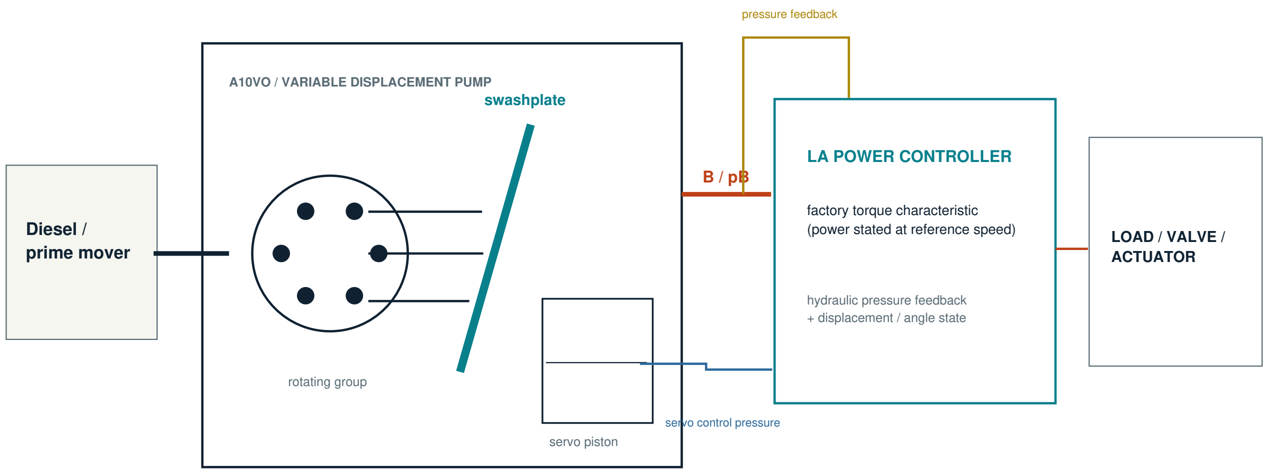
A10VO Series 32
LA Power Control

Operating principle, torque/power physics, servo destroking, LA.D / LA.DG / LA.S / LA.DS and worked examples

A detailed engineering guide to the LA control architecture described in Bosch Rexroth RE 92705, pages 7 and 9-14.



pB rises > controller destrokes > swashplate angle decreases > Vg decreases > Q decreases > shaft torque is limited

English · Rev B · 2026-09

GUIDE SCOPE

What this guide is designed to explain

Instead of memorizing LA as “a constant-power pump”, the goal is to follow exactly why and how the pump destrokes when load pressure rises.

Core statement from the source

RE 92705 page 13 states that, to obtain constant drive torque at varying working pressure, pump swivel angle and output flow are varied so that the product of flow and pressure remains approximately constant. Flow control is possible below the power-control curve.

- How swashplate angle, piston stroke and displacement Vg are connected.
- Why the LA regulator drives the servo system toward destroking as working pressure rises.
- Why the characteristic is fundamentally torque-related although the order setting is stated as kW @ rpm.
- How full-displacement, LA power/torque limiting and DR pressure cut-off differ.
- How LA5-LA9 are read and why an NG71 / 20 kW @ 1500 rpm example falls in LA7.
- How pressure and flow controls combine with the power curve in LA.D, LA.DG, LA.S and LA.DS.

Source boundary

The Rexroth data sheet does not disclose the exact internal spool/spring geometry. “Servo balance” descriptions in this guide are functional explanations consistent with the data-sheet circuit symbols and variable-displacement pump physics; they are not a manufacturer cutaway drawing.

