

# Automotive Testing and Engineering Services



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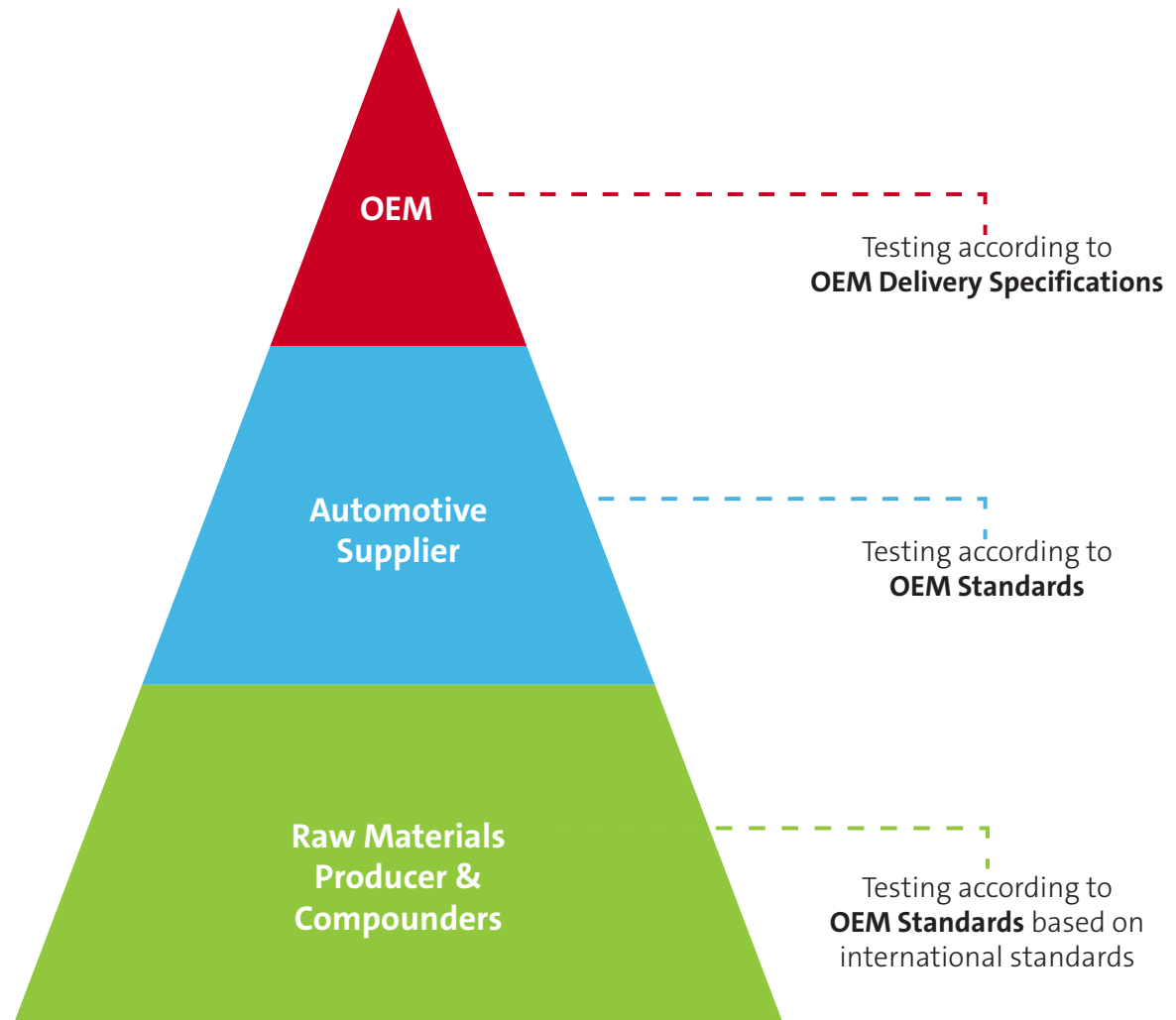
# Materials for Automotive Applications

UL Solutions helps car manufacturers and automotive suppliers to reduce costs, improve product reliability and increase efficiency along the entire automotive supply chain by complementing or substituting internal testing capabilities.

Our independent testing centers will verify material and product performance according to customer-specific requirements, international test standards as well as local and global regulations. UL Solutions supports customers from the product concept stage and early product development, to the final Part Production Approval Process (PPAP). Our DVPR (Design, Verification, Plan and Report) approach to providing product validation helps OEMs achieve optimized time-to-market.

