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ICT

FRAUNHOFER-INSTITUT FÜR
CHEMISCHE TECHNOLOGIE ICT

ENVIRONMENTAL SIMULATION AND PRODUCT QUALIFICATION

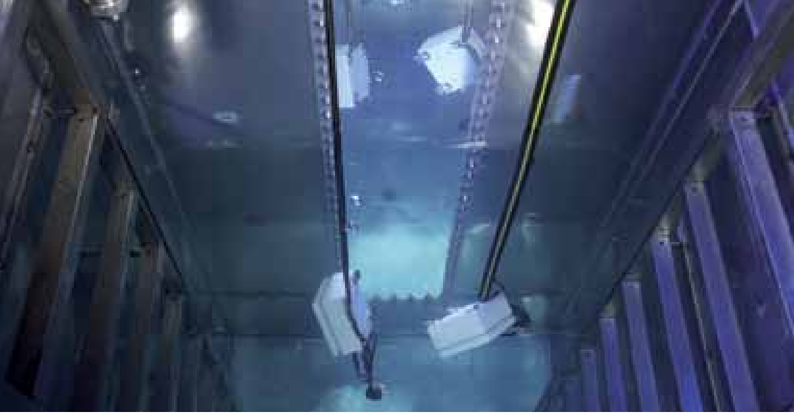
ENVIRONMENTAL SIMULATION AND PRODUCT QUALIFICATION

Throughout their service life, technical products are exposed to a wide variety of environmental influences. These affect their performance and durability, which in turn has an influence on the environment. Using environmental simulation methods, the interactions between objects and their environment is investigated. Based on a holistic approach, the often complex and interdependent chains of effects are structured and analyzed using models.

Environmental simulations investigate the influence of the environment on

- Performance and operational behavior
- Long-term behavior and service life
- Impact on the environment

The aim of environmental simulation is to reveal cause-effect relationships, to qualify products for the environmental conditions to which they will be exposed, and to optimize product development, making it environmentally-friendly and sustainable.
In aging and weathering processes, and in reliability studies, questions of accelerated and artificial aging play an important role. Environmental simulation is an engineering science, and has a wide and interdisciplinary orientation.



Environmental simulation involves the following steps:

- Calculating environmental influences
- Simulating the environmental impact under controlled parameters
- Evaluation of the environmental impact on the object
- Possible impacts on the environment

Tailored environmental tests ensure that a component is sufficiently tested without placing it under excessive stress. Economic factors play an important role in environmental simulation. The cost of environmental qualification of technical products is normally compensated by the higher quality and reliability of the product. Environmental simulations can also form part of life cycle engineering and resource-efficient material management.

Left:
Condensation chamber (Kesternich chamber).

Environmental influences

Environmental influences include all physical, chemical or other influences on the test object. The object may be exposed to them in or close to the site of production, or during transport or use. From this perspective it is not important whether the environmental influences occur naturally (for example earth tremors) or artificially (for example vibrations or impact shocks during transport).

natural	environmental influences	artificial
outdoor exposure compartment	temperature	room climate, engine
tropical climate	humidity	saunas and baths
high and low pressure	atmospheric pressure	transport flights
ocean climate	salt water (/ mist)	de-icing salt
ozone	gases	industrial atmosphere
precipitation	water	washing
sand and dust	particles	particle emissions
earthquakes	vibration and impact shocks	transportation
sun	radiation	light
wind	sound, impact sound	noise
acid rain	chemicals	cleaning agents
geomagnetic field x-rays	electromagnetic field strength	radio transmitters,
radon	radioactivity	nuclear power plants
fungi, algae, biofilms	biogenic influences	food
termites, rodents	vermin	neozoa

In special technical units at the Fraunhofer ICT environmental influences on products are simulated and tailored tests are developed.

For the automotive and construction sectors

- Corrosion
- Destructive gases
- Salt mist and splash water

For transport engineering

- Vibration
- Mechanical shock
- Pressure
- Pressure change
- Climate
- Temperature
- Temperature shock

For the electronics sector

- Dust
- Water
- IP protection category

For materials research

- Chemical resistance
- UV stability
- Aging

TAILORED ENVIRONMENTAL QUALIFICATION TEST TAILORING

Economic factors play an important role in environmental simulation. Tailored environmental tests guarantee sufficient testing of the component, without placing it under too much stress. Test tailoring requires scientific know-how in order to make an accurate, general qualification based on different results. Industrial testing practices and applied research are closely linked.

Sustainable products

Environmental simulation links economy and ecology, environmental protection and product quality through the application of technical knowledge to ecological challenges. Products with a long service life correspond to customers' needs, save resources and energy, and reduce waste.

Instrument panel / door panel box in Arizona (Photo: ATLAS MTT).

