HEXAGON Newsletter 202 Nov./Dec. 2023

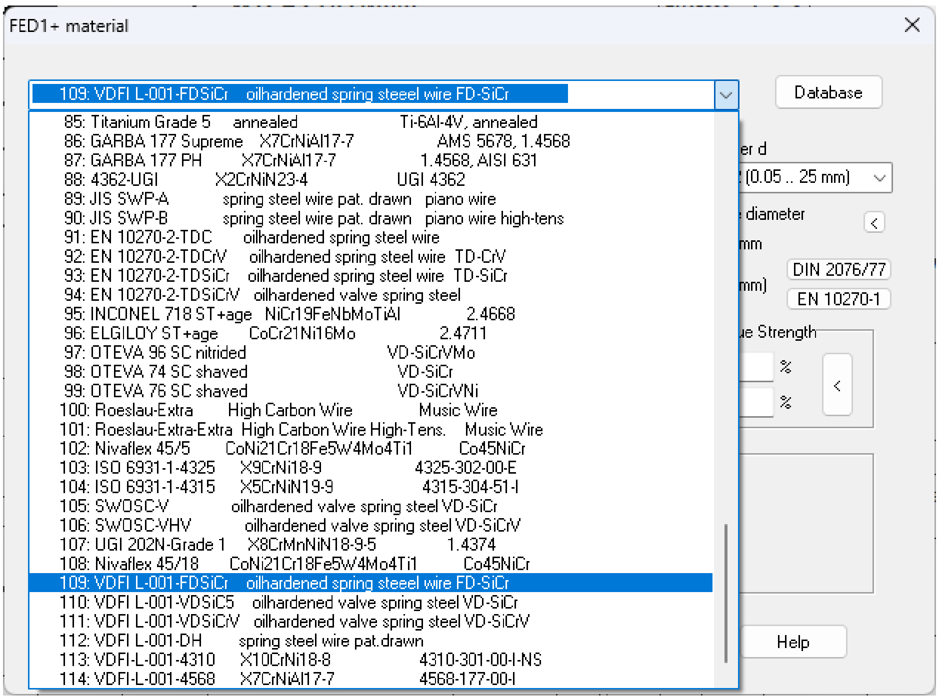
by Fritz Ruoss

FED1+ 2+ 3+ 5 6 7 8 11 17: Goodman diagrams from VDFI guide L-001 added

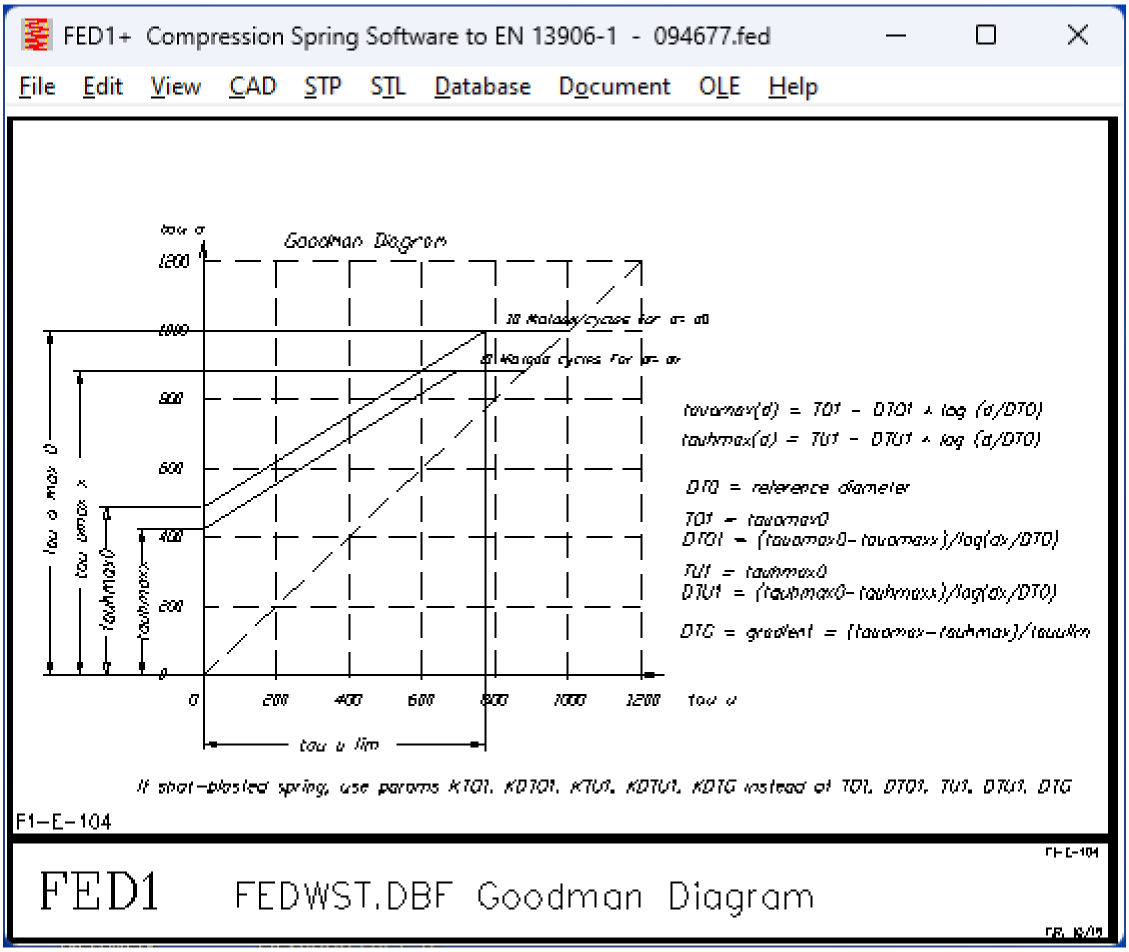
With the adoption of the newly determined Goodman diagrams from IGF project 19693 BR (see also our newsletter 195 and statement from the VDFI), we actually wanted to wait until they were incorporated into EN 13906 and then replace them in the materials database. Instead, we have now added the materials with new Goodman diagrams as new database records instead of replacing them. This means the user can continue to use the materials with the still valid Goodman diagrams according to EN 13906-1. In addition, you can experiment with the newly determined values according to IGF 19693 BR. The new Goodman diagrams are available for download from the German spring manufacturers association as a PDF (34 pages):
https://www.federnverband.de/wp-content/uploads/VDFI-L001_Leitfaden-Dauerfestigkeitschaubilder.pdf

Regarding the usability of the new diagrams, it says:
Please note when designing springs using the new diagrams that neither the VDFI nor the research center (nor HEXAGON) can be held liable.