The UL Solutions service portfolio gives customers access to a single source for compounding trials, test specimen production via injection molding, as well as testing and certification of thermoplastics, rubbers, thermosets and textiles. Beyond testing raw materials, we also evaluate parts and components designed for automotive applications. Moreover, we address safety considerations for the future of automotive, such as our solutions for testing EV battery enclosure materials.

The global testing facilities at UL Solutions offer large-scale testing capacities and reduced lead times. Our global presence ensures easy and clear communication lines to local subject matter experts. Each service is available individually or as part of a customized package.





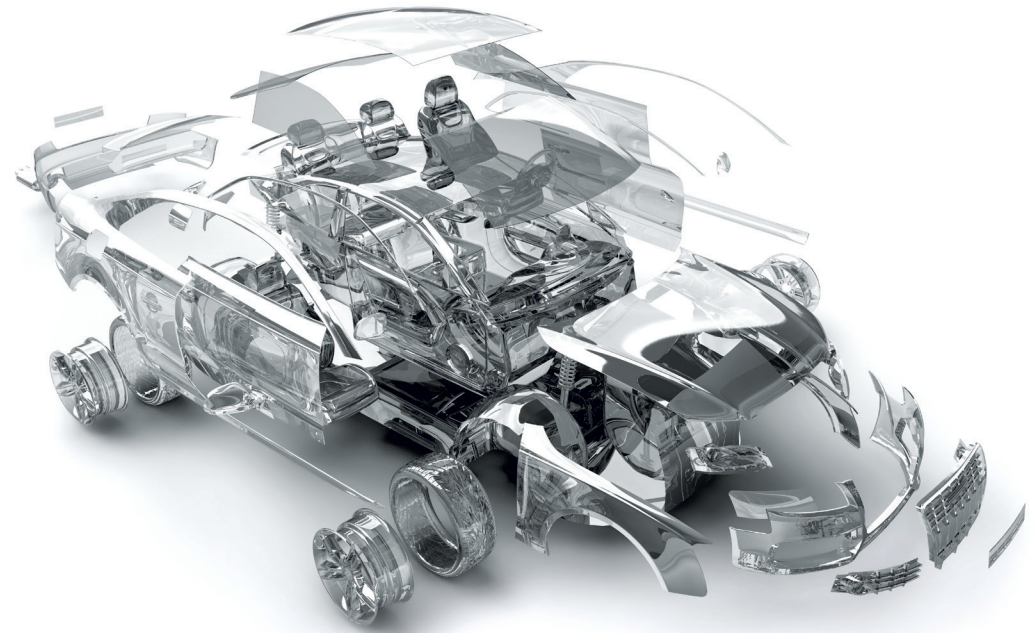
# Automotive Testing and Engineering Services

## Our Services for the Automotive Industry Include:

- Automotive testing in all areas of material characterization and selection, such as emissions, mechanical, electrical, surface properties and flammability resistance.
- Simulation of environmental performance via weathering, temperature, climate change and ozone stress testing.
- Development, execution and management of test programs according to OEM requirements, standards and regulations.
- Preparation of test specimens by injection molding or from finished parts.

## Additional UL Solutions Automotive Services:

- Automotive Wire and Cable Testing
- Battery Testing
- Wireless/EMC Testing
- Functional Safety
- UL Prospector® Supplier Database
- Global Market Access



### Environmental Testing



### Flammability Testing



### Surface Testing



### Electrical Testing



### Optical Testing



### EV Component Testing



### Vehicle Interior Air Quality Testing



### Media Resistance and Analytical Testing



### Mechanical Testing



### Textile Testing



# Environmental Testing

UL Solutions offers a comprehensive range of tests determining the effects of the environment on interior and exterior automotive components. The experts in our labs can provide accelerated processes to help you meet the demands of car manufacturers and end-user expectations.



## Thermal Aging

We can assess durability of parts from external factors, such as heat, by conducting thermal aging testing. Our temperature test chambers can simulate aging in an accelerated process and reveal the effects of long-term heat exposure.

### Common testing methods

- IEC 60216-1
- UL 746 B
- D45 1139 PSA
- D45 1234 PSA
- DIN 53497
- ISO 188
- EN ISO 2578
- VDA 675-310

## Artificial Weathering

Our experts can help you determine whether your components are likely to reveal any optical and mechanical changes following long-term exposure to artificial weathering. Our tests simulate the exposure to sunlight as well as the color fastness and aging properties of all kinds of materials.

