winLIFE 4.0 2017

FE INTERFACE

STZ-Verkehrstechnik / Germany

Inhalt

1. Interface for ANSYS

Note: If you use the V4W then you can perform easily the datatransfer between winLIFE 4.0 2017 and ANSYS to watch stress and fatigue results. Instead of the V4W you can use ANSYS macros and the use is described following. Using ANSYS macros is a more flexible solution and it may be in some special cases more convenient.

1.1. Interface winLIFE to ANSYS (V4.0)

This special interface has been developed by AWOTEC GmbH and Steinbeis.

The ANSYS interface is a collection of APDL (ANSYS Parametric Design Language) macros making the export of the FE results and the import of the winLIFE 4.0 2017 results possible. You can also then view these results.

The pre-processing and post-processing can be carried out in the classic ANSYS user surface "Mechanical APDL" and also in the work platform "ANSYS Workbench".

Below are the individual menus for interactive working followed by the enter sizes of the macros used. The macros can be integrated in an automatic program carried out by APDL Script.

1.1.1. Improvements compared to Version V3.2

- Now includes the export of element stresses for shell elements
- Error corrected in export of node stresses for shell elements

1.1.2. Runtime environment for the macros

The interface has been tested under the following conditions:

ANSYS Release V17.0

Supported element types:

Solid: 45, 92, 95, 185, 186, 187, 190

Plane: 42, 182, 183

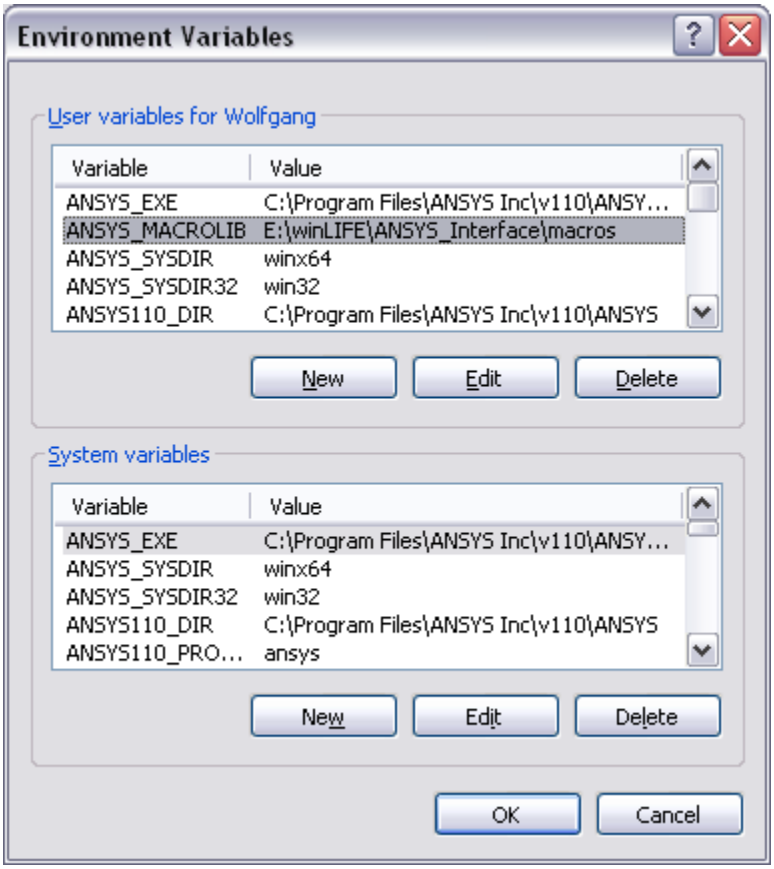
Shell: 41, 43, 63, 93, 181, 281

Supported calculation types:

Uniaxial and multiaxial; welded seams for solids and shells.

1.1.3. Installation

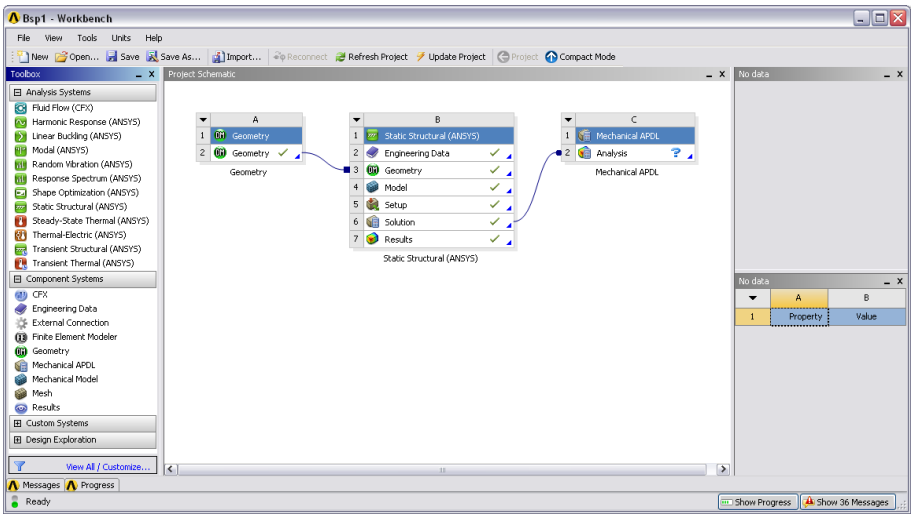
The file for the interface macros "ANSYS to winLIFE" has to be via the system variable ANSYS_macrolib defined in the environment variables of the Windows control system. The macros can be found on the winLIFE 4.0 2017 -CD.



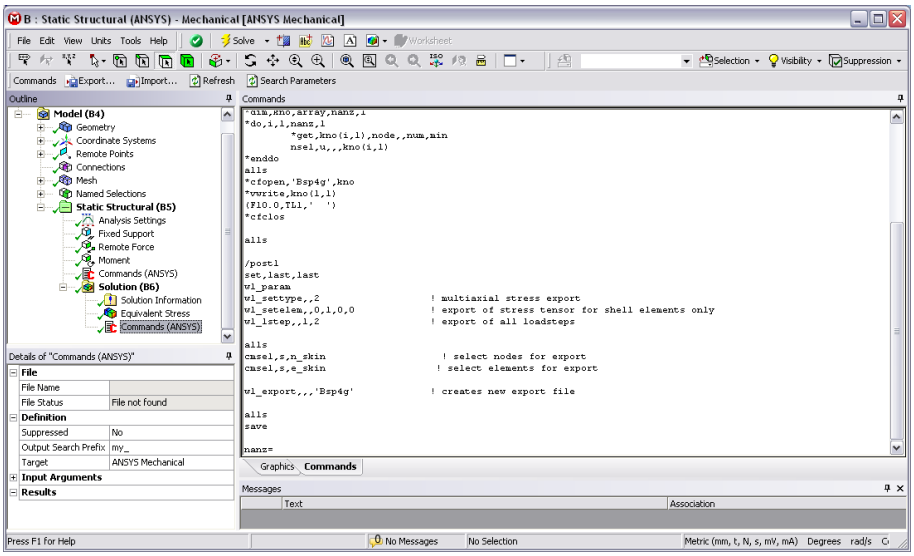
1.1.4. Preprocessing in ANSYS Workbench

1.1.4.1. Project Schematic Workflow

For the interactive use of the interface it is necessary to link an object from the ***Mechanical APDL*** with the solution from the ***Mechanical*** Object (Simulation). It is best if this link is added before the start of the solution!



The data export can also be carried out, however, via the interface macros directly into ***Commands*** Objects in the ***Mechanical*** Structure tree. ***Mechanical APDL*** is then only necessary to show the results.

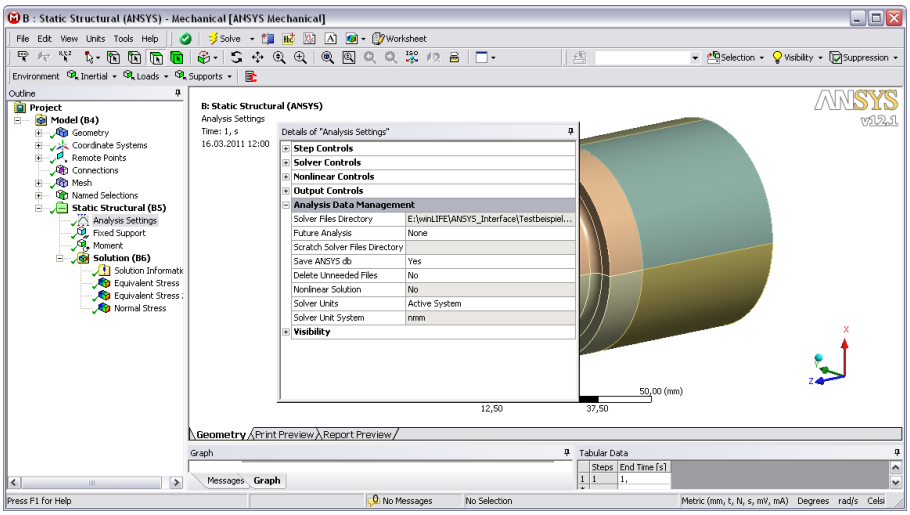


Before starting the equation solver with the command “SOLVE" in the ***Mechanical*** surface, it is necessary to make the following settings in the ANSYS settings in the detail window:

save ANSYS db: YES

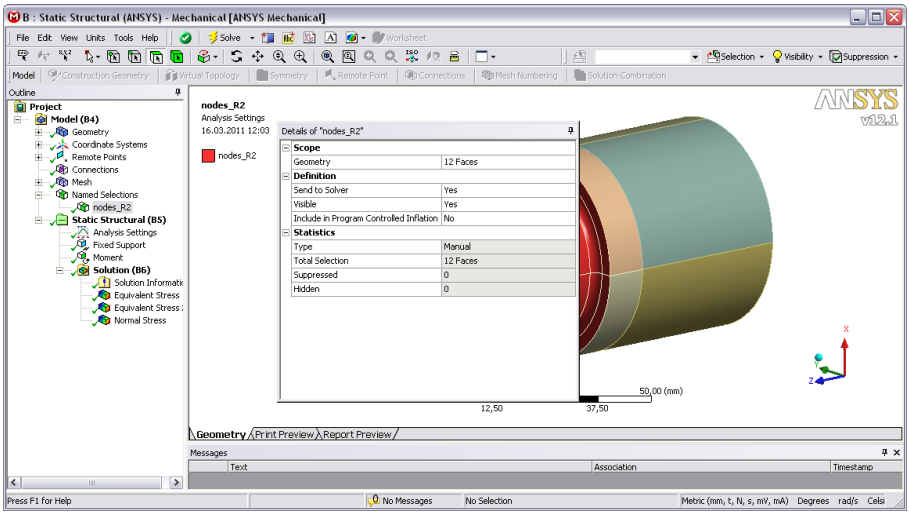
Delete Unneeded Files: NO

If the winLIFE Viewer is used subsequently, the data basis in the *.cdb format has to be saved in a Command Snippet using the command “cdwrite,db,‘



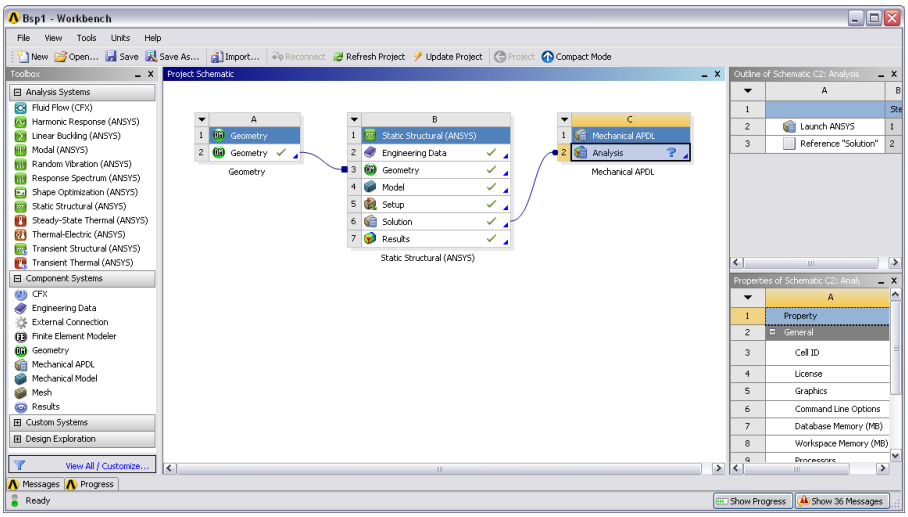
1.1.4.2. Named Selections

All nodes and elements, for which an evaluation is to be carried out, must be defined by Named Selections (Components). When doing this it is important to set the definition "Send to Solver" in the detail window to YES.



1.1.4.3. Starting the Interface

To start the interface, the ***Mechanical APDL*** window must be opened using the RMB-menu with the command "Edit in Mechanical APDL".



Then enter the following commands in the command line.

RESUME

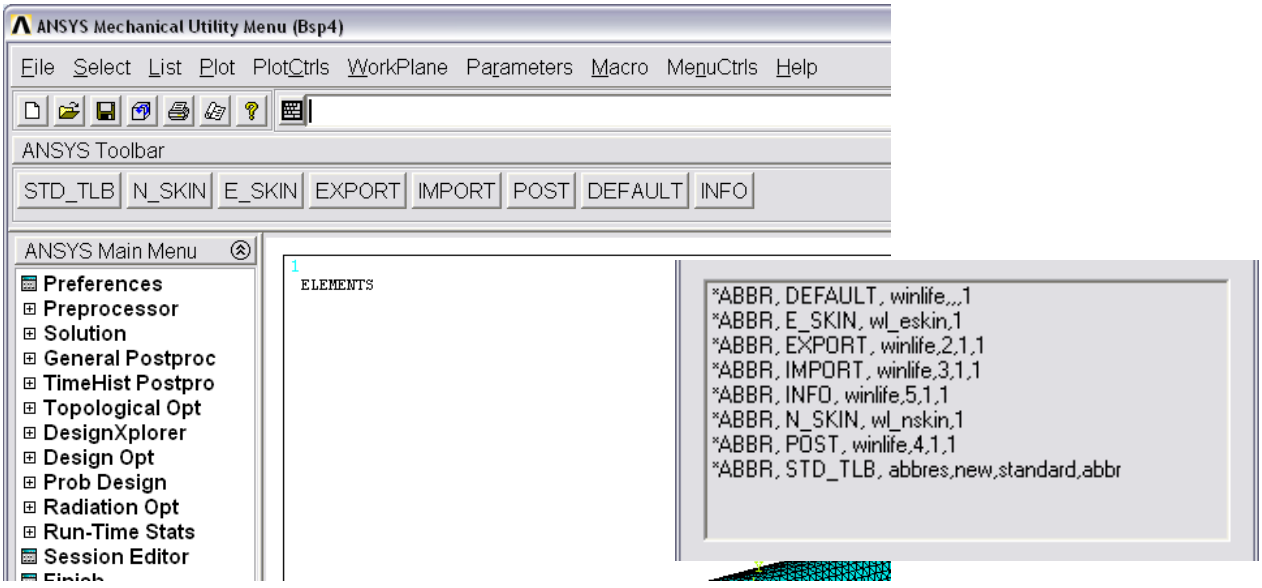
WINLIFE,1

1.1.5. The winLIFE Toolbar

For interactive use there are several command lines in the ***Mechanical APDL***. These can be activated with the command **WINLIFE,1**.

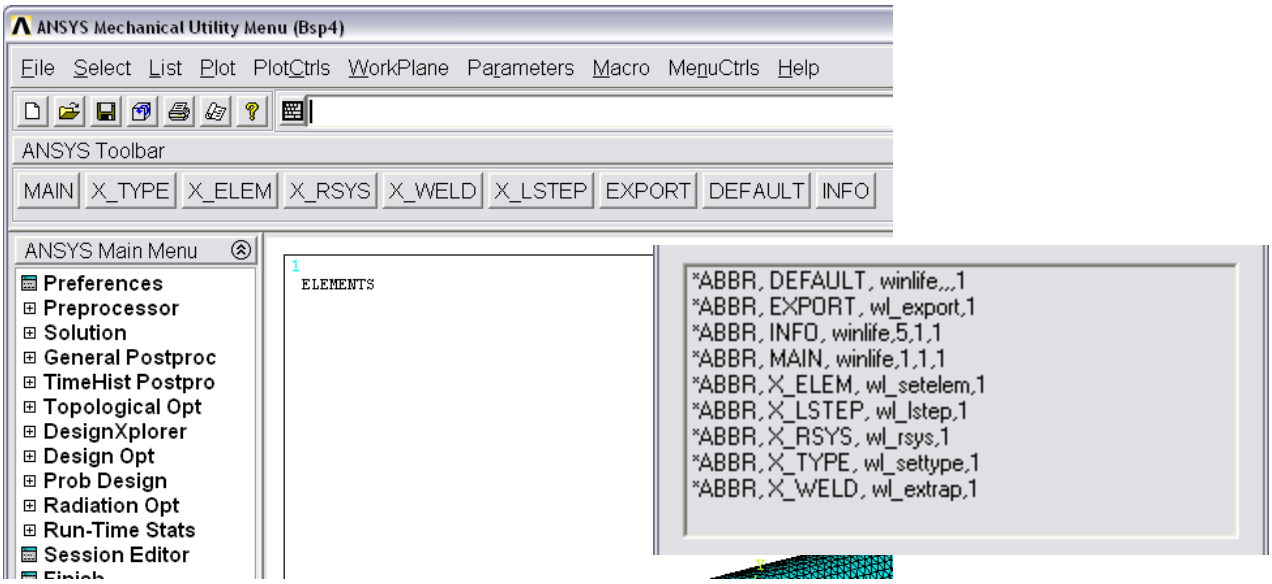
1.1.5.1. winLIFE MAIN Toolbar - winLIFE_main.abbr

Main menu for using the interface:



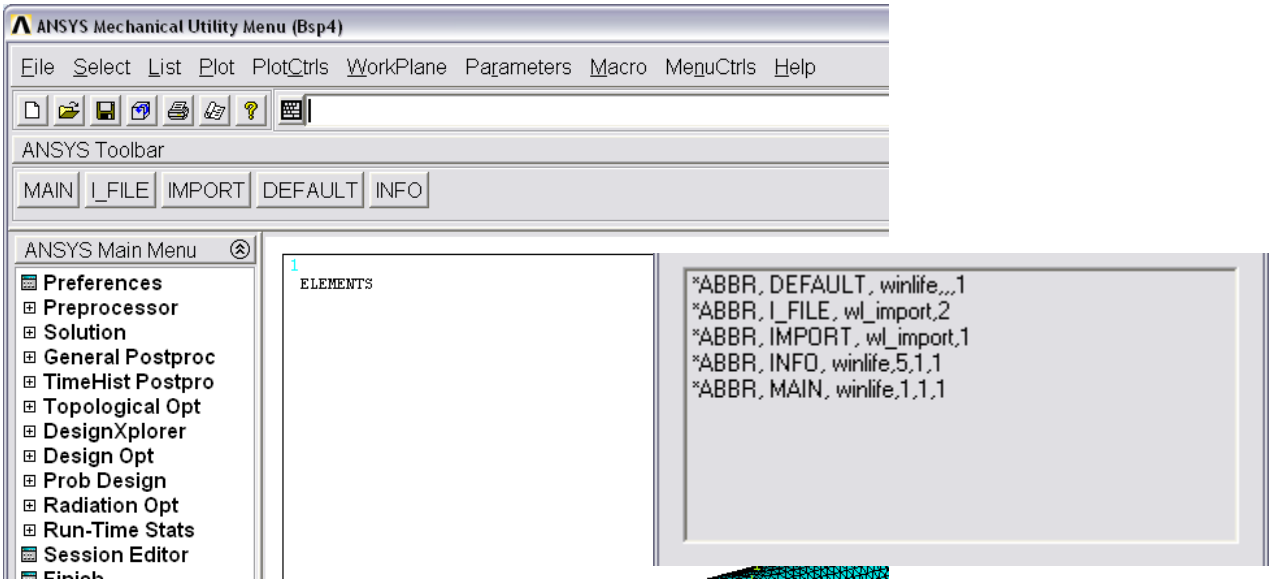
1.1.5.2. winLIFE EXPORT Toolbar - winLIFE_exp.abbr

Definition of the parameters, file names and settings for the export of stresses from the FE-Calculation.



