

# **Quality, tolerance and processing guidelines for products made by BWF Kunststoffe GmbH & Co KG**

Date 24.11.2021

## **Scope of application**

These quality and tolerance specifications as well as processing guidelines are valid for all products manufactured or supplied by BWF Kunststoffe GmbH & Co KG.

Table of contents

<b>1. Tolerance Specifications Extrusion</b> .....	<b>4</b>
1.1. General tolerances.....	4
1.1.1. Cross-section .....	4
1.1.2. Longitudinal direction .....	5
1.2. Tolerances of shape and position .....	6
<b>2. Approval process</b> .....	<b>8</b>
2.1. Adjustment drawing .....	8
2.2. Sample .....	8
2.3. FAI report .....	8
2.4. Functional check.....	8
2.5. Production drawing .....	8
<b>3. Quality inspections</b> .....	<b>9</b>
3.1. General Information .....	9
3.2. Functional check.....	9
3.3. Dimensional inspection .....	9
3.3.1. Length testing.....	9
3.3.2. Straightness .....	9
3.4. Surface.....	10
3.5. Classification of surface imperfections .....	10
3.6. Color.....	11
3.7. Saw cut .....	12
3.8. Stress test .....	13
<b>4. Handling Guidelines</b> .....	<b>14</b>
4.1. Storage.....	14
4.2. Moisture absorption .....	14
4.3. Thermal change in length .....	14
4.4. Protection .....	14
4.5. Cleaning .....	14
4.6. External influences in installation.....	14
<b>5. Processing Guidelines</b> .....	<b>15</b>
5.1. Tensions in plastic parts.....	15
5.2. Machining.....	15
5.3. Machining and sheet saw tolerances .....	15
5.4. Drilling .....	16
5.5. Milling .....	16

5.6. Laser cutting.....	16
5.7. Punching .....	16
5.8. Polishing.....	16
5.9. Threads .....	17
5.10. Screw connections.....	17
5.11. Clamping .....	18
5.12. Gluing .....	18
5.13. Welding .....	18
5.14. Rivets .....	19
5.15. Tempering .....	19

# 1. Tolerance Specifications Extrusion

## 1.1. General tolerances

In the case of general tolerances, a distinction is generally made between two types of observation: On the one hand, the profile cross-section is viewed and, on the other hand, the longitudinal direction of the profile. The general tolerances apply if nothing else is indicated on the profile drawing.

The following limit values apply according to DIN 16941 - 2A and 2B, unless otherwise stated in the drawing

### 1.1.1. Cross-section

The general tolerances apply at any point in the profile. The profile cross-section to be viewed is at right angles to the extrusion direction:

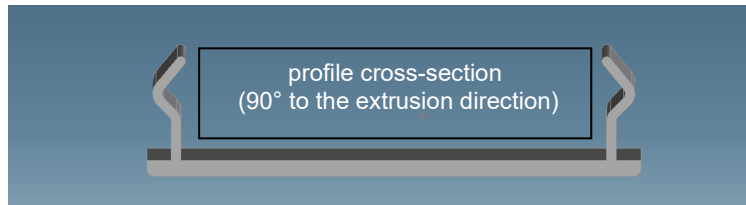


Figure 1: Viewing profile cross section

Allowed limits for **length measurements**:

Tolerance-series	Nominal size range [mm]									
	To 3	above 3 to 6	above 6 to 10	above 10 to 18	above 18 to 30	above 30 to 50	above 50 to 80	above 80 to 120	above 120 to 250	above 250 to 400
2A and 2B	± 0.3	± 0.4	± 0.5	± 0.6	± 0.7	± 0.8	± 1.0	± 1.2	± 2.0	± 3.0

Table 1: Tolerances of Length measurements

Allowed wall **thickness tolerances**:

Tolerance-series	Nominal size range [mm]					
	to 1.2	above 1.2 until 2.5	above 2.5 until 4	above 4 until 6.5	above 6.5 until 10	above 10
2A and 2B	± 0.2	± 0.3	± 0.4	± 0.5	± 0.6	± 8%

Table 2: Tolerances of wall thickness

Allowed limiting dimensions for **rounding** and **chamfer heights**:

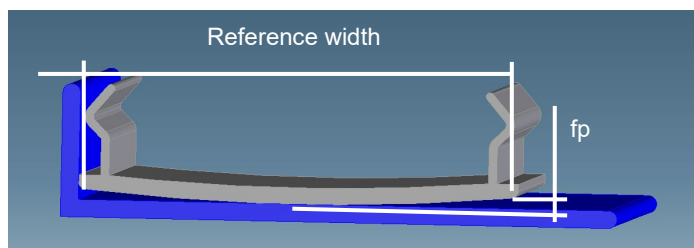
Tolerance-series	Nominal size range [mm]						
	to 3	above 3 to 6	above 6 to 10	above 10 to 18	above 18 to 30	above 30 to 50	above 50
2A and 2B	± 0.5	± 20%	± 18%	± 15%	± 15%	± 12%	± 10%

