isp Rosenheim

Rosenheim Window Study

Analysis of Seals used in Window and Door Systems

isp Rosenheim – Ingenieurbüro Professor Josef Schmid

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Project name
Analysis of Seals used in Window and Door Systems

Project execution
isp Rosenheim – Ingenieurbüro Professor Josef Schmid
Professor Josef Schmid, Dipl.-Ing.
Michael Stiller, M.Eng. Dipl.-Ing. (FH)

Tests performed by
Ingenieurbüro Skora
Timo Skora, Dipl.-Ing. (FH)

Tests
The tests were performed in the Air-Conditioning Systems Laboratory of Rosenheim University of Applied Sciences.

Project objective
The evaluation of the sealing effect of overlap seals for PVC windows following climatic load and simulated utilisation dependent on gasket geometry and material.

Client
Semperit Gummiwerk Deggendorf GmbH

March 2012

1. Starting situation

1.1 Introduction

The increasing demands placed on the heat insulation and energy-saving properties of buildings have led to greater demands also being placed on the building shells, as formulated in the Energy Saving Regulations:

“ … Buildings are to be constructed in such a way that the heat-transferring envelope of the building, including the joints, are rendered permanently airtight in line with the latest technology …”

The implementation of these requirements leads to disturbances in the humidity balance in buildings unless home ventilation and airflow measures are implemented at the same time.

As the impermeability of building shells increases, so does the moisture load and the danger of mould formation in the rooms. As a result, the importance of room-side overlap seals to prevent condensation and mould growth in the rebates of windows is growing.

1.2 Ambient atmosphere

The ambient atmosphere follows an annual cycle, as shown in Figure 1. The critical phase for the formation of condensation and mould growth is the heating period, with high temperature differences between the interior and exterior of the building, relatively high humidity in the outside climate and greatly varying relative humidity in the interior climate, which is determined by the impermeability of the building shell and the possibilities for ventilation.

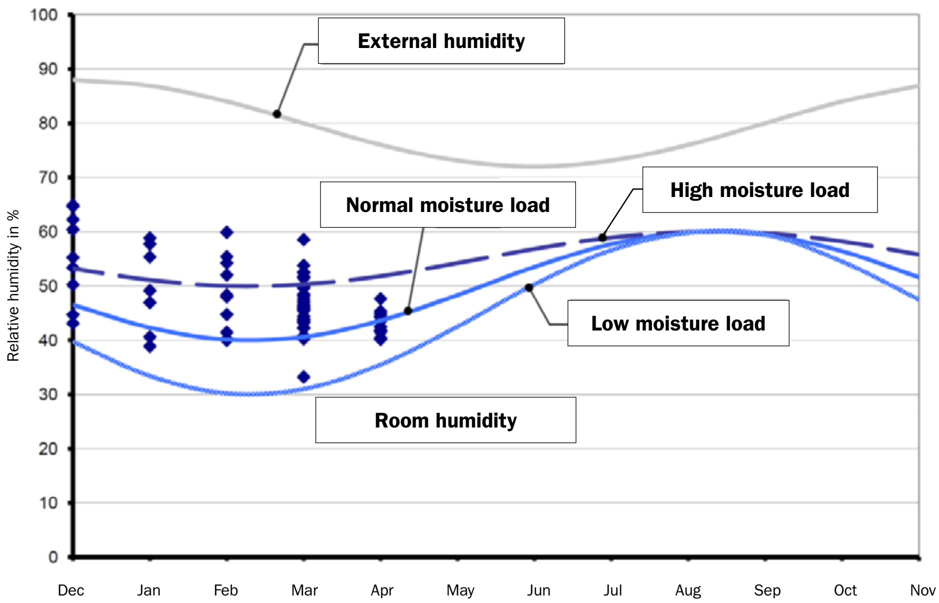

Figure 1: Calculated annual cycle of relative room-side humidity dependent on the exterior humidity and the moisture load (Fraunhofer Institute for Building Physics, Holzkirchen) with additional measurement of the relative humidity of 27 apartments in the Greater Munich area (measurements taken during the joint research programme, “Timber Construction of the Future”, Sub-project 19)

The airtight building shell and the thermal lift affects the pressure distribution in the building in such a way that it exerts overpressure on the window and door rebates on the upper floors, and under-pressure on the window and door rebates on the lower floors.

