PolSelec - Material selection system for plastics

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PolSelec - Intro

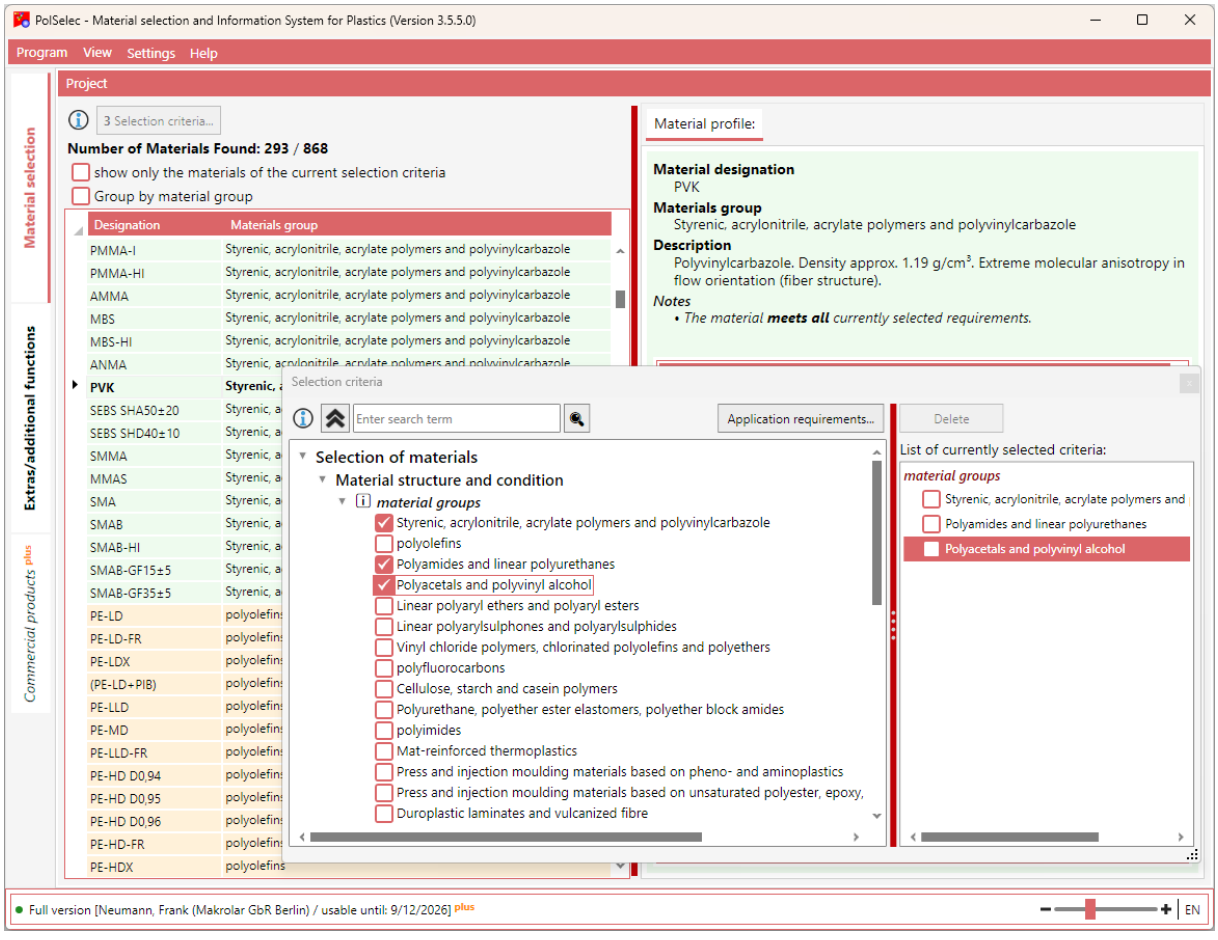
The designer of plastic products must have at least a general idea of the materials and manufacturing processes that can be used no later than after the task has been specified and the working principle solutions have been selected.

We therefore developed the **PolSelec** software for the preliminary selection of materials and processes, enabling the preselection of basic material types and the associated manufacturing processes. The conceptual approach to this decision-making algorithm was developed as early as 1978.

The display and printout of the basic plastic material types use abbreviations defined in accordance with **ISO 1043** and **DIN 7728**, taking into account the respective DIN standards for molding materials. PolSelec requires some modifications and additions to the standard abbreviation system, but these are largely consistent with familiar and commonly used notations.

How to use

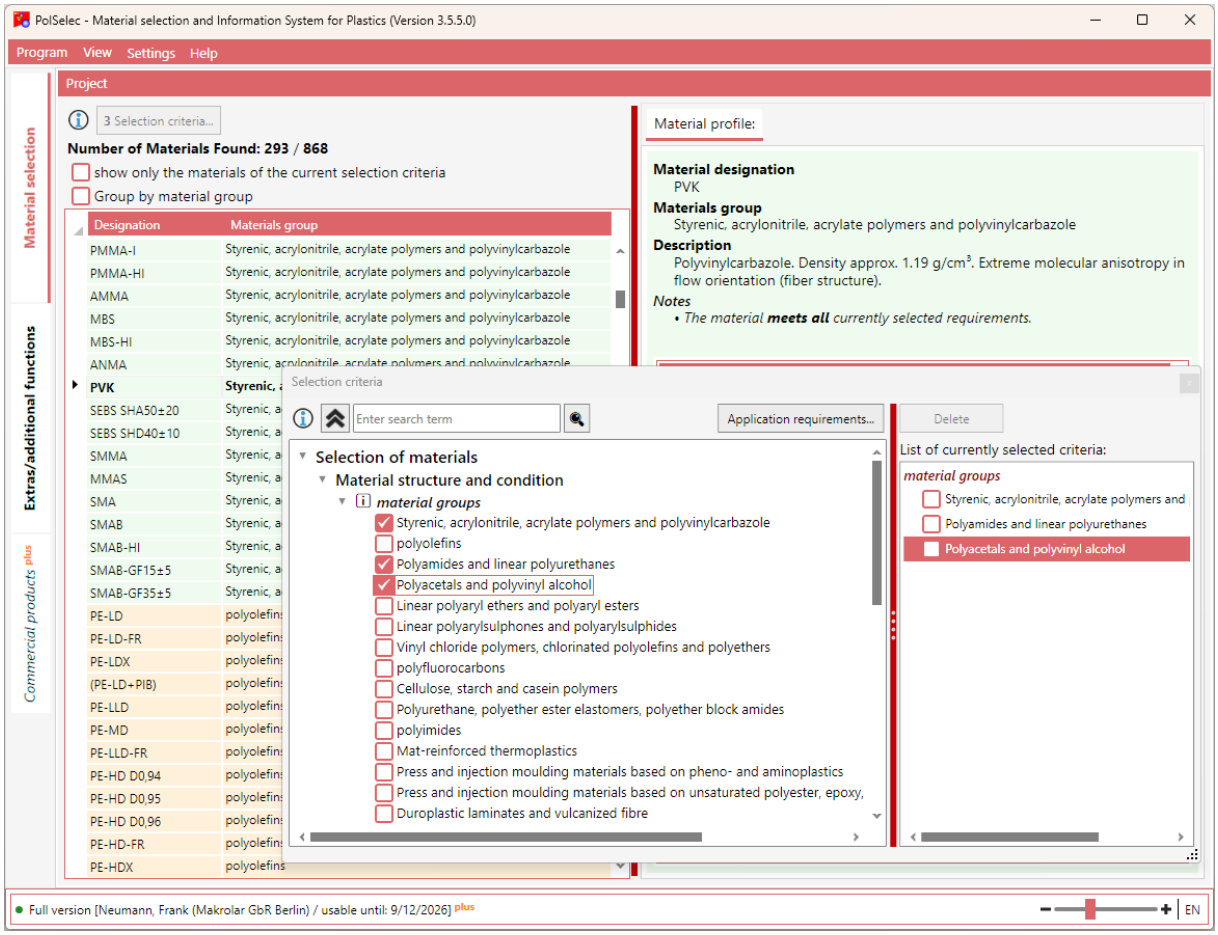
The main window of the software ...



