4 Project planning for drives

4.1 Additional publications

For more detailed information about the project planning for drives, refer to the website of SEW-EURODRIVE where you can download the following publications of the "Drive Engineering – Practical Implementation" series. The series can also be ordered as hard copy.

- Project planning for drives
- EMC in Drive Engineering – Basic Theoretical Principles and EMC-Compliant Installation in Practice
- Efficient Plant Automation with Mechatronic Drive Solutions
- SEW encoder systems
- Servo technology
- Drive Engineering – Practical Implementation: Explosion-Proof Drives to EU Directive 94/9/EC

The complete range of technical documentation is available in various languages for download from the web at

www.sew-eurodrive.com

4.2 Drive and gear unit selection data

Certain data of the application have to be provided to being able to precisely define the components for your drive.

Designation	Meaning	Unit
n_{amin}	Minimum output speed	[1/min]
n_{amax}	Maximum output speed	[1/min]
P_a at n_{amin}	Output power at minimum output speed	[kW]
P_a at n_{amax}	Output power at maximum output speed	[kW]
M_a at n_{amin}	Output torque at minimum output speed	[Nm]
M_a at n_{amax}	Output torque at maximum output speed	[Nm]
F_A	Axial load (tension and compression) on the output shaft	[N]
J_{load}	Mass moment of inertia to be driven	[10^{-4} kgm^2]
R, F, K, S, W **M1 - M6**	Mounting position and required gear unit type → Mounting position of gear units chapter (page 54), → Project planning notes for R, F, K, S, W gear units chapter (page 42)	-
IP..	Required degree of protection	-
ϑ_{amb}	Ambient temperature	[°C]
H	Installation altitude	[m above sea level]
S.., ..% cdf	Duty type and cyclic duration factor (cdf) or exact load cycle can be entered.	-
Z	Starting frequency; alternatively, exact load cycle can be specified	[1/h]
f_{line}	Line frequency	[Hz]
V_{mot} V_{brake}	Operating voltage of motor and brake	[V]
M_B	Required braking torque	[Nm]
For inverter operation: **Required control type and setting range**		

4.3 Project planning procedure – DR. motors

4.3.1 Drive selection – non-controlled operation

The following flow diagram illustrates the project planning procedure for a non-controlled drive. The drive consists of a gearmotor operated on the grid.

Necessary information on the machine to be driven

- Technical data and environmental conditions
- Stopping accuracy
- Output speed
- Start-up acceleration and braking deceleration
- Cyclic duration factor and starting frequency

↓

Calculation of the relevant application data

- Static and dynamic power
- Speeds
- Torques, power ratings
- Travel diagram, if required
- Determine the necessary service factor f_B

↓

Motor selection

- Torque / power / speed (number of poles)
- Acceleration torque / starting torque
- Starting frequency
- Determine energy efficiency class IE
- Mechanical brake (braking work, brake torque, brake service life)
- Motor equipment (brake, plug connector, thermal motor protedction, etc.)

↓

Gear unit selection

- Definition of gear unit size, gear unit reduction ratio and gear unit type
- Check the positioning accuracy
- Check the service factor f_B

↓

Make sure that all requirements have been met.

4.3.2 Drive selection – controlled operation

The following flow diagram illustrates the project planning procedure for a positioning drive. The drive consists of a gearmotor that is powered by an inverter.

Necessary information on the machine to be driven
- Technical data and environmental conditions
- Positioning accuracy
- Speed setting range
- Calculation of the travel cycle

↓

Calculation of the relevant application data
- Travel diagram
- Speeds
- Static, dynamic torques
- Regenerative power

↓

Gear unit selection
- Definition of gear unit size, gear unit reduction ratio and gear unit type
- Check the positioning accuracy
- Check for gear unit utilization ($M_{a\ max} \geq M_{a\ (t)}$).
- Check the input speed (churning losses)

↓

Motor selection
- Maximum torque
- With dynamic drives: effective torque at medium speed
- Maximum speed
- Observe dynamic and thermal torque curves
- Select the correct encoder
- Motor equipment (brake, plug connector, TF selection, etc.)

↓

Inverter selection
- Motor/inverter assignment
- Continuous current and peak current in current-controlled inverters/axes.

↓

Braking resisto selection
- based on the calculated regenerative power, cdf and peak braking power.

↓

Options
- EMC measures
- Operation/communication
- Additional functions

↓

Make sure that all requirements have been met.