In the case of overpressure and the increased moisture load, the moist warm room air is pressed into the rebates of the windows and doors. Where the building shell is impermeable, the rebates of the windows and doors are frequently the only non-airtight areas.

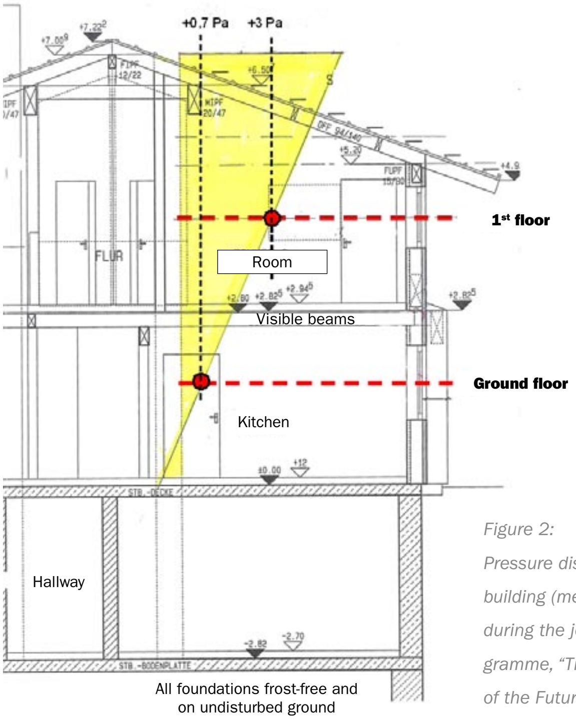

Figure 2: Pressure distribution in the building (measurements taken during the joint research programme, "Timber Construction of the Future", Sub-project 19)

1.3 Formation of condensation and mould growth

The moist, warm room air is cooled to below the dew point temperature and condensation forms. Dust, which is present practically everywhere, then provides a breeding ground for mould growth. Therefore, it follows that, if the effectiveness of the overlap seals of windows and doors is inadequate, the moisture load in the room will result in the formation of condensation and mould growth in the rebates.

The problem of condensation and mould growth, and the associated burden, has become so prevalent in recent years that the issue has attracted media attention. Condensation and mould growth around windows and doors has become a much-discussed problem. From the available findings, it can be assumed that condensation and mould growth represent a widespread problem.

In order to reduce the possibility of warm room air entering the rebates of windows and doors, and thus to counteract the formation of condensation and mould growth, a permanently airtight room side overlap seal is required.

The room-side overlap seals available on the market and used in practice are frequently interrupted near the fittings and in the corners and so do not have the requisite level of effectiveness.

Figure 3: Mould growth in the upper frame rebate (PVC window)

Figure 4: Mould growth in the lower frame rebate (PVC window)

2. Problem definition

The seals between the sashes and frames also fulfil other tasks that are, among other things, determined by their position in the window (Figure 5).

In windows and doors, they play an important role in ensuring fitness for purpose. Their effect is the prerequisite for optimum soundproofing and adequate impermeability with regard to air passage and rainwater penetration.

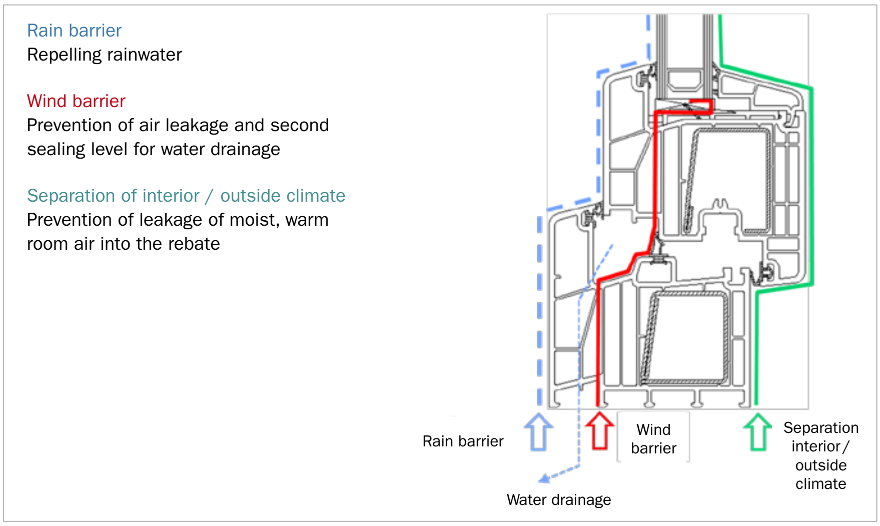

Figure 5: Sealing levels and description of functions

The requirement for a circumferential, airtight overlap seal serves – as previously mentioned – to prevent condensation and mould growth in the rebates.