01 · PUMP FUNDAMENTALS

Understand the variable-displacement mechanism first

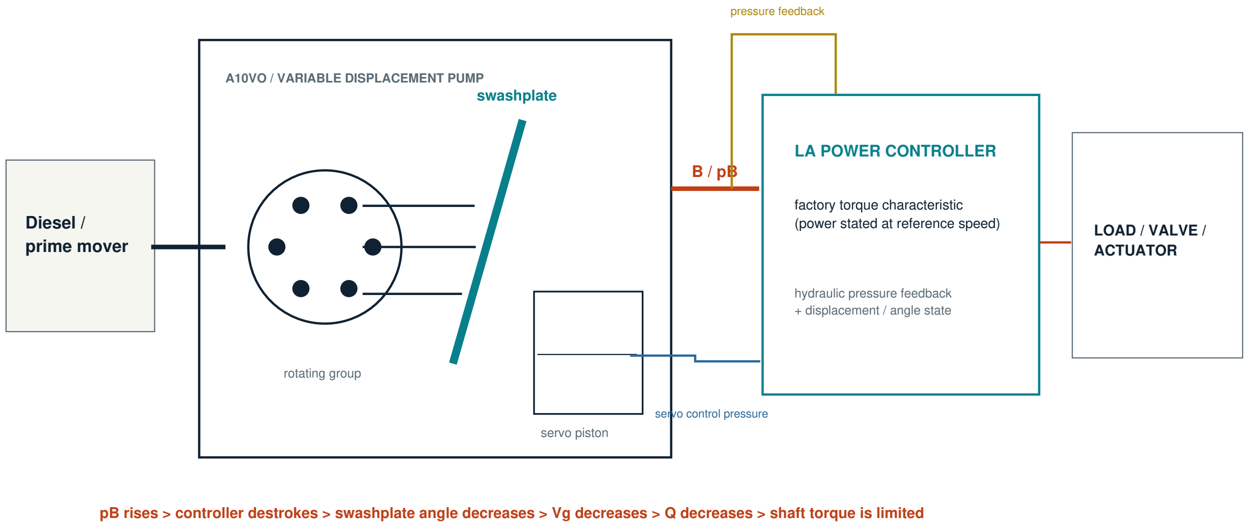


Figure 1 - Functional teaching diagram, not an exact manufacturer cutaway.

Shaft and rotating group: The prime mover rotates the pump shaft. Pistons in the cylinder block rotate against the swashplate. Swashplate angle determines piston stroke during one revolution.

Swash angle → Vg: Larger swash angle gives longer piston stroke and larger geometric displacement per revolution. Reducing the angle reduces Vg; near zero angle the pump approaches zero stroke / minimum displacement.

Vg → flow: At the same speed, larger Vg produces more flow. LA therefore reduces flow mainly by reducing the pump's own displacement rather than by dumping excess flow across a relief valve.

Servo piston: The control block changes servo pressures and therefore swashplate position. The essential output of the LA controller is “allow more or less Vg”.

> **Key difference**
>
> A relief valve can waste excess flow at high pressure as heat. LA reduces the flow produced by the pump when load rises, directly limiting torque demanded from the prime mover.

What happens internally when pressure rises?

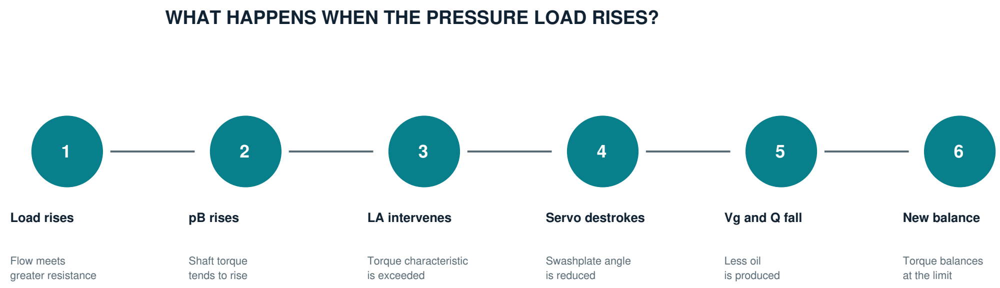


Figure 2 - Functional sequence of the LA response to increasing machine load.

1. Load rises - A cylinder sees more load, a hydraulic motor sees greater resisting torque, or a restriction limits flow. More pressure is required to continue the motion.