Quick start

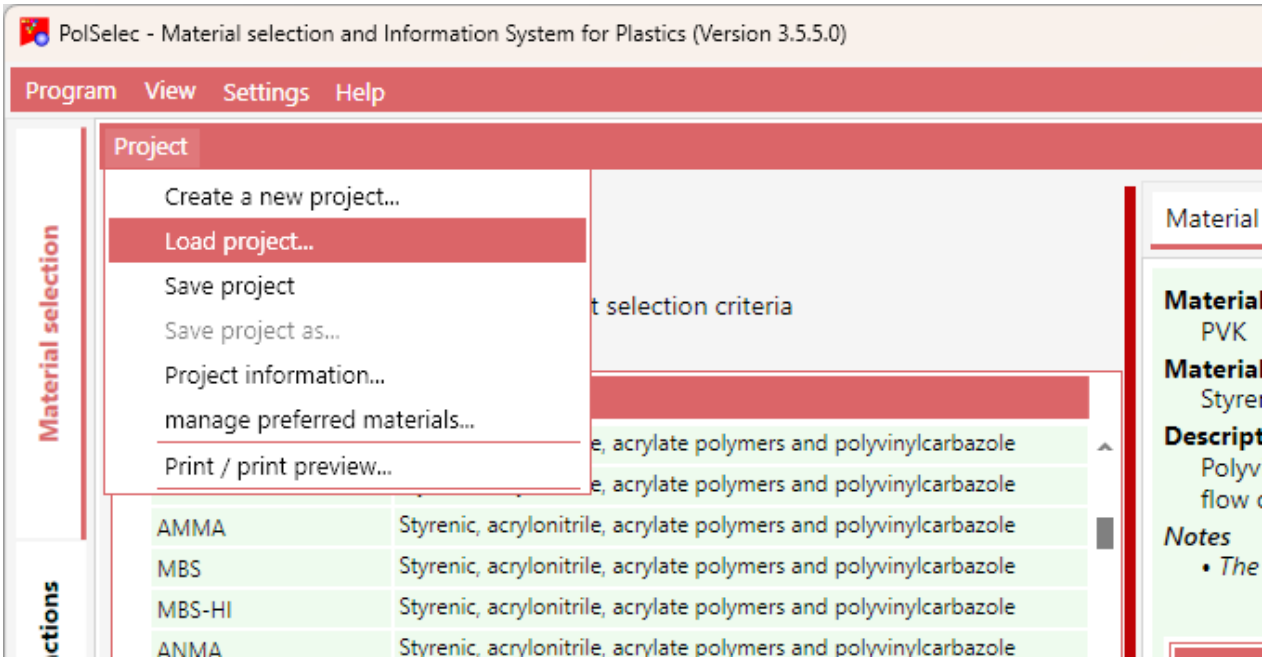
1. If it is not already displayed, click the **"***Material Selection***"** tab on the left. The list of all materials is displayed.
2. Click the **[***Selection Criteria***...]** button. A new window opens showing the hierarchy of selection criteria.
3. Navigate through the hierarchy to the desired selection criteria. At the lowest level, you can select the criteria. The selected criteria are also displayed in a list on the right.

4. As soon as you add or change a criterion, the selection is applied automatically and the list in the main view is updated immediately.
5. In the main view, you can group or filter the material list.
6. When you select an entry in the material list, the details and the material assignment profile are displayed on the right.
7. The information icons in the various views provide additional information and assistance.



Project management

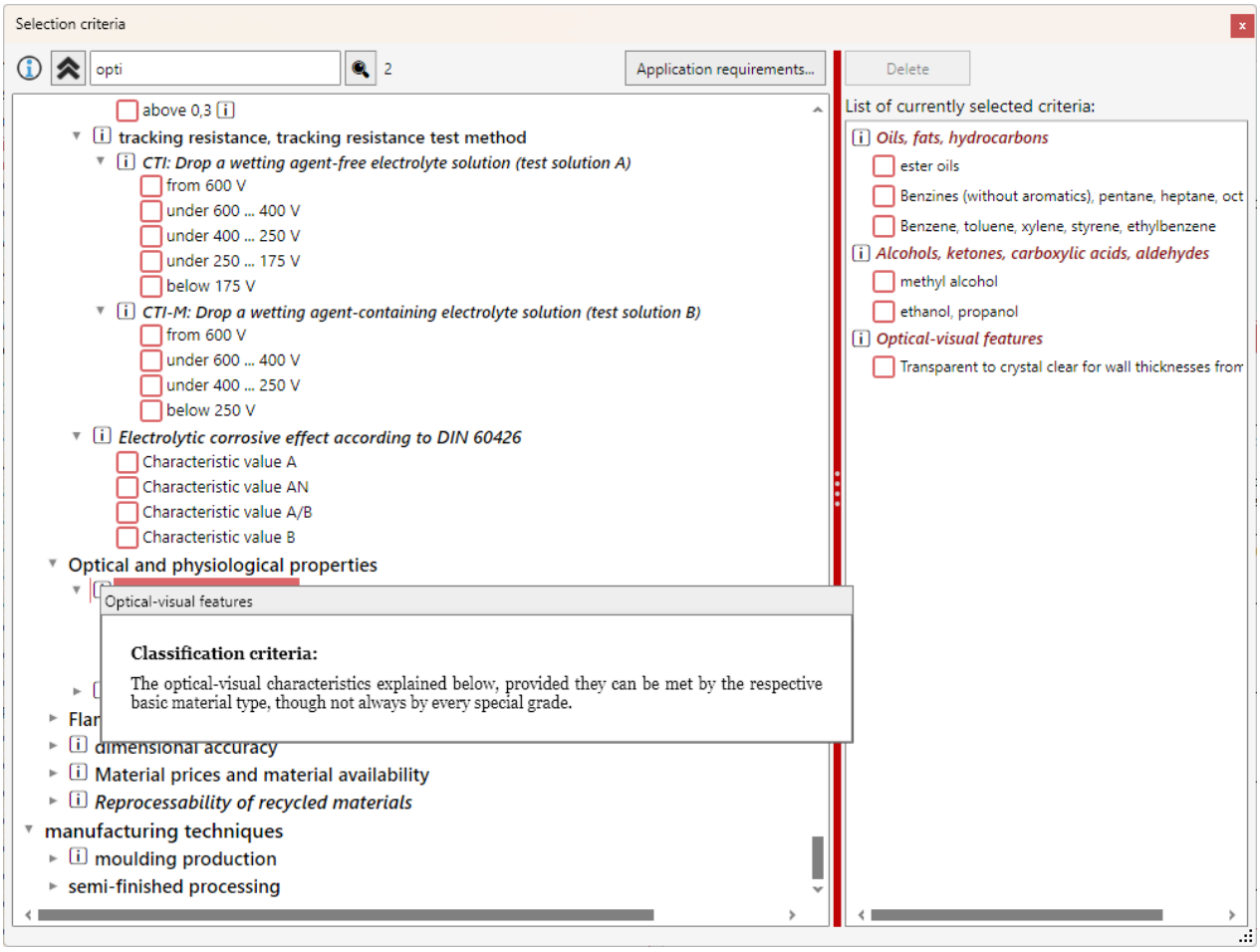
Projects are managed in separate files. The corresponding functions can be found in the **"*Project*"** menu in the main menu bar.



Selection criteria and additional information

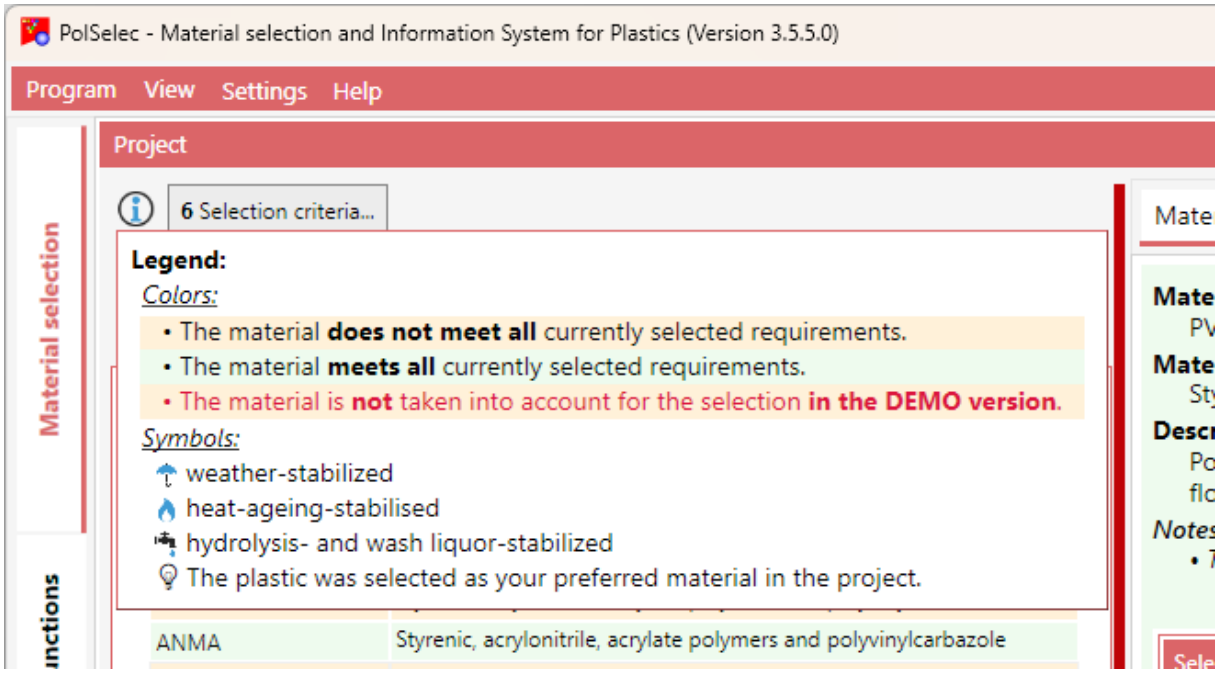
In the "*Selection Criteria*" window, all criteria are displayed in a hierarchy. At the lowest level, you can select the desired criteria.

