Technical Data
for Torsional Vibration Calculation

RE 90261
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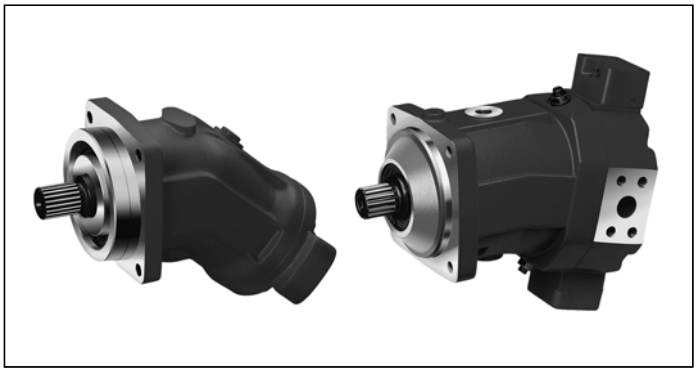


- Axial piston units with bent axis design
  - A2FM/6, A2FE/6, A2FO/6
  - A17FO/1, A17FNO/1, A18FDO/1
  - A6VM/6, A6VE/6, A6VM/7, A6VE/7
  - A7VO/6, A17VO/1, A18VO/1, A18VLO/1
  - A8VO/6, A8VO/7

Note

Simulation calculations can be performed for the design of couplings in drive trains. The additional data provided in this data sheet is necessary for this purpose. The comprehensive basic data can be found in the data sheets of the respective axial piston units. Torsional vibration loads, which must not exceed the limit values specified in this data sheet, are determined through simulation and measurement.

Contents

Description

Rotary stiffness c

The rotary stiffness specifies how much torque (Nm) must be applied in order to turn the shaft by 1 rad while the cylinder is held in place.
The rotary stiffness of the drive shaft is much larger than that of the cylinder barrel synchronization and the coupling on the input or output shaft. For this reason, the rotary stiffness of the drive shaft can be neglected.

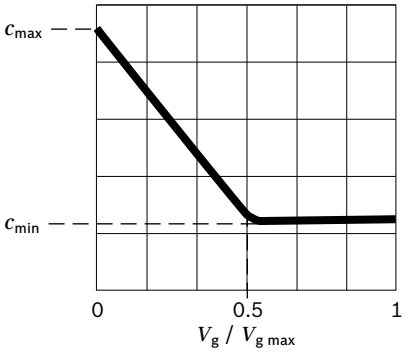
Axial piston fixed units

For the rotary stiffness of the cylinder barrel synchronization, choose the value c directly from the tables on page 4 and 5.

Axial piston variable units

For the rotary stiffness of the cylinder barrel synchronization choose the value c from the following diagram. This value is dependent on the displacement.

Interpolation of the rotary stiffness c (cylinder barrel synchronization)



Note
c_{min} and c_{max} values see tables on page 6 to 11.

Calculation example A6VM size 28

$V_{g\,max}$ = 28 cm³
c_{min} = 5670 Nm/rad
c_{max} = 18100 Nm/rad

▼ **Example 1**

$V_{g\,x}$ = 21 cm³

$V_{g\,x}$ between $\frac{V_{g\,max}}{2}$ = 14 cm³ and $V_{g\,max}$ = 28 cm³

$\frac{V_{g\,x}}{V_{g\,max}}$ = 0.75

c_{21} = c_{min}

▼ **Example 2**

$V_{g\,x}$ = 7 cm³

$V_{g\,x}$ between 0 cm³ and $\frac{V_{g\,max}}{2}$ = 14 cm³

$\frac{V_{g\,x}}{V_{g\,max}}$ = 0.25

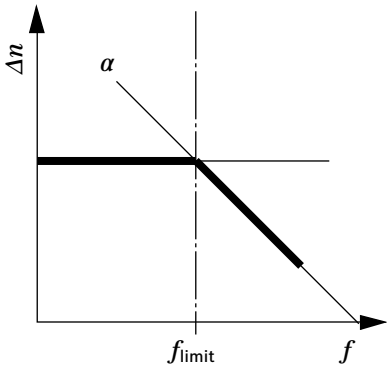
$c_7 = c_{max} - \frac{V_{g\,x}}{\frac{V_{g\,max}}{2}} \cdot (c_{max} - c_{min})$

