FORMULA STUDENT GEARBOX

Shaft-hub connections

Version: **V1-2025**

Information for FSAE / FS-Team

The splined shaft connections should be as free of play as possible. For the ring gear, we even recommend a slightly loose press fit in the aluminum wheel hub. Any damage caused by loose fits is the responsibility of the teams.

The teams are allowed to modify the spline connections of their parts (in this case, the rotor shaft and wheel hub) in order to adjust the foot radii or diameters for other manufacturing processes, or simply for reasons of strength. However, the tooth widths must be taken into account and maintained in order to ensure that there is almost no backlash.
In accordance with DIN5480, concentricity must be maintained at 20 µm to the respective axis (wheel bearings for the spline of the wheel hub or rotor-shaft/ rotor-bearings for the sun gear)

We recommend assembling the spline connections using an assembly paste with high pressure load capacity. Please ensure that your oil is compatible with the paste.

Sun Gear

The sun gear shaft is equipped with a spline that fits the AMK Formula Student motor.
The corresponding dimensions can be found in the tables opposite.
The axial length of the sun gear has been selected so that it can also be secured to the AMK shaft using a retaining ring (see AMK data sheet). If it is not possible for a team to get the motor and gearbox close enough together in their packaging, the sun gear may also be secured with a screw and shimmed on the back. The corresponding shims and washer on the front are not included in the scope of delivery. The teams are responsible for ensuring that these are properly dimensioned and that the shims between the sun gear and the rotor shaft are not crushed.
In any case, HUMBEL is not responsible for loose rings or screws: The teams must use suitable methods (screw locking, Nord-Lock®, or positive locking) to ensure that the connections do not come loose.

Of course, teams with their own rotor shafts can also use the sun according to "AMK specifications." The splined shaft connection should be designed to match AMK.

Ring Gear

Our proposal for a splined shaft connection for the wheel hub (.dxf-file included / table opposite) has an adapted foot radius (increased to > 2 mm). This makes it possible to produce the contour in the wheel hub on a universal milling machine (or of course EDM). The teams thus save themselves gear-specific manufacturing processes such as shaping or gear hobbing.
The ring gear can be secured axially in various ways: with a shoulder in the hub on one side (particularly advantageous as splines can be milled), outer race of the wheel-bearing, a retaining ring, screws, or other concepts developed by the teams.
Deformation of the ring gear due to excessive pressure in the splined shaft must be prevented.

Internal spline toothing DIN 5480 SUN *Innen-Zahnwellenverbindung DIN 5480*		
Normal module [mm] *Normalmodul*	m_n	0.8
Number of teeth *Zähnezahl*	z	-12
Normal pressure angle [°] *Normaleingriffswinkel*	α_n	30
Nominal helix angle [°] *Nennschrägungswinkel*	β	0
Profile shift coefficient *Profilverschiebungsfaktor*	x	-0.325
Reference diameter [mm] *Teilkreisdurchmesser*	d_1	9.600
Tip diameter [mm] *Kopfkreisdurchmesser*	d_{a1}	9.400 (0 / 0.080)
Root diameter [mm] *Fusskreisdurchmesser*	d_f	11.282 - 11.330
Root form diameter [mm] Fussformkreisdurchmesser	d_{Ff}	10.935 - 10.987
Profile control diameter [mm] Start der Profilauswertung	d_{Cf}	10.900
Base diameter [mm] Grundkreisdurchmesser	d_b	8.314
Tooth thickness tolerance *Zahndickentoleranz*	-	DIN 5480 G
Dia. two-ball dimension act. [mm] *Diametrales Zweikugelmass act.*	M_{dK}	7.812 - 7.843
Effective diameter of ball [mm] *Effektiver Messkörperdurchmesser*	D_{Meff}	1.5