### Common testing methods

- ASTM G151
- ASTM G155
- DIN EN ISO 4892
- SAE J2412
- SAE J2527
- PV 1303
- PV 3929
- PV 3930
- DIN EN ISO 105-B06
- DIN 75220





## Climate Change

Fluctuating weather and temperature conditions can weaken automotive components. Our testing capabilities can simulate a broad range of climate conditions and help to create a reliable performance forecast.

### Common testing methods

- PV 1200
- IEC 60721-4
- IEC 60038-2-XX
- GMW 14729
- PR 303.5
- PV 2005
- D47 1309
- GMW 14124
- PR 308.2

## Corrosion

Salt spray and cyclic corrosion tests are used as accelerated test methods to check corrosion resistance of materials and surface coatings.

### Common testing methods

- ASTM B 117
- ASTM D1654
- IEC 60068-2-52
- VDA 233-102
- DIN EN ISO 11997-1
- DIN EN ISO 9227

## Ozone Resistance

Testing for ozone resistance helps you avoid exposure related damage that considerably reduces product longevity.

### Common testing methods

- ASTM D1149
- ISO 1431
- PV 3305
- VDA 675-311
- D47 1100

## Thermal Shock

Thermal shock testing is a variation on cyclical temperature stress. During testing, parts are subjected to considerable temperature differences in a short amount of time. The test evaluates components against thermally-induced flaw patterns, such as cracking in solder joints, adhesive joints and at seals and housings.

### Common testing methods

- ISO 2819
- DIN EN 60068-2-14



# Surface Testing

In order to engineer and produce automotive parts with consistent and market leading quality, it is vital to use appropriate testing technologies to analyze surface characteristics. The test results can help predict real-world product characteristics and lifetime behavior. At UL Solutions, we conduct a wide range of destructive and non-destructive surface tests on standardized specimens and finished components.



## Surface Adhesion

With equipment like the Scratch Hardness Tester, multiple cut, scratch and tear tests can be carried out on all types of coatings and materials.

### Common testing methods

- DIN EN ISO 2409
- ASTM D 3359
- GMW 14829
- PV 3952
- PV 3964
- PV 3987

## Metallic Coating Thickness

Our experts can offer you several test methods to characterize the surface properties of your parts, including scratch tests and adhesion tests. We can also measure the thicknesses of different coatings by using the STEP test.

### Common testing methods

- DIN EN ISO 2177
- DIN EN 16866
- PV 1065





## Car Wash Simulation

With the car wash simulation apparatus, our experts at UL Solutions help determine how surfaces with or without coatings can resist the influence of specifically defined brushes of a common car wash system.

### Common testing methods

- ISO 20566
- PV 3.3.3
- DIN EN ISO 20566
- AA-0054
- STD 423-0019
- MBN 10494-5

## Impact Resistance

The stone impact or stone chip resistance test is used to determine a coating's ability to withstand impacts of small objects, such as stones.

### Common testing methods

- DIN EN ISO 20567
- PV 3.14.7
- DBL 5416
- FORD FLTM BI 157-06
- PSA D24 1312

## DuPont Impact

DuPont Impact is used to test the endurance of a coated material during impact tests involving a falling weight, such as stones, dropped at specified points. The aim is to ascertain how specimens can withstand the impact of rapid impact testing, thus checking for damage or deformation.

### Common testing methods

- TSH 3130G
- TSH 3131G
- ASTM D 2794



# Optical Testing

UL Solutions offers a full range of standard and specialized optical and color measurement services.



## Color Measurement

Color measurements are used to assess color changes induced by various stresses. The following characteristics of a specimen are measured or calculated in an spectral photometer with the help of the CIELAB table system.

- Transmittance
- Reflectance
- Yellowness index
- L\*a\*b\* values
- Standard color values XYZ
- Delta E

### Common testing methods

- DIN 5033
- ASTM E179
- ASTM E313
- ISO 13468-2

## Gloss Measurement

Gloss is an optical property of a surface to reflect light fully or partially, specularly measured at 20°, 60° and 85° using a reflectometer.

### Common testing methods

- ISO 2813
- ASTM D523





## Haze Measurement

This test method for transparent products is used to determine the translucency of a material. Following various load tests such as processing, after-treatment, light aging, weathering and temperature aging, an optical measuring system evaluates all important criteria that determine the transparency of the test specimen.

### Common testing methods

- ASTM D1003

## Gray Scale Determination

By means of the gray scale determination, the optical surface change is identified after different loads. The difference in color of a specimen is compared with the gray scale sections.

### Common testing methods

- ISO 105-A02
- AATCC Evaluation Procedure 1

## UV/VIS/NIR Measurement

In material research, it is sometimes necessary to assess test specimens with a high absorption capacity such as laser protection lenses, optical filters and polarization materials. Most specimens of this kind have to be investigated across the visible electromagnetic spectrum – from UV through VIS to NIR.

