

Bearing reliability calculation

System level bearing life vs. reliability, KISSsoft
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1 Document information

1.1 Document change record

Revision	Date	Author	Comments
0	15.5.15	HD	Original document

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1.3 References

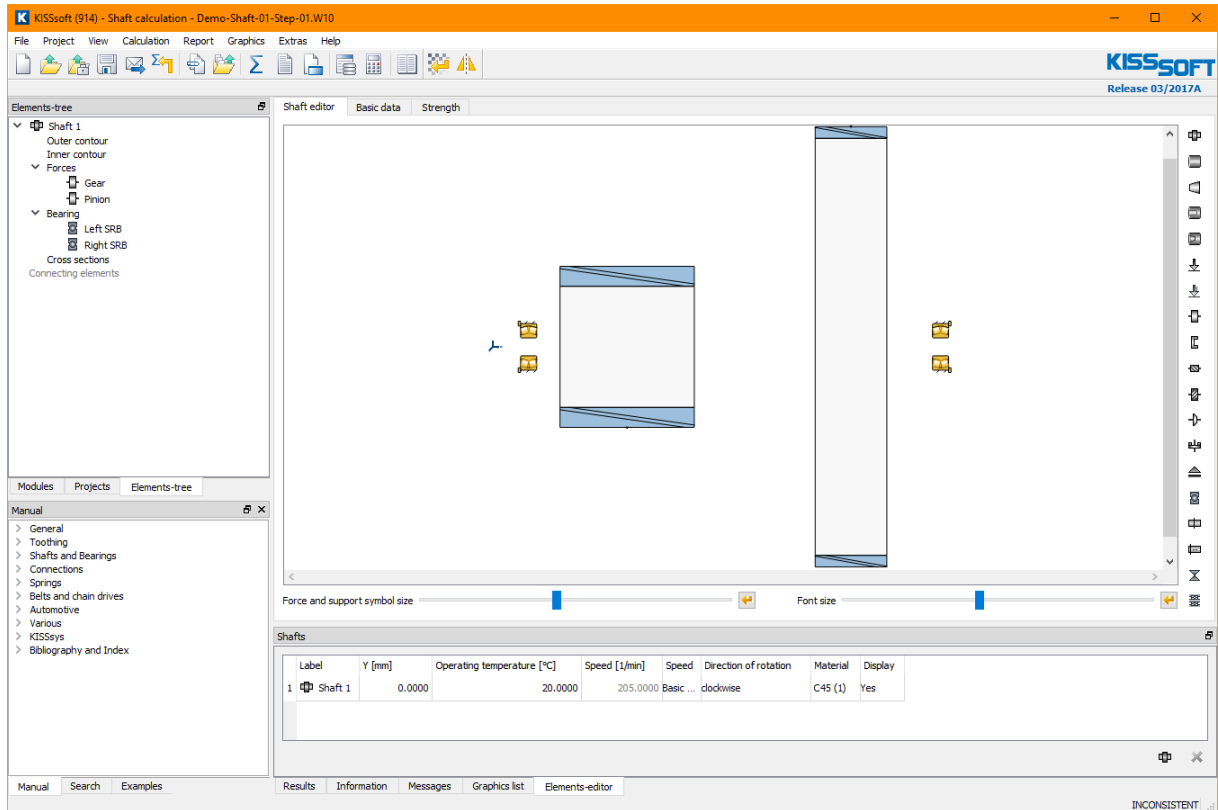
[1] KISSsoft 03-2017A

2 Bearing reliability of a industrial gearbox shaft

2.1 Basic model of shaft

Let us use two SRB, a pinion and a gear on the shaft.

The shaft has a speed of 205Rpm and a power of 400kW is transmitted.



Change the shaft material to 18CrNiMo7-6. Either in the table shown below:

Label	Y [mm]	Operating temperature [°C]	Speed [1/min]	Speed	Direction of rotation	Material	Display
1 Shaft 1	0.0000	20.0000	205.0000	Basic ...	clockwise	18CrNiMo7-6	Yes

Or in the element editor

Elements-editor	
Label	Shaft 1
Drawing number	Input...
Position in global system	Y 0.0000 mm
Operating temperature	T 20.0000 °C
Ambient density	ρ 1.2000 kg/m ³
Speed	n 205.0000 1/min <input type="checkbox"/>
Direction of rotation	clockwise
Material	18CrNiMo7-6, Case-carburized steel, case-hardened

See file "Demo-Shaft-01-Step-01.W10"

2.2 Shaft rough sizing

Use the shaft rough sizing function with the below settings:



K Rough sizing

General data

Equivalent stress σ_v 200.0000 N/mm²

Change only cylinder diameters

Rolling bearings

Consider bearings in sizing

Required service life N_i 20000.0000 h

Match shaft diameter to bearing bore

Use bearing types as defined in model

Move bearing if needed

OK Cancel

A message appears

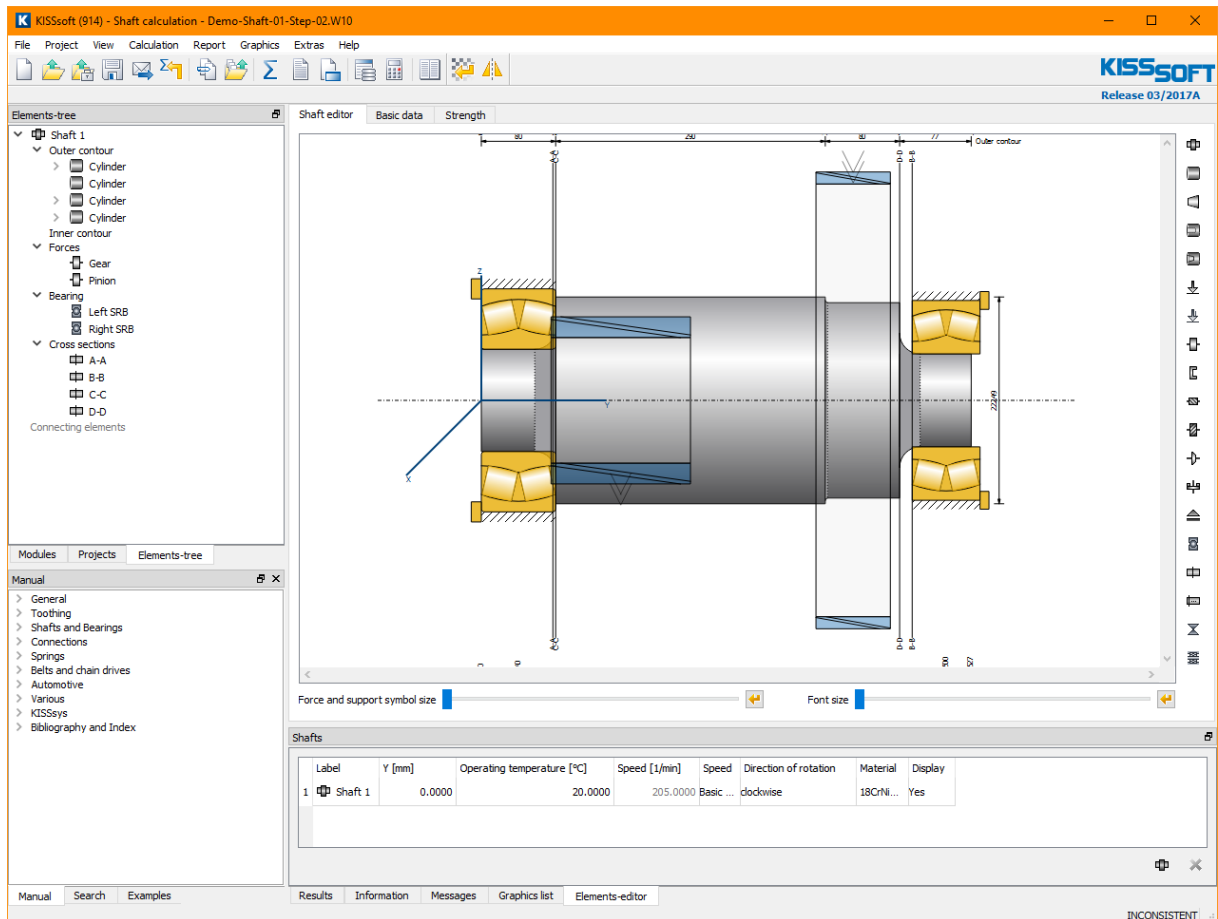
K Progress of calculation

Error in message ressources. Invalid ID (2/2)

70%

Abort

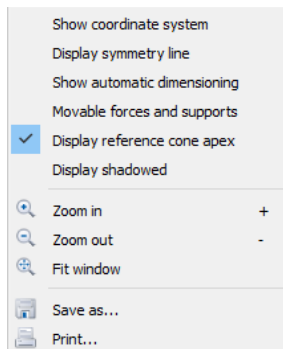
The proposed shaft and bearing geometry is then:



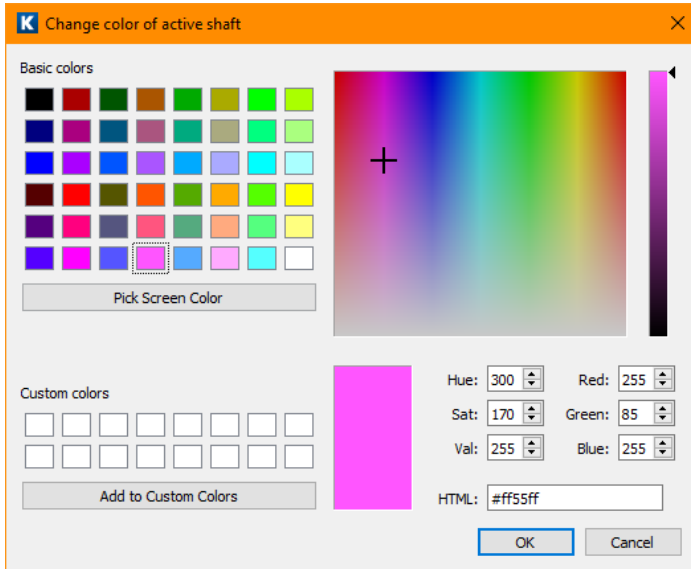
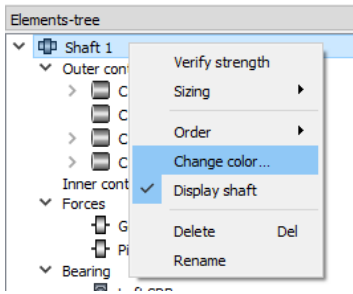
See file "Demo-Shaft-01-Step-02.W10"

To work faster, change the display by removing

- Symmetry line
- Coordinates system
- Shaded view

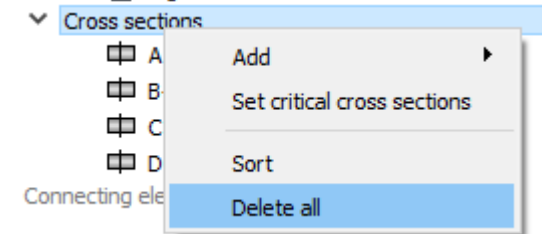


Change the shaft color to something more pleasant:



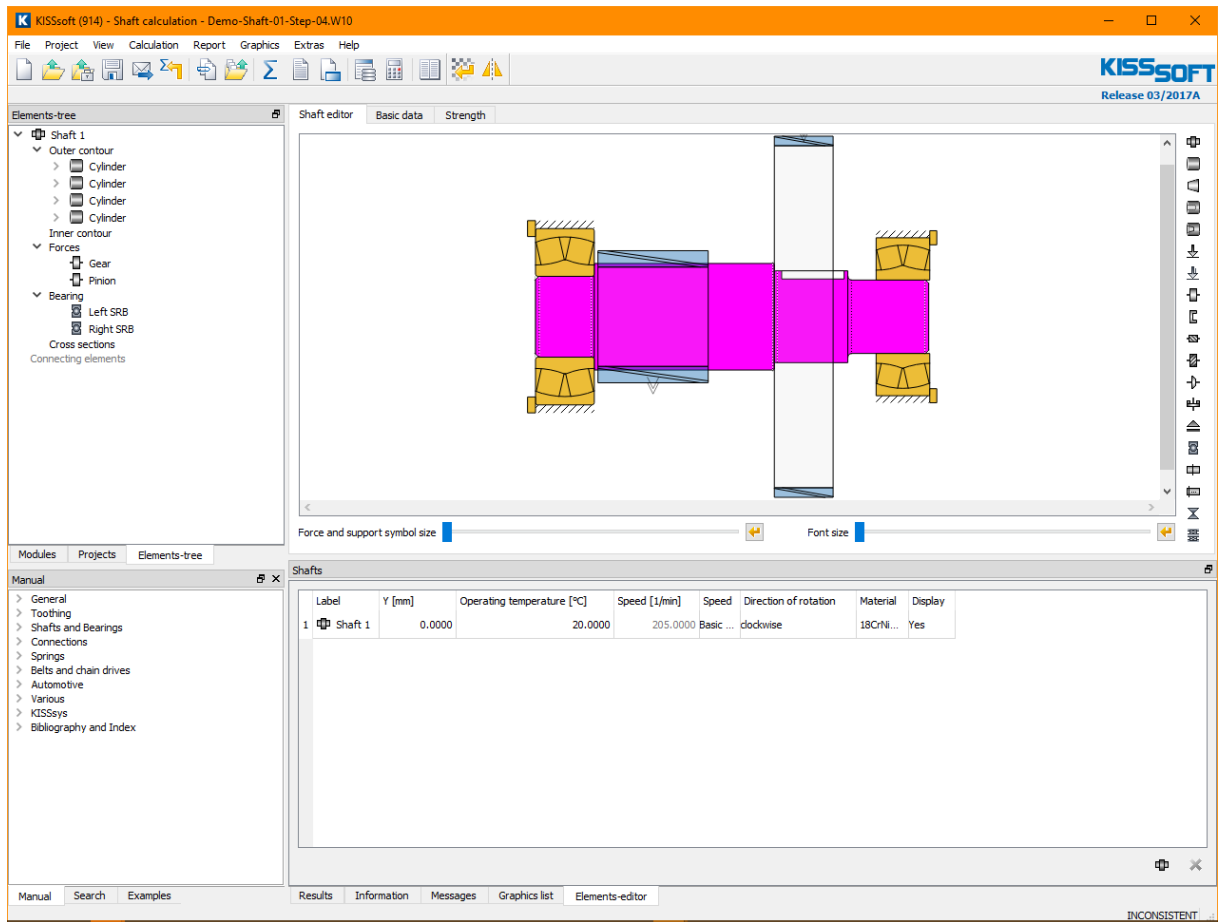
See file "Demo-Shaft-01-Step-03.W10"

Delete the cross sections A-A to D-D as we do not need them right now.



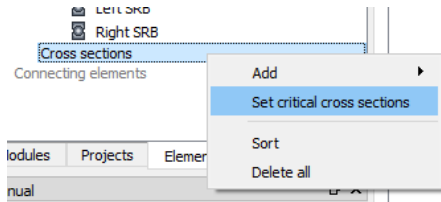
2.3 Finalizing the shaft model

Change the shaft elements diameter and length to get a more reasonable design. Move the gear and the pinon accordingly. Add relief grooves and others.



See file “Demo-Shaft-01-Step-04.W10”

For the strength rating of the shaft with the changed geometry, select:



2.4 Calculation of the shaft

Finally, run the calculation. You will see

- The critical shaft cross sections A-A to F-F
- The bearing life > 20'000h
- The shaft safety factors > 1.20

Results

Results	Value
maximum deflection	151.04 μm
maximum equivalent stress	132.08 N/mm ²
minimum bearing service life	20144.48 h
minimum static bearing safety	5.23
minimum fatigue safety	1.22
minimum static safety	3.04

Safeties	Fatigue	static	Results [%]	static
A-A	1.22	3.34	101.43	278.22
B-B	1.25	3.04	104.39	253.23
C-C	2.14	6.00	178.26	500.26
D-D	2.18	4.33	182.04	360.86
E-E	2.44	6.63	203.51	552.83
F-F	2.69	3.34	224.54	278.18