2. Pump outlet pressure pB rises - The B-line working pressure is fed back to the control block, as represented by the data-sheet circuit diagrams.

3. At the same Vg, shaft torque would rise - $M = Vg \times \Delta p / (20\pi \times \eta hm)$. With fixed Vg, increasing pressure increases torque demanded from the drive shaft.

4. The LA characteristic is reached - The factory characteristic - for example 20 kW @ 1500 rpm - corresponds to a defined torque level. As pressure effect reaches that level, the regulator commands destroking through the servo system.

5. Swashplate angle and Vg decrease - Piston stroke becomes shorter; less volume is displaced per revolution.

6. Pump flow q decreases - Because $q = Vg \times n \times \eta v / 1000$, reducing Vg directly reduces flow at fixed speed.

7. Shaft torque returns near the setting - Despite the higher pressure, the smaller Vg limits $Vg \times p$, and therefore the drive torque, near the LA setting.

8. If pressure falls, the process reverses - The controller permits more displacement and the pump strokes toward larger Vg, unless another control such as DR pressure cut-off or S flow control demands a smaller displacement.

03 · PHYSICS

Why is it called “constant power” when torque is central to the behavior?

$$q = V_g \times n \times \eta_v / 1000$$

Flow [L/min]. At fixed speed, q is directly proportional to Vg.

$$M = V_g \times \Delta p / (20\pi \times \eta_{hm})$$

Pump shaft torque [Nm]. If pressure rises without reducing Vg, torque demand rises.

$$P = 2\pi \times M \times n / 60000$$

Shaft power [kW]. At the same torque, power scales directly with speed.

$$P_{hyd} \approx q \times \Delta p / 600$$

Practical hydraulic-power relationship [kW], ignoring losses.

Page 13 states that flow × pressure is kept approximately constant to obtain constant drive torque. The chain is: **$q \propto V_g \times n$ and $M \propto V_g \times p$. At fixed n, holding $q \times p$ approximately constant also holds $V_g \times p$ - and therefore torque - approximately constant.**

What does 20 kW @ 1500 rpm mean?

It does not mean a 20 kW limit at every speed. 20 kW @ 1500 rpm corresponds to approximately Mset = 127.3 Nm. The same torque equals about 13.3 kW at 1000 rpm and 26.7 kW at 2000 rpm. Always read the kW figure together with its reference speed.

Speed	Shaft power at the same 127.3 Nm torque
1000 rpm	≈ 13.3 kW
1500 rpm	≈ 20.0 kW
2000 rpm	≈ 26.7 kW

