User Guide and Terms of Use

„Material Explorer“

Creation of material data for FEM simulation of electrical machines from thyssenkrupp specific material grades of non-grained electrical steel

The software was created in collaboration with thyssenkrupp Steel Europe AG and is identical with the software

“PowerCore® Explorer“

which is published by thyssenkrupp Steel Europe AG.

elmoCAD Engineering GmbH

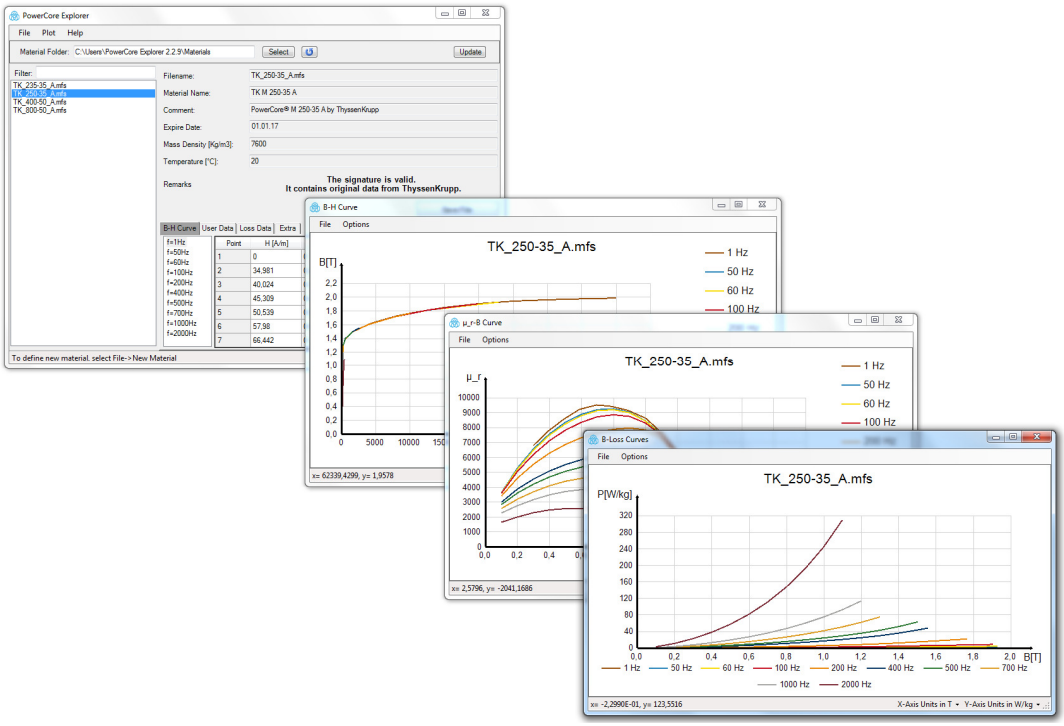
01.12.2017 / V 2.4.0

Content

1 Objective and Purpose

thyssenkrupp provides the PowerCore® Explorer software with which by thyssenkrupp published digitized material data J(H), B(H), specific Losses $P_v(B,f)$ and more different electrical steel grades can be viewed and prepeared for FEM calculation of electrical machines.

The material data are based on measurements in the thyssenkrupp laboratory accordingly to related standards (i.e. EN 10106 for cold milled electrical steel). The displayed mass densities are not the real ones but rather for magnetic measurements standardized densities.



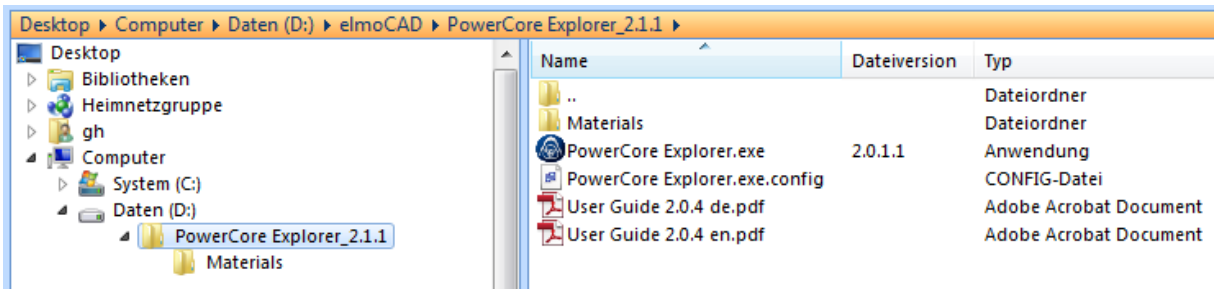
The material data and further non-public and not visible data are provided by thyssenkrupp in mfs files. The material data can be changed and amended by using PowerCore® Explorer and can be provided for different software tools in their related file formats for simulation of electrical machines.

- FEMAG, smartFEM *.mc, *.mca
- JMAG Material files *.jmc
- MAXWELL Material files *.tab
- SPEED Steel file *.stl
- Text file *.txt

elmoCAD Engineering GmbH delivers the PowerCore® Explorer software named as "Material Explorer" as a part of the smartFEM software to clients of elmoCAD Engineering GmbH.

2 Installation

PowerCore® Explorer needs not to be installed on a computer but rather can be opened by starting the file “PowerCore Explorer.exe” from any folder. This folder must contain following shown files:



As far as it contains also a folder „Materials“ all material files *.mfs and *.mc will be listed directly after the start of PowerCore® Explorer.

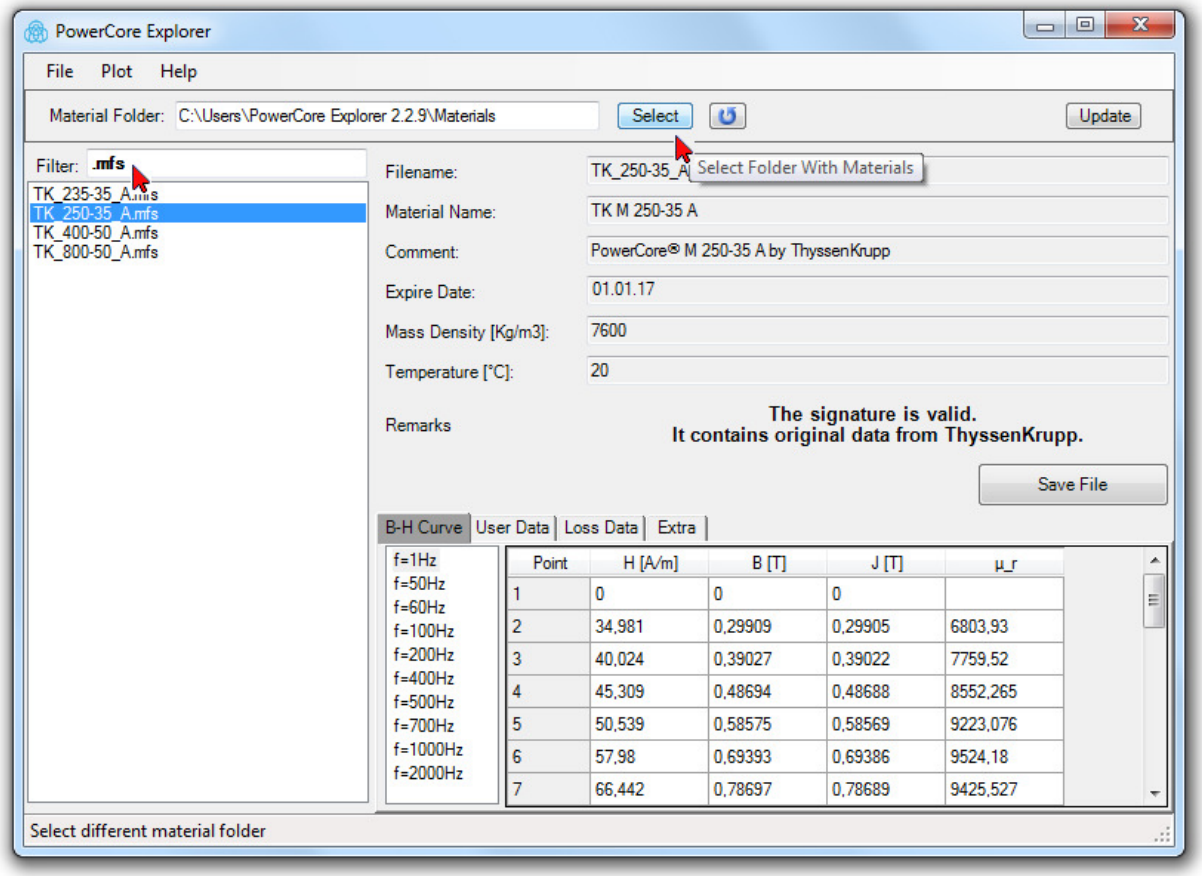
3 Functional Description

3.1 PowerCore® Explorer - Explorer

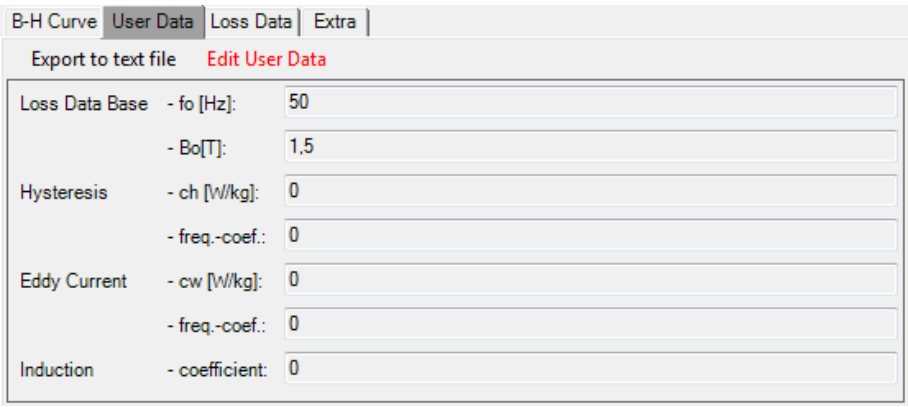
PowerCore® Explorer will be opened in „Explorer" mode.

