



## winLIFE BASIC 2.3

This module is needed for the following additional programs

- winLIFE MULTIAXIAL and
- winLIFE GEAR WHEEL AND BEARING

## Getting Fatigue Material Data

### Creating a S-N-Curve from component and static material data

S-N Curves for the nominal stress method can be created for metal materials according to the FKM-guideline or other authors. An S-N-curve is created based on static material data, data of the component (notch effect factor, treatment of the material, surface, etc.).

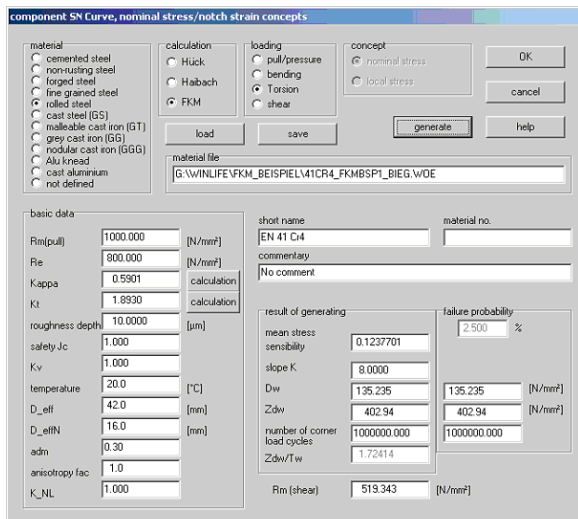


Figure 2: Mask to create the S-N-curve

Figure 2 shows the mask to create such an S-N-curve. The material data can be partially modified by the user. In many cases the user knows only some data from test results and he wants to create the unknown data. So he can use winLIFE to generate the data and then overwrite the values he knows.

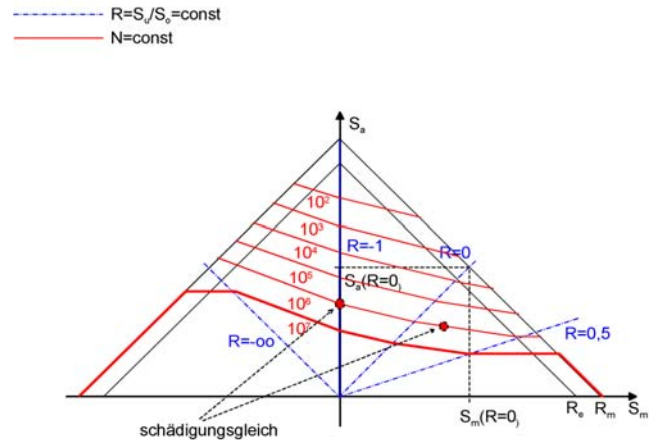


Figure 3: Haigh diagram showing the relation between stress amplitude, mean stress and fatigue life

As well as the S-N-curve, winLIFE uses the presentation in Haigh-diagram, because the influence of mean stress can be seen more evidently (Figure 3).

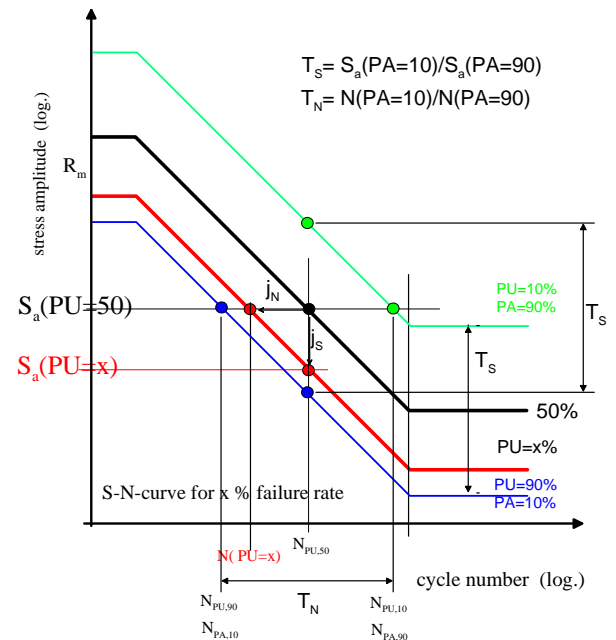


Figure 4: based on a 50% fatigue life curve winLIFE can create curves with other failure rates. These may have different scatter ratios in the endurance and finite life fatigue strength range.

If the failure rate for an analysis is of importance, the user can derive from a 50% S-N-curve other failure rates. winLIFE considers different scatter rates in the endurance range and the range of finite life fatigue strength.