Bearing service life	S0	Ln
Left SRB	5.23	20144 h
Right SRB	5.98	20253 h

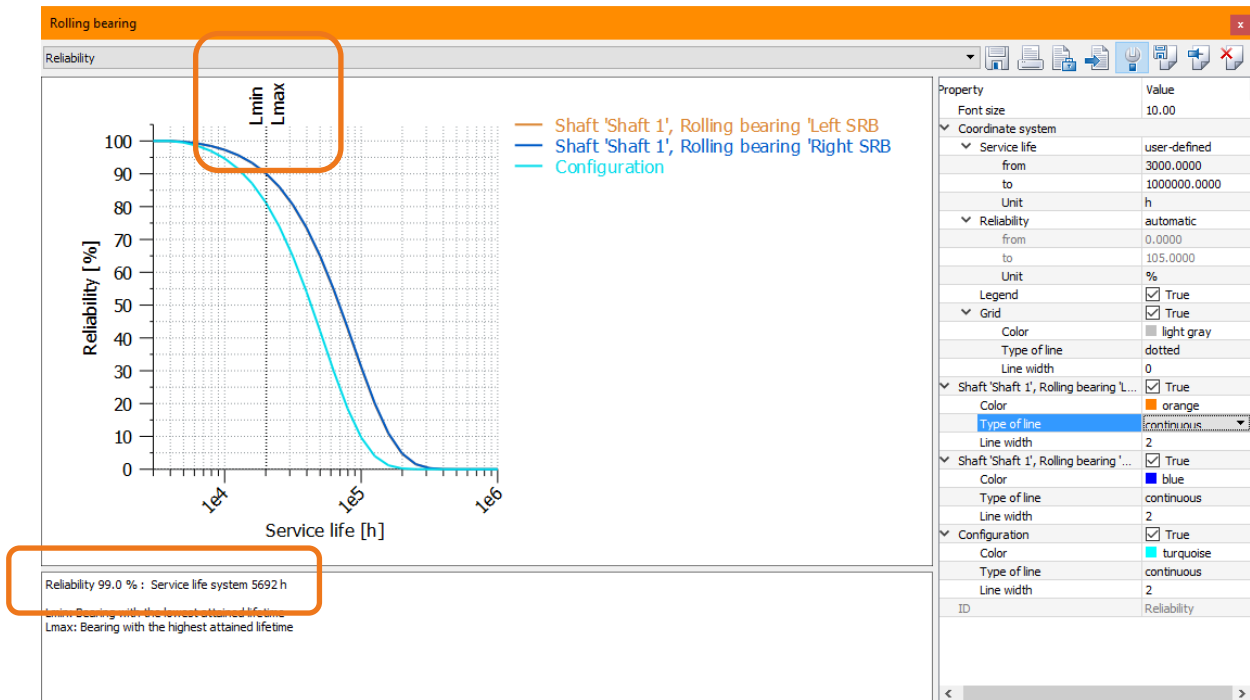
See file "Demo-Shaft-01-Step-05.W10"

2.5 Bearing reliability

Go to the below shown graphic

Graphics

- Shaft
- Tooth trace modification
- Rolling bearing**
 - Reliability**
 - Load distribution
 - Deformation (elastic rings)
 - Stress distribution on raceway
 - Stresses beneath the contact area
 - Pressure curve
 - Pressure curve for each rolling body
 - Stiffness curve
- Close
- Settings

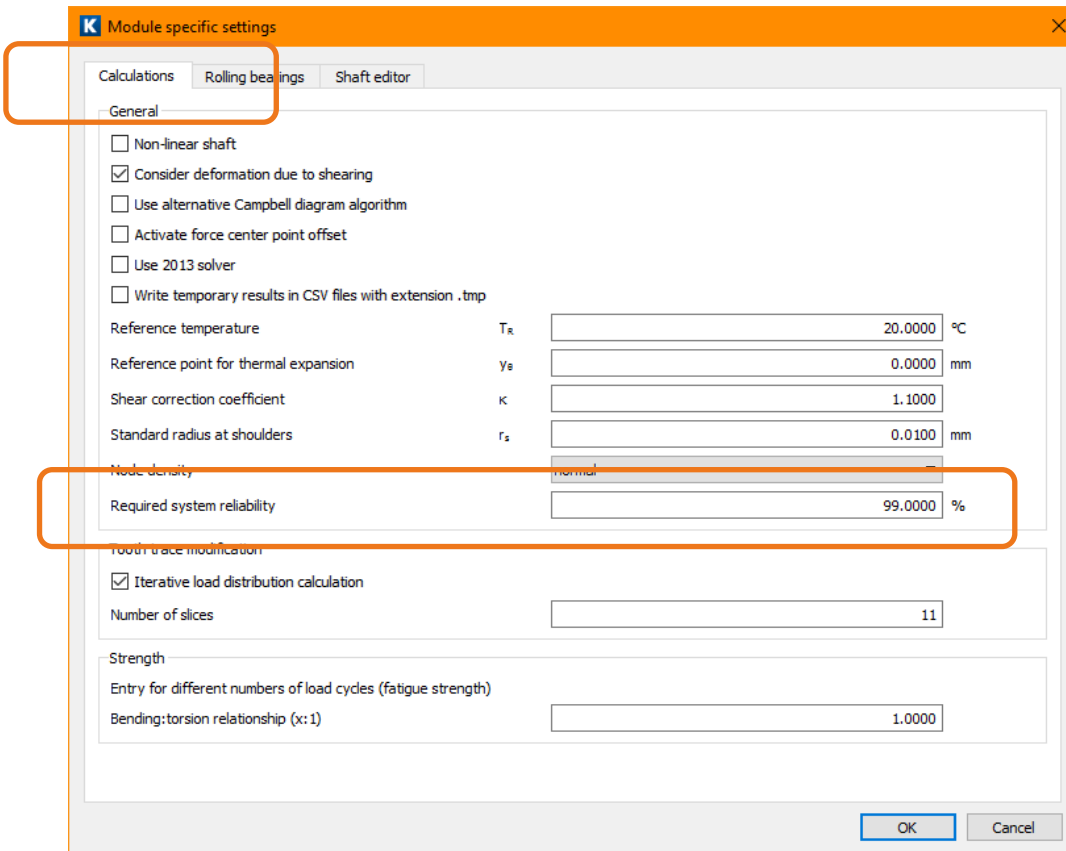
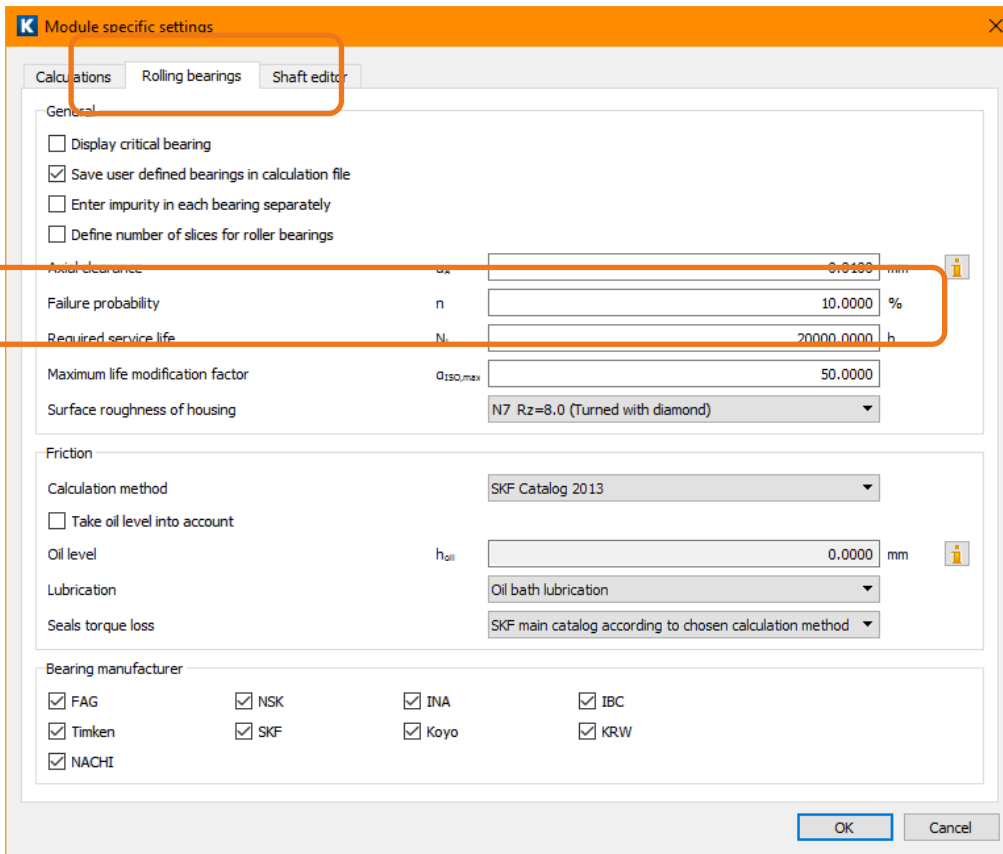


