

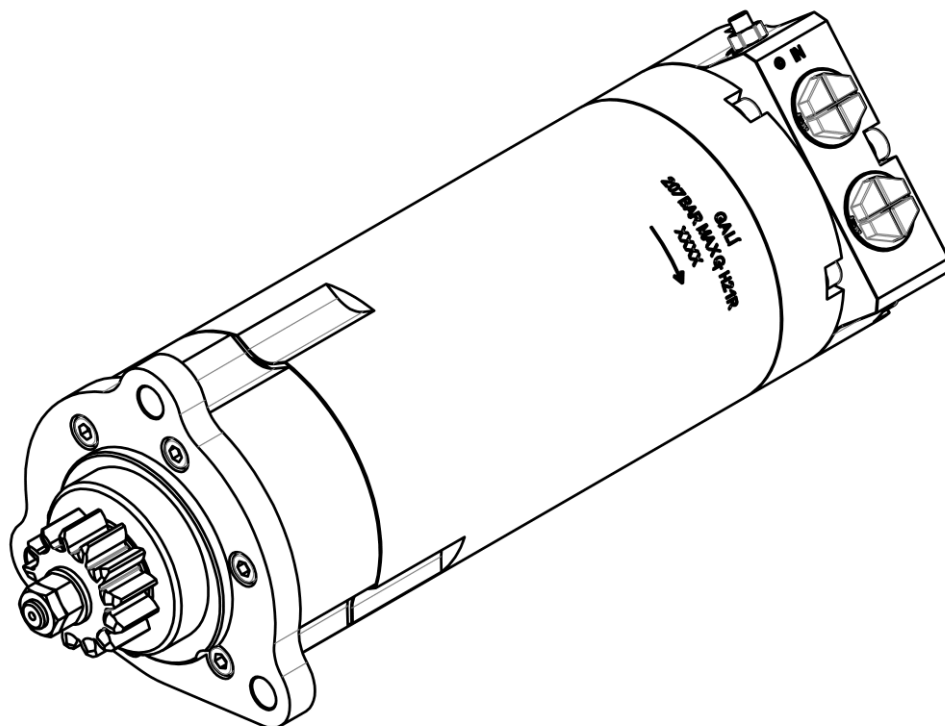


- SAVE THESE INSTRUCTIONS. THIS MANUAL CONTAINS SAFETY INFORMATION
- READ AND UNDERSTAND THIS MANUAL BEFORE USING AND INSTALLING THE DEVICE
- A NOT PROPER USE OF THE DEVICE COULD RESULT IN INJURY

SERVICE MANUAL

HYDRAULIC STARTER FOR DIESEL AND GAS INTERNAL COMBUSTION ENGINES

Type H21



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1. GUARANTEE INFORMATION

GUARANTEE: Within a period of ONE YEAR after the purchase date, GALI will be liable for faulty material or manufacturing defects of its products. The guarantee only covers free replacement of faulty parts and excludes any other indemnity or reimbursement of labour costs involved in alien material. The guarantee is valid only if:

1. The product is always being subject to proper use, maintenance and storage.
2. No modification whatsoever has been introduced in the product.
3. The installation follows the instructions on this manual.

GALI will not be liable for damage, injury or loss of any kind whatsoever, caused by or in connection with the installation or use of its products.

GALI refuse all the responsibility for damage and losses caused by an incorrect use or maintenance of its products.

2. GENERAL INFORMATION

The purpose of this manual is to provide the required information and direct instructions for a correct use and installation of the hydraulic starter type H21.



Gali Internacional strongly recommends reading carefully this manual before the use and installation of the hydraulic starter or before and during the maintenance operations. If there are some other doubts that have not been clarified in this manual, please, feel free to contact one of our dealers or distributors, or contact directly with Gali Internacional (refer to chapter "Distributors and Service").

The H21 hydraulic starter is a lubrication free starting and cranking device. It is intended for its installation on main and auxiliary reciprocating diesel or gas engines of an approximate range of 18~52 L or 447~1100 kW (600~1475 HP). However, the suitability depends on the engine total displacement and the gear ratio between the starter driving pinion and the engine's flywheel ring gear.