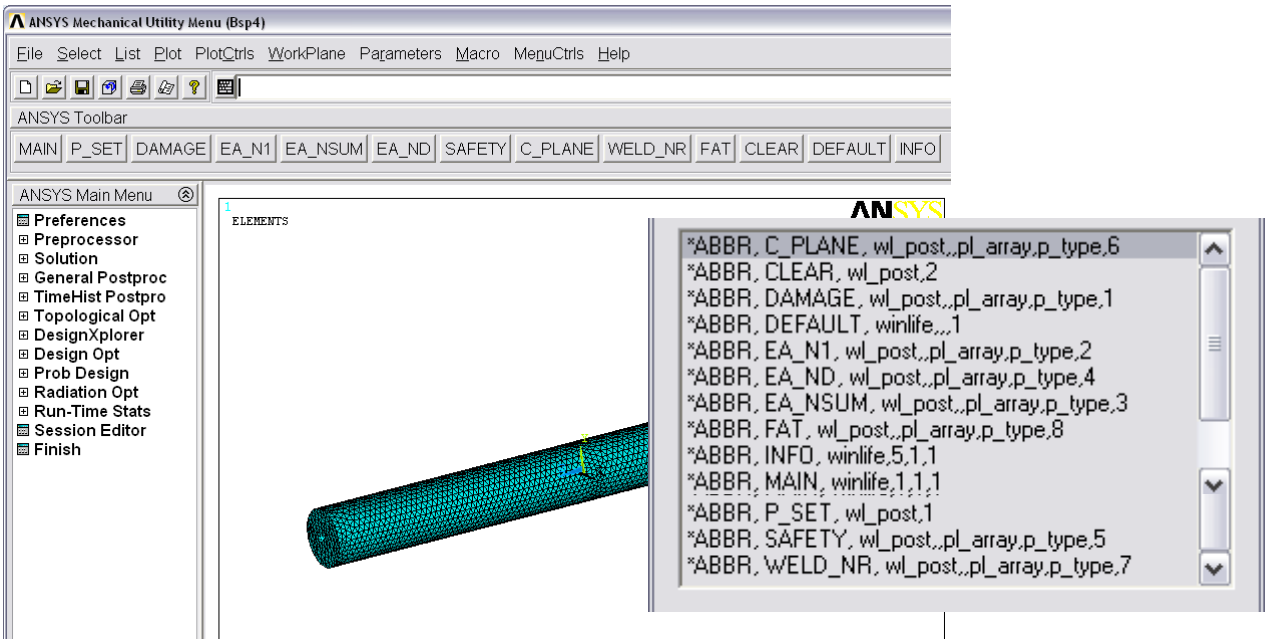
1.1.5.3. winLIFE IMPORT Toolbar - winLIFE_imp.abbr

Definition of the file names and parameters for the import of winLIFE 4.0 2017 result file.



1.1.5.4. winLIFE POST Toolbar - winLIFE_post.abbr

With the commands of the POST-Toolbar the results from winLIFE 4.0 2017 such as damage or safety factor can be shown in ANSYS as contour plots.



1.1.6. winLIFE to ANSYS Interface Macros

1.1.6.1. winlife.mac

WINLIFE,TLB_KEY,PAR_KEY,STD_KEY

Activates winLIFE to ANSYS Toolbar

TLB_KEY …	activates winLIFE menu bars
	1 = Standard Toolbar
	2 = Export Toolbar
	3 = Import Toolbar
	4 = Post Toolbar
	5 = INFO Text
PAR_KEY …	0 = Default Parameter values are set ((wl_param.mac)
	≠0 no action
STD_KEY …	0 = Default Parameter values are set ((wl_param.mac)
	≠0 no action

Note:
For the use of the interface macros using the command line or in a program script, it is not necessary to carry out this command. If, however, the default values of parameters are to be used, it is recommended that these are set at the beginning of the export using the command “wl_param“.

1.1.6.2. wl_nskin.mac

WL_NSKIN,XMODE,CMN_NAME

WL_NSKIN creates a node component 'cmn_name' with the “external” nodes of the selected elements. ("External" nodes are nodes on free element surfaces.)

XMODE …	Selection of the type of interactive mode
	0 = Execution by command line or script
	1 = activates the display of input menus
CMN_NAME …	Name of the node component [Character Parameter]

Note:
When defining the component name with the command, this must be placed between two single inverted commas. (e.g. wl_nskin,,'notch')

For the interactive definition via the dialogue field, however, you must not use these!

1.1.6.3. wl_eskin.mac

WL_ESKIN,XMODE,CMN_NAME,CME_NAME

WL_ESKIN creates shell elements for evaluating the stresses on the surface of solid elements. This technique is also called "skinning". The nodes of the components 'cmn_name' describs the "skin" area. The elements created are grouped in the components 'cme_name'.

XMODE …	Selection of the type of interactive mode
	0 = Execution by an command line or script
	1 = activates the display of input menus
CMN_NAME …	Name of the node component [Character Parameter]
CME_NAME …	Name of the element component [Character Parameter]

Note:
When defining the component name with the command, this must be placed between two single inverted commas. (e.g. wl_eskin,,'notch','skin')

For the interactive definition via the dialogue field, however, you must not use these!

1.1.6.4. wl_settype.mac

WL_SETTYPE,XMODE,WET

WL_SETTYPE defines the export type

XMODE …	Selection of the type of interactive modus
	0 = Execution by a command line or script
	1 = activates the display of input menus
WET …	Export type
	1 = UNIAXIAL

	2 = MULTIAXIAL
	3 = Weld seam extrapolation
	4 = Weld seam Multiplier
	5= non-linear / transient export

Note:
The export type WET=3 is currently only supported for solid elements

1.1.6.5. wl_setelem.mac

WL_SETELEM,XMODE,ESOLID,ESHELL,EBEAM,ELINK,SKINKEY

WL_SETELEM defines the element type for export

XMODE …	Selection of the type of interactive modus
	0 = Execution by an command line or script
	1 = activates the display of input menus
ESOLID …	0/1 = No/Yes - solid elements
ESHELL …	0/1 = No/Yes - shell elements
EBEAM …	0/1 = No/Yes - beam elements (at present not yet supported)
ELINK …	0/1 = No/Yes - bar elements (at present not yet supported)
SKINKEY ...	0/1 = No / Yes – use skinning technique for solids
GRDKEY …	0/1=No/Yes – node information for stress gradient

Note:
To use the skinning technique it is necessary to pre-define the required nodes and elements using the macros wl_nskin.mac and wl_eskin.mac

1.1.6.6. wl_rsys.mac

WL_RSYS,XMODE,CS_EXP

WL_RSYS defines the output coordinate system for the export

XMODE …	Selection of the type of interactive modus
	0 = Execution by an command line or script
	1 = activates the display of input menus
CS_EXP …	Output coordinate system
	-1 = RSYS SOLU (element coordinate system)
	≠-1 = Number of a defined coordinate system

Note:
When exporting unstructured meshed shell elements it is particularly important to check the result coordinate system, because the averaged node results do not automatically take into account the different orientations of the coordinate systems. After automatic meshing but before starting the solver it is strongly recommended to orientate the element coordinate systems correctly!

1.1.6.7. wl_extrap.mac

WL_EXTRAP,XMODE,XTYPE,XF_0,HSTYP,HSTHK,WLFAT,HSTOE,HSPATH,HSPLO

WL_EXTRAP defines the parameter for extrapolation for the export of weldings

Selection of the type of interactive modus

0 = Execution by an command line or script

1 = activates the display of input menus

XTYPE …	Method of extrapolation
	0 = automatic classification according to IIW
	1 = linear extrapolation (2 reference points)
	2 = quadratic extrapolation (3 reference points)
	3 = rough extrapolation for coarse meshes
XF_0 ...	Multiplier for multiplier method
HSTYP ...	1 = „a“ / 2 = „b“ HotSpot
HSTHK ...	thickness of sheet at hot spot
WLFAT...	FAT class (only for documentation)
HSTOE ...	line of the foot point
HSPATH ...	path of extrapolation perpendicular to the weld
HSPLO ...	0/1 = No / Yes – create a path-plot of the extrapolation

Note:
The multipliers according to the IIW recommendations are implemented within the macro. Changes of these multipliers are only possible in the programming code.

1.1.6.8. wl_lstep.mac

WL_LSTEP,XMODE,LSSTART,LSEND

WL_LSTEP defines the area of the load cases to be exported.

XMODE …	Selection of the type of interactive modus
	0 = execution by a command line or script
	1 = activates the display of input menus
LSSTART …	first load case
LSEND ...	last load case

Note:
With the two parameters LSSTART and LSEND all available load cases between these will be exported. If this is not required, the load cases must be exported individually one after the other.

1.1.6.9. wl_export.mac

WL_EXPORT,XMODE,F_APPEND,E_FILNAM,CME_NAME,WLSTART,WLEND

WL_EXPORT writes the stress tensors of the selected nodes taking into account the settings previously selected into the winLIFE 4.0 2017 input files *.lst

XMODE …	Selection of the type of interactive modus
	0 = Execution by a command line or script
	1 = activates the display of input menus
F_APPEND …	Activates writing of data into existing files
	0 = any existing data is overwritten
	1 = any existing data is amended
E_FILNAM ...	File name of the export file [Character Parameter]
CME_NAME ...	Name of the skin – element component [Character Parameter]
WLSTART ...	Number of the first weld or hot-spot for export
WLEND ...	Number of the last weld or hot spot for the export

Note:
When defining the file name with the command, this must be placed between two single inverted commas. (e.g. wl_ import,,,'example').

For the interactive definition via the dialogue window, however, you must not use these!

WARNING! The length of the file name should be limited to 8 characters!

All existing welds in between WLSTART und WLEND are exported. If this is not wished, the welds must be exported one after the other with separate commands.

The macros eu_solid.mac, eu_shell.mac, em_solid.mac, em_shell.mac, ewm_solid.mac, ewm_shell.mac, ewx_solid.mac, enl_solid.mac, enl_shell.mac, ewmu_shell.mac und eme_shell.mac are sub-routines for the export and can only be used in this context.

1.1.6.10. wl_import.mac

WL_IMPORT,XMODE,I_FILNAM,I_ARRAY

WL_IMPORT reads the winLIFE 4.0 2017 result values out of the file *.exp into a user defined ARRAY-parameter.

XMODE …	Selection of the type of interactive modus
	0 = Execution by a command line or script
	1 = interactive import start
	2 = activates the display of the input menu
I_FILNAM …	File name of the import file [Character Parameter]
I_ARRAY ...	Name of the result - ARRAYS [Character Parameter]

Note:
When defining the file name with the command, this must be placed between two single inverted commas. (e.g. wl_ import,,,'example')

For the interactive definition via the dialogue window, however, you must not use these!

WARNING! The length of the file name should be limited to 8 characters!

1.1.6.11. wl_post.mac

WL_POST,XMODE,PL_ARRAY,P_TYPE,R_TYPE

WL_POST reads the winLIFE 4.0 2017 result values out of a defined ARRAY-Parameter and creates a plot or a list of the user requested results.

XMODE …	Selection of the type of interactive modus
	0 = Execution by an command line or script
	1 = activates the display of input menus
	2 = Reset the display to ANSYS results
PL_ARRAY ...	Name of the result - ARRAYS [Character Parameter]
P_TYPE ...	Type of result presentation
	0 = Data only read in
	1 = Contour plots are created
	2 = Results are listed in output window
R_TYPE ...	Result value
	1 = Damage [D]
	2 = Equivalent Amplitude for one cycle [EA_1]
	3 = Equiv. Amplitude for the sum cycle number [EA_nsum]
	4 = Equiv. Amplitude for the endurance limit [EA_ND]
	5 = Utilisation rate
	6 = critical plane
	7 = Weld number
	8 = FAT class

Note:
The presentation of the contour plot occurs in the graphic mode /Graphics,Full The mode /Graphics,Power cannot used for the presentation of the results!

1.1.6.12. wl_param.mac

This file contains the default values for the parameters "Standard" file-names of winLIFE 4.0 2017 to ANSYS interface macros. These values can be changed and adapted by the user. The parameters and the standard values delivered are shown below:

Parameter	**Default**
e_filnam	active jobname
i_filnam	active jobname
wet	1
esolid	1

eshell	1
ebeam	0
elink	0
Skinkey	0
cs_exp	0
hstype	1
xsthk	1
xtype	1
xf_0	1.00
wlfat	100
hsplo	0
hstoe	1
hspath	1
wlstart	1
wlend	1
lsstart	1
lsend	1
f_append	0
cmn_name	n_skin
cme_name	e_skin
i_array	wl_res
pl_array	%i_array%
p_type	1
r_type	1

Note:

1.1.7. File Summary (V4.0)

Term	File	Version
Menu bars	winLIFE_main.abbr	1.0
	winLIFE_exp.abbr	1.0
	winLIFE_imp.abbr	1.0
	winLIFE_post.abbr	2.0
0) General	winLIFE.mac	4.0
1) Pre-processing	wl_nskin.mac	2.0
	wl_eskin.mac	2.0
2) Export of results	wl_settype.mac	4.0
	wl_setelem.mac	4.0
	wl_rsys.mac	2.0
	wl_extrap.mac	2.2
	wl_lstep.mac	2.0
	wl_export.mac	4.0
	eu_solid.mac	3.1
	eu_shell.mac	3.1
	em_solid.mac	3.1
	em_shell.mac	4.0
	ewm_solid.mac	3.1
	ewm_shell.mac	4.0
	ewx_solid.mac	3.1
	enl_solid.mac	3.1
	enl_shell.mac	3.1
	ewmu_shell.mac	3.2
	eme_shell.mac	4.0
3) Import of results	wl_import.mac	2.1
4) Presentation of results in the Post-processor	wl_post.mac	2.0
5) Parameter	wl_param.mac	2.3

2. FEMAP Installation notes and Interface

All existing modules of winLIFE 4.0 2017 :

- winLIFE FKM QUICKCHECK
- winLIFE 4.0 2017
- winLIFE GEARWHEEL&BEARING
- winLIFE MULTIAXIAL
- winLIFE MULTIAXIAL MULTICORE
- VIEWER4WINLIFE
- winLIFE CRACKGROWTH
- winLIFE RANDOM FATIQUE

are all on the installation-CD and are installed during the installation process. They are inaccessible, however, until you buy a license and register with winLIFE 4.0 2017 .

winLIFE 4.0 2017 can be used with
- NX NASTRAN
- NEi NASTRAN

The two programs use FEMAP as a pre and postprocessor. This leads to a totally identical data structure. Other programs which use FEMAP can be connected to winLIFE 4.0 2017 without problems.

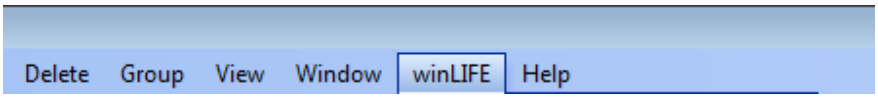
The installation process of winLIFE 4.0 2017 itself has been described before. In this chapter the interface to FEMAP is described.

2.1. Standard Interface (recommended)

Execute the file

winLIFE_interface_to_FEMAP.exe

which is on the winLIFE 4.0 2017 CD while FEMAP is open. This performs that the winLIFE 4.0 2017 menu will be included in the FEMAP menu. After executing this file an additional menu point “winLIFE” appears in the FEMAP menu.



In the case that the winLIFE 4.0 2017 menu is not automatically integrated in FEMAP the user has to customize the menu manually. In the document *Installation_Interface_Femap_winLIFE.pdf* describes how to do this.

2.2. High-Speed interface (only in special cases)

The standard interface is user friendly but slow. If more than 10 000 nodes shall be transferred from FEMAP to the winLIFE 4.0 2017 export file the time for data transfer may be no more acceptable. For this case an alternative solution is available using FEMAP macro language.

The macro must be installed by copying the file LIFE_FMT.esp and the *.PRG files into the FEMAP installation directory (e.g. C:\FEMAPv102).

The use is recommended for users who are familiar with FEMAP and the FEMAP macros.

2.3. Using FEMAP

After successful installation the menu option winLIFE 4.0 2017 is shown in the top line.

If you click on it, the options for the data export/import are shown like

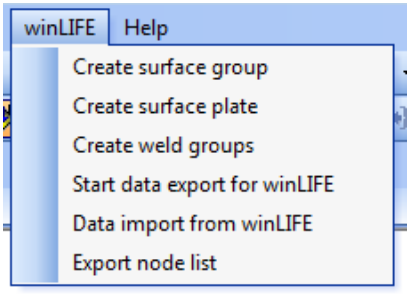


Figure 2-1: winLIFE-Button and sub-menus in the user-interface of FEMAP (is created while the installation process of winLIFE)

2.3.1. Create Surface Group

In most cases, a fatigue calculation only has to be carried out for surface nodes. To do this you select

Create Surface group

and the following mask will appear:

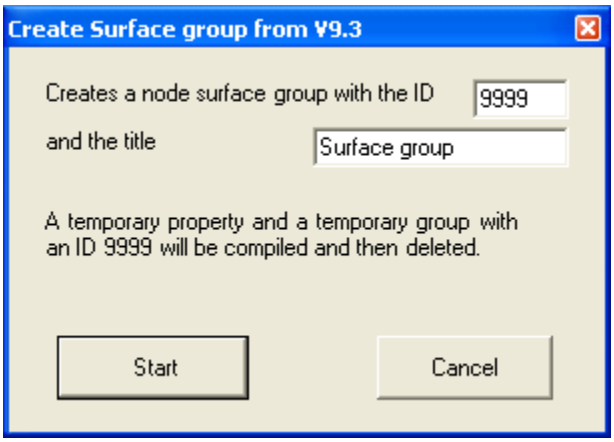


Figure 2-2: Creating a group of nodes located on the surface

Click on ***start*** and this mask will appear:

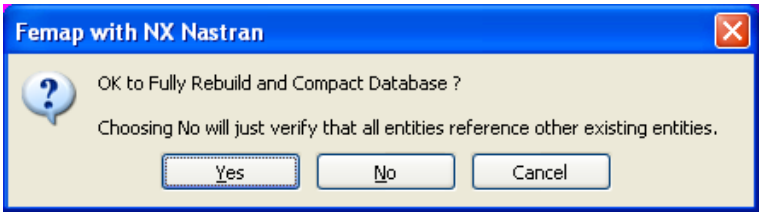


Figure 2-3: Inquiry if a new database shall be created

Click on ***Yes***

2.3.2. Create Surface Plate and Group

If very thin plate elements are located on the surface, the only state possible is a plane stress. Then the stress tensor is simpler because it contains only 3 different elements. The post processing may be simpler (if you use beside FEMAP further postprocessors). You do not need to use plate elements on the surface but some users prefer this procedure.

