Makrolon®

Stress crack test – Makrolon® moldings

Introduction

Inherent stresses develop in thermoplastic moldings as a result of the molding process and subsequent cooling. Plastics that undergo pronounced relaxation eliminate these inherent stresses again in the course of time without any essential change in their external shape.

Plastics that only undergo limited relaxation are less able to eliminate these stresses. The amorphous plastics (e.g. Makrolon®) belong to this category on account of their low tendency to creep under load. The internal stresses are largely retained inside these plastics and are then super–imposed on the external service stresses.

Both compressive and tensile stresses can result as a function of the molded part geometry and the application in question. If an excessive level of tensile stress prevails, this can lead to local deformation zones in the surface and the areas close to the surface and hence to weak points (micro-cracks, crazes).

In order to produce parts that offer a high value in use, it is in the manufacturer's interest to avoid weak points of this type, i.e. to master the stresses prevailing inside the part.

It is possible to use test fluids for a rapid estimate of frozen-in stresses in Makrolon® moldings.

After the molding has been immersed in the fluid, visible cracks form at points at which specific stress values have been exceeded.

The test fluids have different "reaction thresholds" when it comes to their effect on the molding being tested, i.e. they trigger cracks when a defined tensile stress is attained or exceeded.

Method

The molding is fully immersed in the test medium at 23 ± 2 °C. After a defined exposure time, the part is removed and examined with the naked eye to determine the presence and extent of any cracks that may have developed. If the test reveals excessive internal stresses through the development of cracks, this points to a poor shape, a poor mold design or a processing error.

The selection of a test medium is a function of the application in question and the level of security required for this.

A molded part in Makrolon® ought to pass the test with the test fluid n-Propanol or ethyl acetate/methanol 1 : 3 even if no mechanical loading is to be expected when it is in service.

If the part is subject to mechanical stressing (e.g. assembled with other parts), the test should be conducted with a test fluid of TnP 1 : 10 (a mixture of toluene and n-Propanol) or, in the case of bigger external loads or for critical cases, with TnP 1 : 3 or even with propylene carbonate.

Propylene carbonate forms a film of fluid over the surface of the molded parts. It does not evaporate and, with longer immersion times, in particular, makes it more difficult to recognize cracks that have developed. The immersion time in propylene carbonate should therefore not exceed 1 min. Longer exposure times reduce the reaction thresholds – in other words, stress cracks form at even lower tensile stress values.

If so desired, the test fluid of TnP can also be replaced by ethyl acetate/methanol. By altering the mix ratio for ethyl acetate/ methanol to 1 : 2.5, for example, a reaction threshold of some 7 MPa can be achieved.

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Test medium		Exposure time (min.)	Reaction threshold (MPa)
n-Propanol		15	> 15
Ethyl acetate/Methanol, 1 : 3[1)]		15	> 15
Toluene/n-Propanol, 1 : 10[1)]	(TnP 1 : 10)	15	> 9
Toluene/n-Propanol, 1 : 3[1)]	(TnP 1 : 3)	15	> 4
Propylene carbonate		1	> 2

[1)]Volume ratio

If the level of internal stresses in the production of injection moldings in non-reinforced Makrolon® is to be optimized by suitably adjusting the processing parameters on the injection molding machine in order to avoid crack formation, care must be taken to ensure that the stress crack test is only conducted after the part has been stored for at least one hour after production. With low wall thicknesses of < 1 mm it is possible for no crack development to occur in spite of a considerable level of stress.

Sometimes it is difficult to recognize stress cracks on colored plastics. It is therefore recommended that such parts be sampled and tested in a transparent material.

If the TnP mixture is stored for a lengthy period of time, its composition can change through evaporation, thus producing different test results. For this reason, the mixture should be poured back into a sealable supply bottle immediately after use. The mixture should be replaced if necessary. Parts that have undergone testing should be disposed of.