- You can use the search function to filter by specific search terms, making it easier to find particular criteria.
- The information icons provide additional information to help you better assess the respective selection criterion.
- Alternatively, you can also search for materials based on [*Application Requirements*].



Main view/Result view

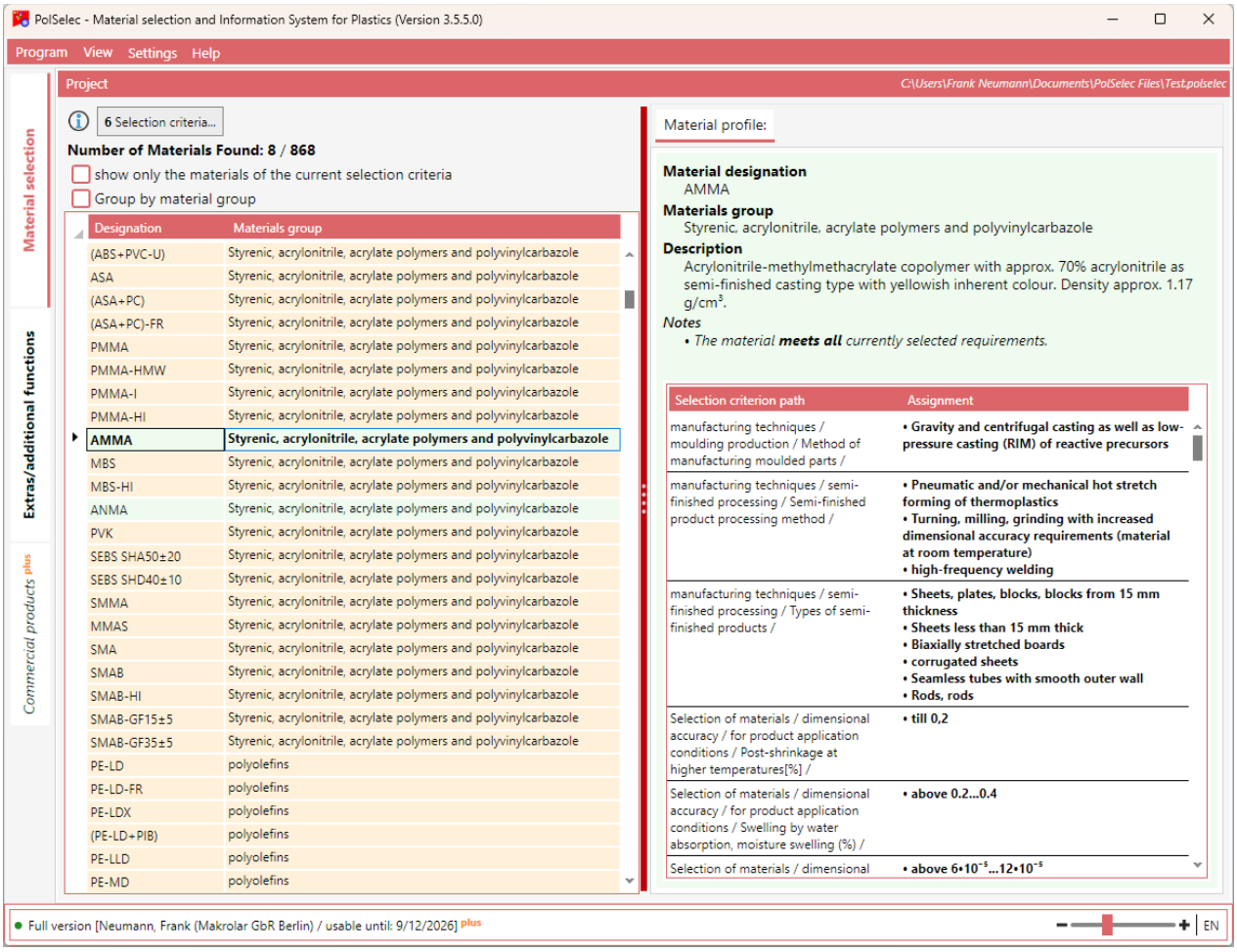
- The material list is automatically updated as soon as the selection criteria change.
- The colors and symbols used are explained in the legend.



- The material list can be grouped by material groups. In addition, the list can optionally be filtered to show either all materials or only the materials matching the current selection. The number of materials

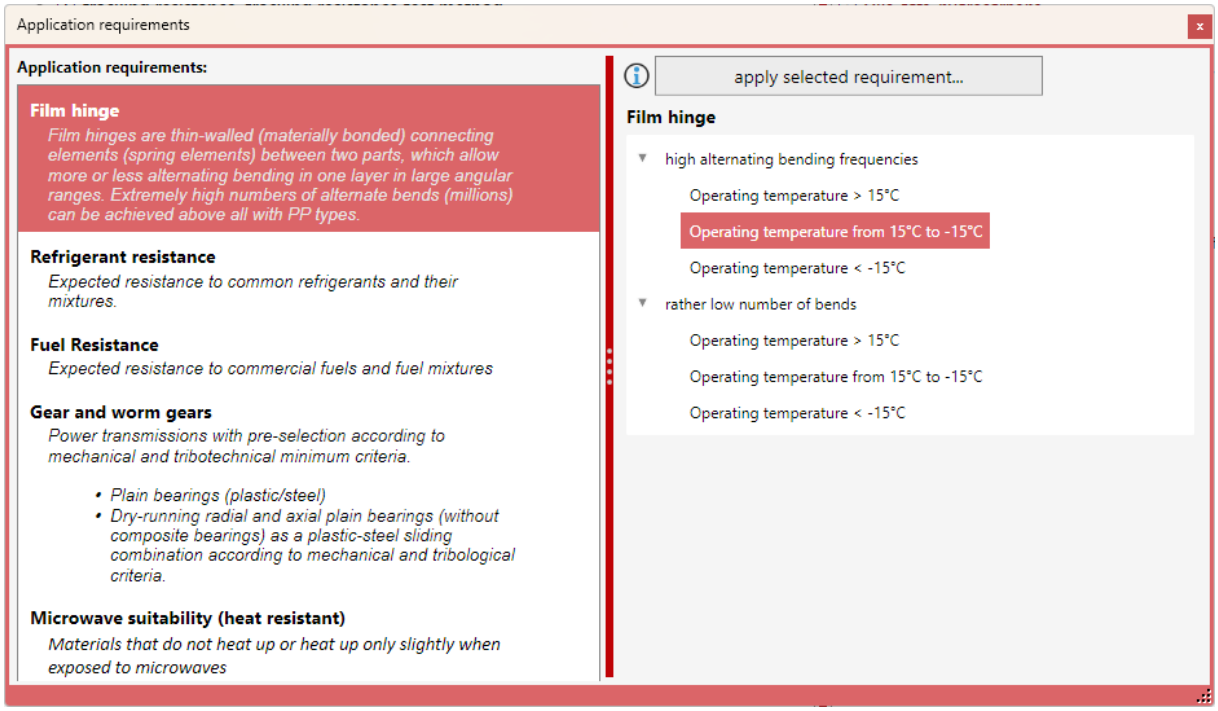
found is displayed above the list.

- In the right-hand area of this view, you can see the details as well as the assignment profile of the currently selected material.



Application requirements

If you click the [*Application Requirements...*] button in the "*Selection Criteria*" window, another window opens.