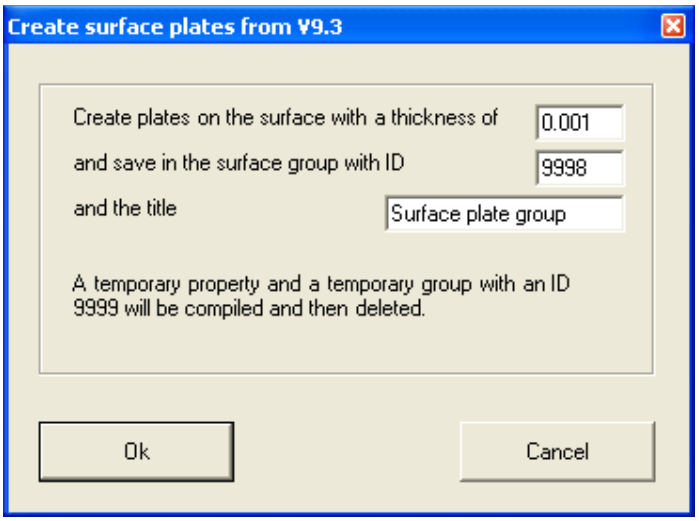


Figure 2-4: Inquiry to create thin plate elements on the surface

The number and the name of the group and the thickness of the new plates on the surface can be changed as the user requires. The Young's modulus should be low compared to the basic material of the structure. It should have no mechanical influence. For steel basic material you can define a separate material specification or you can use aluminium alloy.

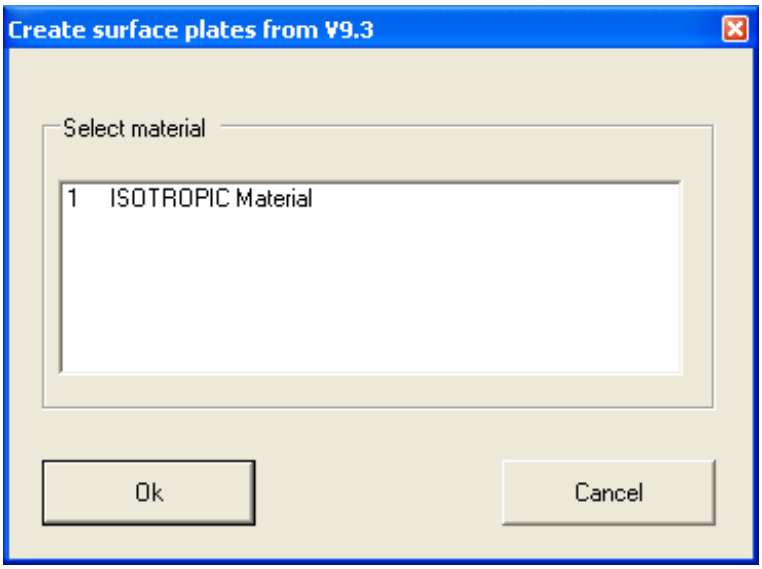


Figure 2-5: Selection of material for the plates of the surface

Now select the material for the plate elements.

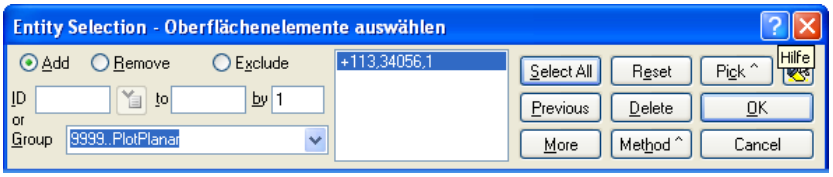


Figure 2-6: Selection of the plate elements on the surface

Select the elements you are interested in.

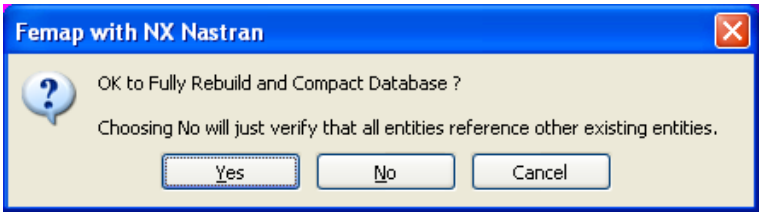


Figure 2-7: Inquiry if a new database shall be created

Click on ***Yes*** to continue.

2.3.3. Create Weld Groups

The various properties of the sheet metal make it possible to identify the welds. Sheets are looked for which are joined together with nodes. The nodes found are where the sheets meet and show the welds. All elements which lie on these seam nodes are grouped together in weld groups.

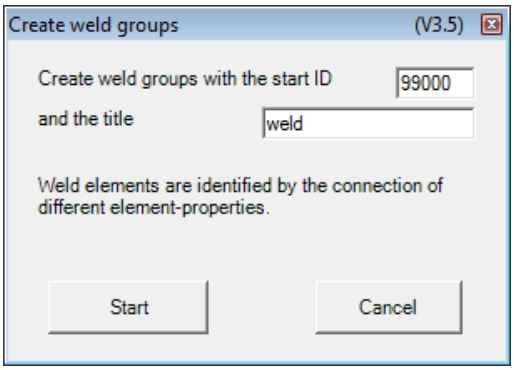


Figure 2-8: Selection to create a weld group

In the following window, the group you wish to create is given a starting number and a title. Click on ***Start*** to continue.

2.3.4. Export of stresses for the uniaxial case

The fatigue calculation differs between the uniaxial and the multiaxial case. Resulting from this the data export is different. The following table shows the possible selections available. The grey marked line gives the possibility for the uniaxial case (it is only one!!)

Table: Menu options of the FEMAP data export

Selection	Necessarity of the module	Suitable for calculation of	Limits	Afford
Uniaxial export	winLIFE 4.0 2017	Proportional fatigue for only 1 loading history	Equivalent stress only from principal stress	small
Multiaxial export and QUICK CHECK	winLIFE MULTIAXIAL	Critical plane approach	Max. 200 loading histories	High
Multiaxial Export and Quick CHECK	winLIFE FKM QUICKCHECK	Static and fatigue proof according to FKM or	Only load spectrum / no loading history possible.	small
Multiaxial Export or Quick CHECK marked	winLIFE FKM QUICKCHECK	Endurance limit proof (not accord. FKM	Only worst case scenario	Very small
Nonlinear export	winLIFE MULTIAXIAL	Geometrically and/or physically nonlinear	Ma. 20 000 nodes	Mean
Welding structural stress concept	winLIFE MULTIAXIAL	Seam weldings / according well known standards	Node lines must be located exactly in strongly defined matter relative to the weld toe	High (mesh creation)
Weld hot spots	winLIFE MULTIAXIAL	Seam weldings, only plate elements useable but normal direction vector used	Acceptable accuracy	Small
Weld hot spots for QUICK CHECK	winLIFE FKM QUICKCHECK	Seam weldings, only plate elements, no direction vector used	Only for hot spot search recommended, only for endurance limit proof	Very small
Create file for the regression analysis of the stress gradient	winLIFE MULTIAXIAL	Creating the related stress gradient to modify S-N curve locally	Only surface nodes	High
Create file for the regression analysis of the stress gradient for some nodes only	winLIFE MULTIAXIAL	Creating the related stress gradient to modify S-N curve locally only for some selected nodes	Only surface nodes	Mean
User defined	winLIFE MULTIAXIAL	User can define selection according to his needs		high

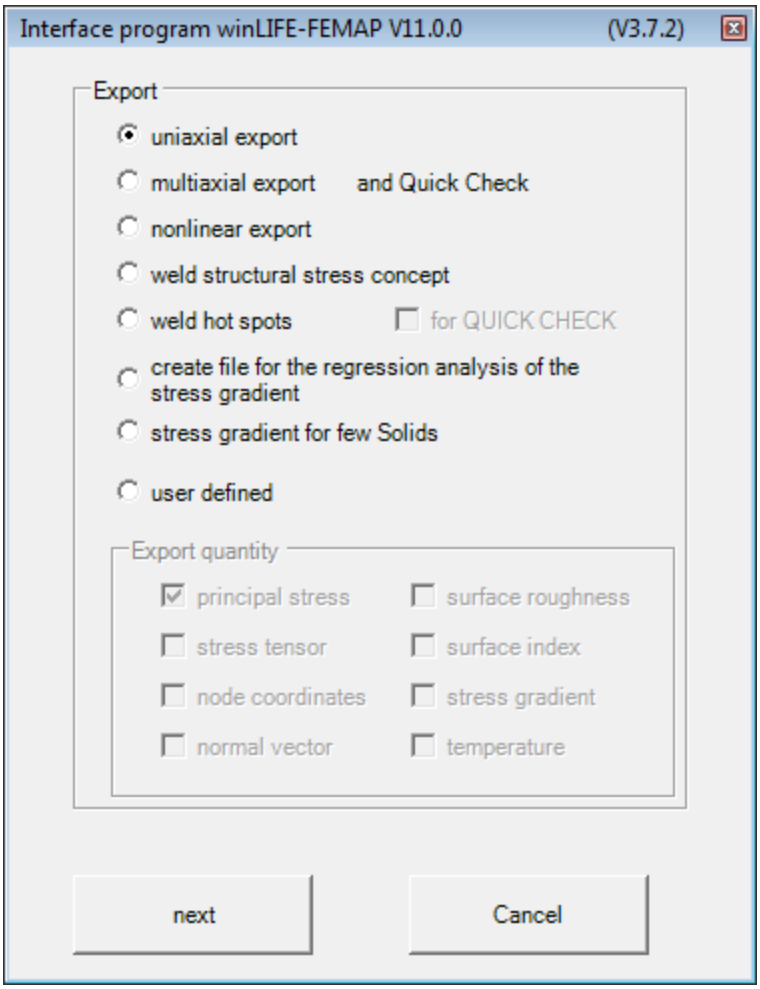


Figure 2-9: Selection to create an export-file for winLIFE

It is possible to export node stresses or element stresses. In case of element stress only plate-elements can be exported at the moment.

The Calculation Method `Average` means that the average stress of the nodes is exported. In the case of Max, the maximum stress on the nodes is exported. We recommend you to use Average.

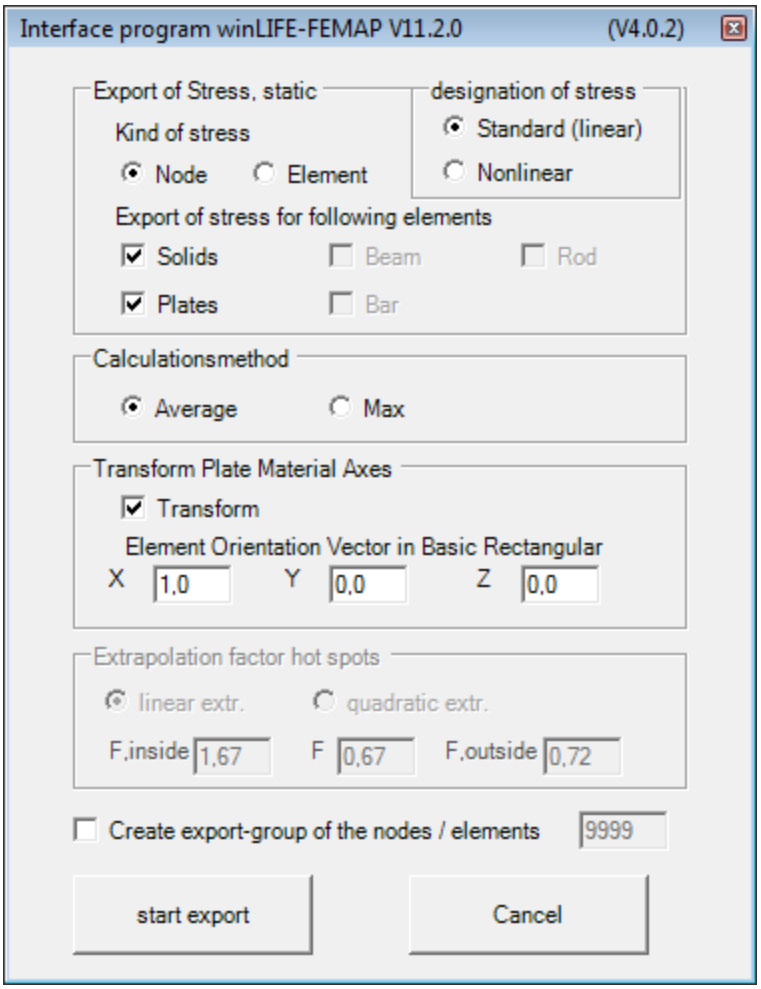


Figure 2-10: Selection to create an export-file for winLIFE

Only the element type you select will be exported

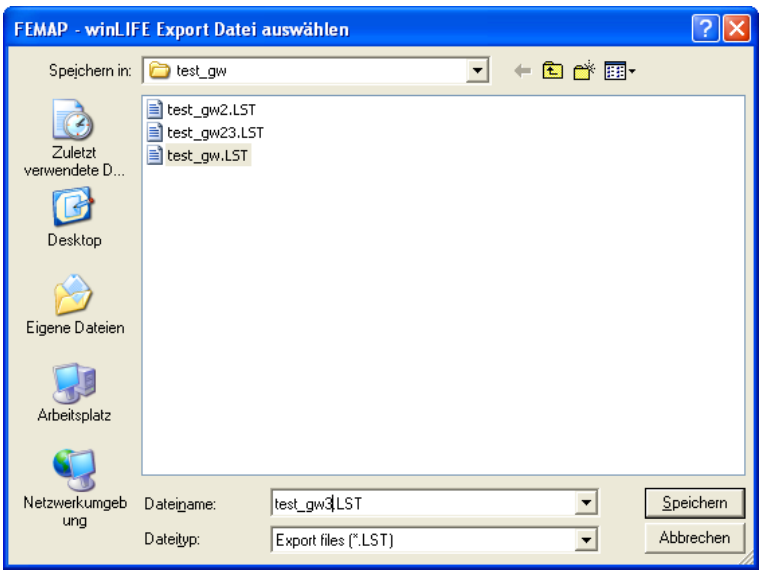


Figure 2-11: Defining the file-name

The filename and the directory are chosen by the user. Keep the name in your mind, because you have to select the file later.

The selection of the load case you can do in the following mask.

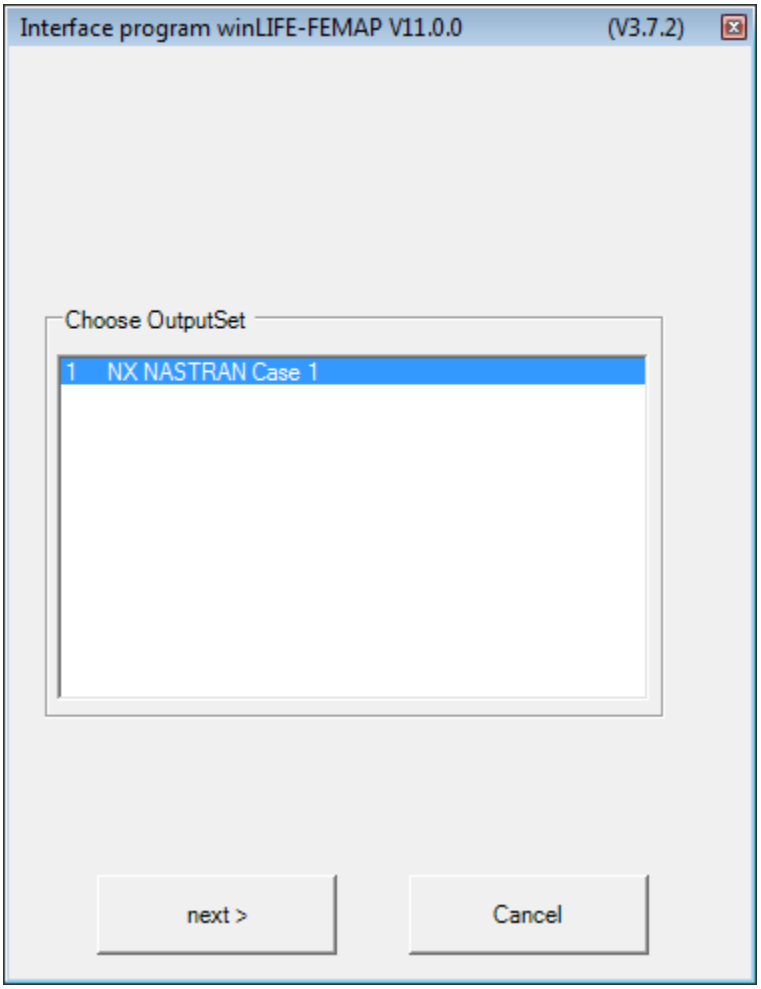


Figure 2-12: Selection of the output set

To select the nodes to be shown you can select single nodes or – in most cases – you will select all.

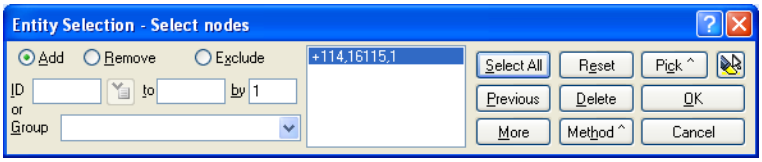


Figure 2-13: Node selection

2.3.5. Export of stresses for the multiaxial case

In the case of multiaxial calculation more data are exported and more information is needed. The grey marked lines are possible for multiaxial export. You can see that only the case for uniaxial export is not possible!