04 · THREE OPERATING REGIONS

An LA.D pump behaves differently depending on load

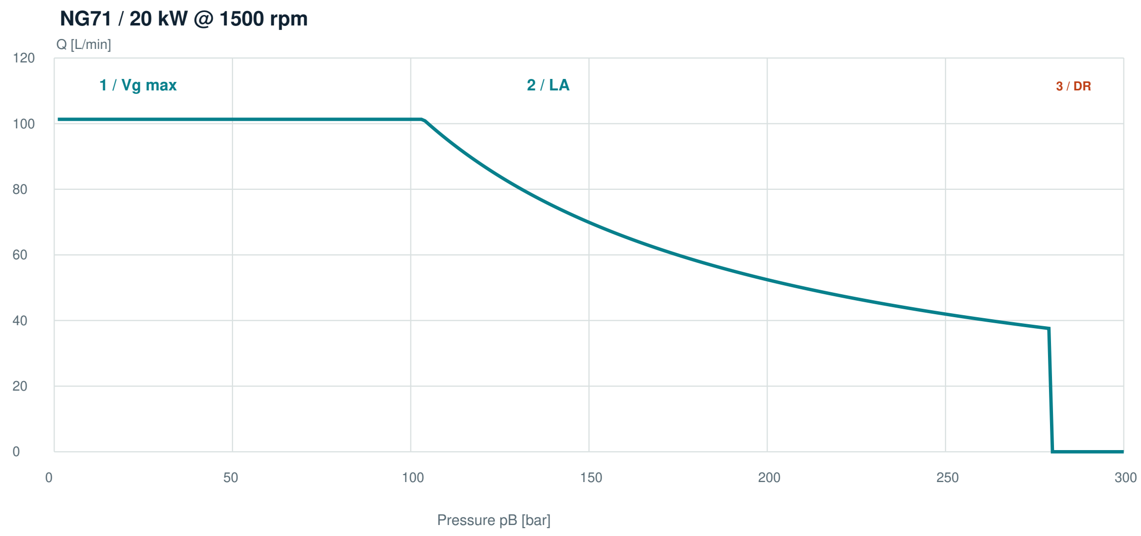


Figure 3 - Educational model. Assumptions: ηv=0.95, ηhm=0.92. DR transition is smoothed for visualization.

Region	What sets it?	Pump action	What the machine shows
1. Full displacement	Load below LA start	Vg ≈ Vgmax	Flow mainly follows speed and Vgmax.
2. LA torque/power	LA characteristic	Vg and q decrease as pB rises	Pressure can rise while drive torque remains limited.
3. DR cut-off	Maximum pressure setting	Pump goes toward minimum stroke	Flow collapses near the pressure limit.

Do not confuse LA and DR

LA limits drive torque along the power characteristic. DR limits maximum outlet pressure by moving the pump toward smaller displacement near the pressure setting. LA.D includes both.

What do the page-13 LA curves actually mean?

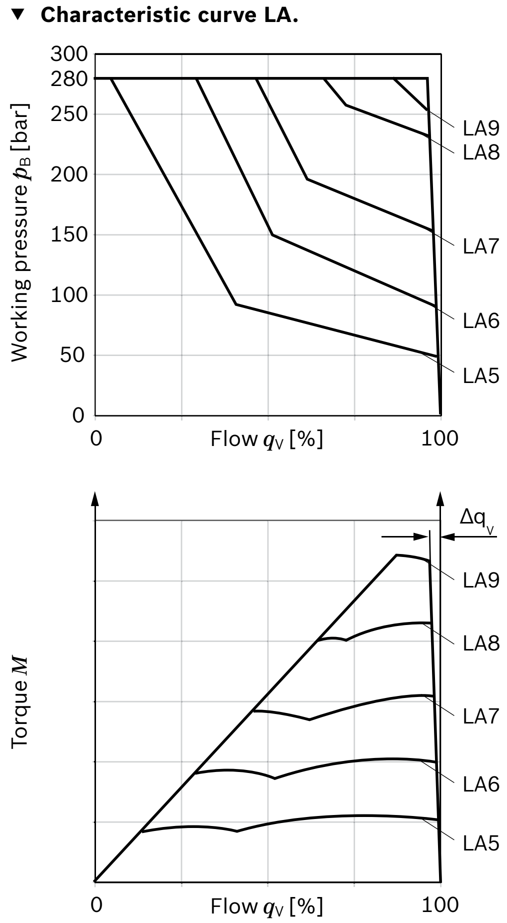


Figure 4 - Source excerpt: Bosch Rexroth RE 92705/2019-03-25, p.13. Cropped for teaching.

- The horizontal axis is flow qV as a percentage; the 100% side corresponds to the high-displacement side of the pump characteristic.
- At low pressure the pump can remain near 100% flow. At the “beginning of control” range for the selected LA class, the curve bends left: pressure rises while permissible flow/displacement is reduced.
- Moving from LA5 to LA9 permits progressively higher torque and a higher control-start range. The same pump size can therefore be matched to different prime-mover torque capabilities.
- The lower torque plot is a real controller characteristic, not a perfect mathematical hyperbola; ΔqV and the curve shape remind us that real regulation is not ideal.
- “Flow control is possible below the power-control curve” means the S/FR function may demand a smaller Vg, but it cannot force a flow above what the power curve permits.

