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Hydraulic Dynamometer
Type DT

Technical Specification

Version/Date: 6.2/ 2007-05-23

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1 A Horiba ATS Product with Convincing Features

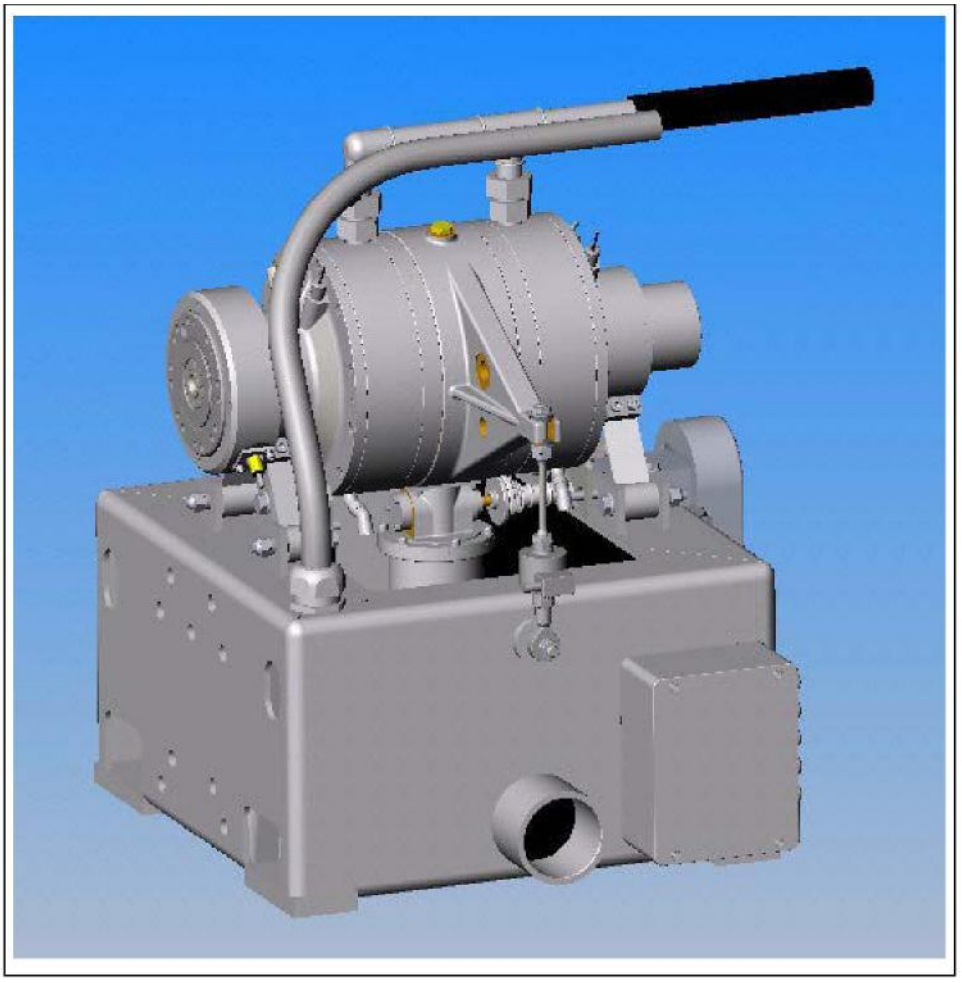


Fig. 1: Hydraulic Dynamometer Type DT

1.1 Fields of Application

The type DT hydraulic dynamometers are mainly used as loading units for production testing of combustion engines, mainly Diesel engines, on engine test stands. Furthermore, they are used as loading unit for powertrain and gearbox test stands as well as chassis dynos. In this function, they absorb the mechanical energy of the driving motor and allow its being loaded with torque. The mechanical energy is converted into warmed-up cooling water.

The hydraulic dynamometers are available in different sizes and constructions so that a great variety of combustion engines can be tested, e.g.:

Combustion engines for passenger cars and commercial vehicles

Aircraft engines and turbines

Large engines for trains and ships

Hydraulic motors

Electric motors

1.2 Multi-Purpose and Flexible in Design

Great Variety of Power Ranges

Hydraulic dynamometers type DT are available with a big variety of power ranges. The standard range extends from 400 kW up to 12,600 kW.

The type designation consists of a DT followed by the maximal power in kW. Thus, DT400 represents a dynamometer with a maximal power of 400 kW.

One and Two Directions of Rotation

Usually, the dynamometers are designed for one direction of rotation. In this direction, they are adjusted for an optimal torque at different speeds. However, we are also able to supply dynamometers for two directions of rotation. The maximal torque of these, however, is slightly lower than one of the dynamometers with one direction of rotation. In the type designation, the number of directions of rotation is represented by the figure behind the size of the dynamometer. That means, DT400-1 is a dynamometer for one direction of rotation.

One and Two Rotors

If high power at high speed is required from fast-running dynamometers, e.g. for fast-running Diesel engines, DYNABAR dynamometers with two rotors are available. These dynamometers allow the same maximal speed as the ones with one rotor, however, the maximal torque doubles.

By that, the double maximal braking force is available as well. In the type designation, dynamometers with two rotors are characterised by a "2" directly behind the DT: DT2-4200-1 is a hydraulic dynamometer with two rotors for one direction of rotation and a maximal power of 4200 kW.

1.3 Your Advantages

The hydraulic dynamometers type D stand out for essential features:

- High accuracy of measurement
- Brushless motor with resolver for the control valve drive (potentiometer has been dropped)
- High dynamical characteristics resulting in better controllability
- Automatic adjustment of the control valve limit positions
- Simple design resulting in low effort required for overhaul, dismantling and installation
- High-quality materials (parts in the swirl range of the water are made of bronze and therefore are very resistant to wear and seawater)
- high-quality materials. The parts lying in the periptery of the water
- are made of bronze. Therefore they are sea water resistant and
- show particularly low wear.
- Reliable operation even in case of not optimal cooling water conditions
- Wide range of standard sizes for different engine power
- Many variants for a great variety of applications
- Excellent price/performance ratio (Euro/kW) as compared with eddy current dynamometers and asynchronous drives
- High power density
- Compact construction for low requirement of space
- Low power requirement
- No remarkable reactive current
- Extensive accessories, also for the adjustment to different cooling water supplies
- Definition of the operating time
- Self-monitoring (standard bearing temperature and cooling water as an option) and therefore intrinsically safe, low risk with running in (new bearing or relubrication), seldom resp. little damage and repair costs occurring in the case of fault
- Prepared for on-site vibration monitoring of the bearings (drilling for vibration sensors)

2 How it Works

21 Principle of Function

The hydraulic dynamometer type DT is connected with the engine to be tested by a shaft. It converts the mechanical energy of the engine existing at the shaft of the dynamometer as torque and speed into warming-up of the cooling water. During that, the water serves as working medium for the creation of the braking moment and, at the same time, as cooling medium for dissipating the kinetic energy converted into heat.

The cooling water supplied by the customer is conducted into the dynamometer, accelerated by the rotor of the dynamometer and decelerated again by the stator. The inner friction occurring in the water during that converts the kinetic energy of the water into heat.

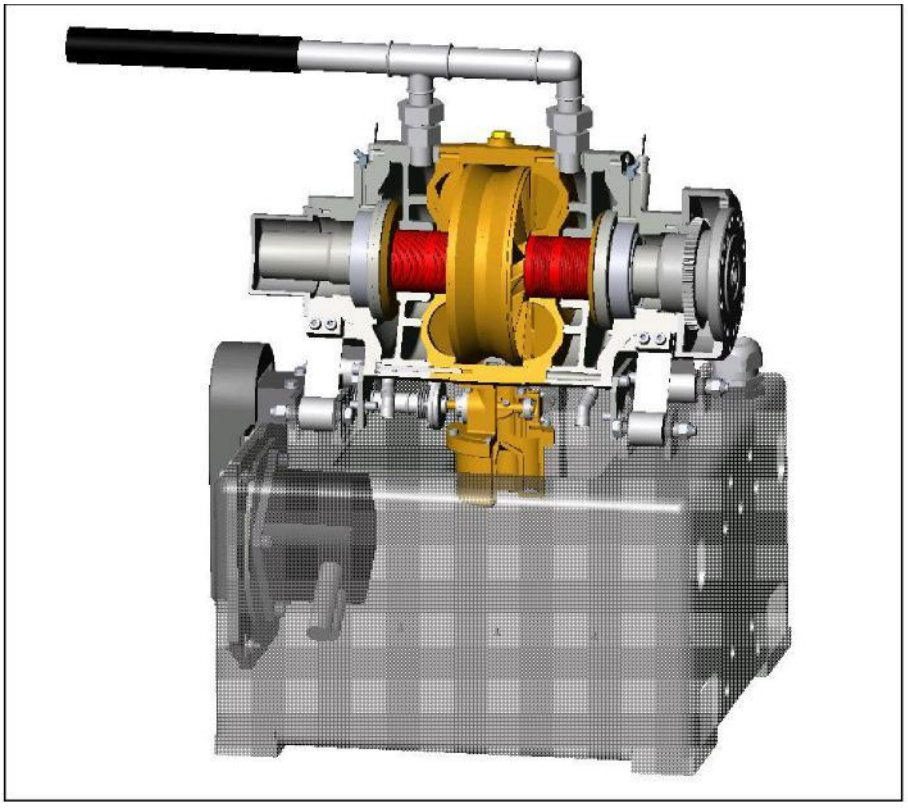


Fig. 2: Inside Construction of the Type DT Hydraulic Dynamometers

The braking power of the dynamometer is water-controlled via the fill factor. For that, a control valve driven by a fast controlling motor is installed at the cooling water outlet at the bottom of the dynamometer. Optionally, the water supply can additionally be controlled by inlet servo valve. With that, the torque response times can still be reduced.

The braking power of the dynamometer is controlled through the water filling level by a motor-operated control valve installed in the cooling water outlet at the bottom.

The lowest torque of the dynamometer, the so-called idling characteristics, results from minimal water filling. This characteristics is not zero if there is no water in the dynamometer because in this case air whirls instead of water whirls develop. With minimal water filling neither air nor water whirls can develop completely which causes the lowest torque. This so-called “idling power” is highest at maximal speed of the dynamometer and correspondingly lower at lower speeds. The idling power, please take from the power ranges in chapter “Technical Data”. These values vary depending on the inlet cooling water quantity.

2.2 Torque Measurement

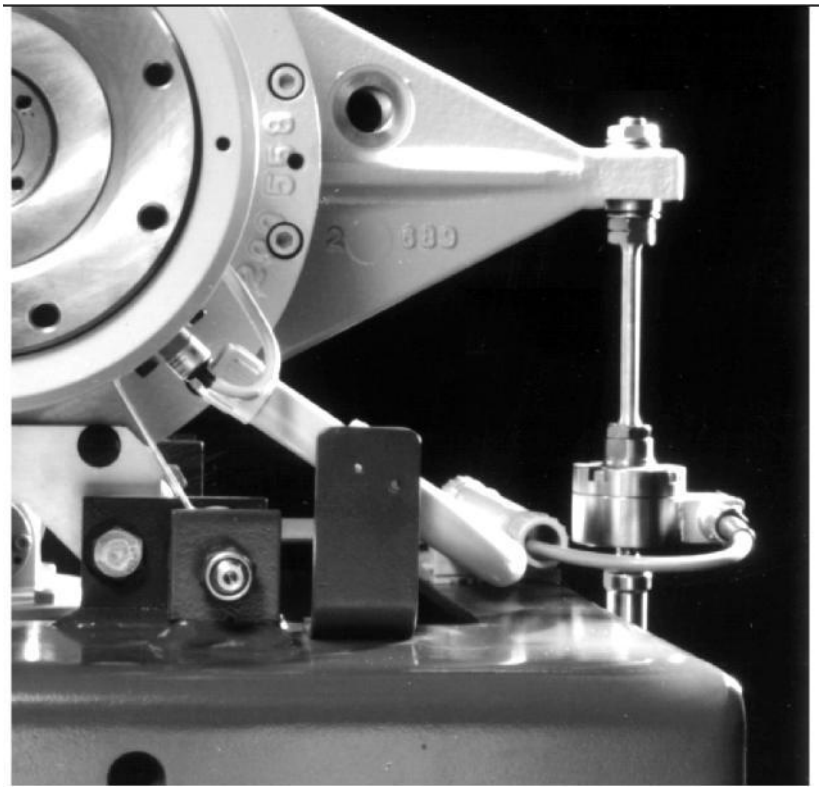


Fig. 3: Torque Measurement Via Load Cell With Pendulum Body Support, Here With a Dynamometer With Flexure Support

The test piece is connected with the rotor of the dynamometer via shaft and flange. Due to the rotating movement of the shaft, the body of the dynamometer "oscillates" as well. The special flexure support of the dynamometer only takes up the weight of the pendulum body and the counterforce to the load cell. Thus, the total torque is effective via a lever arm on the load cell installed by the side of the pendulum body. The measured force is proportional with the braking torque. The flexure strips are almost friction- and maintenance-free. They provide a quick response, allow almost hysteresis-free measurement of the torque and keep theses features permanently.