A spring design based solely on these new diagrams is currently not allowed to take place.
Adopting the new diagrams into DIN EN 13906-1 is only possible under the following two conditions:
1. Widespread acceptance by European spring manufacturers
2. The changes in the standard must be supported by at least four EU countries.

The new Goodman diagrams have been added to the spring material database (No. 109 to 114).
Material descriptions:
109: VDFI L-001-FDSiCr
110: VDFI L-001-VDSiCr
111: VDFI L-001-VDSiCrV
112: VDFI L-001-DH
113: VDFI L-001-1.4310
114: VDFI L-001-1.4568

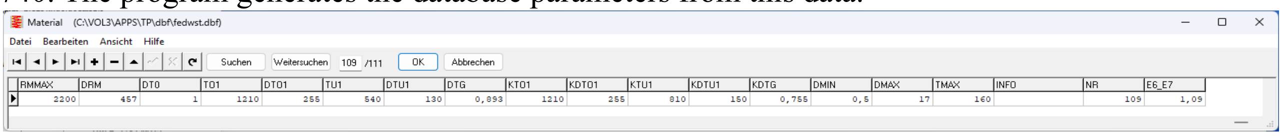


FED Tip: Enter your own fatigue strength diagrams into the fedwst.dbf database
Be careful when changing database records: If you open earlier files that use the changed material after the change, the old calculation will be displayed with the new material data; the old material data will be lost.
It is therefore better to expand the database with a new data record: First select the data record to be changed. Then “Edit\Append”. The new data record has been copied and attached. Now change the data and enter the new material record number.