The H21 hydraulic starter is suitable to operate directly at the high pressure of 20.7 MPa (3000 psi). The engine size and its contour conditions (engine lubrication, oil temperature, ambience temperature, etc.) will determine the exact minimum starting pressure of the starter. The starter will be able to start within the range from 20.7 MPa to the previously mentioned minimum starting pressure.

The H21 hydraulic starter is designed to operate with hydraulic oil. Refer to chapter "Installation requirements" for the required hydraulic oil type and quality.

Its operation principle is based on an axial piston motor type swashplate that rotates thanks to hydraulic oil pressure. The torque generated by the cylinder block is transmitted to the output shaft. A driving pinion assembled to the output shaft will engage the ring gear transmitting the required torque to accelerate the engine until the required speed.

The H21 hydraulic starter is equipped with an internal mechanism to assure a correct engagement and to avoid premature disengagement before the engine is started up.

3. SAFETY INFORMATION

Some safety indications are detailed along this manual. For a correct interpretation, the following symbol criteria should be considered:



ESSENTIAL REQUIREMENT: all starter installation that is not according to the corresponding requirement will be considered as “no conforming”.



RECOMMENDATION: to obtain the maximum lifetime and best operation of the starter.



WARNING: if the corrective actions are not taken into account injury or damage could occur.



Gali recommends using always PPE when manipulating the air starter.

Symbology meanings established by the regulations have been respected for the indications corresponding to safety.

Starter assembly to the engine must be carried out by qualified personnel. On this regard, the qualified personnel must be trained, instructed, and familiarized with the system.

In the event of injury or damage caused by not following the safety instructions, inappropriate conduct procedures, or using the starter for other purposes, the manufacturer is not responsible.

Related to operation



To avoid any injury, use the safety equipment when operating the product.



Use the product under the specification mentioned in the catalog, drawings and specification sheet.



Do not step on the product, hit it, drop it or give strong outside force to it, as one of these actions may cause the failure of work, damage or oil leakage.



Wipe completely off the oil on the product or floor, as the oil creates slippery conditions that may result in dropping the product or injuring.



Assure that all oil connections are correctly tightened before start operating, especially for the first run.

Related to starter's installation and removal



Installation and removal must be done by qualified staff.



Replacing the seals may be required if you use the product after long time storage (refer to chapter "Spare parts").



Assure that the hydraulic unit's power is turned off before installing or removing the starter. Do not perform any maintenance work if the system pressure has not dropped to zero.



Use the specified bolts and keep the specified tightening torque when installing the product. Usage of unauthorized bolts, lack of torque or excess of torque may create problems such as failure of work, damage and oil leakage (refer to chapter "Spare parts").



Clean threads and the mounting surface completely, otherwise you may experience damages or oil leakage caused by insufficient tightening torque or broken seal.



Please use anti-wear hydraulic fluid as operating fluid. The recommended ranges of operating fluid are the following:
 - Viscosity: 30 ~ 100 mm²/s (cSt)
 - Temperature: ~ +40°C
 In case of extreme conditions refer to Chapter "Oil-Operating Fluid".

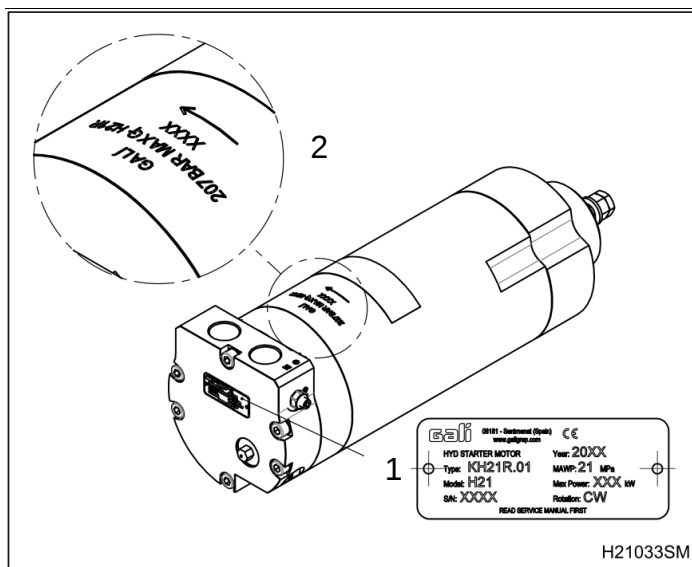
4. PRODUCT IDENTIFICATION

The product can be identified by means of two ways:

- 1) By the starter's nameplate, which is located on the starter's soft engagement valve back side, that provides the following information: type code, starter model, serial number, manufacturing year, maximum starter's allowable pressure, maximum power, manufacturer's address and sense of rotation –viewed from its pinion end – (see figures H21033SM and 0355121SM).
- 2) By inscription on starter's housing, that provides the following information: maximum starter's allowable pressure, starter model, sense of rotation (R = right), serial number and an arrow that informs about the rotation sense (see figures 0355121SM and H21034SM).

For a correct starter identification, you must refer to both serial number and starter type code. Please refer to these data in case of ordering spare parts, querying information as well as service requesting. For starter type code interpretation, please refer to next chapter.

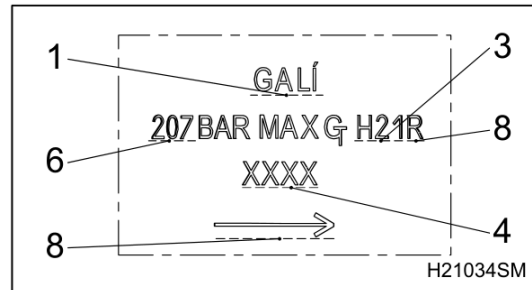
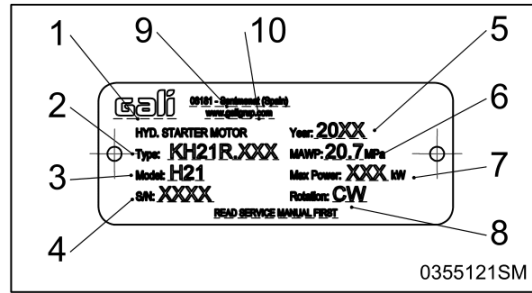
1. Identification plate.
2. Body inscription.



Do not operate this starter at pressures greater than those indicated in the product identification.

4.1. Starter's nameplate and body inscription information

1. Manufacturer.
2. Type (ordering code).
3. Model.
4. Serial number.
5. Year of manufacture.
6. Maximum starter's allowable pressure.
7. Maximum output power.
8. Rotation.
9. Place of manufacturer.
10. Manufacturer's website.



4.2. Starter sense of rotation

Figure H21010SM shows the starter sense of rotation viewed from pinion end.

The **standard rotation** of the hydraulic starter is **CW** (i.e. clockwise rotation sense), see Figure 1.

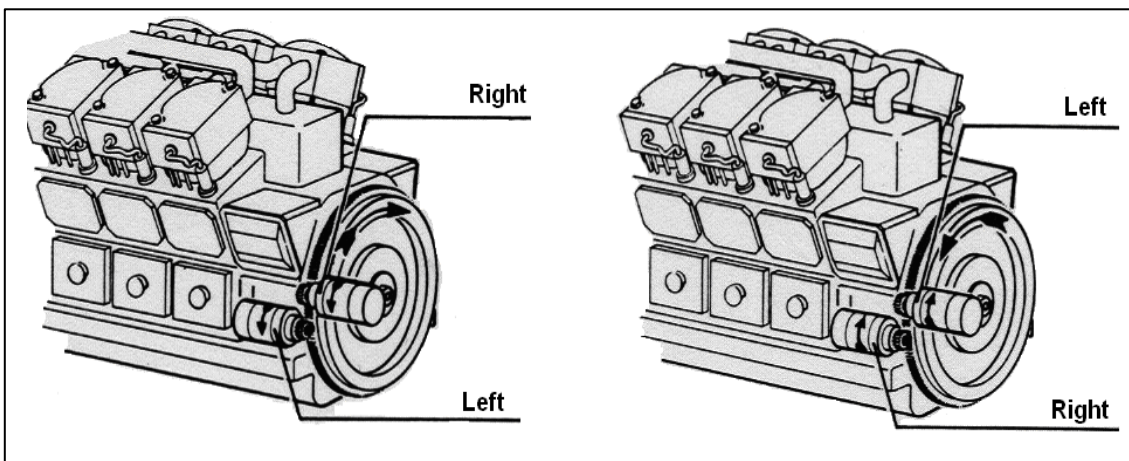
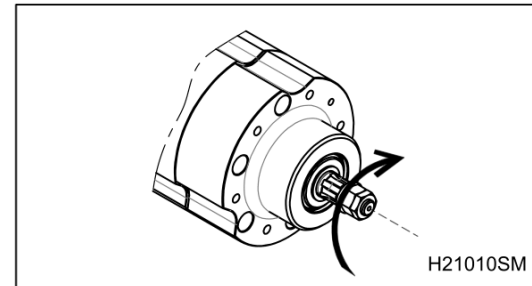