06 · WORKED EXAMPLE

NG71 + 20 kW @ 1500 rpm

Source value: NG71 has Vgmax = 71.1 cm³/rev. The order example is 20 kW @ 1500 rpm. The educational calculation assumes ηv=0.95 and ηhm=0.92.

$$M_{set} = 20 \times 60000 / (2\pi \times 1500) = 127.3\ \text{Nm}$$

Approximate torque represented by the 20 kW @ 1500 rpm factory characteristic.

$$p_{start} \approx M_{set} \times 20\pi \times \eta_{hm} / V_{gmax} \approx 103.5\ \text{bar}$$

Approximate pressure where full-displacement operation reaches the torque limit in the educational model. This is not an OEM tolerance value.

pB [bar]	Vg [cm³/rev]	q [L/min]	M [Nm]	Pshaft [kW]	State
80	71.1	101.3	98.4	15.5	Full displacement
100	71.1	101.3	123.0	19.3	Full displacement
104	70.8	100.8	127.3	20.0	LA limiting
150	49.1	69.9	127.3	20.0	LA limiting
200	36.8	52.4	127.3	20.0	LA limiting
250	29.4	42.0	127.3	20.0	LA limiting

What if LA were absent at 250 bar?

If NG71 stayed at full 71.1 cm³/rev at 250 bar, with ηhm=0.92 it would demand roughly 307.5 Nm and about 48.3 kW at 1500 rpm. LA reduces effective Vg to roughly 29.4 cm³/rev, holding torque near 127.3 Nm and shaft power near 20 kW.

How the controller class is read

Page 13 gives two linked pieces of information for each LA code: the control-start pressure band and the torque range for each pump size. These are not maximum-pressure settings.

Code	Control begins [bar]	NG45 [Nm]	NG71 [Nm]	NG100 [Nm]	NG140 [Nm]	NG180 [Nm]
LA5	≤ 50	≤ 42.0	≤ 67.0	≤ 94.0	≤ 132.0	≤ 167.0
LA6	51-90	42.1-76.0	67.1-121.0	94.1-169.0	132.1-237.0	167.1-302.0
LA7	91-160	76.1-134.0	121.1-213.0	169.1-299.0	237.1-418.0	302.1-540.0
LA8	161-240	134.1-202.0	213.1-319.0	299.1-449.0	418.1-629.0	540.1-810.0
LA9	> 240	> 202.1	> 319.1	> 449.1	> 629.1	> 810.1

NG71 example

20 kW @ 1500 rpm → 127.3 Nm. In the NG71 column, 127.3 Nm lies inside the LA7 range of 121.1-213.0 Nm, so this example is consistent with an LA7 characteristic.

The same power setting on a different pump size produces a different control-start pressure because Vgmax changes. Do not select an LA code from kW alone; pump size, reference speed and required torque must be considered together.