**Table 3: Tolerances of the circular diameter and chamfer heights**

**Planarity:** (term only BWF Profiles in house)

Planarity tolerance  $t_p$ , see drawing text field (e.g.,  $t_p = 0.3$  mm with width to 30 mm)

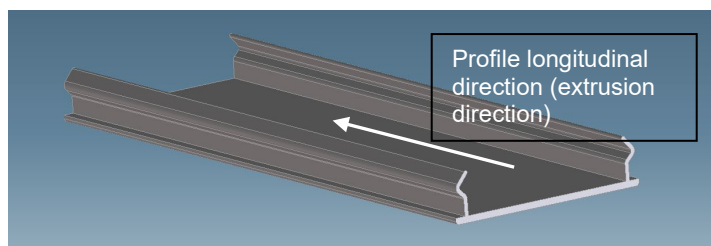
Planarity deviation  $f_p$



**Figure 2: Viewing the planarity**

### 1.1.2. Longitudinal direction

Independent of the profile cross-section, deviations in the longitudinal direction (extrusion direction) may occur with extruded profiles. These deviations depend on the length of the profile. The position of the profile cross-sectional axis may deviate from the ideal axis in the longitudinal direction (extrusion direction).

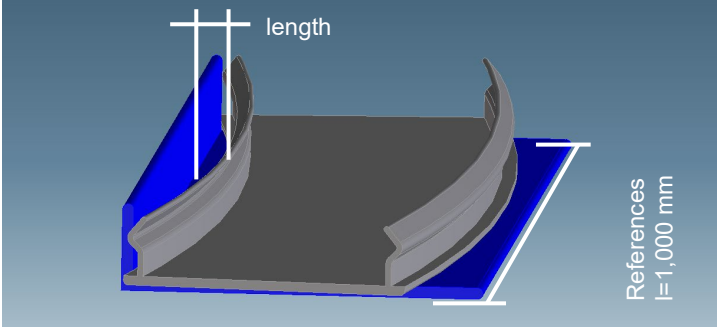


**Figure 3: Viewing the longitudinal direction of the profile**

**1.2. Tolerances of shape and position**

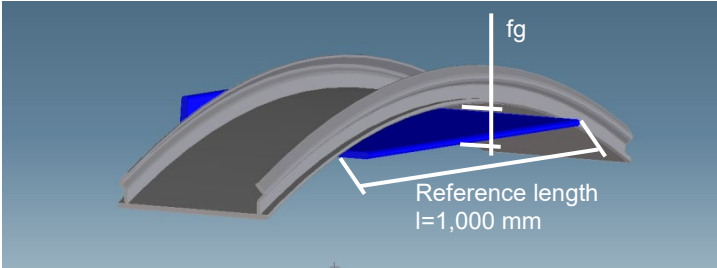
**Straightness:**

Straightness in X-direction: straightness tolerance  $t_g$  (for example  $t_g = \pm 1.5$  mm on a length of 1,000 mm)  
Straightness deviation  $f_g$



**Figure 4: Straightness in the X direction**

Straightness in the Y direction: straightness tolerance  $t_g$  (for example  $t_g = \pm 1.5$  mm on a length of 1,000 mm)  
Straightness deviation  $f_g$

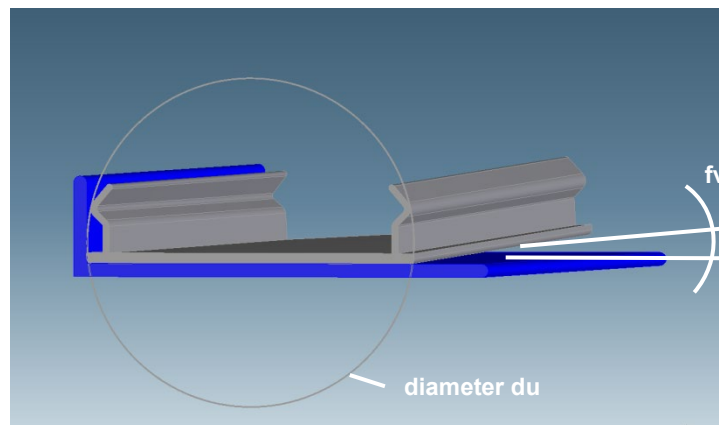


**Figure 5: Y-direction straightness**

**Distortion:** Straightness tolerance tv, straightness deviation fv  
twist tolerance tv in degrees:

Tolerance-line	diameter du [mm]					
	to 30	above 30 to 60	above 60 to 120	above 120 to 180	above 180 to 250	above 250
2A, 3A, 4A	5°	4°	3° 30'	3°	2° 30'	2°

**Table 4 distortion tolerance tv**



**Figure 6: Straightness deviation fv**

## 2. Approval process

### 2.1. Adjustment drawing

After placing the order for a new tool, BWF Profiles first creates a preliminary drawing ("adjustment drawing"), based on the drawing provided by the customer and any agreements made, which is sent to the customer for verification and approval. BWF Profiles expects an approval of the adjustment drawing within two working days in order to allow for a smooth internal tool completion process. Based on the approved adjustment drawing, the tool is designed and manufactured at BWF Profiles.