## Creating a S-N-curve for welded structures

You can calculate welded structures as suggested in the FKM-Guidelines. The analysis is carried out in a similar way to the Nominal Stress Method. You need to classify the welded structure and according to the class a catalogue of S-N-curves exists.

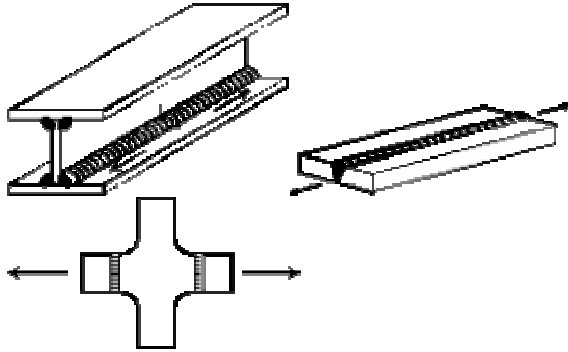


Figure 5 Types of welded components to be selected by the user

The winLIFE S-N-curve generator helps you to establish such a curve.

This is a relatively approximate procedure for a first step. To improve the results you can calculate the welded structure according to the elastic stress or local stress approach using a FEA analysis, where the geometry of the weld has to be modelled in detail.

## Creating e-N-Curve

If you wish to use the Local Strain Approach, the program provides various possibilities for creating cyclic material data (Uniform Material Law etc.). The Figure 6 shows the mask for entering input data. Only static material data is entered and based on this an estimation of the e-N-curve is created. The surface and – if no FEA is used – the notch effect factor are used.

winLIFE is delivered with about 100 material data. For registered winLIFE-users with a support service contract a data base in the Internet is available which contains a lot of common material data records. The data is taken from literature, winLIFE customers who gave permission for publishing. The support contract

enables the user to download 10 records of material data. For a small fee additional data can be downloaded.

Figure 6: Mask to create the e-N-curve

## Using an Internet Material Data Base

Figure 7: Mask including a record of the Internet Material Data Base (One additional site show details such as name and chemical composition, another site the source and author)

## Obtaining Loadings

To perform a fatigue calculation a loading is needed. This can be a measured load versus time or a load spectrum.

## Defining a load spectrum

A load spectrum consist of cycles, which must be defined by

- mean load,
- load amplitude
- and number of cycles.

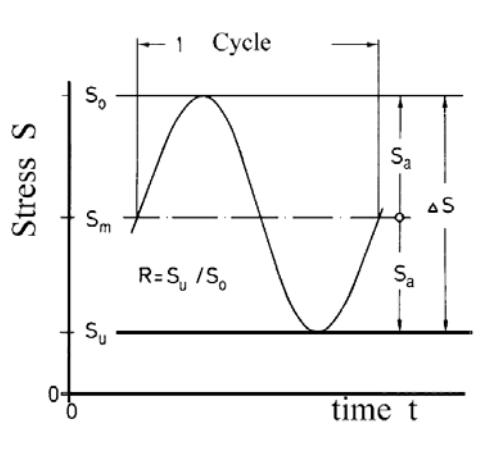


Figure 8: Definition of a cycle

The experiences in various areas of science show that there are different types of load spectra, which can be simply defined. Publications in automotive industry, aerospace or wind energy systems show what kind of load spectrum is acting in a problem such as this. If you have this information the winLIFE spectrum generator allows you to create very fast load spectra. Figure 9 shows three basic types of load spectra.

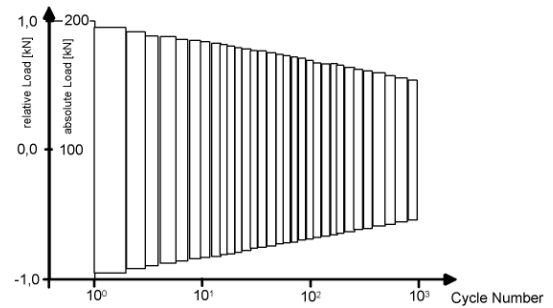
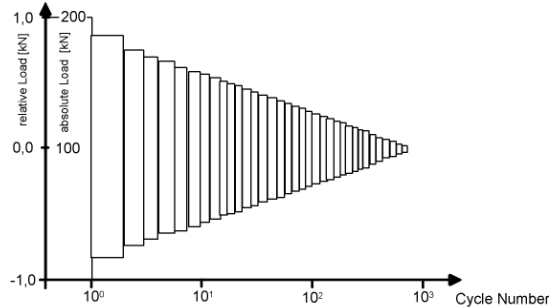
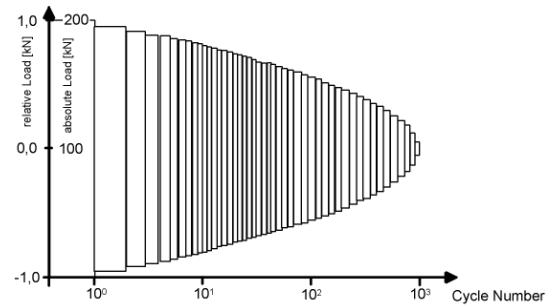