Image from *"AMK-DD5-14-POW-19000"* datasheet

Spline on Shaft: DIN 5480 - W11x0,8x30°x12xh8

Zähnezahl	[z]	12
Zahnbreite (mm)	[b]	11.900
Normalmodul (mm)	[mn]	0.8000
Schrägungswinkel (°)	[beta]	0°0'0" (0.0000)
Schrägungsrichtung		Geradverzahnt
Eingriffswinkel im Normalschnitt (°)	[alfn]	30°0'0" (30.0000)
Werkstoff		42 CrMo 4 (1)
Bezugsprofil		DIN 5480:2006 0.60 / 0.1G / 0.45 Walzfräsen
Kopfhöhenfaktor	[haP*]	0.450
Fusshöhenfaktor	[hfP*]	0.600
Kopfradiusfaktor	[rhaxP*]	0.000
Fussradiusfaktor	[rhafP*]	0.150
Kopffornhöhenfaktor	[hFaP*]	0.000
Protuberanzhöhenfaktor	[hpxP*]	0.000
Protuberanzwinkel (°)	[alfpxP]	0.000
Kantenbrechfankenwinkel (°)	[alfKP]	0.000
nicht überschneidend		
Verzahnungsqualität nach DIN 3961		8
Profilverschiebungsfaktor	[x]	0.3250
Teilkreisdurchmesser (mm)	[d]	9.600
Kopfkreisdurchmesser (mm)	[da]	10.840 (0.000 / -0.110)
Fusskreisdurchmesser (mm)	[df]	9.150 (-0.024 / -0.062)
Zahndickentoleranz		DIN 5480 h
Zahndickenabmass (obere) (oberes) (mm)	[As.e]	0.000
_ im Normalschnitt (untere) (unteres) (mm)	[As.i]	-0.014
Messzähnezahl	[k]	3
Zahnweite (spielfrei) (mm)	[Wk]	6.148
_ (obere) (oberes) (mm)	[Wk.e]	6.148
_ (untere) (unteres) (mm)	[Wk.i]	6.136
Rollendurchmesser (mm)	[DMeff]	2.000
Zwei-Rollenmass (obere) (oberes) (mm)	[MdR.e]	13.521
_ (untere) (unteres) (mm)	[MdR.i]	13.503
Zahndicksehne (spielfrei) (mm)	[`sn]	1.550
_ (obere) (oberes) (mm)	[`sn.e]	1.550
_ (untere) (unteres) (mm)	[`sn.i]	1.536
Höhe über der Sehne (mm)	[ha]	0.836

Spline toothing DIN 5480 SHAFT *Zahnwellenverbindung DIN 5480*		
Normal module [mm] *Normalmodul*	m_n	3
Number of teeth *Zähnezahl*	z	32
Normal pressure angle [°] *Normaleingriffswinkel*	α_n	30
Nominal helix angle [°] Nennschrägungswinkel	β	0
Profile shift coefficient *Profilverschiebungsfaktor*	x	-0.15
Reference diameter [mm] *Teilkreisdurchmesser*	d_1	96.000
Tip diameter [mm] *Kopfkreisdurchmesser*	d_{a1}	96.000 (0 / -0.100)
Root diameter [mm] *Fusskreisdurchmesser*	d_f	91.195 - 91.238
Root form diameter [mm] *Fussformkreisdurchmesser*	d_{Ff}	91.980 - 92.017
Profile control diameter [mm] *Start der Profilauswertung*	d_{Cf}	92.100
Base diameter [mm] *Grundkreisdurchmesser*	d_b	83.138
Tooth thickness tolerance *Zahndickentoleranz*	-	DIN 5480 m
Base tangent lenght [mm] *Zahnweite*	W_k	40.746 - 40.767
Number of teeth spanned *Messzähnezahl*	k	5
Dia. two-ball dimension act. [mm] *Diametrales Zweikugelmass act.*	M_{dK}	103.380 - 103.421
Effective diameter of ball [mm] *Effektiver Messkörperdurchmesser*	D_{Meff}	5.5

Recommendation HUB

DIN 5480 - N 98.40x3.00x32x7H

Internal spline toothing DIN 5480 *Innen-Zahnwellenverbindung DIN 5480*		
Normal module [mm] *Normalmodul*	m_n	3
Number of teeth *Zähnezahl*	z	-32
Normal pressure angle [°] *Normaleingriffswinkel*	α_n	30
Nominal helix angle [°] Nennschrägungswinkel	β	0
Profile shift coefficient *Profilverschiebungsfaktor*	x	0.15
Reference diameter [mm] *Teilkreisdurchmesser*	d_1	96.000
Tip diameter [mm] *Kopfkreisdurchmesser*	d_{a1}	92.100 (0 / 0.080)
Root diameter [mm] *Fusskreisdurchmesser*	d_f	98.526 - 98.569
Root form diameter [mm] *Fussformkreisdurchmesser*	d_{Ff}	96.104 - 96.149
Profile control diameter [mm] *Start der Profilauswertung*	d_{Cf}	96.000
Base diameter [mm] *Grundkreisdurchmesser*	d_b	83.138
Tooth thickness tolerance *Zahndickentoleranz*	-	DIN 5480 H
Dia. two-ball dimension act. [mm] *Diametrales Zweikugelmass act.*	M_{dK}	87.342 - 87.391
Effective diameter of ball [mm] *Effektiver Messkörperdurchmesser*	D_{Meff}	5.25

Maßstab / *Scale* 1:1	A2	Blatt / *Sheet* 02 / 02	Projektname / *Project name* HUMB.2411	Werkstoff / *Material*	Gewicht / *Weight* 0 kg
We reserve all rights in this document and in the information contained therein. Reproduction, use or disclosure to third parties without express authority is strictly prohibited. © Humbel Zahnräder AG		Tolerierungsgrundsatz *Fundamental tolerancing principle*	ISO 8015	Gezeichnet *Drawn by*	tim.schulte	Datum / Date 07.03.2025
		Allgemeintoleranzen *General tolerances*	ISO 2768-mK	Geprüft *Reviewed by*	tim.schulte	17.09.2025
		Revisionskommentar *Revision comment*		Freigegeben *Released by*	dominik.brunner	18.09.2025
HUMBEL Gear Technology		Benennung / *Designation* HU-FS Gearbox - AMK		Zeichnungsnummer / *Drawing number* HU-00139219	Revision A