Methods for revealing removed and illegible identification markings on metal substrates on the example of vehicle VIN number fields

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Abstract

The following article represents a summary of knowledge on: the legal basis of vehicle marking, the structure of the VIN (Vehicle Identification Number), how VINs are applied and how they are displayed on metal surfaces. The knowledge and subject matter summarised are derived from practical aspects and the most commonly used methods.

Keywords: methods of revealing markings, removed markings, number fields, identification markings, VINs, metal substrates, markings falsification, markings alteration, markings counterfeiting

Introduction

The trigger for writing this article was an expert opinion I provided to determine how and with what methods illegible, corroded VINs on a truck chassis can be read. Disclosure of removed and illegible markings takes place when there is a need to establish the authenticity of a marking or to determine whether there has been an attempt to alter it. Over the last few decades, there has been a huge demand on the Polish automotive market. The high demand for cars resulted in an increase in theft and this negative social phenomenon exists in parallel with the development of the automotive market. In the last few years, as a result of the expansion of the European Union's borders, Polish society has gained an increased opportunity to purchase vehicles originating from other countries of the old continent. The main factor determining the attractiveness of such vehicles is, of course, their price. Statistical data shows hundreds of thousands of vehicles imported from abroad, a significant expansion of the Polish automotive market. The demand for cars has led to an increase in thefts and this phenomenon is almost always accompanied by counterfeiting, involving the alteration, or removal of identification markings. This study focuses, for example, on the most common means of forgery and methods of discovering removed characters.

Legal basis for marking vehicles

Currently, the legal basis imposing the obligation to affix identification markings to vehicles is Article 66 section 1 item 3 of the Road Traffic Law of 20 June 1997, which stipulates that a vehicle participating in road traffic should have the following identification markings assigned by the manufacturer, subject to Article 66a:

1. the VIN or the number of the body, chassis or frame;
2. engine number.

Detailed regulations on the VIN,including its location, are provided in relevant appendices to the Regulation of the Ministry of Infrastructure on vehicle registration and marking. §11.1 of this regulation reads:

A motor vehicle shall be equipped with:

3. a vehicle identification number (VIN) or a body, chassis or frame number permanently affixed to the body, frame or other similar basic structural element, and a nameplate as specified in appendix 4 to the regulation;

a VIN shall not be required for a vehicle registered before 1 January 1995 and for a motorbike registered for the first time before 2003, a tractor, a free-running vehicle, a trailer intended to be coupled with these vehicles, and a vehicle with a body/chassis number assigned and stamped in accordance with separate provisions;

4. the number on the engine.

A Vehicle Identification Number (VIN)

Components and structure of the VIN

VIN (*Vehicle Identification Number*) – a vehicle identification number assigned and affixed by the manufacturer. Before 1981, there was no accepted standard for this number and manufacturers used various formats. The modern VIN is composed of 17 characters – digits and letters, excluding the letters I, O and Q. The VIN can be found on the vehicle registration certificate, in the box marked E and on the bodywork below the driver's side window.

The VIN on the vehicle registration certificate should be the same as the number on the individual components of the car. According to a regulation of the European Union, the VIN is placed on the right side of the vehicle.

The VIN was first introduced in 1954, in the USA. In the early years, until 1981, there was no uniform format for writing VINs, and different vehicle manufacturers used different forms of writing this information. This state of affairs proved unacceptable in view of the increasing number of vehicles, so it was decided to regulate it and align the VIN assignment with global ISO standards. Following its introduction, manufacturers who made vehicles for the US market very quickly adapted to this standard. The ISO standards agency introduced recommendations for the use of the VIN standard and its structure and in Europe the number of the body was used, but the sets of information it contained were introduced gradually. For example, Volkswagen started to encode more information between 1995 and 1997, and a check digit between 2009 and 2015 for selected models in the group. The check-digit in the VIN is also used, although not for all brands and models – in European vehicles it is found for example in Audi A1.

There are two ways of recording the vehicle identification number. The ISO 3779 standard, implemented in 1981, is used in the European Union for the content and structure of the VIN, while in North America a more stringent format (including a check digit) but compatible with the European one is used. Previous ISO standards for the VIN are ISO 4030, concerning the location and fixing of the VIN, and ISO 3780, concerning the global standardisation of the first section of the VIN, the WMI.