Figure 1. Starter's sense of rotation.

5. PERFORMANCE DATA

The hydraulic starter general characteristics (performance) are as follow. Figure 2 shows the typical curves of output torque versus speed (measured value at starter's output shaft), at different hydraulic pressures at hydraulic starter's inlet and Figure 3 shows the typical oil consumption versus speed.

The values given in the figures below are mean ones.

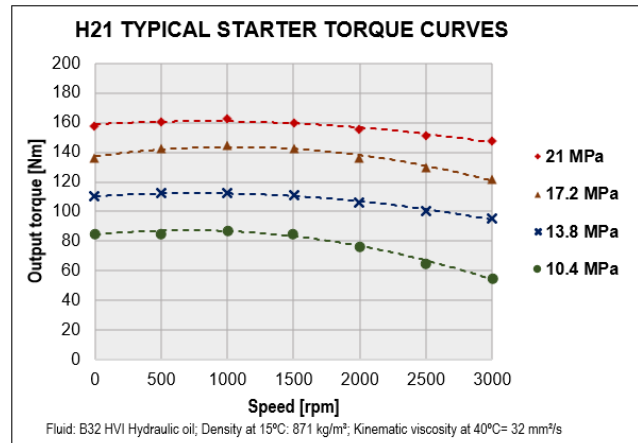


Figure 2. Torque versus speed diagram.

The following table shows the main performance specifications of H21 hydraulic starter:

Model	H21.057
Design	Axial piston starter motor of cradle swashplate design with fix displacement
Stroke	27 ± 1
Displacement ⁽¹⁾ , V	57.26 cm³/rev. (3.5 cu.in³.)
Maximum allowable operating pressure, MAOP	20.7 MPa (3000 psi)
Maximum speed	4500 rpm
Maximum output torque @ 20.7 MPa	163 Nm (120 lbf·ft)
Maximum output power ⁽²⁾	54 kW (73 HP)
Hydraulic fluid	Mineral oil as per DIN 51524
Ambient temperature range	-15°C up to 60°C (Standard) (5 °F up to 140 °F)
Hydraulic fluid temperature range	-15°C up to 80°C (Standard) (5 °F up to 176 °F)
Viscosity	Permissible operating range 12 up to 100 mm²/s (66 up to 464 SUS) Recommended operating range 16 up to 46 mm²/s (82 up to 214 SUS)
Oil quality	NAS 1638, Class 8 / ISO 4406, Class 19/17/14 / SAE AS 4059, Class 9
Duty type	Intermittent periodic ⁽³⁾
Drive type	Positork drive with pre-engagement mechanism
Rotation	CW (Standard)
Motor housing	Aluminium
Type of mounting	SAE type N° 1, 2, 3, 4 mounting flanges ⁽⁴⁾ depending on the model
Mass	16 kg (35.3 lb)

Table 1. H21 hydraulic starter technical specifications and operating conditions.

⁽¹⁾ Ask Gali for starter performance detailed information and lifetime.

⁽²⁾ Effective value at the maximum allowable operating pressure and optimal speed.

(3) Duty type intermittent periodic is defined as a sequence of identical duty cycles, each including a time of operation at constant load and time de-energized and at rest.

(4) According to standard SAE J542.