On the left, the various application requirements are displayed. Clicking on a requirement lists the corresponding requirement variants on the right, if available. Each application requirement has a list of corresponding selection criteria behind it.

Why do these lists exist?

When selecting a material, the user generally has to mentally infer specific material requirements from the application requirements of the product, molded part, or application. It is not always obvious which material selection criteria lie behind a particular application requirement. This list is intended to support you in this translation process – from application requirement to material requirement.

We will expand and refine the application requirements step by step. The new data will be made available to you as part of the corresponding software updates.

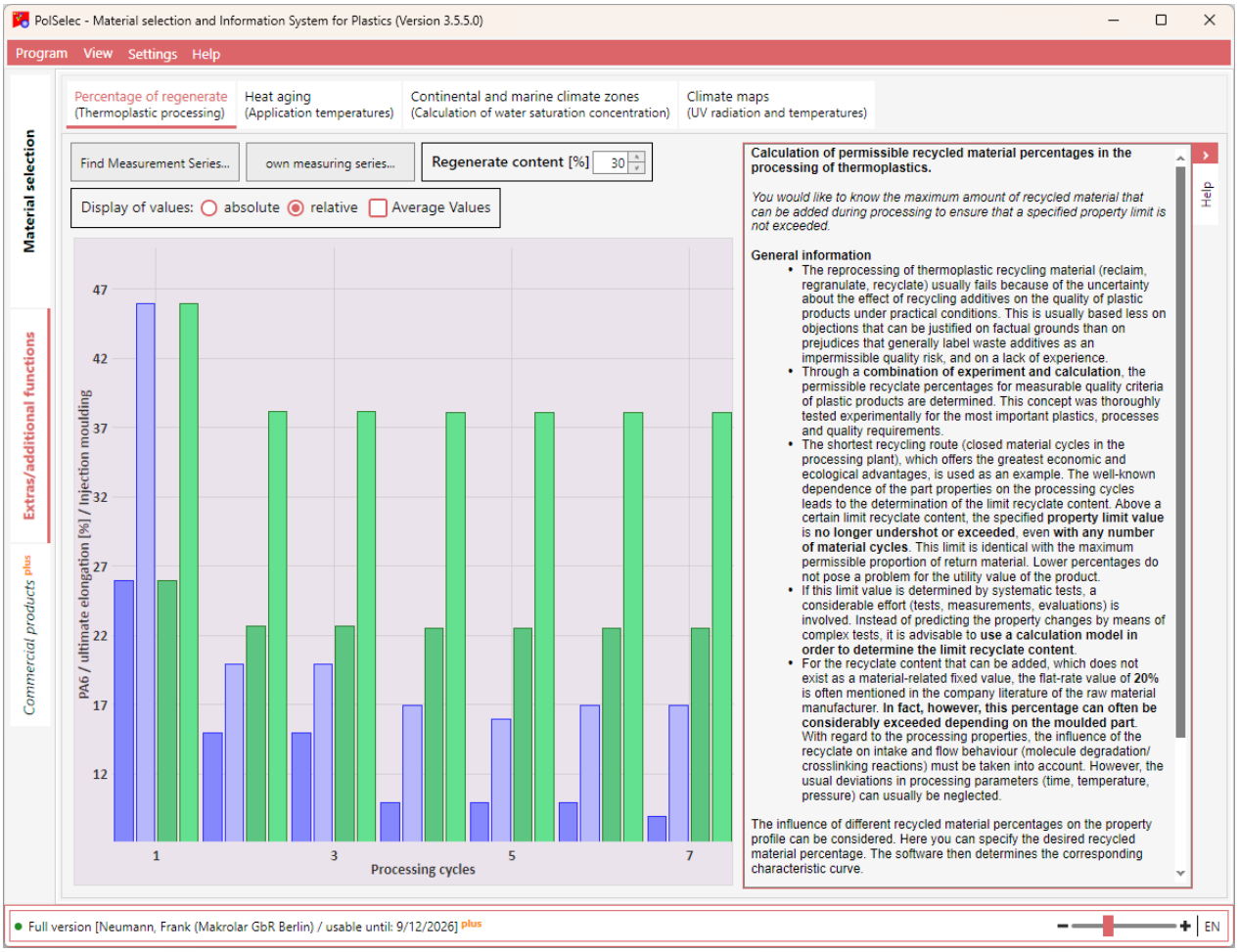
If an application requirement matches your application conditions, select it and then click the [*apply selected requirement*] button. This will add all selection criteria assigned to the application requirement to your material selection.

Extras/additional functions

Currently, the following extras/additional functions are supported:

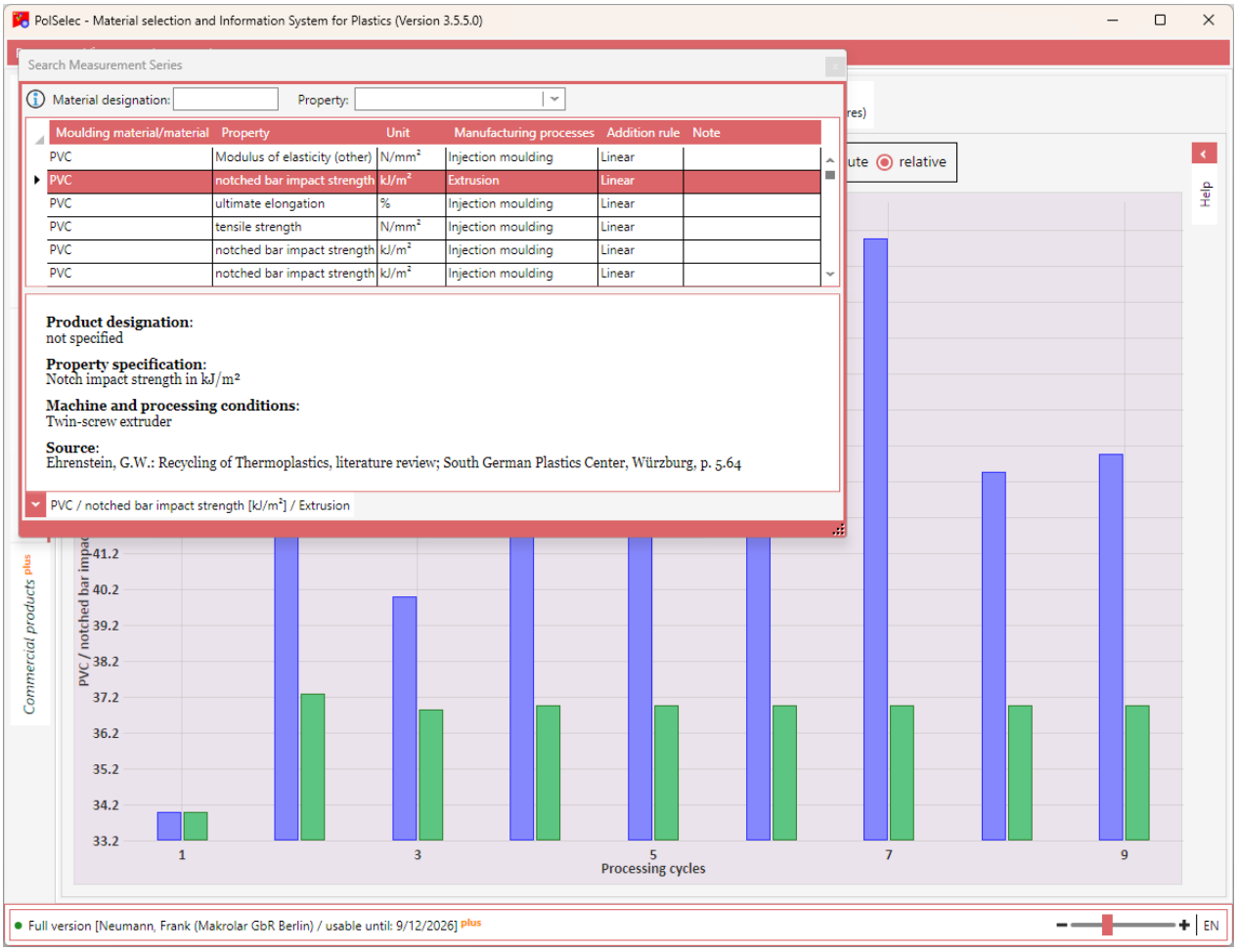
- Permissible regrind content: Determination of the permissible regrind content when processing thermoplastics
- Water saturation concentrations: Calculation of the water saturation concentration
- Heat aging: Determination of the permissible service temperature under continuous thermal load
- Climate maps: Among other things, for taking weather and heat resistance into account

You can find these functions in the main window under the "*Extras/Additional Functions*" tab.



