PolTolerances-AC

Dimensions, tolerances and fits for plastic moulded parts

User Manual

“Dimensions, tolerances and fits” tab

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1 Introduction

Plastic moulded parts change their dimensions in service: through thermal expansion and contraction, swelling, post-shrinkage, wear or deformation. A dimension that is correct at acceptance in production may therefore be out of tolerance under the later application conditions, and a fit may jam or get too much clearance.

The **“Dimensions, tolerances and fits”** tab of PolTolerances-AC converts dimensions and fits between two states:

- **FAC – Fabrication Acceptance Condition:** the state at acceptance of the moulded part (stored at 23 °C ± 2 K and 50 % ± 10 % relative humidity, inspected no earlier than 16 and no later than 72 hours after manufacturing).
- **AC – Application conditions:** all operating and storage conditions during the period of use, insofar as they affect dimensional accuracy and functional performance.

You create a project for a moulded part, assign an application condition and a tolerance group to it, and then enter **independent dimensions** and **fit dimensions**. For each dimension, PolTolerances-AC shows the values under FAC and AC, the possible production deviations according to DIN ISO 20457 and, for fits, the clearance or oversize in both states.

The functions are not limited to plastic parts. Plastic parts are often combined with parts made of other materials (fits, inserts); the tab can be used without restriction for such components as well. Chapter 8 describes the technical background of the conversion.

> **Note:** The other tabs on the left edge of the window (**“Manufacturing tolerances according to DIN ISO 20457 / DIN 16742”** and **“Commercial products plus”**) are not described in this manual. Manufacturing tolerances (PolTolerances) and commercial products each have a manual of their own.

2 User interface

After start-up, the **“Dimensions, tolerances and fits”** tab shows the start page with three buttons.

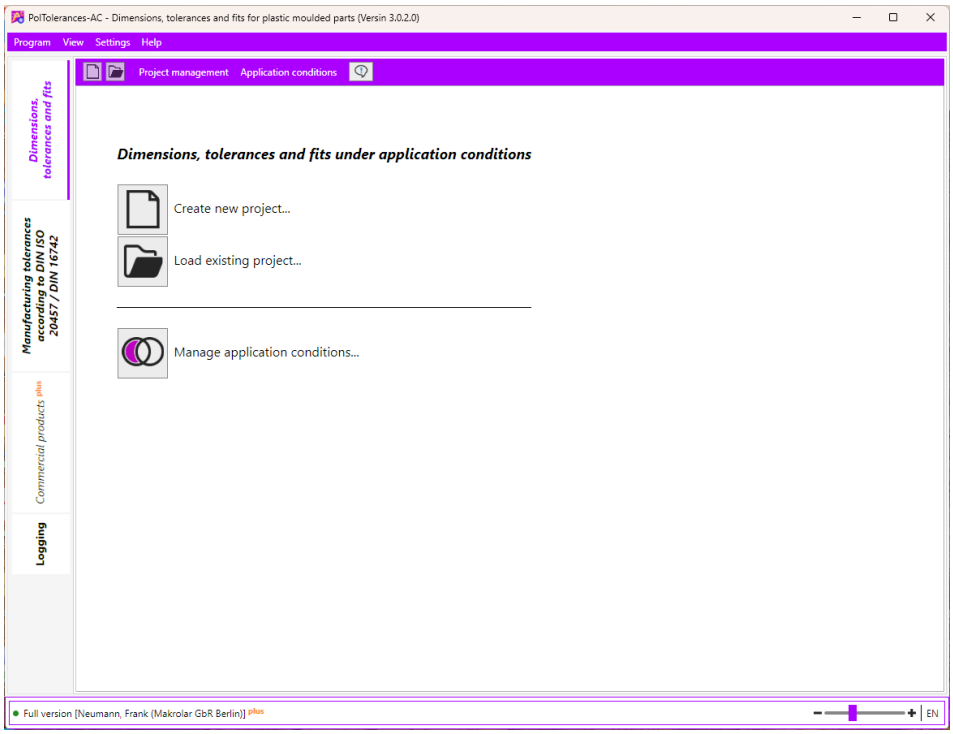


Figure 1: Start page of the "Dimensions, tolerances and fits" tab

Element	Purpose
Menu bar	**"Program"**, **"View"**, **"Settings"** and **"Help"** (chapter 9).
New and **Open** symbols (violet bar)	Create a new project or load an existing one.
"Project management" menu	**New project…**, **Load project…**, **Close all projects**.
"Application conditions" menu	**Manage…** (chapter 6) and **Printing / Print Preview…** of the application conditions.
Speech bubble button	Opens the **"Abbreviations"** window (section 7.2).
Create new project…	Starts the project wizard (chapter 3).
Load existing project…	Opens a saved project.
Manage application conditions…	Library of application conditions (chapter 6).
Status bar	Licence status, zoom slider and user interface language ("EN").

3 Creating a new project

Click **"Create new project…"**. A wizard guides you through the basic settings in four steps. Use **"Back"** and **"Next"** to move between the steps; **"Cancel"** discards the project.

3.1 General project information

1. Enter the **"Project or (Molded)part designation"**.
2. Optionally add a **"Description"** (with simple formatting) and **"Material specifications"**, e.g. "PA6-GF30".
3. Select which case applies (see table) and click **"Next"**.

Option	Meaning

Option	Meaning
Part made of **plastic**, dimensions and fits under **FAC and AC**	The normal case: tolerance group according to DIN ISO 20457 plus conversion to the application conditions.
Part made of **plastic**, dimensions and fits **only under FAC**	Only manufacturing tolerances and fits in the acceptance state, without an application condition.
Part made of a **different material** (other than plastic)	Only the dimensional changes under application conditions, without a tolerance group according to DIN ISO 20457.