Note

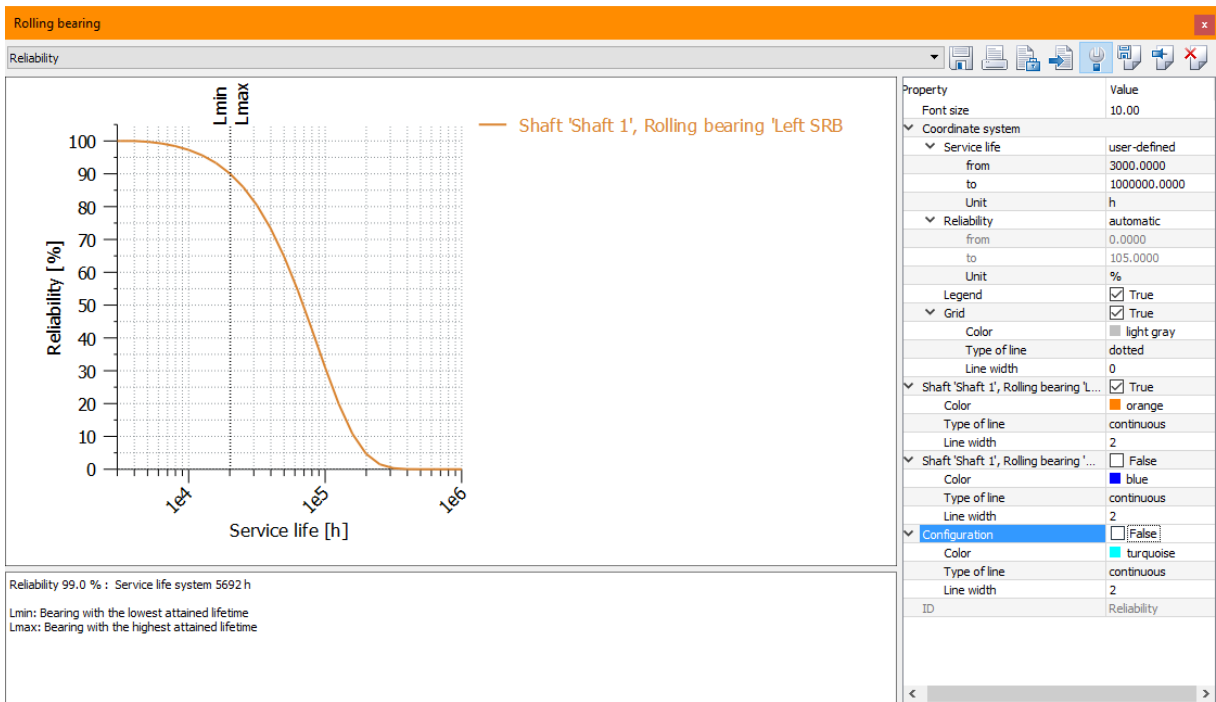
- Set the x axis to 3'000h ... 1'000'000h
- Recommended line width is 2
- Activate grid and legend
- The two reliability lines for the two bearings are almost identical because the two bearings have almost identical life.