Figure 9: examples for different load spectra, generated by the built-in generator (top: normal distribution, middle: linear distribution ( $n=1$ ), bottom:  $p$ -spectrum)

## Using Load histories

Another way is to use a loading history (stress, moment, force) which is normally obtained from a measurement (Figure 10), in special cases the user can type the data in manually. A data-import from other programs is usually possible without any problems. The length of time history is only limited by the disk space.

Interactive data input and data modification for load spectra, load histories and rainflow-matrix is possible by marking the range in the graphic account and modifying comfortably by use of mouse or keyboard.

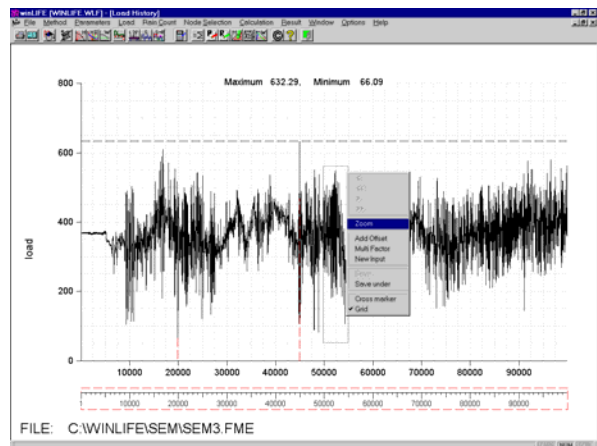


Figure 10: Measured load history



STEINBEIS TRANSFER CENTER  
NEW TECHNOLOGIES IN TRAFFIC ENGINEERING

The winLIFE Program uses the Rainflow method as is usual when calculating fatigue life. The rainflow matrix only contains the signal parts relevant to the damage (Figure 13)

winLIFE shows the results of the damage calculation in the rainflow matrix in colour. The critical signal parts are therefore immediately obvious.

If the local concept is used, the stress- strain paths from the rainflow matrix are calculated and shown in a graph (Figure 15). The total damage is obtained by adding together the damage proportions (linear damage accumulation hypothesis).

---

## Fatigue Life Calculation

### Using FEA

winLIFE can import data from FEA and use it for the fatigue calculation. In this case the local stresses and further conditions of each node are considered.

Because, generally speaking, not all the nodes of a structure are endangered - the damage usually begins on the surface - the user can select nodes for the fatigue life calculation according to various criteria. By doing this, the number of nodes to be examined can be substantially reduced and the calculation time shortened accordingly.

Macros are supplied with winLIFE so that data can be transferred from FEA-Programs. The results from winLIFE, i.e. the damage for each individual node, can be shown by the FEA-program in colour. A separate colour is used for each different range of damage. The FEMAP user-interface is available for all data transactions between winLIFE and NASTRAN Users will therefore have no difficulties using this program.

You can use winLIFE in collaboration with the following FEA-codes:

- FEMAP-based programs (MSC.NASTRAN, NEiNASTRAN , NX.NASTRAN)-
- IDEAS
- SAMCEF

The interface to FEA is described in detail and many users wrote their own interface. Successful links to MEDINA, ANSYS and other programs were achieved.

In a short description the fatigue calculation procedure is shown. Figure 11 shows part of a truck suspension which is loaded dynamically by a force (Figure 12). Because of the symmetry only half of the part is analysed.-



Figure 11: component of a truck suspension, which was used to predict fatigue life

In the first step a static FEA calculation is used to ascertain the stress within the component. For this purpose the state of stress is calculated in a structure which is subjected to a standard load  $F_0$ . The direction of the standard load must correspond to the acting force  $F(t)$ .

The elastic stress for each load  $F(t)$  can then be calculated in a linear way corresponding to the quotients  $F(t)/F_0$ . If, for example, a force  $F(t)$  exists as shown in Figure 12, then the stress within a component can be calculated for any required moment. In the case of local concept, there is an actual stress-strain curve. This means that the actual stress path for each node, including plastic deformation can be calculated using Neuber's rule.