Table: Menu options of the FEMAP data export

Selection	Necessarity of the module	Suitable for calculation of	Limits	Afford
Uniaxial export	winLIFE 4.0 2017	Proportional fatigue for only 1 loading history	Equivalent stress only from principal stress	small
Multiaxial export and QUICK CHECK	winLIFE MULTIAXIAL	Critical plane approach	Max. 200 loading histories	High
Multiaxial export and QUICK CHECK	winLIFE FKM QUICKCHECK	Static and fatigue proof according to FKM or	Only load spectrum / no loading history possible.	small
Multiaxial Export and Quick CHECK	winLIFE FKM QUICKCHECK	Endurance limit proof (not accord. FKM	Only worst case scenario	Very small
Nonlinear export	winLIFE MULTIAXIAL	Geometrically and/or physically nonlinear	Ma. 20 000 nodes	Mean
Welding structural stress concept	winLIFE MULTIAXIAL	Seam weldings / according well known standards	Node lines must be located exactly in strongly defined matter relative to the weld toe	High (mesh creation)
Weld hot spots	winLIFE MULTIAXIAL	Seam weldings, only plate elements useable but normal direction vector used	Acceptable accuracy	Small
Weld hot spots for QUICK CHECK	winLIFE FKM QUICKCHECK	Seam weldings, only plate elements, no direction vector used	Only for hot spot search recommended, only for endurance limit proof	Very small
Create file for the regression analysis of the stress gradient	winLIFE MULTIAXIAL	Creating the related stress gradient to modify S-N curve locally	Only surface nodes	High
Create file for the regression analysis of the stress gradient for some nodes only	winLIFE MULTIAXIAL	Creating the related stress gradient to modify S-N curve locally only for some selected nodes	Only surface nodes	Mean
User defined	winLIFE MULTIAXIAL	User can define selection according to his needs		high

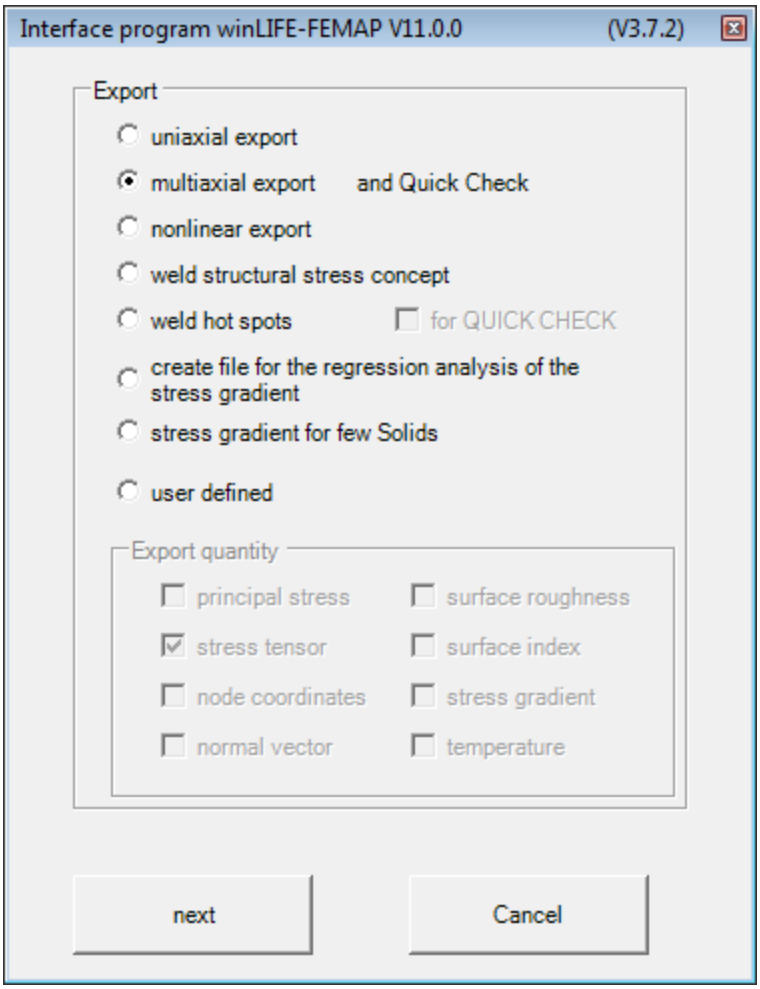


Figure 2-14: Selection to create an export-file for winLIFE

If all selected plate elements don`t have the same direction at the material axes FEMAP cannot build the correct node stress–tensor. So you have to transform all material axes into the same direction. This direction should not be perpendicular to the surface.

If you select a vector, which is perpendicular to any plate element, then you will get an error message.

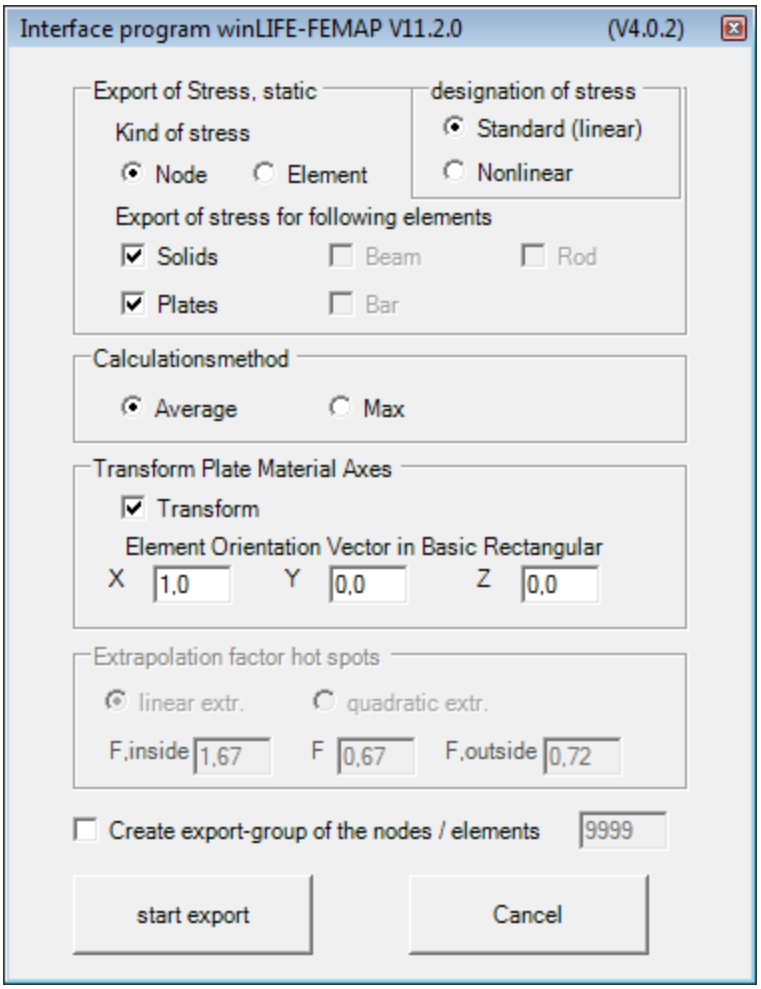
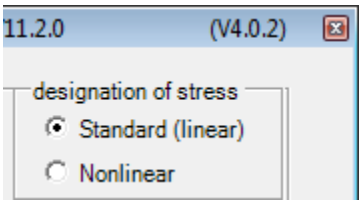


Figure 2-15: Selection to create an export-file for winLIFE

Remarks to the stress export



Selecting ***Standard linear*** in a multiaxial export the following vectors are exported:

Solid-Elements	Shell elements
60010..Solid X Normal Stress 60011..Solid Y Normal Stress 60012..Solid Z Normal Stress 60013..Solid XY Shear Stress 60014..Solid YZ Shear Stress 60015..Solid ZX Shear Stress	7020..Plate Top X Normal Stress 7021..Plate Top Y Normal Stress 7023..Plate Top XY Shear Stress 7420..Plate Bot X Normal Stress 7421..Plate Bot Y Normal Stress 7423..Plate Bot XY Shear Stress

If the kind of stress is ***Nonlinear*** the following vectors are exported::

Solid-Element type	Shell elements
60160..Nonlinear Solid X Normal Stress 60161..Nonlinear Solid Y Normal Stress 60162..Nonlinear Solid Z Normal Stress 60163..Nonlinear Solid XY Shear Stress 60164..Nonlinear Solid YZ Shear Stress 60165..Nonlinear Solid ZX Shear Stress	7142..Nonlinear Plate Top X Normal Stress 7143..Nonlinear Plate Top Y Normal Stress 7145..Nonlinear Plate Top XY Shear Stress 7542..Nonlinear Plate Bot X Normal Stress 7543..Nonlinear Plate Bot Y Normal Stress 7545..Nonlinear Plate Bot XY Shear Stress

In the case of uniaxial export the principal stresses (linear, nonlinear) are exported.

Note: Results from ADINA are listed as nonlinear stresses in Femap

After a winLIFE 4.0 2017 fatigue calculation is done the results can be read from FEMAP to present the results in a contour plot. To export the results of FEA an export file name has to be created by the user:

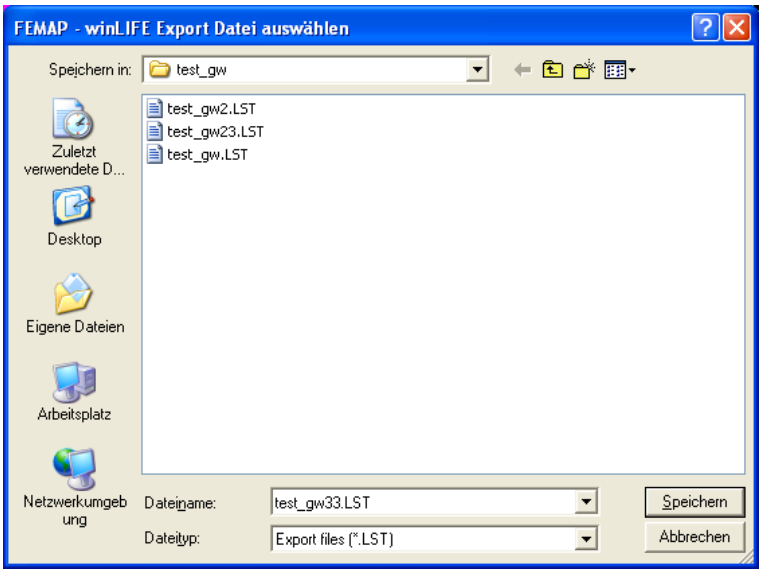


Figure 2-16: Defining the file-name

Next step is to select the load case.

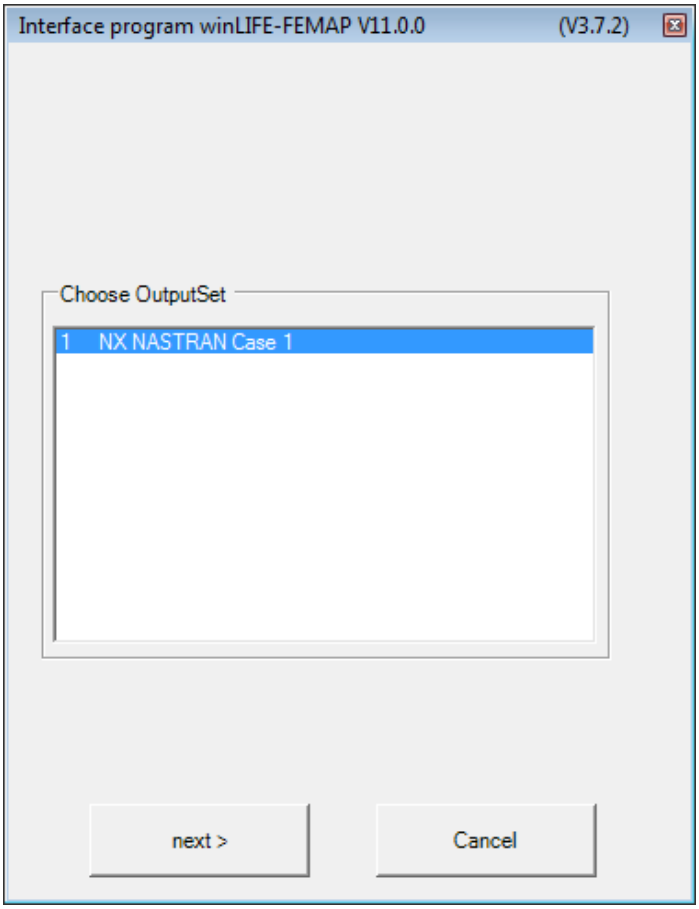


Figure 2-17: Selection of the output set

You can select the nodes of interest. In most cases you will select the nodes of the surface which are included in the group you have created.

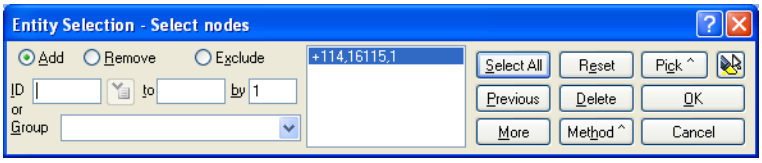


Figure 2-18: Selection of the nodes

Consult your analysis program's documentation concerning the original coordinate system definition. The new component forces, stresses, and strains will be placed in the user defined output vector numbers (300000+).

2.3.6. Import the fatigue results from winLIFE into FEMAP

The fatigue results – the damage sum – is written from winLIFE 4.0 2017 into a file. You can import these results and show them in FEMAP by choosing from the menu

winLIFE / data import from winLIFE

It is the same procedure for uniaxial and multiaxial case. You have to select the filename as shown in the following mask:

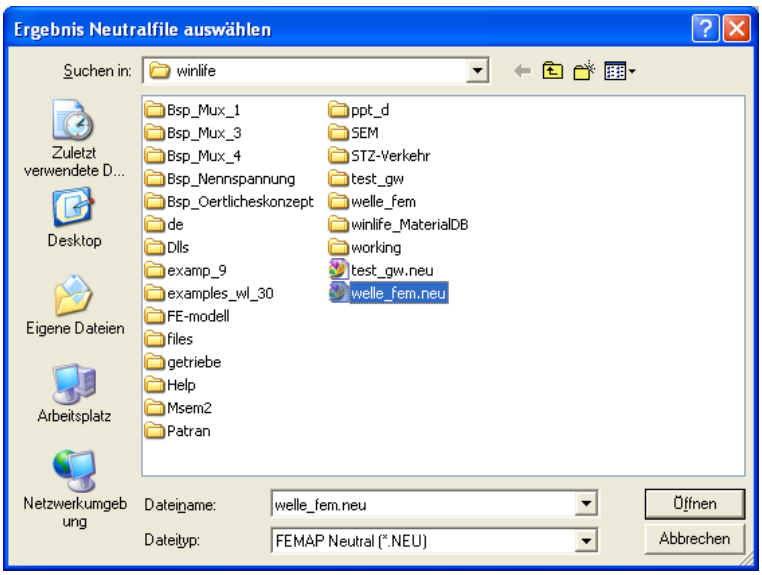


Figure 2-19: Selection of winLIFE result file containing the fatigue results

You select the file name which you created in winLIFE 4.0 2017 to store the results.

The following message will occur if just a result file exists in FEMAP. Press OK and rename in FEMAP the existing Output-Set. Or delete the existing Output-Set. Then repeat the import of the winLIFE 4.0 2017 result file.

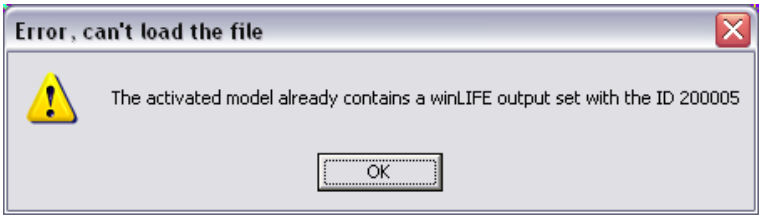


Figure 2-20: Message appears if the file name just exists

To show the results in FEMAP choose

View / Select / Deformed and Contour Data

and the following mask will appear. You have to select the output set 200005 by clicking the drop down button and choose the Output Vectors.

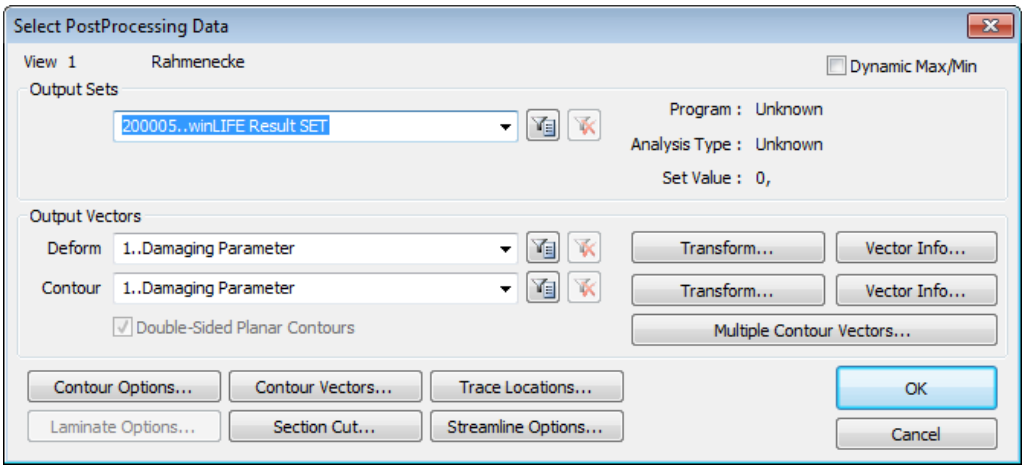


Figure 2-21: Selection of the winLIFE result set

After clicking

OK

The following graphic containing your fatigue results will appear.

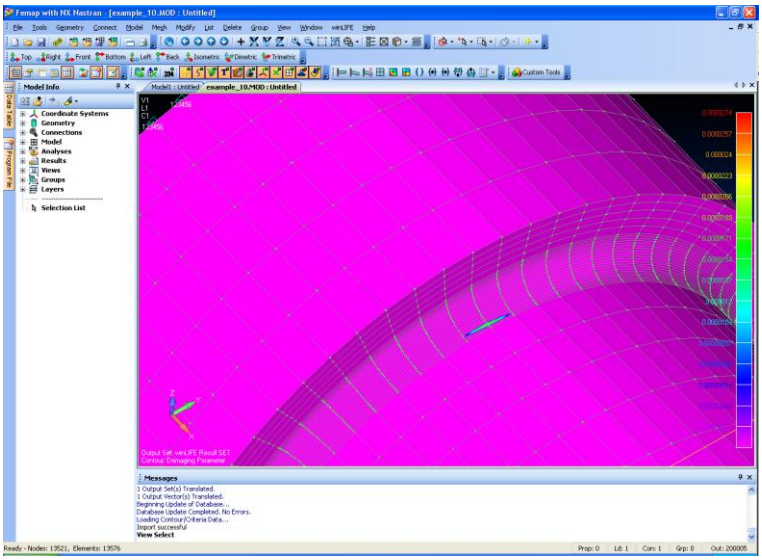


Figure 2-22: Visualisation of the result in FEMAP

To improve the presentation you can change the colour range. Select

View / Options

And the following mask will appear where you can change the minimum and maximum value of the damage presented in the graph.