4.4 Project planning information – R, F, K, S, W gear units

4.4.1 Efficiency of gear units

General information

The efficiency of gear units is mainly determined by the gearing and bearing friction. Keep in mind that the starting efficiency of a gear unit is always less than its efficiency at operating speed. This factor is especially pronounced in the case of helical-worm and SPIROPLAN® right-angle gearmotors.

R, F, K gear units

The efficiency of helical, parallel-shaft and helical-bevel gear units varies with the number of gear stages, between 96% (3-stage), 97% (2-stage) and 98% (1-stage).

S and W gear units

The gearing in helical-worm and SPIROPLAN® gear units produces a high proportion of sliding friction. This is the reason why these gear units have higher gearing losses and lower efficiency than R, F or K gear units.

The efficiency depends on the following factors:

- Gear ratio of the helical-worm or SPIROPLAN® stage
- Input speed
- Gear unit temperature

Helical-worm gear units from SEW-EURODRIVE are helical gear/worm combinations that are significantly more efficient than plain worm gear units.

The efficiency may reach $\eta < 0.5$ if the helical-worm gear stage has a very high gear ratio.

The SPIROPLAN® W37/W47 gear units from SEW-EURODRIVE have an efficiency of more than 90%, which drops only slightly even for large gear unit ratios.

Self-locking

Retrodriving torque in helical-worm or SPIROPLAN® gear units produces an efficiency of $\eta' = 2 - 1/\eta$, which is significantly less favorable than the forward efficiency. The helical-worm or SPIROPLAN® gear unit is self-locking if the forward efficiency η is ≤ 0.5. Some SPIROPLAN® gear units are dynamically self-locking. Contact SEW-EURODRIVE if you want to make technical use of the braking effect of self-locking characteristics.

INFORMATION

Note that the self-locking effect of helical-worm or SPIROPLAN® gear units is not permitted as the sole safety function for hoists.

Run-in phase

The tooth flanks of new helical-worm and SPIROPLAN® gear units are not yet completely smooth. This makes for a greater friction angle and less efficiency during the run-in phase than during later operation. This effect intensifies with increasing gear unit ratio. Subtract the following values from the listed efficiency during the run-in phase:

	Worm	
	i range	**η reduction**
1-start	About 50 – 280	About 12%
2-start	About 20 – 75	About 6%
3-start	About 20 – 90	About 3%
5-start	About 6 – 25	About 3%
6-start	About 7 – 25	About 2%

	SPIROPLAN® W..
i range	**η reduction**
About 30 – 75	About 8%
About 10 – 30	About 5%
About 3 – 10	About 3%

The run-in phase usually lasts 48 hours. Helical-worm and SPIROPLAN® gear units achieve their listed rated efficiency values when the following conditions have been met:

- The gear unit has been completely run-in
- The gear unit has reached nominal operating temperature
- The recommended lubricant has been filled
- The gear unit is operating in the rated load range

Churning losses

In certain gear unit mounting positions (see chapter "Gear Unit Mounting Positions"), the first gearing stage is completely immersed in the lubricant. When the circumferential velocity of the input stage is high, considerable churning losses occur in larger gear units that must be taken into account. Contact SEW-EURODRIVE if you wish to use gear units of this type.

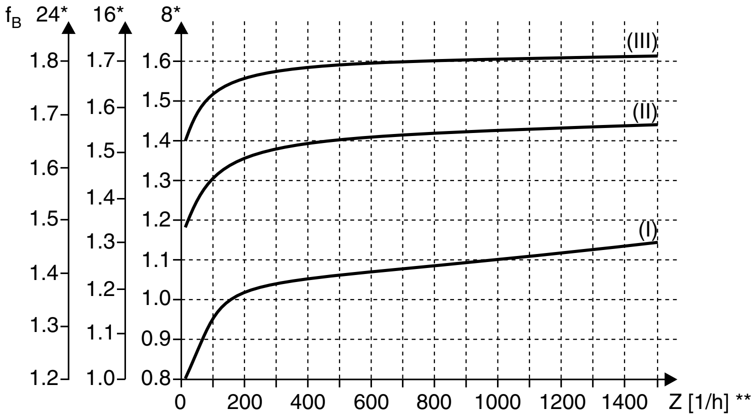
To reduce churning losses to a minimum, use gear units in M1 mounting position.