c_7 = 11885 Nm/rad

Limit values α, Δn, f_{Limit} and α_A

Due to backlash in the cylinder barrel synchronization between drive shaft and cylinder barrel, speed variations are only permissible to a certain level. This is frequency dependent. At an excitation frequency f smaller f_{limit} is a maximal speed variation as listed in the table Δn permissible.
At an excitation frequency f larger f_{limit} less is permissible; here the specified permissible angular acceleration α limits the size of the speed variation: $\Delta n_{adm} = 3.04 \cdot \alpha / f$.

▼ **Angular acceleration α**

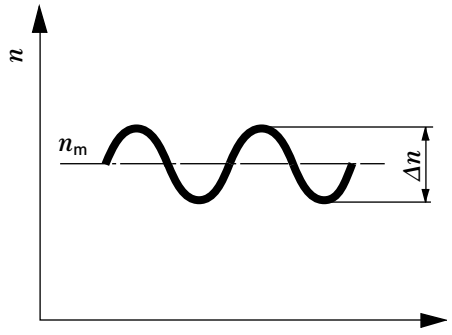


The angular acceleration specifies the change in angular speed over time.

▼ **Startup angular acceleration α_A**

The startup angular acceleration is equivalent to the angular acceleration, though this acceleration occurs only short term when starting and braking the rotary group. In the event of frequent starting or abrupt acceleration in alternating direction, the permissible angular acceleration α_A must not be exceeded due to backlash in the cylinder barrel synchronization.

▼ **Speed variation Δn**

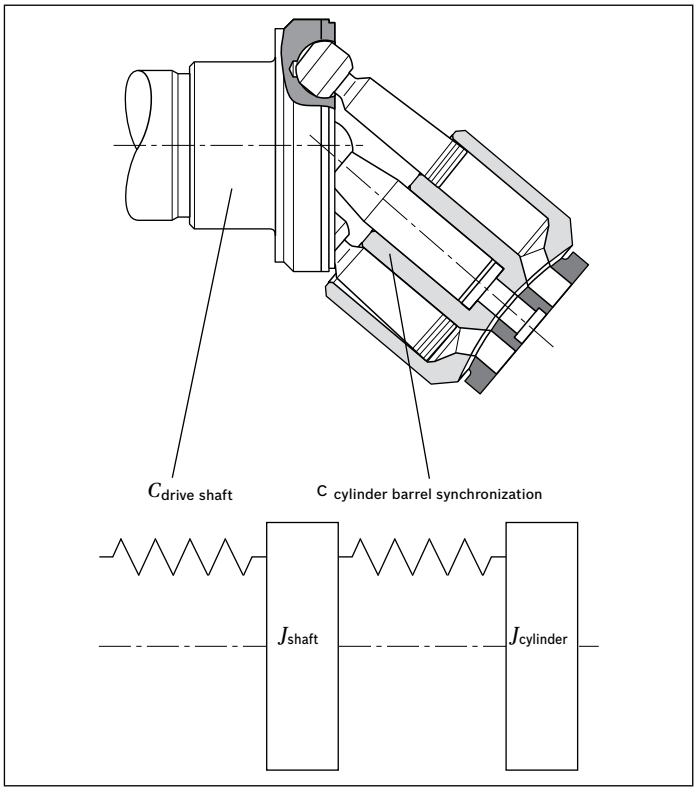


The speed variation specifies between which maximum and minimum speed the input speed varies to due external influences.

Simulation model

Recommendations

For the simulation of torsional vibrations in the drive train, we recommend representing the bent-axis unit as follows:



During acceleration of the pump or motor, the entire moment of inertia of the rotary group J_{TW} must be overcome. For vibration analysis, divide the value 50:50 % between both drive shaft and cylinder. The limit values for angular acceleration α, speed variation Δn etc. apply at the cylinder barrel synchronization.