Reading the pressure-cut-off LA.D symbol

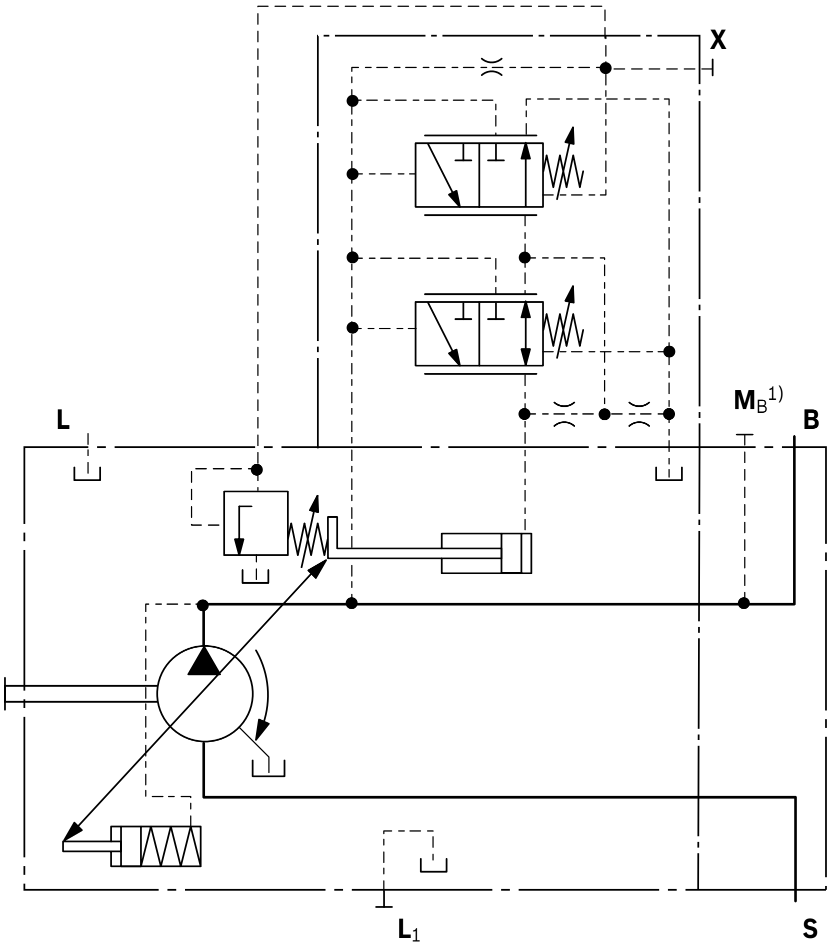


Figure 5 - LA.D circuit. Source: Bosch Rexroth RE 92705/2019-03-25, p.13.

B port: Main pump outlet where working pressure pB appears.

S port: Pump suction port.

L / L1: Case-drain / tank connections; apply the manufacturer installation rules on the real machine.

Servo arrangement: Represents the mechanism that changes pump displacement. Controllers change servo balance to reduce or increase Vg.

LA power element: Destrokes according to the interaction of working pressure and the factory-set power/torque characteristic.

DR pressure element: Destrokes when pressure command is exceeded, limiting maximum outlet pressure. Page 9: 20-280 bar, standard 280 bar.

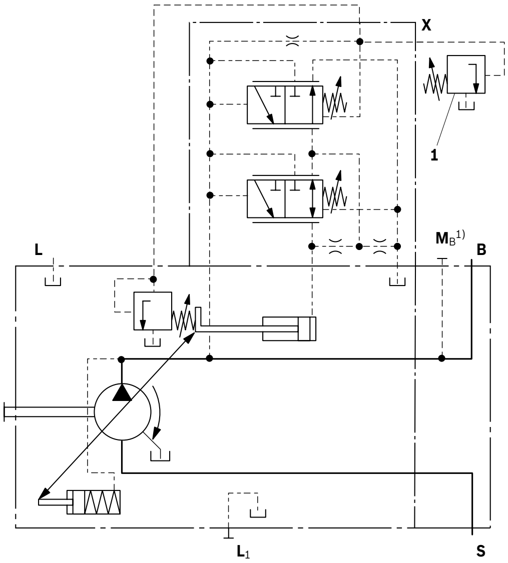
X / MB: Control/measurement connections depending on variant and port plate; MB is noted only with port plates 22 and 32.

During pressure cut-off

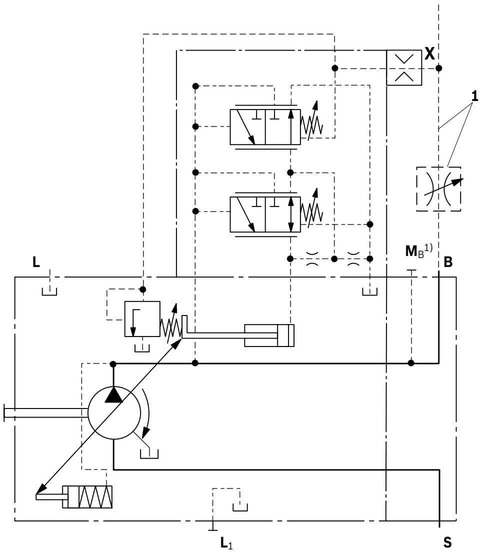
Near a DR setting such as 280 bar, DR also demands a smaller Vg independently of the LA torque curve. Because displacement reduction has priority, the pump moves toward minimum stroke.

