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CUSTOMER-TAILORED CLIMATE SIMULATION

FOR QUALITY ASSURANCE AND DEVELOPMENT

INTRODUCTION

Industrially manufactured products are known to have a finite service life. Damage or functional defects may end a product's operation before its intended service life, with replacement or at least repair work as an inevitable consequence. This is the reason why weather resistance and functional reliability are essential factors when it comes to evaluate a product's economic viability and sustainability. A wide range of standardized product quality assurance tests has been around for quite a long time now. Those standardized tests however do often reach their limits when it comes to new products as well as in case of common products that are about to be used in a different way. In such cases, **climate simulation, an imitation of specific hygrothermal environmental conditions** is the state of the art procedure for making reliable statements about a given product's suitability and potential service life.

DEFINITION OF TERMS

Climate simulation – refers to subjecting products to artificial stress through exposure to changing climatic parameters. Principal goals of climate simulation:

- investigation of weather resistance and suitability for use under changing hygrothermal conditions,
- research into hygrothermal behavior of materials and systems under diverse types of climatic conditions as well as validation of model approaches for a mathematical description of observed phenomena,
- development of products that protect against extreme climate loads.

Suitability for use – suitability for predefined functions and uses without restrictions or unacceptable side-effects.

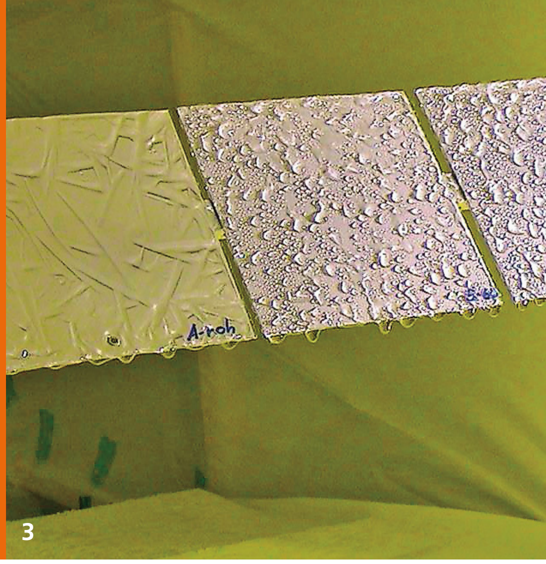
Weather resistance – suitability for proper use throughout the planned service life of a product, i. e. durability, functional reliability, appearance, hygienic and environmental safeness, etc. must be guaranteed throughout a product's service life.

Climate load – single or multidimensional, steady-state or dynamic loads acting on an object due to climate effects. The latter consist of meteorological parameters such as air temperature, air humidity, short and long wave radiation, precipitation, wind and sometimes salt, sand, etc. as well as indoor climate conditions of any kind.

CLIMATE SIMULATION METHODS

Climate simulation is usually being conducted in special climate chambers within the laboratory; however, other procedures may as well be possible, as presented in the following passage:

Laboratory climate simulation serves to artificially create product exposure to various climatic loads in special climate chambers.



Usually, there are only a few selected climate parameters being considered, especially those with specific relevance for the intended investigation. Depending on the intended use the product may be exposed to the same or to different climate loads on both sides. Lab climate simulation allows to run whatever climate cycles desired, regardless of real local weather conditions or seasonal restrictions. Furthermore, new numerical simulation models may be validated in a shorter period. In addition to this, reproduction of boundary conditions is quite easy, so products may be compared without difficulty thanks to standardized tests. Boundary conditions may as well be altered with ease which allows testing of components of real construction projects anywhere around the world.

Outdoor climate simulation refers to exposure of products to real climate conditions. Small adaptations to the natural conditions are still possible, e.g. partial shading, enhanced radiation by altering the reflectivity of surrounding surfaces, reduction of driving rain by periodical sheltering or load increase by artificial rain, etc. Products are often being exposed to a predefined indoor climate on their back side. Control and documentation of indoor climate conditions is mandatory, as well as a detailed recording of outdoor climate parameters. Local weather variations are likely to be the most important disadvantage of outdoor climate simulation, although some abnormalities may be compensated by adjusting indoor conditions in order to command an opportune differential of loads. On the other hand, the response of a product being exposed to real environmental factors is particularly telling, so climate parameters with significant impact on a product´s performance may be identified. Investigations into microbial growth on construction products may serve as an example, as well as investigations into product aging behavior under unknown weathering mechanisms. Thus, outdoor climate simulation is considered an indispensable reference for both lab and numerical climate simulation.

Numerical or computational climate simulation works with mathematical models simulating the physical behavior of products under given boundary conditions. An example are hygrothermal simulation models in compliance with EN 15026, developed and validated to assess components´ performance when exposed to fluctuating heat and moisture. In addition to rapidity and cost efficiency, numerical climate simulation offers the advantage of high flexibility and the possibility of conducting parameter studies and extrapolating them into the future. Numerical climate simulation has already been used successfully to optimize and develop construction materials and components. One disadvantage is the fact that only identified transportation and aging phenomena may be represented, and their corresponding material properties must be known. Thus, in case of new areas of application, validation of results via experimentation is mandatory.

ADDED VALUE THROUGH COMBINING

Outdoor and laboratory climate simulations tend to be expensive. For this reason, planning and optimizing those test series with the help of numerical simulation may be beneficial. For example, before selecting product variants and boundary conditions, it is possible to determine in advance the most crucial combinations of those, through comparative calculations. Absolute figures of simulation results frequently show some uncertainty, whereas results of comparative calculations use to be highly reliable.
Lab climate simulation usually aims at speeding up regular aging processes intensifying determined parameters (e.g. temperature, radiation load, frequency of change) or eliminating irrelevant time periods (e.g. night, transitional phases). However, triggering unnatural modifications of performance should be avoided, especially those caused by inopportunely altered climate parameters. Tests related to construction projects must also be adapted to local climatic zones, especially when potential spontaneous failure due to more extreme weather conditions is a focus of investigation, along with testing of long-term performance. Numerical simulations or results of outdoor investigations can help to identify actual maximum strains, such as summer temperature peaks or winter lowest temperatures, for example. However, even moderate temperatures may be the deciding factor, if accompanied by high levels of humidity. For instance, systematic observations have shown that microorganism growth on façades is primarily taking place during fall time, since higher humidity leads to a more intense condensation on surfaces. Lining up typical maximum loads, such as average fall days or as well hot summer days or cold winter days, allows us to generate climate chamber load cycles which cause weathering phenomena to occur earlier than they would under normal circumstances. This procedure makes a custom tailored quick test concept possible which is also referred to as »test tailoring«.

For more informations see
www.klimasimulation.de

1 *Time-lapsed weathering of a glass roof with interstitial shading elements.*

2 *Driving rain test of a façade construction.*

3 *Climate wind tunnel testing of an ice protective coating (right hand side with feature layer, left hand side without).*