▶ Partitioning of J_{TW} in J_{shaft} and $J_{cylinder}$ (overall):
$J_{shaft} = J_{cylinder\ barrel} = 50\ \% J_{TW}$

Technical data

Fixed motor/pump A2FM/6, A2FE/6, A2FO/6, A17FO/1, A17FNO/1

Size			5	10	12	16
Initial data for simulation						
Rotary stiffness	c	Nm/rad	625	922	1250	1590
Moment of inertia for rotary group	J_{TW}	kgm²	0.00006	0.0004	0.0004	0.0004
Limit values, maximum permissible						
Angular acceleration maximum	α	rad/s²	5000	5000	5000	5000
Speed variation in frequency range $f < f_{limit}$	Δn	rpm	40	40	40	40
Frequency range, upper limit	f_{limit}	1/s	380	380	380	380
Startup angular acceleration	α_A	rad/s²	3700	3700	3700	3700

Size			23	28	32	45	56	63	80
Initial data for simulation									
Rotary stiffness	c	Nm/rad	2560	2930	3120	4180	5940	6250	8730
Moment of inertia for rotary group	J_{TW}	kgm²	0.0012	0.0012	0.0012	0.0024	0.0042	0.0042	0.0072
Limit values, maximum permissible									
Angular acceleration maximum	α	rad/s²	6500	6500	6500	14600	7500	7500	6000
Speed variation in frequency range $f < f_{limit}$	Δn	rpm	40	40	40	50	50	50	40
Frequency range, upper limit	f_{limit}	1/s	494	494	494	888	456	456	456
Startup angular acceleration	α_A	rad/s²	2000	2000	2000	1800	1400	1400	1100

Size			90	107	125	160	180	200
Initial data for simulation								
Rotary stiffness	c	Nm/rad	9140	11200	11900	17400	18200	57300
Moment of inertia for rotary group	J_{TW}	kgm²	0.0072	0.0116	0.0116	0.022	0.022	0.0353
Limit values, maximum permissible								
Angular acceleration maximum	α	rad/s²	6000	4500	4500	3500	3500	11000
Speed variation in frequency range $f < f_{limit}$	Δn	rpm	40	35	35	30	30	80
Frequency range, upper limit	f_{limit}	1/s	456	391	391	355	355	418
Startup angular acceleration	α_A	rad/s²	1100	800	800	650	650	1600

Size			250	355	500	710	1000
Initial data for simulation							
Rotary stiffness	c	Nm/rad	73100	96100	144000	270000	324000
Moment of inertia for rotary group	J_{TW}	kgm²	0.061	0.102	0.178	0.55	0.55
Limit values, maximum permissible							
Angular acceleration maximum	α	rad/s²	10000	8300	5500	4300	4000
Speed variation in frequency range $f < f_{limit}$	Δn	rpm	80	60	50	50	50
Frequency range, upper limit	f_{limit}	1/s	380	420	334	261	243
Startup angular acceleration	α_A	rad/s²	1200	750	400	350	300

2-circuit fixed pump A18FDO/1

Size			63	80
Initial data for simulation				
Rotary stiffness	c	Nm/rad	12000	15000
Moment of inertia for rotary group	J_{TW}	kgm^2	0.0093	0.0134
Limit values, maximum permissible				
Angular acceleration maximum	α	rad/s^2	3800	3000
Speed variation in frequency range $f < f_{limit}$	Δn	rpm	23	20
Frequency range, upper limit	f_{limit}	1/s	502	456
Startup angular acceleration	α_A	rad/s^2	370	280

Variable motor A6VM/6, A6VE/6

Size				28	55	80	107	140
Initial data for simulation								
Rotary stiffness	$V_{g\,max}$ to $V_g/2$	c_{min}	Nm/rad	5670	10400	15500	21000	33900
	$V_g/2$ to $0_{(interpolated)}$	c_{max}	Nm/rad	18100	32000	47900	65200	93400
Moment of inertia for rotary group		J_{TW}	kgm²	0.0014	0.0042	0.008	0.0127	0.0207
Limit values, maximum permissible								
Angular acceleration maximum		α	rad/s²	47000	31500	24000	19000	11000
Speed variation in frequency range $f < f_{limit}$		Δn	rpm	200	160	130	110	80
Frequency range, upper limit		f_{limit}	1/s	714	598	561	525	418
Startup angular acceleration[1)]		α_A	rad/s²	8500	5900	4400	2800	2700