4.5 Service factor

4.5.1 Determining the service factor

The effect of the driven machine on the gear unit is taken into account to a sufficient level of accuracy using the service factor f_B. The service factor is determined according to the daily operating time and the starting frequency Z. Three load classifications are taken into account depending on the mass acceleration factor. You can read the service factor applicable to your application from figure 3. The service factor determined from this diagram must be smaller than or equal to the service factor according to the selection tables.

$$M_a \times f_B \leq M_{a\max}$$



* Daily operating time in hours/day

** Starting frequency Z: The cycles include all starting and braking procedures as well as changeovers from low to high speed and vice versa.

Load classification

Three load classifications are distinguished:

(I) Uniform, permitted mass acceleration factor ≤ 0.2
(II) Non-uniform, permitted mass acceleration factor ≤ 3
(III) Heavy shock load, permitted mass acceleration factor ≤ 10

Mass acceleration factor

The mass acceleration factor is calculated as follows:

$$\textbf{Mass acceleration factor} = \frac{\textbf{All external mass moments of inertia}}{\textbf{Mass moment of inertia at motor end}}$$

"All external mass moments of inertia" are the mass moments of inertia of the driven machine and the gear unit, scaled down to the motor speed. The calculation for scaling down to motor speed is performed using the following formula:

$$J_X = J \times \left(\frac{n}{n_M} \right)^2$$

J_X = Mass moment of inertia scaled down to the motor shaft
J = Mass moment of inertia with reference to the output speed of the gear unit
n = Output speed of the gear unit
n_M = Motor speed

"Mass moment of inertia at the motor end" is the mass moment of inertia of the motor and, if installed, the brake and the flywheel fan (Z fan).

Service factors f_B > 1.8 may occur with large mass acceleration factors (> 10), high levels of backlash in the transmission elements or large overhung loads. Contact SEW-EURODRIVE in such cases.

4.5.2 Servicefactor: SEW f_B

The method for determining the maximum permitted continuous torque M_{amax} and using this value to derive the service factor $f_B = M_{amax} / M_a$ is not defined in a standard and varies greatly from manufacturer to manufacturer. Even at a SEW service factor of f_B = 1, the gear units afford an extremely high level of safety and reliability in the fatigue strength range (exception: wearing of the worm wheel in helical-worm gear units). The service factor may differ from specifications of other gear unit manufacturers. If you are in doubt, contact SEW-EURODRIVE for more detailed information on your specific drive.

Example

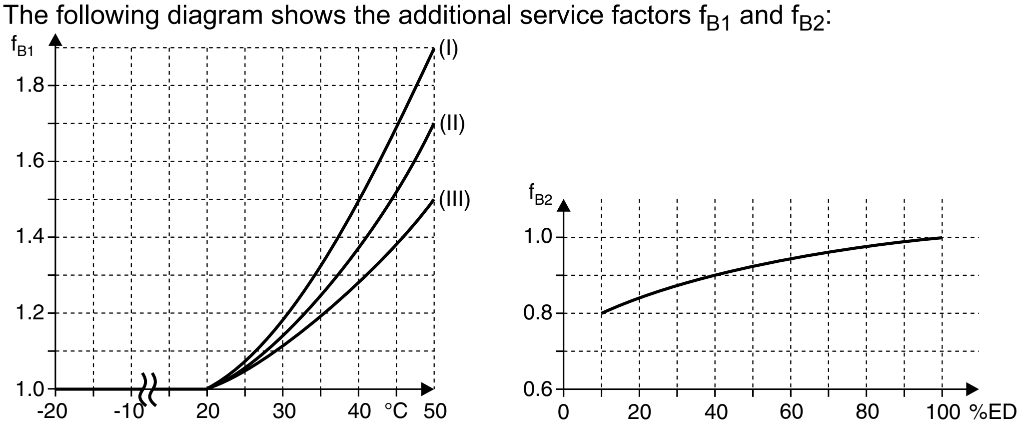
Mass acceleration factor 2.5 (load classification II), operating time 14 hours/day (read off at 16 h/d) and 300 cycles/hour produce a service factor f_B = 1.51 as shown in the figure on the previous page. According to the selection tables, the selected gearmotor must have an SEW f_B value of 1.51 or greater.