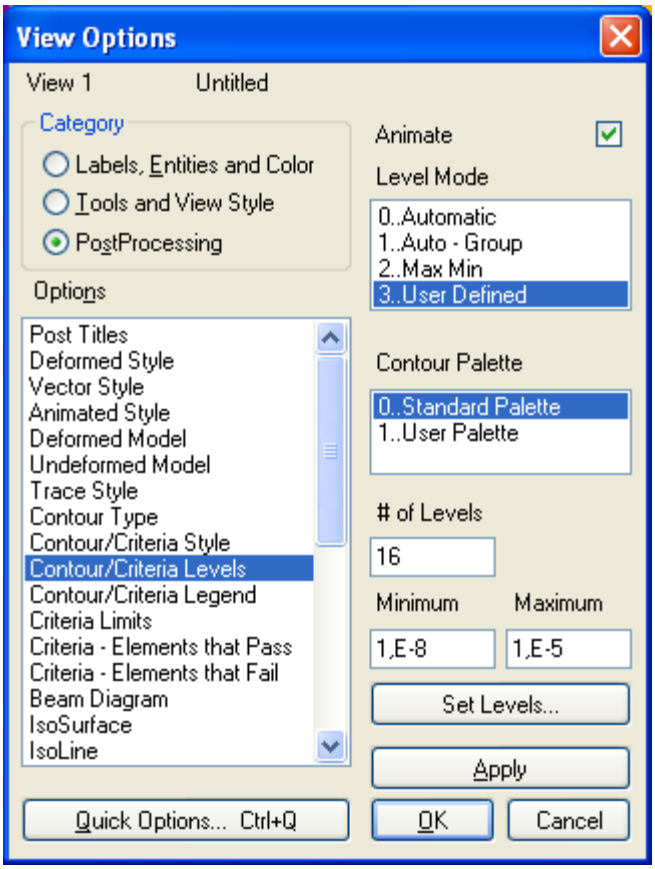


Figure 2-23: Options for result presentation

The result is shown in the following picture. In this way this you can show all other results such as safety factor, equivalent stress etc.

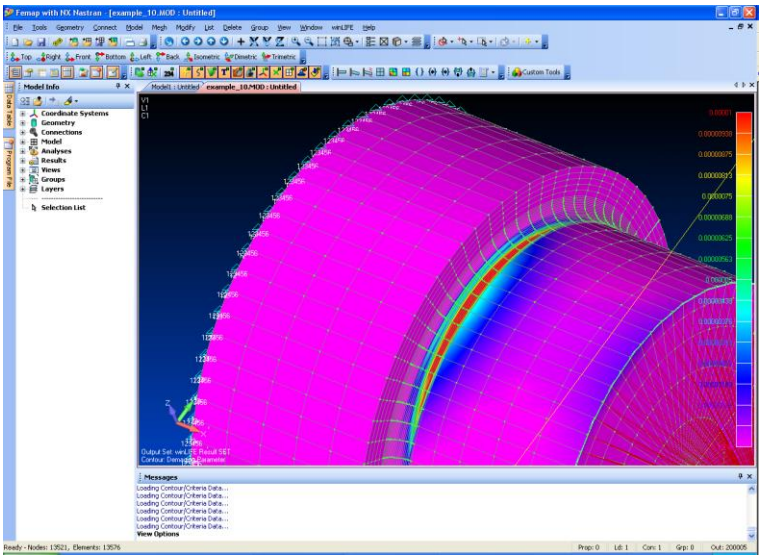


Figure 2-24: Modified view after changing the colour range

In case of exporting element-stresses from FEMAP to winLIFE 4.0 2017 the following FEMAP options are reasonable.

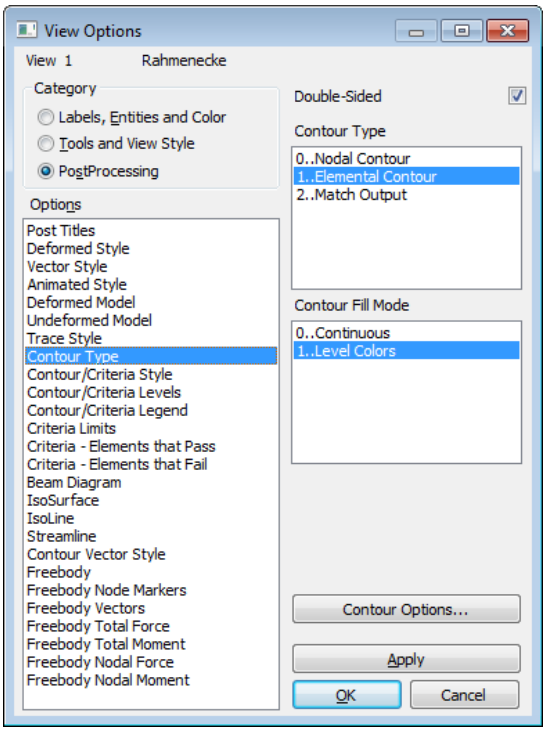


Figure 2-25: Settings for export of element stresses

2.3.7. Description of the winLIFE import file *.LST

A file *.lst is created by the FEA program as transfer file to winLIFE 4.0 2017 . All data which shall be used for a fatigue calculation (e.g. the nodes) must be in this file. The structure is defined in the chapter “Data transfer between FEA and winLIFE”.

2.3.8. Export node list

The command Export node list exports nodes in a file with the extension *.kno.

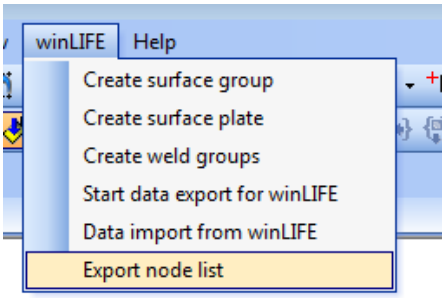


Figure 2-26: Selection to create a node list

To do this the user selects nodes of interest and specifies a file in which the node numbers are written.

2.4. Using the original FEMAP commands

The winLIFE 4.0 2017 standard interface based on FEMAP APIs is comfortable and tested. If the number of nodes is very large (> 10 000) the time for the data transfer can be long and it is recommended to export directly from the FEMAP user interface. For this purpose the winLIFE 4.0 2017 CD has a file LIFE_FMT.esp which provides the data structure. This has to be copied into the FEMAP installation directory e.g. into: C:\FEMAPv102\.

In FEMAP under File -> Preferences in the tab "Library/Startup" enter the file LIFE_FMT.esp as the format file (instead of e.g. format.esp). The macros are subsequently carried out as program file in FEMAP.

Because this method is more complicated that using the API-interface, it is only recommended for experienced users.

In FEMAP changes are often made to the APIs. Therefore we only use an example here to describe the basic procedure. Version 10.2.0 of FEMAP is used.

The example represents a uniaxial load using plate elements.

The commands can be recorded with the help of the FEMAP macro recorder and a program file is created. The following diagrams show the process. The order of the commands is labelled with the numbers 1, 2 etc.

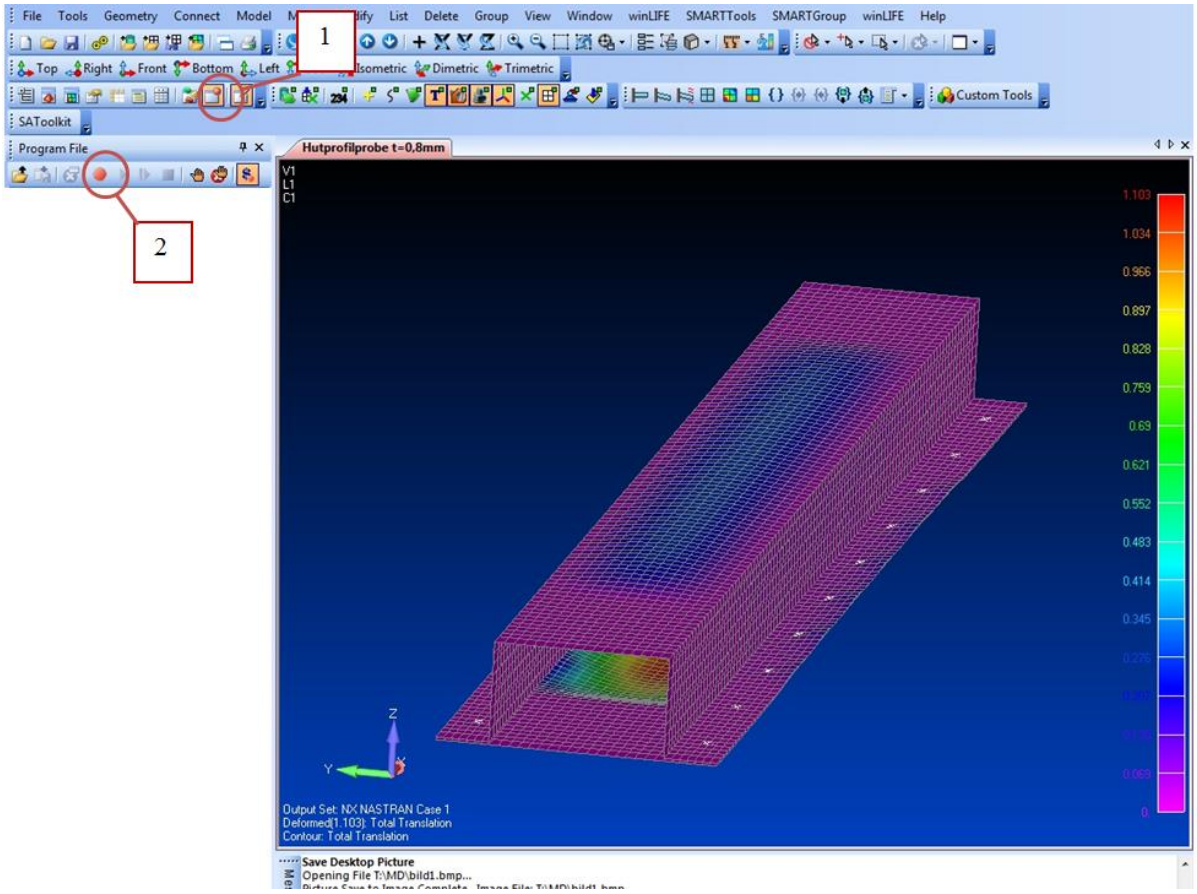


Figure 2-27: order of actions using original FEMPA commands

To copy the output vectors into a new output set.
Command: Model → Output → Process

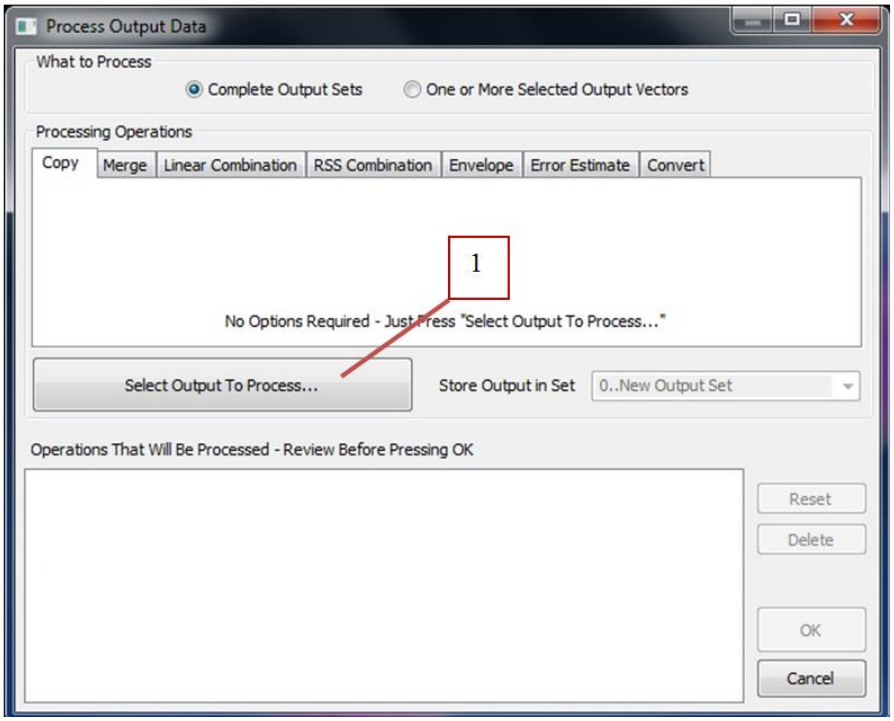


Figure 2-28: order of actions using original FEMPA commands

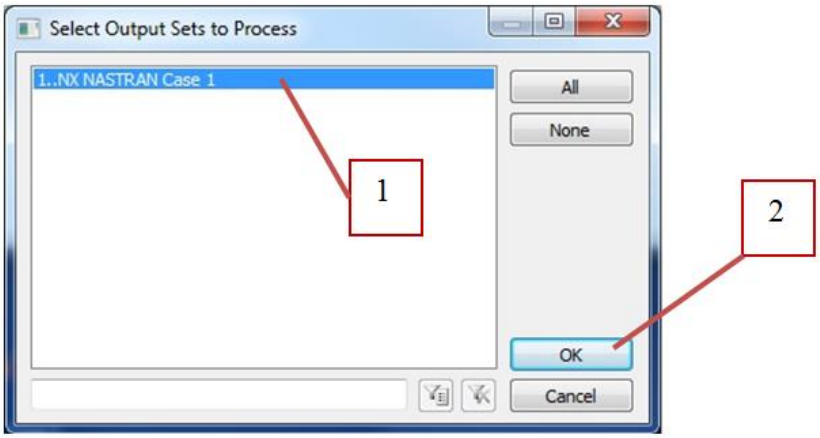


Figure 2-29: order of actions using original FEMPA commands

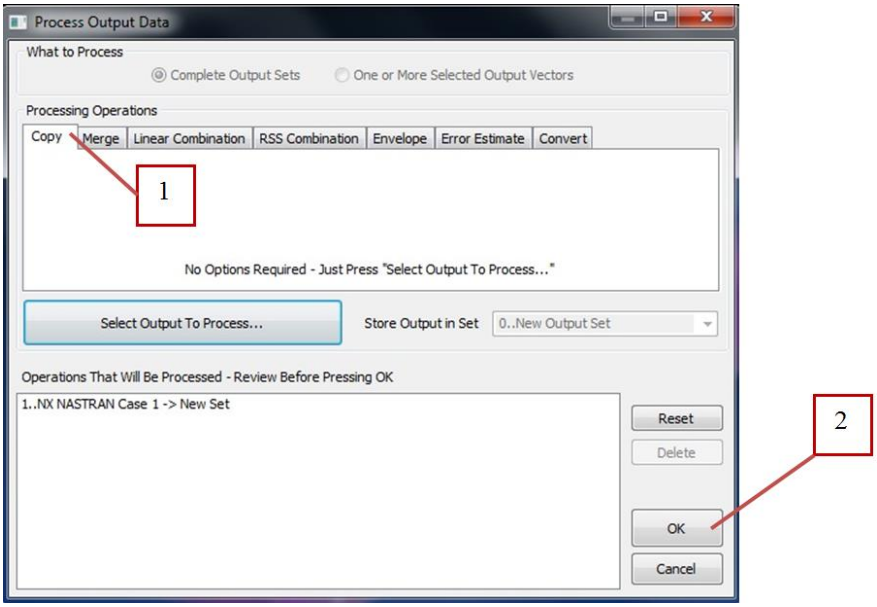


Figure 2-30: order of actions using original FEMPA commands

Command: Model → Output → Process
To convert the element stresses into node stresses

