanian Motor Registry on a social network. (Volkswagen Self Study Program 203 – The 1.0 Liter Petrol Engine with Camshaft in Block (OHV) – Design and Function, Volkswagen Self Study Program 233 – 2.0 Liter Engine – Design and Function).

MATERIAL AND METHODS

The technical inspection is performed only on road vehicles that are presented with:

-the registration certificate or the replacement proof of the registration certificate, issued by the police (duly completed with the data necessary for identification); -the vehicle's identity card. The order of execution of the specified operations will be established by each station according to its own technological flow, except for identification, which will be the first operation performed. For each road vehicle presented for the technical inspection, a technical inspection report is completed, corresponding to the category of the road vehicle. The technical inspection report is recorded in the computer and in the Register of evidence of technical inspections (until the date established by the Romanian Auto Registry).

Road vehicles presented for the technical inspection must be clean, especially the body, chassis, assemblies and subassemblies to be checked. They must be presented with tires inflated to the nominal pressure.

EQUIPMENT REQUIRED FOR NOXES DETERMINATION

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Engine temperature reader

Instead of the oil dipstick, a wire temperature probe with an adjustable stop is inserted, the distance is adjusted depending on the length of the dipstick, as well as an engine speed reader through a magnetic tip detonation sensor, which, depending on the number of engine cylinders, transmits the engine speed to the gas analyzer. The gases are analyzed only if the engine temperature is at least 8000C, because a lower temperature can influence the characteristics of the analyzed gas. The engine speed must be transmitted to the analyzer because the gas measurement is performed at idle as well as in accelerated mode 2000-3000 RPM (in the case of spark ignition engines). In the case of MAC (compression ignition engines), the gas measurement is performed at maximum speed, given by the throttle controller.

Computer

The vehicle data has been entered into the computer. The computer used in the auto repair shop to enter vehicle data is often referred to as a "workshop management system" or "auto repair shop management software". This type of software allows technicians and staff to record vehicle information, including:

Vehicle identification data: license plate number, VIN (vehicle identification number), make, model, and year of manufacture.

Maintenance history: previous services performed, repairs, parts replaced, and any other interventions.

Appointments: manage maintenance or repair appointments.

Billing: generate invoices and manage payments.

Parts inventory: track the stock of spare parts and consumables.

Reporting: generate reports on workshop performance, revenue, and costs.

This type of software improves the efficiency of workshop operations and helps maintain an accurate record of all activities related to customers' vehicles. There are several software solutions available on the market, each with specific features to meet the needs of different types of car services.

Opacimeter (opacimeter chamber). The opacimeter has the role of creating a vacuum and drawing a quantity of gases from the drum. The sucked gas is passed through a light beam and a photocell, thus measuring the quantity of soot in the gas. The unit of measurement is m^{-1}. The limit values of opacity are established according to the engine's pollution standard. When measuring opacity, two engine accelerations are made, one to determine the maximum speed and one to measure the opacity at maximum speed. The text presented describes the main aspects of exhaust gas opacity, including the mechanism of carbon particle formation during the combustion process and the impact of opacity on the degree of pollution. It also presents the evolution of the standards regarding the level of nox emission in grams per kilometer, as well as the device used to measure exhaust gas opacity, called an opacimeter.

Opacimeter - is a device used to measure the luminous opacity of a gas. It is based on the partial flow principle. It consists of a tube-shaped measuring chamber, which allows the determination of the opacity of exhaust gases.

Opacimeter component: -Measuring chamber: tube with a length of 182 mm and a diameter of 20 mm. A gas sample taken from the engine exhaust gases is used. The optical part of the device is composed of: beam splitter; converging lens. Mirror, which provides an optical measurement length of 364 mm, double the length of the measuring chamber. The light beam used in measuring the opacity of the exhaust gases has the ability to act exclusively on the carbon particles suspended in the measuring chamber.

The electronic part of the opacimeter consists of three essential blocks:

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Electronic block: This is responsible for performing the algorithms necessary to determine the opacity of the gases.