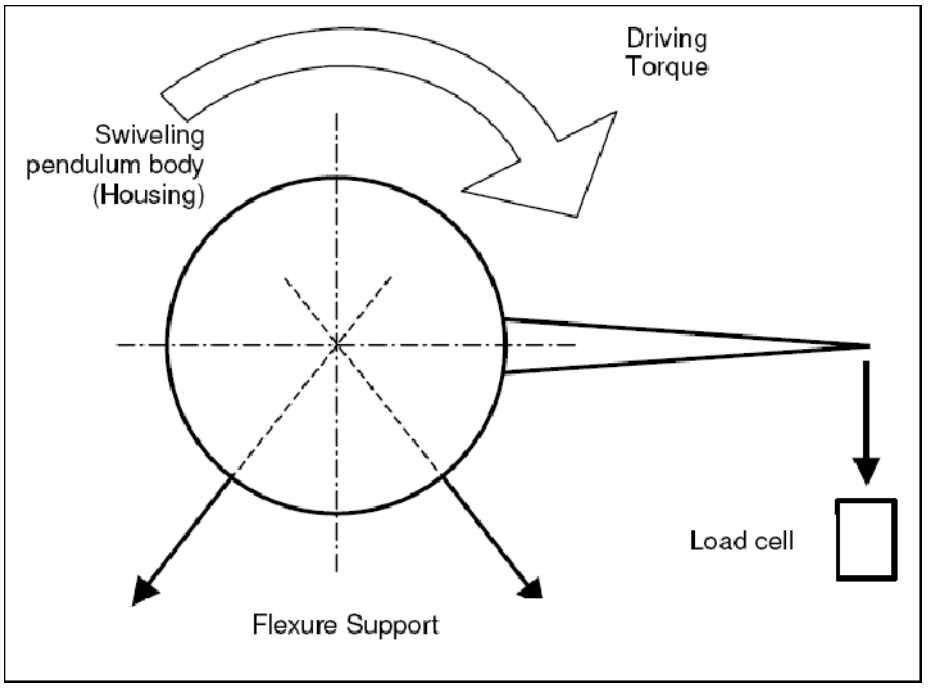


Fig. 4: Principle of Torque Measurement With Pendulum Support

Large dynamometers from D9800 on can exclusively be supplied with roller support. In this case, the pendulum body is supported by eight rollers instead of four flexure strips which is usual for large dynamometers.

As alternative for flexure/roller support, the hydraulic dynamometers are available with trunnion bearings in which the dynamometer is supported by one rolling bearing each at both ends.

2.3 Speed Acquisition

The speed is acquired digitally at the shaft of the dynamometer via a toothed wheel and a pulse generator.

2.4 Frame

The dynamometer is installed on a stable welded frame. In this frame, cooling water outlet and connection point for the electric lines are integrated as well.

2.5 Power Supply

The control valve is equipped with power supply and electronic control. Power supply unit LED 2003 integrates the complete electronic system in one 19“ plug-in unit.

Higher adjusting torques of the throttle operated with a stronger motor require the use of special power supply unit LED 2005 for dynamometers from size DT6300.

Fig. 5: Power supply unit LED 2003 as 19“ plug-in unit for all dynamometer sizes up to DT4500

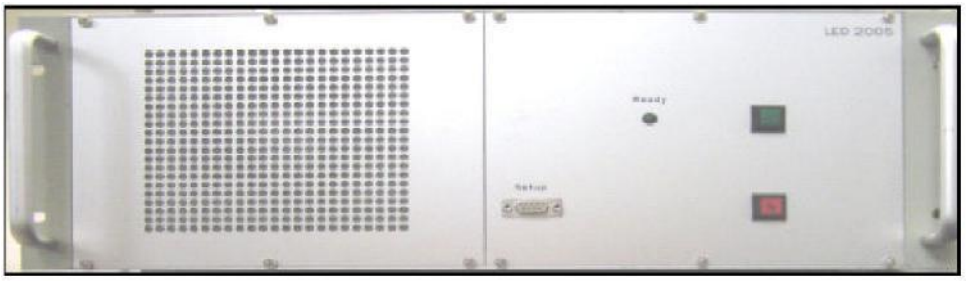


Fig. 6: Power supply unit LED2005 as 19“ plug-in unit for dynamometers size DT6300 and up

2.6 Brake monitor

The dynamometer is equipped with a device to monitor the operation and major functions. The standard version monitors the operating time (dynamometer is switched on and running) and the bearing temperature. Exceeding the set maximum permissible bearing temperature triggers a fault message on the monitor and switches off the test stand via the safety circuit. Consequential damage caused by destroyed bearings can be avoided in this way. The bearing temperature is also monitored during running in after relubrication. Bearing temperatures can be displayed on the SPARC test stand controller. Cooling water monitoring is available as an option and is already prepared in the standard design of the dynamometer. This device monitors the maximum and minimum inlet pressure together with the cooling water outlet temperature. Limit exceeding also initiates a fault message and opening of the safety circuit. The brake monitor transmits data to SPARC via CAN-Bus. Fault messages are displayed with clear text. The monitor is equipped with an additional contact to output signals “Dynamometer ready“ and “Fault“.

2.7 Test Stand Controller SPARC

The digital test stand controller SPARC by Horiba ATS GmbH controls the speed and the desired torque. The unit is optimally matched to operation with the power component of the hydraulic dynamometer. Further information, please take from the corresponding technical specification “Digital Test Stand Controller SPARC”.

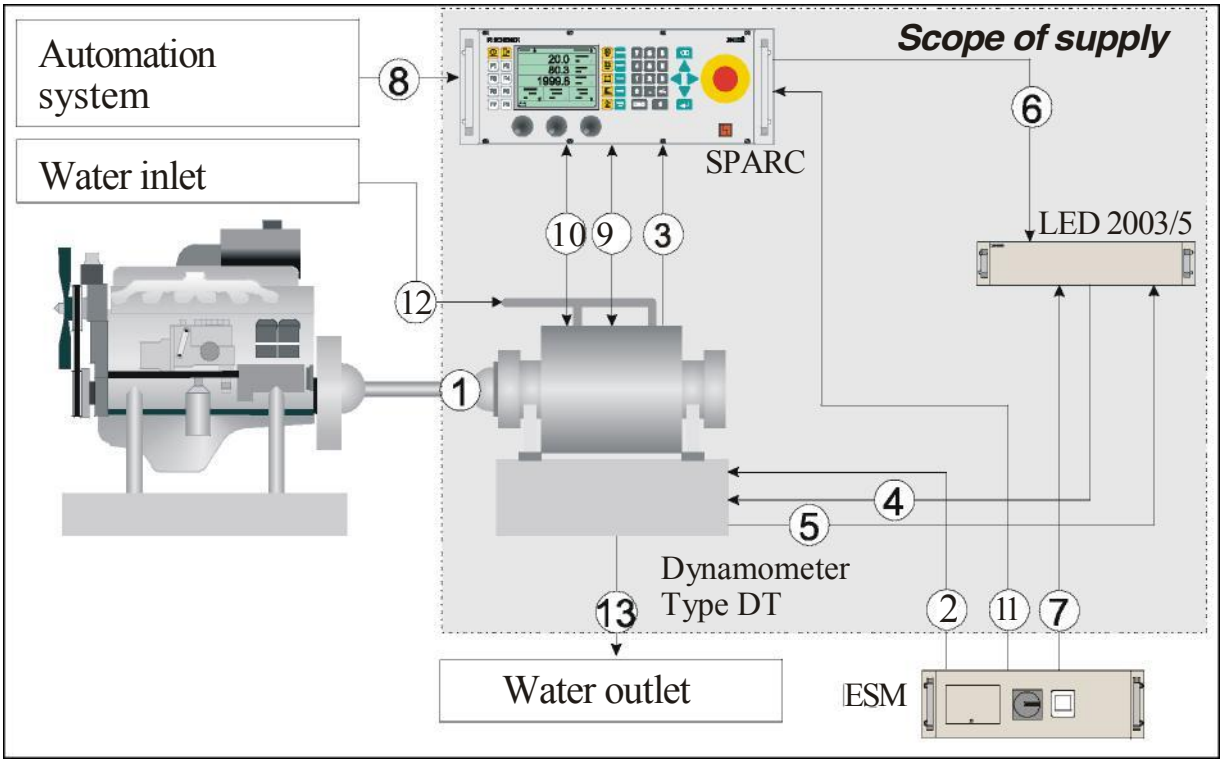
Fig. 7: Digital Test Stand Controller SPARC

2.8 Interfaces

See also the interface diagram of hydraulic dynamometer type DT

Interface 1	Coupling flange, for connection data, please see chapter "Dimensions"
Interface 2	24-V-supply for the inlet valve (option) via the ESM supply module (option)
Interface 3	Bridge input signal for torque measurement with load cell in 6-wire technology DMS full bridge with 2 mV/V Excitation 10 V @ 5 kHz Resolution 16 Bit Accuracy 100 ppm/°C MBE
Interface 4	Power supply for servo motor of the outlet throttle valve
Interface 5	Actual value 0...10 V throttle valve angle of the outlet valve of the hydraulic dynamometer
Interface 6	Demand value 0...10 V for throttle valve angle of the outlet valve of the hydraulic dynamometer
Interface 7	Power supply LED 2003: 1 ~ PEN, 230 V, 50/60 Hz LED 2005: 3 ~ PEN, 400 V, 50/60 Hz Max. current consumption LED 2003: approx. 7 A, LED 2005 approx. 3 * 11 A Conductor area LED 2003: 3 * 1,5 mm^2, fused with 10 A LED 2005: 5 * 2,5 mm^2, fused with 16 A, supplied via optional ESM supply module
Interface 8	Operating modes and demand values: Analogue values ≙ 10 V; Bit-parallel signals 0 / 24 V DC
Interface 9	CAN-Bus: Bearing temperature, water temperature (option), water pressure (option), control of the inlet valve (option)
Interface 10	Voltage supply +15V for brake monitor Actual value of speed to SPARC Signal “Dynamometer ready“ to SPARC
Interface 11	Power supply for SPARC: 1~PEN, 85-264V / 48-62Hz Supply via ESM supply module (option)
Interface 12	Water inlet, connection data see chapter "Dimensions"
Interface 13	Water outlet, connection data see chapter "Dimensions"

Fig. 8: Interfaces of hydraulic dynamometer type DT with the Controller Set



3 What we Deliver

3.1 Scope of Supply

The following is included in the basic scope of supply

The **dynamometer** including:

Pendulum body

Cradled bearing with flexure supports *

Pulse generator for speed measurement

Load cell for torque acquisition

Temperature sensor for bearing temperature measurement

Frame

Electrically controlled control valve in the cooling water outlet

Brake monitor with service-hour counter and bearing temperature monitoring

* for large dynamometers roller support

Controller Set

Power electronics for the control valve

- 19“ plug-in unit LED 2003 for dynamometers up to DT4500
- 19“ plug-in unit LED 2005 for dynamometers DT6300 and up

Test stand controller

- SPARC
- Cable set
- Technical documentation

Options

Further components and services completing the standard scope of supply can be ordered additionally as well. For a description of the options, please see chapter "Product Options".