Add VDFI Goodman diagrams to fedwst.dbf
If you have the Goodman diagram for fatigue strength or 10 million load cycles (N=10^7), you can expand the database yourself. You can find the formulas in help screen F1-D-104. You can describe the new Goodman diagrams from VDFI with relatively few parameters. You should only expand the materials database itself if the field E6_E7 already exists in your fedwst.dbf and the last data record in the NR field has the serial number 108. Otherwise it's better to order an update.

In the menu go to Database\fedwst.dbf. Add new material: yes or no, you can also add new materials directly in the database table. Example FDSiCr according to VDFI L-001: Wire diameter d0=1mm, Rm0=2100, dx=10, Rmx=1643, Rmmax=2200, dmin=0.5 dmax=17
tau0 at d=1: 1220, dx=10, tauo at d=10: 955, tauh0 at d=1: 540, tauhx at d=10: 410, tauulim at d=1: 740. The program generates the database parameters from this data.



RMMAX	DRM	DT0	T01	DT01	TU1	DTU1	DTG	KT01	KDT01	KTU1	KDTU1	KDTG	DMIN	DMAX	TMAX	INFO	NR	E6_E7
2200	457	1	1210	255	540	130	0,893	1210	255	810	150	0,755	0,5	17	160		109	1,09

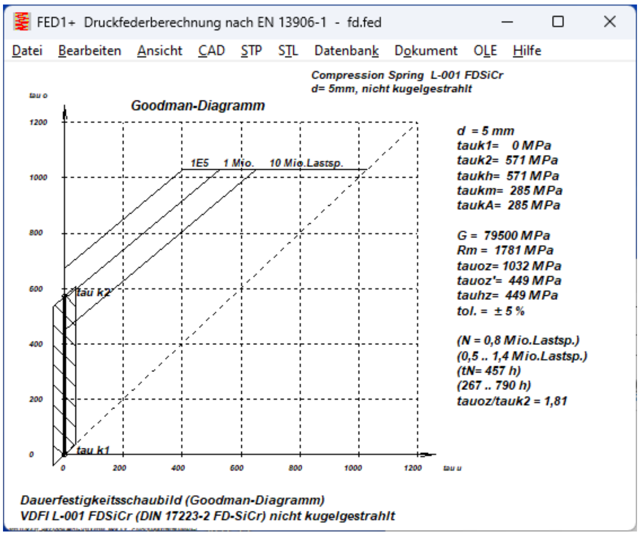
The Goodman diagram data for shot-peened springs is not queried. You have to enter these yourself. Instead, you can also enter all parameters directly in the data table. The “+” button creates space for a new data record.