LA.DG, LA.S and LA.DS

▼ **Circuit diagram LA.DG** with pressure cut-off, remotely controlled



▼ **Circuit diagram LA.DS**



1 The metering orifice and the pressure relief valve and line are not included in the scope of delivery.

▼ **Circuit diagram LA.S** with separate flow control

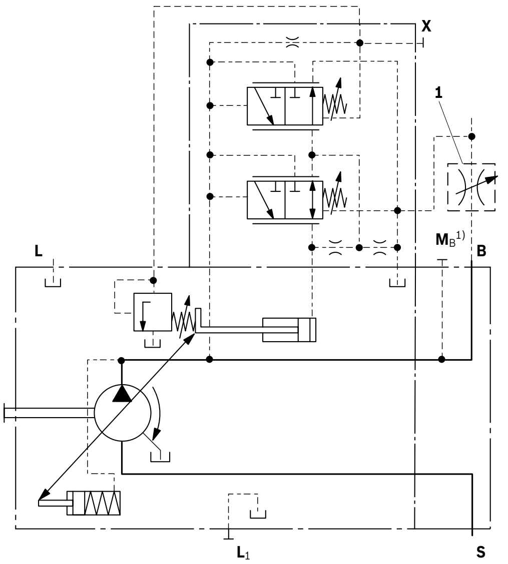


Figure 6 - LA variants. Source: Bosch Rexroth RE 92705/2019-03-25, p.14. Cropped for teaching.

Variant	Power	Pressure	Flow	Practical meaning
LA.D	LA	Local DR	-	Prime-mover torque + maximum pressure
LA.DG	LA	Remote DRG / X	-	Maximum pressure can be commanded by external relief
LA.S	LA	No D	S / FR type	Separate metering orifice sets demand flow
LA.DS	LA	DR	S / FR type	Power + pressure + flow together

LA.DG - X line

Page 10: an external pressure relief valve is piped to port X; maximum line length 2 m is recommended. Standard differential pressure is 20 bar, adjustable 10-22 bar, and pilot flow at X is approximately 1.5 L/min. Unloading X to tank gives standby approximately 1-2 bar above the defined Δp, excluding system influences.

LA.S / LA.DS - flow control

Pages 11-12: flow control maintains a differential pressure across an adjustable metering orifice. Standard Δp is 14 bar, adjustable 14-22 bar. Pump flow is matched to the consumer's actual demand.

10 · CONTROL PRIORITY

If power, flow and pressure controls act together, which one wins?