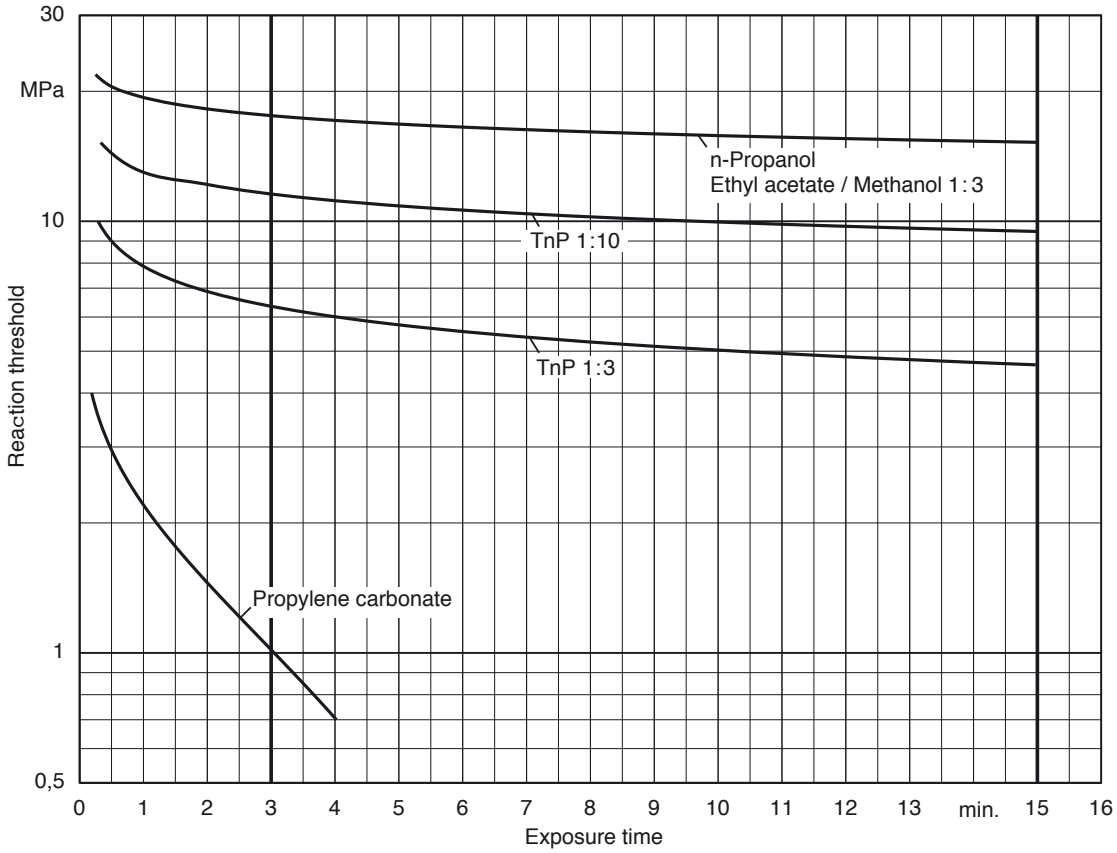

Fig. 1: Stress crack test under load to DIN EN ISO 6252. Tensile creep method on medium viscosity Makrolon®.

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Safety advice

When handling the recommended adhesives and solvents, the advice contained in the Safety Data Sheets for these products must be observed.

The Safety Data Sheets include data on labeling, transport and storage, as well as information on handling, product safety and toxicological and ecological properties; they are provided by the supplier in each case.

n-Propanol, n-propylalcohol; $CH_3CH_2CH_2$-OH

Potential hazards identification
Highly flammable. Risk of serious eye damage. Vapors may cause drowsiness and dizziness.

Toluene, methylbenzene; Ph-CH_3

Potential hazards identification
Highly flammable. Harmful by inhalation. Harmful to aquatic organisms. Harmful: may cause lung damage if swallowed. Vapors may cause drowsiness and dizziness.

Ethyl acetate, "acetic ester"; $CH_3COOCH_2CH_3$

Potential hazards identification
Highly flammable. Irritating to eyes. Repeated exposure may cause skin dryness or cracking. Vapors may cause drowsiness and dizziness. Harmful to aquatic organisms.

Methanol, methylalcohol; CH_3-OH

Potential hazards identification
Highly flammable. Toxic by inhalation, in contact with skin and if swallowed. Toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.

Propylene carbonate, 4-methyl-1,3-dioxolan-2-on

Potential hazards identification
Irritating to eyes.

When handling the solvents referred to above, the relevant safety instructions must be observed. Protective eyewear and approved gloves should be worn. The recommended wearing time of the gloves must not be exceeded due to the danger of the solvent diffusing through the glove material. Vapors should not be inhaled, and adequate ventilation of the workplace should be ensured. Work is therefore best carried out under an exhaust hood. Any residual solvent or waste solvent should be disposed of by a technically suitable incineration plant authorized for this purpose.

Typical value
These values are typical values only. Unless explicitly agreed in written form, they do not constitute a binding material specification or warranted values. Values may be affected by the design of the mold/die, the processing conditions and coloring/pigmentation of the product. Unless specified to the contrary, the property values given have been established on standardized test specimens at room temperature.

The manner in which you use and the purpose to which you put and utilize our products, technical assistance and information (whether verbal, written or by way of production evaluations), including any suggested formulations and recommendations, are beyond our control. Therefore, it is imperative that you test our products, technical assistance, information and recommendations to determine to your own satisfaction whether our products, technical assistance and information are suitable for your intended uses and applications. This application-specific analysis must at least include testing to determine suitability from a technical as well as health, safety, and environmental standpoint. Such testing has not necessarily been done by Covestro. Unless we otherwise agree in writing, all products are sold strictly pursuant to the terms of our standard conditions of sale which are available upon request. All information and technical assistance is given without warranty or guarantee and is subject to change without notice. It is expressly understood and agreed that you assume and hereby expressly release us from all liability, in tort, contract or otherwise, incurred in connection with the use of our products, technical assistance, and information. Any statement or recommendation not contained herein is unauthorized and shall not bind us. Nothing herein shall be construed as a recommendation to use any product in conflict with any claim of any patent relative to any material or its use. No license is implied or in fact granted under the claims of any patent.

With respect to health, safety and environment precautions, the relevant Material Safety Data Sheets (MSDS) and product labels must be observed prior to working with our products.

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