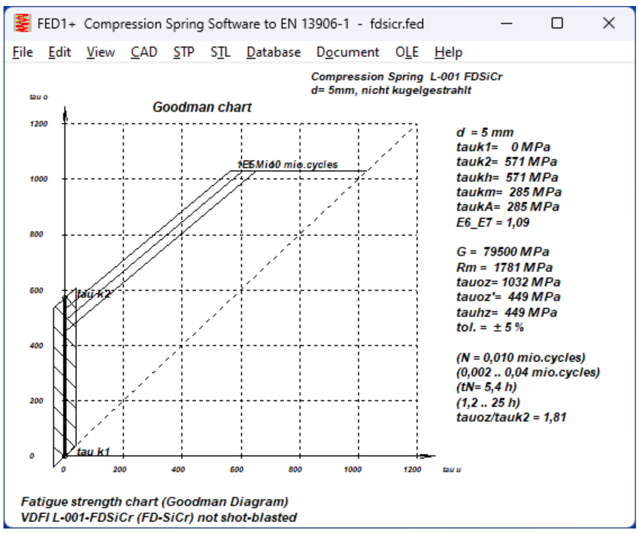
1. Example: Spring steel wire FDSiCr according to VDFI L-001 Aug.21:
first you need the diagram N=10^7, not shot peened:
DT0: Reference wire diameter = 1mm, largest wire diameter dx=10mm
TO1: upper shear stress at d=1mm =1210 MPa (at d=10mm: 955 MPa)
DTO1: (1210-955)/log(10/1) = 255 (log = logarithm of ten)
TU1: Stroke tension at tau1=0 and d=1mm: 540 MPa (at d=10mm: 410 MPa)
DTU1=(540-410)/log(10/1)=130
DTG=(1210-540)/750 = 0.8933
Instead of calculating DTG you can also measure the angle and take the tangent of it (41.8°)
That's all for FDSiCr, not shot peened, N=10^7

Now the same for FDSiCr, shot peened, N=10^7:
DTO=1
KTO1=1210
KDTO1=(1210-955)/log(10/1)= 255
KTU1=810
KDTU1=(810-660)/log(10/1)=255
KDTG=(1210-810)/530 = 0.755

Enter the serial number in the "NR" field: 109

Now we can go back into the program and draw the Goodman diagrams. Fits with N=10^7, d=1, 2, 3, 5, 8, 10mm, shot blasted or unblasted.





What doesn't yet fit is the conformity with the diagrams at N=10^6 load cycles. There are differences in the permissible stroke stress, which is the distance between the oblique straight lines. The Goodman diagrams according to EN 13906 and VDFI L-001 differ significantly. That's why there has been a new factor E6_E7 in fedwst.dbf for a year now, which is the ratio of the permissible stroke stress for 1 million and 10 million load cycles. In the Goodman diagrams from EN 13906 this factor was 1.25; in the new Goodman diagrams from the VDFI guide, this factor is consistently lower.
Back to fedwst.dbf: For the example with FDSiCr, the factor E6_E7 is for d=1mm not shot peened: 590/540=1.092, d=1 shot peened: 880/810=1.086, for d=10 mm not shot peened 450/410= 1,097, d=10 shot peened: 720/660=1.09. Voted 1.09. Enter this value in fedwst.dbf. This changes the distance between the oblique lines for 1 million and 100,000 load cycles.

The middle oblique line is the one for N=10^6, now agrees with the diagram FDSiCr, N=10^6.
E6_E7=1.09 means: If the stroke stress is 9% above the permissible stroke stress, the life expectation is 10 times shorter (1 million instead of 10 million load cycles).

The next material is valve spring wire VD-SiCr. The data is very similar to that of FD-SiCr.
DT0: 1mm, largest wire diameter dx=10mm
TO1: 1185 MPa (at d=10mm: 945 MPa)
DTO1: (1145-945)/log(10/1) = 240
TU1: 540 MPa (at d=10mm: 410 MPa)
DTU1 = (540-410)/log(10/1)=130
DTG = (1185-540)/710 = 0.908

VDFI L-001-VD-SiCr shot peened:
DT0 = 1
KTO1 = 1185
KDTO1 = 1185-945)/log(10/1) = 240
KTU1 = 810
KDTU1 = (810-660)/log(10/1) = 150
KDTG = (1185-810)/505 = 0.743

E6_E7 (not shot peened) = 590/540 = 1.09
E6_E7 (shot peened) = 880/810 = 1.09

Then follows valve spring wire VDSiCrV
initially not shot blasted, N=10^7
d=1 didn't fit into the diagram, so here d0=2 and dx=10
DT0 = 2
TO1 = 1230
DTO1 = (1230-1035)/log(10/2) = 279
TU1 = 510 (at d=2)
DTU1 = (510-440)/log(10/2) = 100
DTG = (1230 -510)/790 = 0.911

then VDSiCrV shot peened, N=10^7
DT0 = 2
KTO1 =1230
KDTO1 = (1230-1035)/log(10/2) = 279
KTU1 = 775 (at d=2)
KDTU1 = (775-695)/log(10/2) = 114
KDTG = (1230-775)/620 = 0.734