Page 11 explicitly states that in all controller combinations **"Vg reduction has priority."** A useful engineering model is:

```
Vg,final ≈ min(Vg,power
, Vg,flow ,
Vg,pressure)
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Each function permits a displacement according to its own limit. The function demanding the smallest displacement sets the operating point.

Situation	Dominant control	Result
Low load + low flow demand	S / flow control	Pump reduces displacement to required flow.
Load rises, high flow requested	LA	At the power curve, LA prevents additional flow.
Pressure reaches DR setting	DR / DRG	Pump moves toward minimum stroke.
X is unloaded (DG)	DRG remote	Pump can be brought to low standby pressure.

Diagnostic consequence

"Joystick is at 100% but flow is missing" does not automatically mean pump failure. The system may be on the LA power limit or DR pressure cut-off. Diagnose pB, pump angle/Vg, engine speed and requested flow together.

Recognizing normal LA behavior in the field

Cylinder moves fast unloaded

Pressure is low → LA inactive → large Vg → high flow.

Cylinder slows when it hits load but engine speed stays healthy

Pressure rises → LA reduces Vg → flow falls → engine torque is protected. This may be normal LA behavior.

Pressure is at maximum and motion nearly stops

DR/DRG pressure cut-off may be active; pump approaches minimum displacement.

Available power seems to change with engine speed

The torque characteristic can remain the same, while $P=M\omega$ changes with speed.

On an S variant, reducing valve opening reduces flow

Orifice Δp control sets demand flow; if the LA curve requires an even smaller Vg, the power limit wins.

> **Minimum diagnostic data**
>
> Engine speed n, pump outlet pressure pB, pump swash angle / Vg if available, consumer flow demand, DR/DRG pressure setting, and the factory LA power characteristic. A “low flow” observation alone is not enough.

Verify the physics in ALGO TEAM

Lab: https://algo-team.com/hydraulic-simulator/la-power-controller/
Hydraulic circuit simulator: https://algo-team.com/hydraulic-simulator/

Test	Change	Expected physics
1	NG71, 1500 rpm, 20 kW, p=80 bar	Vg ≈ Vgmax; LA does not limit yet.
2	Increase pressure 150 → 200 → 250 bar	Vg and q fall while torque stays near 127 Nm.
3	Change speed 1000 → 2000 rpm	At the same torque setting, shaft power rises with speed.
4	Reduce DR cut-off 280 → 220 bar	Pump destrokes earlier due to pressure limit.
5	Reduce flow demand in LA.S / LA.DS	Below the power curve, flow control dominates.
6	Increase Pref 20 → 30 kW at same pressure	Allowed torque and Vg increase; LA limits later / at more flow.

Model boundary

The simulator is a quasi-static educational model. It does not reproduce exact spool transient response, spring tolerances, hysteresis, pilot-line dynamics, temperature/viscosity effects or proprietary internal geometry.

Values to keep in view

- LA pilot fluid consumption: maximum approx. 5.5 L/min (RE 92705 p.13).
- DR pressure-control setting range: 20-280 bar; standard 280 bar (p.9).
- DRG differential pressure: standard 20 bar; 10-22 bar adjustment; maximum X-line length 2 m recommended (p.10).
- DRS/DRSC flow-control differential: standard 14 bar; 14-22 bar adjustment (p.12).
- Flow, torque and power equations: p.7.
- LA principle, LA5-LA9 table and power conversion: p.13.
- LA.DG / LA.S / LA.DS circuit variants: p.14.

Use of this guide

For learning, preliminary sizing and understanding system behavior. Final pump selection, settings, safety and circuit design must use the current Bosch Rexroth technical data and application-specific manufacturer approval.

LA... – Pressure, flow and power controller

Pressure controller equipped as DR(G), see page 9 (10).
Equipment of the flow controller like DRS, see page 11.
In order to achieve a constant drive torque with varying working pressures, the swivel angle and with it the output flow from the axial piston pump is varied so that the product of flow and pressure remains constant. Flow control is possible below the power control curve. When ordering please state the power characteristics to be set at the factory in plain text, e.g. 20 kW at 1500 rpm.

Controller data

- ▶ For technical data of pressure controller DR see page 9.
- ▶ For technical data of flow controller FR see page 11.
- ▶ Pilot fluid consumption max. approx. 5.5 l/min.

	Torque M [Nm] for size					
Beginning of control	**45**	**71**	**100**	**140**	**180**	**Type code**
up to 50 bar	up to 42.0	up to 67.0	up to 94.0	up to 132.0	up to 167.0	**LA5**
51 to 90 bar	42.1 - 76.0	67.1 - 121.0	94.1 - 169.0	132.1 - 237.0	167.1 - 302.0	**LA6**
91 to 160 bar	76.1 - 134.0	121.1 - 213.0	169.1 - 299.0	237.1 - 418.0	302.1 - 540.0	**LA7**
161 to 240 bar	134.1 - 202.0	213.1 - 319.0	299.1 - 449.0	418.1 - 629.0	540.1 - 810.0	**LA8**
over 240 bar	over 202.1	over 319.1	over 449.1	over 629.1	over 810.1	**LA9**

Conversion of the torque values in power [kW]

$P = \frac{M}{6.4}$ [kW] (at 1500 rpm) or $P = \frac{2\pi \times M \times n}{60000}$ [kW] (For rotational speeds see page 7)