Advantages of environmental simulation

- Controllable conditions
- Reproducibility
- Compatibility
- Time savings
- Safety due to laboratory tests before real-life application
- Qualification of components before their integration into a system
- Information allowing early decision-making in the development of a product

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- Development of tailored testing programs
- Identification and measurement of relevant environmental conditions
- Environmental testing
- Evaluation of the effects on materials and products
- Subsequent investigations (chemical-analytical, mechanical, microscopic and morphologic, photometric and colorimetric, REM, LSM, TEM)

CORROSION TESTING WITH CORROSIVE GASES, SALT SPRAY, OZONE

In our corrosion testing unit we can test functionality and estimate the service life of products. This involves salt spray, condensation tests, corrosive gas tests with 1-4 components, SO_2 Kesternich tests and ozone tests.

Corrosive gas tests

Gases: For example sulfur dioxide, hydrogen sulfide, chlorine, nitrous oxides, ozone and gas mixtures

- Test chamber volume: 70 to 980 l
- Temperature: 25 °C
- Humidity: 75 %
- Other temperatures / humidities on request

Salt spray tests

Salt: sodium chloride, others on request
Admixtures: For example acetic acid, calcium chloride, copper chloride

- Temperature: up to 60 °C
- Test chamber volume: 1 000 or 2 000 l
- Condensation and/or controlled humidity
- Sea water
- Tests according to CASS, ESS, SWAAT, Nissan

Salt spray chamber.

Ozone resistance

Materials can be tested with or without mechanical loads.

- Test chamber volume: 580 l
- Ozone: up to 1 000 ppm
- Temperature: up to 70 °C
- Humidity: 15 to 90 %

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- Corrosive gas tests
- Salt spray tests
- Ozone tests
- Evaluation of the effects on materials and products
- Subsequent investigations (chemical-analytical, mechanical, microscopic and morphologic, photometric and colorimetric, REM, LSM, TEM)

CHEMICAL RESISTANCE

Chemical resistance tests are necessary to determine the application possibilities, the durability and also the service life and functionality of a material or product in a technical environment and on contact with different media.

Particular expertise

Various possibilities are available for introducing liquids onto the surface, such as wetting with a cotton cloth or a brush, wetting through immersion, pouring, dipping or spraying. The Fraunhofer ICT also has a spraying unit that enables the drop size to be adjusted to ensure the consistent application of the liquid and therefore the reproducibility of the results.

Impact of battery acid on bare steel.

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We support you in the design, development and performance of chemical resistance tests. We also provide advice in interpreting and evaluating the results.

- Development of individual / new testing programs
- Corrosion of materials and components
- Stress corrosion cracking
- Chemical requirements on electrical / electronic devices and components
- Resistance against battery electrolytes

CLIMATE
TEMPERATURE
TEMPERATURE SHOCK

The influence of climatic conditions can be evaluated on the basis of the expected site of operation or the life-cycle of a technical product. Climatic data are summarized for different outdoor climates (which occur naturally), and room climates (which occur artificially and depend on the different use of buildings). Where products are used worldwide, exposure levels are constructed based on the worst-case conditions in the different climate models. This is important in the case of automotive components, for example.

The following facilities are available for research and for tests accompanying the development process:

- Climate chambers from 300 l to 25 m^3
  Minimum temperature: -80 °C or -40 °C
  Maximum temperature: +180 °C
  Humidity: 10 to 98 %
  Temperature chambers from 50 l to 16.6 m^3
  Temperatures: -45 °C to 300 °C
- Temperature shock air-water (splash water)
  Air temperature: up to 180 °C
  Water temperature: 0 °C to 4 °C

Walk-in climate chamber (25 m³) with solar simulation.

- Temperature shock air-air
  Minimum temperature: -80 °C
  Maximum temperature: +220 °C / +180 °C
  Volume: 120 l / 600 l
  Transition time: <10 s
- Temperature shock liquid-liquid available on request

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We perform the following tests:

- Temperature shock tests
- Constant / cyclic dust tests
- Warm / cold storage
- Splash tests

We investigate:

- Suitability for tropical climates
- Corrosion resistance
- Climate / temperature resistance

IP PROTECTION CATEGORY
PRESSURE
LOW PRESSURE
LEAK-TIGHTNESS

In order to test the tightness of product casings or their dust or water resistance, various testing procedures can be used. The Fraunhofer ICT has a wide range of facilities and equipment, some of which have automated and programmed exposure profiles. A frequent task is to determine the necessary IP protection for a component.

Standardized materials can be used as dusts, including

- Talc (IP5X, IP6X)
- Portland cement / flue dust (IP5KX, IP6KX)
- Arizona dust (IP5KX, IP6KX)
- Kanto clay according to JIS standards
- Other dusts can be used on request.

Tests with water include:

- Dripping water (IPX1, IPX2)
- Spray water (IPX3)
- Splash water (IPX3)
- Jet water (IPX5, IPX6, IPX6K)
- Immersion / submersion (IPX7, IPX8)
- High-pressure / steam jet cleaning (IPX9K)

Steam jet test.

Pressure

Tests can be carried out with constant pressure, pressure ramps and pressure changes. Beside functionality tests, applications include tightness tests on components.

- Pressure range: 0.1 to 0.6 bar (absolute pressure)
- Temperature range: -75 °C to +300 °C

Low pressure

These tests can be used to investigate tightness and also to simulate transport in flights without pressure equalization.