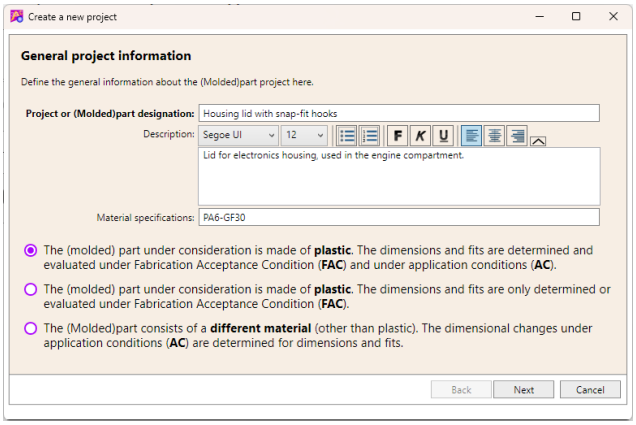


Figure 2: Step 1: general project information

3.2 Selecting the application condition

Click **“Select Application Condition (Plastic Molding)”**. The **“Manage Application Conditions”** window shows all existing application conditions as cards. Each card shows the **designation**, the **resulting dimensional shift** and the **resulting dimensional variation** in percent. **“show more details”** reveals the individual dimensional changes that make up these values.

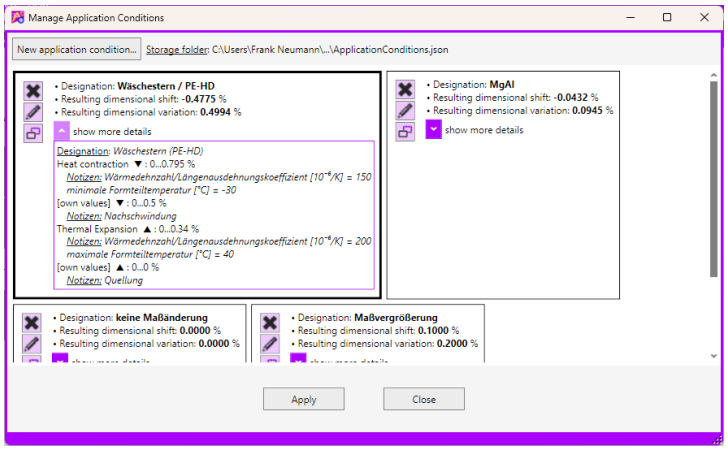


Figure 3: Selecting an application condition; the selected card has a black frame

1. Click the matching card.
2. Click **“Apply”**. The wizard shows the selected condition under **“currently used application condition”**.
3. Click **“Next”**.

If no suitable application condition exists, create one in the same window via **“New application condition…”** (chapter 6).

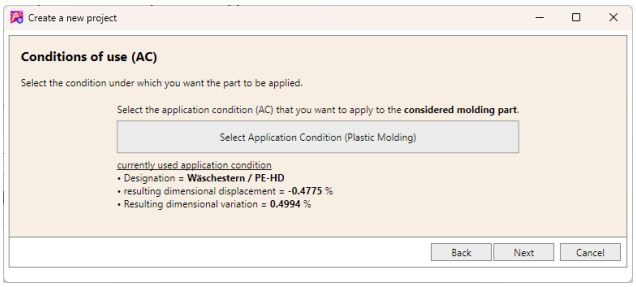


Figure 4: Step 2 with the selected application condition

3.3 Defining the tolerance group

In the **“Fabrication Acceptance Condition (FAC) according to DIN ISO 20457”** step, select the tolerance group directly (TG4 to TG9) or determine it via **“Determine the tolerance group (TG)…”**.

The **“Determine tolerance group”** dialog offers, as in PolTolerances, a **“Point evaluation”** (manufacturing process, material stiffness, processing shrinkage, differences in shrinkage) and **“Assignment help(s)”** based on the moulding compound group. The tolerance group appears on the right as soon as all information is available. **“Apply”** enters it in the wizard.

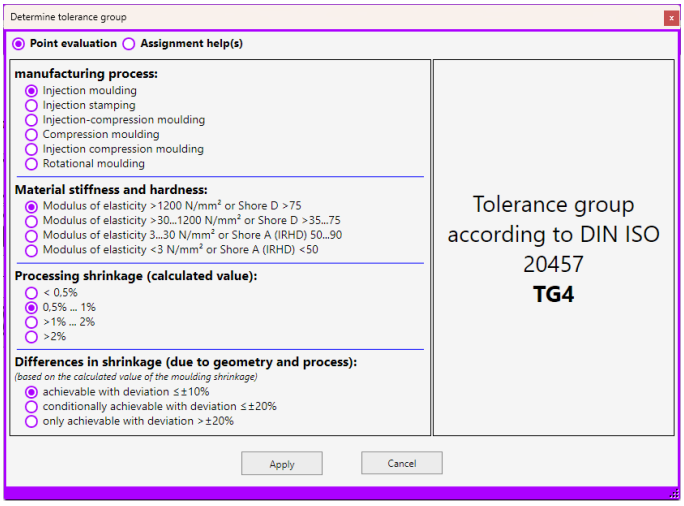


Figure 5: Determining the tolerance group by point evaluation: TG4

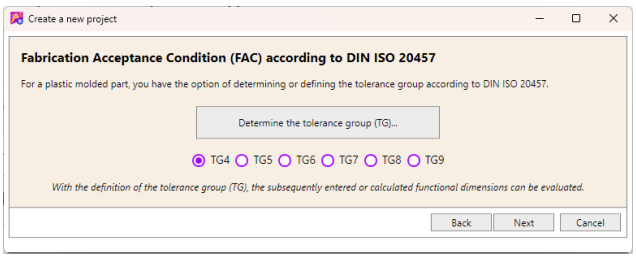


Figure 6: Step 3 with the applied tolerance group TG4

3.4 Finish

The last step confirms that the basic settings are defined and that you can now add dimensions. Click **“Finish”**. Most entries can be corrected afterwards; changes are immediately reflected in all dimensions.

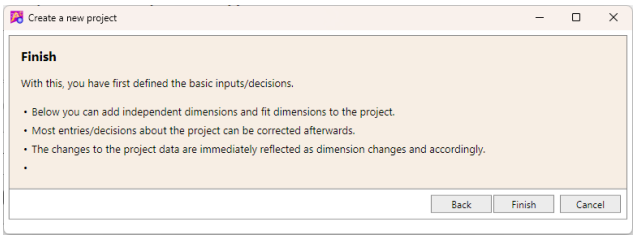


Figure 7: Step 4: Finish

4 The project view

After finishing, the project opens. The header shows its designation; below are the project settings and – once added – the dimensions as tabs of their own.