The fitness for purpose, which, among other things, is described by the above properties, can only be assured over an adequate lifetime if the gaskets satisfy the demands placed on them throughout their lifetime, taking into consideration their position in the profile system. Monitoring of the windows and doors market has shown that, in recent years, the gaskets between sashes and frames do not always meet the demands placed on them.

In order to compare the gaskets available on the market, it is necessary to be able to evaluate individual gaskets. Within the frame of the project, it is intended to measure the air passage and thus the effect of room-side overlap seals on normal PVC systems.

Particular importance is attached to

- *the gaskets being tested in an installed state.*
- *the test specimens being typical systems available on the market*
- *the utilisation phase being simulated through climatic load and deformation of the gaskets.*
- *the possibility of comparing the gaskets.*

The gaskets are evaluated on the basis of the results of the measurements and the findings gained.

3. Tests

The joint permeability is measured during the tests. The utilisation phase is simulated through climatic load and varied deformation of the gaskets.

3.1 Test specimens

- *Dimensions 500 x 500 mm*
- *Typical designs available on the market*
- *Various PVC window systems*
- *2 x EPDM and 1 x TP test specimen(s) per window system*
- *Room-side EPDM and TP overlap seals*
- *Aluminium stabilising frame, uniform clearance between sash and frame*
- *Apparatus for adjusting the clearance between sash and frame and, thus, the seal deformation*

3.2 Testing set-up

The test specimens are spanned on a test facility and the joint permeability is measured at overpressure.

- *Joint permeability tested at 600 Pa overpressure*
- *Determination of the joint permeability along the stiles/rails and in the corners*
- *Air conditioning of the test specimens in the climatic chamber of the Air-Conditioning Systems Laboratory of Rosenheim University of Applied Sciences*

Figure 6:
Test set-up and measurement equipment
Detail: testing joint permeability in the corners

3.3 Test procedure

After extensive air conditioning at standard climate (20 °C / 50 %), the joint permeability was measured. This first measurement can be considered an ex-factory condition reference measurement. The clearance between sash and frame is set according to the system manufacturer's specifications.

The simulation of the utilisation phase envisages air conditioning with a -20 °C / +60 °C climatic cycle and two different deformation sizes for the gaskets. The distance between sash and frame is set prior to climatic load, and the measurement at the end of the load phase.

Gasket sizes:

Maximum	=	gasket is still attached and is effective.
Specified	=	system owner specification
Minimum	=	gasket is compressed to the full extent. (without causing material crush/displacement)

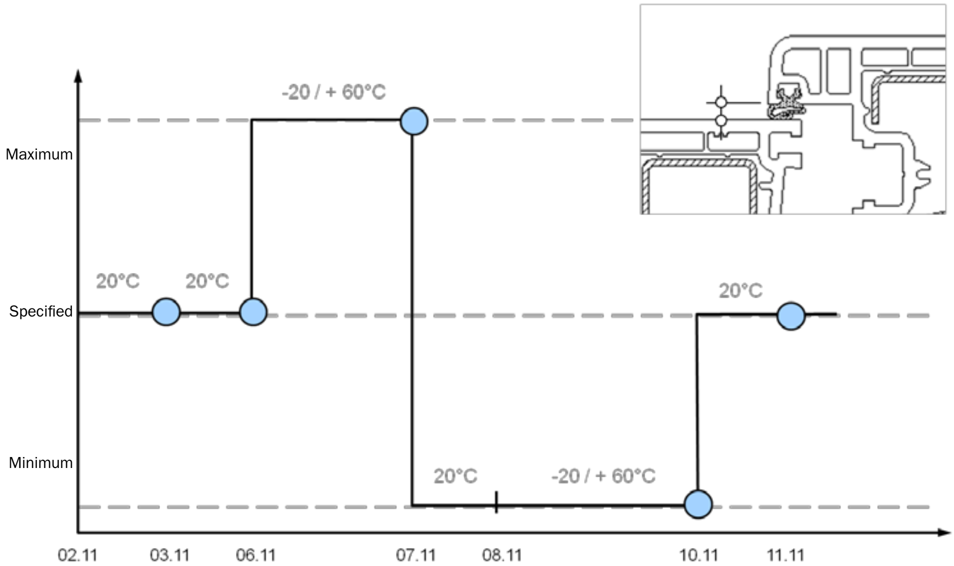

Figure 7: Chronological sequence of the tests with data on gasket compression, air conditioning and measurements of joint permeability (blue points)