### 2.2. Sample

After completion of the tool, the first test production ("adjustment") begins. Based on the results of this adjustment, the tool may pass through several stages of rework until the extruded profile cross-section is both dimensionally and functionally (see point 2.4) accurate. Following the final adjustment, samples are produced, which must be checked and approved by the customer prior to the profile entering production stage. The samples may either be approved solely by the customer, or together with the customer, in the case of a profile inspection at BWF Profiles. The approved samples are archived by BWF Profiles and serve as a reference for comparative tests for all subsequent serial productions.

### 2.3. FAI report

During the final adjustment, a first article inspection report (FAI), based on the adjustment drawing, can be created upon request.

### 2.4. Functional check

BWF Profiles will ensure the correct installation of the profile, as well as the desired function, by means of a counterpart ("installation gauge") provided by the customer. The mounting jig must always reflect the final installation state, i. e. any optional additional machining steps, such as painting, coating, etc., must be taken into account. Should slight deviations from the clearance tolerances specified under point 1 or the data on customer or BWF profile drawings be required, BWF Profiles shall, at the discretion of BWF Profiles, adapt these accordingly. This applies both to the production of the initial samples as well as to all subsequent serial productions. It is the responsibility of the customer to inform BWF Profiles about changes to the installation situation and to provide the modified installation gauge if it is relevant for the functional test. Further functional tests can be individually arranged between BWF Profiles and customer. If no installation instructions are provided by the customer, BWF Profiles will produce according to the adjustment drawing. In this case, a flawless installation or function cannot be guaranteed and BWF Profiles accepts no liability for resulting complaints.

### 2.5. Production drawing

After approval of the samples by the customer (see point 2.2.), a dimensional revision of the adjustment drawing may be carried out in order to match the dimensions of the samples. The revised drawing is sent to the customer for approval. After approval, it serves as a final production drawing and the basis on which future productions are carried out. In order to ensure smooth internal processes, the approval of the production drawing is requested from the customer no later than 15 working days before the start of production. The customer shall be informed by BWF Profiles in good time of the relevant deadline and the planned start of production. If the approval is not given in time, it is at the discretion of BWF Profiles to produce on the basis of the production drawing.



## 3. Quality inspections

### 3.1. General Information

Unless described otherwise in the relevant documents of the relevant profile, the following standard test procedures apply:

Documents relevant for examination:

- Drawing
- Profile-specific test instructions
- Production order
- Packing instructions

All tests listed below are carried out during production and documented in the relevant quality records.

#### Test pieces

A 100 mm sample is created for each test.

At the start of production (SP) and end of production (EP), a 1,000 mm test piece is additionally checked and archived.

Comparative tests must always be carried out between test piece and approved sample, as well as between test piece and SP samples.

The following tests shall be carried out and confirmed on the quality record:

### 3.2. Functional check

If test gauges are available, a functional test must be carried out.

The test is carried out in the application situation using 100 mm samples and with a longer profile in the customer installation jig. In the case of symmetrical profiles, an overlap check is carried out.

### 3.3. Dimensional inspection

All dimensions are subject to a reference temperature of 20 °C.

The nominal drawing dimensions are checked using a 50 or 100 mm sample. Test measurements shall be documented.

Pre-tension dimensions and profile width dimensions are additionally measured on a longer profile piece and are marked accordingly on the drawing.

#### 3.3.1. Length testing

BWF profiles distinguish between precise lengths (= defined longitudinal tolerance) and multiple lengths (= longitudinal tolerance + 20 mm). In general, length and tolerance data correspond to a reference temperature of 20 °C and a relative humidity of 30%.

##### Precise lengths:

Precise lengths are measured and documented on the measuring table, taking into account the change in length due to temperature and humidity, as stated above. The indicated lengths refer to the reference temperature of 20 °C and are checked at the measuring table.

##### Multiple lengths:

Multiple lengths are measured and documented using a tape measure.

#### 3.3.2. Straightness

The straightness is checked according to the specification at the straightness measuring table.

For profiles the test must be carried out in X and Y direction.

For round tubes, the maximum deflection must be measured.

### 3.4. Surface

#### Profiles:

From a distance of approx. 1 m, a purely optical inspection takes place in the visible region of the entire component, both in the illuminated and in the unlit state. The test duration is 10 seconds per meter. No obvious inclusions, scratches caused by mechanical damage, or extrusion lines, unless caused by the natural extrusion process, are allowed.

#### Sheets:

Sheets made of PMMA base material are manufactured according to EN ISO 7823-2.

Sheets made of PC base material are manufactured according to the surface requirements according to EN ISO 7823-2 4.2.

### 3.5. Classification of surface imperfections

Derived from commonly used specifications for extruded plastic sheets (e. g. DIN ISO 7823-2 for PMMA types and 11963-2013-0P3 for PC types), the specifications for plastic products made by BWF Profiles have been amended more strictly and can be interpreted as described in the available document.