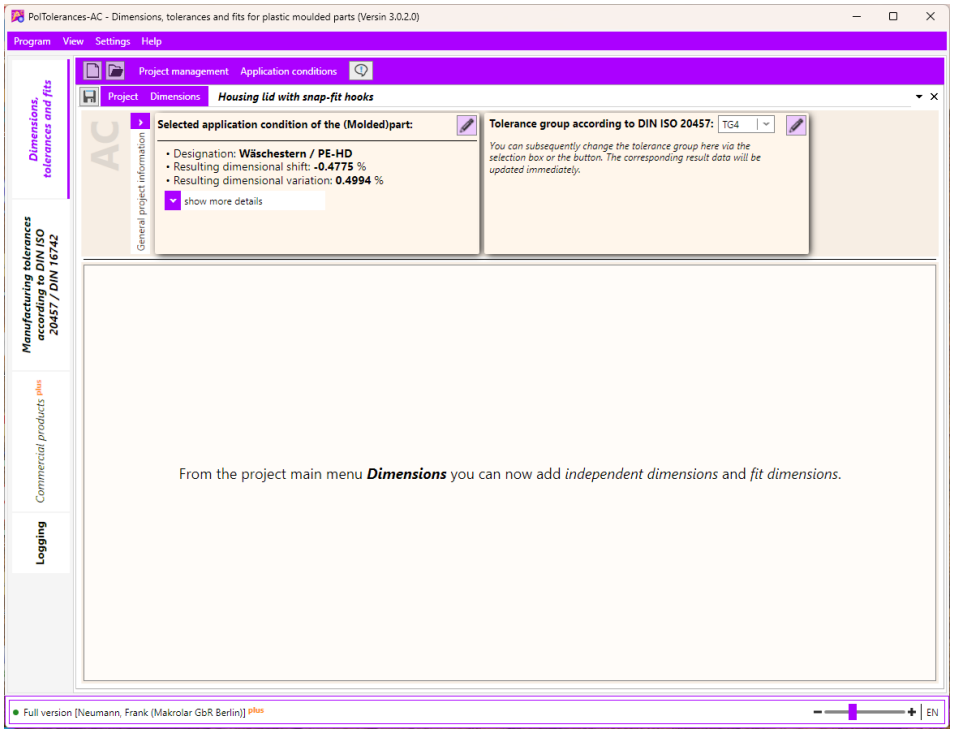


Figure 8: New project without dimensions

Element	Purpose
Disk symbol, **“Project”** and **“Dimensions”** menus	Save the project; “Project” menu: **Save project**, **Save project as**, **Printing / Print Preview…**, **Close project**. “Dimensions” menu: **New independent dimension…**, **New fit dimension…**.
“General project information” flap	Expands and collapses designation, description and material specifications for editing.
“Selected application condition of the (Molded)part”	Designation, resulting dimensional shift and variation. The pencil symbol lets you choose a different application condition.
“Tolerance group according to DIN ISO 20457”	Drop-down list of the tolerance group; the pencil symbol opens “Determine tolerance group”. Changes are applied to all results immediately.
Dimension tabs	One tab per dimension, labelled with the dimension and the reference system, e.g. “120.000±0.500 mm (FAC)”. ✕ deletes, the pencil edits the dimension.

Element	Purpose
✕ at the top right	Close the project.

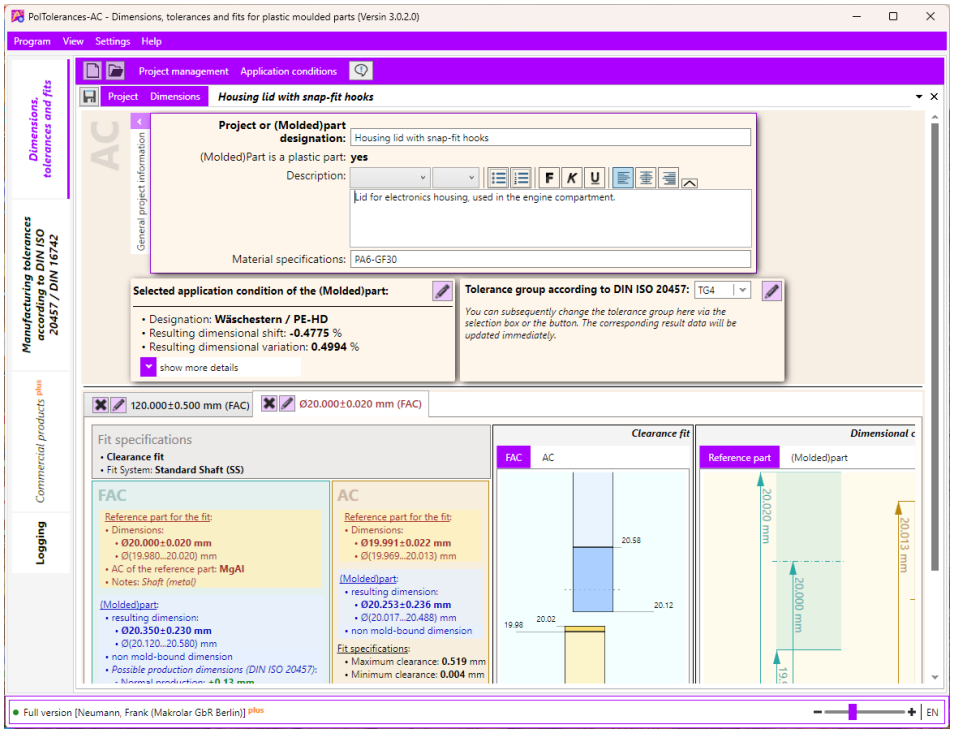


Figure 9: Expanded general project information

Each project is saved in a file of its own. Several projects can be open at the same time; each project window has its own menu, and the windows can be arranged or docked by drag and drop. You specify the folder in which projects are saved by default under **“Settings” › “Options…”**.

Among other things, you can change the application condition and tolerance group of the project later; for independent dimensions the mid-dimension, deviation and dimension-specific application condition; for fits the mid-dimension, deviation and application condition of the reference part as well as the maximum/minimum clearance or oversize; and also the designation, description and material specifications. All results are updated immediately.

5 Entering dimensions

5.1 Independent dimension

An independent dimension is a single dimension of the moulded part without a mating part, e.g. a width or a length.