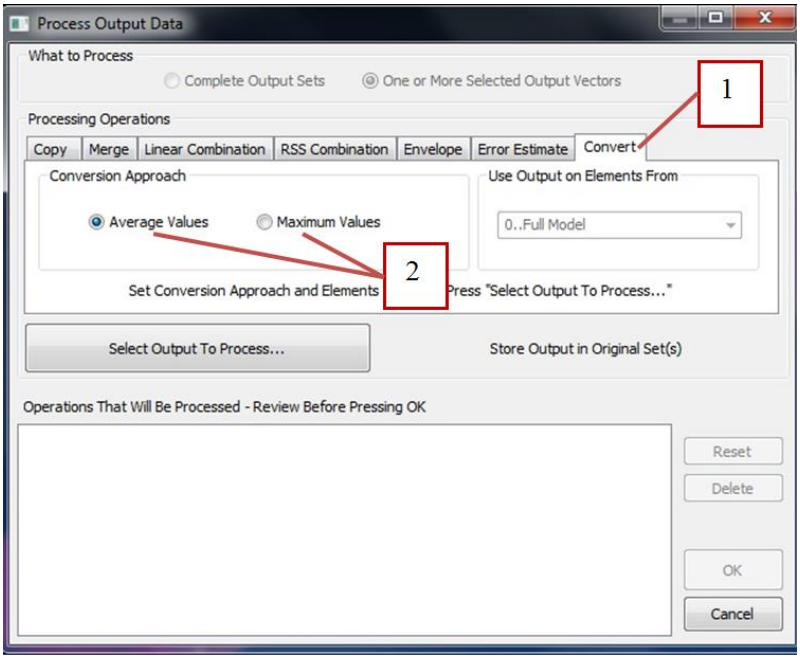


Figure 2-31: order of actions using original FEMPA commands

For the uniaxial case: Select the vectors 7026, 7027, 7426, 7427

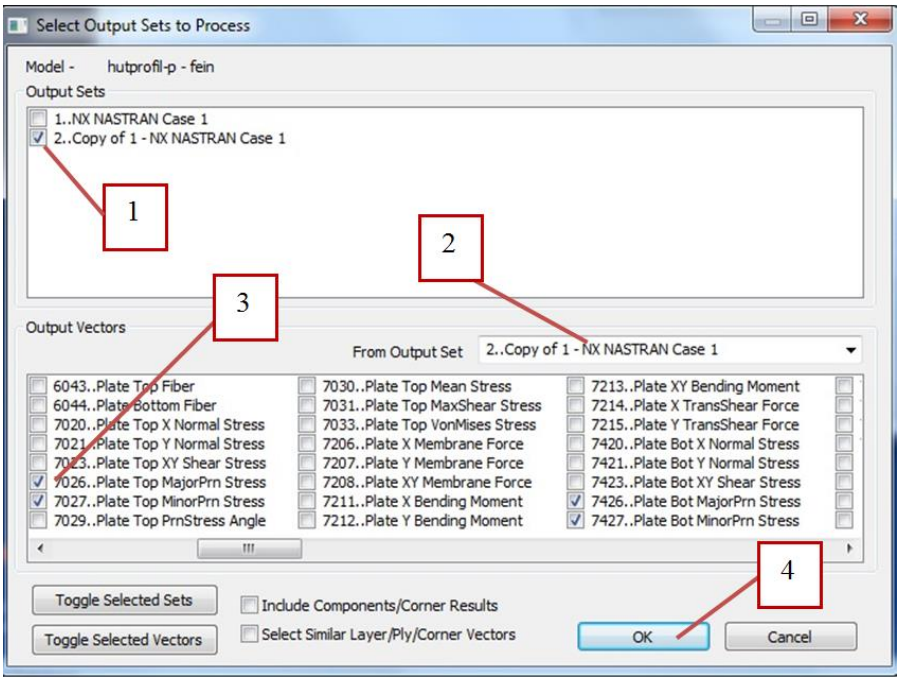


Figure 2-32: order of actions using original FEMAP commands

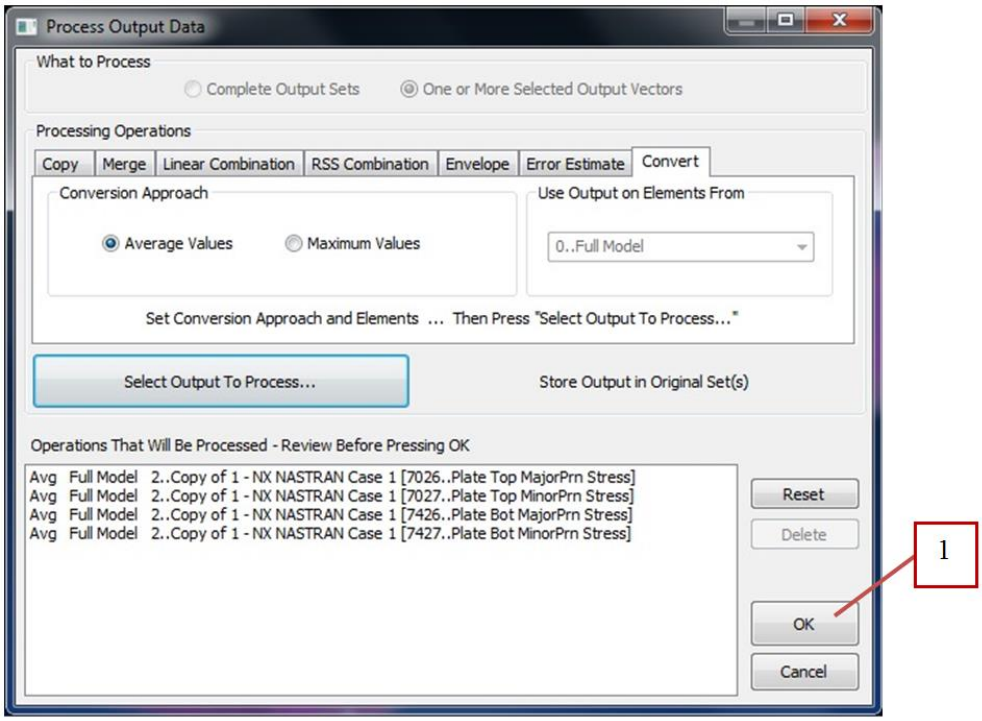


Figure 2-33: order of actions using original FEMPA commands

Output of the stresses
List → Output → Use Format
Select the output sets

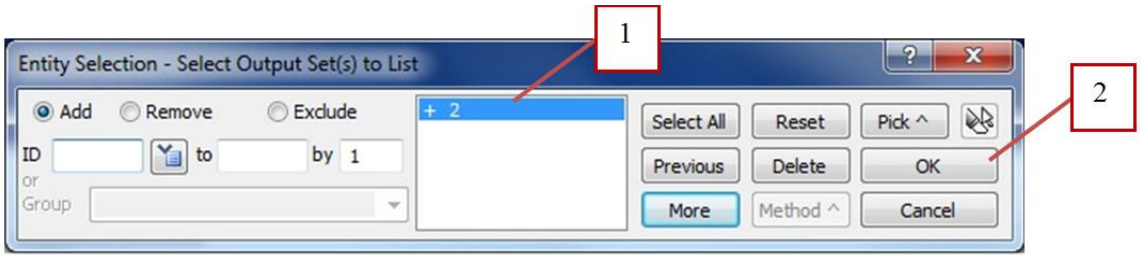


Figure 2-34: order of actions using original FEMPA commands

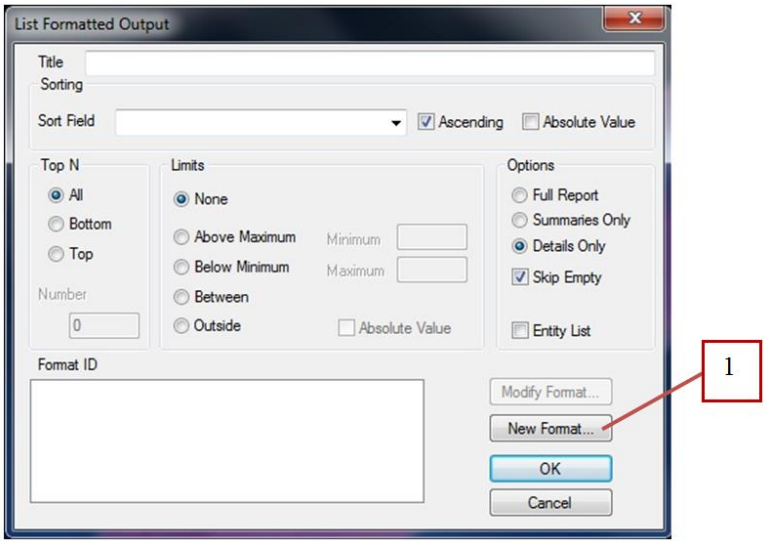


Figure 2-35: order of actions using original FEMPA commands

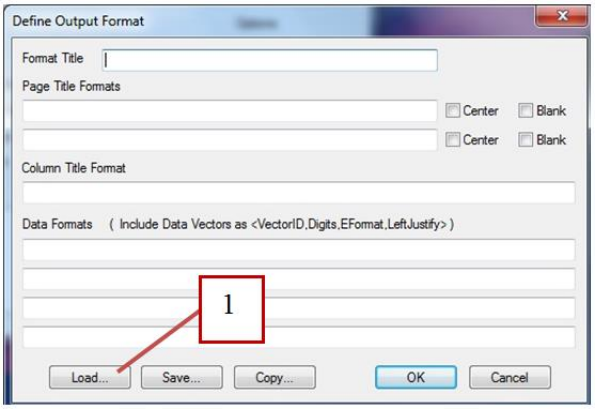


Figure 2-36: order of actions using original FEMPA commands

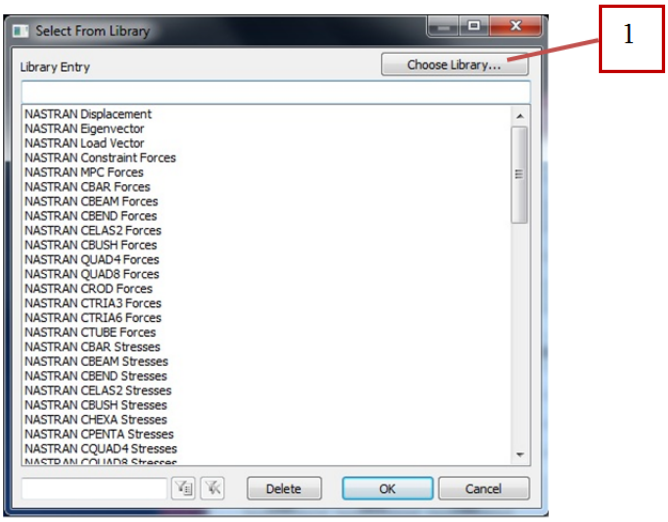


Figure 2-37: order of actions using original FEMPA commands

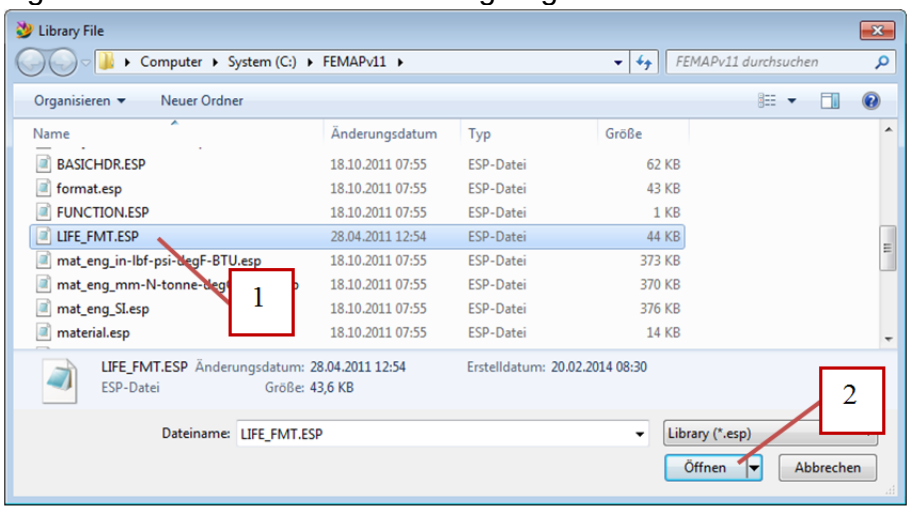


Figure 2-38: order of actions using original FEMPA commands

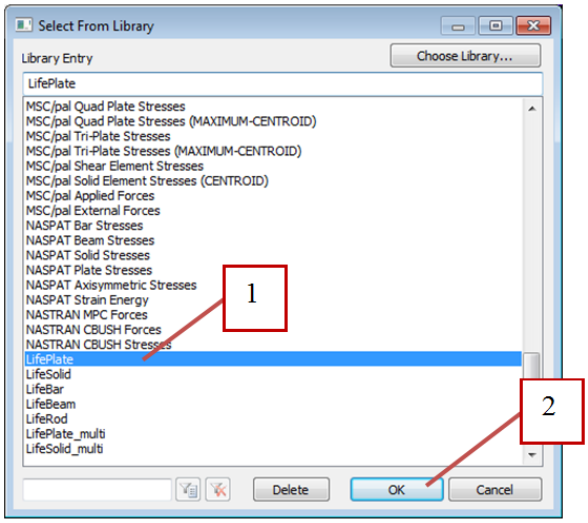


Figure 2-39: order of actions using original FEMPA commands

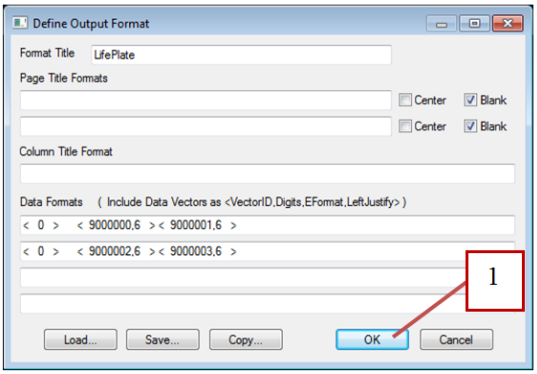


Figure 2-40: order of actions using original FEMPA commands

Selection of the output nodes

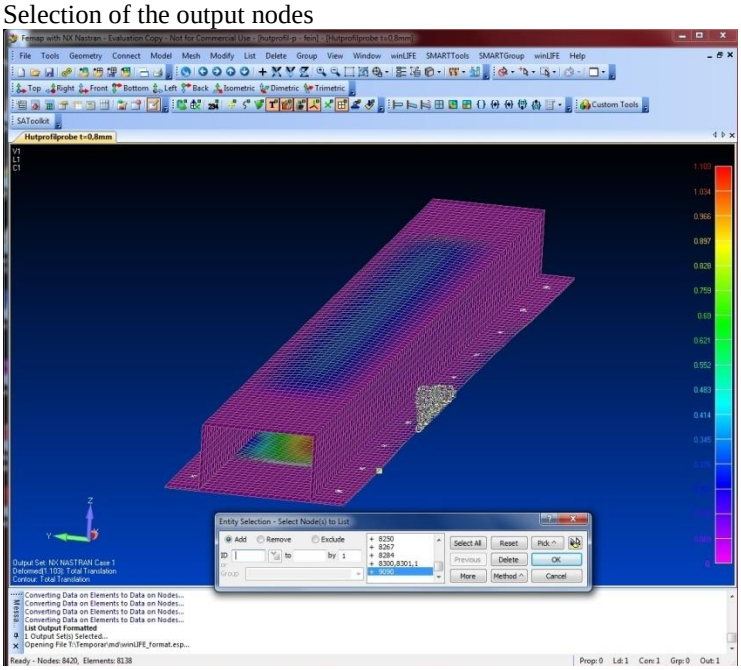


Figure 2-41: order of actions using original FEMPA commands

The output of the node stresses occurs in the message window. The values can now be copied to create a *.LST file.

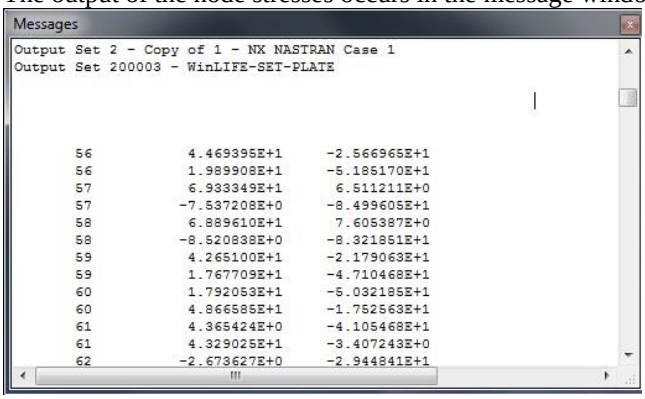


Figure 2-42: result file

3. ADINA Data export to winLIFE

3.1. Using CDI

Data conversion is performed by help of the CDI (**C**ustom designable **D**ata **I**nterface). The user has to create an ADINA-result file including the data in ASCII. This we show here for plate elements and solids.

3.1.1. Creating an ASCII-file for plates

For the following model of a notched plate shown in figure below the output-file shall be created. The ADINA-user should be able to create such a file himself as it is shown in the following.

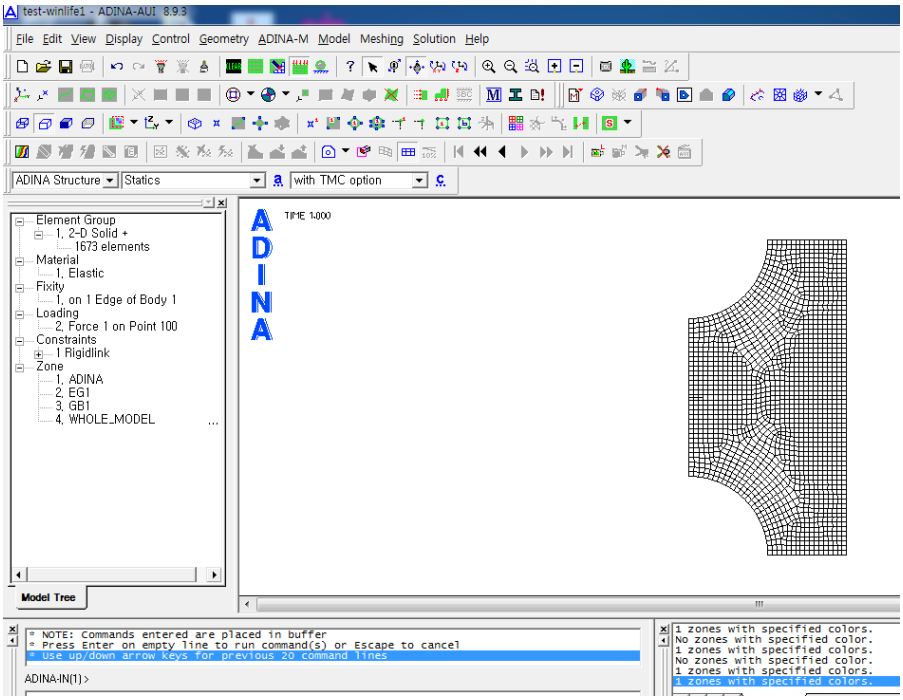


Figure 3-1: Model of a tension bar in ADINA (the symmetric properties were used to reduce the size of the model). Only the right part of the model is shown.

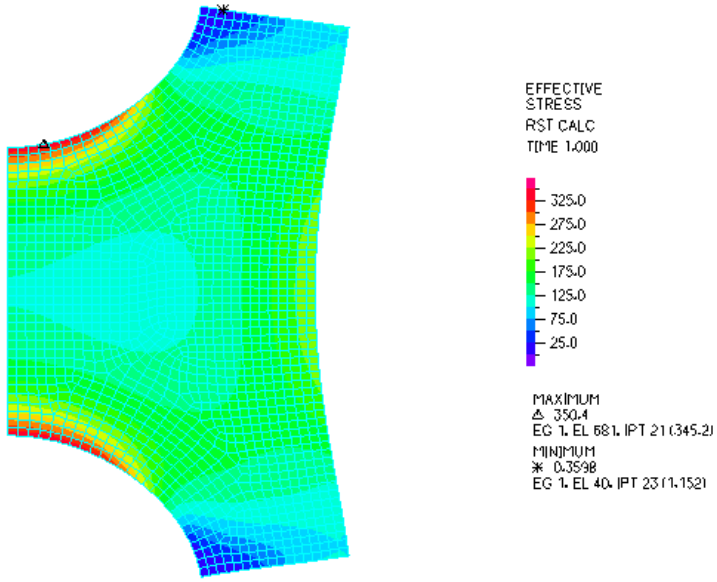


Figure 3-2: Model of a tension bar with stress results

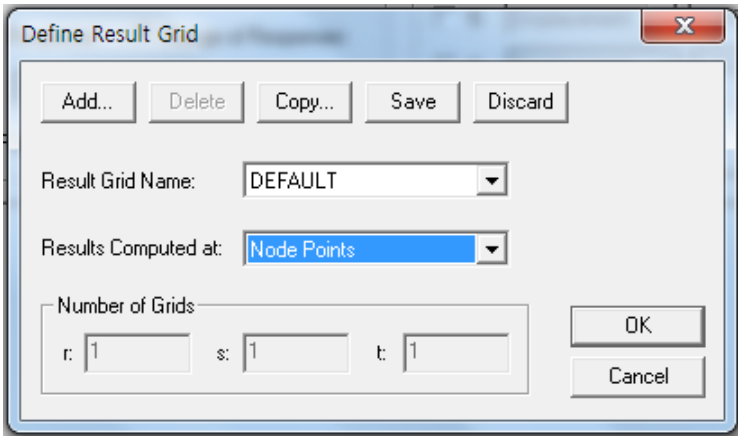


Figure 3-3: Selection of parameters for output

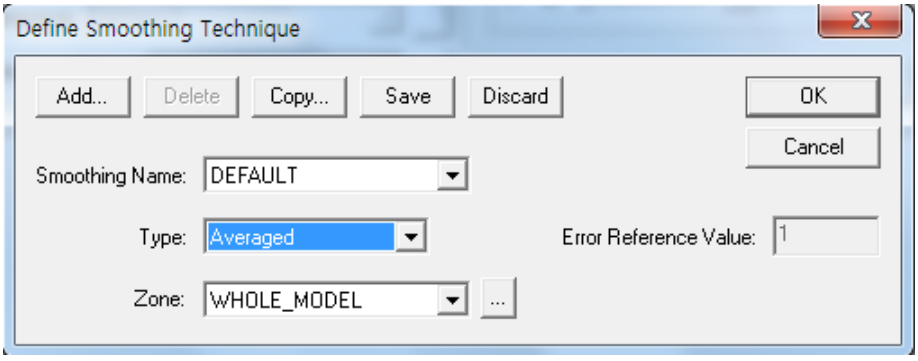


Figure 3-4: Selection of methode for mean values.