We check the surface quality in accordance with the template. The below mentioned test criteria apply.

The reference weight is 1 kg. The reference weight can be translated into a profile length or a reference area (sheets).

Size of the inclusion [mm <sup>2</sup> ]		0,2	0,5	0,8	total number of inclusions
Possible amount in	BWF standard materials	3	2	1	max. 5
	BWF ecoRAIL®	5	3	2	max. 8
Different shapes of inclusions		—	—	—	
		-	-	-	
		.	.	.	
		·	·	·	
		•	•	•	



This size of the inclusion is permitted

**Table 5 Classification of inclusions**

Please print the available template on transparent foil for rating the material inclusions in sheets supplied by BWF Profiles.



Scale in mm

### 3.6. Color

Individual coloring is possible. The customer receives color samples ("color strips") in advance. The color of the first samples of BWF Profiles is assessed and released on the basis of the color strip approved by the customer.

BWF Profiles carries out a visual comparison test (top-view and transmission) in the illuminated and unlit state in comparison to the approved sample.

The illuminated test is carried out in the installation situation of the customer or (if not available) with the customer's illuminant at the respective workplace on the machine. The allowed color deviation is  $\Delta E \leq 3$ .

In the case of non-colored profiles, a visual comparison test of the inherent color must be also carried out.

#### Top view test:

Visual inspection in reflected light.



Figure 8: Top view test in incident light; Work lamp (transmission) is switched off

#### Transmission test:

Visual inspection in the lit condition.

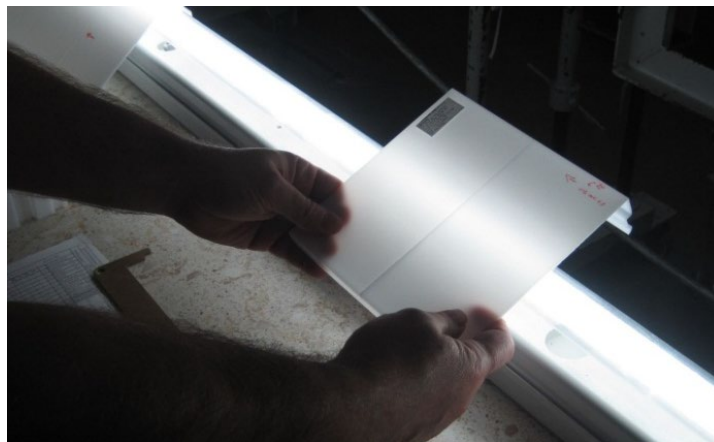
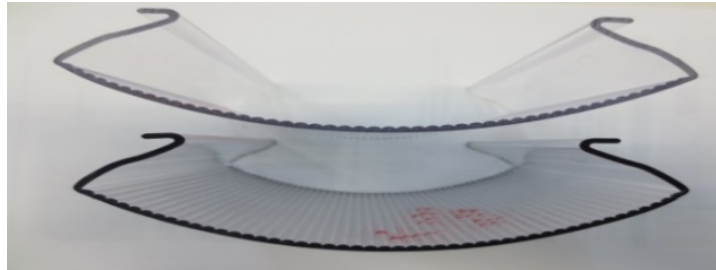


Figure 9: Visual inspection in transmitted light

**Inherent color test:**

Visual inspection at the cutting edge.



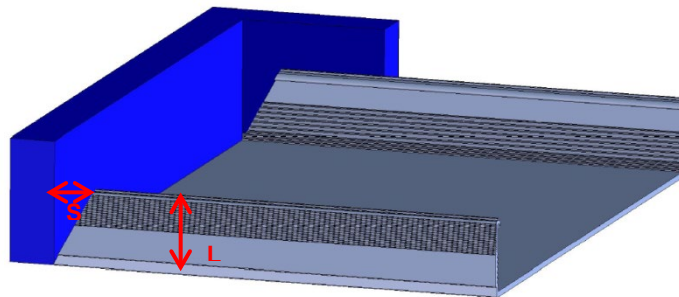
**Figure 10: Inherent color test**

**3.7. Saw cut**

A distinction is also made between precise lengths and multiple lengths in the case of the saw angle. For precise lengths, the saw cut quality as well as the saw angle are assessed. The saw angle is measured at the angle stop.