32 Order Numbers

321 Basic scope of supply

Hydraulic dynamometers with **flexure strips** and **one** rotor

Dynamometers with **one** direction of rotation		Dynamometers with **two** directions of rotation	
Type	**Order no.**	**Type**	**Order no.**
DT400-1	1000011563	DT400-2	1000011564
DT700-1	1000011697	DT700-2	1000011698
DT900-1	1000011720	DT900-2	1000011721
DT1200-1	1000011981	DT1200-2	1000011982
DT2100-1	1000012447	DT2100-2	1000012448
DT3600-1	1000012449	DT3600-2	1000012450
DT4500-1	1000012975	DT4500-2	1000012976
DT6300-1	1000012376	DT6300-2	1000012377

Hydraulic dynamometers with **roller support** and **one** rotor

Dynamometers with **one** direction of rotation		Dynamometers with **two** directions of rotation	
Type	**Order no.**	**Type**	**Order no.**
DT9800-1	1000012977	DT9800-2	1000012978

Hydraulic dynamometers with **flexure strips** and **two** rotors

Dynamometers with **one** direction of rotation		Dynamometers with **two** directions of rotation	
Type	**Order no.**	**Type**	**Order no.**
DT2-800-1	1000012904	DT2-800-2	1000012905
DT2-1400-1	1000012981	DT2-1400-2	1000012982
DT2-2400-1	1000012979	DT2-2400-2	1000012980
DT2-4200-1	1000012983	DT2-4200-2	1000012984
DT2-7200-1	1000012885	DT2-7200-2	1000012886

Hydraulic dynamometers with **roller support** and **two** rotors

Dynamometers with **one** direction of rotation		Dynamometers with **two** directions of rotation	
Type	**Order no.**	**Bezeichnung**	**Order no.**
DT2-12600-1	1000012987	DT2-12600-2	1000012988

Controller Set
(Power-Supply Unit LEW and Test Stand Controller SPARC):

for dynamometer **by DT4500**		for dynamometer **from DT6300**	
Type	**Order no.**	**Type**	**Order no.**
LED2003 and SPARC	1000012918	LED2005 and SPARC	1000012919

Alternative design

3.2.2 Trunnion Bearings

Hydraulic dynamometers with **trunnion bearings** and **one** rotor

Dynamometers with **one** direction of rotation		Dynamometers with **two** directions of rotation	
Type	**Order no.**	**Type**	**Order no.**
DT400-1	1000012989	DT400-2	1000012990
DT700-1	1000012991	DT700-2	1000012992
DT900-1	1000012993	DT900-2	1000012994
DT1200-1	1000012995	DT1200-2	1000012996
DT2100-1	1000012997	DT2100-2	1000012998
DT3600-1	1000012999	DT3600-2	1000013000
DT4500-1	1000013001	DT4500-2	1000013002

Hydraulic dynamometers with **roller support** and **one** rotor

Dynamometers with **one** direction of rotation		Dynamometers with **two** directions of rotation	
Type	**Order no.**	**Type**	**Order no.**
DT6300-1	1000013003	DT6300-2	1000013004

Hydraulic dynamometers with **trunnion bearings** and **two** rotors

Dynamometers with **one** direction of rotation		Dynamometers with **two** directions of rotation	
Type	**Order no.**	**Type**	**Order no.**
DT2-800-1	1000013005	DT2-800-2	1000013006
DT2-1400-1	1000013007	DT2-1400-2	1000013008
DT2-2400-1	1000013009	DT2-2400-2	1000013010
DT2-4200-1	1000013011	DT2-4200-2	1000013012
DT2-7200-1	1000013013	DT2-7200-2	1000013014

Optionen

3.2.3 Second Coupling Flange

Second coupling flange for dynamometers with **one rotor**

for Dynamometer Type	**Order no.**
DT400	1000008065
DT700	1000008066
DT900	1000008067
DT1200	1000008068
DT2100	1000008069
DT3600	1000008070
DT4500	1000006717
DT6300	1000009294

Second coupling flange for dynamometers with **two rotors**

for Dynamometer Type	**Order no.**
DT2-800	1000008065
DT2-1400	1000008068
DT2-2400	on request
DT2-4200	on request
DT2-7200	1000009000
DT2-12600	1000010629

3.2.4 Modification of the control valve drive

for Dynamometer Type	Order no.
Modification of the control valve drive with 15 m cable D400, D700, D900, D1200, D2100, D3600, D2-800, D2-1400, D2-2400	1000012251
Cable set 25 m	1000006050
Cover plate for valve drive D2-2400	on request
Cover plate for valve drive D3600	1000012605

4 Figures, Data, Facts

4.1 Type Key

The type D hydraulic dynamometers by Horiba ATS GmbH are characterised by the letter "DT":

DT 2 -xxx -1

- Number of directions of rotation
- Braking power in [kW]
- Number of rotors
- Hydraulic dynamometer type DT

4.2 Technical Data

Torque / Speed Measuring System		
Measuring error, speed *	U/min	± 1, not smaller than 0.025 % of final value of measuring range
Measuring error, torque *	%	Accuracy class 0,2 (related to the measuring range final value), that means hysteresis error < 0,2, linearity error < 0,2 temperature drift < 0,2 per 10 K change of the ambient temperature
Control error, speed *	U/min	± 10
Control error, torque *	%	± 1 , specific to final value of measuring range
General data		
Color		Light-grey RAL 7035
Transport and storage temperature	°C	-50 by + 85
Working temperature	°C	0 to 60 without coolant additives

* specific to the system hydraulic dynamometer, power component and test stand controller

4.2.1 Hydraulic Dynamometers with one Rotor and one Direction of Rotation

Type	P_{nom}	Maximal Speed n_{max}	Rated Torque M_{nom}	Max. Share of Coupling Mass at n_{max} / Distance from the coupling flange	Max. axial force at the shaft	Rotor	Torsion-spring constant up to middle of dynamometer	Weight
	kW	1/min	Nm	kg / mm	kN	kgm^2	10^6 Nm/wheel	kg
DT400-1	400	10000	1300	6,3 / 38	0,32	0,08	0,374	200
DT700-1	700	7500	3000	15 / 50	0,9	0,3	0,923	370
DT900-1	900	6500	4000	24 / 57	0,9	0,6	1,31	500
DT1200-1	1200	5500	7500	36 / 66	0,9	1,2	2,55	650
DT2100-1	2100	4000	15000	110 / 86	1,46	3,9	5,2	1300
DT3600-1	3600	3000	35000	280 / 114	1,31	18,4	11,9	3200
DT4500-1	4500	2700	50000	350 / 125	1,31	29,5	12,4	3400
DT6300-1	6300	2500	80000	530 / 150	2,64	50,5	26,8	6600
DT9800-1	9800	1500	180000	1480 / 197	4	200	63,6	11500

4.2.2 Dynamometers with One Rotor and Two Directions of Rotation

Type	P_{nom}	Maximal Speed n_{max}	Rated Torque M_{nom}	max. Share of Coupling Mass at n_{max} / Distance from the coupling flange	Max. axial force at the shaft	Rotor	Torsion-spring constant up to middle of dynamometer	Weight
	kW	1/min	Nm	kg	kN	kgm^2	10^6 Nm/wheel	kg
DT400-2	400	10000	1000	6,3 / 38	0,32	0,08	0,374	200
DT700-2	700	7500	2600	15 / 50	0,9	0,3	0,923	370
DT900-2	900	6500	4000	24 / 57	0,9	0,6	1,31	500
DT1200-2	1200	5500	6000	36 / 66	0,9	1,2	2,55	650
DT2100-2	2100	4000	15000	110 / 86	1,46	3,9	5,2	1300
DT3600-2	3600	3000	30000	280 / 114	1,31	18,4	11,9	3200
DT4500-2	4500	2700	40000	350 / 125	1,31	29,5	12,4	3400
DT6300-2	6300	2500	70000	530 / 150	2,64	50,5	26,8	6600
DT9800-2	9800	1500	170000	1480 / 197	4	200	63,6	11500

4.2.3 Dynamometers with Two Rotors and one Direction of Rotation

Type	P_{nom}	Maximal Speed n_{max}	Rated Torque M_{nenn}	max. Share of Coupling Mass at n_{max} / Distance from the coupling flange	Max. axial force at the shaft	$\Sigma(\cdot)$ Rotor	Torsion-spring constant up to middle of dynamometer	Weight
	kW	1/min	Nm	kg / mm	kN	kgm^2	10^6 Nm/wheel	kg
DT2-800-1	800	10000	2600	4 / 38	0,5	0,16	on request	360
DT2-1400-1	1400	7500	6000	10 / 50	0,9	0,6	on request	760
DT2-2400-1	2400	5500	15000	24 / 66	1,46	2,4	2,82	1350
DT2-4200-1	4200	4000	30000	73 / 86	1,46	7,8	5,92	2300
DT2-7200-1	7200	3000	70000	188 / 114	2,64	36,8	12,8	4000
DT2-12600-1	12600	2500	160000	277 / 150	4	101	36,3	8500

4.2.4 Dynamometers with two Rotors and two Directions of Rotation

Type	P_{nom}	Maximal Speed n_{max}	Rated Torque M_{nom}	max. Share of Coupling Mass at n_{max} / Distance from the coupling flange	Max. axial force at the shaft	$\Sigma(\cdot)$ Rotor	Torsion-spring constant up to middle of dynamometer	Weight
	kW	1/min	Nm	kg / mm	kN	kgm2	10^6 Nm/rad	kg
DT2-800-2	800	10000	2000	4 / 38	0,5	0,16	on request	360
DT2-1400-2	1400	7500	5000	10 / 50	0,9	0,6	on request	760
DT2-2400-2	2400	5500	10000	24 / 66	1,46	2,4	2,82	1350
DT2-4200-2	4200	4000	30000	73 / 86	1,46	7,8	5,92	2300
DT2-7200-2	7200	3000	60000	188 / 114	2,64	36,8	12,8	4000
DT2-12600-2	12600	2500	150000	277 / 150	4	101	36,3	8500

4.3 Power Ranges

The power ranges of the hydraulic dynamometers, please take from the diagrams on the following pages.

