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Corrosion validation of a nut used in automotive headlights

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Abstract. The article presents a real-life situation from the industry, namely the validation of a support nut from an automotive headlight. The validation of this product is based in particular on corrosion, as corrosion is quite common with this product. Corrosion is an electrochemical interaction between metal and environmental factors such as water, oxygen, and road salts (especially in cold climates). Corrosion-induced deformation changes the lamp's aim. A corroded headlight nut may lead to misalignment of the headlamp (poor beam, safety risk), vibration or even detachment — similar in consequence (though lower in scale) to structural bracket failures in suspension.
Keywords: *Corrosion validation, automotive headlights, salt spray tests, saline environment*

Introduction

Metal corrosion includes chemical, electrochemical (galvanic, pitting, crevice) and biochemical corrosion caused by microorganisms. Corrosion can also be uniform across the entire surface or localized on only part of the surface.
Depending on the initiation mechanism, corrosion can be generated by friction, erosion, cracking, or it can be selective in the sense that it affects only certain elements in an alloy—e.g., dezincification, where only zinc is affected in brass, not copper.
Corrosion in a saline environment is electrochemical corrosion, as the saline environment is an electrical conductor and corrosion is accelerated by the presence of salt. Salt reduces the resistance of the metal surface layer and increases the electrical conductivity of the environment, facilitating electrochemical reactions.
Corrosion of metals is closely related to the absorption of water in metal joints. Corrosion of a substrate leads to rapid failure of the bonded joint in a short period of time and is thus a critical aspect. Corrosion often progresses rapidly, especially when other corrosion-promoting substances (e.g., salts, acids, bases, etc.), in addition to water, can attack from the outside or are present in the adhesive itself. However, this effect can be controlled in many cases by protecting the entire substrate, and particularly the bonded joint.

Corrosion is a very challenging issue in metal industry
Corrosion to evaluate how well protective strategies like coatings and passivation layers are at protecting metals from harsh environments. [[https://standards.globalspec.com/std/10150236/iso-9227]]
SALT SPRAY TESTS – tests the resistance to corrosion in an artificial saline environment performed on materials, assemblies, or surface coatings.
History - The USA is the pioneer in salt spray testing, with the first mention of such a test appearing in 1914 within the ASTM- American Society for Testing Materials International.
The official ASTM B117 standard – Standard Practice for Operating Salt Spray (Fog) Apparatus (Neutral salt spray/NSS NaCl 5%, pH neutral) was published in 1939 and remains the main reference standard. Such tests, which validate the resistance of materials in corrosive conditions, have been carried out and are necessary in various industrial sectors, both in Japan, where JIS Z 2371 is a reference standard in this field, and in Europe. In Europe, the equivalent of the ASTMB 117 standard is ISO 9227/DIN EN ISO 9227, which appeared in 1990. Between 2000 and 2025, ISO 9227 was revised and remains the basic standard with updates added – test variants corresponding to other known methods (besides NSS) such as AASS – Acetic acid salt spray – NaCl and acetic acid, CASS - Copper Accelerated Acetic Acid Salt Spray [https://www.gester-instruments.com/salt-spray-chamber-astm-b117] [https://standards.globalspec.com/std/10150236/iso-9227]
This standard serves a wide variety of industries, from automotive and aerospace to construction, consumer goods, and surface coatings. Thus, the salt spray tests performed by OEM manufacturers in Europe comply with DIN EN ISO 9227, and for the approval/validation of the resistance of parts/coatings, manufacturers define target hours and acceptance criteria depending on the intended use of the tested samples/products. Automotive products from BMW, Renault, Daimler, Volvo, Volkswagen, etc. use ISO 9227 as a basis in combination with their own internal specifications, which specify target hours and acceptance criteria. The standard is also used as a basis for validating component/subassembly suppliers. [https://www.ascott-analytical.com/test-standards/pv-1209/]
Chamber construction, testing procedure and testing parameters are standardized under national and international standards, such as ASTM B 117 and ISO 9227. These standards describe the necessary information to carry out this test; testing parameters such as temperature, air pressure of the sprayed solution, preparation of the spraying solution, concentration, pH, etc. Wikipedia.
The standards ensure/establish testing methods, equipment specifications for the spray chamber, testing conditions – parameters such as the composition of the saline solution, temperature, humidity, deposition rate, sample preparation – surface preparation and orientation in the test chamber, evaluation of results – criteria for assessing the degree of corrosion. (https://www.q-lab.com/education/introduction-corrosion)
Corrosion testing comprises two kinds of tests: natural outdoor testing and accelerated laboratory testing. They are complementary and form a complete corrosion test.
An usual way to to test products' corrosion resistance is in laboratory test chambers. orrosion testing can accelerate the forces of corrosion in a controlled lab environment, to provide faster results about corrosion resistance.
The benefits of accelerated corrosion testing are that it is relatively quick compared to exposure to atmospheric conditions, it is repeatable,
Advantages - increase in product life span, by evaluating corrosion resistance
Save material costs: Avoid premature failure, long-term resistance in corrosive conditions contributing to product quality and durability
Testing must be performed consistently to provide similar results under the same conditions—repeatability and reproducibility? It also helps in the decision-making process regarding the development of new products or the improvement of existing ones by detecting problematic elements in a joint/surface coating, choosing the right suppliers, and determining which manufacturing or process parameters to choose.
Corrozion tests could be developed in few ways, depending on OEM needs and could be:

continuous salt spray tests. The most well-known of these tests are ASTM B117 and ISO 9227, which expose specimens to a salt mist, or fog, at moderately elevated temperatures from 35-50 °C.
These tests do not feature any cyclic wetting or dry-off steps
Cyclic Corrosion testing introduces additional drying and high-humidity wetting steps, to provide a better laboratory simulation of natural atmospheric corrosion.
advance in modern corrosion test equipment, however, is the introduction of precise relative humidity control, including controlled transitions between different test conditions. (General Motors 2006, Nissan) [https://www.q-lab.com/sites/default/files/Technical_Articles/LF-8116_New_Era_Corrosion_Testing.pdf]
The main advantages are ale testelor NSS

- The method is inexpensive compared to other advanced corrosion tests methods, the test is easy to perform
- The simple, non-cyclic nature of ISO 9227 allows for very good consistency - **Reproducibility and Repeatibility** from test to test, laboratory to laboratory

Disadvantages
They are not always representative of how products perform in real environmental conditions.
When tests are performed under harsher conditions (acidic environments), the deterioration of the parts analyzed may be greater than under existing environmental conditions.
Since the simple test does not analyze behavior under cyclic conditions or conditions involving other factors—temperature fluctuations, UV rays, pollution factors, there is a possibility that the results may not accurately reflect behavior in the real environment.
When analyzing the corrosion resistance of the protective layer, it is analyzed in terms of resistance to the corrosive environment through exposure to a saline environment and does not evaluate their protection against the layer in the immediate vicinity.

Standards available in Romania
The international standard ISO 9227 (corrosion tests by salt spray) is adopted in the national version (TS EN ISO 9227- Corrosion tests in artificial atmospheres — Salt spray tests). It is the basis for most accelerated corrosion tests used in industry.

Table 1. Standard description

Standard / Protocol Românesc	Description
Renault D17 2028 (test ECC1)(Essai de Corrosion Cyclique 1)	Automatic salt, drying, and humidity cycles for corrosion testing
ISO/TR-EN ISO 9227	International test for salt spraying, adopted nationally

1.1. RENAULT / DACIA standards and protocols (locally)
Renault has a series of relevant internal standards. Among these, the following stand out:
Renault D17 2028 – corrosion test with automatic change of salt spray, drying, and humidity phases (known as the ECC1 test
At the Dacia technical center (Titu), around 2,000 accelerated corrosion tests are carried out each year, including with saline solutions, on parts such as hoods, tailgates, bodywork, paintwork, and metalized elements.

1.2. Corrosion resistance testing of component/assembly joints
Corrosion resistance testing component/assembly joints and surface treatments applied to the welded area provide information on their behaviour in aggressive environments. Among the possible tests applied is the salt spray test, which is performed by exposing the assembly to an extremely corrosive

environment (sprayed NaCl solution), simulating accelerated conditions of moisture in a saline environment and corrosion.

In the case of adhesive bonding, this test will allow the evaluation of the adhesive's adhesion and the mechanical strength of the joint if they are maintained over time:

Salt spray tests do not directly measure the strength of the adhesive, but rather the complex interaction between the substrate, surface treatment, and adhesive. If the results are good, it means that:

- the substrate does not corrode under the bonded layer,
- the adhesive resists the humid/saline environment,
- the joint remains mechanically stable in the long term.