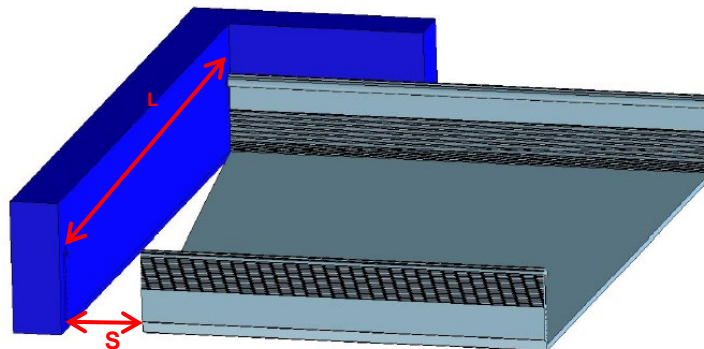
**Gap size:**

Gap S maximum for HEIGHT



**Figure 11: Gap height**

Gap S maximum for the WIDTH



**Figure 1: Gap Width**

A table with the permissible tolerances for the clearance can be made available if required. The **quality of the saw** cut is assessed by visual inspection:

For precise lengths:

Neither visible cracks, breakouts nor burr formation are allowed.

For production lengths:

Small cracks, breaks and burr formation are allowed, but these should be as small as possible.

**Offline cut**

Measurement possible with the measuring table => length and angle test [mm]							Measuring tape, no angle test
< 500	> 500	> 1,000	> 1,500	> 2,000	> 3,000	> 4,000	> 45.00
± 0.3	± 0.5	± 1.0	± 1.5	± 2.0	± 3.0	± 4.0	± 0.1%

**Inline cut**

Measurement possible with the measuring table => length and angle test [mm]							Measuring tape, no angle test
< 500	> 500	> 1,000	> 1,500	> 2,000	> 3,000	> 4,000	> 4,500
± 0.5	± 0.8	± 1.0	± 1.5	± 2.0	± 3.0	± 4.0	± 0.1%

**Table 6: Saw tolerances**

- 1) In the case of multiple lengths, in which there may be tears on the profile ends, the tolerance +20 mm is maintained and cut to length with the crosscut saw.
- 2) An inline saw is required for multiple lengths with a required clean cut. Profile cuts are maintained with a tolerance of +10 mm.
- 3) Inline cuts for fixed lengths can be manufactured with the above tolerances.

**Note:** Measuring lengths over 4,500 mm can no longer be checked with the length measuring table, so no angle test is possible and the profile blanks must be measured with the measuring tape ± 0.1% tolerance.

**3.8. Stress test**

**Profiles:**

No standard stress test is required for profiles.

**Tubes:**

For tubes. The following standard stress test shall be carried out at the start of production, once per shift and when changing production parameters:

Standard PMMA test  
Ethyl alcohol 90% / 10% dist. Water

Standard-PC-Test:  
TnP 1/3

## 4. Handling Guidelines

### 4.1. Storage

It is not recommended to store plastic products in the open, as weather-related influences may impair or damage the material. It is recommended to store plastic products on a flat base at an ambient temperature of 20 °C and an average humidity of approx. 50%.

### 4.2. Moisture absorption

Depending on the storage and ambient conditions, plastic profiles, sheets and tubes will absorb moisture. This may have an effect on the length but also on the processability of the products. If different areas of a profile, sheet or a tube are exposed to different environmental conditions (e. g. upper and lower surfaces), uneven dimensional changes can occur due to differences in temperature and / or moisture content (waves, bulges, etc.).

### 4.3. Thermal change in length

The thermal expansion of PMMA and PC is 0.7 mm (impact-resistant PMMA up to 1.1 mm) per meter at a temperature change of 10 °C. Assuming an ambient temperature of 20 °C during installation, PMMA expands by 2.1 mm/m at 50 °C. The thermal change in length must be taken into account during further processing. Failure to do so may result in damage or deterioration of the material.

### 4.4. Protection

To avoid contamination and scratches, BWF Profiles puts a protective film on the profile surface (visible side). This film must be removed no later than six months after delivery. The plastic parts must be protected from direct sunlight, since changes in the adhesive film due to temperatures above 40 °C and UV radiation may occur. As a result, glue residues can form on the surface of the plastic parts. The protective film must also be removed prior to a possible vacuum forming process. When the protective film is peeled off, a static charge can occur, which attracts dust and dirt particles. Possibly an antistatic treatment is necessary (e. g. with ionized compressed air) before further processing.

### 4.5. Cleaning

Water is sufficient to clean PMMA and PC. In the case of heavier soiling, the water should be slightly heated and treated with a mild detergent (e.g., soap). Rubbing on dry material should be avoided. Before drying the material (e. g., using a sponge), ensure that any particles on the surface have been removed to avoid scratches.

### 4.6. External influences in installation

The use of soft PVC together with amorphous plastics such as PMMA or PC is not recommended. The plasticizers contained in soft PVC (for example rubber coatings, cable insulation, etc.) can migrate at rising temperatures and deposit on the surface of the plastic parts made of PMMA or PC. This reduces the tensile strength of the plastic parts, which can lead to stress cracking. This is especially the case when there are additional external loads (e.g., clamping forces and other stresses that are often unavoidable through installation).

In the lighting industry, plastic parts are installed together with electronic components such as ballasts, cables, etc. As a result of rising operating temperatures in the luminaire, these components increase the risk of emission of volatile constituents. If these volatile constituents are aggressive or corrosive, the tensile strength of the plastic parts is reduced, which can lead to stress cracking. Therefore, electronic components must be specifically suitable for use with amorphous plastics such as PMMA or PC. If the properties of the electronic components are unclear, their influence on the plastics must be tested before installation in order to avoid possible damage.