### Common testing methods

- IN-HOUSE STANDARD



# Vehicle Interior Air Quality Testing

The use of polymers and other performance materials may result in the release of unwanted or irritating substances. In small spaces, concentrated emissions can affect comfort or user health. The nature and quantity of these emissions are strictly regulated and quantified in specifications that include qualitative smell tests, quantitative fogging measurements and extensive emission tests.



## Headspace

Headspace analysis can be used to determine odor-related issues with polymers, compare material recipes and analyze polymer softening agents.

### Common testing methods

- VDA 277
- PV 3341
- VCS 1027,2749

## Semi-volatile and Volatile Organic Compounds (SVOC and VOC)

Our experts can provide a detailed breakdown of emissions, including the assessment of critical substances, according to OEM requirements.

### Common testing methods

- VDA 276-3
- VDA 278
- ISO 12219-3
- ISO 12219-4
- PV 3942
- GS 97014-2/3
- VCS 1027,2769
- DBL 5430





## Fogging

Condensing of organic substances can cause window fogging and thus limit visibility. Fogging is a method to simulate desorption of substances out of interior car parts in a measurable, representative and reproducible way.

### Common testing methods

- PV 3015
- D45 1727 PSA
- SAE J1756
- ISO 6452
- ISO 17071
- DIN EN ISO 17071
- DIN 75201

## Carbonyl

Carbonyl (aldehydes/ketones) emissions may adversely affect user comfort. We evaluate interior air quality by testing at the material level as well as at the component level.

### Common testing methods

- VDA 275
- PV 3925
- ISO 16000-3

## Odor

New car odors should not be unpleasant to users. Testing and qualitative ratings are applied per various OEM requirements for user comfort.

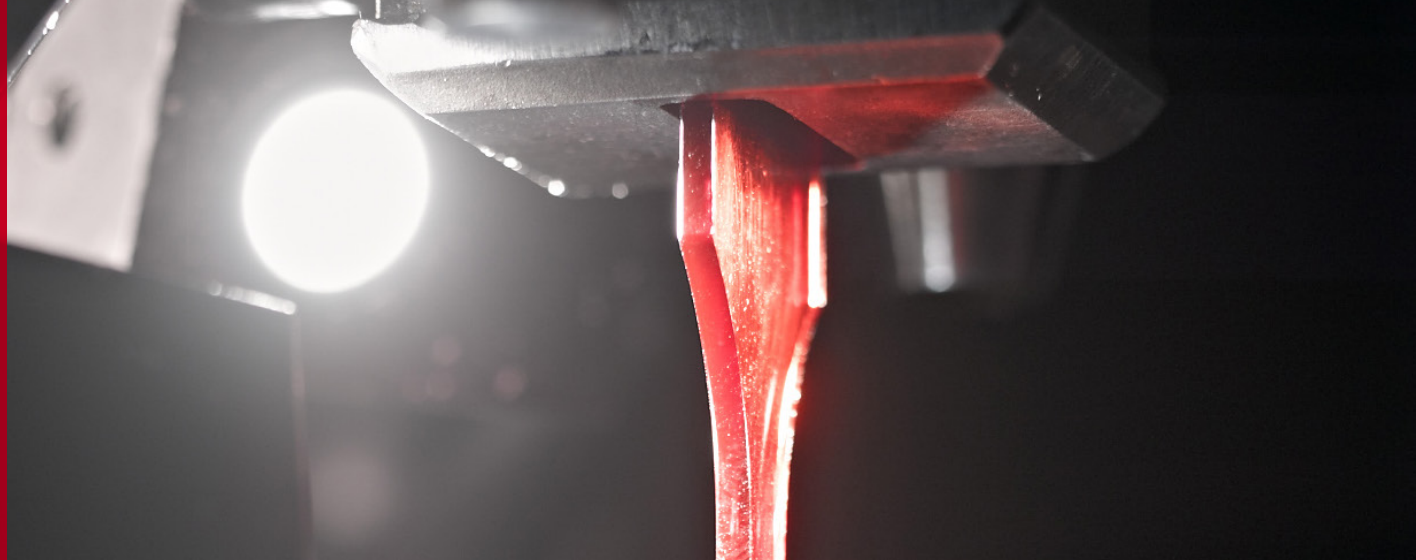
### Common testing methods

- VDA 270
- PV 3900
- ISO 12219-7
- DBL 5430
- GS 97014-4



# Mechanical Testing

UL Solutions is an industry leader in polymer testing, with a global network of laboratories offering a diversified range of destructive testing in a fully automated start-to-finish sequence.