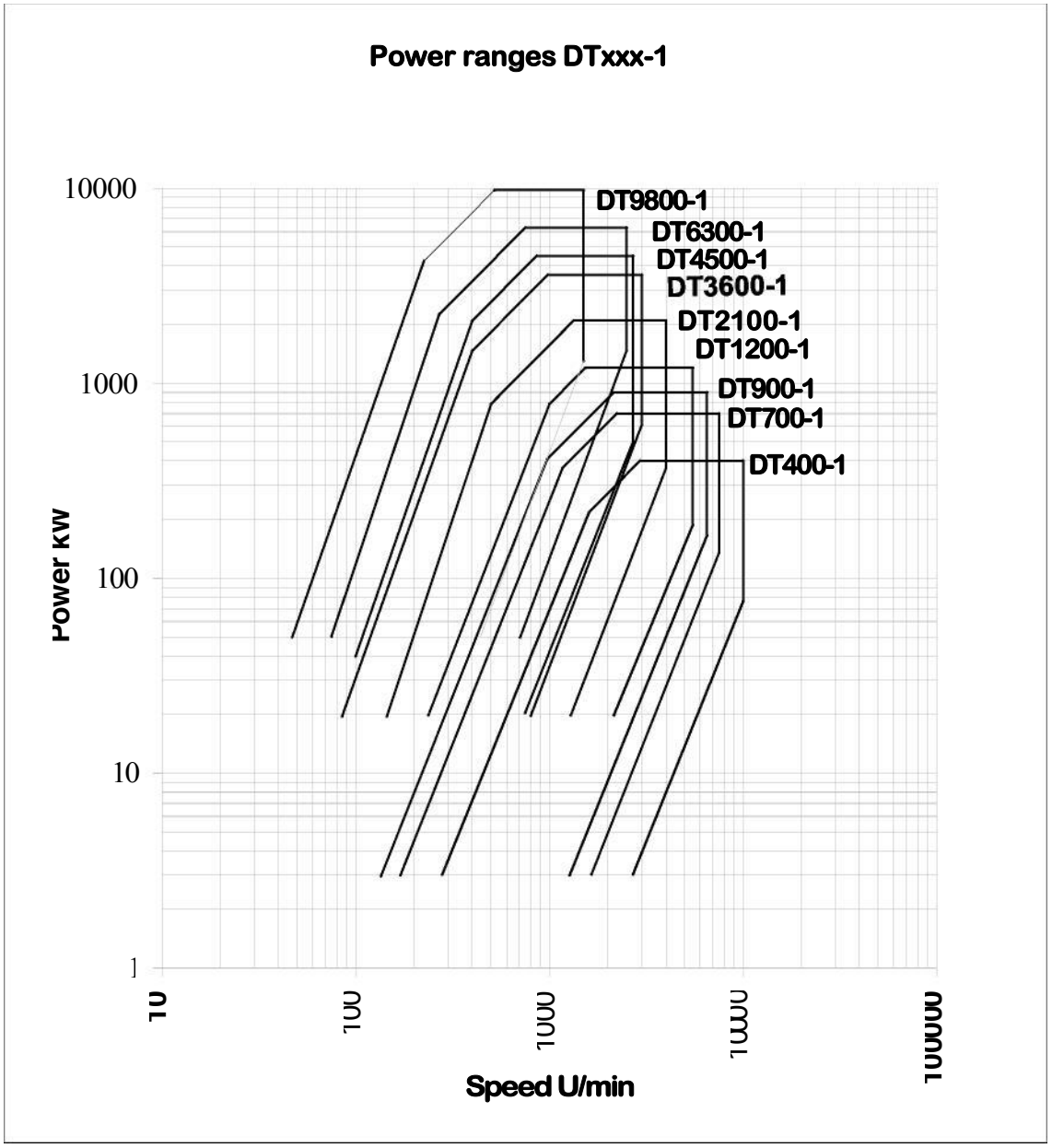


Fig. 9: Power ranges of the dynamometers with **one** rotor and **one** direction of rotation

Fig. 10: Power ranges of the dynamometers with **one** rotor and **two** directions of rotation

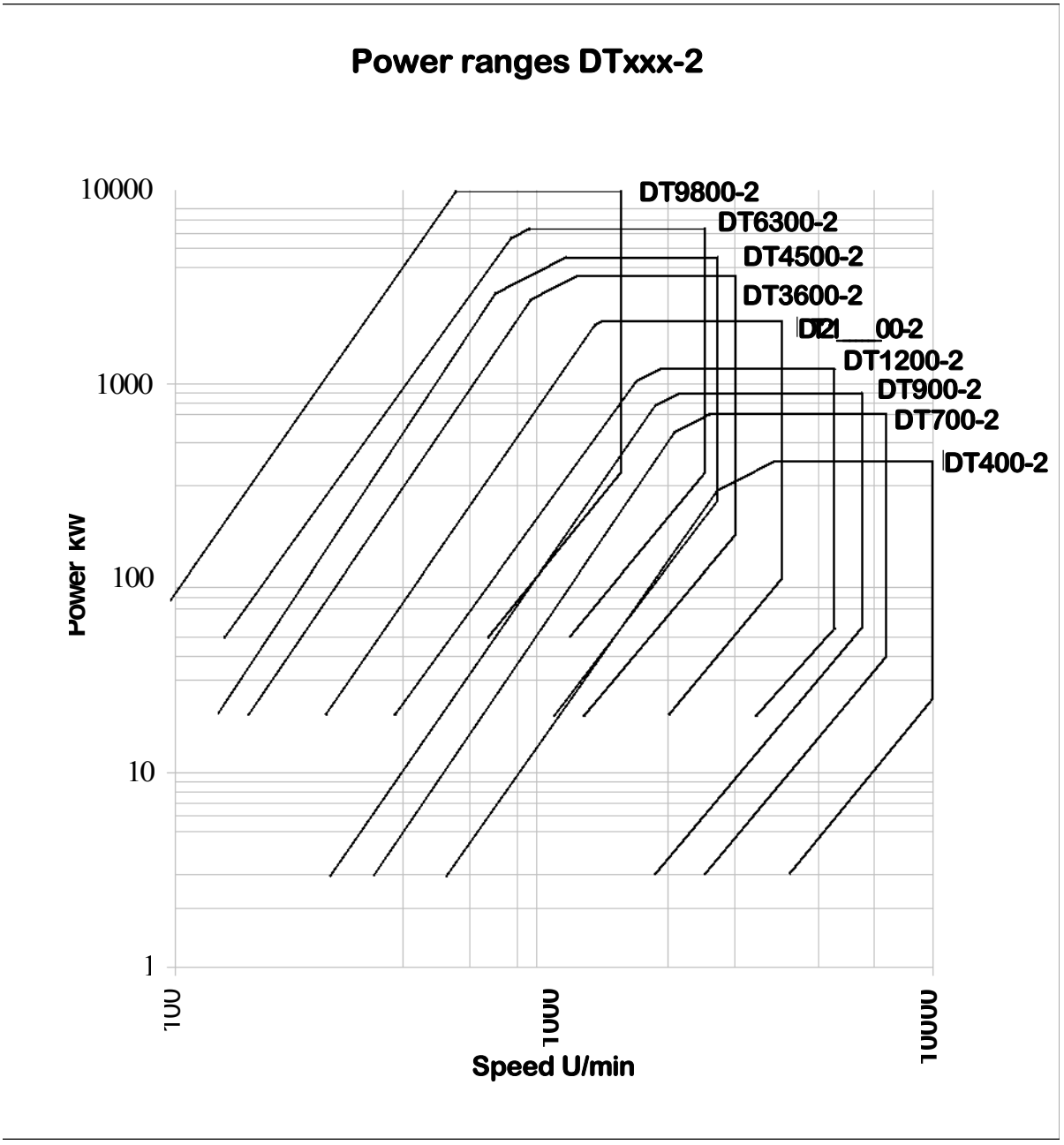


Fig. 11: Power ranges of the dynamometers with **two** rotors and one direction of rotationr

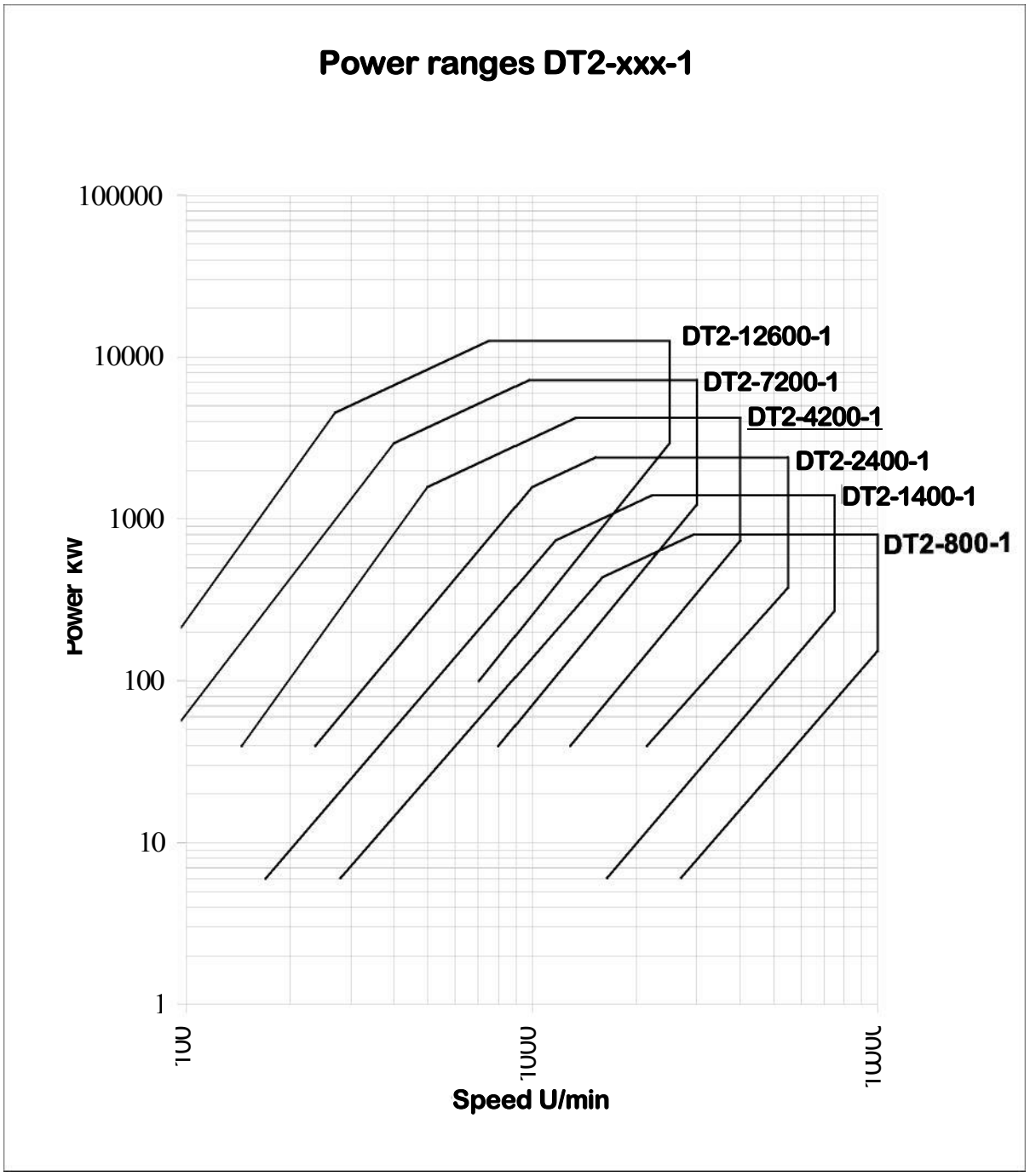
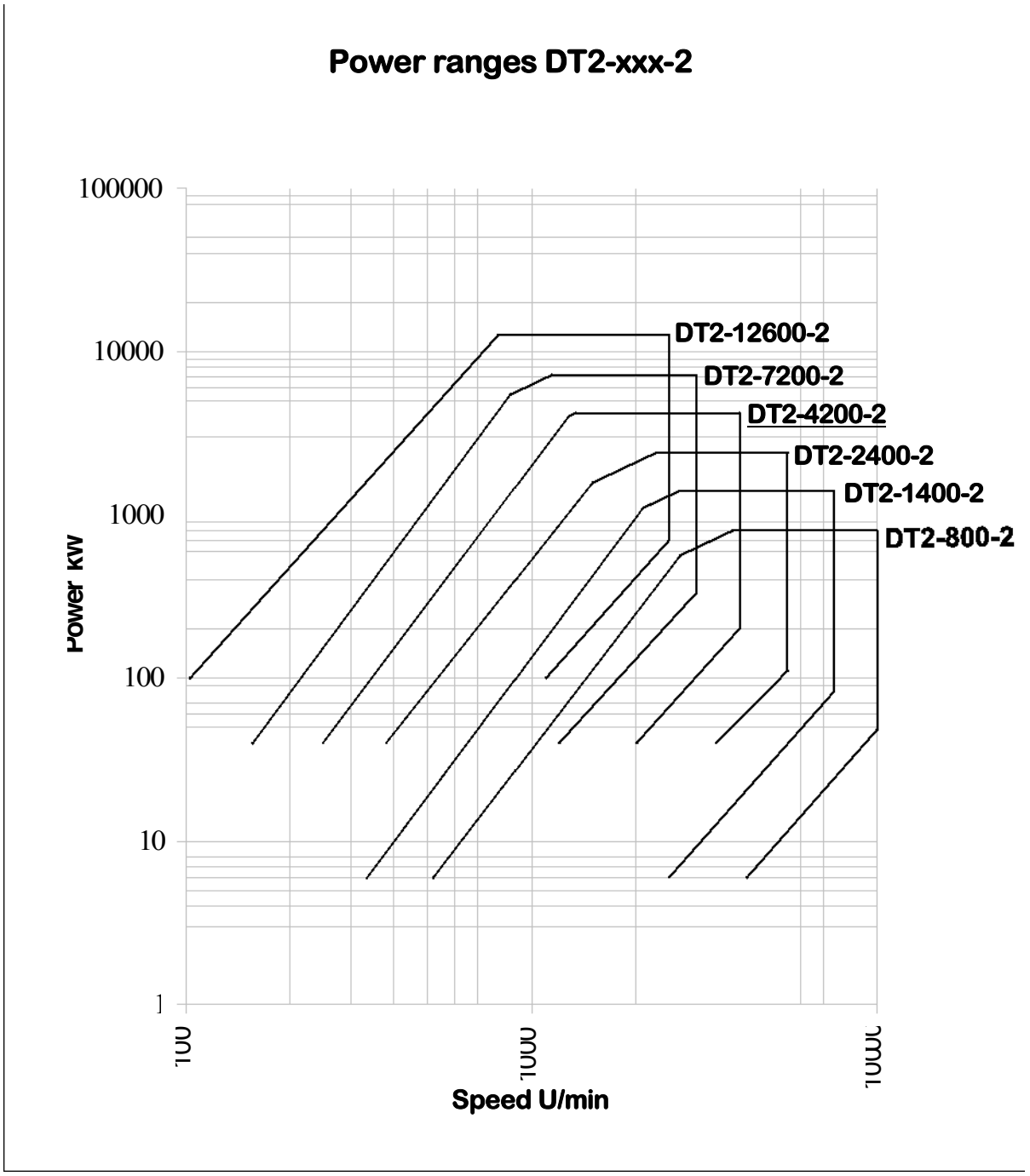