3.4 Results

The results of the measurements show that there are differences between the systems – in particular in the corners – and it can be assumed that the gaskets along the stiles/rails are functional. Therefore, the further evaluation primarily shows the results for the corner areas.

Initial condition (reference measurement):

The results of the joint permeability measured in the initial condition show that

- *there are gasket geometry-related differences.*
- *no significant differences between the tested EPDM and TP gasket materials were measured.*

At maximum size:

The comparison between the reference measurement and the measurement after climatic load at maximum size shows that

- *in general, higher joint permeability was measured at maximum size.*
- *there are no significant differences between the EPDM and TP gasket materials tested.*

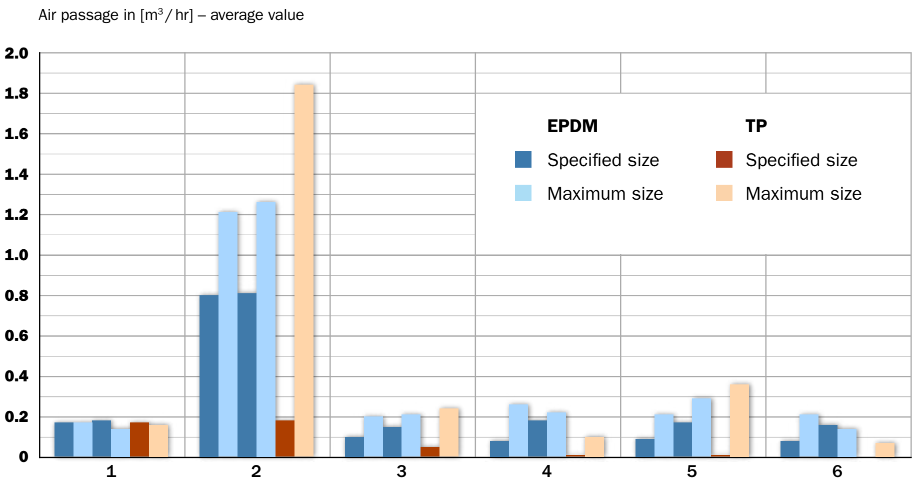

Figure 8: Comparison of the air passage at the specified size (reference measurement) and after climatic load at maximum size (average values of the measurements in the corners)

Significant differences can be seen when comparing the percentage change in joint permeability at maximum size relative to the specified size.

It can be seen that TP gaskets exhibit greater changes in joint permeability after climatic load than EPDM gaskets.

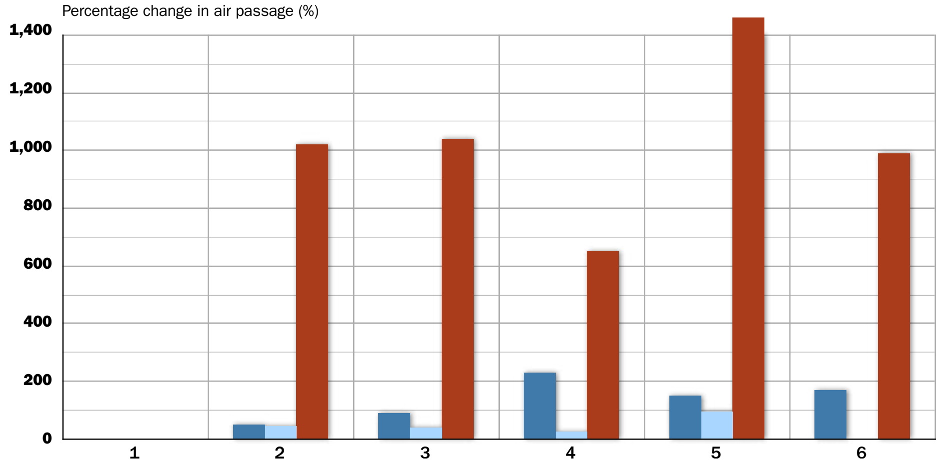

Figure 9:
Comparison of percentage change in air passage (average values of the measurements in the corners) after climatic load at maximum size relative to the specified size (reference measurement)