4.5.3 Helical-worm gear units

Two further service factors have to be taken into account with helical-worm gear units in addition to the service factor f_B shown in the above diagram. These are:

- f_{B1} = Service factor from ambient temperature
- f_{B2} = Service factor from cyclic duration factor

The additional service factors f_{B1} and f_{B2} can be determined by referring to the diagram below. For f_{B1}, the load classification is taken into account in the same way as for f_B. The following diagram shows the additional service factors f_{B1} and f_{B2}:



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$$cdf(\%) = \frac{\text{Time under load in min/h}}{60} \times 100$$

Contact SEW-EURODRIVE in case of temperatures below -20 °C (→ f_{B1}).

The total service factor for helical-worm gear units is calculated as follows:

$$f_{Bges} = f_B \times f_{B1} \times f_{B2}$$

Example

The gearmotor with the service factor f_B = 1.51 in the previous example is to be a helical-worm gearmotor.

Ambient temperature ϑ = 40 °C → f_{B1} = 1.38 (read off at load classification II)

Time under load = 40 min/h → cdf = 66.67 % → f_{B2} = 0.95

The total service factor is f_{Btot} = 1.51 × 1.38 × 0.95 = 1.98

According to the selection tables, the selected helical-worm gearmotor must have an SEW f_B service factor of 1.98 or greater.

4.6 Overhung and axial loads

4.6.1 Determining the overhung load

An important factor for determining the resulting overhung load is the type of transmission element mounted to the shaft end. The following transmission element factors f_Z must be considered for various transmission elements.

Transmission element	Transmission element factor f_Z	Comments
Gears	1.15	< 17 teeth
Chain sprockets	1.40	< 13 teeth
Chain sprockets	1.25	< 20 teeth
Narrow V-belt pulleys	1.75	Influence of pre-tensioning
Flat belt pulleys	2.50	Influence of pre-tensioning
Toothed belt pulleys	2.00 – 2.50	Influence of pre-tensioning
Gear rack pinion, pre-tensioned	2.00	Influence of pre-tensioning

The overhung load exerted on the motor or gear shaft is calculated as follows:

$$F_R = \frac{M_d \times 2000}{d_0} \times f_Z$$

F_R = Overhung load in N
M_d = Torque in Nm
d_0 = Mean diameter of the installed transmission element in mm
f_Z = Transmission element factor

4.6.2 Higher permitted overhung loads

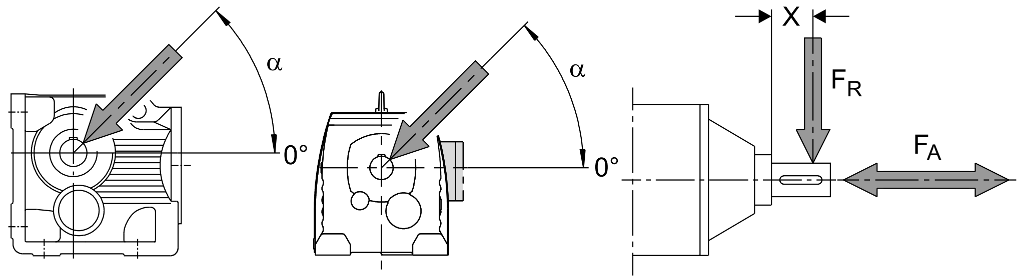
Exactly considering the force application angle α and the direction of rotation makes it possible to achieve a higher overhung load than listed in the selection tables.

Furthermore, higher output shaft loads are permitted if heavy duty bearings are installed, especially with R, F and K gear units.

Contact SEW-EURODRIVE in such cases.

4.6.3 Definition of the force application

Force application is defined according to the following figure:



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F_X = Permitted overhung load at point x [N]
F_A = Permitted axial load [N]

4.6.4 Permitted axial forces

If there is no overhung load, then an axial load F_A (tension or compression) amounting to 50% of the overhung load given in the selection tables is permitted. This condition applies to the following gearmotors:

- Helical gearmotors except for R..137... to R..167...
- Parallel-shaft and helical-bevel gearmotors with solid shaft except for F97...
- Helical-worm gearmotors with solid shaft

INFORMATION

Contact SEW-EURODRIVE for all other types of gear units and in the event of significantly greater axial loads or combinations of overhung load and axial load.