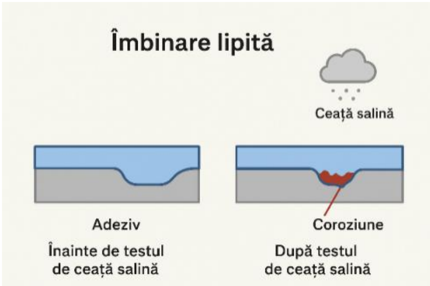

Figure 1. Example of embedded figure

Factors affecting bonding and salt spray performance

- Corrosion of the metal substrate

The adhesive bonds to the metal surface; if the metal rusts under the adhesive layer, delamination and loss of adhesion occur.

- Type of surface treatment

Phosphating, priming, anodizing, or passivation are commonly used to stabilize the surface before bonding. An untreated surface will fail much more quickly in salt spray.

- Type of adhesive

Epoxies, polyurethanes, acrylics—each has a different resistance to moisture and saline environments. In automotive applications, epoxies are preferred for load-bearing structures (bodywork), polyurethanes for elastic joints (windows, panels).

- Microdefects in bonding

Porosity, air pockets, or uneven application → allow salt solution to infiltrate → local corrosion and propagation of delamination.

The body and bonded components are permanently exposed to road salt, moisture, and thermal cycles.

Salt spray tests show whether a bonding solution is durable and can replace or supplement welding or riveting.

In many cases, bonding + corrosion tests are required by car manufacturers for:

- exterior panels (doors, hoods, doors),
- hybrid structures (metal + composite),
- bonded windows,
- invisible structural reinforcements.

1.3. The importance of salt spray testing for automotive headlights

Salt spray testing is vital to ensure that automotive headlights remain reliable, watertight, and corrosion-resistant, maintaining their performance and safety over the long term, even in harsh road conditions (de-icing salt, high humidity).

Figure 2. The importance of the test

The salt spray test plays an essential role in assessing the reliability and durability of car headlights, as they are constantly exposed to difficult road conditions (salt, moisture, temperature variations).

Main importance:

1. Checking corrosion resistance

Metal parts in headlights (brackets, connectors, metalized reflectors) can be affected by corrosion. The test shows how well they withstand saline environments.

2. Headlight seal check

If the seals or joints are not designed correctly, the saline solution penetrates inside → deposits appear, electrical contacts oxidize, and optical performance decreases.

3. Lifespan of finishes and coatings

Protective layers (chromium plating, painting, reflective or anti-scratch coatings) are checked to ensure they do not deteriorate prematurely in a saline environment.

4. Electrical and LED component reliability

Oxidation of electrical contacts or internal electronic boards can lead to lighting failure. The test confirms protection against these risks.

5. Road safety and compliance

Headlights must provide the same light output throughout their entire service life. Salt spray tests are required by automotive industry quality standards (e.g., ISO, SAE, UNECE).

Validation of an alternative nut for car headlights from the perspective of the salt spray test

In the automotive industry, salt spray tests are performed on components received from suppliers, not just on finished products. The responsibility for testing is shared, with the supplier having to provide a series of documents and reports to ensure that the protective coatings and parts meet the company's requirements (approval and validation) and those of the manufacturer, while the manufacturer will carry out validation and verification tests through acceptance audits and compliance campaigns.

Corrosion resistance (salt spray test)

ISO 9227 (NaCl 5%) → min. 120 h without white rust, min. 240 h without red rust
Product approval (PPAP) + periodic (e.g., quarterly)
Supplier (with report sent to the customer)
In Romania, the salt spray test is an integral part of the automotive component validation process—both at Renault/Dacia (through the ECC1 test and tests at the Titu technical centre)—and may also be required for parts approval by RAR. The ISO/TR-EN ISO 9227 standard is the officially adopted methodological basis.
The salt spray test involves exposing the nut to a salt spray chamber (5% NaCl) in accordance with ISO 9227 / ASTM B117:

- Corrosion resistance of the material (steel, stainless steel, aluminium, etc.)
- Performance of surface treatment (zinc coating, passivation, phosphating, special coatings)
- Behaviour of the metal + protective layer assembly under accelerated conditions.