Determination of permissible recycled material percentages

You want to know how much regrind can be added at most during processing without exceeding or falling below a specified property limit value.



General information

Reprocessing thermoplastic return material (regrind, reground pellets, recyclate) generally fails due to uncertainty about the effect of recyclate additions on the quality of plastic products under practical conditions. This uncertainty is usually based less on factually justified objections than on prejudices that categorically brand waste addition as an unacceptable quality risk, as well as on a lack of experience.

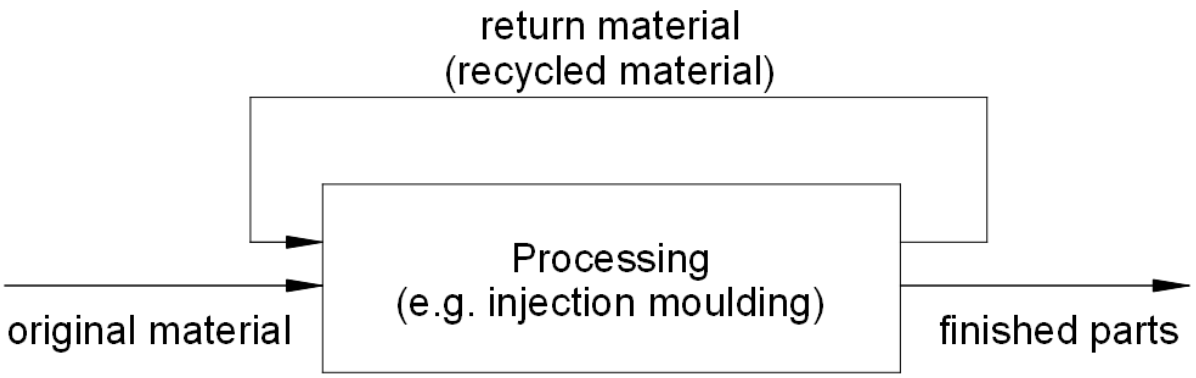
By combining experiment and calculation, the permissible recyclate proportions for measurable quality criteria of plastic products are determined. This concept has been thoroughly verified experimentally for the most important plastics, processes, and quality requirements.

As an example, the shortest recycling route (closed material loops within the processing plant) is considered, which offers the greatest economic and ecological advantages. The well-known dependence of part properties on processing cycles leads to the determination of the limiting recyclate content. From a certain limiting recyclate content onward, the specified **property limit value** is **no longer exceeded or undercut, even with any number of material passes**. This limit is identical to the maximum permissible proportion of return material. Lower proportions are unproblematic for the utility value of the product.

If this limit value is determined through systematic testing, this involves considerable effort (tests, measurements, evaluations). **Instead of using elaborate experiments, it makes sense to predict the property changes using a calculation model** in order to determine the limiting recyclate content in this way.

For the addable recyclate proportion, which does not exist as a fixed material-related value, raw material manufacturers' company publications often cite a blanket figure of **20%**. **In reality, however, this percentage can often be significantly exceeded depending on the molded part**. With regard to processing properties, the influence of the recyclate on feeding and flow behavior (molecular degradation/crosslinking reactions) must be taken into account. Usual deviations in processing parameters (time, temperature, pressure) can, however, mostly be neglected.

Processing cycle for determining permissible proportions of regenerated material:



Basic data / master curves

The basis for the forecasts is a **measurement series** or **master curve**. This measurement series represents the course of a measured property of a certain type of plastic with 100% use of regenerated material. This means that original material is processed and then the determining property is measured on the products or test pieces. Then all products or test specimens are regenerated and 100% reprocessed. Subsequently, measurement is carried out again, regenerated and returned. This cycle should be repeated approx. 6 to 10 times.

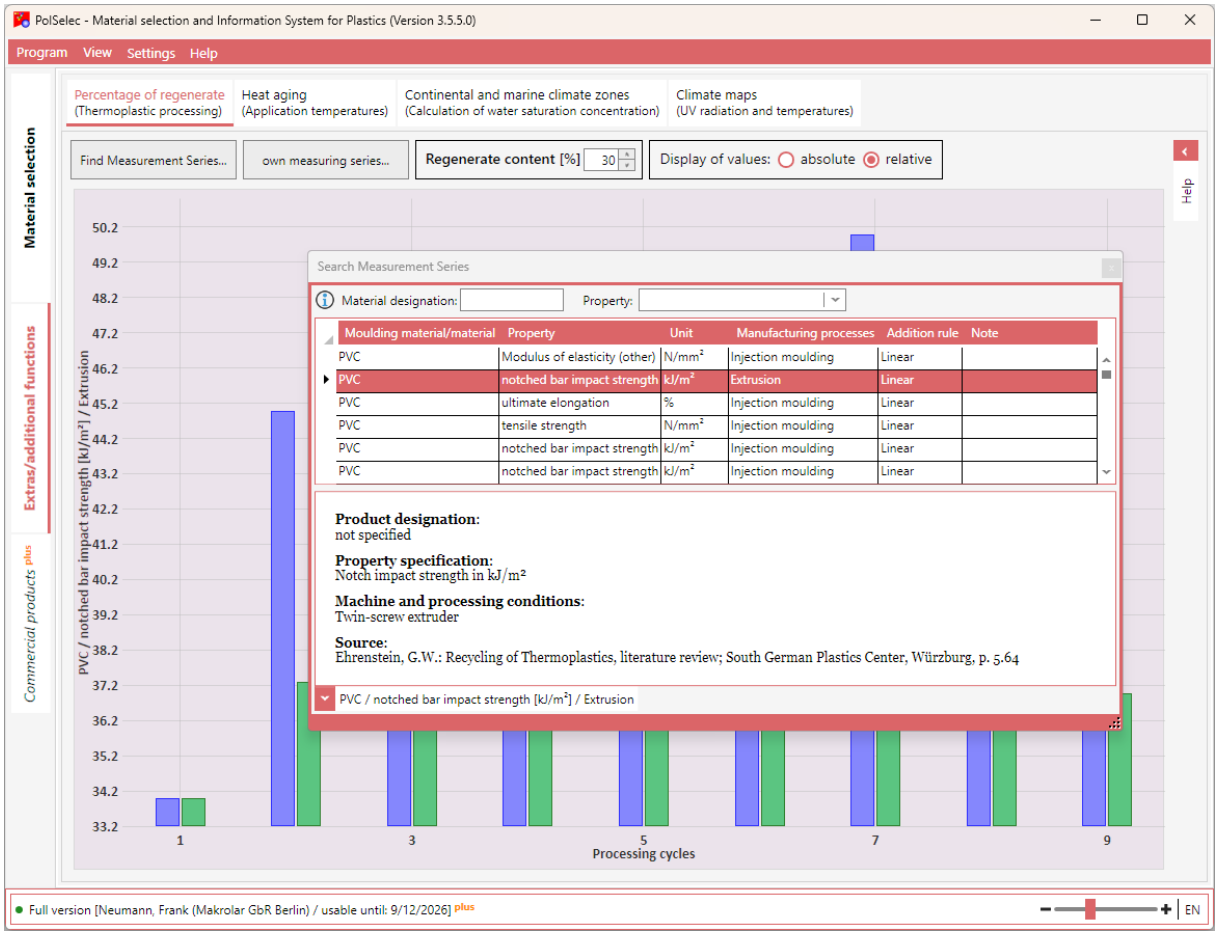
The software currently contains **approx. 200** of these **master curves** for different plastics, properties and manufacturing processes.

Furthermore, you can also enter measured values of your own measurement series/master curves and have the permissible regenerate content determined from them.

Using the functions

The influence of various regrind proportions on the property curve can be examined. Here, you can specify the desired regrind content. The software then determines the corresponding property curve.

- Click the [*Find measurement series...*] button and search for a suitable measurement series.
- Select the appropriate entry in the list (the list can be sorted by the respective column content). Additional filters are shown above the list.



If a property change due to the use of recyclate exists or existed for the selected entry, the corresponding measured and calculated values are displayed graphically. Otherwise, you will receive a corresponding notice that no property change due to the use of recyclate could be observed.