The VIN consists of the following sections:

<table>
<tr><td>Standard</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td></tr>
<tr><td>ISO 3779</td><td colspan="3">WMI</td><td colspan="6">VDS</td><td colspan="8">VIS</td></tr>
<tr><td>North America</td><td colspan="3">Identification of the manufacturer</td><td colspan="5">Type attributes</td><td>Check digit</td><td>Year of manufacture</td><td>Plant code</td><td colspan="6">Numer egzemplarza
Vehicle number</td></tr>
</table>

World Manufacturer Identifier (WMI) – the first three positions of the VIN, with which the region and name of the vehicle manufacturer are coded. WMI regions – the first WMI symbol identifies the region in which the manufacturer is located. In practice, each number is assigned to a manufacturer's country. The next 2 symbols identify the manufacturer. This is most often the code that SAE has officially assigned to countries and manufacturers. **The Vehicle Descriptor Section (VDS)** are the characters at positions from 4 to 9. They specify the type of vehicle. They are used in accordance with local regulations to identify the type of vehicle and may contain information about the design and type of body. Each manufacturer has its own system for using this field. Check digit (North America). The element in the 9th position acts as the VIN check digit for North American vehicles. As of 6 July 2022, Commission Implementing Regulation (EU) 2021/535 of 31 March 2021 entered into force. The rule, which

repeals EU Regulation No. 19/2011, establishes, for example, new technical parameters for the manufacturer's nameplate and vehicle identification number (VIN).

The Vehicle Identifier Section (VIS) is made up of the characters on positions from 10 to 17. These are used to assign a unique number to a specific vehicle. The VIS is used by the manufacturer in the event of complaints. It includes information on installed options, engine, drive type; however, it is often simply an ordinal number automatically assigned to the next vehicle to come out of production. The last four characters are always digits.

Year of manufacturing in North America – the character in position 10 is used in North America to code the year of manufacturing.

Manufacturer's plant code – the character in position 11 is used in North America to code the manufacturer's plant. Each manufacturer has its own marking system, but its position in the VIN is fixed.

Location of the VIN

Vehicle manufacturers place the VIN in visible and easily accessible places on the right side of the vehicle at the front of the vehicle if possible. In the US, regulations require the VIN to also be located inside the passenger cabin (behind the windshield near the A-pillar on the left side – known as the public VIN).

If the vehicle has a frame, the number is affixed to the frame, the general rule is that the part on which the VIN is affixed should not be easily replaceable. In practice, the numbers are placed in: the engine compartment on the partition wall, the belt under the window (Lexus GS), the front suspension mounting dome (BMW), under the front passenger seat (Toyota, Mercedes, Ford, Opel, Tesla), on the frame behind the right front wheel (Iveco, Land Rover), in the rear luggage compartment (Audi Q7). It may happen that in new or rare car models the expert does not know where the factory VIN is or was located. The FAVI (Forensic Aid in Vehicle Identification) database, created and maintained by experts from the Central Forensic Laboratory of the Police in Warsaw, is very helpful, and in some cases invaluable, as it allows the expert to determine the exact location of the VIN.

Ways of affixing VIN to vehicles: stamping, burning, embossing, and other techniques

The ISO standard specifies the range of character sizes that make up the body number. In all cases, the letters and digits that make up the VIN shall be legible, durable and difficult to reshape. The shape, method and technique of manufacture, the layout of the characters and their positioning depend on the manufacturer. In practice, manufacturers use the following techniques to produce VINs: milling, embossing, burning (electro-spark or laser technology), punching (mechanical, spot, manual), chiselling.

Milling – the application of characters using a computer-controlled milling machine. Visually, it is not possible to clearly distinguish this method from characters stamped using special numbering machines. Only visual inspection under suitable magnification makes it possible to distinguish between these techniques. The milling technique is difficult to counterfeit and counterfeiting of characters is easily detected.

Embossing – a technique of placing characters with a device that works using a press consisting of two dies with positive and negative signs placed opposite each other in exactly the same place, the signs on the positive and negative dies are convex on one part of the die and concave on the other part. After embossing, a convex character is formed on a sheet of metal. The limitation on the use of this method is the thickness of the material on which the characters are applied, hence it is mostly used for the production of nameplates. Nowadays, nameplates are often made of multilayer plastic material and the characters are laser burned.