Explanations

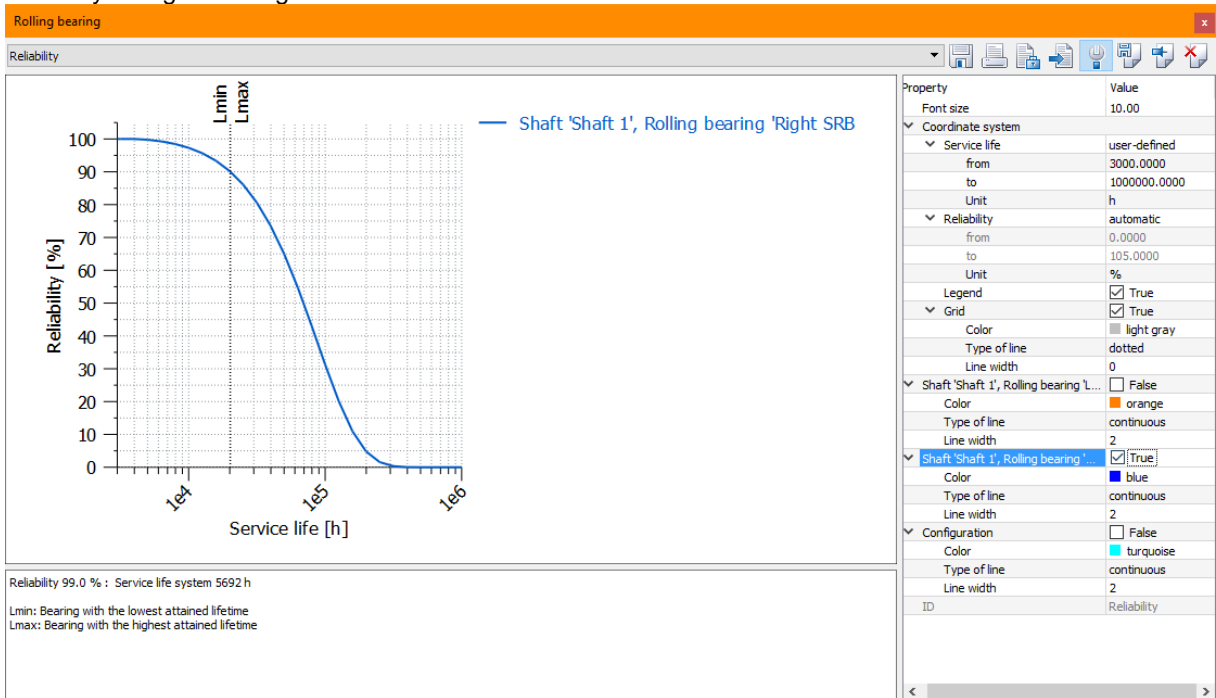
- Lmin is the achieved lifetime for the failure probability as defined in the module specific settings (by default, this is 10% or 90% reliability):
- The system reliability is currently 99% and then, a life of 5692h results. The system target reliability can be defined in the module specific settings as shown below