User can then select that folder, which contains his material data files. All material data files *.mfs (thyssenkrupp) and *.mc (FEMAG, smartFEM) will be listed which fulfill the conditions of the text filter. All file types of the other software tools mentioned in §1 are not displayed because they don't contain all information.

After selection of one file all saved public data will be shown in tables which can be selected by tabs "B-H-Curve", "User Data" and "Loss Data" "Extra". B(H,f) values are recalculated from J(H,f) values which were measured by thyssenkrupp. The loss data are also based on by thyssenkrupp measured values.



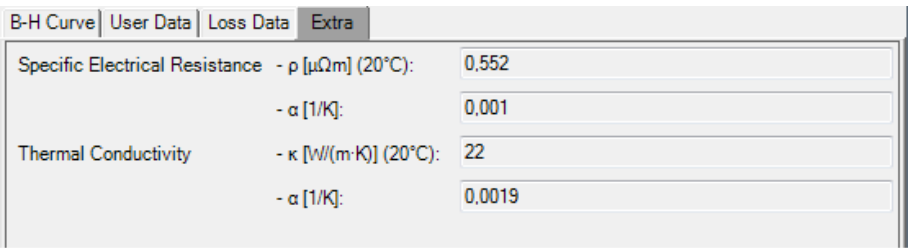
„User Data“ can be edited by user. They are saved in the public area of the thyssenkrupp specific material files (*.mfs):



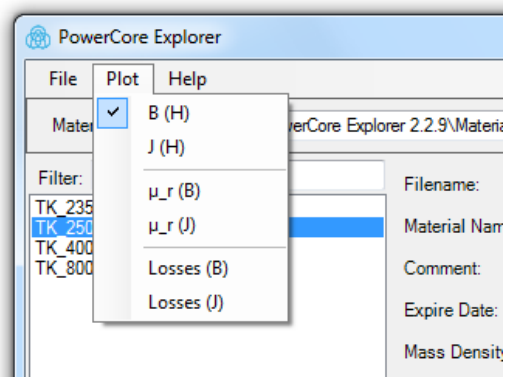
„Loss Data“ contains loss data P = f(B,f):

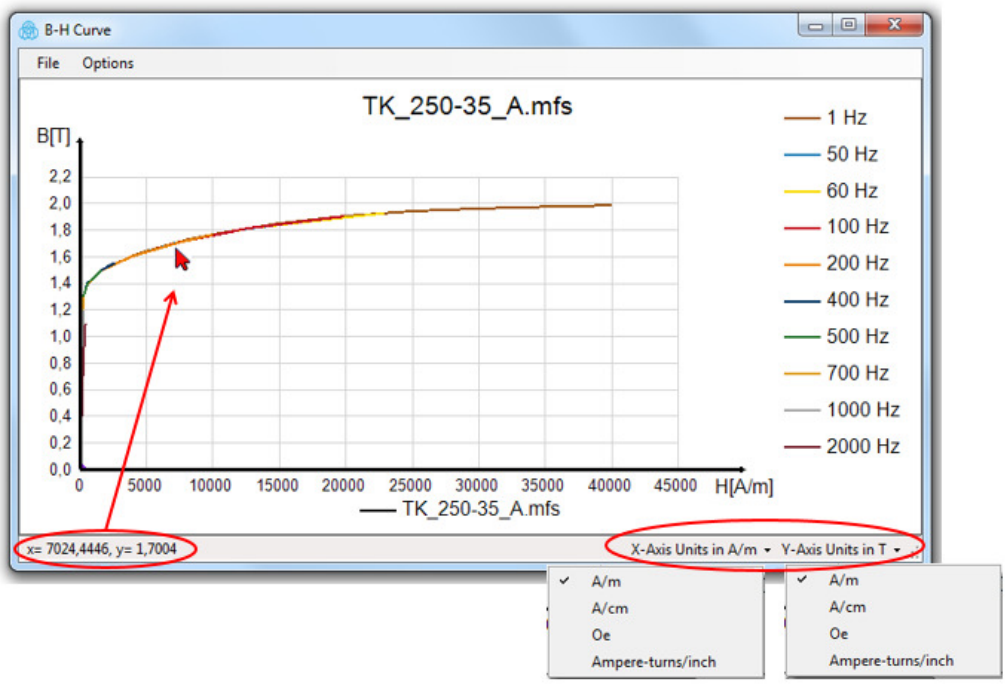
Point	B[T]	J[T]	P[W/kg]	H[A/m]
1	0,29909	0,29905	0,00198	34,981
2	0,39027	0,39022	0,00305	40,024
3	0,48694	0,48688	0,00432	45,309
4	0,58575	0,58569	0,00576	50,539
5	0,69393	0,69386	0,00725	57,98
6	0,78697	0,78689	0,00911	66,442
7	0,88945	0,88935	0,01108	77,275

„Extra“ contains electrical und thermal coefficients:



By selection in the menu *„Plot“* the related table data B(H,f) respectively J(H,f) and loss values are displayed in a graphic window:

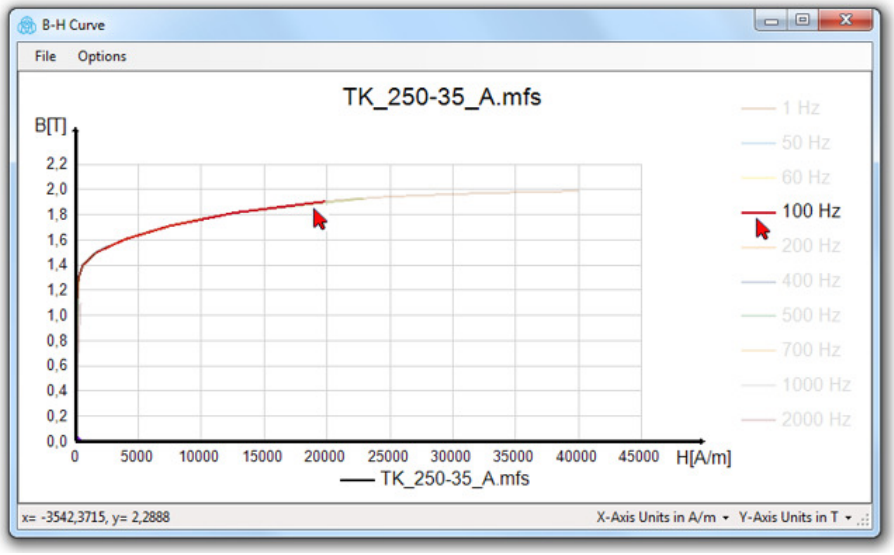




B(H) curve

Physical units of x and y axis can be selected by menus in the right part of the status bar. The left side of the status bar shows the physical values of the xy position of the mouse pointer.

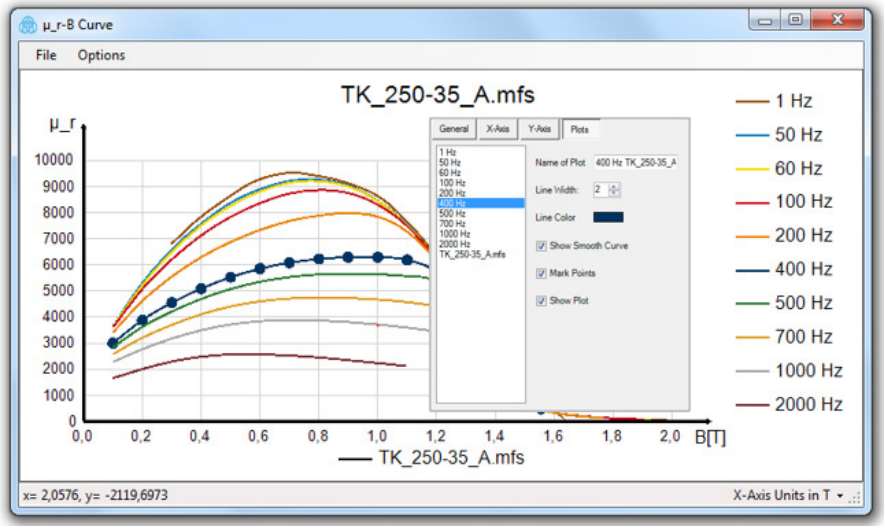
Single graphs can be foregrounded by click with right mouse button on the related graph or legend:



selection of single graphs

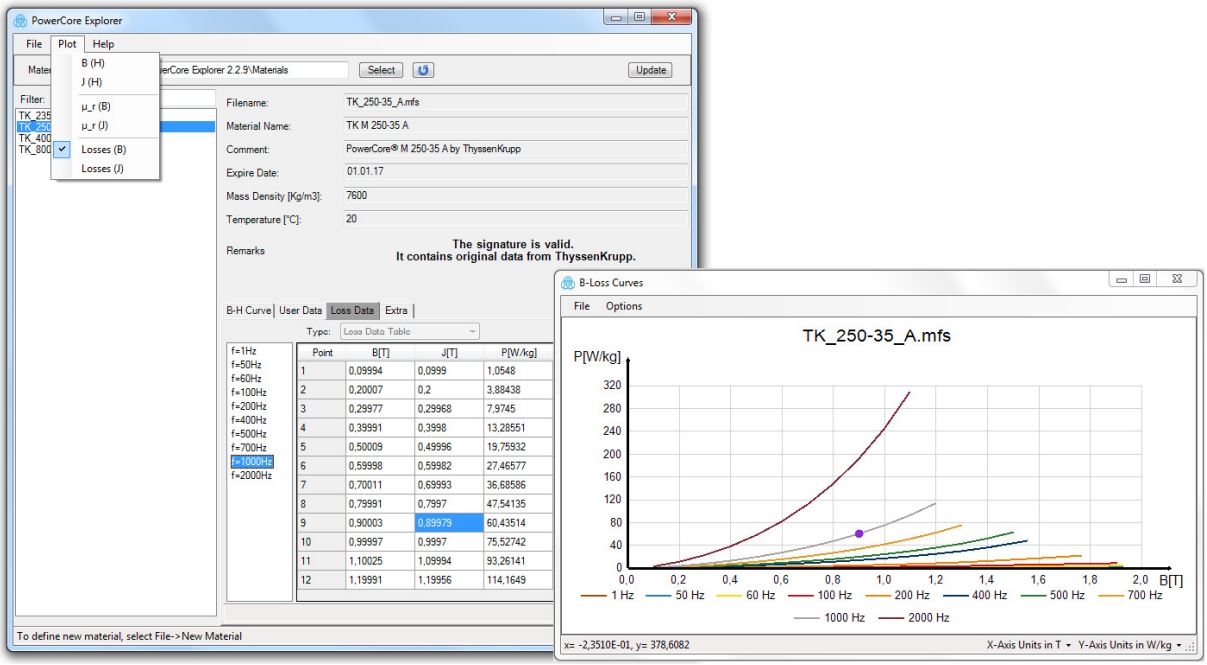
Additionally can the graphics be formatted in a popup window after click with right mouse button into the graphic window, i.e.:

- text
- scalining of axis
- selection and presentation of the graphs
- display of the sampling points



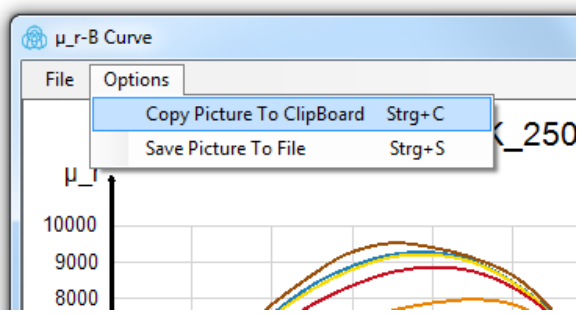
format of graphs

The data of permeability and losses can displayed as function of magnetic flux density B(H,f) or polarization J(H,f)



Specific losses P(B,f): selcted table cells are marked as dots on the related graph

All diagrams can be copied by menu *„Options“* as jpg-pictures to clipboard or saved to file .



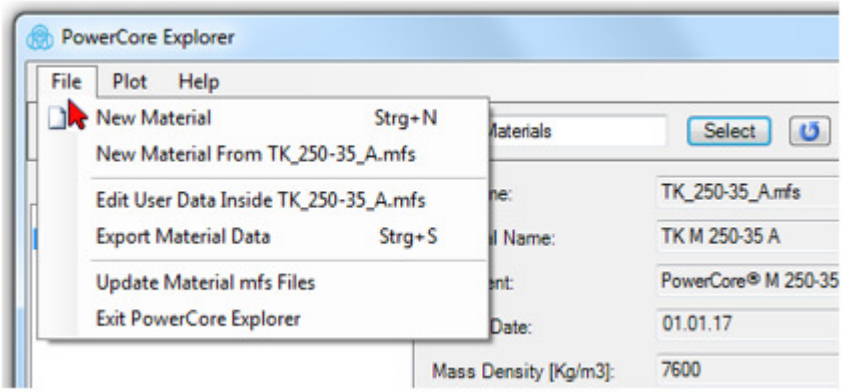
User defined settings of the diagrams are saved in config-files per user:

- working directory
- position and size of the main window
- position and size of the plot windows
- scaling of the plots
- agreement to EULA

3.2 PowerCore® Explorer - Editor

For creation of material data files which can be used in other software systems (i.e. SPEED, MAXWELL, JMAG, etc.) are different functions available. When in menu „File“ one of the

functions „New Material …" or "Edit User Data …" is selected, then will the material editor be opened.



- *„New Material"*

  Empty tables are displayed which can be filled with material data for B(H) curves and specific losses. The new material data can be saved as *.mc (binary) file or *.mca (ASCII) file.

- *"New Material From selected material"*

  The material editor opens with tables in which all public values of the selected material file are filled in. The values can be changed respectively new can be added. The new material data can be saved as *.mc (binary) file or *.mca (ASCII) file.

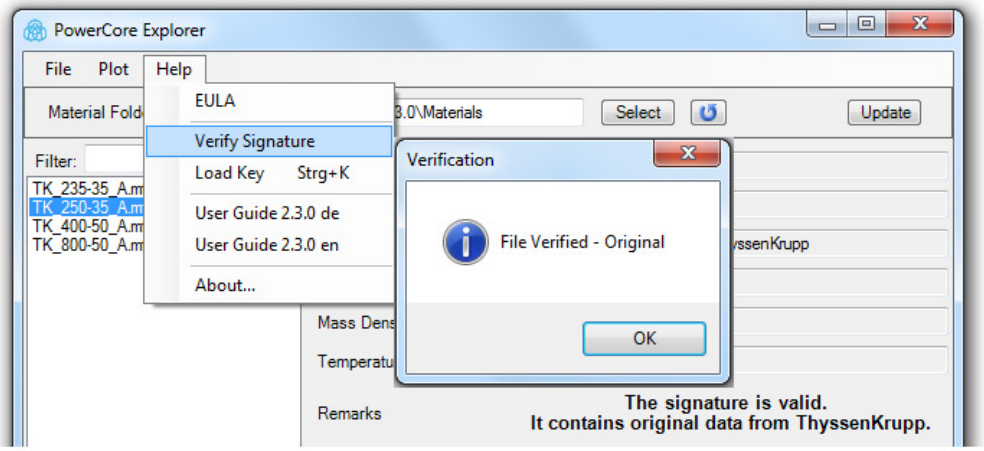
- *"Edit User Data Inside selected material"*

  The material editor opens with tables in which all public values of the selected material file are filled in. Only the values in tab "User Data" can be changed or additional parameter can be defined. The material data can be saved in *.mfs, *.mc or *.mca files.

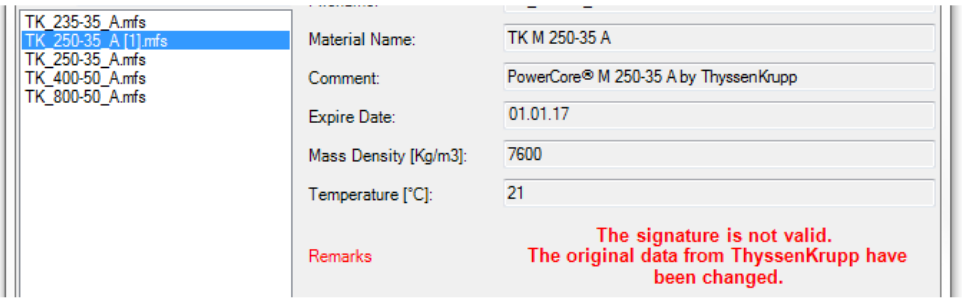
- *"Export Material Data"*

  The data of the selected material can be exported for use by the in §1 mentioned software tools in its related files format.

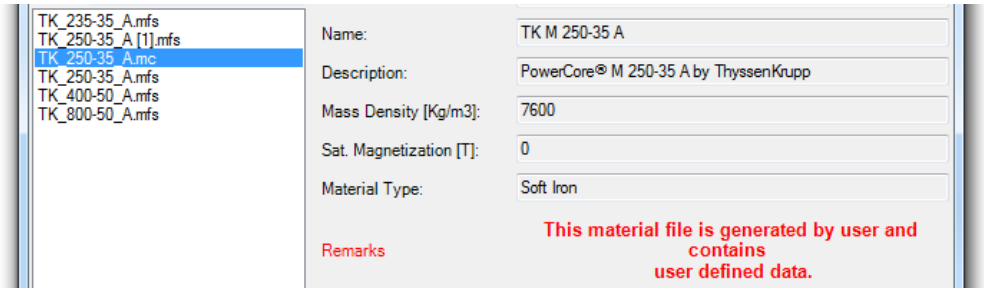
The material files of thyssenkrupp (*.mfs) are encrypted with a private thyssenkrupp key and signed. By the menu „Help - About - Verify Signature“ can user check, whether the selected mfs file is an origin file provided by thyssenkrupp or an unchanged copy. Additionally is the signature of a selected mfs file checked and a related information displayed:



The signature is valid.



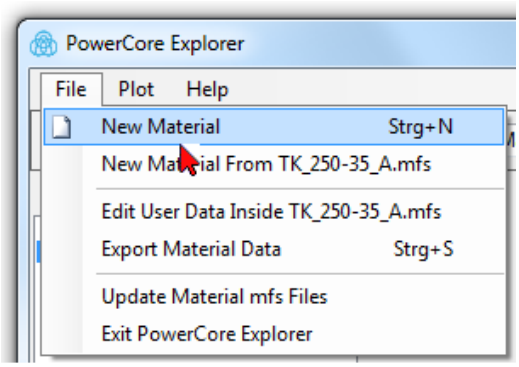
The signature is not valid, data are changed.



This material file was created by a user and contains no signature.