1. Choose **“Dimensions” › “New independent dimension…”**.
2. Under **“Direction of transformation”**, specify in which state you enter the dimension: **under FAC** (you receive the dimensions under AC) or **under AC** (you receive the dimensions under FAC). Click **“Next”**.
3. Select **“Diameter dimension”** or **“Other dimension”** and enter **“Center dimension [mm]”** and **“Functionally required dimension [±mm]”**.
4. Tick **“Wall thickness”** or **“mold-bound dimension”** if applicable and add **“Notes”**.

5. Optional: **“Select additional application condition (for the current measurement)…”** applies a different application condition to this dimension only, e.g. for wear or deformation.
6. Click **“Next”** and then **“Finish”**.

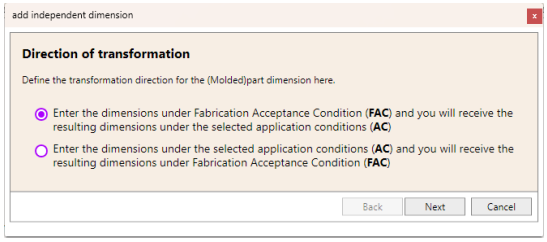


Figure 10: Specifying the direction of transformation

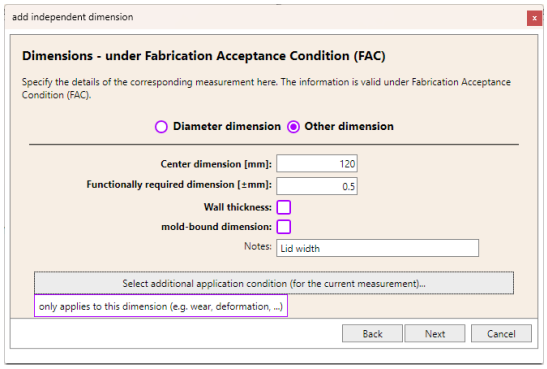


Figure 11: Dimensions under Fabrication Acceptance Condition: 120 mm ±0.5 mm

The result appears as a new tab:

- **FAC** (green): the entered dimensions, whether the dimension is mold-bound, and the **possible production dimensions according to DIN ISO 20457** for normal production, accurate manufacturing, precision production and precision special production. A warning triangle marks tolerance series that have to be agreed with the manufacturer of the moulded part.
- **AC** (beige): the dimensions under application conditions, i.e. shifted by the dimensional shift and widened by the dimensional variation.
- **“Dimensional change (variation and shift)”** chart: position and width of the tolerance zone under FAC and AC with center, maximum and minimum dimension.

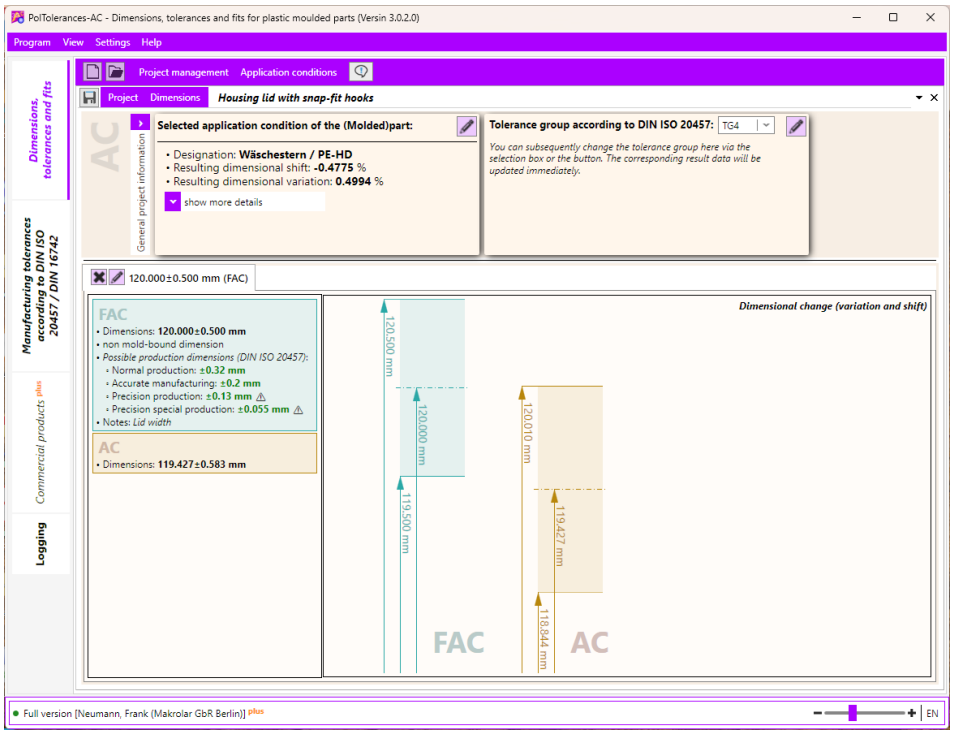


Figure 12: Independent dimension: 120.000 ±0.500 mm under FAC becomes 119.427 ±0.583 mm under AC

5.2 Fit dimension

A fit dimension describes how the moulded part interacts with a mating part (fit reference part), e.g. a bore in the plastic part on a metal shaft. PolTolerances-AC calculates the matching part dimension from the required clearance or oversize and checks the fit under application conditions, where moulded part and reference part may change differently.

1. Choose **“Dimensions” › “New fit dimension…”** and specify the **“Direction of transformation”** (as in section 5.1).
2. **Fit Reference Part / Dimensional Reference System:** tick that the dimensions of the fit cover part under FAC are also known. Both parts must be available in the same dimensional reference system.
3. **Application condition (AC) of the reference part for the fit:** tick that it is **identical** to that of the moulded part (same material), or choose a separate one via **“Select the application condition (AC) of the reference part for the fit…”**, e.g. for a metal part.
4. **Dimensions for (Molded)part and partner fitting:** select **“Diameter dimension”** or **“Other dimension”**, mark a tool-bound dimension if applicable and enter **center dimension**, **functionally required dimension** and **notes** of the partner fitting. Tick whether the partner fitting is the **enclosing part** of the fit; this determines the fit system (**Standard Shaft** or **Standard Hole**).
5. **Type and dimensioning of the fit:** select **“Clearance fit”** or **“Interference fit”** and enter maximum and minimum clearance or maximum and minimum oversize. The mean clearance and the **resulting dimensions** of the moulded part are calculated immediately and shown graphically on the right.
6. Click **“Next”** and then **“Finish”**.