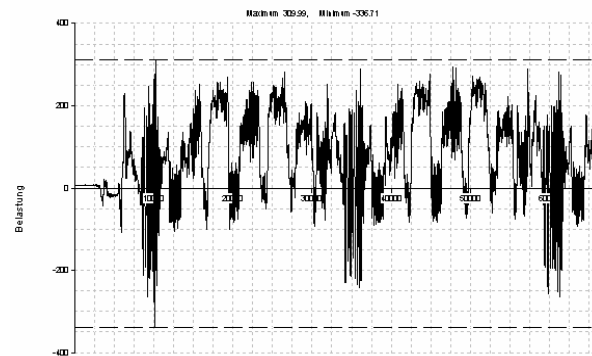


Figure 12: Loading of the component versus time

The loading (Figure 12) was obtained from a measurement made on a test drive. winLIFE makes a rainflow count of the loading as shown in Figure 13.

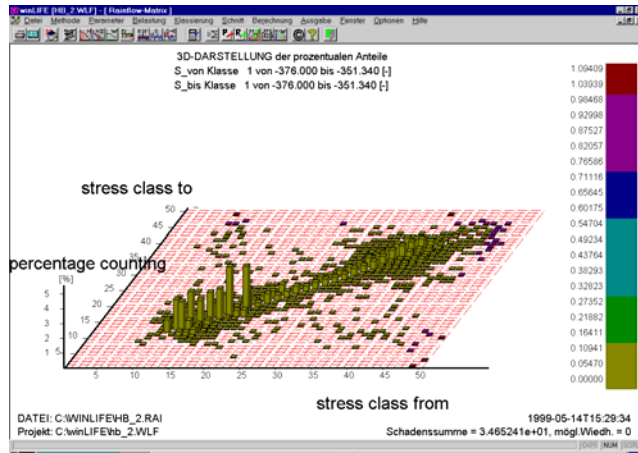


Figure 13: Rainflow Matrix

The Material data for fatigue analysis are the cyclic properties (Figure 14) and the damage parameter life curve (Figure 1.)

From the rainflow count and the cyclic properties the stress-strain-path is calculated (Figure 15). Based on the counting and the damage parameter life curve (Figure 16) a damage sum is calculated for each node of the structure. The results are shown as a map on the structure.

Beside the Local Strain Approach shown here, it is possible to use stress based methods using S-N-curves.

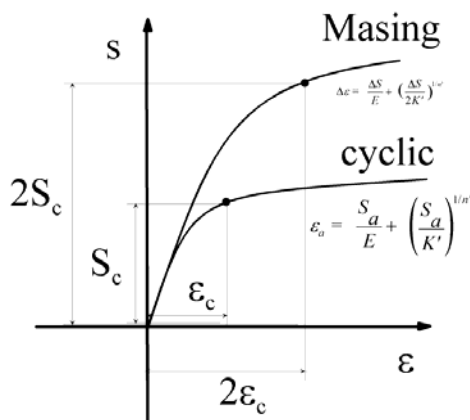


Figure 14: cyclic stabilized material properties

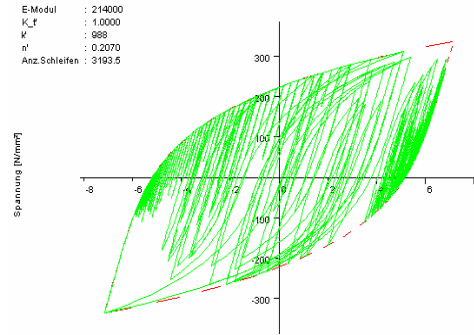


Figure 15: stress-strain path calculated from the rainflow matrix for the critical node

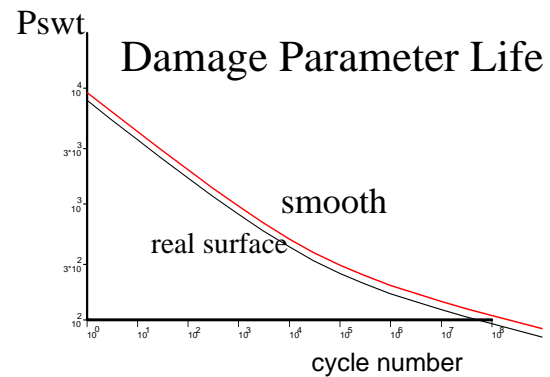


Figure 16: Damage Parameter Life Curve according to Smith Watson and Topper

### Without FEA

If no FEA is used the calculation is done only for one point – typically the notch. The information about the geometry and the relation between stress and load now must come from the user. This means he has to enter the notch factor, stress gradient, surface, etc.