Only reliability curve for left bearing shown



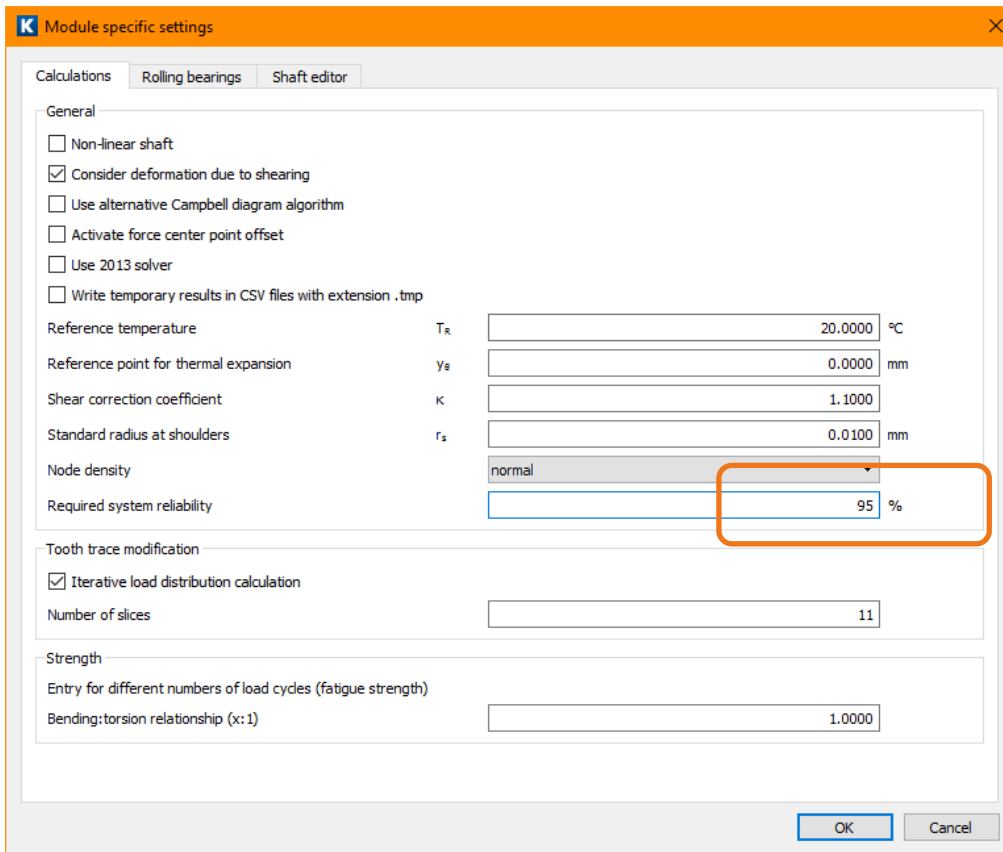
And only for right bearing



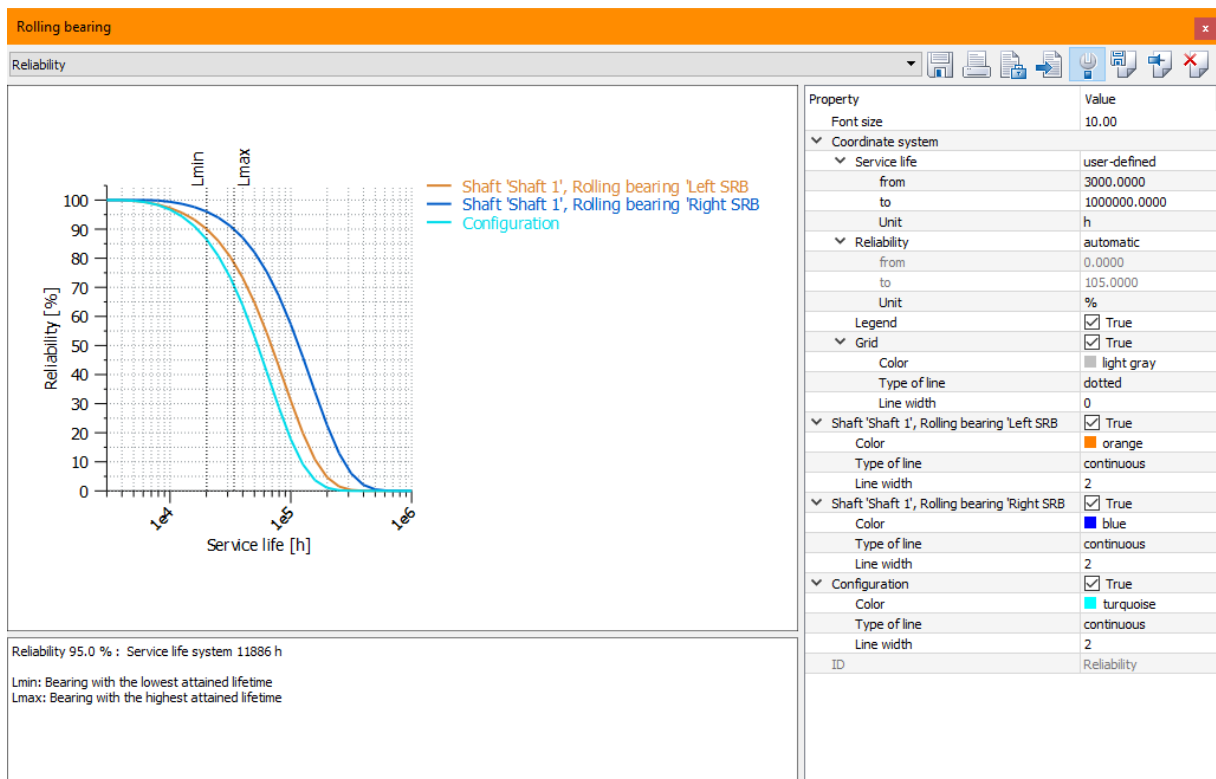
2.6 Variation of bearing reliability

Let us define that we want a system reliability of 95%.

And for some reason, let us use a bearing on the right side with a higher inner diameter



We then find the system life at reliability of 95% at 11'886h and the below reliability curves.

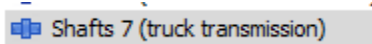


See file "Demo-Shaft-01-Step-06.W10"

3 Bearing reliability of a complex vehicle transmission shaft system

3.1 Files

For this demonstration, use the file as shown below which is part of the software installation:

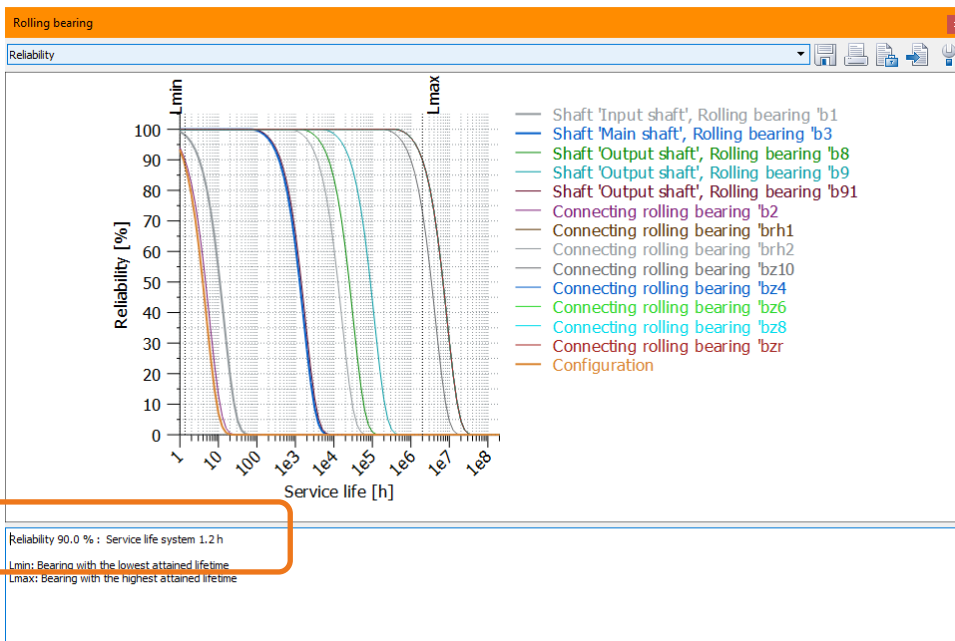


3.2 Reliability curves

Open the file and run the calculation. Open the graphic for bearing reliability. You will get the below shown results and the curves.

Note that the reliability curves are based on the most complex bearing rating method activated. In the below case, all four rating methods (basic rating, modified basic rating, reference rating and modified reference rating) are shown, hence, reliability curves are based on modified reference rating).