Size				160	200
Initial data for simulation					
Rotary stiffness	$V_{g\,max}$ to $V_g/2$	c_{min}	Nm/rad	35300	43800
	$V_g/2$ to $0_{(interpolated)}$	c_{max}	Nm/rad	105000	130000
Moment of inertia for rotary group		J_{TW}	kgm²	0.0253	0.0353
Limit values, maximum permissible					
Angular acceleration maximum		α	rad/s²	11000	11000
Speed variation in frequency range $f < f_{limit}$		Δn	rpm	80	80
Frequency range, upper limit		f_{limit}	1/s	418	418
Startup angular acceleration[1)]		α_A	rad/s²	2100	1600

Size				250	355	500	1000
Initial data for simulation							
Rotary stiffness	$V_{g\,max}$ to $V_g/2$	c_{min}	Nm/rad	59500	74800	115000	281000
	$V_g/2$ to $0_{(interpolated)}$	c_{max}	Nm/rad	181000	262000	391000	820000
Moment of inertia for rotary group		J_{TW}	kgm²	0.061	0.102	0.178	0.55
Limit values, maximum permissible							
Angular acceleration maximum		α	rad/s²	10000	8300	5500	4000
Speed variation in frequency range $f < f_{limit}$		Δn	rpm	80	60	50	50
Frequency range, upper limit		f_{limit}	1/s	380	420	334	243
Startup angular acceleration[1)]		α_A	rad/s²	1200	750	400	300

1) For operation exclusively in $V_{g\,max}$, higher values are permissible. Please contact us.

Variable motor A6VM/7, A6VE/7

Size				60	85	115	150	170
Initial data for simulation								
Rotary stiffness	$V_{g\,max}$ to $V_g/2$	c_{min}	Nm/rad	14500	22400	37300	43500	51900
	$V_g/2$ to $0_{(interpolated)}$	c_{max}	Nm/rad	45300	67500	103800	124000	156400
Moment of inertia for rotary group		J_{TW}	kgm²	0.0043	0.0072	0.0110	0.0181	0.0213
Limit values, maximum permissible								
Angular acceleration maximum		α	rad/s²	21000	17500	15500	11000	11000
Speed variation in frequency range $f < f_{limit}$		Δn	rpm	90	90	90	80	70
Frequency range, upper limit		f_{limit}	1/s	709	591	523	418	478
Startup angular acceleration[1)]		α_A	rad/s²	4500	3300	2100	2000	1600

Size				215	280
Initial data for simulation					
Rotary stiffness	$V_{g\,max}$ to $V_g/2$	c_{min}	Nm/rad	69600	71800
	$V_g/2$ to $0_{(interpolated)}$	c_{max}	Nm/rad	195600	208900
Moment of inertia for rotary group		J_{TW}	kgm²	0.0303	0.0479
Limit values, maximum permissible					
Angular acceleration maximum		α	rad/s²	10000	7000
Speed variation in frequency range $f < f_{limit}$		Δn	rpm	65	50
Frequency range, upper limit		f_{limit}	1/s	468	426
Startup angular acceleration[1)]		α_A	rad/s²	1200	700

1) For operation exclusively in $V_{g\,max}$, higher values are permissible. Please contact us.

Variable pump A7V0/6

Size				28	55	80	107	160
Initial data for simulation								
Rotary stiffness	$V_{g\,max}$ to $V_g/2$	c_{min}	Nm/rad	5546	10594	15911	21469	36073
	$V_g/2$ to $0_{(interpolated)}$	c_{max}	Nm/rad	16541	32103	48971	67666	104622
Moment of inertia for rotary group		J_{TW}	kgm²	0.0042	0.0042	0.008	0.0127	0.0253
Limit values, maximum permissible								
Angular acceleration maximum		α	rad/s²	35900	31600	24200	19200	15300
Speed variation in frequency range $f < f_{limit}$		Δn	rpm	207	171	143	116	98
Frequency range, upper limit		f_{limit}	1/s	527	562	514	503	475
Startup angular acceleration[1)]		α_A	rad/s²	8955	6324	4628	3063	2302