Fig. 12: Power ranges of the dynamometers with **two** rotors and **two** directions of rotation



4.4 Electric Power Components

Power component	for Dynamometer Type	Design	Size
LED2003	< DT4500	19“-Modul	2 HE, 410 mm deep (incl. plug)
LED2005	> DT6300	19“-Modul	4 HE, 410 mm deep (incl. plug)

Standard cable lengths

between dynamometer and power component	15 m
between power component and controller	2 m

Other cable lengths can be delivered on request.

Please note the additional space requirement as well as the environmental conditions for the digital test stand controller *SPARC*, please see specification *SPARC*.

4.5 Dimensions

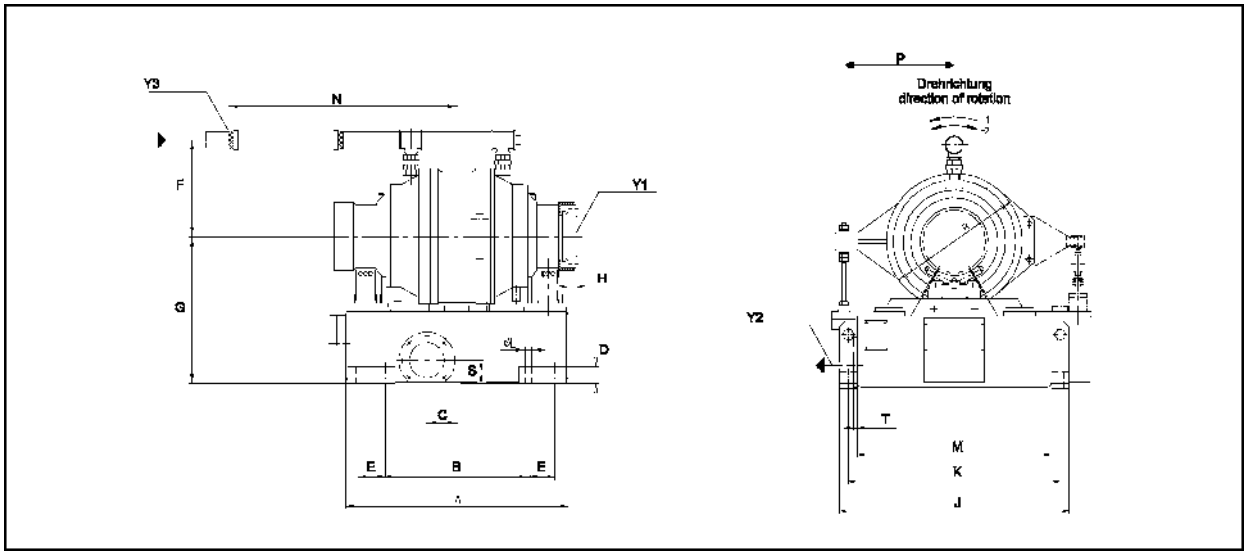


Fig. 13: Connection data of dynamometer DYNABAR with horizontal water supply and calibration system (optional)

Y1 Coupling flange
Y2 Cooling water outlet
Y3 Cooling water inlet

Type	A	G	F	J	P	B	E	D	ØL	K	M	H	N	S	C	T
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
DT400	540	500	230	540	293	470	-	21	27	375	-	-5	480	73	0	71
DT700	640	550	285	680	365	580	-	21	27	500	-	20	665	88	0	83
DT900	710	630	330	740	394	640	-	21	27	520	-	30	750	95	0	20
DT1200	800	700	360	850	460	720	-	21	27 22	640 750	-	40	806	107	0	20
DT2100	1000	800	450	1050	570	900	-	21	27	750	-	65	1015	112	0	20
DT3600	1260	835	545	1300	625	810	150	95	36	1200	1100	44	1295	135	170	20
DT2-800	790	498	230	750	335	690	-	65	27	680	610	-10	710	88	50	83
DT2-1400	945	550	285	930	430	845	-	65	27	860	790	21,5	884	107	60	20
DT2-2400	1210	635	360	1000	470	840	130	97	30	900	800	68	1167	122,5	190	20

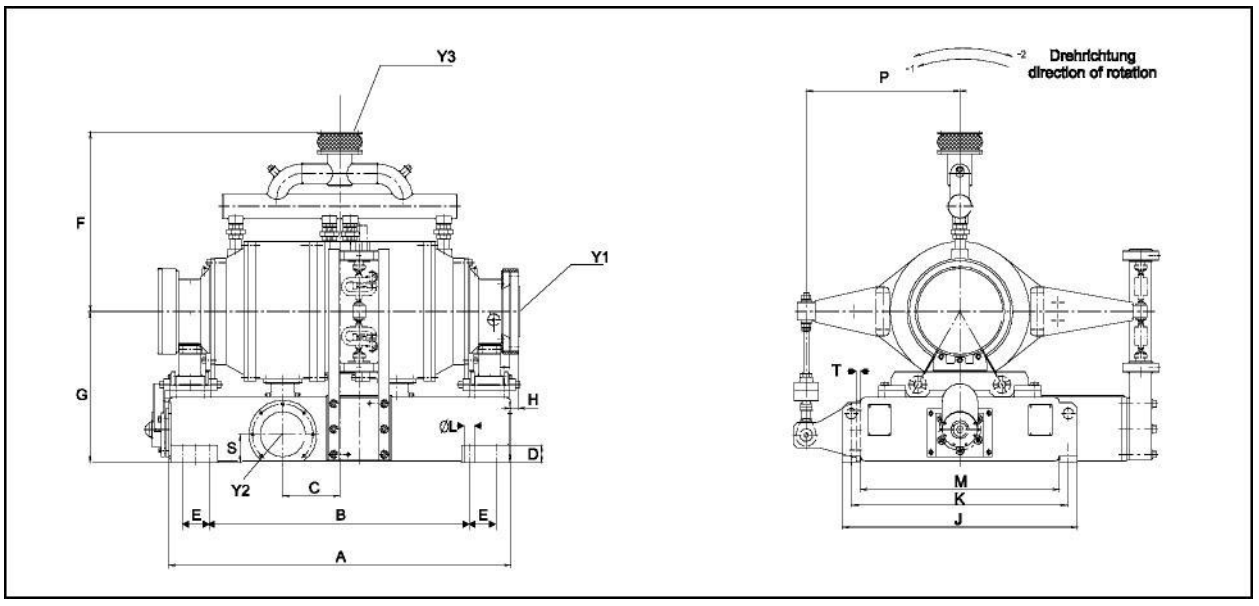


Fig. 14: Connection data of dynamometer type D with vertical water supply and calibration system (optional)

Y1 Coupling flange
Y2 Cooling water outlet
Y3 Cooling water inlet

Type	A	G	F	J	P	B	E	D	ØL	K	M	H	S	C	T
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
DT4500	1355	835	~800	1300	635	905	150	95	36	1200	1100	47	160	178	20
DT6300	1696	1100	~900	1640	970	1006	240	115	36	1500	1400	9	170	160	20
DT9800	2130	1450	~1070	2030	1100	1490	180	125	38	1900	1770	100	225	0	18
DT2-4200	1500	835	~845	1050	535	1150	130	95	27	950	850	65	145	350	20
DT2-7200	1890	835	~990	1300	850	1440	150	97	36	1200	1100	44	157	315	20
DT2-12600	2460	1100	~1180	1685	1000	1770	240	115	36	1500	1400	45	170	400	20

The dynamometers D9800, D2-4200, D2-7200 are equipped with two transversally opposite cooling water outlet connection pieces - the ones of D2-12600 are directly opposite - which can be used alternatively

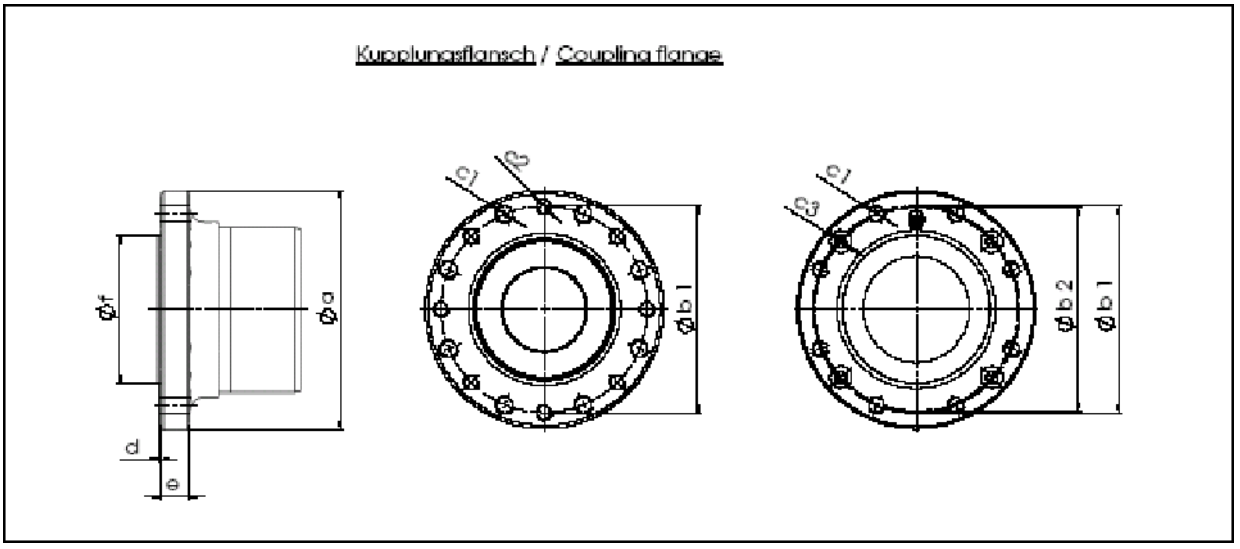


Fig. 15: Connecting dimension of coupling flange (partly prepared for bolts acc. DIN 15451