Control device: This block controls the fans and the heating circuit of the measuring chamber, ensuring optimal conditions for the measurements performed.

Electrical power circuit: It guides the safety and consistent operation of the device**.**

The opacity value is expressed in percentages, representing the level of obscurity on a scale from 1 to 100. This can be reported in terms of the light absorption coefficient in units of M^-1 or in percentages (%). Examples of opacity values and their equivalences are as follows:0 % = 0 m^-1, 64 % = 2.5 m^-1; 71 % = 3 m^-1; 99 % = 11.31 m^-1

Procedures for determining opacity

To determine opacity, two distinct procedures are used:

Technical inspection procedure (ITP) and roadworthiness test: This is used to assess whether a vehicle is in good working order and complies with the pollution regulations in force.

Vehicle type-approval procedure: This process is intended to verify opacity for the official approval of vehicles, thus ensuring that they comply with legal standards regarding gas emissions.

These procedures are crucial for maintaining an environmentally friendly and high-performance fleet.

Requirements for measuring equipment

The opacimeter for technical inspection stations for vehicles equipped with DIESEL engines must meet certain technical specifications to ensure accurate and efficient measurement of exhaust gas opacity. Here is a detailed overview of the requirements:

Accuracy: The opacimeter must allow partial flow measurement according to the UN R 24 EEC standard, with a minimum accuracy of ±0.3 m^-1. This ensures that the values obtained are reliable and compliant with regulations.

Measuring chamber: The opacimeter's measuring chamber must be mobile, which facilitates its use in different conditions and for different types of vehicles.

Temperature measurement:

The opacimeter must be equipped with appropriate instruments for measuring the inlet temperature of the exhaust gases.

It must be able to display the equivalent opacity value at the standard temperature of 100°C, in order to allow comparison of values obtained under uniform conditions.

Additional devices:

Engine oil temperature measurement: It is important to have a device to monitor the temperature of the engine oil, as this can influence engine performance and emissions.

Engine speed determination: The opacimeter must have a device that allows the engine speed to be measured, regardless of the diameter of the injection pipes. This ensures that the measurements are accurate and relevant, regardless of the engine configuration.

Printer: The opacimeter must be equipped with a printer to be able to generate measurement reports, which are essential for documenting technical inspections and providing evidence in the event of controls.

These features are essential for an opacimeter used in technical inspection stations, ensuring that the measurements are accurate and in compliance with the regulations in force.

Gas suction probe

The gas sampling probe must have a length not exceeding 1 m and a diameter of 10 mm for vehicles with a maximum authorized total mass of up to 3.5 tons. The device program will comply with the provisions of the RNTR and must allow the measurement of the base time.

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The gas suction probe is inserted into the exhaust pipe of the car.

The opacity limit values for the aspirated engine are Kmax = 2.5 m^{-1}.

For supercharged engines (with turbo):

Kmax = 3 m^{-1} (for engines with pollution standards E0 – E3).

Kmax = 1.5 m^{-1} for E4-E5 engines.

Kmax = 0.7 m^{-1} for E6.

Exceeding the opacity coefficient limits is due to technical problems of the engine as well as due to subsequent changes in engine power or modification of the exhaust system.

RESULTS AND DISCUSSIONS

Comparison of 2 cars, both VW brand, Passat E6 vs Golf E4.

The Volkswagen Passat E6 refers to the sixth generation of the Passat model, which was produced between 2005 and 2010. This generation was available in both sedan and estate (Variant) versions and brought numerous improvements over its predecessors.

Key features of the VW Passat E6:

Design: The Passat E6 has an elegant and modern design, with clean lines and an aerodynamic silhouette. The cabin is spacious and comfortable, with an emphasis on quality and finishes.

Engines: It was available with a wide range of gasoline and diesel engines, including turbo options. Diesel engines are appreciated for their efficiency, while gasoline engines offer good performance.

Technology and Safety: The Passat E6 was equipped with advanced technologies for its time, including navigation systems, Bluetooth connectivity, and various safety features such as multiple airbags, ABS, and stability control.