Size				250	355	500	1000
Initial data for simulation							
Rotary stiffness	$V_{g\,max}$ to $V_g/2$	c_{min}	Nm/rad	59500	74800	115000	281000
	$V_g/2$ to $0_{(interpolated)}$	c_{max}	Nm/rad	181000	262000	391000	820000
Moment of inertia for rotary group		J_{TW}	kgm²	0.061	0.102	0.178	0.55
Limit values, maximum permissible							
Angular acceleration maximum		α	rad/s²	10000	8300	5500	4000
Speed variation in frequency range $f < f_{limit}$		Δn	rpm	80	60	50	50
Frequency range, upper limit		f_{limit}	1/s	380	420	334	243
Startup angular acceleration[1)]		α_A	rad/s²	1200	750	400	300

1) For operation exclusively in $V_{g\,max}$, higher values are permissible. Please contact us.

Variable pump A17V0/1, A18VO/1, A18VLO/1

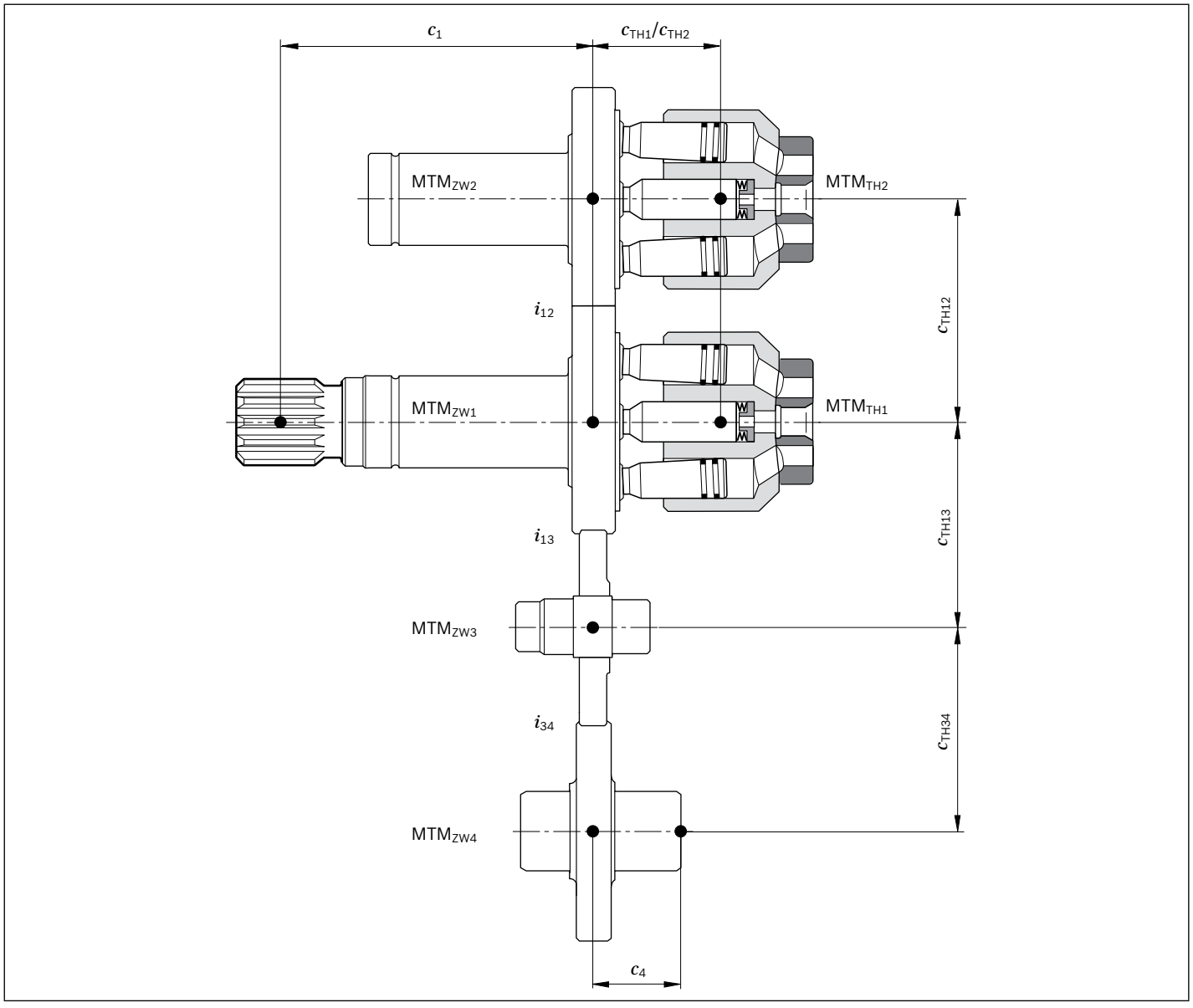
Size				55	80	107
Initial data for simulation						
Rotary stiffness	$V_{g\,max}$ to $V_g/2$	c_{min}	Nm/rad	10594	15911	21469
	$V_g/2$ to $0_{(interpolated)}$	c_{max}	Nm/rad	32103	48971	67666
Moment of inertia for rotary group		J_{TW}	kgm²	0.0034	0.0066	0.0109
Limit values, maximum permissible						
Angular acceleration maximum		α	rad/s²	31600	24200	19200
Speed variation in frequency range $f < f_{limit}$		Δn	rpm	171	143	116
Frequency range, upper limit		f_{limit}	1/s	562	514	503
Startup angular acceleration[1)]		α_A	rad/s²	6324	4628	3063