Acceptance criteria (typical in automotive)

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- No red rust on the functional surface after a certain number of hours (e.g., 240h, 480h, or even 720h depending on OEM requirements).
- Maintenance of thread and tightening capacity after testing.
- No flaking or peeling of the protective coating.
- In some cases: additional verification with a tightening torque test after exposure to confirm that the nut has not lost its mechanical properties.

Context in the automotive industry

- Automotive manufacturers (e.g., Renault, VW, Ford, etc.) have their own specifications → they usually require accelerated corrosion tests for exposed fasteners.
- In Romania, at Dacia – Renault Titu, these tests are mandatory for the qualification of alternative suppliers of screws, nuts, or accessories.
- An alternative nut cannot be approved based solely on geometric and mechanical conformity → it must also be validated in terms of corrosion resistance.

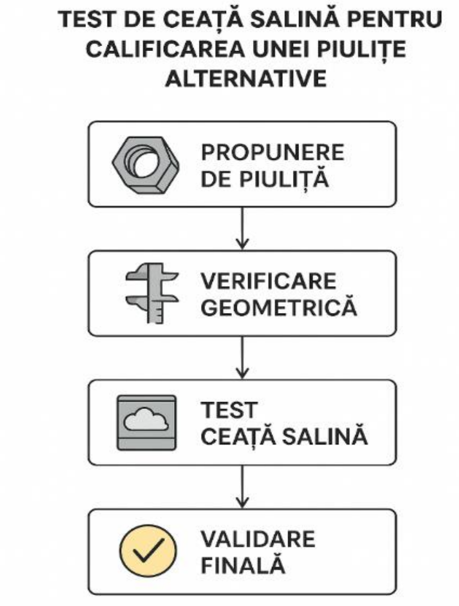

Figure 3. Steps of the test

General
Part under test: SA BL 014.979 butterfly nut

Table 2. Test timeflow	
Article	199.238-00
Date of manufacture	15.01.2020
Date of receipt	21.05.2020

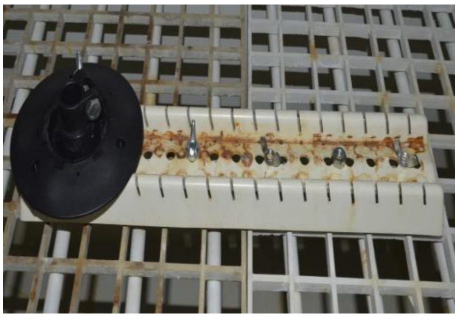

Figure 4. Sample during the test

Reason for the test: The supplier can no longer deliver the current series nut. An alternative nut is being tested for series production qualification.

Test: Salt spray
Standard: DIN EN ISO 9227 – NSS – 240 h: 03.2017
Samples tested: 5 samples were received to be subjected to the salt spray test
Objective of the test: The test is performed to check corrosion resistance under foggy conditions Sample saline

Parameters:

Table 3. Test parameters

Required parameters	Measured parameters
Temp: 35 °C ±2 °C	35 °C ±2 °C
Humidifier temp: 49°C ±2 °C	49°C ±2 °C
Solution concentration: 5 ± 1% NaCl	5.0 % NaCl
Ph. Solution: 6.5-7.2	pH: 6.62
Test duration: 240 h	-

Figure 5. Sample during the test

Criteria to be evaluated: Critical damage (i.e. rust) or excessive corrosion is not allowed either during the test or after its completion, as a result of exposure to salt.
The used equipment is a *Salt Spray Chamber* Vötsch Industrietechnik GmbH Type: VSC/UKWT 1000. This is a corrosion chamber with recirculating air and alternating climate control. This kind of corrosion chamber performs tests involving salt spray, condensed water and normal climate conditions with the possibility to control and regulate the humidity and temperature inside the testing space ensuring a uniform flow of mist and purging of corrosive air.