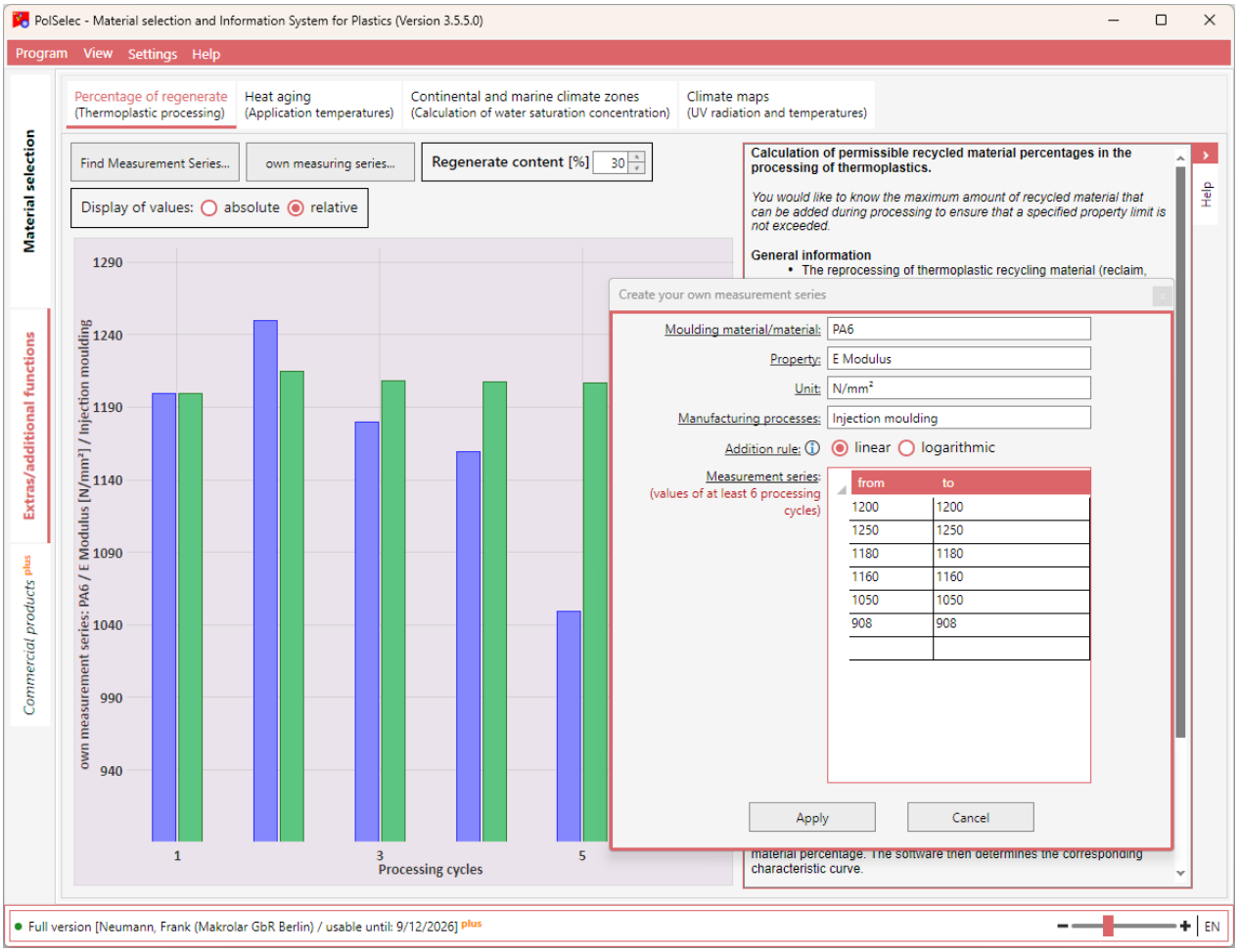
You can now vary the regrind proportion so that a specific property limit value is not undercut or exceeded. The calculation starts immediately after the corresponding value is changed.

You can switch the display between absolute values and relative values (relative to the minimum value).

If the master curves contain value ranges (from/to values), you additionally have the option of using the corresponding mean values instead of the from/to values.

own measurement series/master curve

Clicking the [*own measurement series...*] button opens another window.



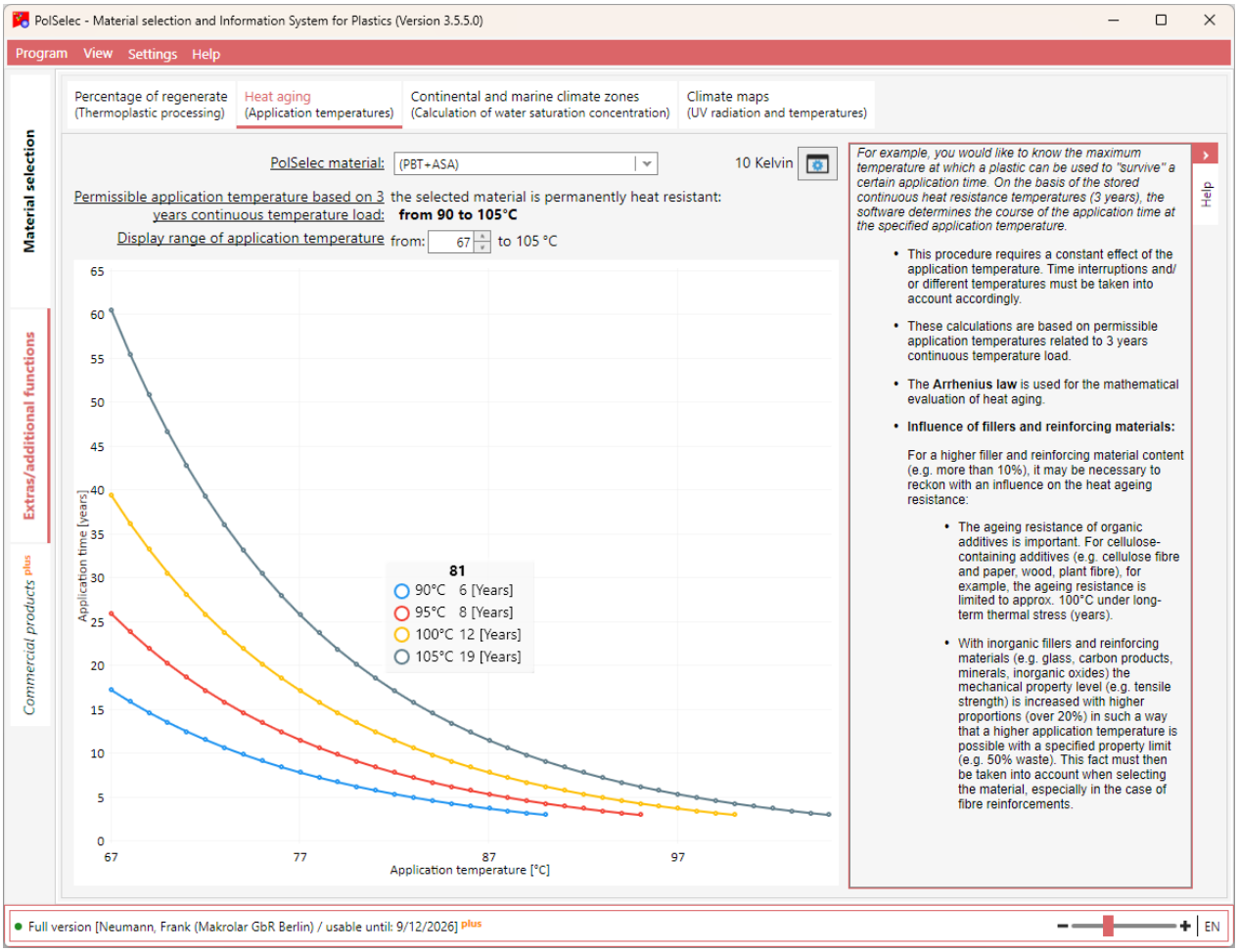
Here, enter information about the material, the property, and, if applicable, the unit of measurement, and select the addition rule. Then enter your measured values in the list. At least 6 values must be entered.

To delete a row in the list, select it and press the [Del] key.

When you are finished, click the [*Apply*] button. The window closes and the measurement series is immediately displayed graphically.

Heat aging

In the "*Extras/Additional Functions*" tab, you will find another tab called "*Heat Aging*".