	Coupling flange								
		Screw-hole circle			Hole circle acc. DIN 15 451 part 1 cardan-shafts				
Dynotype	**a**	**b1**	**c1**	**c2**	**b2**	**c3**	**d**	**e**	**f h6**
	mm	mm			mm		mm	mm	mm
DT400	150	130	8*M10	8*M12	-	-	2	15	90
DT700	180	155,5	8*M12	8*M16	-	-	2	18	110
DT900	225	196	8*M16	-	-	-	3	20	140
DT1200	225	196	8*M16	-	192	4*B21	3	23	140
DT2100	290	245	8*M20	-	240	4*B28	5	30	175
DT3600	355	310	10*M20	-	300	4*B32	5	35	220
DT4500	390	345	10*M24	-	340	4*B32	6	40	250
DT6300	435	385	10*M27	-	378	4*B35	6	50	280
DT9800	700	615	18*,38	-	-	-	10	60	400
DT2-800	180	155,5	8*M12	8*M16	-	-	2	18	110
DT2-1400	225	196	8*M16	-	192	4*B21	3	23	140
DT2-2400	290	245	8*M20	-	240	4*B28	5	30	175
DT2-4200	355	310	10*M20	-	300	4*B32	5	35	220
DT2-7200	435	385	10*M27	-	378	4*B35	6	50	280
DT2-12600	690	600	30*M30	-	378	4*B35	6	45	280

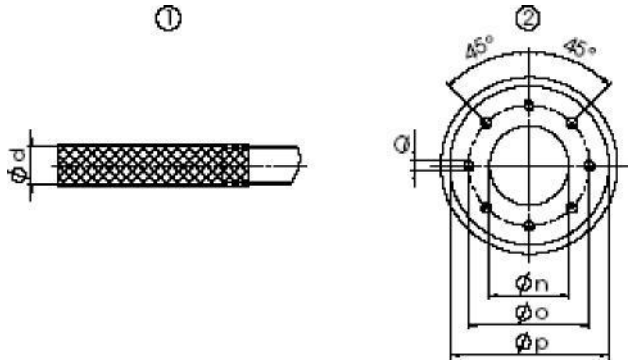


Fig. 16 Dimensions cooling water inlet

	Cooling water inlet with tube		Cooling water inlet with expansion joint flange			
Dyno type	**r**		**n**	**o**	**p**	**q**
	"	mm	mm	mm	mm	
DT400	1	33,7				
DT700	1 %	48,3				
DT900	2	60,3				
DT1200	2	60,3				
DT2100	2 %	76,1				
DT3600	3	88,9				
DT4500			100	180	220	8*M16
DT6300			125	210	250	8*M16
DT9800			150	240	285	8*M20
DT2-800	1 %	48,3				
DT2-1400	2	60,3				
DT2-2400	2 %	76,1				
DT2-4200			100	180	220	8*M16
DT2-7200			125	210	250	8*M16
DT2-12600			200	295	340	8*M20

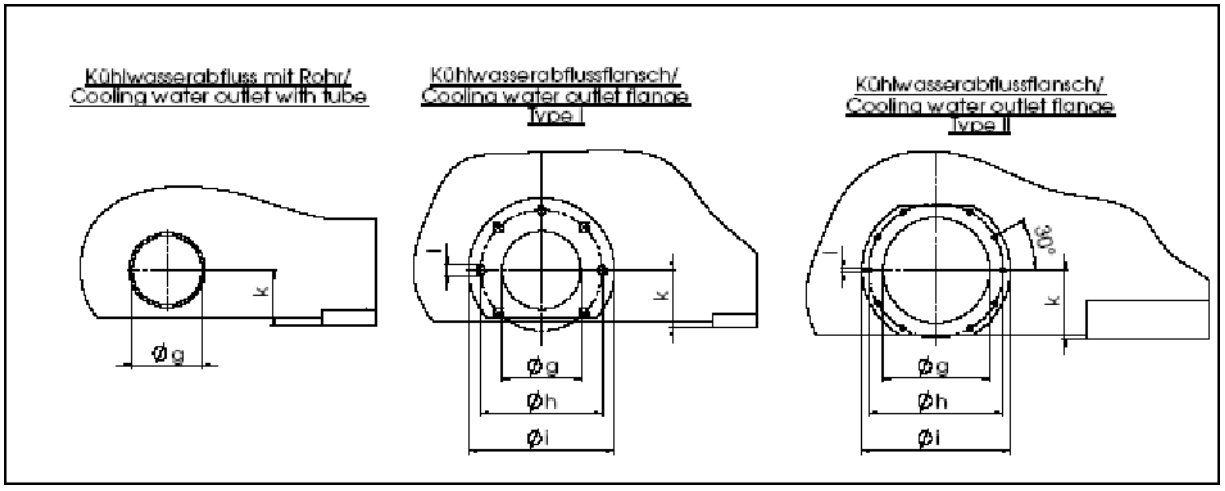


Fig. 17: Dimensions cooling water outlet

	Cooling water outlet						
	Pipe thread	flange					
Dyno type		**Type of flange**	**g**	**h**	**i**	**k**	**l**
		I	mm	mm	mm	mm	
DT400	R3“						
DT700	R4“						
DT900		I	125	200	240	85	7*M16
DT1200		I	150	225	265	95	7*M16
DT2100		I	160	225	265	95	7*M16
DT3600		I	200	280	320	122	7*M16
DT4500		I	250	335	375	155	11*M16 1)
DT6300		I	250	335	375	160	7*M16
DT9800		II	350	445	490	215	10*M16
DT2-800	R4“						
DT2-1400		I	150	225	265	95	7*M16
DT2-2400		I	175	225	295	117,5	7*M16
DT2-4200		I	200	280	320	125	7*M16
DT2-7200		I	250	335	375	147	7*M16
DT2-12600		I	250	335	375	160	7*M16

4.6 Fluctuating Torque

The max. superposed oscillating torque (mechanical vibration) must be lower than 20% of the rated torque

The mean value over several seconds shall not exceed 100 % of the rated torque.

4.7 Connectable mass

With the help of the water consumption diagram (following pages) you can determine the desired data for the cooling-water supply of the dyno without any calculation.

The diagram can be used for determination of cooling water flow and pressure decrease. It applies for different dynamometer sizes. Therefore you need the actual absorbed power and the temperature difference Δt between cooling water inlet and outlet of your dynamometer.

The determination can be done as follows:

- Enter your temperature difference Δt in the right diagram and draw in a vertical line upwards
- Find out the intersection point with the curve of your actual absorbed power. From that point draw in a horizontal line to the left and read off the water flow
- Extend the horizontal line to the left diagram and find out the intersection point with the curve of your dynamometer size

Vertically underneath that intersection point you can read the pressure decrease between inlet and outlet of your dynamometer.

5 Things you Should Observe

5.1 Planning Assistance

In this chapter, you will find additional information you require for planning the installation of the dynamometers. The mechanical dimensions of the dynamometers are stated in chapter "Dimensions", the electric interfaces are stated in chapter "Interfaces". Further general information regarding foundation, cooling water quality and cooling water consumption, you will find in this chapter.

5.1.1 Foundation

All dynamometers are supplied with processed frame bottom and can be fixed on clamping rails or groove plates as well as on a concrete foundation.

Installation position

- Transversal slope max. ± 15°
- Longitudinal slope max. ± 15°

For foundation fixing, the dynamometer has to be aligned with water level on the correspondingly prepared concrete foundation, underpoured and anchored with stone bolts.

Dynamometer sizes DT400 to DT1200 with one rotor and dynamometer sizes DT2-800 to DT2-2400 with two rotors are designed for a standard shaft height of 700 mm above normal level, for larger dynamometers, the centerline is higher.

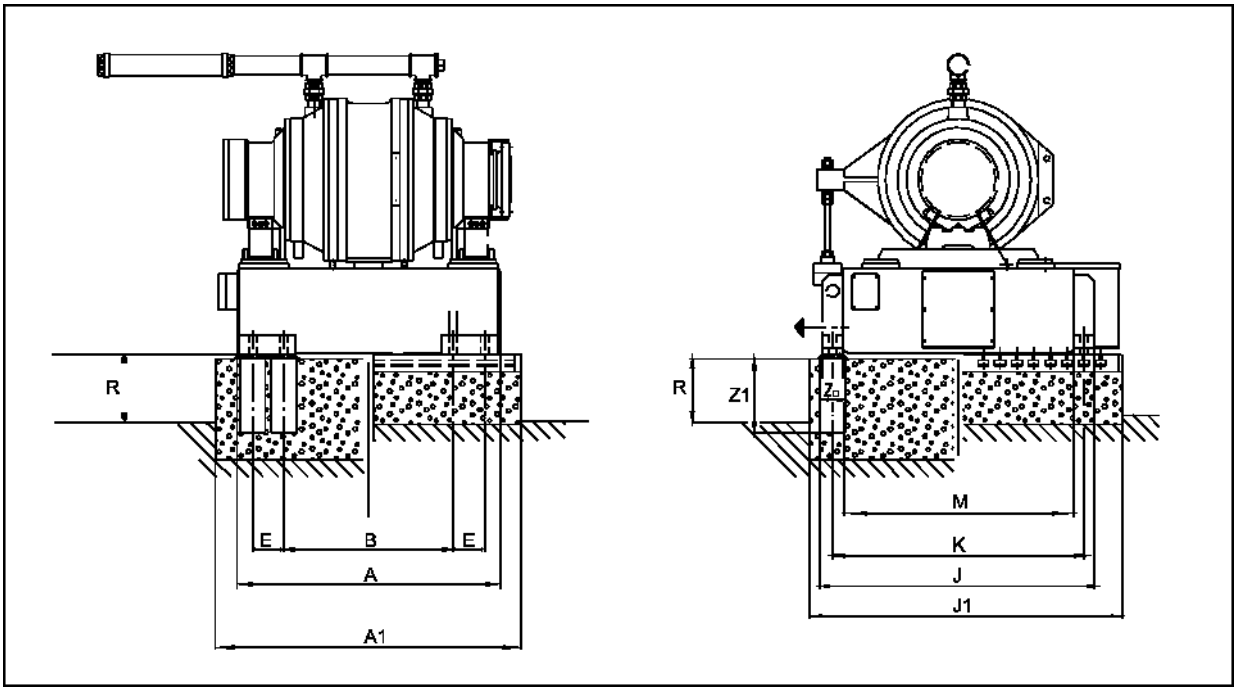


Fig. 16: Connection data foundation with anchor bolts

Type	A	A1	B	E	J	J1	K	M	R	Z	Z1
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
DT400	540	660	470	-	540	660	375	-	202	100	250
DT700	640	760	580	-	680	800	500	-	150	100	250
DT900	710	830	640	-	750	870	520	-	70	120	250
DT1200	800	920	720	-	850	970	640	-	0	120	250
DT2100	1000	1120	900	-	1050	1170	750	-	0	120	350
DT3600	1260	1380	810	150	1300	1420	1200	1100	0	120	350
DT4500	1355	1480	905	150	1300	1420	1200	1100	0	120	350
DT6300	1696	1820	1006	240	1640	1760	1500	1400	0	120	350
DT9800	2130	2260	1490	180	2030	2160	1900	1770	0	120	350
DT2-800	910	790	690	-	750	870	680	610	202	100	250
DT2-1400	945	1065	845	-	930	1050	860	790	150	100	250
DT2-2400	1210	1350	840	130	1000	1140	900	800	65	120	250
DT2-4200	1500	1630	1150	130	1050	1180	950	850	0	120	350
DT2-7200	1890	2020	1440	150	1300	1430	1200	100	0	120	350
DT2-12600	2460	2590	1870	240	1640	1770	1500	1400	0	120	350

Foundation Pit Load

Type		Stone bolt	Number for type...		Fixing Torque	Preload per bolt
D-xxxx	D2-xxxx	DIN 529 (4.6)	D-xxxx	D2-xxxx	Nm	kN
DT400	DT2-800	M24*320	4	4	265	60
DT700	DT2-1400	M24*320	4	4	265	60
DT900	-	M24*320	4	-	265	60
DT1200	DT2-2400	M24*320	4	8	265	60
DT2100	DT2-4200	M24*400	4	8	265	60
DT3600	DT2-7200	M30*320	8	8	520	96
DT4500	-	M30*320	8	-	520	96
DT6300	DT2-12600	M30*320	8	8	520	96
DT9800	-	M30*320	8	-	520	96

5.1.2 Transportation, Unpacking, Storage

For transportation and loading/unloading of the dynamometer, the corresponding safety regulations for the operation of lifting devices and material handling equipment must be observed.