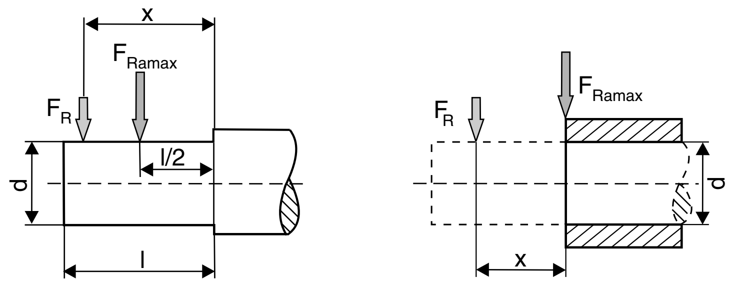
4.6.5 On the output side: Overhung load conversion for off-center force application

The permitted overhung load values F_{Ramax} and F_{Rapk} listed in the data tables are valid for force application at l / 2 (solid shaft) or force application at the shaft end face (hollow shaft). If the force is applied closer or further away from the gear unit, the permitted overhung loads must be redetermined again according to the project planning workflow. The following conditions must be met:

$$F_R \leq F_{Ra\max} \cdot \frac{a}{b+x} \; [N] \qquad F_R \leq \frac{c}{f+x} \; [N]$$

F_{Ramax} = Permitted overhung load [N]
x = Distance from the shaft shoulder to the force application point in [mm]
a, b, f = Gear unit constants for overhung load conversion [mm]
c = Gear unit constant for overhung load conversion [Nmm]

The following figure shows the overhung load F_R with increased distance x to the gear unit.



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Gear unit constants for overhung load conversion

Gear unit type	a [mm]	b [mm]	c [Nmm]	f [mm]	d [mm]	l [mm]
RX57	43.5	23.5	1.51×10^5	34.2	20	40
RX67	52.5	27.5	2.42×10^5	39.7	25	50
RX77	60.5	30.5	1.95×10^5	0	30	60
RX87	73.5	33.5	7.69×10^5	48.9	40	80
RX97	86.5	36.5	1.43×10^6	53.9	50	100
RX107	102.5	42.5	2.47×10^6	62.3	60	120
R07	72.0	52.0	4.67×10^4	11	20	40
R17	88.5	68.5	$6{,}527 \times 10^4$	17	20	40
R27	106.5	81.5	1.56×10^5	11.8	25	50
R37	118	93	1.24×10^5	0	25	50
R47	137	107	2.44×10^5	15	30	60
R57	147.5	112.5	3.77×10^5	18	35	70
R67	168.5	133.5	2.65×10^5	0	35	70
R77	173.7	133.7	3.97×10^5	0	40	80
R87	216.7	166.7	8.47×10^5	0	50	100
R97	255.5	195.5	1.06×10^6	0	60	120
R107	285.5	215.5	2.06×10^6	0	70	140
R137	343.5	258.5	4.58×10^6	0	90	170
R147	402	297	8.65×10^6	33	110	210
R167	450	345	1.26×10^7	0	120	210
F27	109.5	84.5	1.13×10^5	0	25	50
F37	123.5	98.5	1.07×10^5	0	25	50
F47	153.5	123.5	1.40×10^5	0	30	60
F57	170.7	135.7	2.70×10^5	0	35	70
F67	181.3	141.3	4.12×10^5	0	40	80
F77	215.8	165.8	7.87×10^5	0	50	100
F87	263	203	1.06×10^6	0	60	120
F97	350	280	2.09×10^6	0	70	140
F107	373.5	288.5	4.23×10^6	0	90	170
F127	442.5	337.5	9.45×10^6	0	110	210
F157	512	407	1.05×10^7	0	120	210

Gear unit type	a [mm]	b [mm]	c [Nmm]	f [mm]	d [mm]	l [mm]
K19	103.7	83.7	8.66×10^4	0	20	40
K29	124.5	99.5	1.26×10^5	0	25	50
K37	123.5	98.5	1.30×10^5	0	25	50
K47	153.5	123.5	1.40×10^5	0	30	60
K57	169.7	134.7	2.70×10^5	0	35	70
K67	181.3	141.3	4.12×10^5	0	40	80
K77	215.8	165.8	7.69×10^5	0	50	100
K87	252	192	1.64×10^6	0	60	120
K97	319	249	2.80×10^6	0	70	140
K107	373.5	288.5	5.53×10^6	0	90	170
K127	443.5	338.5	8.31×10^6	0	110	210
K157	509	404	1.18×10^7	0	120	210
K167	621.5	496.5	1.88×10^7	0	160	250
K187	720.5	560.5	3.04×10^7	0	190	320
S37	118.5	98.5	6.0×10^4	0	20	40
S47	130	105	1.33×10^5	0	25	50
S57	150	120	2.14×10^5	0	30	60
S67	184	149	3.04×10^5	0	35	70
S77	224	179	5.26×10^5	0	45	90
S87	281.5	221.5	1.68×10^6	0	60	120
S97	326.3	256.3	2.54×10^6	0	70	140
W10	84.8	64.8	3.6×10^4	0	16	40
W20	98.5	78.5	4.4×10^4	0	20	40
W30	109.5	89.5	6.0×10^4	0	20	40
W37	121.1	101.1	6.95×10^4	0	20	40
W47	145.5	115.5	4.26×10^5	35.6	30	60