Comfort: The interior is well thought out, offering enough comfort features such as heated seats, automatic climate control, and various customization options.

Performance: The model offers a pleasant driving experience, with a suspension that absorbs bumps well and a precise steering system.

Common Problems: Like any vehicle, the Passat E6 can have certain problems, some of the most common being related to the electrical system, turbo problems, or premature wear of some mechanical components. It is important to perform regular maintenance to prevent these problems.

The Golf E4 refers to the fourth generation Volkswagen Golf model, which was produced between 1997 and 2006. This generation brought many improvements over its predecessor, the Golf III, and was well received by the public due to its modern design, performance and efficiency.

Key features of the Golf E4:

Design: The Golf IV had a more rounded and aerodynamic design compared to previous models. It was available in several body styles, including three- and five-door hatchbacks, as well as a station wagon (Variant).

Engines: It was offered with a wide range of petrol and diesel engines, including 1.0L to 2.8L units for the GTI models. The diesel engines were appreciated for their fuel efficiency.

Performance: The GTI model, in particular, was well received for its sporty performance, featuring a stiffer suspension and a more powerful engine.

Safety: The Golf IV was equipped with several safety features, including front and side airbags, ABS and traction control.

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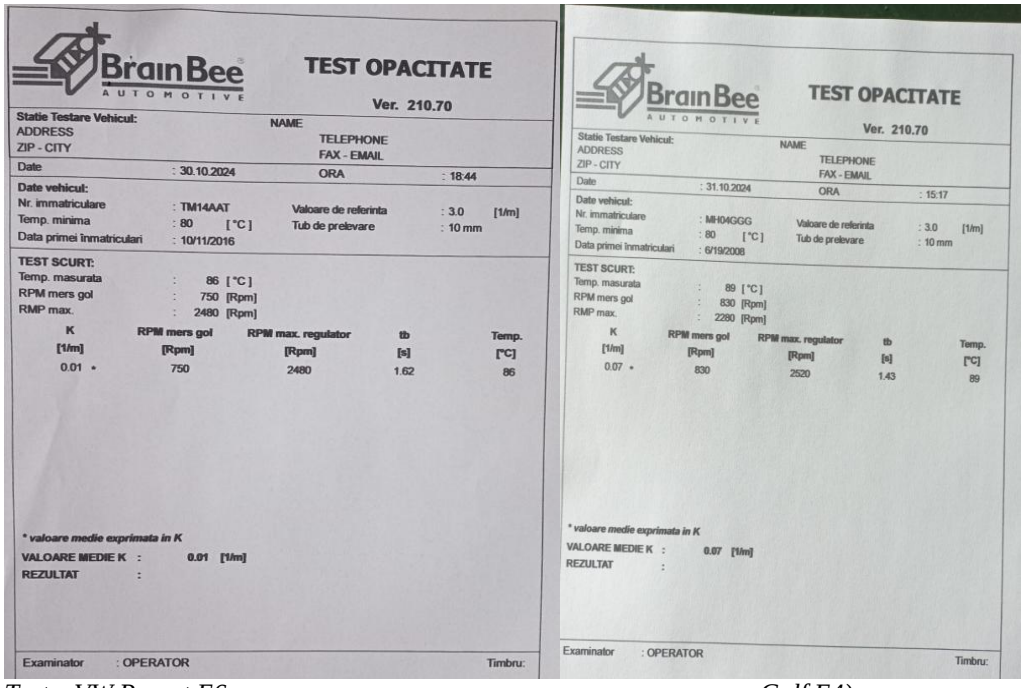
Interior: The interior was designed for comfort and ergonomics, with quality materials and a functional design. Passenger and luggage space was also well thought out.

Technology: Depending on the equipment, the Golf IV was equipped with various technology options, including audio systems, automatic climate control and navigation.

Popularity:

The Golf IV was a popular model in markets around the world and helped to solidify Volkswagen's reputation as a quality car manufacturer. It was also the basis for the development of the successful Golf V, which continued the successful tradition of the Golf series.