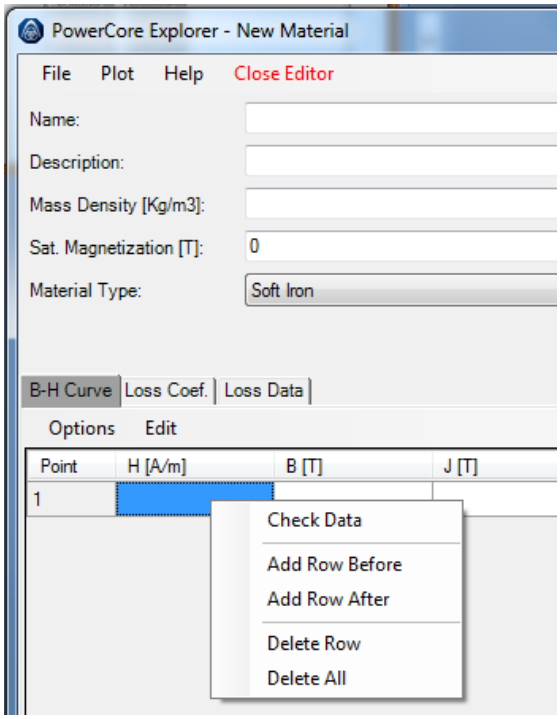
3.2.1 Creation of new material data

User can define and edit his own material data by the menu *„File - New Material“* and save it as *.mc or *.mca files.

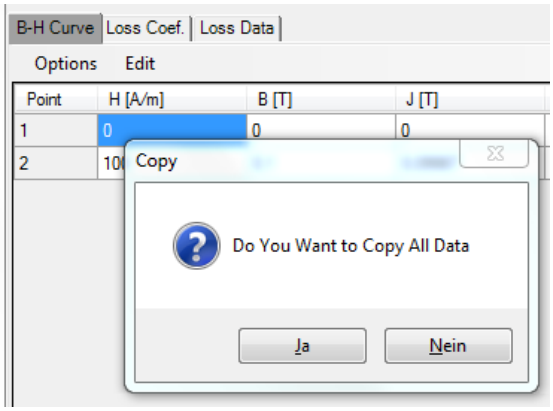


All data can be entered manually or copied from other applications (i.e. Microsoft® Excel) by clipboard into the tables of PowerCore® Explorer.

manual input



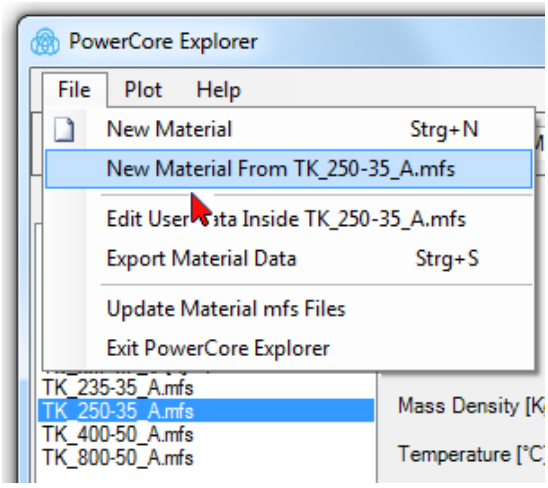
input by Copy/Paste

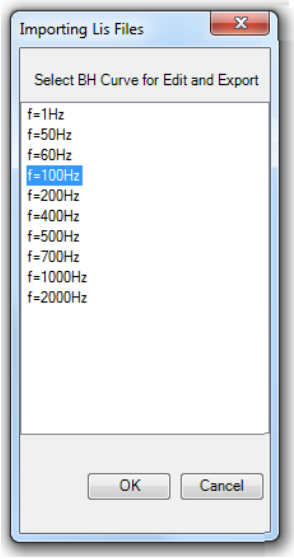


3.2.2 Creation of new material data of existing material files

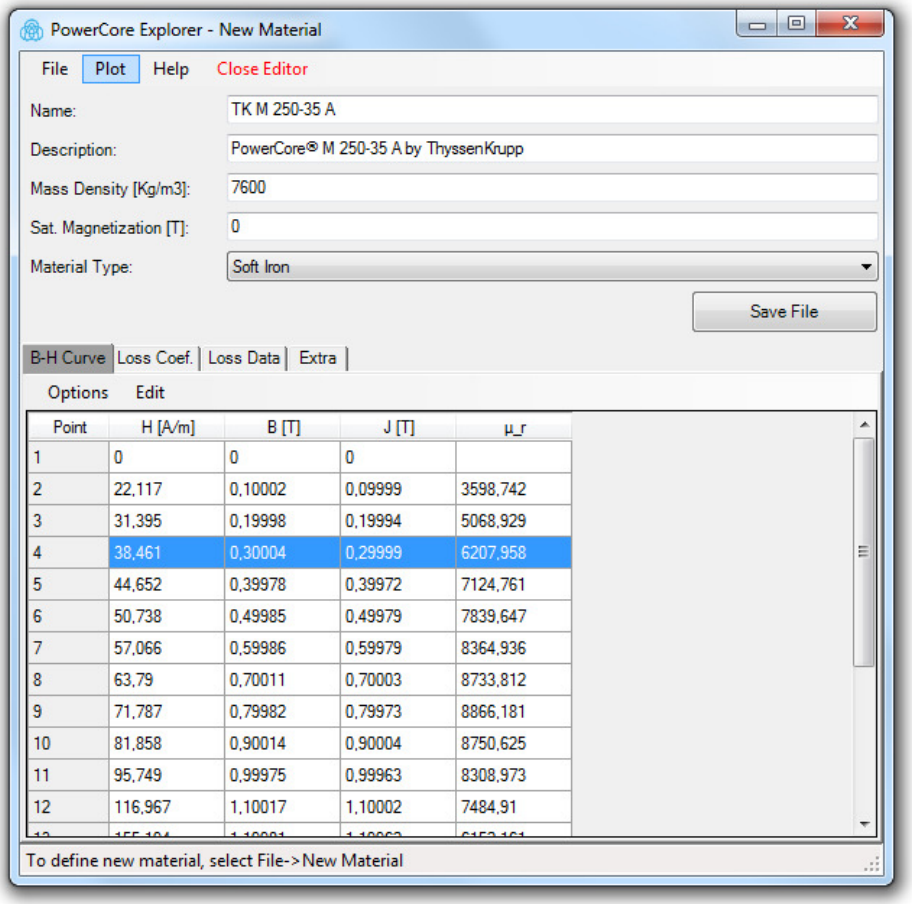
Material data of existing material files *.mfs and *.mc can be copied by the menu *„File - New Material From selected material“* into the tables of the editor. All data can be changed, additional data added and saved as *.mc or *.mca files.

First of all a window for selection of the frequency is opened and afterwards the window of the Material Editor.





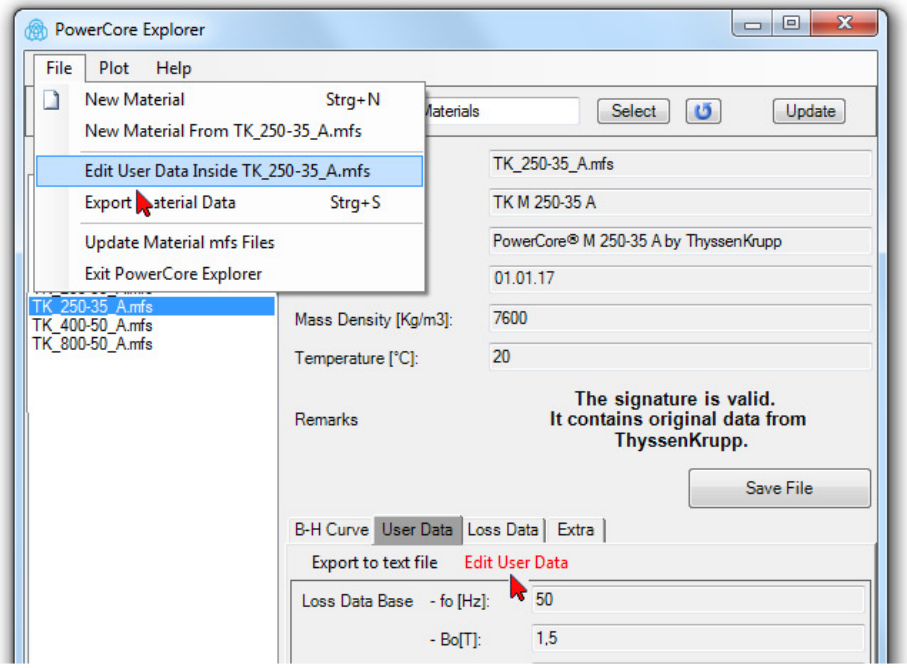
PowerCore Explorer – Editior

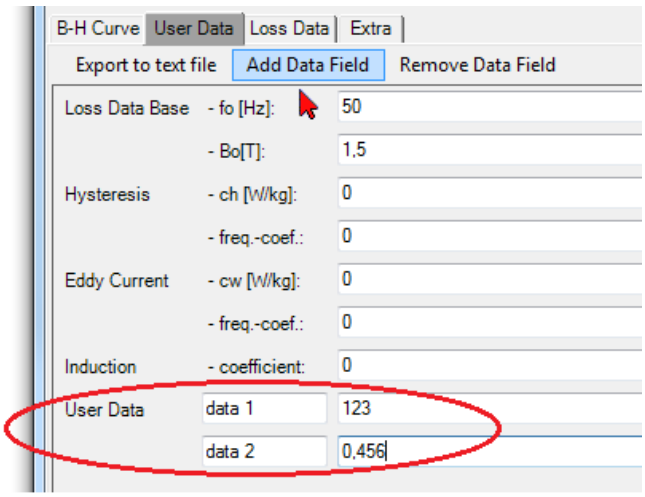


Point	H [A/m]	B [T]	J [T]	μ_r
1	0	0	0	
2	22,117	0,10002	0,09999	3598,742
3	31,395	0,19998	0,19994	5068,929
4	38,461	0,30004	0,29999	6207,958
5	44,652	0,39978	0,39972	7124,761
6	50,738	0,49985	0,49979	7839,647
7	57,066	0,59986	0,59979	8364,936
8	63,79	0,70011	0,70003	8733,812
9	71,787	0,79982	0,79973	8866,181
10	81,858	0,90014	0,90004	8750,625
11	95,749	0,99975	0,99963	8308,973
12	116,967	1,10017	1,10002	7484,91

3.2.3 Modification of user defined material data

By the menu *„File - Edit User Data Inside selected_material.mfs"* can all material data which are displayed in tab "User Data" be changed or new data added.