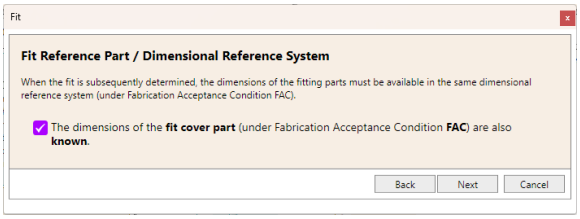


Figure 13: Fit reference part and dimensional reference system

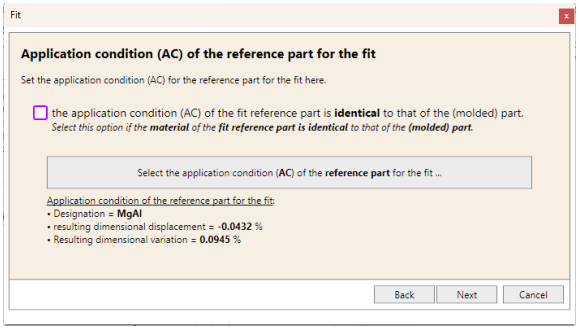


Figure 14: Separate application condition "MgAl" for the metal reference part

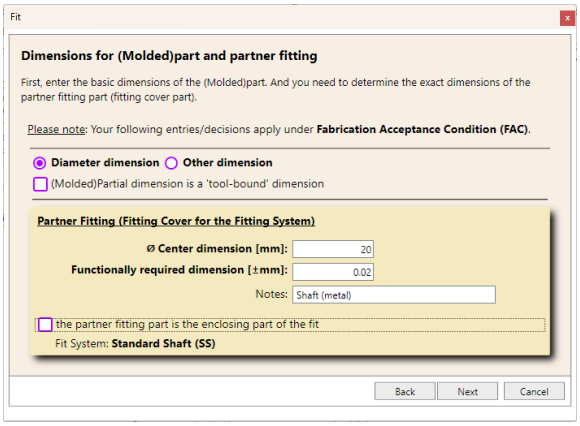


Figure 15: Partner fitting: shaft Ø 20 ±0.02 mm, fit system Standard Shaft

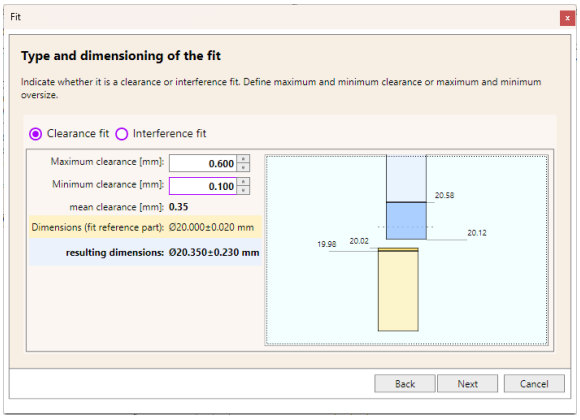


Figure 16: Clearance fit with 0.1 … 0.6 mm clearance: bore in the moulded part Ø 20.350 ±0.230 mm

The tab of the fit shows:

- **"Fit specifications"**: type of fit and fit system.
- **FAC** column: dimensions and application condition of the reference part, the resulting dimension of the moulded part with the possible production dimensions according to DIN ISO 20457, and maximum, minimum and mean clearance.

- **AC** column: the same values under application conditions. This is where you see whether the fit still works in service.
- **“Clearance fit”** or **“Interference fit”** chart with the **FAC** and **AC** tabs, and the **“Dimensional change”** chart with the **Reference part** and **(Molded)part** tabs.

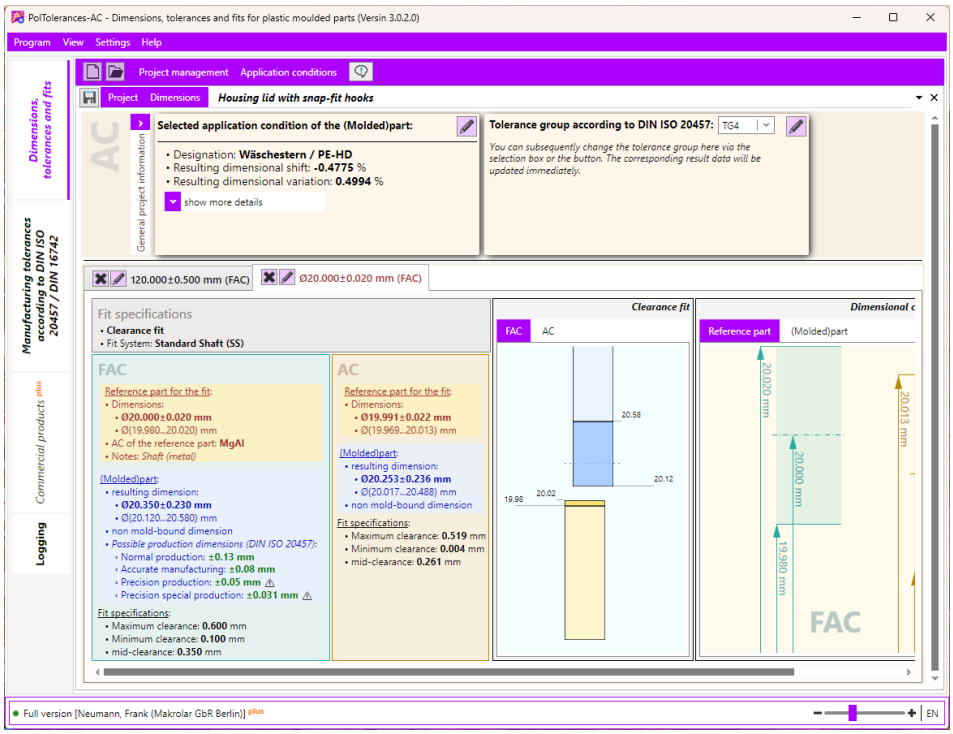


Figure 17: Result of the fit: under AC the minimum clearance drops from 0.100 mm to 0.004 mm

> **Tip:** If the minimum clearance under AC is close to zero or negative, the fit will jam in service. Increase the minimum clearance using the pencil symbol on the tab, or choose a tighter tolerance series.