Laser burning – In laser marking, the marking is applied directly to the surface using an intense pulsed laser beam. The interaction of the focused beam with the surface causes material modification – for example, discolouration, structuring, engraving or material loss. The way in which the material is modified depends largely on the laser wavelength, the pulse time and the power density of the laser beam at the focus. It is the method that has superseded the electrodeposition method.

Electrodeposition – special devices equipped with electro-depositors are used to apply characters using the electrodeposition method. When the metal surface is touched, an electric arc is produced which causes surface melting of the material. The surface changes of the material are small, do not go deep into the material and do not affect the strength of the structure, but they can easily be removed and are very susceptible to corrosion.

Punching (by hand and with composite markers) – the former was done with numbering machines that were the 'negative' of the sign, creating a concave-'positive' imprint of the sign on the surface. During hand-punching,

the signs are created with different strength and therefore vary in depth. This type of marking is hardly used anymore and has been superseded by automated punching with composite markers using high-precision automatic numbering machines. This allows all numbers to be aligned and punched with uniform depth.

Chiselling – a relatively new technique used on more expensive car models. The creators of this technique claim that it is impossible to counterfeit. Chiselling means cutting out a sign with a stylus. The mechanism for creating the sign is similar to that of the chisel, however, it is done by a special device that 'carves' the sign into the metal. The shape of the sign is so characteristic that it is very easy to distinguish the real sign from the fake one. At the bottom of the sign it can be very clearly seen where exactly the stylus has finished its work.

Types of VIN counterfeiting

Many experts find it difficult to distinguish between counterfeiting and alteration of vehicle identification markings, as the knowledge of techniques, manufacturing methods, typefaces of letters, numbers and characters is extensive and can change over time depending on the model and the country in which the vehicle is manufactured. Counterfeiting means creating a completely new series of characters, whereas alteration refers to the change in the content of individual characters or elements of the identification mark.

Forgery by counterfeiting includes:

- cutting out the entire content of the VIN markings,
- counterfeiting by scraping off the entire content of the genuine markings,
- thermal removal of the content,
- covering up of original markings,
- replacement of entire components with identification markings.

Forgery by alternation includes:

- changing the content of individual characters,
- perforation of individual characters or parts of characters,
- cutting out parts of the identification markings,
- covering up part of the original markings.
- changing the order of the original markings and characters.

Methods of revealing removed and illegible markings

In order to make it more difficult to identify a stolen vehicle, criminals usually try to remove the VIN characters and then apply new, legalised markings. The method used to remove the metal layer with the VIN depends on the criminal's ingenuity and the tools at their disposal, which may include primitive manual methods such as a chisel, cut-off tool, file, hammer, punch or grinder. Disclosure of removed characters is possible when the structure of the deformed metal has not been breached and the layer removed is not too large and does not go too deep. Fig. 1 – shows a diagram of the material structure after the character stamping process. Metals and their alloys have the ability to deform plastically. Plastic deformation carried out 'cold', e.g. the stamping of a sign with a numbering machine, causes crushing which changes the physical and mechanical properties of the material and alters its structure. In accordance with the direction and reversal of the applied force, the metal grains are bent and compacted below the bottom of the stamped sign (dashed line). The phenomenon of compaction of the material structure allows for the use of examination methods to reveal the removed number.