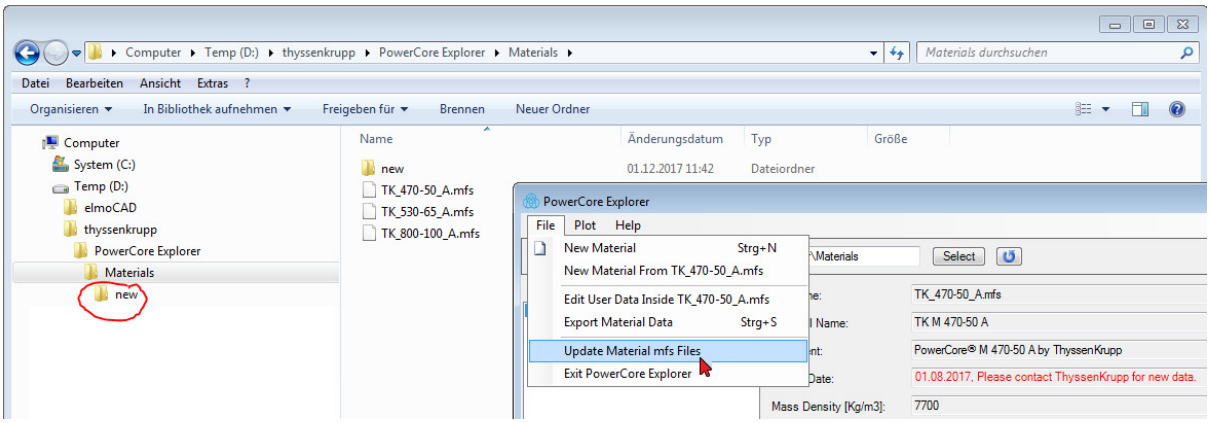




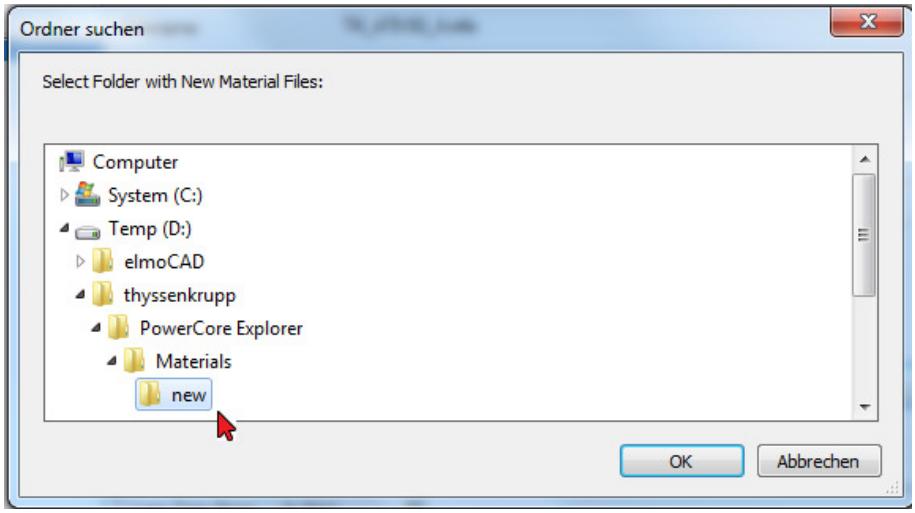
Saving can be as mfs-, mc- or mca-files.

3.2.4 Amending updated material data with user defined material data

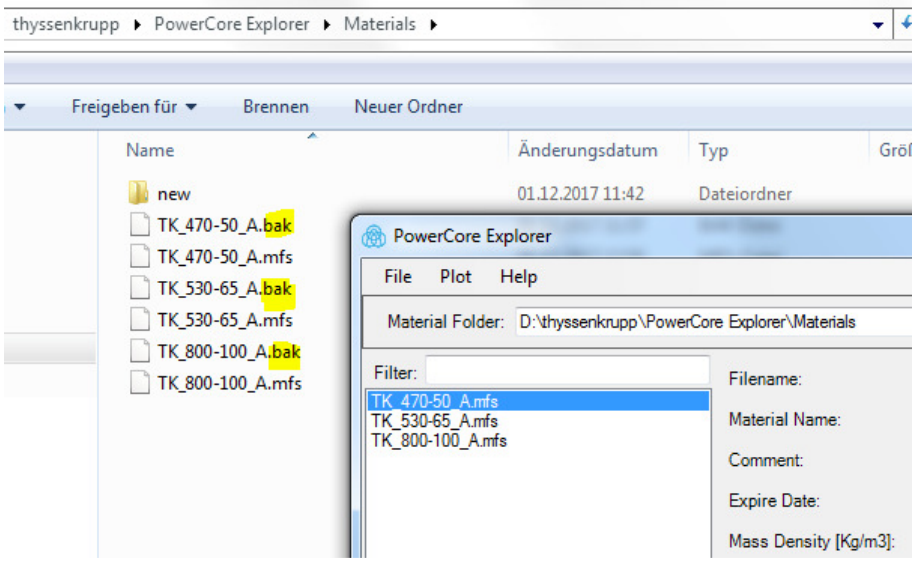
If thyssenkrupp delivers new mfs-files with updated material data then can these amended by user defined material from older mfs-files. To this user has to select in the main menu *„Update Material mfs Files“*.



In a popup windows can then the folder be selected in which the by thyssenkrupp updated material data are saved.

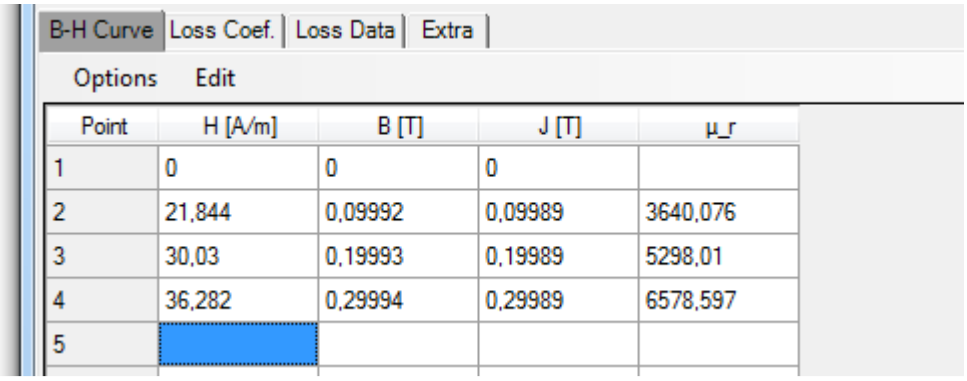


After *"Ok"* are backup copies *.bak of the user defined mfs-files created and origin mfs-files are updated with the by thyssenkrupp updated material data.



3.2.5 Interpolation of field strength values

Values of the induction B as well as values of the field strength H can be entered in table B-H-Curve.



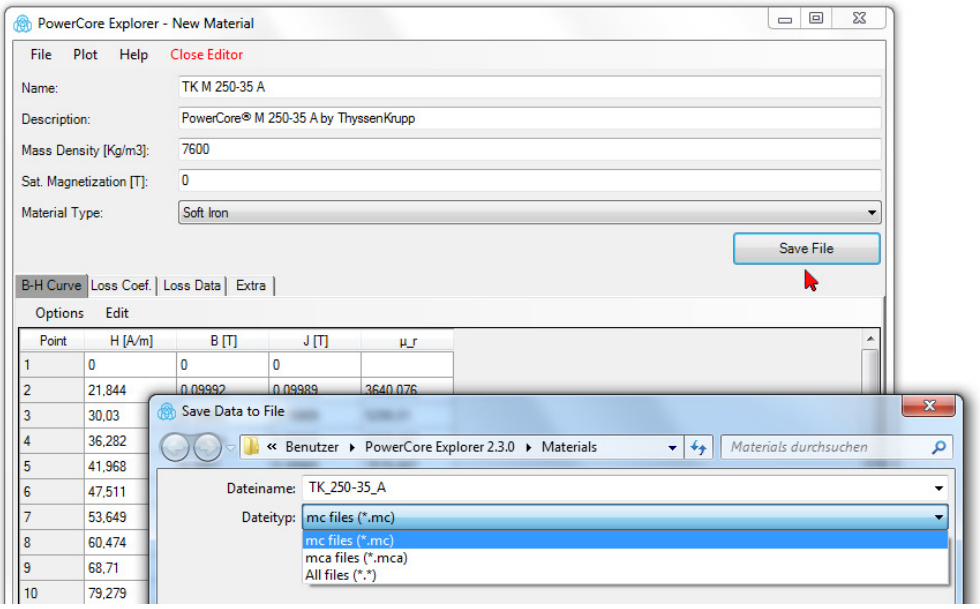
Point	H [A/m]	B [T]	J [T]	μ_r
1	0	0	0	
2	21,844	0,09992	0,09989	3640,076
3	30,03	0,19993	0,19989	5298,01
4	36,282	0,29994	0,29989	6578,597
5				

Based on the conditions shown in following table will the H values be recalculated by interpolation of the already entered data:

	State	Action by user		Reaction of PowerCore® Explorer
a)	cell H is empty	B value is entered	>	H value is recalculated
b)	cell B is empty	H value is entered	>	no action
c)	B value exists	H value is entered	>	no action
d)	H value exists	B value is entered	>	no action
e)	H und B values exists	H value is deleted	>	H value is recalculated

3.2.6 Saving of material data files

New material data can be saved as FEMAG formatted *.mc (binary) or *.mca (ASCII) files which can be used directly by FEMAG and smartFEM for simulation. These files contents are conform to the public data which are saved in mfs-files by thyssenkrupp.