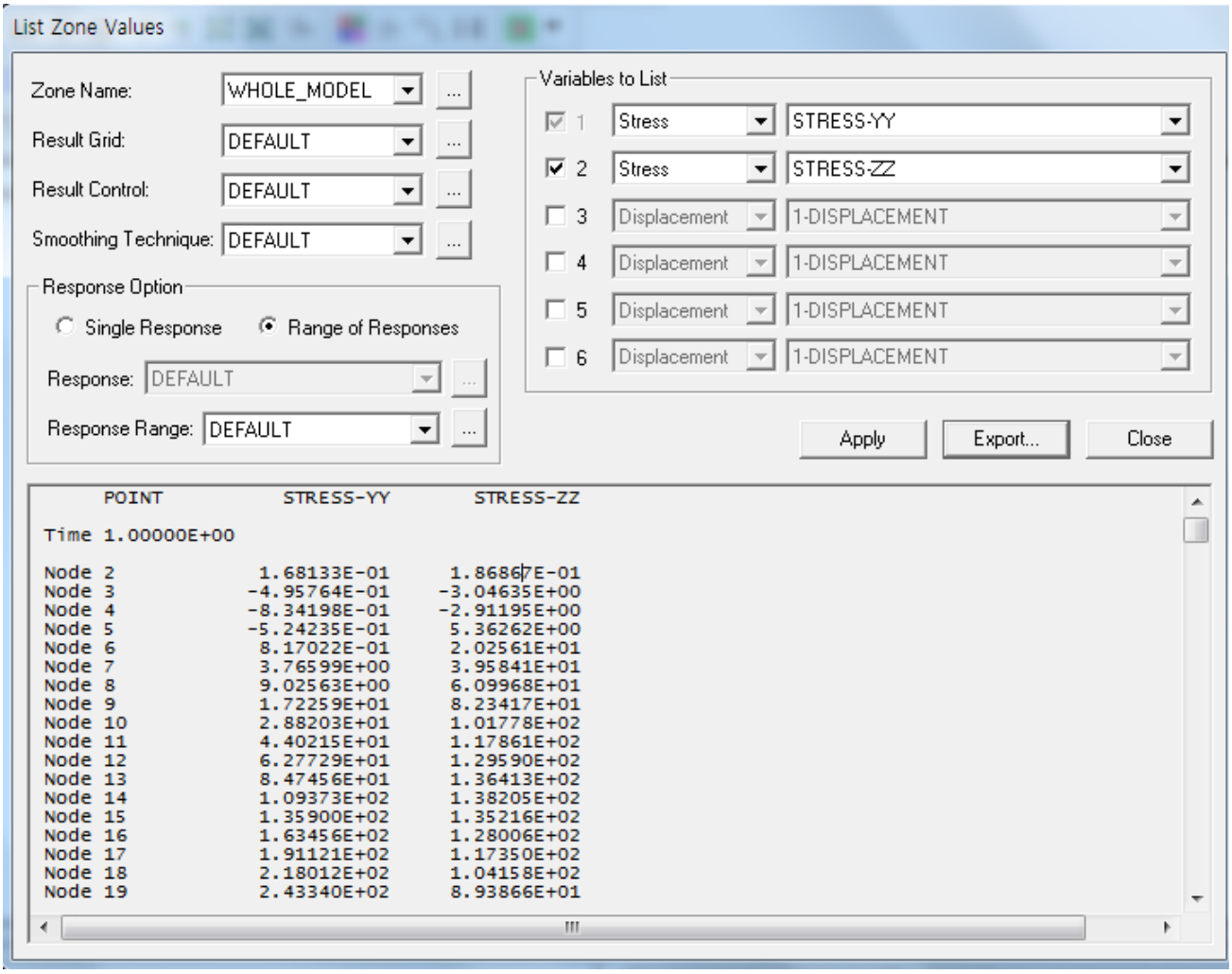


Figure 3-5: Result of the output in ASCII-format

The so created file can be read in with the winLIFE 4.0 2017 CDI.

3.1.2. Creating an ASCII-file for solids

The model is a simple cylinder built by solids, which are under tension stresses. How to create the ASCII file is shown in the next figures. By help of CDI it is read into winLIFE 4.0 2017 and the fatigue calculation is done. The results of winLIFE 4.0 2017 can be read in back to ADINA.

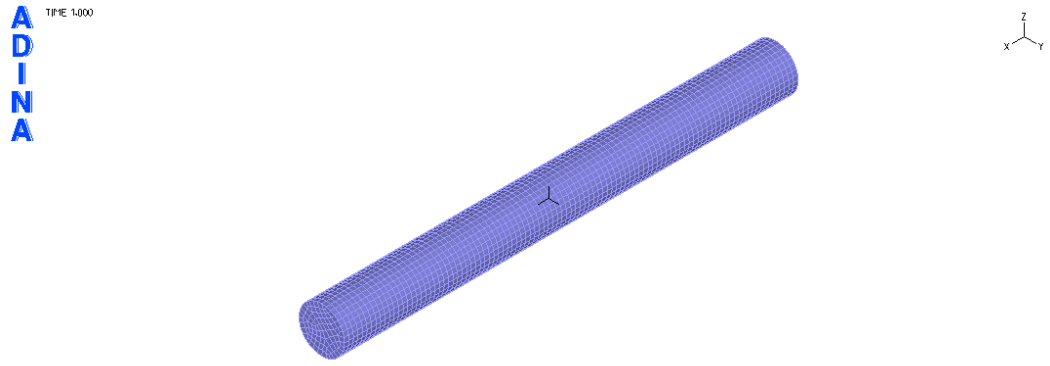


Figure 3-6: Model of the cylinder

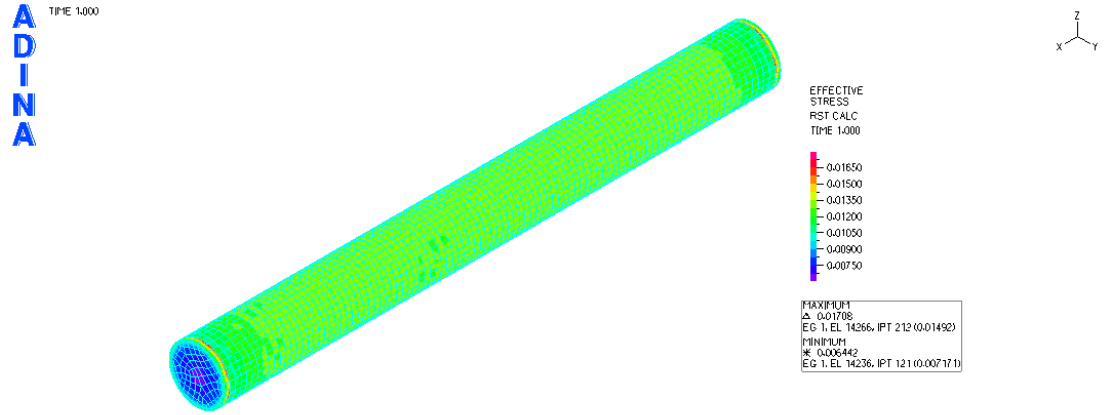


Figure 3-7: result of stress calculation

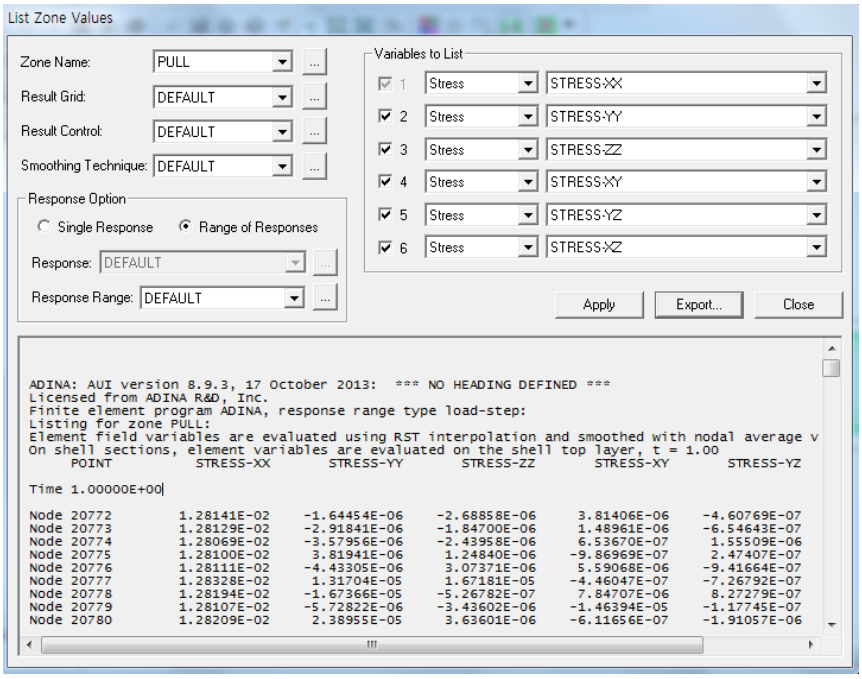


Figure 3-8: Settings to create the here discussed ASCII-file.

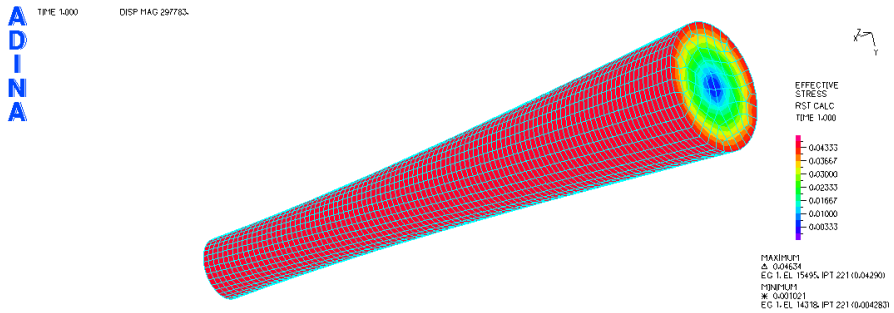


Figure 3-9: Result of the winLIFE fatigue calculation reimported to ADINA and shown there

4. ABAQUS Data export to winLIFE

Note: If you use the VIEWER4WINLIFE then you can perform easily the datatransfer between winLIFE 4.0 2017 and ABAQUS to watch stress and fatigue results. Instead of the VIEWER4WINLIFE you can use the winLIFE CDI and the use is described following.

4.1. Using CDI

The data is transferred with the aid of CDI (**C**ustom designable **D**ata **I**nterface). To do this, an ASCII-File has to be created in ABAQUS. This can be seen in the following SOLID-Elements diagram.

4.1.1. Creating an ASCII-file for solids

The necessary winLIFE 4.0 2017 output file is created for the ABAQUS-Model of a beam. An experienced ABAQUS user will be able to adapt this briefly explained procedure to create output files for any other model or element type.

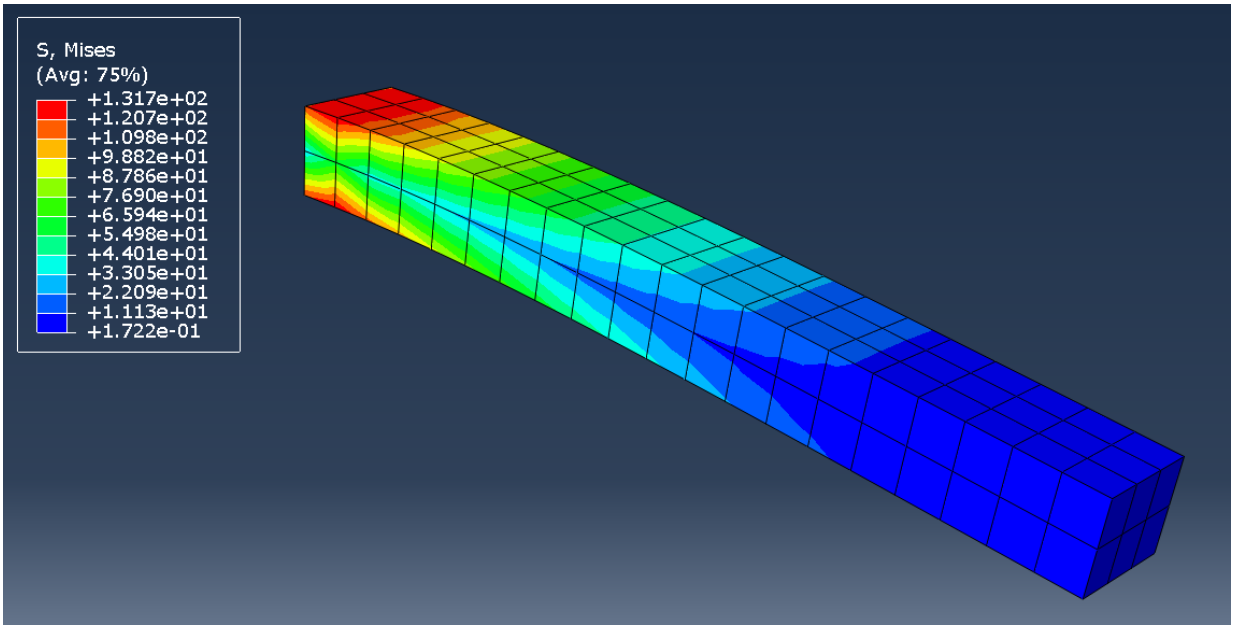


Figure 4-1: Model of a Beam in ABAQUS

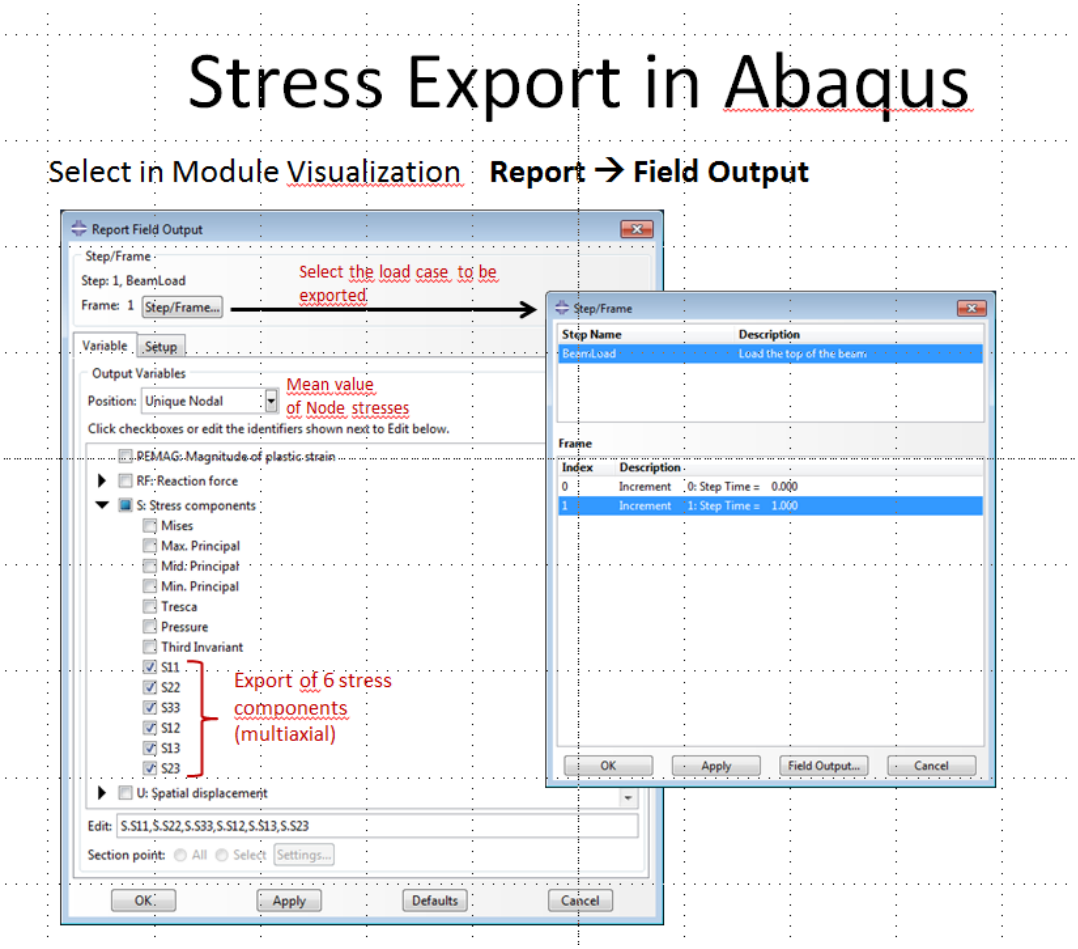


Figure 4-2: Dialogue Report Field Output

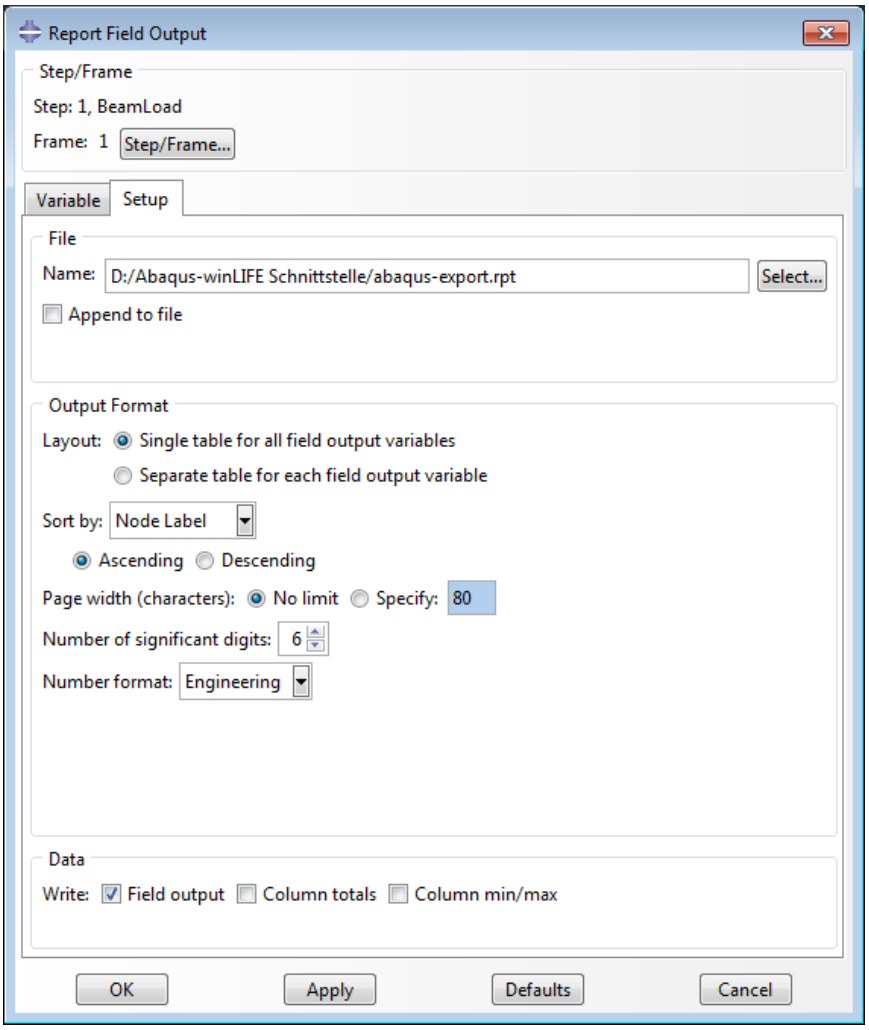


Figure 4-3: Defining the Output Format in ABAQUS

When the file has been created, go to winLIFE 4.0 2017 and open the CDI (see next diagram). The file created in ABAQUS will be shown.