- Temperature: -75 °C to +300 °C
- Absolute pressure: up to 20 mbar

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The following tests can be carried out:

- Dripping water, spray water, splash water, water jet
- Steam jet test
- Immersion / submersion tests
- Constant / cyclic dust tests
- Protection against penetration of solid matter
- Investigation of leak-tightness

VIBRATION AND MECHANICAL SHOCK

Vibration and impact tests applying sine-wave vibrations, random noise and shock combined with temperature and moisture are useful for transport simulation, the optimization of packaging and the measurement of stability / durability.

Beside investigations into functionality, vibration tests are also carried out to estimate the service life of a component. These tests are therefore comparable to investigations into operational stability, although characterizing frequencies are often in a much higher range. In combined tests, for example changes to temperature and humidity in parallel to noise stimulation, almost all the vibrations which can lead to the failure of a component are applied.

As the failure of a component is often preceded by warming due to the absorption of mechanical energy, infrared cameras can be used to measure local heating within the component during the experiment, in order to identify weak points in the design.

Beside the periodic and stochastic signals that form part of vibration exposure, unique events also occur, such as sudden exposure to mechanical shock. This can happen during manufacture, during transport or where a component is used. A single mechanical shock may be enough to destroy the component (for example if it falls out of a person's hand). Almost all electronic devices are affected, including laptops, mobile telephones, control units and smaller components such as batteries, fuel cells or airbag parts.

Shaker with sliding table.

Vibration

- Performance range up to 11.7 kN
- Amplitude: ± 12.7 mm
- Sliding table for investigation on several axes

Shock

- Type of shock: semi-sinusoidal, rectangular, trapeze
- Maximum acceleration: 10 000 g
- Duration of shock: 1 to 60 ms

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At the Fraunhofer ICT various facilities are available to qualify products on exposure to mechanical influences.

- Vibration tests
- Resonance tests
- Mechanical shock
- Drop tests

SOLAR SIMULATION
UV STABILITY
NATURAL WEATHERING

The content of plastics, for example in transparent plastic packaging, has increased significantly in the past few years, and this is a trend which is continuing in many parts of the world. As a result, accelerated photostability tests for plastics or consumables are increasing in importance.

In developing suitable testing processes the first step is to determine the stress factors to which the plastics will be exposed. The most important of these are radiation, oxygen, and temperature. These individual stress factors are investigated with respect to the exposure level in a given processing step, and this generates a set of requirements which can be incorporated into the testing methodology.

For example, if solar radiation is used to induce the aging mechanism, solar simulation with xenon lamps (xenon test) is applied in the testing procedure. If, on the other hand, UV radiation at low sample temperatures or higher humidity is required, a UV weathering device is the most appropriate choice.

Metal halide-lamps are often used: they consume less energy than xenon lamps, but with an altered spectrum.

Instrument panel / door panel box for under-glass exposure.

Units for solar simulation and investigation of UV stability

- Walk-in climate chamber with solar simulators
- Xenotest Beta
- UV radiation device UVA-Sol 400
- Natural weathering
- Instrument panel / door panel box
- Under-glass exposure
- Combination sun / corrosive gas

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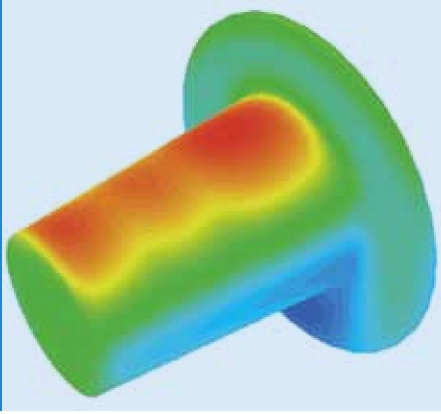
We carry out aging tests according to recognized standards or tailored to our customers' needs

- Material investigations
- Component investigations
- Natural weathering
- Subsequent investigations (chemical-analytical, mechanical, microscopic and morphologic, photometric and colorimetric, REM, LSM, TEM)

VIRTUAL PRODUCT QUALIFICATION

The climate exposure of materials and components enables holistic testing of all environmental influences on the materials. In long-duration studies of at least 1 year, the yearly climate exposure and the resulting material changes can be determined. The material evaluation after different exposure times can be used to calculate the effect of the different stimuli (doses). The dose-effect relationship can be used by simulation programs to extrapolate the behavior of the component and the material properties.

If data concerning the dose-effect relationship are already available, simulation tools can be used to calculate the environmental stress on a component, and therefore deduce the material aging. Virtual product qualification is therefore possible.



Temperature distribution in a polymer component during solar simulation.

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The Fraunhofer ICT has its own exposure facilities where components can be tested, and the institute works closely together with other institutes and service providers. Numerous analytical and optical methods are available for evaluation of the changes to the material properties. Mechanical data for plastics can also be determined, and electrical measurements can be made.

Together with our partners we provide virtual product qualification services to our customers.

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