6 Managing application conditions

Application conditions are stored in a library that is shared by all projects. The path of the file is shown at the top of the window next to **“Storage folder”**. You open the library from the start page, via **“Application conditions” › “Manage…”** or when selecting a condition in a project.

Symbol on the card	Purpose
✕	Delete the application condition.
Pencil	Edit the application condition.
Double rectangle	Clone the application condition, e.g. as a template for a similar one.
Arrow **“show more details”**	Shows the individual dimensional changes with direction, range and notes.

- Application conditions are identified uniquely by their **designation**; each designation may only occur once. Projects, reference parts and dimensions refer to the application condition by this designation.
- If you delete an application condition that is used in a project, the assignment there is lost; the program points this out the next time the project is loaded.

- Several dimensional changes can be defined for each application condition. The conditions can be reused across projects and assigned to the moulded part, a fit reference part or individual dimensions.
- The application conditions are saved in a readable file. Make copies for backup if required. You change the storage folder under **“Settings” › “Options…”**.

6.1 Creating a new application condition

1. Click **“New application condition…”**.
2. Enter a **“Designation”** and optionally a **“Description”**.
3. Next to **“Application-related dimensional changes”**, click **“Add…”**.
4. Select the **“Type of dimensional change”** and click **“Next”**.
5. Enter the characteristic values. PolTolerances-AC calculates the **“Result [%]”** from them. Alternatively, click “Next” without input and enter the values directly.
6. In **“Summary and notes”**, check direction (dimensional increase or decrease) and minimum and maximum values, then click **“Next”** and **“Finish”**.
7. Add further dimensional changes if needed and save the application condition with **“OK”**.

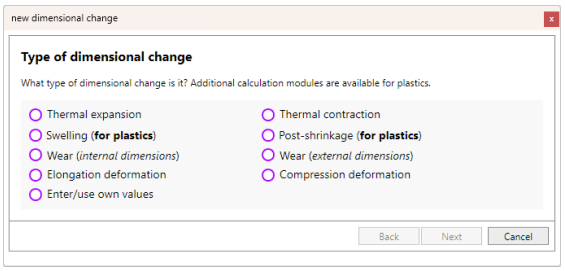


Figure 18: Selecting the type of dimensional change

Type of dimensional change	Note
Thermal expansion / thermal contraction	From the coefficient of linear thermal expansion [10^{-6}/K] and the maximum or minimum part temperature.
Swelling, post-shrinkage	Additional calculation modules for plastics.
Wear (internal / external dimensions)	Material removal in service.
Elongation deformation, compression deformation	Deformation under load.
Enter/use own values	Enter the dimensional change directly in percent.

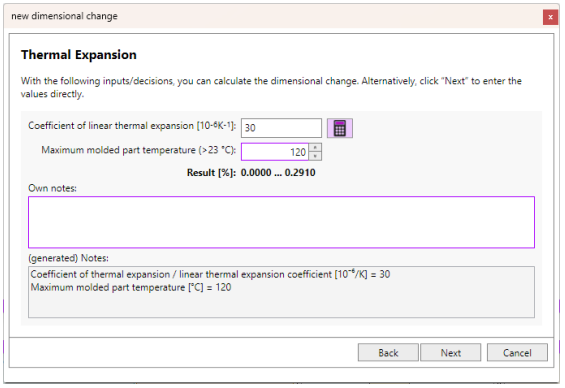


Figure 19: Thermal expansion: 30·10^{-6}/K up to 120 °C gives 0 … 0.291 %

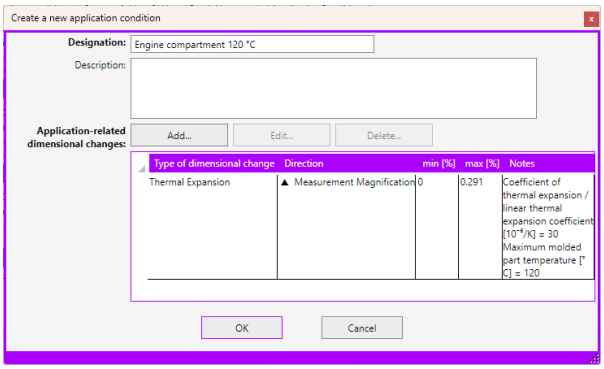


Figure 20: New application condition with one dimensional change

Section 8.2 describes how to determine suitable values for the dimensional changes. Further details on the individual dimensional changes and their calculation modules can be found in the book “Entwicklung und Konstruktion von Kunststoffteilen” (development and design of plastic parts).

7 Printing and help

7.1 Printing / Print Preview

In the project, choose **“Project” › “Printing / Print Preview…”**. The preview contains the project data (designation, description, material, application condition, tolerance group, creation and update date) and all fits and independent dimensions with their FAC and AC values. Use the printer symbol at the top left to print; at the bottom right you change the page view and the magnification.

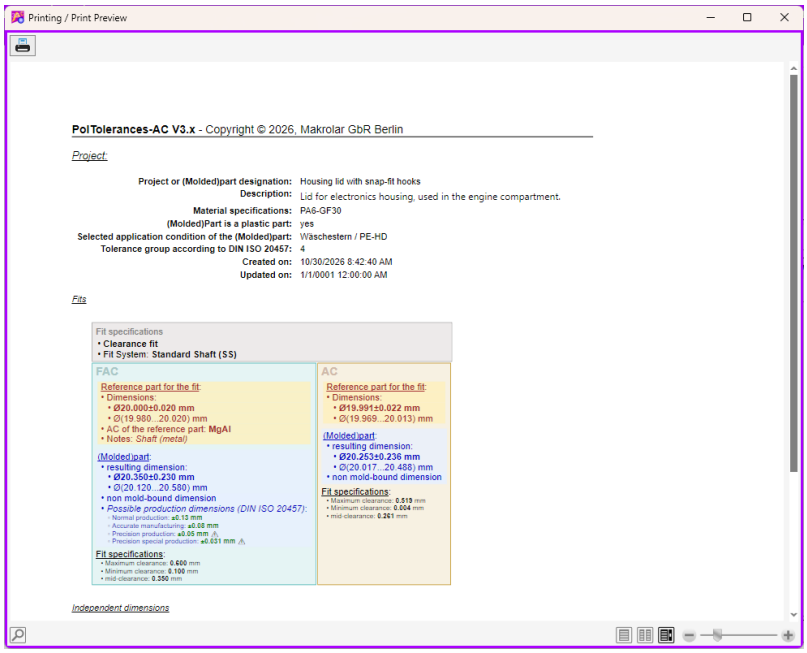


Figure 21: Print preview of a project

To print the list of all application conditions, choose **“Application conditions” › “Printing / Print Preview…”**.