The loss data which are saved in mc/mca files are used by the simulation software smartFEM in loss calculation algorithms which were specially developed for the calculation with material data of thyssenkrupp.

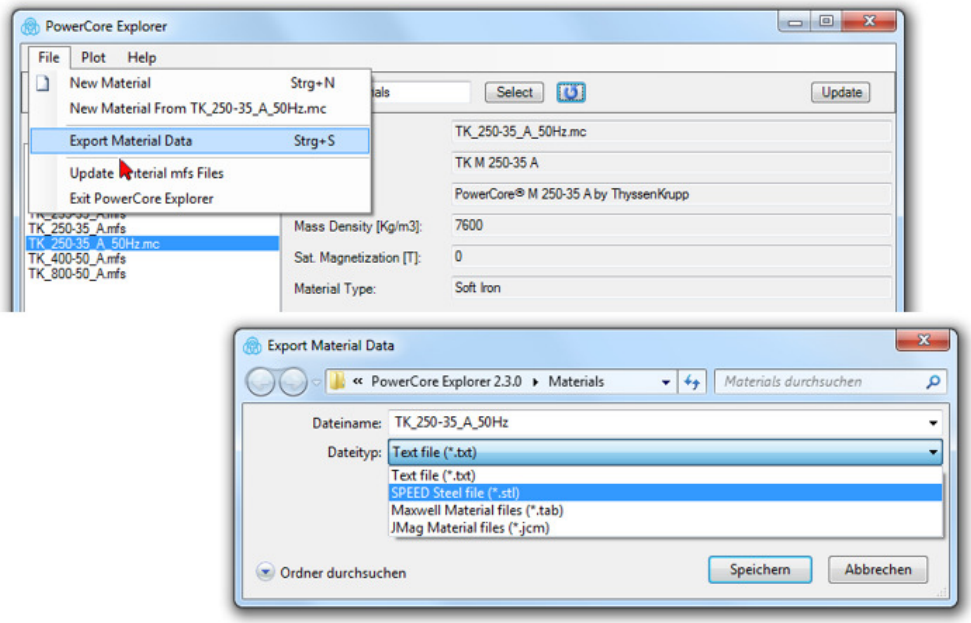
FEMAG uses loss coefficients which can be calculated by FEMAG from the thyssenkrupp loss data. They can be entered manually in tab „Loss Coef.“. With this can these mc/mca files used by smartFEM and by FEMAG for loss calculation.

Menu „Close Editor“ opens PowerCore® Explorer again and the saved material data can then be exported in different formatted files for use in other simulation programs.

3.3 Export of material data

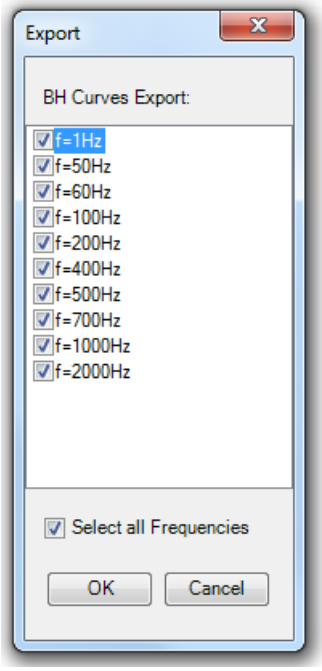
Material data can be exported as:

- tabled text file *.txt for further use in other applications
- formatted files which can be used for import of the data in the FEM software programs JMAG, MAXWELL and SPEED



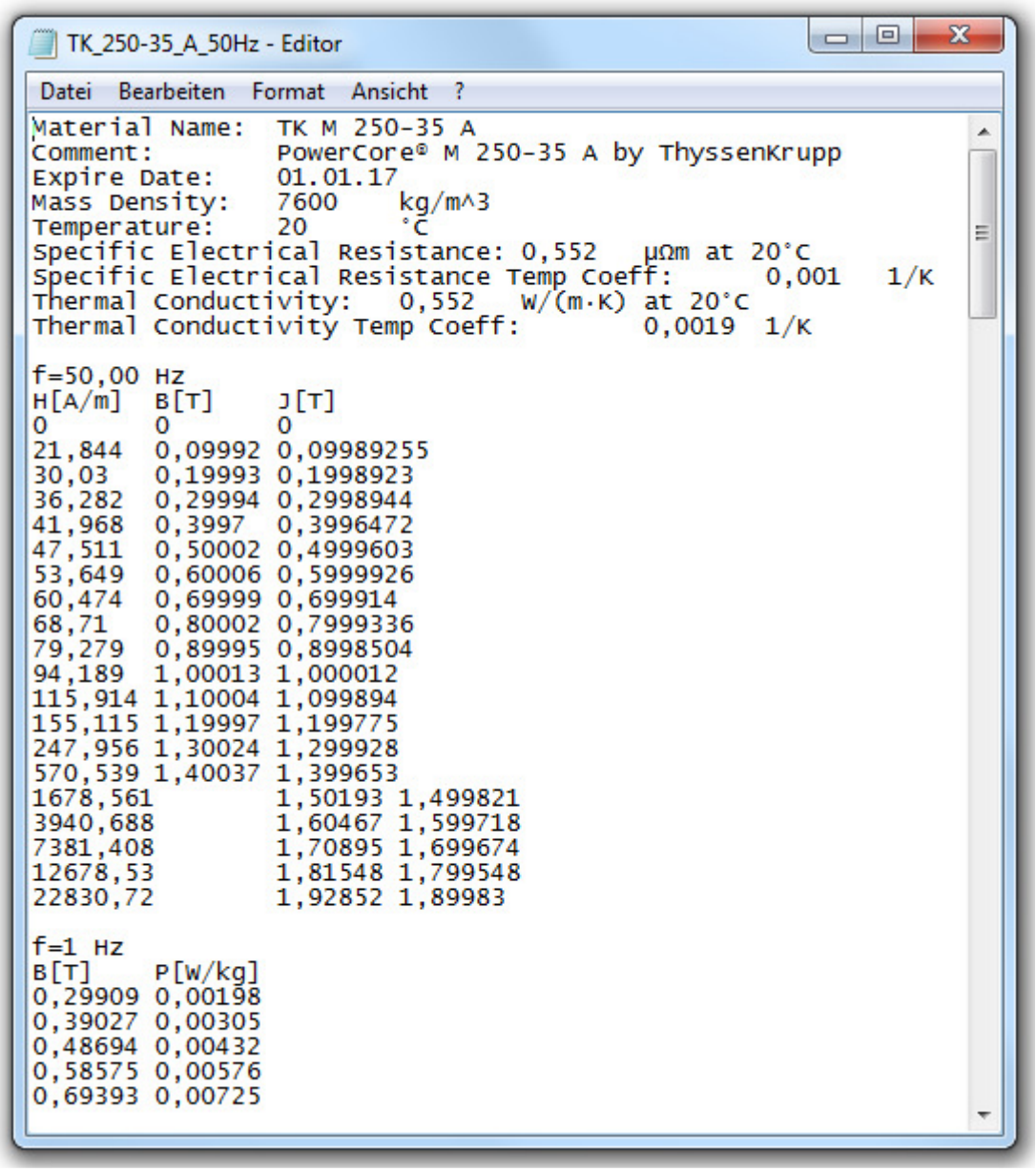
After selection of the file format a window for selection of the related frequencies is displayed:

- FEMAG one file *„MaterialName_Frequenz.mc“* or *„.mca“* per selected frequency will be saved.
- JMAG one file *„MaterialName.jcm“* will be saved which contains all data of all selected frequencies
- MAXWELL one file *„MaterialName_Frequenz_BH.tab“* per selected frequency which contains B(H) data and one file *„MaterialName_Frequenz.tab“* per selected frequency which contains loss data will be saved.
- SPEE: one file *„MaterialName_Frequenz.stl“* per selected frequency which contains B(H) data and one file *„MaterialName.dat“* which contains loss data of all selected frequency will be saved.



3.3.1 Export into tabled text file

The tabled text file (*.txt) contains all public material data of the related mfs or mc/mca file.



TK_250-35_A_50Hz - Editor

Datei Bearbeiten Format Ansicht ?