## Tensile Test

This test method is used to assess the behavior of polymers when subjected to uniaxial tensile stress.

Common testing methods

- DIN EN ISO 527
- ISO 527
- ISO 527-2/ISO 178
- ASTM D638
- DIN 53504

## Tensile Impact Test

The tensile impact test is a test with a very high deformation speed.

Common testing methods

- DIN EN ISO 8256

## High Speed Tensile Test

This complex test method simulates crash conditions and is used to determine the data of plastic materials at very high strain rates. This test can be run at hot and cold.

Common testing methods

- IN-HOUSE STANDARD

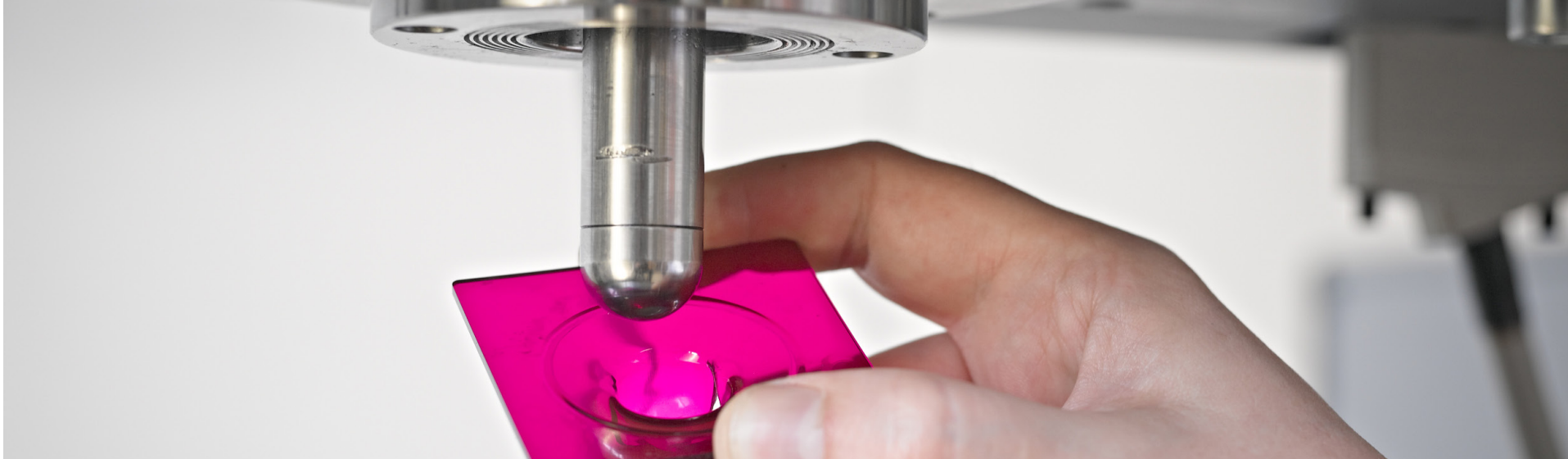
## Izod & Charpy Impact Tests

These are quick and simple tests to facilitate a comparative assessment.

Common testing methods

- DIN EN ISO 180
- ASTM D256
- DIN EN ISO 179





## Puncture Impact

The instrumented test in accordance with this standard describes a test method that is used to determine the puncture impact behavior of solid plastics.

Common testing methods

- DIN EN ISO 6603-2
- ASTM D3763

## Ball Drop Test

This test method is to determine the penetration resistance and flexibility of coatings and the adhesion at low temperatures of acoustic damping systems.

Common testing methods

- PV 3905
- PV 3989

## Ball Indentation

The ball indentation hardness is the quotient of the applied load and the surface area of the indentation that is present underneath a ball.

Common testing methods

- DIN EN ISO 2039-1

## Tensile Creep

Creep tests are used to determine the amount of deformation a material experiences over time while under a continuous tensile or compressive load at a constant temperature.

Common testing methods

- ISO 899-1
- ASTM D2990

## Hardness

This test method is used to determine the hardness of a test specimen as a function of the depth of indentation, taking the elastic recovery into consideration.

Common testing methods

- DIN EN ISO 2039-2
- ASTM D785
- PV 3931
- ISO 48-4
- TSH 1539G

## Bending Test

This test method determines the strength and dimensional change properties of plastics when subjected to three-point loading.