At minimum size:

In practice, load on the gaskets involving strong deformation is a frequently observed situation, if

- *the window/door remains closed for a long period of time.*
- *the fittings have been so firmly set that readjustment of the fittings does not appear to be required for the longest possible period.*

The measurement results of joint permeability show that

- *there is a recognisable change in the effect of the gaskets.*
- *higher joint permeability was measured.*
- *differences between the tested EPDM and TP gasket materials are present.*

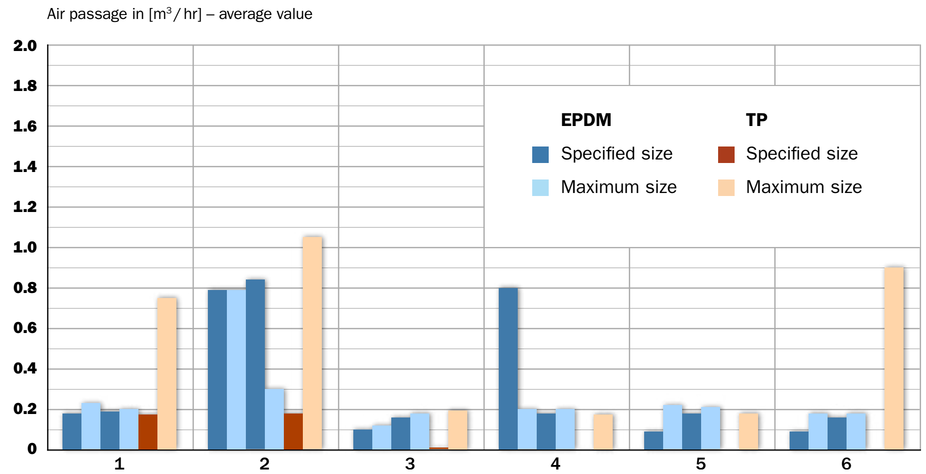

Figure 10:
Comparison of the air passage measured in the corners before and after the test cycle at the specified size (average values of the measurements in the corners)

Significant differences can be seen when comparing the percentage change in joint permeability after the test cycle.

TP gaskets show more significant changes in joint permeability after the test cycle and the simulated utilisation phase than EPDM gaskets.

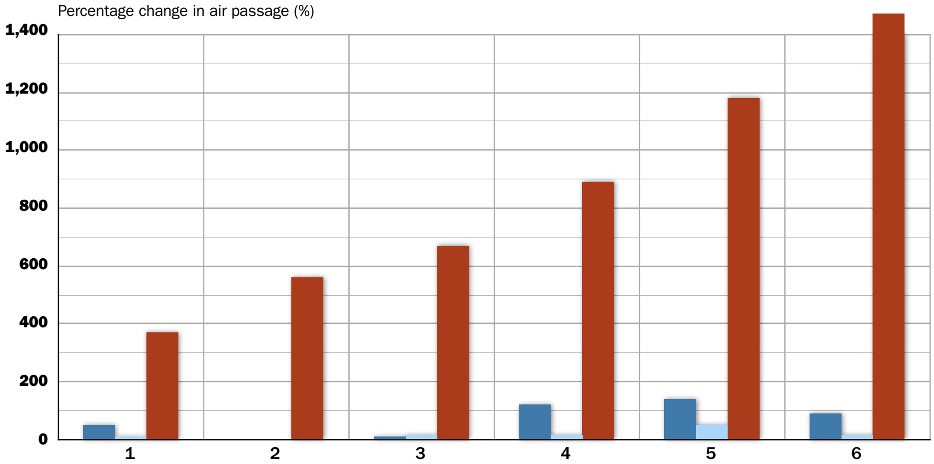

Figure 11:
Percentage change in air passage at specified size after the test cycle relative to the specified size at the initial condition

Along the stiles/rails:

It is assumed that the geometry and the design of the gaskets are specified for the stiles/rails. In the ex-factory condition, a low level of joint permeability was measured in all of the gaskets tested.