Transporting, loading and unloading of the dynamometer

The dynamometer is carefully packed by the manufacturer and thus extensively protected against mechanical damages and atmospheric exposure. Anyway, harsh impacts and extreme weather conditions should be avoided during transportation. The packaging containers must neither be turned on edge nor tipped nor piled up. When packed, the dynamometer should preferably be loaded and unloaded with fork lift truck or similar lifting devices.

Unpacking of the dynamometer

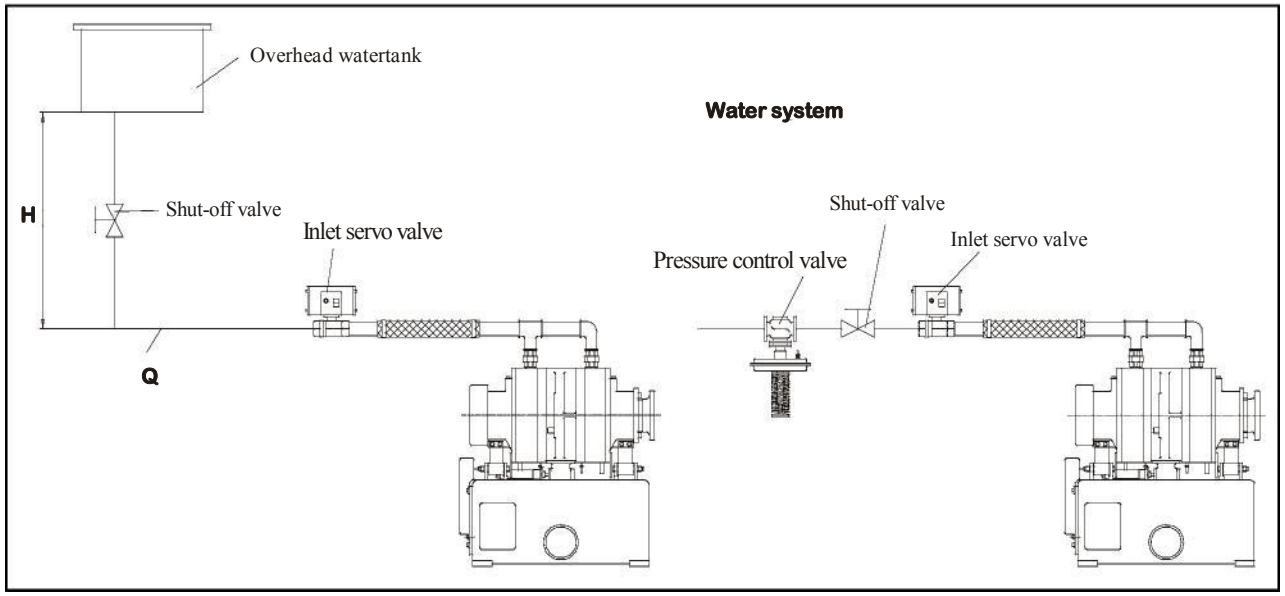
When unpacking, take care that the dynamometer does not get damaged. In case the dynamometer is boxed for foreign shipment, first of all the steel strips, then the cover and the side walls of the packaging have to be removed. After having unpacked, please check the dynamometer for being complete and undamaged.

Storage of the dynamometer

Perfect storage conditions are provided by an air-conditioned room. Bare metal parts must additionally be coated with an anticorrosive. The dynamometer and all parts of the facility must be protected against soiling and dust. For storage outside air-conditioned rooms, the dynamometer has to be heat-sealed into a polyethylene foil of at least 0.2 mm together with a desiccant (e.g. Silicagel). For that, the air inside the cover has to be sucked off and a humidity indicator has to be installed visibly. Due to the danger of corrosion, the desiccant must not get in contact with bare metal parts. The cover has to be protected against mechanical damages. The cover has to be checked regularly approx. every four weeks and, if required, the desiccant or the humidity indicator have to be exchanged. Furthermore, the transportation protection has to be removed and the rotor has to be turned by 15 to 20°.

5.1.3 Cooling Water

The working principle of the hydraulic dynamometer requires flow-off of the cooling water without hindrance and counter-pressure. The cooling water flows through the control valve into the collection tank arranged inside the frame of the dynamometer. From there, it flows through the pressure-free return pipe into the outlet duct in case of once-through flow or into the cooling system in case of re-cooling systems. Thus, cooling water can be supplied alternatively from the normal water system with pressure control valve (once-through flow through the dynamometer, then into the sewage canal) or from an overhead water tank (multiple flow through the dynamometer via re-cooling and pumping back into the overhead water tank). A simple shut-off valve and optional controlled inlet valve for setting the required flow rate must be installed directly in front of the dynamometer.



Fog. 17: Cooling water supply from the overhead water tank, alternatively from the pressure water system with options

Height H of the water tank bottom normally is 4 – 6 m above the cooling water inlet pipe of the hydraulic dynamometer.

Cross-sectional area Q of the connecting pipe of the water tank must be at least as big as the sum of the cooling water inlets of all hydraulic dynamometers being operated simultaneously.

Once-through flow

For designing the outlet pipe for free outlet of the cooling water from the dynamometer, please take care that the pipe has a sufficient gradient and that the connection pipe is dimensioned according to the size of the connection piece or the flange at the frame of the dynamometer. In case one common outlet is used for several dynamometers together, the outlet pipe has to be dimensioned larger according to the common inlet in order to avoid a back draught.

Multiple flow

Due to the fact that the cooling water has to flow off without pressure, the dynamometer must not be operated in a closed circuit. However, it is possible to channel the free water outlet into a container installed at a lower level and to return it into the cooling circuit via pumps. For monitoring the water flow, flow control units can be installed in the outlet pipe and connected with the safety circuit of the control unit. In case of a lack of water, the test stand will be switched off.

Laying the pipes

The cooling water inlet pipe must be rigidly mounted by the customer directly in front of the flexible element (hose or rubber bellows). This is to prevent transmission of undesired forces via the water inlet and thus influence on torque measurement or even damage to the water inlet.

With free outlet of the cooling water from the dynamometer, the discharge pipe must be installed with sufficient gradient to prevent backwater in the collector. No counter pressure is allowed in case of water outlet connection to a closed cooling circuit.

Prior to connecting the dynamometer, please flush the pipelines regardless of new or overhauled cooling water pipes.

Cooling water quality

Requirements to the water quality		
Permitted size of solid ingredients	max. 1 mm	
Viscid ingredients e.g. components containing oil, tar and resin	not allowed	
	Cooling water system type	
	once-through flow	re-cooling system
Total water hardness °dH*	< 30	< 40
Carbonate hardness °dH*	< 10	< 5
Non-carbonate hardness °dH*	< 28	< 35
Total salt content mg/l (solid residue from evaporation)	< 1200	< 1200
Algae growth	not allowed	

* 1 °dH = 10 mg CaO/l = 1.787 French hardness = 1.25 British hardness.
The figures stated refer to concentrated circuit water not to make-up water to be conditioned.

Cooling water pressure

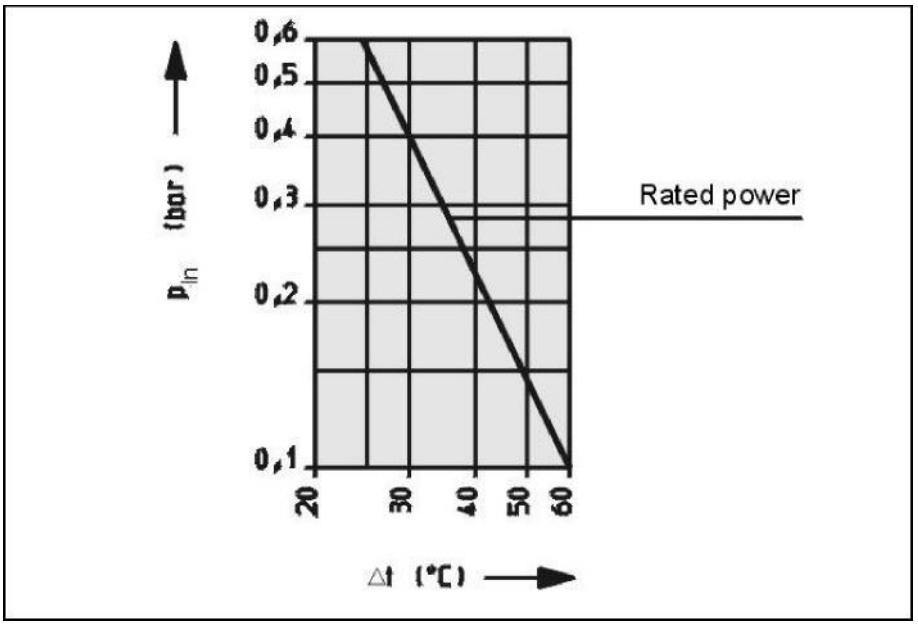


Fig. 18: Cooling water pressure required for type DT dynamometers de-pending on the cooling water heating Δt

The maximally allowed water pressure of 0.6 bar in front of the dynamometer must not be exceeded. Dynamometer bearings failing as a result of water damages due to excessive inlet pressure cannot be replaced within the framework of our warranty.

Pressure variations in the cooling water inlet: < 5 %

Cooling water requirement

The cooling water requirement depends on the size of the dynamometer as well as on the combustion engine to be tested. Basically, the dynamometer should be connected in a way that it can dissipate its maximal braking power as heat via the cooling water with permissible cooling water temperatures and pressures. For examinations with combustion engines with lower power, the cooling water quantity can be reduced to the minimal water quantity for these tests.

The cooling water quantity required Q (m^3/h) depending on the temperature difference Δt in °C (Δt = cooling water outlet t_A minus cooling water inlet t_E) and the power to be braked P (kW) is

$$Q = 0{,}86 \cdot \frac{P}{\Delta t}$$

Q [m3/h] = cooling-water quantity

P [kW] = capacity to be braked down

t [°C] = temperature range t_A - t_E

t_A [°C] = cooling-water outlet temperature

t_E [°C] = cooling-water inlet temperature

With the help of the water consumption diagram (following pages) you can determine the desired data for the cooling-water supply of the dyno with-out any calculation. On the right side of the diagram the cooling-water flowing-through quantity of the dyno is indicated above the temperature difference dependent on the max. capacity to be braked down (engine capacity). The temperature difference is the difference between the temperature of the cold water flowing within the dyno and the temperature of the warmed-up water leaving the dyno.

On the left side of the diagram the cooling-water flowing-through quantity of the dyno is indicated above the (constant-controlled) cooling-water pressure in front of the dyno dependent on the dyno size. The minimum pressure should not be allowed to fall below 0.1 bar. Pressure losses within the pip-ings mounted in front of the dyno are not taken into consideration in the dia-gram.