Common testing methods

- DIN EN ISO 178
- ASTM D790
- DIN EN ISO 527



# Flammability Testing

Combustion and ignition tests are used to determine the quality and safety of materials in critical applications. Many requirements of the automotive industry can be met using standard test methods.



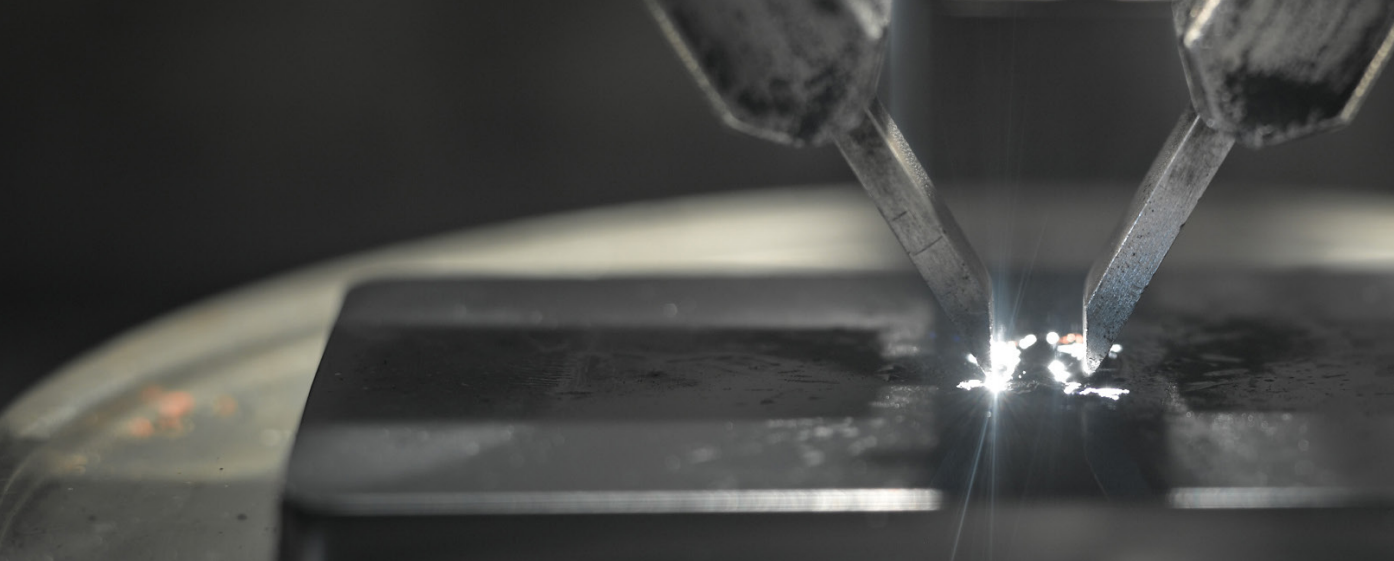
## Burning Behavior

UL Solutions offers a wide range of testing capabilities to determine the burning characteristics of raw materials, components and finished products.

### Common testing methods

- US FMVSS 302
- TL1010
- TL1011
- ISO 3795
- UL 94
- IEC 60695-2-13
- IEC 60695-2-12
- PV 3343
- PV 3357
- DIN 75200
- DBL 5307.10
- D45 1333





# Electrical Testing

UL Solutions has a long history of testing for electrical safety and performance with regard to many materials and multiple industries. The following tests are most common for automotive applications.

## Volume Resistivity Test

This method is used to determine the volume resistivity of an insulating material. The surface flows of the test specimen are eliminated using an electrode.

Common testing methods

- UL 746A
- ASTM D257
- ISO 62631-3-1

## Surface Resistivity Testing

This method is used to determine the surface resistivity of a test specimen. The volume flows of the insulating material are eliminated using an electrode.

Common testing methods

- UL 746A
- ASTM D257
- ISO 62631-3-2

## Dielectric Strength Test

This method is used to assess the dielectric strength of an insulating material. It calculates the voltage at which a harmonic alternating voltage collapses upon destruction of the insulating material.

Common testing methods

- IEC 60243
- ASTM D149

## Comparative Tracking Index (CTI)

This method is used to assess the relative resistance of insulating materials to tracking.

Common testing methods

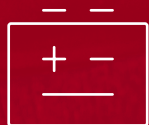
- IEC 60112
- ASTM D3638

## High Voltage Tracking Resistance (IPT)

This method can be used to assess the susceptibility to tracking of insulating materials that are exposed to high voltages outdoors.