Values for types not listed are available on request.

4.7 *Multi-stage gearmotors*

4.7.1 General information

You can achieve extremely low output speeds by using multi-stage gear units or multi-stage gearmotors. This means an additional second gear unit, usually a helical gear unit, is installed in front of the gear unit or between gear unit and motor.

The resulting total reduction ratio might make gear unit protection necessary.

4.7.2 Limiting the motor power

Reduce the maximum output motor power according to the maximum permitted output torque on the gear unit ($M_{a\ max}$). For this purpose you first have to determine the maximum permitted motor torque ($M_{N\ zul}$).

You can calculate the maximum permitted motor torque as follows:

$$M_{N\ zul} = \frac{M_{a\ max}}{i_{ges} \cdot \eta_{ges}}$$

Use this maximum permitted motor torque $M_{N\ zul}$ and the load diagram of the motor to determine the associated value for the motor current.

Take appropriate measures to prevent the continuous current consumption of the motor from exceeding the pre-determined value for the motor torque $M_{N\ zul}$. An appropriate measure would be to set the trip current of the motor protection switch to this maximum currnt value. A motor protection switch offers the option to compensate for a brief overload, for example during the startup phase of the motor. A suitable measure for inverter drives is to limit the output current of the inverter according to the determined motor current.

4.7.3 Checking brake torques

If you use a multi-stage brakemotor, you have to limit the braking torque (M_B) according to the maximum permitted motor torque $M_{N\ zul}$. The maximum permitted braking torque is 200% $M_{N\ zul}$.

$M_{B\ max} \leq 200\%\ M_{N\ zul}$

If you have questions regarding the starting frequency of multi-stage brakemotors, please consult SEW-EURODRIVE.

4.7.4 Avoiding blockage

Blockage on the output side of the multi-stage gear unit or multi-stage gearmotor is not permitted. The reason is that indeterminable torques and uncontrolled overhung and axial loads may occur. The gear units may suffer irreparable damage as a result.