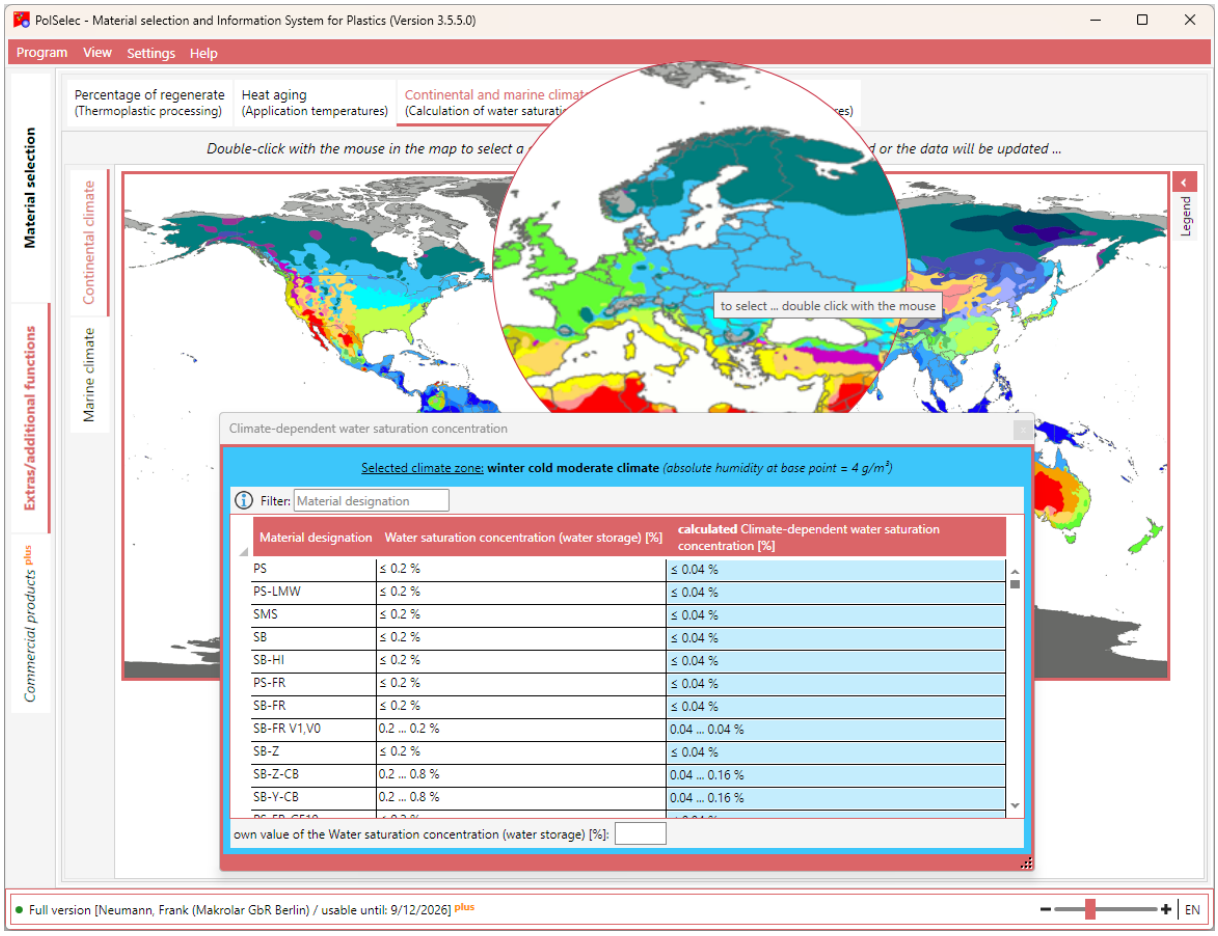


The basis is the empirically based Montsinger's rule, according to which the service life of organic materials halves with a temperature increase of 10 K. The Arrhenius equation is used for the mathematical evaluation of heat aging.

Further information/help can be found within the software in the corresponding view.

Calculation of water saturation concentrations

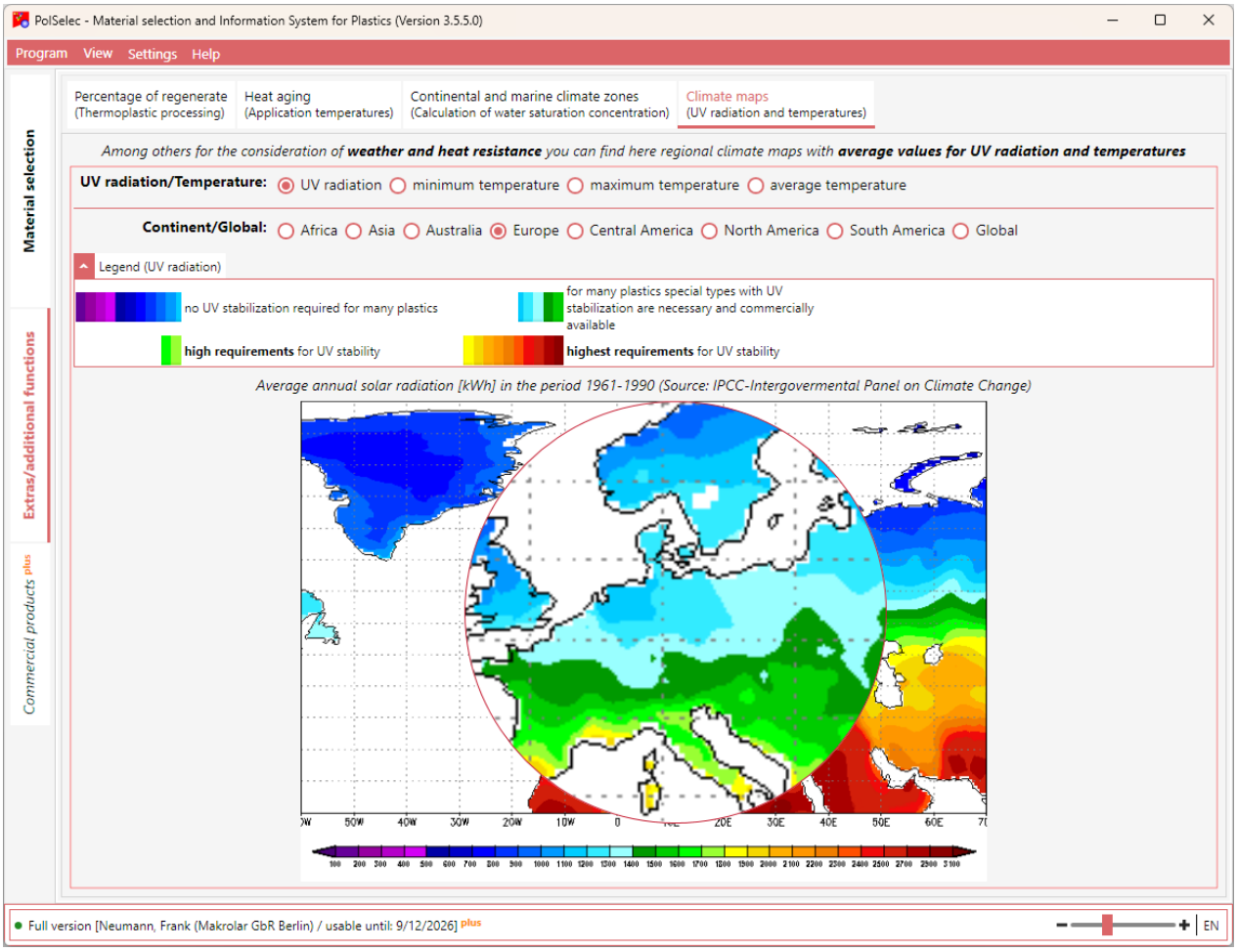
In the "*Extras/Additional Functions*" tab, you will find another tab called "*Continental and Maritime Climate Zones (Calculation of Water Saturation Concentration)*".



- You can choose between continental climate and maritime climate. A corresponding color legend can be displayed on the right.
- When you move the mouse over the map, a magnifying glass is displayed.
- Double-click with the mouse on the desired region. Another window opens. Leave this window open and select a different map/region if needed.
- The selected region is displayed with color, designation, and the absolute humidity at the base point. The data is immediately (re-)calculated and the values in the list are updated.
- Using the input field below the list, you can calculate your own values by specifying the water saturation concentration (water storage).
- You can filter the list by material designation.

Climate maps

In the "*Climate Maps*" tab, you will find map material for UV radiation as well as minimum, maximum, and mean temperatures. This can be used to assess weather and heat resistance.



PolSelec - Material identification

The formal framework of the abbreviation notation is the three-part data block system provided with examples below:

block 1				block 2	block 3
filed 1	field 2	field 3	field 4		
PP	-B	-HI	-FR	V0	T20+GF10
(PC+ABS)				VST/B130±5	GF15±5
S/B	-T				
PE	-UHMW				CG+AL-D
PF31.5	-N				
Hgw2082					
PA6	-G				
UP			-CR		GM30
EP					(GF+M)65±5

block 1

If necessary, the **block 1** can be composed of four fields, each separated from the other by "-". In the **field 1**, the base polymer is entered by abbreviations in accordance with DIN 7728 or the future DIN ISO standard. In the case of polymer blends, the polymer with the highest mass content is written first. After this basic polymer, the blend is assigned to the characteristic polymer groups in ***PolSelec***. In

addition, the blend composition can be indicated by mass percentages on the respective polymer abbreviation, e.g. (PC+ABS35).