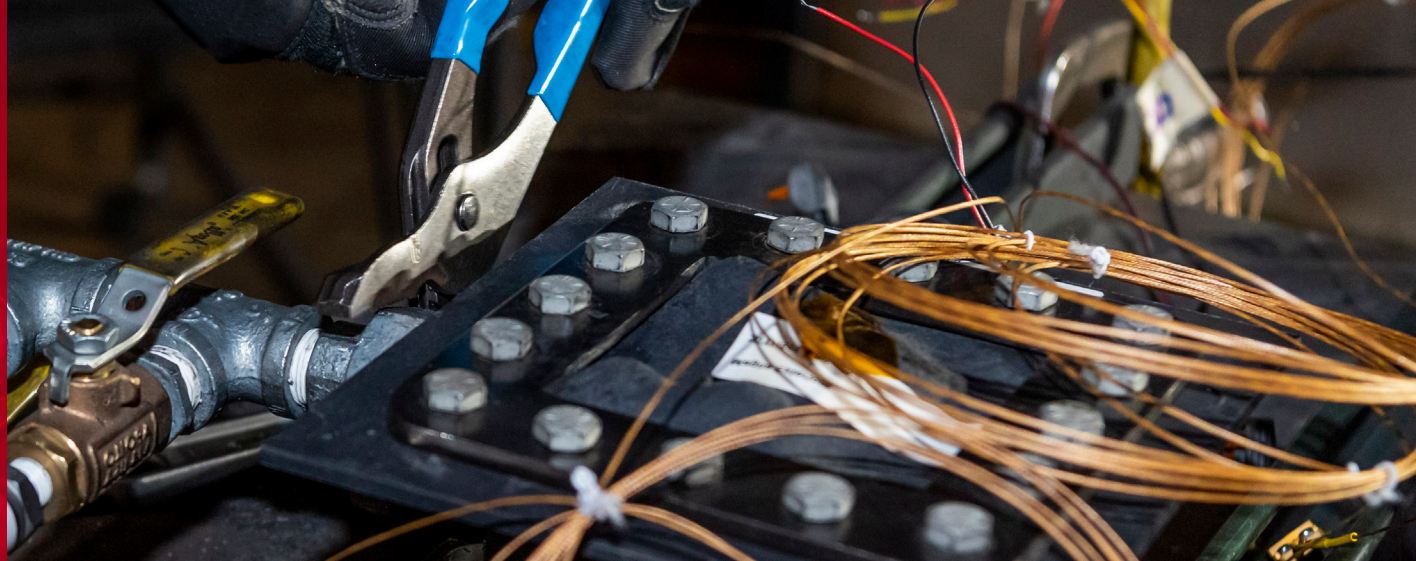
Common testing methods

- ASTM D2303
- IEC 60587



# Electric Vehicle (EV) Component Testing

Lithium-ion batteries are the energy accumulator of choice for portable electronics and cordless machines and tools. In addition, they are also the driving force behind the electric vehicle (EV) industry. Most EVs use powerful lithium-ion batteries, but these kinds of batteries come with safety concerns, making a battery's enclosure in the vehicle incredibly important.



## Battery Enclosure Material Screening (BEMS)

At UL Solutions, we developed a unique set of test methods, known as Battery Enclosure Material Screening (BEMS), to evaluate the performance of different battery enclosure materials in response to a thermal runaway event, outlined under UL 2596, Test Method for Thermal and Mechanical Performance of Battery Enclosure Materials. Our Torch and Grit (TaG) test method screens for the dynamic stresses found in a thermal runaway event, focusing on the evaluation of temperature and mechanical abrasion. We have also developed the Battery Enclosure Thermal Runaway (BETR) evaluation to rigorously test material performance in a simulated thermal runaway scenario, which includes evaluating temperature, mechanical abrasion and pressure elements. Our solutions are designed to help material manufacturers, suppliers and automotive OEMs select EV battery enclosure materials with greater confidence.

Common testing methods

- UL 2596





# Media Resistance and Analytical Testing

## Media Resistance

At UL Solutions, we evaluate the interior and exterior materials' resistance to various media or liquids, depending on the specific OEM requirements.

### Common testing methods

- DIN EN ISO 22088-3
- ISO 175
- DIN ISO 1817
- DIN EN ISO 22088-3

## Analytical Testing

Very common test methods, such as TGA, DSC, IR, TMA or MCC also form the basis for material analyses relevant for the automotive industry.