E6_E7 (not shot peened) = 555/510 = 1.088
E6_E7 (shot peened) = 840/775 = 1.084

Next is spring steel wire DH
initially not shot blasted, N=10^7
DT0=1, dx=10
TO1 =1195
DTO1 = (1195-760)/log(10/1) = 435
TU1 = 430
DTU1 = (430-280)/log(10/1) = 150
DTG = (1195-430)/870 = 0.879 better with d=5: (890-340)/595 = 0.924

now DH shot blasted, N=10^7
KTO1 = 1195
KDTO1 = (1195-760)/log(10/1) = 435
KTU1 = 710
KDTU1 = (710-530)/log(10/1) = 180
KDTG = (890-600)/375 (d=5) = 0.773

E6_E7 (not shot peened) = 375/340 = 1.1 (d=5)
E6_E7 (shot peened) = 655/600 = 1.1 (d=5)

Next is Nirosta 1.4310
initially not shot blasted, N=10^7:
DT0=1, dx=8
TO1 = 900
DTO1 = (900-625)/log(8/1) = 305
TU1 = 335
DTU1 = (335-210)/log(8/1) = 138
DTG = (900-335)/620) = 0.911

then 1.4310 shot blasted, N=10^7:
KTO1 = 900
KDTO1 = (900-625)/log(8/1) = 305
KTU1 = 595
KDTU1 = (595-440)/log(8/1) =172
KDTG = (725-500)/280 = 0.804

E6_E7 (not shot peened) = 300/255 = 1.17 (d=4)
E6_E7 (shot peened) = 570/500 = 1.14 (d=4)

Now follows another stainless steel, 1.4568, not shot blasted, N=10^7:
DT0=1, dx=8
TO1 = 1005
DTO1=(1005-735)/(log(8/1) = 299
TU1 = 330
DTU1 = (330 -220)/(log(8/1) = 122
DTG = (1005-330)/740 = 0.912

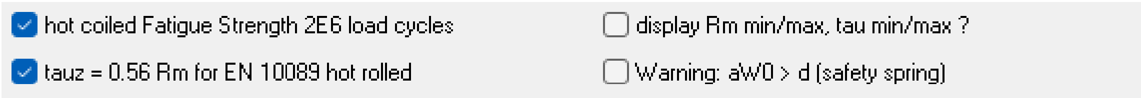
then 1.4568, shot peened, N=10^7:
KT01 = 1005
KDTO1 = (1005-735)/log(8/1) = 299
KTU1 = 590
KDTU1 = (590-460)/log(8/1) = 144
KDTG = (815-515)/390 = 0.769 (d=4)

E6_E7 (not shot peened) = 380/330 = 1.15 (d=1)
E6_E7 (shot peened) = 590/515 = 1.15 (d=4)

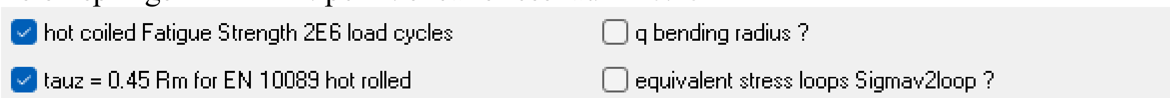
That's all. We have now captured the new Goodman diagrams in 6 database rows.