In Germany, plastic type abbreviations for curable moulding compounds and laminates that have already been bindingly defined are entered in the **field 1** in accordance with the applicable DIN standard:

DIN 7708: Phenolic and aminoplastic moulding compounds, cold moulding compounds
DIN 16913: Polyester resin mats (prepreg)
DIN 16946: Casting resin moulding materials
DIN 16926: Decorative laminates A
DIN 7735: Hard paper, hard tissue and hard mat laminated materials
DIN 7737: Vulcanized fibre

If appropriate, these type designations are supplemented by the basic polymer abbreviation (e.g. MF152) and reduced in scope (e.g. Vf311 instead of Vf3111).

In the **field 2**, information on substance formation processes and/or material composition may be given by the following letter meanings:

B: Block polymer
C: chlorinated
E: Emulsion polymer
G: Cast resin
H: Homopolymerisate
L: graft copolymer
M: Bulk polymer
N: Novolak
P: plasticized
Q: Polypropylene-olefin elastomer blend
R: Statistical copolymer;resol
S: Suspension polymer
U: plasticizer-free

If several characteristics are specified, these are separated by commas (e.g. PVC-U,S).

The **field 3** is used to indicate characteristic polymer properties by a combination of the following letter characters:

D: Density
F: flexible, soft
H: high
I: impact resistant
L: linear, low
M: mass, medium, molecular
N: normal
U: ultra
V: very
W: Weight
X: networked, networkable

Examples:
ultra-high molecular weight - UHMW
linear & low density - LLD
very soft - VF
high impact - HI

The equality of some letters with those of the **field 2** does not lead to misinterpretations, since they cannot appear as single characters.

In the **field 4**, special properties of the plastics are displayed if necessary, which are achieved by special equipment and/or processing or by chemical modification:

AR: particularly low frictional resistance and/or high wear resistance
CR: particularly resistant to chemicals
FR: Fire protection equipment
GC: particularly suitable for electrochemical metallization
RM: modified for reduced water absorption (Reduced Moisture)
T: increased transparent
Y: electrically conductive (volume resistance below 1000 W-cm)
Z: antistatic equipment

It is not possible to confuse the abbreviation CR with the same abbreviation for polymers with a narrow molecular weight distribution (controlled rheology), since **PolSelec** does not take rheological properties into account. If several special properties apply to the basic plastic type, these are separated by commas and inscribed in the **field 4** (e.g. PC-AR,FR).

block 2

Type characteristics can be specified in the **block 2** by class allocation or numerical value ranges. In **PolSelec** these are mainly the following properties:

○ Material density in g/ccm at 23°	D...
○ Fire classes according to UL94:	V0, V1, V2
○ Dimensional stability temperature in °C according to DIN 53461:	HDT/A..., HDT/B...
○ Martens temperature in °C according to DIN 54462:	MT...
○ Vicat temperature in °C according to DIN ISO 306:	VST/A..., VST/B...
○ Shore hardness A or D acc. to DIN 53505:	SH/A..., SH/D...
○ Ball indentation hardness in N/mm² according to DIN 53456:	H...

block 3

The **block 3** is intended for marking the type, quality and quantity of additives, in particular fillers and reinforcing materials. Quantities are given in percent by mass as fixed values or ranges. Types and forms of additives are designated by letters or letter combinations in accordance with ISO 1043, whereby extensions of this designation system are required for **PolSelec**:

AF: asbestos fibre
AP: Asbestos paper
AT: Asbestos cords
AW: Asbestos fabric
CF: carbon fiber
CB: carbon black
CG: Graphite
CR: Carbon fiber strands
CW: carbon fibre fabric
COC: Cotton shred
COF: cotton fibre, cotton flocks
COW: Cotton fabric
GB: solid glass microspheres
GHB: hollow glass microspheres
GD: glass powder
GF: glass fibre
GFC: chemically coupled glass fibre
GG: Glass fibre ground material, very short glass fibre
GK: Glass fibre knitted fabric
GM: Glass fiber mats and matte analog structures
GR: Glass fibre roving,Unididirectional glass fabric
GS: long glass fibre reinforced rod moulding compound (duromers only)
GW: orthogonal glass fibre fabrics and scrims
K: chalk, calcium carbonate
LC: Cellulose paper pulp

LF: cellulose fibre and flakes
LGF: long glass fibre
LGFC: chemically coupled long glass fibre
LP: cellulose paper
M: unspecified minerals
PD: Mica powder
PS: mica scales, leaflets
PP: mica paper, foil
RF: aramid fibre
RM: Aramid fibre mats
RR: Aramid fibre strands
RW: orthogonal aramid fibre fabric
SC: Synthetic fabric chips
SF: Synthetic fibre
SK: Synthetic knitted fabrics
SM: Synthetic mats and scrims
SW: orthogonal synthetic tissues
SR: synthetic fibre strands, unidirectional synthetic fabric
T: Talcum
WD: wood flour
WC: wood chips and shavings
WV: Wood veneers

In the case of all additives not listed above or not specified precisely, the substance name can, if necessary, be indicated by standardized or industry-standard abbreviations (e.g. abbreviations for metal alloys, plasticizer abbreviations according to DIN 7723) or, in the case of substances sufficiently defined chemically, by the chemical gross formula (e.g. pure iron = Fe, barium sulphate or barite = BaSO4). It is also possible to use a capitalized text name to describe the substance. Polymer additives which are not to be regarded as blending components (e.g. PTFE, silicone) are designated like other additives. If necessary, the form and nature of the additives, separated by "-", are indicated after the substance name with the following letter meanings:

B: balls, beads, lenses
C: Schnitzel, shavings
D: Flour, powder, semolina
F: fibre, fibre tufts, flakes
G: Fibre ground material
H: Whiskers
K: Knitted fabrics
M: Mats, fleeces
P: Paper, foil
R: Roving, strands, wires, unidirectional amplification general.
S: Leaflets, scales
V: Veneer
W: Fabric, scrim

Examples:

aluminium powder:	Al-D
Aluminium powder:	Al-D
Aluminium hydroxide:	$Al(OH)_3$
Polycaprolactam fabric:	PA6-W
Dioctylphthalate:	DOP
Metal whiskers in general:	METALL-H
Steel fiber tuft:	St-F
Titanium white, titanium dioxide:	TiO_2

The indication of the additives in the **block 3** is possible in the following variants:

1.) ONE ADDITIVE:
- Without quantity specification (e.g. PE-HD-Z...CB)
- Percentage mass fraction as fixed value or range (e.g. PA6...GF30, PA6...GF30±5)

2.) SEVERAL ADDITIVES:
- Without quantity specification (e.g. PE-UHMW...Al-D+CG)
- Flat-rate percentage of total mass as fixed value or range (e.g. EP...(GF+M)65, EP...(GF+M)65±5)
- Differentiated percentage mass components as fixed values or ranges (e.g. PP...GF20+T15, PP...GF15±5+T10±5)
- Various additives in small proportions alternatively individually or combined (e.g. POM-AR...SILIKON,MoS2).

FAQ's

Question/Problem:

What distinguishes *PolSelec* from other plastic databases or plastic selection programs?

Answer:

PolSelec is a selection program in which the materials or basic material types are assigned to characteristic value ranges. It serves for the pre-selection of plastics at the beginning of the development process. The aim of this preselection is to ensure that the optimum material to be specified later is definitely among the selected basic material types. **All basic material types are assigned to all selection criteria (without gaps)**. This ensures that all materials are taken into account in the selection. The fact that a material is not included in the selection due to missing data is excluded in *PolSelec*.

Question/Problem:

What is a basic material type?

Answer:

Basic material type in the sense of this selection procedure is a superordinate type representative for a different number of special commercial products (special material types) with very similar properties and similar material properties.

Question/Problem:

Why should a pre-selection of plastics be made?

Answer:

Material decisions begin with the selection of materials at the earliest possible stage of the design development process. The starting point is relatively few product requirements that determine the use of the material. In plastics technology, the particularly close relationship between product design, material and manufacturing process forces the material selection and the predetermination of the manufacturing process to be carried out simultaneously. The results of the material selection are all basic material types for which there is a certain chance of application. The optimum material to be specified later must certainly be among these basic types.