Durability of Joint Sealing Tapes on the basis of a Pre-Compressed Polyurethane Foam

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Abstract. In the paper there was analyzed a mechanism of loss of performance in properties of joint sealing tapes on the basis of pre-compressed flexible polyurethane foam. The results of tests reflect the operation of the two main functional factors are discussed, i.e. resistance to change in temperatures and resistance to the effects of UV radiation in the presence of moisture. After those tests the water tightness of the samples, appearance and the remaining compression deformation were assessed. The results of laboratory tests showed that the biggest influence on the remaining compression deformation in the tapes has UV radiation and the main reason for the loss of water tightness are changing temperatures.

1. Introduction
Polyurethane expansion tapes [1, 2] are one of the solution used to seal the joints of the frame with the jamb. Their task is to ensure tightness against water penetration as well as the migration of air. They are gaining popularity as an alternative method to polyurethane foams that are foamed in situ. They are a simple product in usage that does not require processing after application. Expanding tapes are made of polyurethane foam impregnated with an acrylic suspension. They are usually offered in several types, varying in density which results from a diverse level of impregnation saturation. The degree of impregnation and the degree of expansion of the tape after being placed in the joint determine the product's performance. The tapes are delivered in a compressed form, wound on a roll. With free expansion, their thickness increases by 5 times. They are fixed to the frame with a self-adhesive layer. They are offered in a wide range of dimensions. Their effectiveness depends on the appropriate selection of the tape dimensions and the width of the joint. In order for these products to properly perform the function of sealing, they cannot be damaged as a result of usage conditions in the considered period of use. According to well-established technical knowledge, the basic factors that can cause degradation of the products are temperature changes and UV radiation in the presence of moisture.

2. Experiment
2.1. Scope
The Building Research Institute in Warsaw (Poland) has undertaken research aimed at assessing the durability of selected performance properties of expandable polyurethane tapes impregnated with an acrylate suspension. The results of the work, described in this article, do not exhaust the topic, presenting only selected aspects of the problem. The research was carried out in two parallel paths, i.e.
assessments of the resistance to change in temperature,
assessments of the resistance to the effects of actions of UV radiation in the presence of moisture.
Assessment of changes in the appearance and watertightness of the tested products as well as their remaining compression deformation are taken as a measure of durability of tapes after the above-mentioned exposures.

2.2. Materials
After initial elimination tests performed on different products in the same group, we chose seven joint sealing tapes on the basis of a pre-compressed flexible polyurethane foam for sealing around windows and joints in building facades. Basic characteristics of these tapes and basic dimensions that have a significant impact on the performance of the product under the conditions of use in figure 1 were presented in the table 1.

| Specimen number | Dimensions of the tape, mm | Joint width | Degree of decompression $a, \%$ | Density of impregnated sealing tapes, kg/m$^2$ |
|-----------------|-----------------------------|-------------|-----------------------------|---------------------------------|
|                 | width $t_F$ | thickness of the uncompressed sealing tape $b_0$ | min $b_{min}$ | max $b_{max}$ | min $a_{min}$ | max $a_{max}$ |
| T1              | 20            | 46           | 8                          | 16                              | 17                           | 35                           | 87                           |
| T2              | 25            | 70           | 12                         | 24                              | 17                           | 34                           | 83                           |
| T3              | 20            | 54           | 9                          | 18                              | 17                           | 33                           | 84                           |
| T4              | 20            | 36           | 6                          | 12                              | 17                           | 33                           | 86                           |
| T5              | 20            | 46           | 8                          | 15                              | 17                           | 33                           | 130                          |
| T6              | 20            | 35           | 6                          | 12                              | 17                           | 34                           | 147                          |
| T7              | 20            | 41           | 7                          | 18                              | 17                           | 44                           | 163                          |

Nominal width $b_N$ of the joint according to declaration of the manufacturer have to be:

$$b_{min} + (b_N \times 25 \%) \leq b_N \leq b_{max} - (b_N \times 25 \%)$$
2.3. Methods of tests

For the needs of the work, 9 samples were prepared for each type of tape. The tapes were placed in metal, rigid frames simulating a joint with a width corresponding to the minimum degree of tape expansion (a\textsubscript{min} = 17\%). The depth of filling of the joints with the tape corresponded to their width t\textsubscript{f} (figure 1). Samples have been glued with the self-adhesive side to one side of metal supports. The second surface of the tape was free. The same sample preparation method was used for tested tapes listed in table number 1, i.e. three samples have been prepared with anti-adhesive spacers between the tape and the frame to prevent it from sticking to the frame permanently and other six samples without spacers (figure 2). For all tested tapes mentioned samples have been divided in such way (see figure 3):

- two samples with anti-adhesive spaces and one without them, has been conditioned in standard climate for 24 hours,
- three samples mentioned above were subjected to the tests related to the assessment of tape’s resistance to the effects of actions of UV radiation in the presence of moisture,
- three samples mentioned above were subjected to the tests related to the assessment of tape’s resistance to change in temperature.