### Common testing methods

- DIN 51005
- ISO 11359-2
- ISO 11357
- ISO 11358
- ASTM D7309

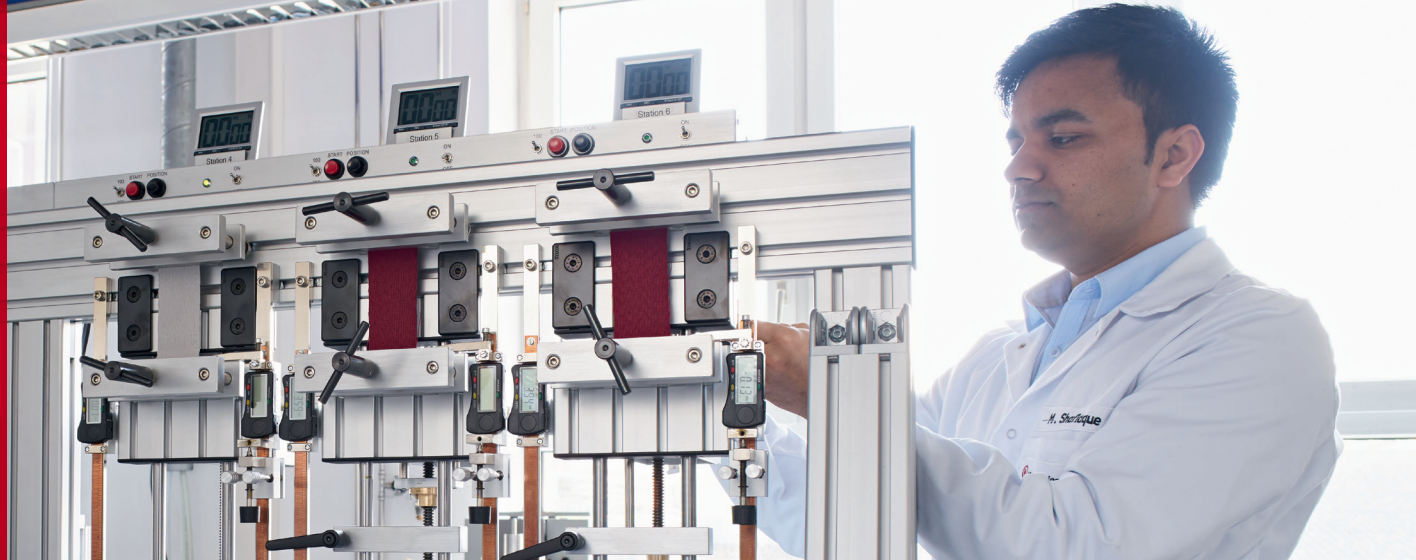
Automotive applications have to be aligned with global regulations, international standards as well as legal requirements. In addition, automotive products need to comply with dedicated OEM and supplier delivery specifications. With the help of chemical and analytical testing, vehicle and part manufactures can help ensure that consumers are protected from potential risks through early development reviews combined with a root cause analysis.





# Textile Testing

Many physical testing methods can be used for automotive textiles. UL Solutions provides textile tests in accordance with car manufacturers and industry standards for samples and quality assurance.



## Wet and Dry Abrasion

Electric Crockmeter equipment is commonly used for wet and dry abrasion testing. This testing can include the determination of color or structural alternations occurring in textiles, leather and carpeting e.g. as a result of long-term wear.

Common testing methods

- PV 3906
- DIN EN 105-X12
- ISO 105-D02

## Martindale Abrasion and Pilling

OEMs frequently require Martindale abrasion and pilling tests to determine the abrasive wear and pilling properties of textiles and upholstery. In addition to textiles, the Martindale abrasion can also be used for thermoplastic surfaces to define the influence of abrasion.

Common testing methods

- DIN EN ISO 12945
- DIN EN ISO 12947
- ASTM D4966
- PV 3356
- PV 3968
- PV 3961



## Abrasion Tester (Schopper Type)

Test equipment like the Schopper abrasion tester forms the basis for the determination of a textile's resistance to soiling, cleaning and abrasion related wear or discoloring. A subsequent surface analysis complements the textile performance evaluation.

### Common testing methods

- DIN 53863
- PV 3908
- PV 3353

## Flock Testing

UL Solutions offers a demonstrative test to determine the wear resistance of flocked surfaces. Typically, the APG 1000 abrasion tester is used to evaluate the quality of flocked surfaces.

### Common testing methods

- DBL 5578
- PV 3366
- PV 3949

## Tumble Pilling

To determine the product resistance to form pills and other wear on textile fabrics, UL Solutions uses the Random Tumble Pilling Tester. Similar to abrasion test technologies, this particular test relates to microscopic and macroscopic changes at the substrate surface.

### Common testing methods

- PV 3360
- ASTM D3512
- ISO 12945 - 3



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