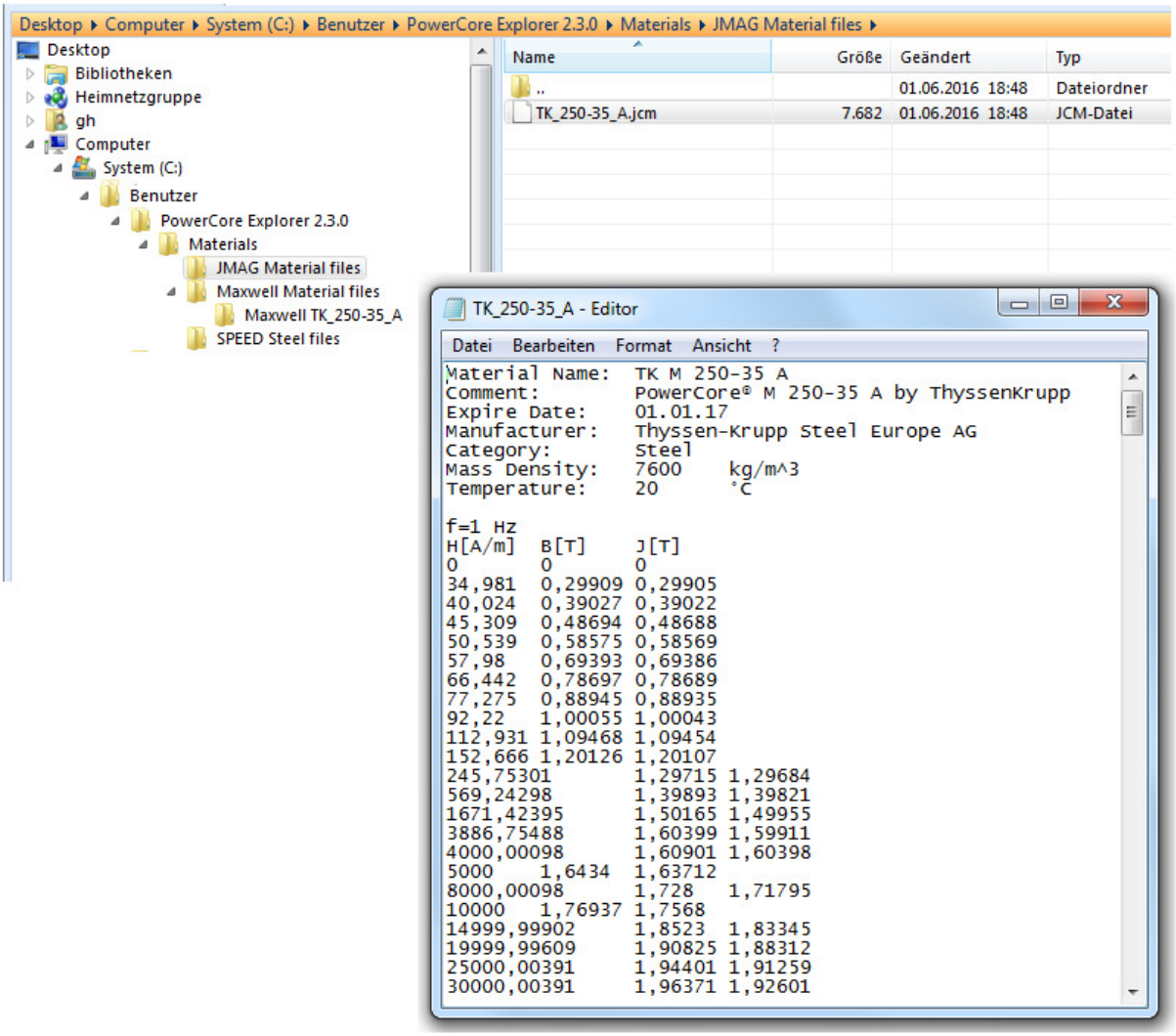
```
Material Name:  TK M 250-35 A
Comment:        PowerCore® M 250-35 A by ThyssenKrupp
Expire Date:    01.01.17
Mass Density:   7600    kg/m^3
Temperature:    20      °C
Specific Electrical Resistance: 0,552   µΩm at 20°C
Specific Electrical Resistance Temp Coeff:      0,001   1/K
Thermal Conductivity:   0,552   W/(m·K) at 20°C
Thermal Conductivity Temp Coeff:        0,0019  1/K

f=50,00 Hz
H[A/m]  B[T]    J[T]
0       0       0
21,844  0,09992 0,09989255
30,03   0,19993 0,1998923
36,282  0,29994 0,2998944
41,968  0,3997  0,3996472
47,511  0,50002 0,4999603
53,649  0,60006 0,5999926
60,474  0,69999 0,699914
68,71   0,80002 0,7999336
79,279  0,89995 0,8998504
94,189  1,00013 1,000012
115,914 1,10004 1,099894
155,115 1,19997 1,199775
247,956 1,30024 1,299928
570,539 1,40037 1,399653
1678,561        1,50193 1,499821
3940,688        1,60467 1,599718
7381,408        1,70895 1,699674
12678,53        1,81548 1,799548
22830,72        1,92852 1,89983

f=1 Hz
B[T]    P[W/kg]
0,29909 0,00198
0,39027 0,00305
0,48694 0,00432
0,58575 0,00576
0,69393 0,00725
```

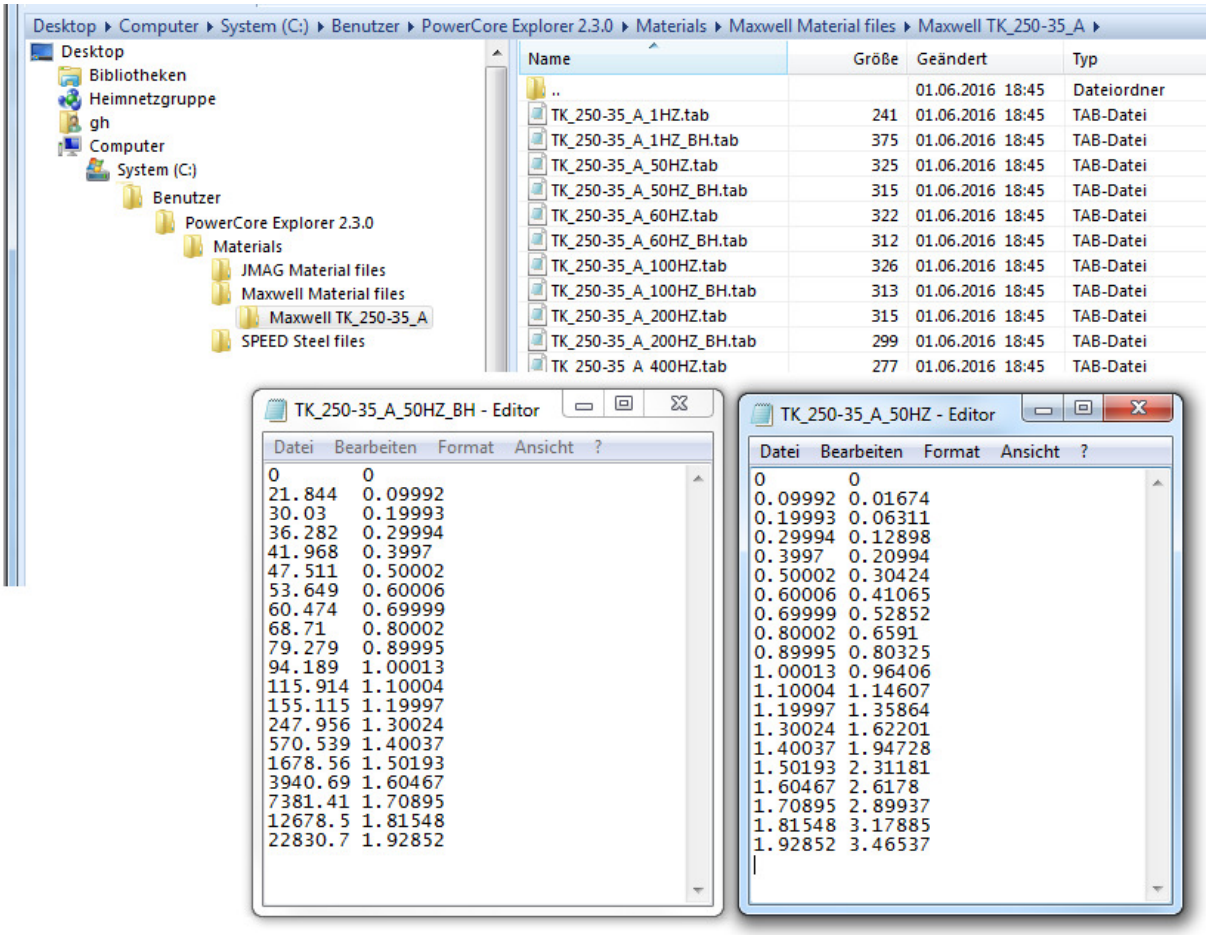
3.3.2 Export into JMAG formatted file

The material data are saved as text in jcm files and contain B(H) and loss data.