7.2 Abbreviations

The speech bubble button in the violet bar opens the **“Abbreviations”** window:

Abbreviation	Meaning
AC	Dimensional reference system Application conditions: all operating and storage conditions during the period of use and after manufacturing, insofar as they affect dimensional accuracy and functional performance.
FAC	Dimensional reference system Fabrication Acceptance Condition: storage until acceptance at 23 °C ± 2 K and 50 % ± 10 % relative humidity, inspection no earlier than 16 and no later than 72 hours after manufacturing.
TG	Tolerance groups (TG1 to TG9): classification of the material- and process-related variation range of manufacturing tolerances for plastic moulded parts, approximating the ISO system according to DIN EN ISO 286-1 and -2.
SS	Fit system Standard Shaft: the shaft has a fixed tolerance zone; the hole is adjusted.
SH	Fit system Standard Hole: the hole has a fixed tolerance zone; the shaft is adjusted.

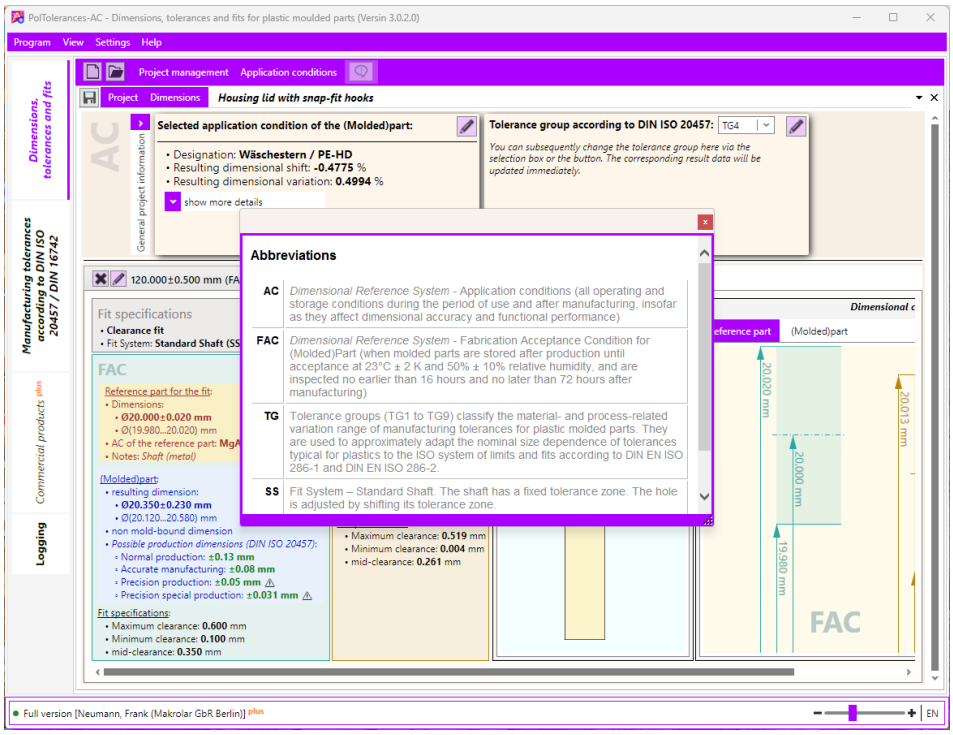


Figure 22: "Abbreviations" window

8 Technical background

8.1 Dimensional reference levels and transformation

The basis for part development, mould design and production are the service or **application conditions (AC)** of the part. If dimensional changes after production are relevant to the function, they must be taken into account when specifying the **dimensional position**, **dimensional shift** and **dimensional variation**. Starting from the functional requirements for dimensions, tolerances and fits, the values are therefore converted to the other dimensional reference level: from the application conditions (AC) to the fabrication acceptance conditions (FAC) or vice versa.

In general, three closely linked dimensional reference levels are distinguished: part application, part production and mould making. For each level, position (mid-tolerance dimension C), shift (dimensional shift Δl, with sign) and variation (tolerance T) are considered. The design is worked out in the opposite

direction to the way the dimensions are created – from the application to production. PolTolerances-AC deals with the two upper levels, AC and FAC.

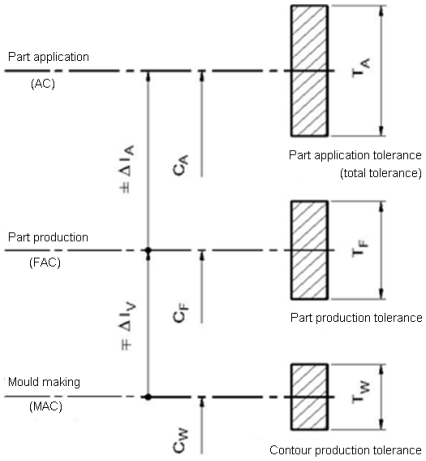


Figure 23: Dimensional reference levels for application and production of plastic parts

In the figure, MAC stands for the acceptance conditions of mould making (German: AWB, ABF, ABW for AC, FAC, MAC).

If the dimensions under FAC are known or have been calculated, PolTolerances-AC additionally evaluates them according to DIN ISO 20457: whether, how and under which conditions the dimensions, tolerances and fits can be achieved in production. This may mean that decisions on the part material or on supplied parts have to be refined, which in turn may require corrections to the mould design. The design is therefore usually an **iterative process**.

The conversion is based on the defined application conditions with their (material-dependent) dimensional changes. They can be assigned to the **moulded part**, the respective **fit reference part** and/or **individual dimensions** – the latter e.g. for wear, elongation or compression at a specific point.