Changes to the gaskets occurred as a result of the load of the simulated utilisation phase and the deformation of the gaskets at minimum size. Due to the rapid elastic recovery, EPDM gaskets regained their sealing effect in the stiles/rails at the end of the test cycle (Figure 12).

In TP gaskets, such severe plastic deformation was, at times, ascertained along the stiles/rails that the sealing effect was no longer present (Figure 13). The fitness for purpose of the room-side overlap seal and, thus, the prevention of condensation and mould growth cannot be assured.


Fig. 12


Fig. 13

Figure 12:
Sealing effect present along the stiles/rails at the end of the test cycle due to rapid elastic recovery in EPDM gaskets

Figure 13:
No sealing effect along the stiles/rails at the end of the test cycle due to plastic deformation in TP gaskets

In the corners:

The evaluation of the measurement results shows that there are, in particular, differences between the tested gaskets in the corners. The sealing effect in the corners in EPDM gaskets is significantly influenced by the geometry of the gaskets.

At the end of the test cycle, some corners were found where the EPDM gaskets are buckled and, thus, there is only a limited sealing effect.

Shortening of the EPDM gasket was found, caused by the load of the simulated utilisation phase, in particular, was evidenced by gasket curling. Depending on geometry, the sealing effect is still present even after the test cycle (Figure 14).

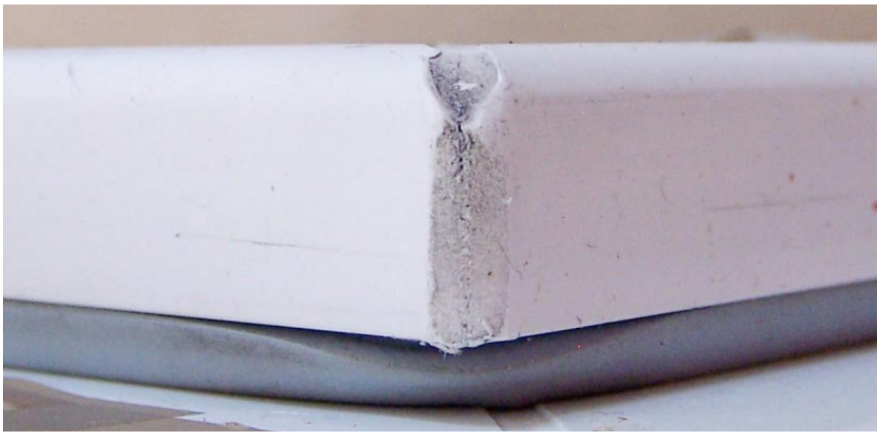

Figure 14: Corner of an EPDM gasket that had curled at the end of the test cycle. The sealing effect was still present.

When the window is manufactured, the TP gaskets are welded to the PVC profile in the corner. The manufacturing process causes hardening of the gasket in the corners around the welding joint. The effect and functionality of the gasket is thereby limited.

After concluding the test cycle, a change (relative to the ex-factory condition) was identified in the corners of the TP gaskets. At times, plastic deformation of the gaskets in the corners occurred so that the sealing effect was not present (Figure 15).

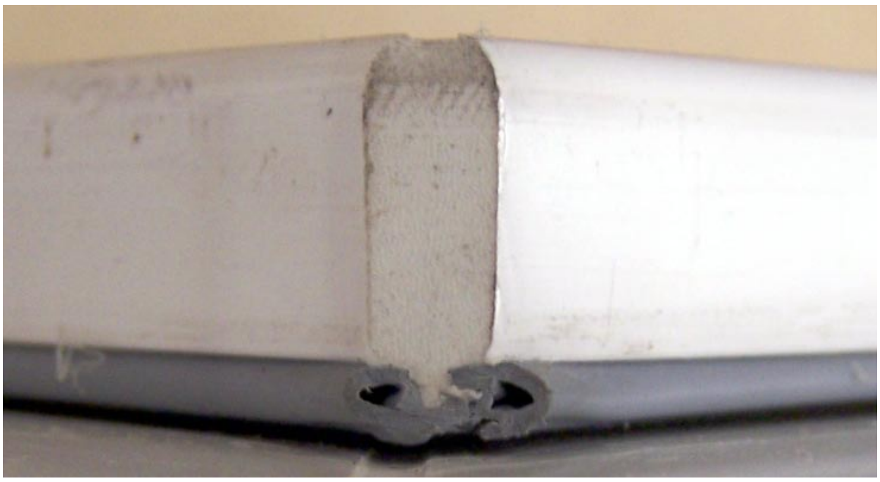

Figure 15: Corner of a TP gasket with recognisable deformation and lack of sealing effect

The longitudinal join:

EPDM gaskets, by the nature of the manufacturing process, have a longitudinal join in the gasket. As a result of the load caused by the simulated utilisation phase, shortening of the EPDM gasket was found. As a result of this shortening, sporadic cases of leakage in the longitudinal join were found after the test cycle (Figure 16).