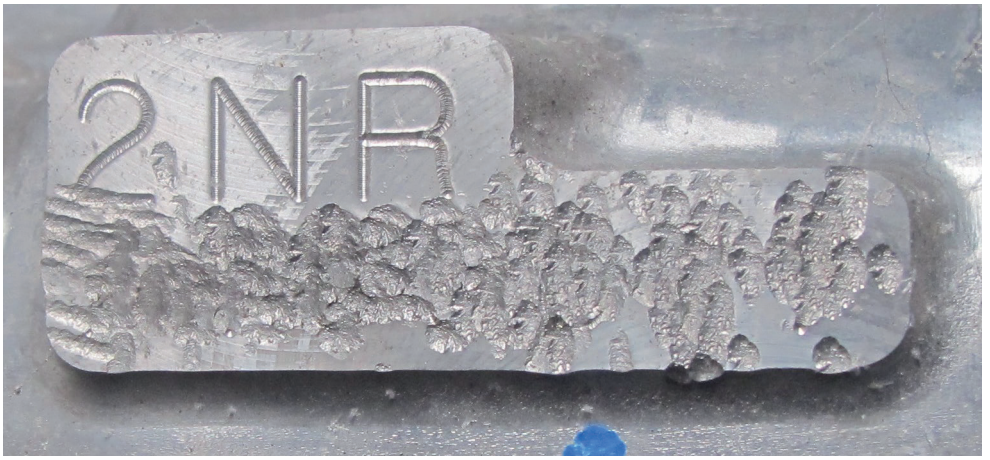

Fig. 1. The method of welding the number field or the relatively deep removal of characters made by chiselling or laser-burning causes irreversible changes and the inability to reveal the removed characters.
Source: own resources

Research methods

The basic types of testing are non-destructive and destructive. Pursuant to Article 207 of the Code of Criminal Procedure § 2 – 'If an object may be destroyed or disfigured during the test, a part of this object should, if possible, be preserved in an unchanged state, and if this is not possible, this state should be preserved in another way. This is why we always start our tests with non-destructive methods; if the results of our work in revealing the number and after exhausting all available possibilities prove unsatisfactory, only then do we proceed to destructive testing. Prior to the testing, we secure the object in an unaltered state, for example with silicone masks and photographs.

Not every mechanoscopic testing laboratory is equipped to use all the methods for non-destructive testing, including: visual method, magnetic method, optical method, eddy current method, X-ray method, ultrasound method. The focus here is on two methods commonly used in forensic laboratories.

Visual method of testing – in this method experts use their eyes, a magnifying glass, a microscope, lighting, a lamp with an ultraviolet light source, measuring instruments. At this stage of the testing, it can be determined whether the vehicle's markings have been counterfeited or whether additional tests need to be carried out to determine this. Magnetic method – also known as magnetic powder defectoscopy or magnetic powder method. It involves the use of a permanent-magnetic defectoscope consisting of two magnets connected by a cable. A suspension of a special ferromagnetic powder is applied to the surface of the examined number field. The magnetic field exerts a force on the powder particles directed towards the surface of the examined material, causing them to accumulate in clusters that reflect in their shape the defects, deformations and, in this case, the content of the removed number. Before conducting this test, the number field must be prepared by: thoroughly degreasing the surface, polishing, positioning the magnets in two directions, along and across the number field, thoroughly mixing the suspension and evenly spraying the entire number field, visual inspection of the number field should be checked under suitable, strong lighting – preferably side lighting. The test results should be documented photographically. The advantages of this method, apart from the fact that it is non-destructive, include the ease of execution, the direct legibility of the results, the possibility of repeated testing, the safety of use, and the possibility of reading characters that have been ground to a considerable depth. The disadvantages of this method include the fact that it only works with ferromagnetic surfaces, the shape and size of the magnets restricts the use of this method in all places, and in the case of reworked characters, the test result cannot be interpreted unambiguously.

Destructive testing includes such methods as the chemical method, electrochemical method and recrystallisation method.

Chemical method – the method most often used in practice due to its simplicity and high efficiency; it is economical and does not require expensive apparatus or materials. A variation of this method is the electrochemical method, differing only by the fact that the etching process is accelerated by means of direct current. The chemical method consists of treating the surface of the number field with suitable chemical reagents. The basic rules to be followed when conducting tests using this method are: making photographs and silicone casting (a requirement