FED1+, 2+, 5, 6, 7, 8, 17: Permissible shear stress for hot-formed springs

For helical compression springs, the permissible shear stress according to EN 13906-1 is determined as tauz = 0.56 Rm. For all materials? No, there is an exception: for hot-formed springs with wire diameters between 10 and 60 mm made of hot-rolled spring steel according to EN 10089, the diagram in Figure 7 applies, calculated in HEXAGON software with tauz=840-250*log(d/20).
For tension springs according to EN 13906-2, the permissible shear stress is tauz = 0.45 Rm, here too there is an exception for hot-rolled spring steel according to EN 10089: tauz = 600 MPa.
For torsion springs according to EN 13906-3, the permissible bending stress is sigmaz = 0.7 Rm. Without exception, this also applies to hot-formed springs.
In practice, the exception for hot-formed tension and compression springs means that when selecting a material, the permissible shear stress always remains the same, even if a material with a higher tensile strength is chosen.
Under Edit\Calculation method you can now tick that tauz=0.56 Rm for compression springs or tauz=0.45Rm for tension springs always applies, even for hot-formed springs made of EN 10089 spring steel, so that the diagram is from EN 13906-1 or tauz=600 MPa from EN 13906-2 is not used.

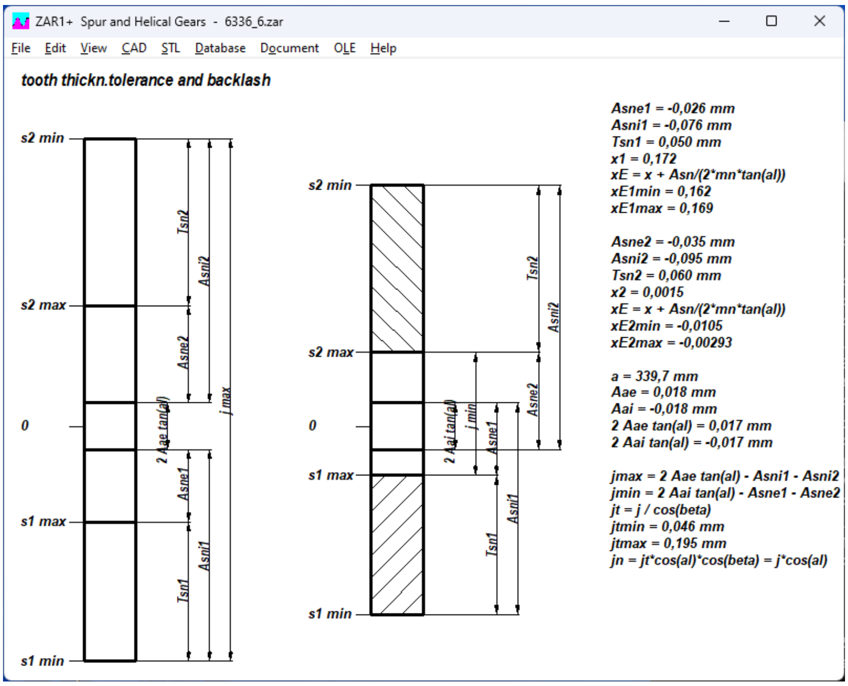


Extension springs in FED2+: perm. shear stress tauz = 0.45*Rm



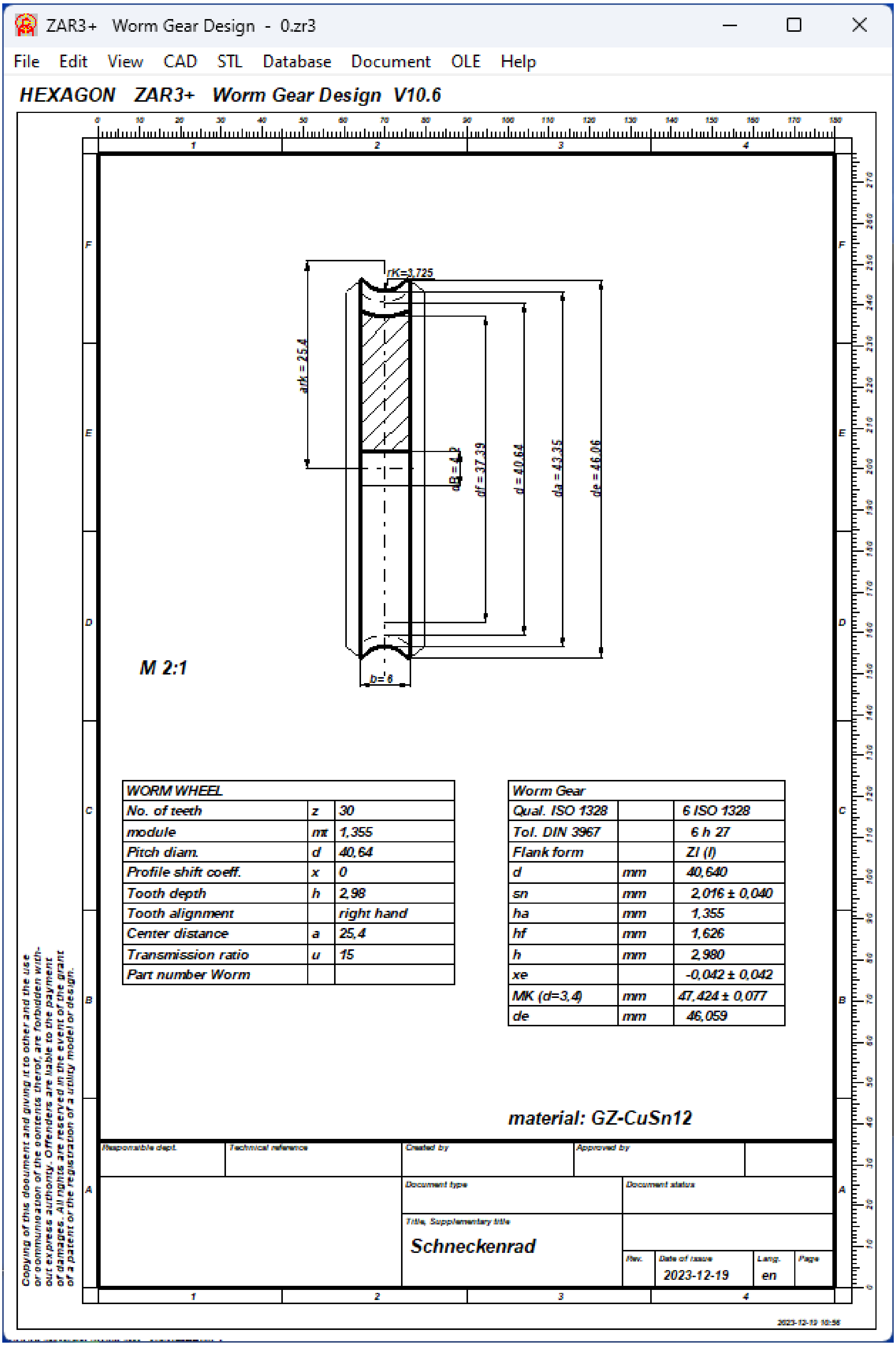
ZAR1+: jt = j / cos(ß) added in tooth thickness tolerance drawing

The tolerances are calculated in the pitch circle, the relevant backlash jt is output in the tangential section. The backlash jn is along the mesh line, not in the pitch circle. Therefore, “jn” was renamed “j” in the sketch. The sketch was supplemented by the formulas for j:
jt = j / cos(beta)
jn = jt * cos(al) * cos(beta) = j * cos(al)