3.3.3 Export into MAXWELL formatted file

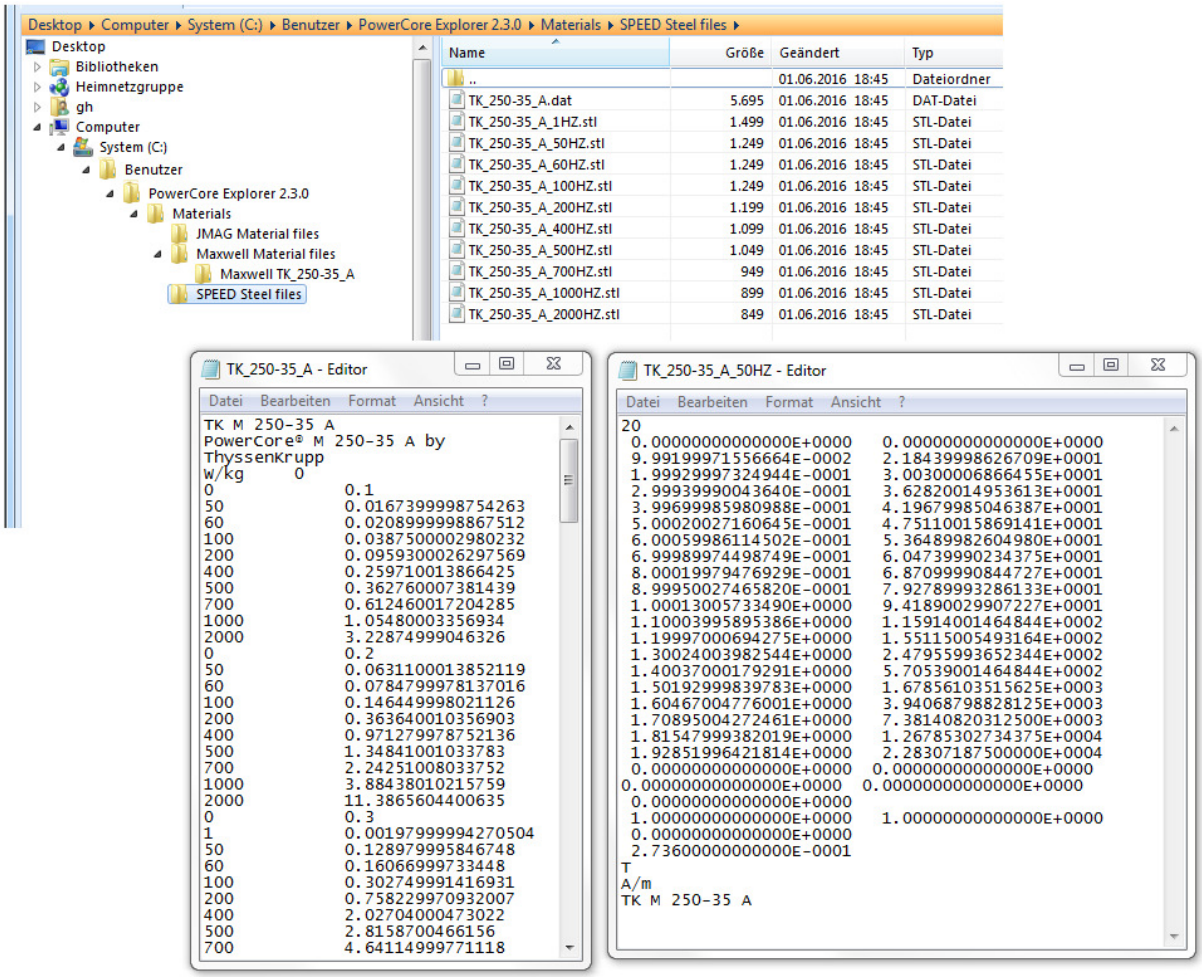
The exported files are saved in a directory named „Maxwell materialname“. The files are named as „materialname_BH.tab“ for the B(H) data and „materialname_nnnHz.tab“ for the loss data per frequency. Only B(H) and loss data are exported.



3.3.4 Export into SPEED formatted file

The exported material data are named „materialname_nnnHz.stl“ for the B(H) curve and “materialname.dat” for the loss data.

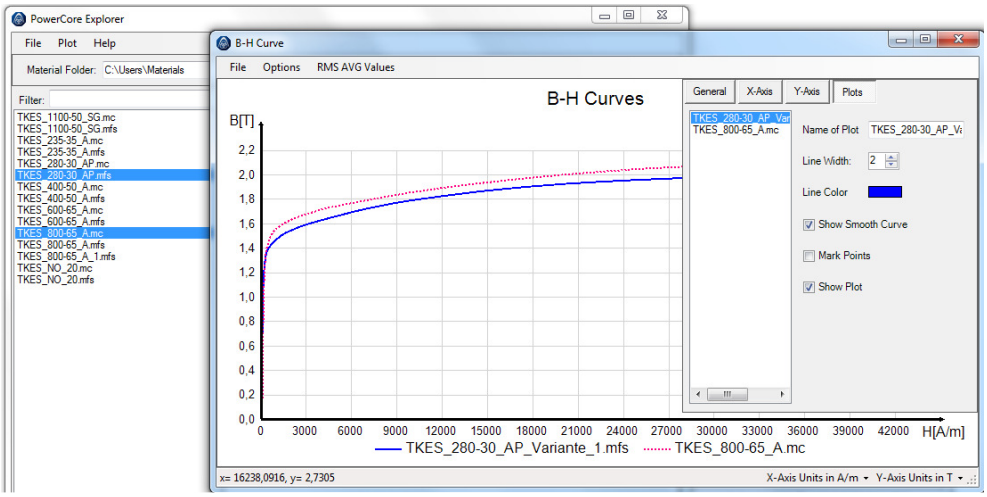
The exported data must be adapted accordingly to the specification in the user guide of SPEED before these files are imported by SPEED.

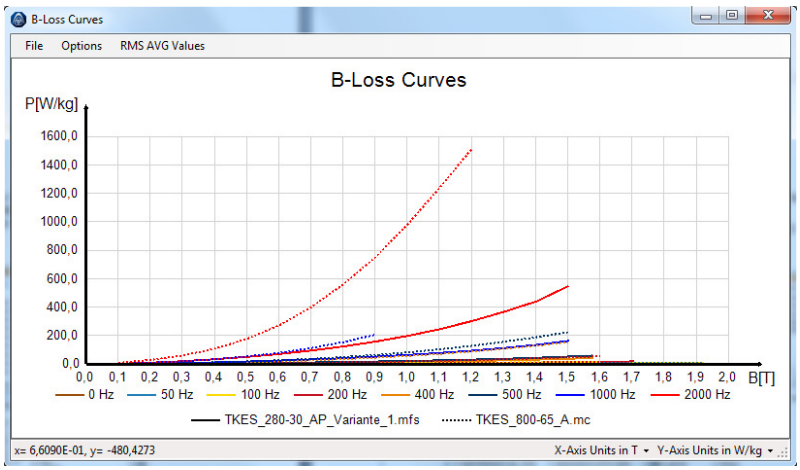


3.4 Comparison of different material data files

PowerCore® Explorer offers convenient possibilities to select different material data files and display the graphs for comparison in the same plots.

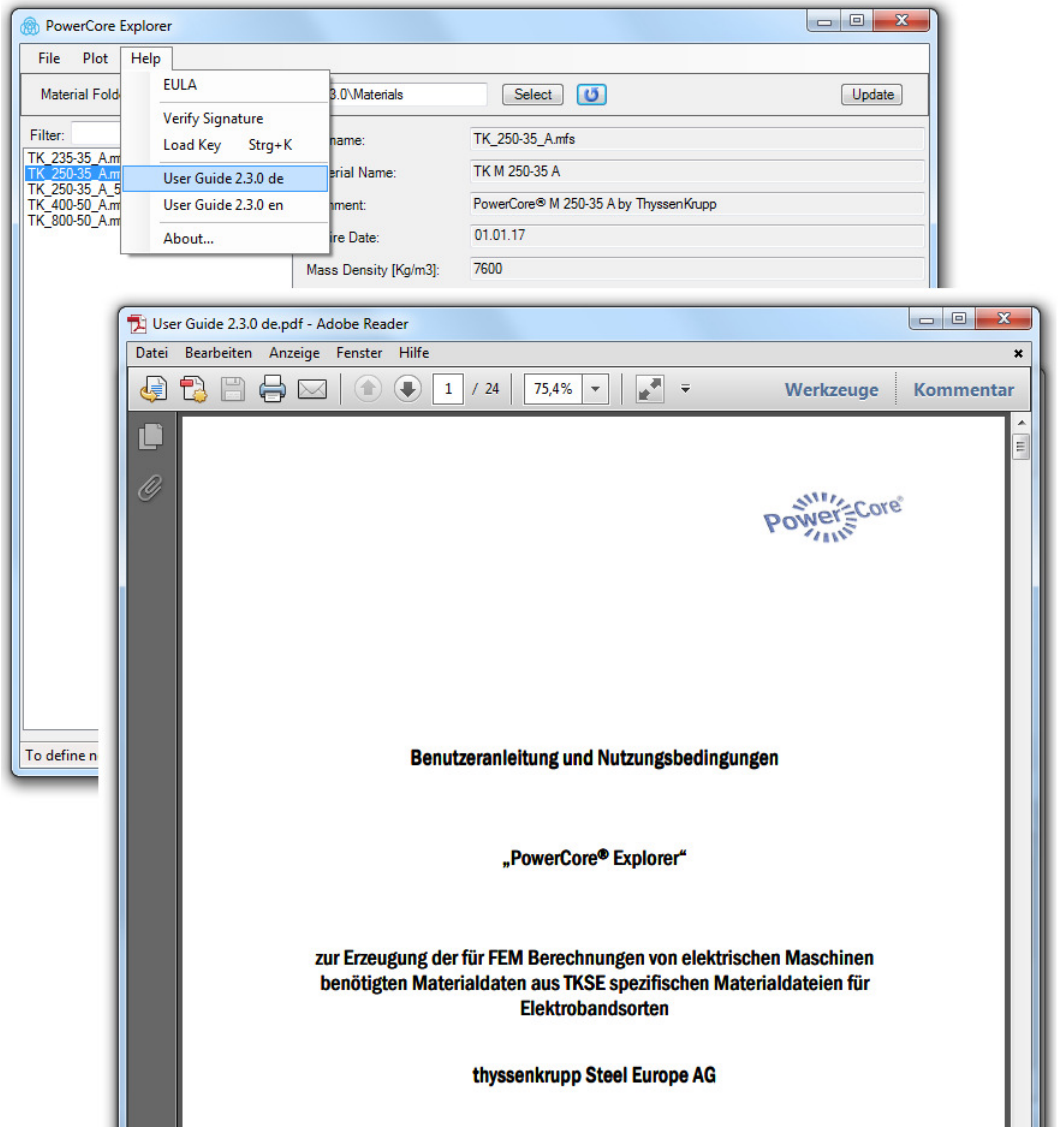
Different materials are displayed with different line patterns and different frequencies are displayed with different colors. Colors and additional parameter can be selected after click with right mouse button into the plot windows and adapted individually for all selected plots at the same time.





4 User Guide

User can open the UserGuide by “Help” menu in case that Adobe Reader® is installed on the computer. All pdf documents will be displayed which are saved in the same directory as „PowerCore Explorer.exe“. User can therefore additionally save own documents and open them by PowerCore® Explorer.



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