![Figure 2](image1.png)

Figure 2. Rectangular tubes made of aluminum for mounting the tapes for ageing tests:
(a) alone (a), with the sample (b) and with the pipe used for water tightness test (c).

| for laboratory conditions | for UV and moisture effect | for temperature effect |
|---------------------------|----------------------------|------------------------|
| • degree of decompression (samples with anti-adhesive spacer) | • degree of decompression (samples with anti-adhesive spacer) | • degree of decompression (samples with anti-adhesive spacer) |
| • appearance (samples without anti-adhesive spacer) | • appearance (samples without anti-adhesive spacer) | • appearance (samples without anti-adhesive spacer) |
| • watertightness (samples without anti-adhesive spacer) | • watertightness (samples without anti-adhesive spacer) | • watertightness (samples without anti-adhesive spacer) |

Figure 3. Types of samples used in the research.

Specimens were subjected to the test of resistance to the effects of action of light and moisture [3]. They were hung up in a Xenon test apparatus and were weathered for a total of 3 months in the test chamber at a light/dark alternation with cycles according to EN ISO 4892-2, table 3, Method A, cycle 1. The sum of the radiation during this period per test area amounts to 240 MWs/m\textsuperscript{2} ± 5 %. Conditions in the test chamber are shown on the figure 4. Afterwards the samples have been stored in the drying oven at temperature of 50 °C for 1 h and a further 24 h at standard climate [3].
To test the resistance to change in temperature specimens were pre-stored for 7 days at standard climate and after that have been subjected to three times the following cycle of storing (figure 5):

- exposure in an oven at 50 ± 2 °C for 22 h, followed by 2 h in an oven at 80 ± 2 °C (this process have been repeated twice),
- immersion in distilled water at 23 ± 2 °C for 1 day,
- exposure in a freezer at -20 ± 2 °C for 3 days,

Subsequently the test specimen has been stored one more day at standard conditions.

After each of the aging test, the change in the appearance and water tightness of the samples as well as remaining compression deformation were assessed. Remaining compression deformation was determined after 6h after finishing aging action, in accordance with EN ISO 1856. Water tightness has been tested with a head of water of 60 mm in a tube test during 180 second at standard climate conditions.

2.4. Results and discussion

For the first batch of samples, in none of the tested cases water leaks were found after the test was completed. But after two ageing tests only 4 tapes fulfill requirements of water tightness. Results of these tests are presented on the figure 6.
There is no visible leakage of impregnating agent. Comparative combination of the results of remaining compression deformation after actions of UV radiation in the presence of moisture and after temperature aging conditions are shown on figure 7.

The values of remaining compression deformation of tapes as a result of simulation of working conditions are higher in the case of UV radiation in the presence of moisture than in the effect of variable temperatures, which is graphically shown in figure 8. There is a correlation between effects of these two influences as an ageing coefficient submitted as a quotient residual deformation after UV treatment in the presence of moisture and residual deformation after changing temperatures. This coefficient ranges from 1.3 to 2.5. If the coefficient varies between 1.3 and 1.6, tapes fulfill requirements of water tightness after temperature ageing. In the case, when it rises above 2, the water resistance of the tapes is lost. There is no relation between discussed factor and the density of the tapes.
3. Conclusion

Test results discussed in this article suggest conclusions described below regarding the durability of pre-compressed flexible polyurethane joint sealing tapes:

- there are no visible changes in external appearance of all tapes after aging tests, i.e there is no visible leakage of impregnating agent,
- working conditions have a significant impact on the successive loss of functional properties of the tapes, identified as remaining compression deformation of the cross-sectional area after squeezing the tape in the test joint,
- the influence of UV radiation in the presence of moisture has the greatest influence on the remaining compression deformation of the tapes. In the majority of cases studied, the remaining compression deformation is from 1.3 to 2.5 times higher after UV treatment in the presence of moisture than in the effect of changing temperatures. The exception is one sample showing even greater disproportions in this case,
- observation mentioned above is not reflected in the results of the watertight test. The waterproofness of the joint is adversely affected mainly by the influence of variable temperatures and not by the action of UV radiation in the presence of moisture. The deviation from this statement is visible only on one tested tape, in which also the deformation caused by the UV radiation was deviated from the average.

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