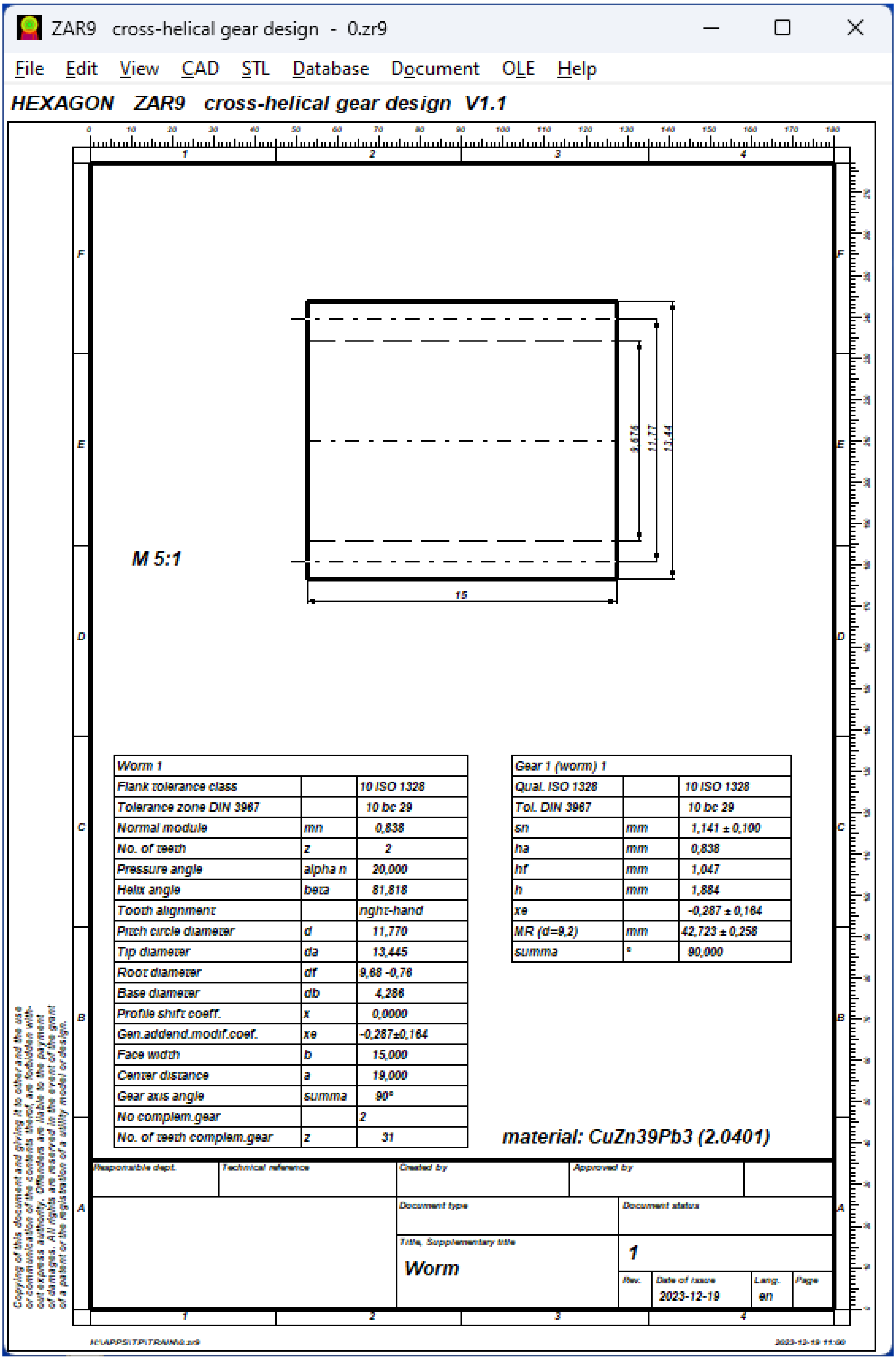
ZAR3+: Gear quality and tolerance zone in production drawing

If a gear quality and a tolerance field have been selected, these details are included in the tables. In this case, the production drawing is also supplemented by the table with the measuring dimensions.



ZAR9: Gear quality and tolerance zone in production drawing

ZAR9 can be used to calculate screw gears and worm gears. Similar to ZAR3+, the production drawing is now supplemented by the table with the measuring dimensions if a tolerance field was previously selected or tooth thickness tolerances were entered.



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