Results						
P-P	0.96	0.66	80.36		55.20	
Q-Q	1.69	3.36	140.46		280.32	
R-R	2.17	4.64	181.24		386.40	
Bearing service life	S0	Ln_h	Ln_{mh}	Ln_{rh}	Ln_{m_{rh}}	p_{max_i}
b1	2.70	85 h	41 h	12 h	3 h	4780 N/mm ²
b3	5.24	269 h	161 h	619 h	378 h	2141 N/mm ²
b8	5.43	2536 h	4300 h	5486 h	7341 h	1910 N/mm ²
b9	12.31	21170 h	78032 h	17390 h	25910 h	1667 N/mm ²
b91	4.42	243 h	168 h	611 h	417 h	2178 N/mm ²
b2	1.47	20 h	6 h	6 h	1 h	6297 N/mm ²
brh1	9999.99	> 1000000 h	> 1000000 h	> 1000000 h	> 1000000 h	0 N/mm ²
brh2	10.92	766 h	1629 h	1993 h	3722 h	1434 N/mm ²
bz10	1.77	> 1000000 h	> 1000000 h	> 1000000 h	> 1000000 h	11520 N/mm ²
bz4	6169.86	> 1000000 h	> 1000000 h	> 1000000 h	> 1000000 h	106 N/mm ²
bz6	6721.62	> 1000000 h	> 1000000 h	> 1000000 h	> 1000000 h	82 N/mm ²
bz8	9377.65	> 1000000 h	> 1000000 h	> 1000000 h	> 1000000 h	109 N/mm ²
bzr	6747.38	> 1000000 h	> 1000000 h	> 1000000 h	> 1000000 h	99 N/mm ²
Bearing reaction force	Component	X	Y	Z	R_{xz}	
b1	F	29.257 kN	13.273 kN	-39.208 kN	48.920 kN	
	M	-420.758 Nm	0.000 Nm	-383.729 Nm	569.461 Nm	

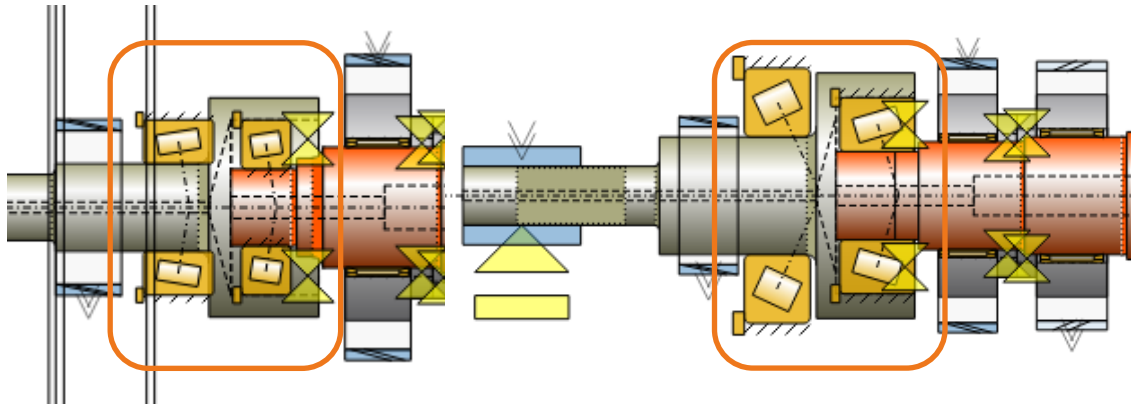


We can see from the results table that bearing b1 has only 3h life and bearing b2 has only 1h life. These two determine the system life.

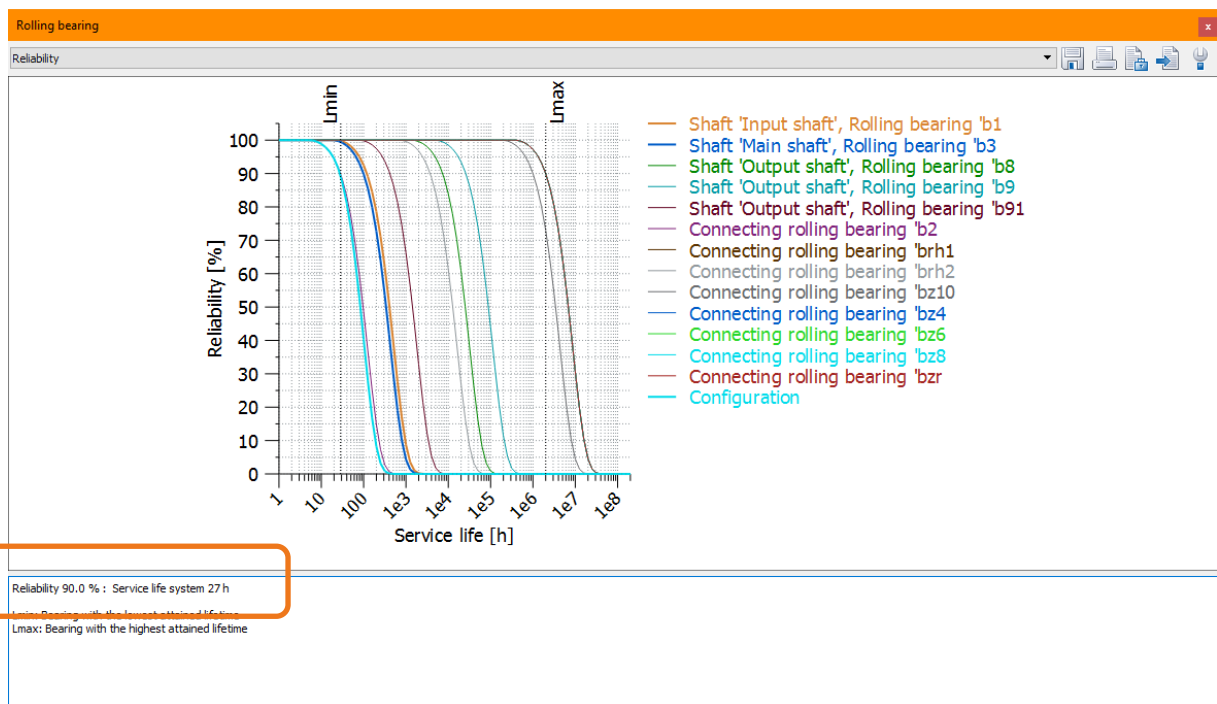
See file Demo-Shaft-02-Step-01.W10

3.3 Design change for higher reliability

Now, we can change the design in the critical area. Left: old design. Right: new design.



When we re-run the calculation with the new design, we now find a change in the reliability curves:



See file Demo-Shaft-02-Step-02.W10