Temperature range Salt spray test 35 Condensed water test 40. Direct spraying of saline solution RENAULT D17 2028/-C (2007), Test ECC1 UKWT 1000
This type of test involves spraying a saline solution directly onto the test surface for a specified period of time in order to simulate accelerated corrosion conditions and conditions in saline environments, followed by observations and evaluations.
Such tests are also essential to ensure the durability and safety of the vehicle in terms of ensuring the correct and long-lasting operation of the headlights as a whole, as the tested component is a connecting element in its construction.
Test conditions
- Alternating corrosion/recirculating air (UKWT 1000)
- Temperature test 35
- Saline solution concentration 5% NaCl
- pH 6.5-7.2
- Test duration – 240 h, 500 h, or other cycle

A complete test cycle consists of a main cycle (salt spray for a period of time) and a series of subcycles (exposure to a humid environment and drying) which are repeated as many times as necessary, depending on the desired test period.
D17 2028 is associated with EEC 1 and the acceptance criteria
-no red rust – ferric corrosion by the end of the specified duration – up to 240 h (ISO 9227)
No flaking – No critical defects – cracks, visible holes on the surface
Acceptable surface corrosion white rust, white oxide – can be accepted within controlled limits and without compromising functionality – no white rust up to 120 h ISO 9227
Visual appearance – no large corrosion spots affecting geometry or function
Mechanical integrity – the part must function as required and after testing, without its performance being altered.
Set-up: The samples were placed in the device in such a way that they were not in the direction of the spray. The samples are arranged in the device so that the surfaces are exposed to the free circulation of the spray.
Procedure: Before the final evaluation, the samples were taken from the device, put to dry for 1 hour, before being washed. This was done to reduce the risk of removing traces of corrosion from the parts. Before the final evaluation, traces of saline solution were carefully removed from the surface of the parts by washing with water and then dried by means of an air jet at a pressure of 200 Kpa, air jet blown from a maximum distance of 300 mm.

Figure 6. Test Set-up

Test period: 25.05.2020 – 05.06.2020
Test result: After the completion of the test, all samples subjected to the test showed traces of corrosion of both red and white oxidation. The assembled sample, the nut + screw and washer mounted on the rubber casing show traces of red oxidation and the coating is also affected.
From the samples tested, the BOSSARD nut looks the best, which visually looks much better than the nut in series production, but it also shows signs of corrosion. The samples with traces of oxidation of white color, after being washed it was observed that the coating was also affected.

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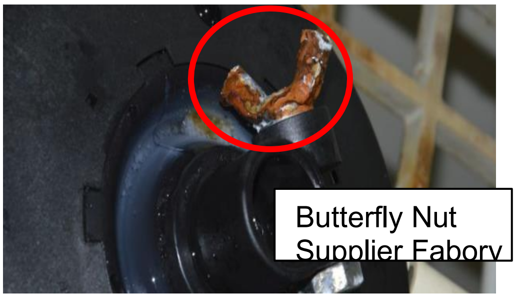

Figure 7.sample after 240 H

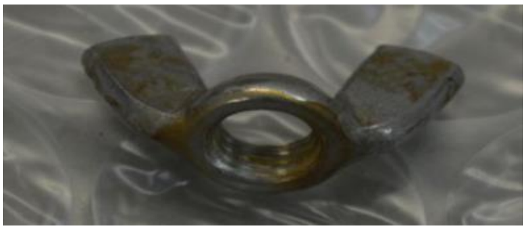

Figure 8. Future nut supplier BOSSARD

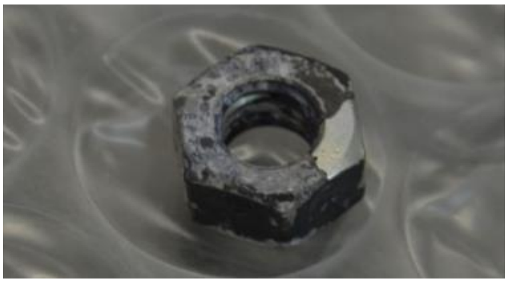

Figure 9. Nut from series production

Conclusions

A corroded headlight nut can result in headlamp misalignment (suboptimal beam, safety hazard), vibration, or even detachment.
A corroded headlight nut can:

- Weaken the fastening integrity,
- Freeze adjustment mechanisms,
- Cause beam misalignment due to loosening or deformation.

Over time, this undermines driver visibility, road safety, and adherence to lighting regulations.

The study shows that the choice was that the nut from the supplier BOSSARD, made of stainless steel, is superior to the other nuts. As a result of this test, the use of the nut from the supplier BOSSARD for series production was approved.

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