Negative changes to the longitudinal join can be avoided through correct installation.

TP gaskets do not have any longitudinal join.

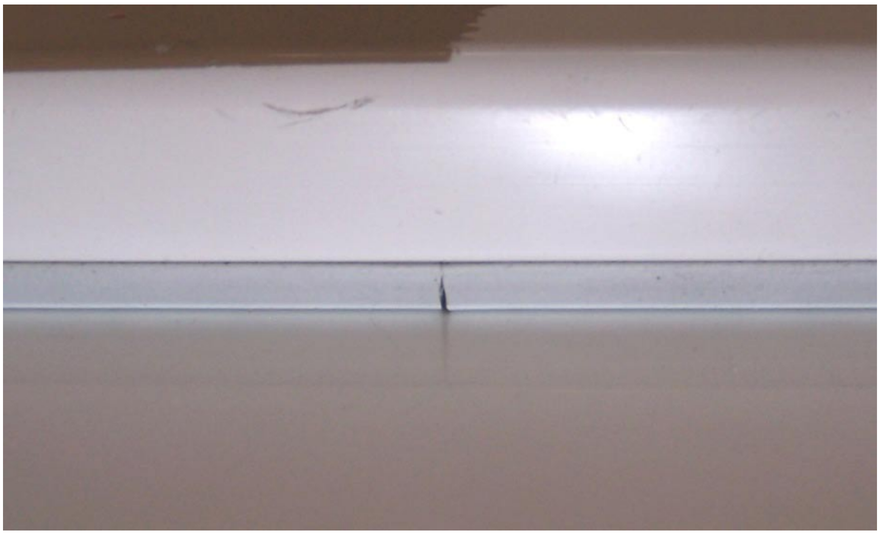

Figure 16: Leakage in the longitudinal join of one EPDM gasket upon conclusion of the test cycle

Summary of the results:

- *In the ex-factory condition, joint permeability is, and should be, very low in all gaskets.*
- *Significant differences in joint permeability in the corners between the EPDM and TP gaskets used occur during the utilisation phase.*
- *The percentage change in joint permeability is considerably higher in TP gaskets than in EPDM gaskets.*
- *The gasket geometry has a significant influence on the sealing effect in the corners.*

3.5 Findings

As a result of the stresses of the simulated utilisation phase, changes to the joint permeability in all gaskets were found. In the corners, in particular, higher joint permeability was found at the end of the test cycle. The extent of the change identified is, according to the evaluated measurement results, dependent on

- the geometry of the gasket,
- the gasket material,
- the level of care exercised when manufacturing the PVC window.

The percentage change in joint permeability is higher in TP gaskets. From a technical point of view, it can therefore be assumed that, in the course of the utilisation phase, a negative change in joint permeability occurs and thus the danger of condensation formation and mould growth increases.

Figure 17: Assessment of the gaskets from a technical point of view on the basis of the tests performed

	Stiles / Rails	**Corners**	**Longitudinal join**
EPDM	+ + +	+ +	+ −
TP	+	−	

On the basis of the findings, from a technical point of view, the gaskets can be assessed with regard to their sealing effect over the utilisation phase (Figure 17).

The advantages for the building contractor of using professionally designed EPDM gaskets:

- *Functional seal over an adequate lifetime,*
- *Hygienic conditions in the rebates,*
- *Retention of value of the windows/doors and the building structure.*

4. Literature

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Prof. Josef Schmid
Dipl.-Ing.

Michael Stiller
M.Eng. Dipl.-Ing. (FH)

Rosenheim

isp Rosenheim
Hechtseestrasse 16
83022 Rosenheim
Germany

Tel.: +49 8031 2227 - 864
Fax: +49 8031 2227 - 862
E-mail: mail@isp-rosenheim.de

www.isp-rosenheim.de