INFORMATION

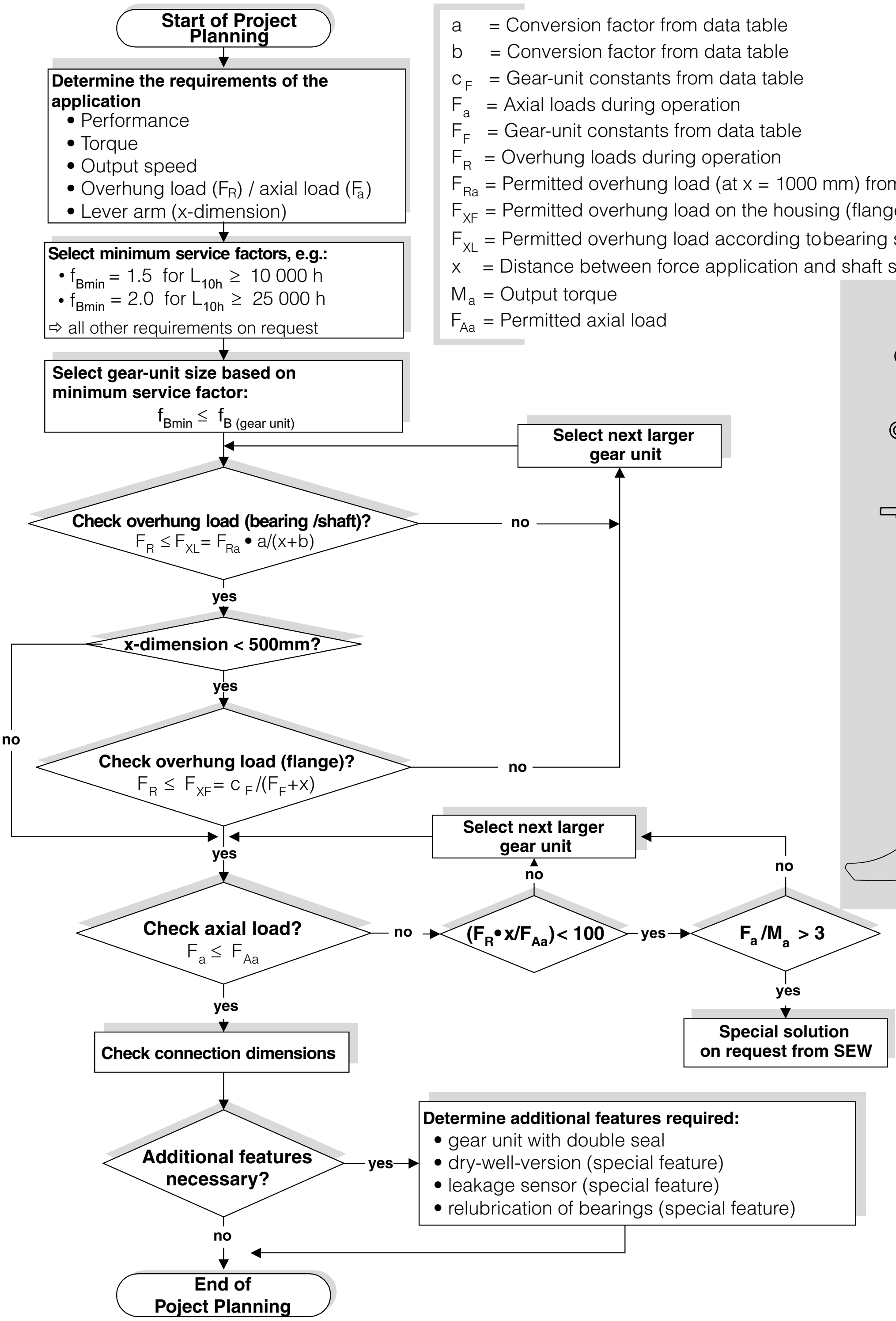
Consult SEW-EURODRIVE if blockages of the multi-stage gear unit or multi-stage gearmotor cannot be avoided due to the application.

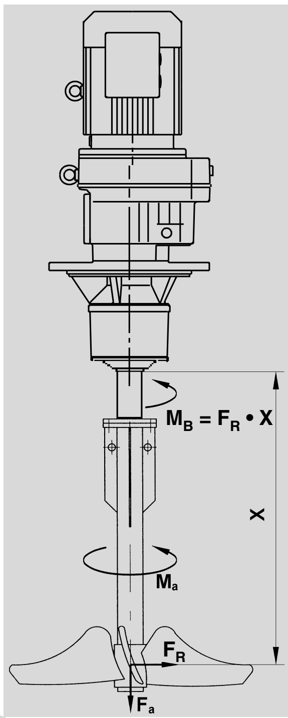
4.8 *Project planning for RM gear units*

4.8.1 Project planning procedure

Take account of the higher overhung loads and axial forces when planning projects with RM helical gearmotors with extended bearing housing. Observe the following project planning procedure:

- a = Conversion factor from data table
- b = Conversion factor from data table
- c_F = Gear-unit constants from data table
- F_a = Axial loads during operation
- F_F = Gear-unit constants from data table
- F_R = Overhung loads during operation
- F_{Ra} = Permitted overhung load (at x = 1000 mm) from data table
- F_{XF} = Permitted overhung load on the housing (flange tensile strength)
- F_{XL} = Permitted overhung load according tobearing service life
- x = Distance between force application and shaft shoulder
- M_a = Output torque
- F_{Aa} = Permitted axial load





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4.8.2 Permitted overhung loads and axial forces

The following table shows the permitted overhung loads F_{Ra} and axial loads F_{Aa} for various service factors f_B and nominal bearing service life L_{10h}.