A fatigue life calculation without FEA can be carried out by the two classic methods - Nominal Stress Method and Local Strain Approach.

With the Nominal Stress Method, various hypotheses can be used to consider the fatigue limit (original, modified according to Haibach, elementary, Liu and Zenner). Figure 17 shows these possible hypotheses.

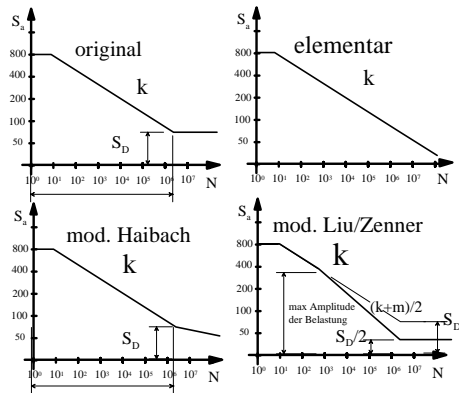


Figure 17: possible hypotheses available in winLIFE

If the calculation is done according to the Local Strain Approach, this is done similarly to the procedure using FEA.

## Addition of different calculation results

Assume you are developing a car which runs on different road types. You have measurements of each road and fatigue calculations for each road for the measured length.

Customers use on the road types will be different in length from that which you have measured. You can now transform the fatigue results from your measured road length to the other length of customers use and you can add the damage sum for the total length of all road types.

By adding a weight factor, winLIFE adds together the results of different calculations for each node.

## Data Handling and Correction

If measured data is used in many cases a data correction is needed. A lot of faults occur and in the first step the user has to check the data. With winLIFE the data can be checked and corrected in a simple interactive manner.

You can modify load histories and load spectra in the following way:

- - find and remove Spikes
- - select data and multiplying, adding or overwriting them

Additionally you can modify the number of cycles in a rainflow matrix. This helps to check the results too.

## Presenting and analysing the results

All common graphics in result presenting are available, such as:

- Rainflow-Matrix
- Range Mean Pair Count
- Level Crossings
- S-N-Curve together with the load spectrum and percentage damage
- Haigh-diagram including the loads as points
- Protocol file including the results for each node

## Report Generator

The report generator enables the user to print without individual steps such as opening the graphics. The report generator makes it easier to document a project using only a few work steps. For each method an individual collection of graphics can be selected as shown in the following mask for the Nominal Stress Method. Only one mouse click is needed to create a printout or a PDF-file.



**STEINBEIS TRANSFER CENTER  
NEW TECHNOLOGIES IN TRAFFIC ENGINEERING**

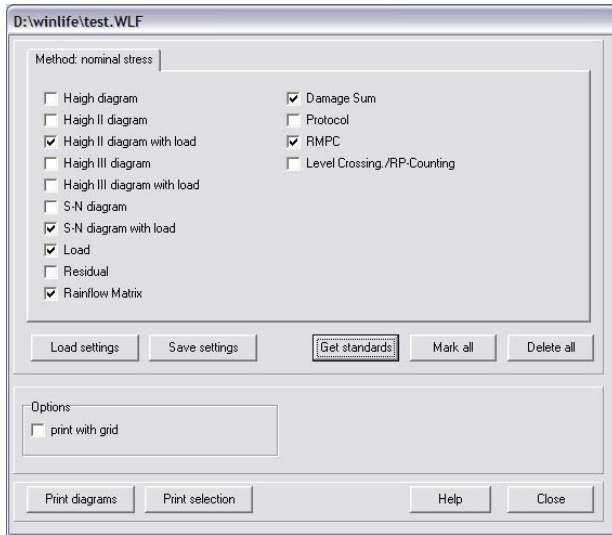


Figure 18: Input mask for the report generator

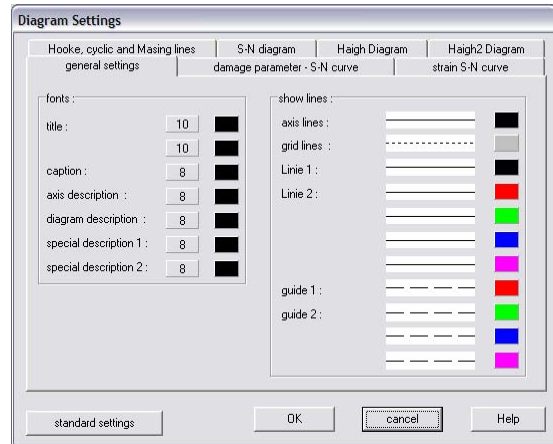


Figure 19: Input mask for diagram settings

### Individual Scaling and designing of Graphics

For each diagram special settings of colour and line type are possible. To perform this click the required kind of diagram in the mask below and a further mask opens where the settings can be entered.