## 5. Processing Guidelines

### 5.1. Tensions in plastic parts

The extruded profiles, tubes and sheets produced by BWF Profiles have a low degree of internal stress. However, even these low stresses can result in dimensional deviations during machining (sawing, milling, drilling, tapping, welding, bending, heating, etc.).

A reduction of the internal mechanical stresses caused by additional machining is achieved by subsequent annealing (see point 5.15.). If the stresses are not reduced as recommended, subsequent processing steps can cause damage to the material (e. g., cracks, breaks, etc.), e.g.

- bonding
- painting
- tempering (under false conditions, e.g. temperature, duration)
- cleaning

### 5.2. Machining

Plastic profiles made of PC or PMMA can usually be machined with most of the tools which are also used in the processing of wood or metal. The tool speeds must be chosen in such a way that the material does not melt due to frictional heat. Cutting tools must always be kept sharp. Since plastic has poor thermal conductivity, the heat generated by machining must be absorbed by the tool. Ensure that the tool is cooled (e. g. by directed airflow). Cooling lubricants must be tested for chemical resistance in contact with plastics prior to use.

### 5.3. Machining and sheet saw tolerances

Tolerances for machined parts:

Tolerances for machined parts [mm]							
to 50	above 50 to 120	above 120 to 250	above 250 to 400	above 400 to 1,000	above 1,000 to 2,000	above 2,000 to 4,000	above 4,000
± 0.3	± 0.5	± 0.8	± 1.0	± 1.2	± 1.5	± 2.0	± 4.0

Table 7: Machining tolerances

Tolerances for sheets:

Dimensional tolerances for panel blanks (All types of sheets) [mm]			
Width / Length:	Tolerance package cut	Tolerance single cut	Tolerance CNC
10 to 49 mm	+/- 0.3 mm	+/- 0.3 mm	+/- 0.3 mm
50 to 200 mm	+/- 0.4 mm	+/- 0.3 mm	+/- 0.3 mm
201 to 500 mm	+/- 0.5 mm	+/- 0.4 mm	+/- 0.3 mm
501 to 750 mm	+/- 0.6 mm	+/- 0.5 mm	+/- 0.3 mm
751 to 1,000 mm	+/- 0.8 mm	+/- 0.6 mm	+/- 0.4 mm
1,001 to 2,000 mm	+/- 1.2 mm	+/- 1.0 mm	+/- 0.8 mm
2,001 to 3,050 mm	+/- 2.0 mm	+/- 1.5 mm	+/- 1.2 mm

Table 8: sheet saw tolerances

#### 5.4. Drilling

Blunt drills which are unsuitable for plastic processing must be avoided. Standard spiral drills for wood or metal can be used. However, it is recommended to use special drills designed for plastics.

Diameter of the hole [mm] = Diameter of the screw + L [mm] x 5/1,000;

L = length of the plastic profile in millimeters.

Minimum distance of the hole from the edge: 1.5 x diameter of the hole

Care must be taken to avoid overheating due to friction. Chips must be removed continuously. The drill part must be secured or clamped in order to avoid cracking or slipping.

#### 5.5. Milling

For milling, universal, copying, table and manual milling machines are used. The cutting speeds must be adapted to the respective plastic. For small tool diameters single or two-edged finger milling cutters should be used.

They allow for a high cutting speed due to their good chip removal and create nice edge images. For single-edged cutters, the chuck must be carefully balanced to avoid marking on the component.

#### 5.6. Laser cutting

Profiles, sheets and tubes can be cut with a laser beam. A laser beam can be used to create difficult holes and complex patterns. The tolerances can be better controlled with the aid of a laser beam than with conventional machining devices. The force and speed of the laser beam must be adjusted to the product. Burr formation during laser cutting is dependent on speed, laser power and the nature of the base material. For PC the cut edges turn brownish.

For cutting edges that are supposed to be sharp, clean and clear, laser cutting is not recommended for PC. Other processing options should be used in such cases.

If the feed rate and the laser power are not correctly matched, stress cracks in the material may occur.

#### 5.7. Punching

It is possible to punch PC profiles and sheets up to a thickness of 2 mm when regular, very sharp tools suitable for metal working are used. In this case, the sheet must always rest firmly against the counter-edge / blade in order to avoid squeezing. The punching of PMMA profiles and sheets is not recommended.

#### 5.8. Polishing

Products from BWF Profiles can be polished on the saw or milling edges to remove machining marks. There are two possibilities: dry or wet grinding and polishing with a diamond milling machine. It is important in any case to ensure that the plastic surfaces do not come into contact with abrasive paper. This leads to permanent surface damage which cannot be removed.