f_{Bmin} = 1.5; L_{10h} = 10 000 h

		n_a [1/min]							
		< 16	16-25	26-40	41-60	61-100	101-160	161-250	251-400
RM57	F_{Ra} [N]	400	400	400	400	400	405	410	415
	F_{Aa} [N]	18800	15000	11500	9700	7100	5650	4450	3800
RM67	F_{Ra} [N]	575	575	575	580	575	585	590	600
	F_{Aa} [N]	19000	18900	15300	11900	9210	7470	5870	5050
RM77	F_{Ra} [N]	1200	1200	1200	1200	1200	1210	1210	1220
	F_{Aa} [N]	22000	22000	19400	15100	11400	9220	7200	6710
RM87	F_{Ra} [N]	1970	1970	1970	1970	1980	1990	2000	2010
	F_{Aa} [N]	30000	30000	23600	18000	14300	11000	8940	8030
RM97	F_{Ra} [N]	2980	2980	2980	2990	3010	3050	3060	3080
	F_{Aa} [N]	40000	36100	27300	20300	15900	12600	9640	7810
RM107	F_{Ra} [N]	4230	4230	4230	4230	4230	4230	3580	3830
	F_{Aa} [N]	48000	41000	30300	23000	18000	13100	9550	9030
RM137	F_{Ra} [N]	8710	8710	8710	8710	7220	5060	3980	6750
	F_{Aa} [N]	70000	70000	70000	57600	46900	44000	35600	32400
RM147	F_{Ra} [N]	11100	11100	11100	11100	11100	10600	8640	10800
	F_{Aa} [N]	70000	70000	69700	58400	45600	38000	32800	30800
RM167	F_{Ra} [N]	14600	14600	14600	14600	14600	14700	-	-
	F_{Aa} [N]	70000	70000	70000	60300	45300	36900	-	-

f_{Bmin} = 2.0; L_{10h} = 25 000 h

		n_a [1/min]							
		< 16	16-25	26-40	41-60	61-100	101-160	161-250	251-400
RM57	F_{Ra} [N]	410	410	410	410	410	415	415	420
	F_{Aa} [N]	12100	9600	7350	6050	4300	3350	2600	2200
RM67	F_{Ra} [N]	590	590	590	595	590	595	600	605
	F_{Aa} [N]	15800	12000	9580	7330	5580	4460	3460	2930
RM77	F_{Ra} [N]	1210	1210	1210	1210	1210	1220	1220	1220
	F_{Aa} [N]	20000	15400	11900	9070	6670	5280	4010	3700
RM87	F_{Ra} [N]	2000	2000	2000	2000	2000	1720	1690	1710
	F_{Aa} [N]	24600	19200	14300	10600	8190	6100	5490	4860
RM97	F_{Ra} [N]	3040	3040	3040	3050	3070	3080	2540	2430
	F_{Aa} [N]	28400	22000	16200	11600	8850	6840	5830	4760
RM107	F_{Ra} [N]	4330	4330	4330	4330	4330	3350	2810	2990
	F_{Aa} [N]	32300	24800	17800	13000	9780	8170	5950	5620
RM137	F_{Ra} [N]	8850	8850	8850	8830	5660	4020	3200	5240
	F_{Aa} [N]	70000	59900	48000	37900	33800	31700	25600	23300
RM147	F_{Ra} [N]	11400	11400	11400	11400	11400	8320	6850	8440
	F_{Aa} [N]	70000	60600	45900	39900	33500	27900	24100	22600
RM167	F_{Ra} [N]	15100	15100	15100	15100	15100	13100	-	-
	F_{Aa} [N]	70000	63500	51600	37800	26800	23600	-	-

4.8.3 Conversion factors and gear unit constants

The following conversion factors and gear unit constants apply to calculating the permitted overhung load F_{xL} at point x ≠ 1000 mm for RM gearmotors:

Gear unit type	a	b	c_F (f_B = 1.5)	c_F (f_B = 2.0)	F_F
RM57	1047	47	1220600	1260400	277
RM67	1047	47	2047600	2100000	297.5
RM77	1050	50	2512800	2574700	340.5
RM87	1056.5	56.5	4917800	5029000	414
RM97	1061	61	10911600	11124100	481
RM107	1069	69	15367000	15652000	554.5
RM137	1088	88	25291700	25993600	650
RM147	1091	91	30038700	31173900	756
RM167	1089.5	89.5	42096100	43654300	869

4.8.4 Additional weight of RM gear units

Type	Additional weight compared to RF with reference to the smallest RF flange Δm [kg]
RM57	12.0
RM67	15.8
RM77	25.0
RM87	29.7
RM97	51.3
RM107	88.0
RM137	111.1
RM147	167.4
RM167	195.4