8.2 Determining application-related dimensional changes

Determining the dimensional changes under application conditions requires **condition parameters** and **material properties**. The principle is that the functionally required dimensional accuracy must be ensured **at every point in time during the application period**. If you do not have your own values and experience, you can work out a basis for orientation with the following scheme.

- **Condition parameters** result from the specific application environment: indoor climates, the outdoor climate zones of the earth and special conditions due to heat sources (e.g. engine heat, greenhouse effect, heating) and heat sinks (e.g. refrigerators, cold stores).
- **Material properties** (e.g. coefficient of thermal expansion, swelling) come from manufacturers' datasheets or other sources; many commercial plastic grades are also included in the “Commercial products plus” module. Because the properties depend on temperature, reference temperatures may have to be observed.

Relative dimensional changes after FAC. Any number of different courses of the dimensional change ε during the application period are bounded by the extreme values **εmax** (expansion) and **εmin** (contraction). Assuming normally distributed courses, PolTolerances-AC calculates the **mean relative dimensional shift** and the **relative dimensional variation** from them – shown on the cards of the application conditions as the resulting dimensional shift and variation.

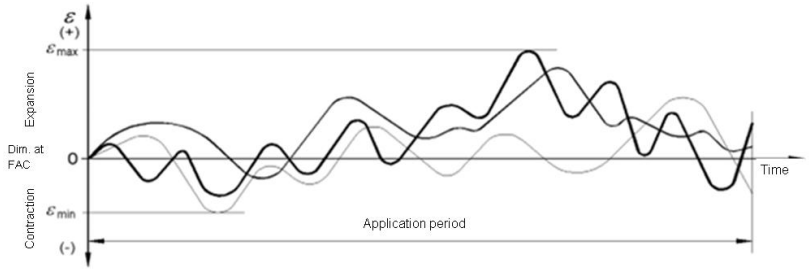


Figure 24: Courses of the relative dimensional change during the application period, bounded by εmax and εmin

Dimensional changes due to mechanical stress must be differentiated into **elongation** and **compression**. Wear is taken into account by wear rates V in %, separately for **inner parts** (shafts) and **outer parts** (bores). Calculation modules for thermal expansion, thermal contraction, swelling and post-shrinkage are available when you create a dimensional change (section 6.1).

8.3 Causes of application-related dimensional changes

The **application conditions** include all conditions of use and storage after production that affect dimensional accuracy and function. If individual parts are assembled long after production, storage and assembly conditions may have to be treated as a special case of the AC. For soft or rubber-like materials and for assemblies made of identical materials, their influence can often be neglected. In principle, however, the AC must be determined depending on the situation and function; a general standardization is not possible because of the large number of influences. Causes are:

- climatic influences from ambient temperature, humidity, precipitation and solar radiation
- use-related energy input from heat sources and high-energy radiation
- diffusion contact with vapours and liquids and migration contact with solids
- material removal (wear) by friction, cavitation, erosion and biological influences
- mechanical deformation by external forces and moments and by relaxation of internal stresses
- molecular and micromorphological structural changes

8.4 Fabrication acceptance conditions (FAC)

According to DIN 16742 and DIN EN ISO 291, the inspection dimensions are the acceptance values if the parts are stored after production at 23 °C ± 2 K and 50 % ± 10 % relative humidity and inspected no earlier than 16 h and no later than 72 h after production. If the conditions differ, the dimensional position and deviations, inspection method, inspection period and storage and inspection conditions must be agreed and documented separately between manufacturer and buyer. Deviations can result from:

- subsequent operations with material application (painting, coating) or material removal (machining, grinding, polishing)
- annealing (anticipating post-shrinkage, relieving internal stresses, post-curing) or subsequent operations with considerable thermal load (painting, solder bath)
- conditioning, e.g. water storage (anticipating swelling, increasing toughness)
- low dimensional stability of the material, e.g. transformation of the crystalline phase (PB) or swelling and plasticization of thin-walled parts made of hydrophilic polymers (PA6, PA66, PA46, biopolymers)

Note: The basics of manufacturing tolerances according to DIN ISO 20457 / DIN 16742 – tolerance groups, processing shrinkage, tool-specific dimensions and tolerance series – are described in the PolTolerances user manual.

9 Menus

Menu	Commands
Program	**Exit Program**; **Info about…**
View	Switch between **"Dimensions, tolerances and fits under application conditions"**, **"Manufacturing tolerances according to DIN ISO 20457 / DIN 16742"** and **"Commercial products"**; **Original size (100%)**; **Results Change View**.
Settings	**Server connection…**; **Activate the license…**; **Reset the license…**; **Options…**; **Language/Sprache…**
Help	**Check for software update…**; **To our homepage…**; **Register for the software…**; **View online help**; **View local help…** (F1 key); **View local Help (Commercial products database)…**
Project management (violet bar)	**New project…**; **Load project…**; **Close all projects**.
Application conditions (violet bar)	**Manage…**; **Printing / Print Preview…**
Project (in an open project)	**Save project**; **Save project as**; **Printing / Print Preview…**; **Close project**.
Dimensions (in an open project)	**New independent dimension…**; **New fit dimension…**

10 Tips and frequently asked questions

Question	Answer
What is the difference between FAC and AC?	FAC is the state at acceptance in production, AC the state in service. Tolerances according to DIN ISO 20457 apply under FAC; PolTolerances-AC converts them to AC.
Which direction of transformation should I choose?	"Enter under FAC" if you know the drawing dimensions and want to know how they behave in service. "Enter under AC" if the function in service is specified and you are looking for the production dimensions.
Moulded part and reference part are made of different materials.	Select a separate application condition for the fit reference part (section 5.2, step 3).
I want to change the application condition or tolerance group later.	Use the pencil symbol in the respective box of the project view. All dimensions are recalculated immediately.
Different conditions apply to a single dimension.	When entering the dimension, select an "additional application condition (for the current measurement)".
Where do I get values for the dimensional changes?	From datasheets, your own measurements or the calculation modules when creating a dimensional change. The decisive values are the extremes during the entire application period (section 8.2).

Question	Answer
Can I also use PolTolerances-AC for metal parts?	Yes. In the project wizard, select a part made of a different material; the tolerance group according to DIN ISO 20457 is then omitted.
What does the warning triangle next to the production dimensions mean?	This tolerance series has to be agreed with the manufacturer of the moulded part.