When polishing by hand, the polishing process must be preceded by a grinding operation. Grinding paper of 80-600 grit is recommended for grinding by hand. In this case, it is necessary to work from coarse to fine in several grinding operations. For machine grinding, belt grinding machines with a belt speed of 5-10 m / s should be used. High temperatures of the material surface are avoided by only slightly pressing the work piece under movement.

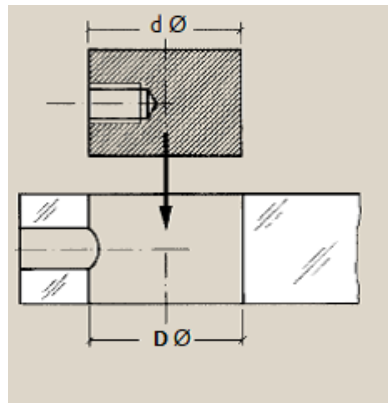
Another possibility is polishing with diamond tools. A good surface quality can be achieved within a few runs without pre-grinding. No further processing is needed. With this technique, there are hardly any internal stresses. Tempering, necessary for the other methods can be omitted if necessary.

Flame polishing is only recommended for PMMA since the polishing edges of PC turn brown due to the high heat development and there is a build-up of high stress in the processing area, which can adversely affect the mechanical properties.



### 5.9. Threads

The cutting of internal and external threads with PMMA and PC plastic parts is not recommended as this causes internal stresses. Instead, thread inserts made of plastic (not soft PVC) should be used (see illustration). Please note:  $D > d$  to prevent tensions.



### 5.10. Screw connections

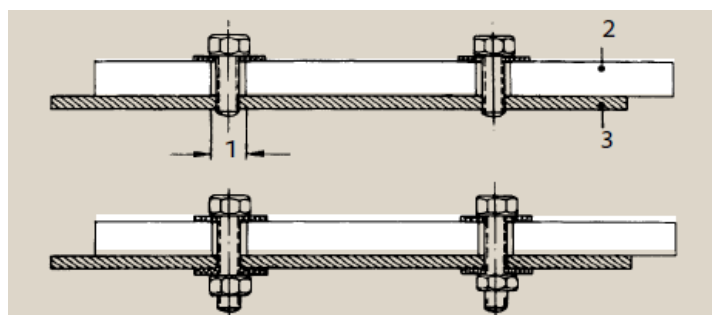
If parts made of amorphous plastics are drilled to allow for a screwed connection, it is essential to ensure a low stress installation.

The tightening forces of the screw must be limited by a torque wrench. Large diameter washers help to distribute the forces on the screw head to a larger area and thus reduce the pressure on the plastic part. A load distribution can be achieved by using several screws.

Due to the expansion of plastics by moisture and heat (see sections 4.2 and 4.3), it is recommended to increase the clearance of the installation in general about 5 mm/m. Large holes, the allowance for movement at the ends of the plastic part, as well as a systematic installation with fixed and flexible points (fixed and floating bearing principle), prevent the generation of harmful stresses in the plastic part (see following figures).

Simple screw connection:

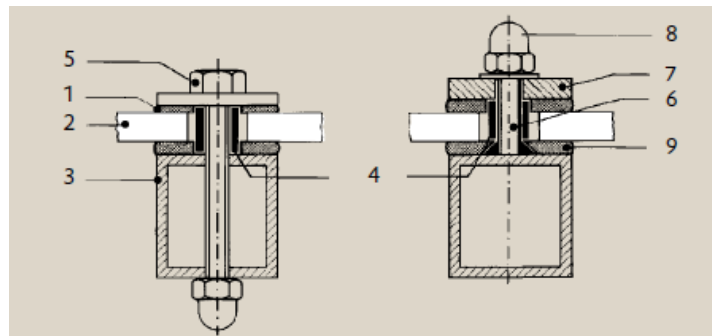
Drill hole with distance (1), plastic (2), metal (3)



The clamping forces acting on the plastic part decrease with falling temperatures and increase with rising temperatures. This effect can be compensated by the use of washers made of EPDM, PE, PTFE (non-plasticized PVC!), etc. (see figure below).

Example of suitable screw connections:

EPDM washer (1), plastic part (2), counterpart (3), protective film (eg PE) (4), screw with large washer and screw head (5), welded bolt (6), flat metal part (7), Cap nut (8), EPDM strip (9)



Self-tapping screws, which penetrate only into the plastic, are not suitable. However, they can be used if the thread is in contact with a metal counterpart and through holes are provided in the plastic (see above). In addition, the head of the self-tapping screw as well as the washer must be large enough as described above.

#### 5.11. Clamping

If amorphous plastics, such as PMMA or PC, are installed by clamping forces, the effective forces must be distributed over the largest possible area and sufficient space for the material expansion must be provided. To avoid stress cracking, elastic seals (see section 4.6) must be selected. The clamping pressure must be kept as low as possible, as this may cause friction between the plastic and the seal. This friction prevents the plastic part from slipping when expanded by heat or moisture.

#### 5.12. Gluing

In order to reduce internal stresses caused by extrusion, injection molding, sawing, milling, drilling, tapping, thermoforming, welding, etc., the plastic part should be annealed before gluing (see Tempering). Most liquid adhesives and adhesive solutions also increase the risk of stress cracking.