For each graphic you can select the

- Font size
- Line colour
- Line type
- range of axis

### Units

Internal Calculation in winLIFE is always done using the following units

length	[mm]
force	[N]
strain	[‰]
stress or pressure	[N/mm <sup>2</sup> ]
RPM	[1/min]
torque	[N/m]

If the user wants to define his own units, he has to enter the conversion factor for every unit.

winLIFE is shipped with 2 files containing conversion units:

The default units are ISO-standards

- <Default.unt> : All conversion units are 1:
- units: [mm], [N], [‰], [N/mm<sup>2</sup>]

In the US you will use other units which are in the following file stored.

- <PSI.unt> :
- units: [in], [lbf], [‰], [lbf/in<sup>2</sup>]





---

## Contact

Steinbeis Transfer Center  
New Technologies in Traffic Engineering  
Prittwitzstr. 10  
89075 Ulm  
Germany  
Phone +49 (0) 7325 3306  
www.stz-verkehr.de

---

## Publications

[15] Willmerding, G.:

Fatigue calculation of dynamic loaded structures using winLIFE; Vortrag auf der MSC/Tagung in Malta September 1997.

[17] Willmerding, G.:

Lebensdauerberechnung einer dynamisch belasteten Kupplung, Vortrag auf der MSC/Anwenderkonferenz am 18. und 19. Juni 1998 im Kloster Andechs, Herausgeber Mac Neal Schwendler Corporation, München

[19] Willmerding G.:

Vorhersage der Lebensdauer dynamisch belasteter Bauteile durch Kombination von Lebensdauerberechnung mit Finite Element Methode, Vortrag Nr. 14 auf der Tagung Fahrwerk-Tech 99 Adaptive Fahrwerksysteme, 4-5. März, München, Tagungsunterlagen TÜV-Akademie München.

[20] Willmerding, G.:

Lebensdauerberechnung dynamisch belasteter Bauteile für den multiaxialen Fall in Kombination mit Mehrkörperdynamik und Finite Element Methode, Vortrag auf der MSC/Anwenderkonferenz am 21. und 22. Juni 1999 in Weimar, Herausgeber Mac Neal Schwendler Corporation, München

[22] Willmerding, G.; Häckh, J.; Berthold, A.: Driving Cycle, Load and Fatigue Life Predictions based on measured Route Data, Vortrag auf der ATT-Tagung in Barcelona 2001, SAE-Paper 01ATT120

[23] Häckh, J.; Willmerding, G.; Kley, M.; Binz, H.; Körner, T.: Rechnerische Lebensdauerabschätzung von Getriebegehäusen unter Einbeziehung realer multiaxialer Belastungen, DVM-Tagung Fulda vom 5. bis 6.6.2002, VDI-Berichte N2. 1689, 2002 Seite 303 - 317

[24] Körner, T.; Depping, H.; Häckh, J.; Willmerding, G.; Klos, W.: Rechnerische Lebensdauerabschätzung unter Berücksichtigung realer Belastungskollektive für die Hauptwelle eines Nutzfahrzeuggetriebes, DVM-Tagung Fulda vom 5. bis 6.6. 2002, VDI-Berichte N2. 1689, 2002 Seite 275 - 285

[25] Körner, T.; Depping, H.; Häckh, J.; Willmerding, G.: Fatigue Life Prognosis for Transmissions based on critical Component Spectrum, World Automotive Congress FISITA 2002, Helsinki, Paper Nr. F02V091

[26] Willmerding, G.; Häckh, J.; Schnödewind, K.: Fatigue Calculation Using winLIFE, NAFEMS-Tagung Wiesbaden 2000.

[29] Häckh, J.; Klos, W.; Willmerding, G.: Bestimmung der Lastkollektive von Nutzfahrzeugen durch Kombination von Messung und Simulation, Vortrag auf der Tagung „Simulation von Fahrzeugantrieben, Augsburg 1.3.2005 bis 2.3. 2005