under Article 207 of the Code of Criminal Procedure), preparation of the surface by cleaning, degreasing and smoothing with papers of possibly low gradation, use of unspecified reagents, disclosure taking place at room temperature, use of sidelight, photographic documentation should be kept up to date – there is a possibility that the revealed characters may disappear, when the characters disappear, the field should be washed with distilled water. Most importantly, OHS regulations should be followed during the testing, the tests should be conducted outdoors, the vapours of the chemical reagents are very harmful to the respiratory tract and highly reactive on contact with the skin. An example of revealing a removed VIN in Photos 1 and 2 and a removed gearbox number from a car made by Toyota is shown in Photos 3, 4 and 5 – Adler II solution was used to reveal these numbers. The advantages of this method, apart from its effectiveness, include its simplicity, as it does not require specialised equipment, it can be carried out outside the laboratory and is cost-effective. The disadvantages of this method are that it is not very effective on cast iron engine blocks, the method cannot be repeated – it is destructive, and there is the possibility of damaging other parts of the vehicle including the body. The most popular compounds currently used to reveal removed characters on metal substrates (steel and aluminium) made by chemical and electrochemical methods include Adler's reagents I, II and III and sodium hydroxide solution (aluminium). For the etching of alloyed and acid-resistant steels, highly corrosive royal water (90 ml of concentrated hydrochloric acid and 30 ml of concentrated nitric acid) is helpful.

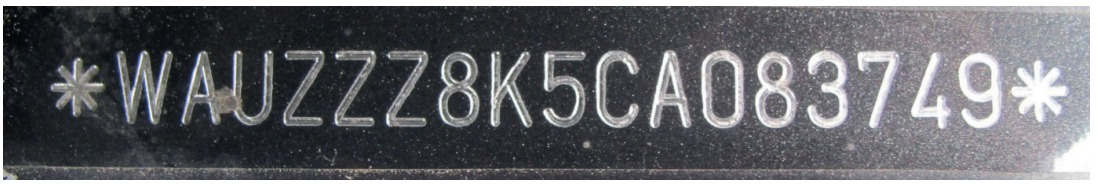

Fig. 2. VIN before etching.
Source: own resources

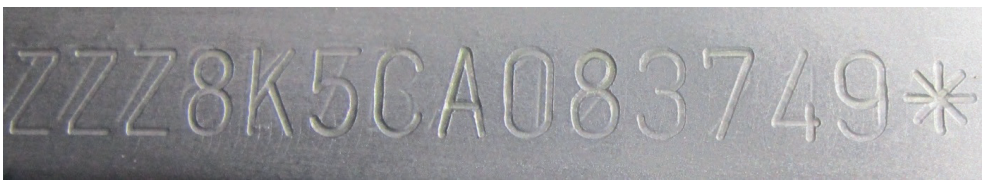

Fig. 3. VIN after etching with Adler II reagent.
Source: own resources

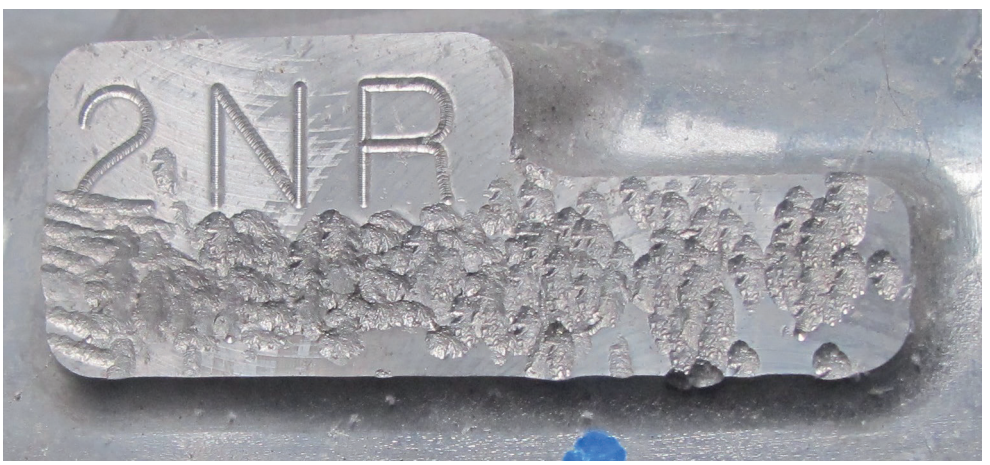

Fig. 4. Number field of the gearbox before testing.
Source: own resources.