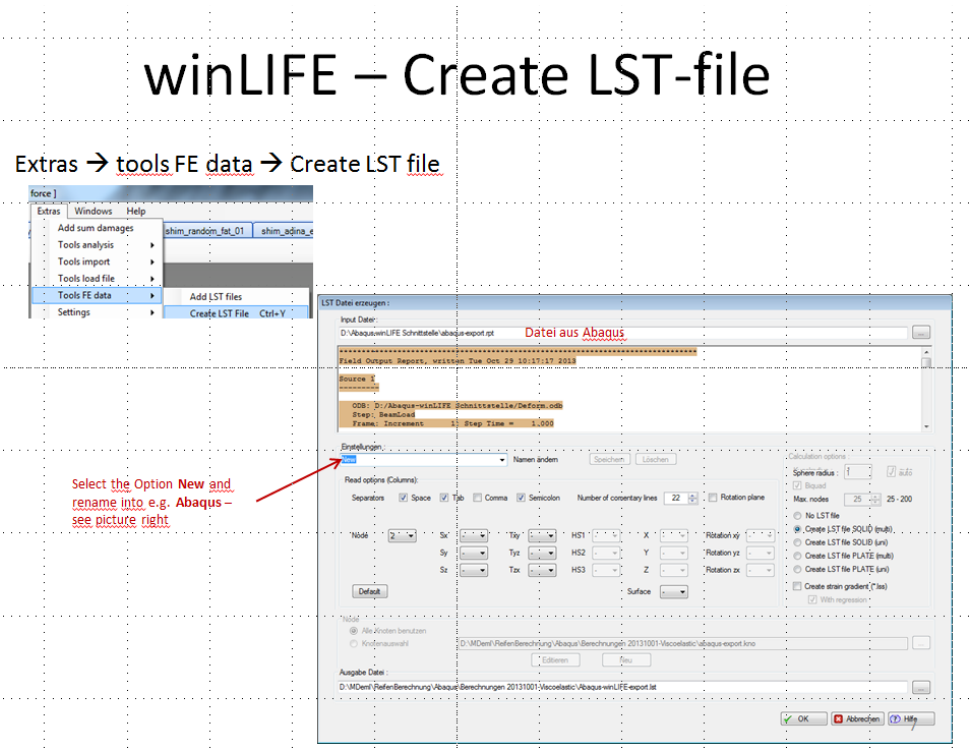


Figure 4-4: Dialogue of the CDI for defining the Data Transfer

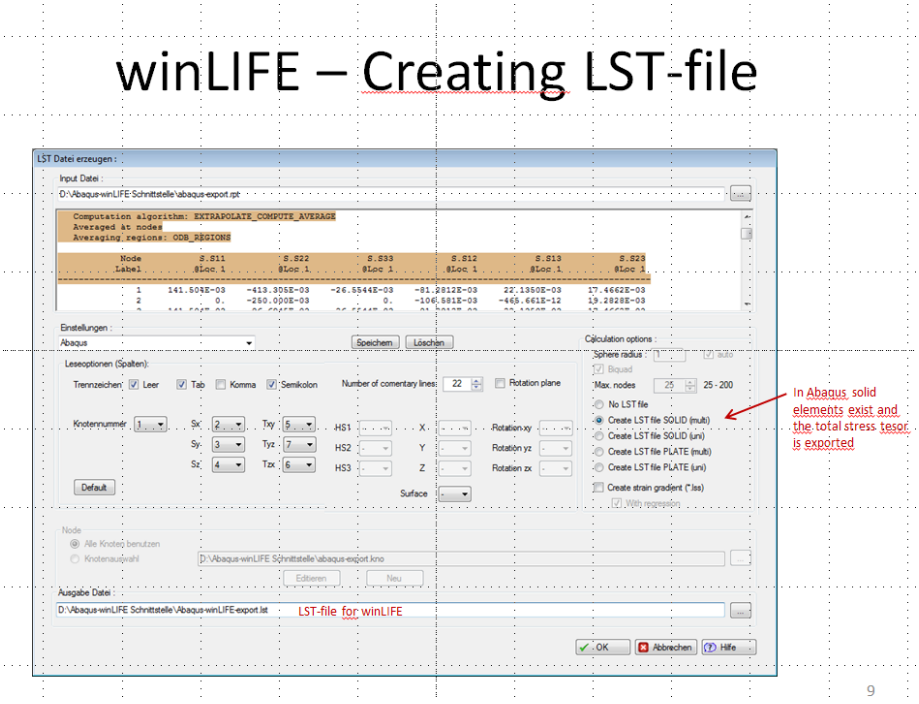


Figure 4-5: All Entries in the Dialogue for Data Transfer

Note that this structure of data transfer is saved under a name defined by the user – in this example Abaqus. For future data transfers you only have to enter this name.

The result of this operation is the following file which can now be read into winLIFE 4.0 2017 .

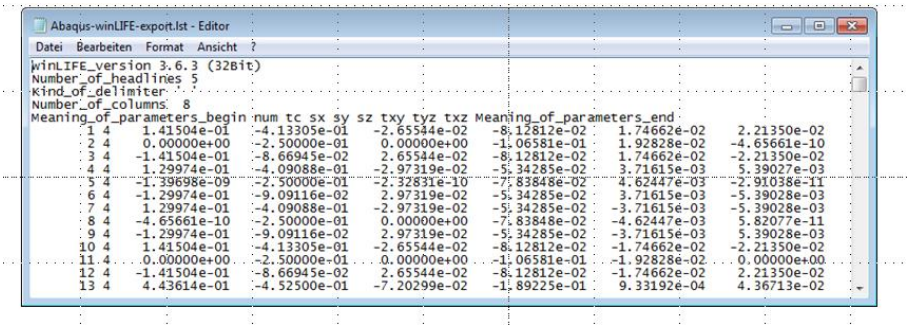


Figure 4-6: Result of the Data Transfer

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6. Legal Liability

6.1. § 1 Subject of this Agreement

1.1 The buyer purchases the winLIFE Software from

Steinbeis GmbH & Co. KG for Technology Transfer

Represented by

Steinbeis Transfer Centre

New Technologies in Traffic Engineering

Prittwitzstrasse 10, 89075 Ulm, Germany

- hereinafter referred to as the “seller” -

under the terms of use agreed to in this contract.

1.2 The source code for the software is not part of the subject of this agreement.

1.3 The nature of the software delivered by the seller is subject to the service description valid at the time of the software being despatched and which was available to the buyer at the time of the contract being finalised. The service provided by the seller is not expected to exceed this.

1.4 The general business terms & conditions of the buyer are not a subject of this contract, not even when an offer request, order or declaration of acceptance is attached and/or not contradicted.

6.2. § 2 Conditions of Use

2.1 Once the buyer has paid the total amount, the seller grants him use of the **winLIFE** software. The conditions of use are for a single licence, valid for an unlimited length of time, and not sub-licensable.

2.2 The buyer may only use the **winLIFE** software for internal business purposes or for other companies within the same concern, according to paragraph 15 of the AktG. Commercial sub-leasing of the software is not permitted.

2.3 The buyer is only permitted to copy the **winLIFE** software if this is necessary for use according to the contract. The buyer may make safety backup copies of the **winLIFE** software as necessary according to technical standards. Backup copies on mobile data storage media must be labelled as such and endorsed with the copyright of the original data storage medium.

2.4 The buyer is only permitted to make changes, extensions and other alterations to the **winLIFE** software as allowed by law according to paragraph 69c No.2 of the UrhG. The buyer is not permitted to execute his own rights and conditions of use other than stated in this contract.

2.6 Should the seller permit the buyer to make improvements or carry out maintenance on alterations (eg patches, alterations in the user instructions) or create a new version of the winLIFE software (eg update, upgrade, new user instructions) which replace former objects of the contract, then these alterations or new versions will also be subject to the rules of this contract.

2.7 If the seller produces a new version of the winLIFE Software then the seller's authorisation regarding the old winLIFE software in this contract becomes invalid as soon as the buyer uses the new winLIFE software. This is the case even when the seller does not explicitly demand the return of the old software. However, the seller allows the buyer a changeover period of three months in which both versions of the software can be used simultaneously.

6.3. § 3 Sales Price, Terms of Payment

3.1 The buyer purchases the rights of use as stated in the offer for the sales price also stated in the offer. The sales price complies with the offer on which this software sales contract is based. The buyer is only permitted to use the software according to the rights of use stated in this contract. Any other use requires prior consent in writing from the seller. In the case of multiple use without consent (in particular when the software is used simultaneously by a more users than agreed to) the seller has the right to invoice the additional use according to the seller's price list valid at that particular time unless the buyer can prove a lower sum of damage. This does not have any effect on other non-contractual compensation claims.

3.2 The sales price is due and must be paid in full when the software is delivered or provided.

3.3 In addition to the given price, VAT at the current rate must be paid.

3.4 The delivery prices include transport and packing for posted deliveries. For goods which are to be transferred on the net, the seller bears the costs of making the software accessible; the buyer bears the costs of the retrieval.

3.5 The ownership of surrendered copies remains subject to alteration until the payment has been made in full.

6.4. § 4 Installation, Training, Maintenance

4.1 When installing the **winLIFE** software, please read the installation notes included in the user documentation, in particular those regarding the hardware and software environment needed by the buyer. By installing the program onto his computer, the buyer commits himself to the terms of this contract. If the buyer does not agree to the terms, then the CDs and all other documentation is to be returned immediately. The purchase price will then be reimbursed from where it was purchased.

4.2 At the buyer's request the seller will assume the training and maintenance of the **winLIFE** software based on a separate contractual agreement and applicable price list. The seller is prepared to maintain the software based on the terms of a separate maintenance contract

6.5. § 5 Protection of Software and user documentation

5.1 Unless the buyer is granted specific rights within this contract then all rights regarding the **winLIFE** software (and all copies made by the buyer) – in particular the copyright, the patent rights and the technical protection rights – apply to the seller.

6.6. § 6 Transfer

6.1 The buyer is only permitted to pass the **winLIFE** software on to a third party provided he transfers the total product and renounces his own use of the software completely and finally.

6.2 A temporary transfer of the **winLIFE** software to a third party is not permitted either as a hard copy or otherwise.

6.3 If the buyer passes on data storage media, memory or other hardware on which objects of the contract (complete or partial, altered or edited) have been saved,

6.3.1 to third parties without being subject to a transfer according to paragraph 6 or

6.3.2 renounces his direct ownership hereof

then he carries the responsibility that the **winLIFE** software is completely deleted.

6.7. § 7 User Cooperation and Information Obligations

7.1 The buyer has informed himself of the essential function characteristics of the **winLIFE** software and carries the risk whether these are in accordance with his needs and wishes. If there is any doubt he should obtain qualified information from the seller.

7.2 It is the sole responsibility of the buyer to ensure that he has a working and – bearing in mind the additional storage requirements of the **winLIFE** software - sufficiently dimensioned hardware and software environment.

7.3 Before using it, the buyer is to test the **winLIFE** software extensively for its usage in the existing hardware and software configuration. This is also the case for software acquired within the framework of the guarantee.

7.4 The buyer is to make sufficient provisions for the case that the **winLIFE** software does not work properly, either wholly or partially (for example by making daily backups, error diagnoses, regular controls of the data results).

6.8. § 8 Time of Delivery and Performance, Acts of God

8.1 Unless otherwise agreed upon, the current version of the software will be delivered.

8.2 The seller delivers the goods according to his choice as follows:

8.2.1 He provides the buyer with (1) a copy of the software program on a computer-legible data storage medium, together with user documentation for each user according to section 2.1.

8.2.2 He makes the software available in a network where it can be retrieved and informs the buyer accordingly and provides user documentation for each user according to section 2.1.

8.3 The time of delivery and the passing of risk for material despatch are considered to be the time when the seller hands over the software and user documentation to the transport company. Otherwise it is the time when the software is made available in a network where it can be retrieved and the buyer is informed accordingly.

8.4 As long as the seller

8.4.1 is still waiting for cooperation or information from the buyer or

8.4.2 is delayed in his performance due to strikes or lock-outs in third-party companies or in the seller's company (in the latter case, however, only if the industrial action is legal), intervention through the authorities, legal bans or other circumstances that are no fault of his own (act of God).

then the times of delivery and performance are considered extended for the length of the hindrance ("time of non-use") and no breach of duty is regarded for the time of non-use. The seller is to immediately inform the buyer of such hindrances and their anticipated length. If an "act of God" continues continually for longer than three months then both parties are freed of their delivery duties.

6.9. § 9 Material and Warranty Defects, other Performance Failures, Statute of Limitations

9.1 The seller is liable for any material and warranty defects of the subject of agreement as in section 1.3 according to the terms and conditions of sale and for the fact that the buyer does not conflict the rights of third parties regarding the use of the subject of agreement to the extent of the contract.

The liability for the freedom of the subject of agreement by rightful third parties is, however, only valid for the country in which the subject of agreement is to be used, as agreed upon by the parties. Unless otherwise agreed upon, the country of liability is The Federal Republic of Germany.

9.2 In the case of material defect, the seller firstly provides supplementary performance. As decided by the seller, the buyer either receives new faultless software or the defect is corrected. A valid method of correction is also if the seller shows the buyer a reasonable possibility of correcting the failure.

In the case of legal defects the seller firstly provides supplementary performance. As decided by the seller, the buyer either receives a legally faultless possibility of use for the delivered subject of agreement or replaces it with an exchanged or altered subject of agreement of the same value.

9.3 The buyer is obliged to accept new software as long as its function remains the same and its acceptance does not lead to any considerable disadvantage.

9.4 If two attempts to provide supplementary performance fail, then the buyer is entitled to insist on an acceptable date for removal of defects. In doing so he must clearly and in writing state that he has the right, should the supplementary performance again be unsuccessful, to withdraw from the contract and/or demand compensation.

If the error cannot be corrected even in the period of grace, the buyer can withdraw from the contract or reduce the payment unless the failure is a "petit" failure. The seller is liable for compensation or replacement of correction measures carried out in vain within the limits stated in section 10.

9.5 If there are claims made by third parties which deter the buyer from assuming his rights of use as stated in the contract then the buyer is to inform the seller immediately and completely in writing. Herewith he authorises the buyer to dispute the matter with the third party either in court or out of court.

The seller is obliged to defend the claims at his own cost and to release the buyer from all costs and damages relating to the defence of the claims as long as these are not caused by his lack of duty.

9.6 The limitation period for all guarantee claims is one year beginning with the delivery or moment when the subject of agreement is made available. The same period is valid for other claims, of whatever manner, against the seller.

9.7 In the case of malice intent or gross negligence on the part of the seller, or in the case of fraudulent concealment regarding a fault, in cases of personal injury or legal faults as in § 438 Abs. 1 a BGB, and in guarantees (§ 444 BGB) the legal limitation period is valid. This also applies for claims according to the Product Liability Law.

6.10. § 10 Reliability

10.1 For all cases of contractual and ex-contractual reliability, the seller provides compensation only within the following limits:

10.1.1 In cases of intent totally, also if there are errors in the configuration guaranteed by the seller.

10.1.2 in cases of negligence only for the amount of the foreseeable damage caused by the negligence.

10.1.3 in other cases only to the extent of the typically foreseeable damage. If the typically foreseeable damage is higher than the purchase price of the **winLIFE** software for one damage case, then the buyer is obliged to inform the seller within 2 weeks of finalising the contract. In this case the seller has the right to withdraw from the contract unless a liability limit has otherwise been agreed to.

10.2 The liability limitation according to paragraph 10.1 does not apply to the liability for personal damage and for the liability according to the product liability law.

10.3 The seller is at liberty to raise objection to the contributory negligence (e.g. as in paragraph 7).

10.4 The statute of limitations is according to paragraph 9.6. The legal statutes of limitations apply to claims according to paragraphs 10.1.1 and 10.2. The statute of limitations for Part 1 begins at the time stated in paragraph 199 No.1 of the BGB. This comes into account at the latest at the event of the statutory period stated in paragraph 199 Nos.3 and 4 of the BGB.

10.5 As long as the liability according to these terms is excluded or limited, then this also applies for the personal liability of the organisation, the staff, representatives and sub-agents of the seller.

6.11. § 11 Secrecy, Data Protection

11.1 The parties of the contract are obliged to treat all the other party's confidential information and company trade secrets which come to knowledge during the initiation and implementation of the contract confidentially for an unlimited period of time. These are only to be used for the implementation of this contract. The subject(s) of agreement and the performance agreed to in the contract are also matters which are included in the seller's company trade secrets.

11.2 The buyer may only allow staff and other third parties access to the subject of agreement as long as this is necessary for the execution of the authorisation of use agreed to.

11.3 The above mentioned obligations are not valid for company trade secrets which

11.3.1 were already obvious or known to the other party at the time of conveyance.

11.3.2 became obvious after the time of conveyance through the contractual partner through no fault of the other contractual party.

11.3.3 became known to the other contractual party after conveyance by the contractual partner by a third person in a manner which is not illegal and without limitation in regard to secrecy or usage.

11.3.4 which have been developed by one of the contractual partners independently without using the trade secrets of the contractual partner.

11.3.5 which must be made public according to the law, authoritative decision or court order – providing the party releasing the information informs the contractual partner hereof immediately and supports him in the defence of such decisions or orders; or

11.3.6 as long as the contractual partner is permitted to use or pass on the trade secret due to urgent legal conditions or as a result of this contract.

11.4 The seller is to adhere to the rules of data protection, in particular when he is granted access to the buyer's company or to his hardware/software

6.12. § 12 Final Clause

12.1 Exclusive Place of Jurisdiction for all disputes relating to or resulting from this contract is the seller's business location. If the seller has a claim, he is also entitled to choose the Place of Jurisdiction and the buyer's business location. The right for both parties to apply for preliminary injunction legal protection from a court legally responsible remains untouched.

12.2 Only German law applies excluding UN-purchase laws (CISG).

12.3 The completion of the contract as well as any later alterations and additions must be in writing to be effective. That is also the case for changing this clause. It does not apply to verbal subsidiary agreements. All declarations by the parties are to be in writing.

12.4 Should a condition of this contract be or become invalid, or if there is an invalid time period or a gap, then the legality of the other conditions remains untouched hereby. As long as the invalidity does not violate §§ 305ff. BGB (Validity of General Business Terms and Conditions) then instead of the invalid condition, a valid condition is agreed to which is nearest to that intended by the parties in a commercial sense. The same applies in the case of a gap. In the case of an unacceptable period, the legally acceptable period becomes valid. If there is a violation to §§ 305ff. BGB then the parties shall find an amicable solution in terms of paragraph 2.

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