1) For operation exclusively in $V_{g\,max}$, higher values are permissible. Please contact us.

Simulation model for A8VO

Recommendations

For the simulation of torsional vibrations in the drive train,
we recommend representing the bent-axis unit as follows:



Technical data

Variable double pump A8VO

Size				55	80	107	120	140	200
Initial data for simulation									
Rotary stiffness	$V_{g\,max}$ to $V_{g/2}$	$c_{TH1\,=\,}c_{TH2min}$	Nm/rad	11213	17985	25565	22000	41408	39505
	$V_{g/2}$ to $0_{(interpolated)}$	$c_{TH1\,=\,}c_{TH2max}$	Nm/rad	41442	67666	89381	81600	146677	156876
		c_1	Nm/rad	159436	168823	247004	241400	264216	404020
		c_{TH12}	Nm/rad	1059739	1218721	1657076	1833000	2024908	3152154
		c_{TH13}	Nm/rad	793565	793585	1218483	1004400	1196017	1807261
		c_{TH34}	Nm/rad	656759	743315	1007570	1021300	1196066	879669
		c_4	Nm/rad	633899	1162000	902000	1430100	3077000	3411000
Gear ratio		i_{12}		1.0	1.0	1.0	1.0	1.0	1.0
		i_{13}		1.128	1.128	1.283	1.244	1.186	1.243
		i_{34}		0.887	0.887	0.780	0.804	0.843	1.0
Moment of inertia for rotary group									
MTM_{ZW1}			kgm²	0.0041	0.0044	0.0071	0.0075	0.0099	0.0200
MTM_{ZW2}			kgm²	0.0040	0.0043	0.0069	0.0074	0.0096	0.0197
MTM_{ZW3}			kgm²	0.0012342	0.0012455	0.0013453	0.0016481	0.0023170	0.0037225
MTM_{ZW4}			kgm²	0.0020	0.0020	0.0034	0.0038	0.0048	0.0027
$MTM_{TH1} = MTM_{TH2}$			kgm²	0.0022	0.0043	0.0074	0.0066	0.0153	0.0177
with power take-off, without attachment pump		J_{TW}	kgm²	0.0161	0.0209	0.0345	0.0345	0.0581	0.0849
without power take-off		J_{TW}	kgm²	0.0126	0.0173	0.0288	0.0281	0.0500	0.0750
Limit values, maximum permissible									
Angular acceleration maximum		α	rad/s²	25800	21800	17100	6400	7500	11000
Speed variation in frequency range $f < f_{limit}$		Δn	rpm	156	130	100	60	80	80
Frequency range, upper limit		f_{limit}	1/s	503	510	520	324	285	418
Startup angular acceleration[1)]		α_A	rad/s²	5000	3700	2500	2250	2000	1600

Note

TH = rotary group hydraulic

ZW = gearwheel + shaft

1) For operation exclusively in $V_{g\,max}$, higher values are permissible. Please contact us.

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