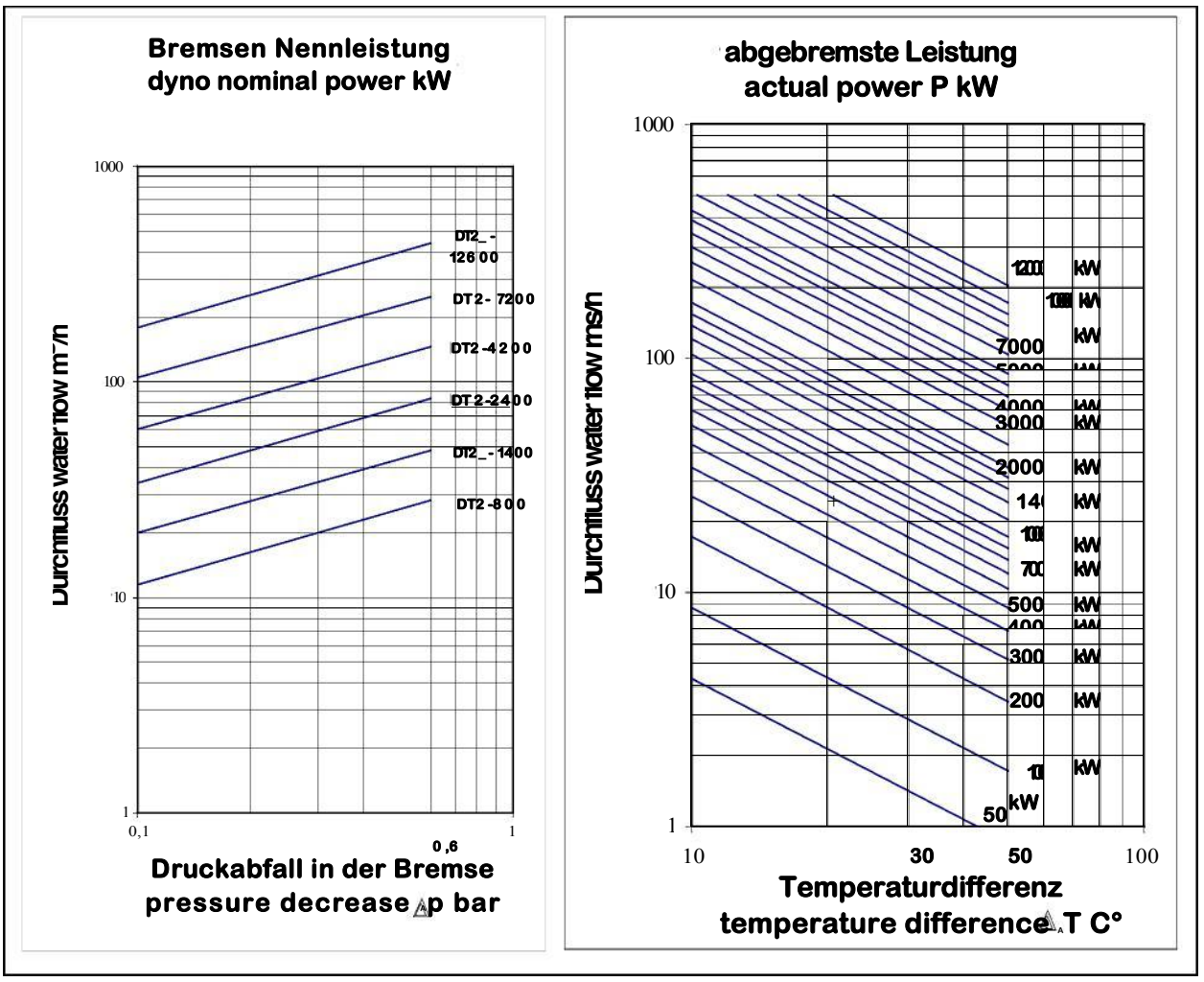


Fig. 19: Cooling water pressure required for type DT dynamometers de-pending on the cooling water heating Δt

Cooling water outlet temperature:

For a carbonate hardness of the water up to 5° dH, cooling water outlet temperatures up to 80°C are allowed. Due to the fact that, depending on the cooling water composition, the formation of scale will be increased, 50°C must not be exceeded for a carbonate hardness of the water >5° dH.

Minimal cooling water quantity

The idling characteristics (see power range) cannot be reached with the water quantity required for heavy duty, it can only be reached with the minimal cooling water quantity. The minimal cooling water quantity is approx. 20 to 25% of the cooling water quantity required for the rated power of the dynamometer and a cooling water heating of Δt = 44.5 °C. The cooling water quantity must not be lower than this, not even for low testing power.

Minimal cooling water quantity required			
Dynamometers with one rotor	Q_{min} (m^3/h)	Dynamometers with two rotors	Q_{min} (m^3/h)
DT400-1, DT400-2	1,6	DT2-800-1, DT2-800-2	3,2
DT700-1, DT700-2	3	DT2-1400-1, DT2-1400-2	6
DT900-1, DT900-2	4	-	-
DT1200-1, DT1200-2	5	DT2-2400-1, DT2-2400-2	10
DT2100-1, DT2100-2	9	DT2-4200-1, DT2-4200-2	18
DT3600-1, DT3600-2	16	DT2-7200-1, DT2-7200-2	32
DT4500-1, DT4500-2	19	-	-
DT6300-1, DT6300-2	27	DT2-12600-1, DT2-12600-2	54
DT9800-1, DT9800-2	47	-	-

5.1.4 Shaft Connection Parts

All connection parts you manufacture or supply yourself (e.g. intermediate disks, flywheels, ring gears etc.) must be balanced with a balancing quality of at least Q 6.3. Lateral and axial run-out of the centering of these parts must not exceed 0.01% of the outside diameter. For drive and clutch shafts as connection between engine to be tested and dynamometer, a shaft guard is required. Furthermore, we recommend to carry out a corresponding shaft calculation.

5.1.5 Installation Power Electronics

All 19” modules are designed for installation in 19” housings or 19” control cabinets. Horiba ATS GmbH offers this measuring cabinet with a basic cabling, the measuring cabinet can be ordered separately. Control cabinets for the power electronics on the mounting plate can be offered as well.

5.1.6 Assembly and Commissioning

Commissioning cannot be carried out unless cooling water pipes have been laid and a test engine has been provided. Foundation fixings must have dried. For assembly and commissioning, we will be pleased to place experienced fitters and commissioners from our house at your disposal (against invoicing).

6 Product Options and Accessories

6.1 Trunnion Bearings

As standard, the hydraulic dynamometers type D are equipped with a pendulum body supported in flexure strips, alternatively, trunnion bearings can be supplied except for the dynamometers from size D6300 on. D6300 can be supplied with roller support as alternative for the flexure strips. The technical data and dimensions stated in chapter "Figures, Data, Facts" will not change if trunnion bearings are used. The order numbers, please take from chapter "Order Numbers".

6.2 Second Coupling Shaft

For some applications such as for engines for starting and tractor operation supplied by the customer, a connection to the rear shaft end of the dynamometer is required. For that, the protection cover of the rear end of the shaft will be removed and an additional coupling flange will be installed. The connection drawing (centering diameter, hole circle etc.) as well as the projection of the base frame correspond with the coupling flange of the engine.

For operation with two coupling flanges and connection of masses at both sides, the following must be observed:

for maintaining the masses coupled on, the speeds allowed have to be reduced to 90% of the corresponding values and

for maintaining the speeds, the masses allowed on both sides reduce to 81% of the corresponding values.

The order numbers for the coupling flanges of the various dynamometer sizes, please take from chapter "Order Numbers".

Scope of supply:

second coupling flange

protection cover for coupling flange (The protection cover for the rear end of the shaft is not required)

6.3 Cooling water monitoring

This device monitors operation of the dynamometer under correct water pressure and availability of the amount of cooling water as required for the set absorbing power. Therefore the minimum and maximum admissible cooling water inlet pressures are checked at the dynamometer inlet. A warning message will appear on the test stand controller, the dynamometer be switched off and a contact be output to the test stand, if these values are exceeded. The same occurs in case of exceeding the admissible cooling water outlet temperature of the dynamometer.

The inlet pressure governor must be installed directly at the level of the cooling water inlet in front of the dynamometer and the inlet valve (available as an option). Level offset results in wrong values and unreliable monitoring. Please take further information from the relevant technical specification.

6.4 Shaft Connection

For connecting the engine to be tested with the hydraulic dynamometer, a double-cardanic shaft is required. Horiba ATS GmbH offers different shafts for all applications. Further information, please take from the corresponding technical specification.

6.5 Starter System

For test stands without starter system of the engine, we offer a starter system with different power ranges installed at the free shaft end of the dynamometer. Further information, please take from the corresponding technical specification.

6.6 Calibration System

A calibration of the hydraulic dynamometer is recommended after each operation in the area of the load cell or the pendulum body receptacle. For controlling the torque measurement system, we recommend the Horiba ATS GmbH calibration system. Further information, please take from the corresponding technical specification.

6.7 Pressure Control System

The pressure control system type D is always a space-saving, good-value alternative when an overhead water tank cannot be used for the cooling water. It is used to reduce and to control the pressure of the water supply in Type DT400 to Type DT3600 hydraulic dynamometers. The system is easy to assemble and to connect to the normal water system. Integrated manometers are used to additionally control the inlet and outlet pressure. Easily accessible dirt traps guarantee the trouble-free operation of the system. If maintenance work is required on the dynamometers, the water supply can easily be blocked by ball cocks. Further information, please take from the corresponding technical specification.

6.8 Inlet Servo Valve

The inlet valve adjusts the cooling water flow according to performance requirements to the dynamometer and enables extremely low torque in idling operation as well as maximum braking power.

Further information, please take from the corresponding technical specification

6.9 Special Sizes

Type DT hydraulic dynamometers can also be manufactured in sizes other than the standard sizes. If required, they will be manufactured to your specifications. Combinations with additional flywheel masses or gear are possible as well. Please, do not hesitate to contact us.

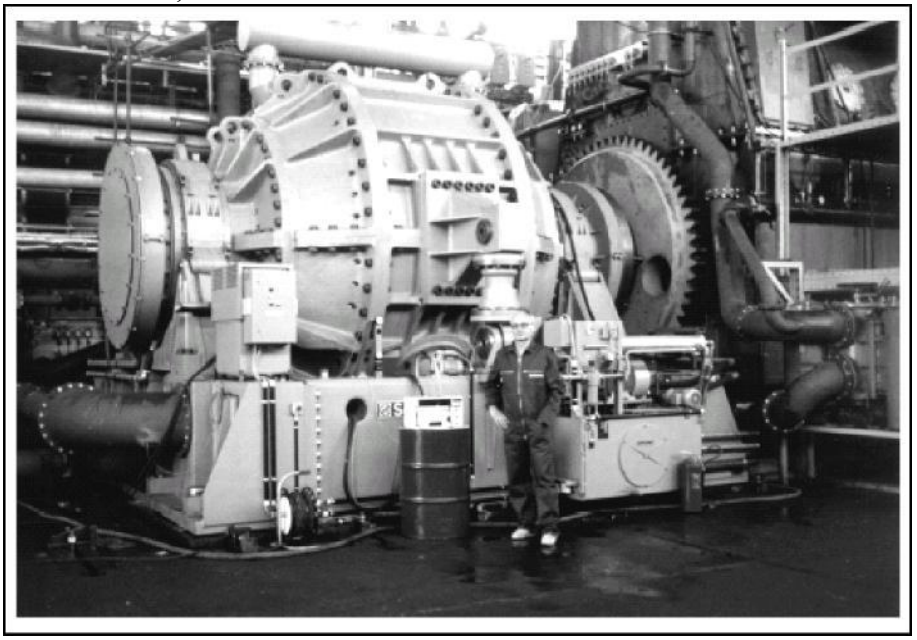


Fig. 20: Special-size dynamometer type D with 50.000 kW

6.10 Modification of the control valve drive

The control valve drive of standard D-dynamometers with one rotor, D400 – D3600, and two rotors, D2-800 – D2-2400, from year of construction 1990, can be converted to brushless motor design of the DT-dynamometers. Increased reliability and dynamical characteristics of the control valve drive and better control characteristics of the dynamometer are benefits from this design. Prerequisite:

Controller type LSG2000, LSG2010, x-act or or SPARC available on the electrics side.

Scope of supply:

Brushless servomotor mounted on the motor plate

Power supply unit LED 2003

Cable set, control valve drive 15 m

With design sizes D2-2400 and D3600, a new cover plate is required in addition for the valve drive motor in the frame for conversion. With these brakes[1], the screw fitting of the cable routing must be screwed out of the motor plate and into the new cover plate.

For further info or sales enquiries please contact us:

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