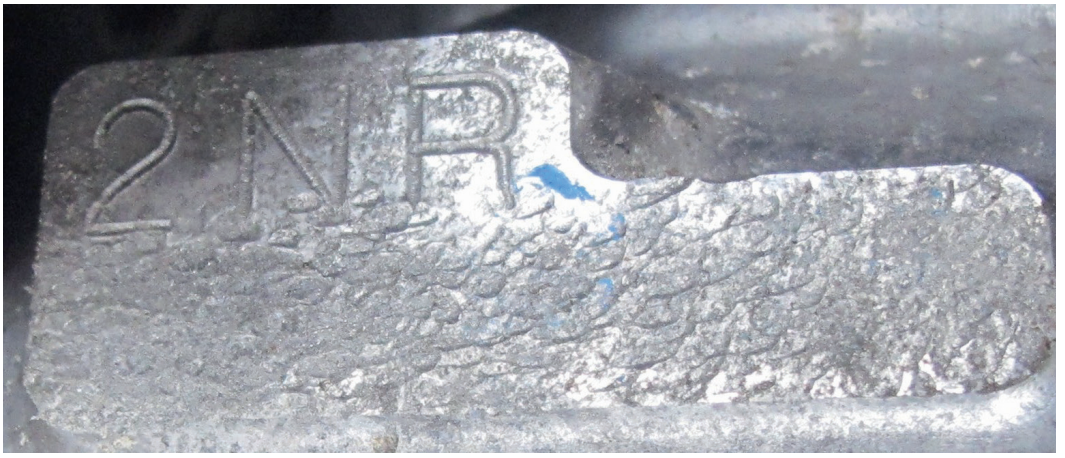

Fig. 5. Number field during testing after initial surface grinding.
Source: own resources

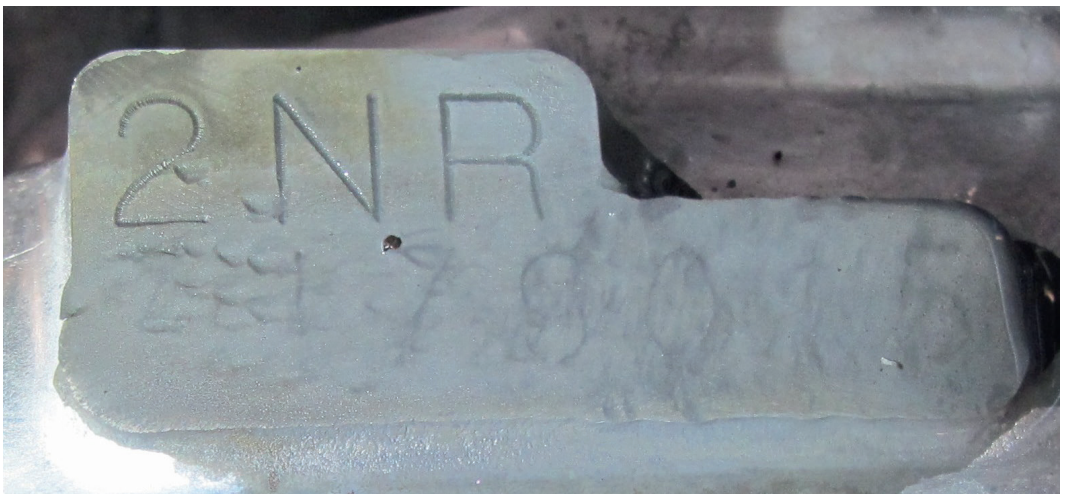

Fig. 6. Number field during etching with Adler II reagent.
Source: own resources

Conclusions

When working to uncover removed identification characters, each expert develops their own method based on their knowledge and experience. The practical knowledge of experienced experts often comes in handy. As I mentioned in the introduction, the subject of this article is the question of what action needs to be taken to reveal an illegible VIN on the vehicle frame. The answer is provided in the body of this article. For example, motor vehicle diagnosticians carrying out technical vehicle examinations very often have problems with reading the VIN due to excessive corrosion in the areas where the VIN is located. This phenomenon is known as stress corrosion cracking and occurs at points of 'cold' plastic deformation where the stamped characters are located. The methodology undertaken by diagnosticians in their attempts to read the VIN number permanently affixed to the vehicle does not prohibit any of the methods mentioned in this publication, provided the vehicle is not damaged. It is known that the phenomenon of car theft is inextricably linked to the counterfeiting of identification markings. Many people are involved in car crime, including diagnosticians who certify false documents. The law enforcement authorities are very sensitive to such actions, a fact that is reflected in charges brought against diagnosticians.

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