Stress cracks can be caused by internal as well as external stresses. External stresses are generated by large clamping forces during the positioning of the various plastic parts to be bonded. These are to be avoided.

#### 5.13. Welding

Amorphous plastics such as PMMA or PC can easily be welded. Upon heating, these materials undergo a short viscoelastic range (rubbery elasticity) before becoming soft and moldable over a wide temperature range. The connection in the welding area can be achieved in various ways, e.g. welding with heating mirror / heating element, beam welding, ultrasonic welding, etc.

These welding techniques generate a high degree of tension in the welding area. This stress is caused by the much higher temperatures in the welding zone compared to the cooler outer areas.

The clamping forces necessary for positioning the welded parts can also lead to an excessive tension in the plastic part.

Therefore, the clamping forces should be adjustable in order to avoid cracks in the plastic part.

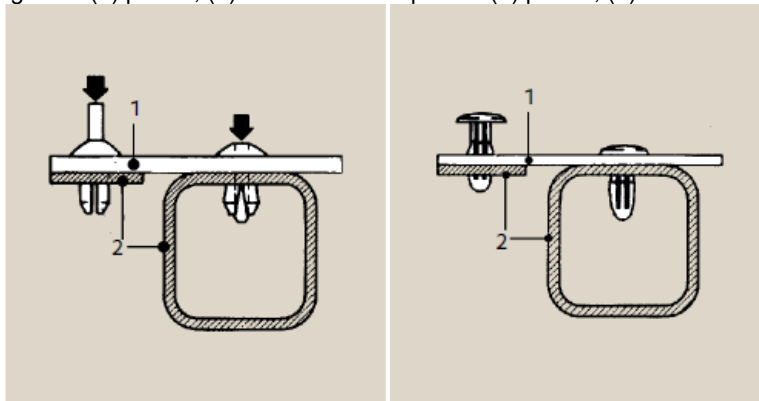
If the influence of corrosion agents is to be expected during subsequent installation, tempering is recommended.

#### 5.14. Rivets

The use of rivet connections with PMMA or PC using metal rivets is not recommended. For these materials, expanding rivets or clip rivets made of plastic are recommended. These are commonly available (see below).

Expanding rivet: (1) plastic, (2) metal

Clip rivet: (1) plastic, (2) metal



#### 5.15. Tempering

During tempering, plastic parts are first heated and then slowly cooled again.

Plastics can withstand the permissible stresses as long as they are not exposed to corrosion agents at the same time. Decisive for successful heat treatment is the adherence to a material-dependent temperature program.

Tensions can be caused, among others by:

- Cutting operations such as sawing, milling, turning and grinding
- Thermoforming
- Uneven heating
- Shrinking of protective films
- Deformation by fastening (clamping, drilling, screwing)
- Shrinkage after local overheating, caused by incorrectly sharpened tools
- Preventing of thermal expansion
- Unavoidable internal stresses in the plastic, caused by the manufacturing process (injection molding, extrusion), especially with tubes
- External load (weight, application load)

Contact with corrosive agents, such as solvents and diluents during gluing, printing or varnishing, gassing during laser cutting or flame polishing, softeners in PVC insulations, seals and protective films, as well as aggressive detergents, can lead to hair cracks that make the parts unusable.

The simultaneous occurrence of tensions and corrosive media should be avoided.

Since it is impossible to completely avoid tensions (see examples above), these must be eliminated by stress-relieving annealing.

PMMA and PC have to be tempered in a suitable furnace. During a sufficient tempering time, the temperature must be below the softening point. Subsequently, the plastic part is slowly cooled. When cooling is too rapid, a cold, stiff outer layer is created, which in turn can create stresses, since the hotter material inside shrinks more than on the outside (see below).

**The following tempering rules apply:**

The protective film must be peeled from the plastic part. Should the film remain on the plastic part, BWF Profiles does not assume any responsibility for deposits which result from the destruction of the film or of the plastic part.

**Parameter PMMA:**

From ambient temperature to **80 °C within 1h**

**3h + t [h]** (wall thickness 1-3 mm)

Cool to room temperature not faster than 15 °C/h

(E.g. If the wall thickness is 1 mm, then hold **3h + 1h = 4h**)

**Parameter PC:**

von Umgebungstemperatur auf **120° innerhalb 1h aufheizen**

**3h + t [h]** (Wandstärke 1-3 mm) halten

Abkühlen auf Raumtemperatur nicht schneller als 15 °C/h

z.B. wenn die Wandstärke 1mm beträgt, dann **3h + 1h = 4h** halten

BWF Kunststoffe GmbH & Co. KG  
Bahnhofstraße 20  
89362 Offingen  
Germany  
Phone +49 8224 71-601  
[info@bwf-profiles.com](mailto:info@bwf-profiles.com)  
[www.bwf-profiles.com](http://www.bwf-profiles.com)