BrainBee AUTOMOTIVE

TEST OPACITATE

Ver. 210.70

Statie Testare Vehicul:
ADDRESS
ZIP - CITY
NAME
TELEPHONE
FAX - EMAIL

Date : 30.10.2024 ORA : 18:44

Date vehicul:
Nr. immatriculare : TM14AAT
Temp. minima : 80 [°C]
Data primei inmatriculari : 10/11/2016
Valoare de referinta : 3.0 [1/m]
Tub de prelevare : 10 mm

TEST SCURT:
Temp. masurata : 86 [°C]
RPM mers gol : 750 [Rpm]
RMP max. : 2480 [Rpm]

K [1/m]	RPM mers gol [Rpm]	RPM max. regulator [Rpm]	tb [s]	Temp. [°C]
0.01 *	750	2480	1.62	86

* valoare medie exprimata in K
VALOARE MEDIE K : 0.01 [1/m]
REZULTAT :

Examinator : OPERATOR Timbru:

BrainBee AUTOMOTIVE

TEST OPACITATE

Ver. 210.70

Statie Testare Vehicul:
ADDRESS
ZIP - CITY
NAME
TELEPHONE
FAX - EMAIL

Date : 31.10.2024 ORA : 15:17

Date vehicul:
Nr. immatriculare : MH04GGG
Temp. minima : 80 [°C]
Data primei inmatriculari : 6/19/2008
Valoare de referinta : 3.0 [1/m]
Tub de prelevare : 10 mm

TEST SCURT:
Temp. masurata : 89 [°C]
RPM mers gol : 830 [Rpm]
RMP max. : 2280 [Rpm]

K [1/m]	RPM mers gol [Rpm]	RPM max. regulator [Rpm]	tb [s]	Temp. [°C]
0.07 *	830	2520	1.43	89

* valoare medie exprimata in K
VALOARE MEDIE K : 0.07 [1/m]
REZULTAT :

Examinator : OPERATOR Timbru:

Teste VW Passat E6 *Golf E4)*

To compare the emissions of the Volkswagen Passat E6 and the Volkswagen Golf E4, we need to look at the technical specifications and emission standards of each model.

Volkswagen Passat E6

Emission standard: Euro 6

Engine: Available in various petrol and diesel variants, each with different CO2 and NOx emissions.

NOx emissions: Euro 6 diesel models are designed to have low nitrogen oxide emissions, usually below 80 mg/km, but these values can vary depending on the engine and exhaust gas treatment technology (e.g. use of the SCR system with AdBlue).

Volkswagen Golf E4

Emission standard: Euro 4

Engine: Also available in petrol and diesel variants, but with older technologies.

NOx emissions: Euro 4 models have higher NOx emissions compared to Euro 6, usually around 180 mg/km for diesel models.

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Comparison

Emissions control technology:

The Passat E6 uses advanced technologies to reduce emissions, including particulate filters and SCR systems.

Golf E4, fiind un model mai vechi, are tehnologii de control al emisiilor mai puțin eficiente, ceea ce duce la emisii mai mari de NOx.

Environmental impact:

The Passat E6 contributes to lower pollution due to stricter emission standards, making it more environmentally friendly.

The Golf E4, with higher NOx emissions, has a higher environmental impact.

Regulations and taxes:

In most countries, Euro 6 vehicles benefit from lower taxes and incentives for low-emission vehicles, while Euro 4 vehicles may be subject to higher taxes and restrictions in cities.

CONCLUSIONS

Although both models marked important eras in Volkswagen history and were appreciated for their reliability and quality, the Volkswagen Passat E6 is clearly superior in terms of environmental performance. This superiority is due to the Euro 6 pollution standard, which imposes much stricter limits on emissions, compared to the Euro 4 standard of the Golf E4.

Thus, the major difference between the two cars lies not only in the different class (family vs. compact), but, more importantly, in the exhaust gas treatment technology, which has evolved significantly between the years of production of the two models.

Consequently, the Passat E6 represents a more environmentally responsible choice and, in the long term, may be more economically advantageous, by avoiding the high taxes and traffic restrictions imposed in certain cities on more polluting vehicles.

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