**Do not operate this starter free of load (not installed on an engine).
Always follow the engine maker instructions for engine starting up.**

6. DIMENSIONS

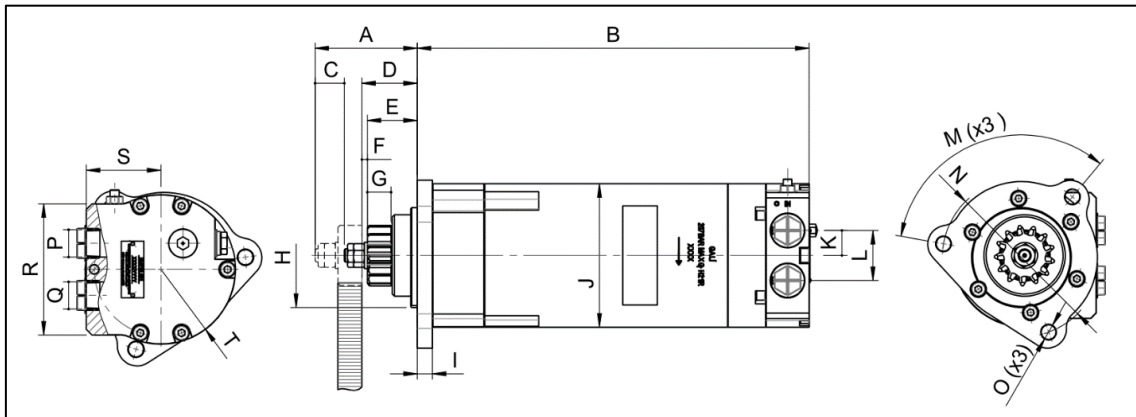


Figure 3. H21hydraulic starter dimensions. ⁽⁵⁾

A	B	C	D	E	F	G	ØH	I	ØJ
94	362	27±1	51 ⁽⁵⁾	46	5±1	22	Ø92 e9 ⁽⁵⁾	14	Ø132
K	L	M	N	O	P	Q	R	S	T
23	46	120° ⁽⁵⁾	Ø146 ⁽⁵⁾	Ø13 ⁽⁵⁾	3/4" BSPP (DN19)	3/4" BSPP (DN19)	116	66	132

Table 2. Dimensions of the Gali hydraulic starters.

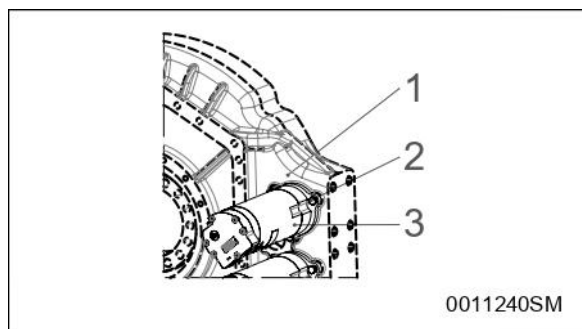
(5) Other dimensions available under request.

7. INSTALATION ON ENGINE

7.1. Securing on engine

The starter can be coupled to the engine by different ways:

- By means of a flange (that assures the connection dimensions, almost always according to SAE J542B).
- By bracket, in case the engine is not equipped with flywheel housing (big size engines mainly).
- By cradle, where the starter is assembled by its body diameter to the engine block (very unusual system).



To get a secure starter coupling to the engine it is recommended to use 8.8 screws tightened with the proper torque.

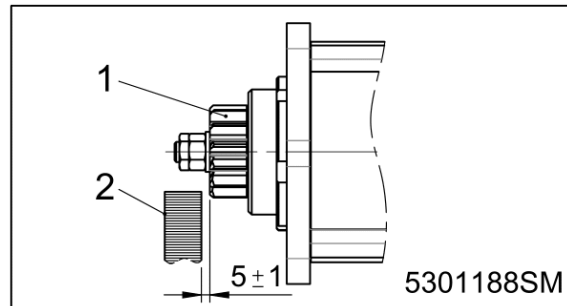
Item	Size	Type	Value/Standard
Allen screw DIN 912 (8.8)	M10	Tightening torque	35 Nm
Allen screw DIN 912 (8.8)	M12	Tightening torque	59 Nm
Allen screw DIN 912 (8.8)	M16	Tightening torque	145 Nm

Table 3. Tightening torque coupling starter.

7.2. Distance to engine's ring gear

The distance between the pinion front and engine's ring gear front must be 5 mm with an allowable tolerance of ± 1 mm.

1. Driving pinion.
2. Engine's ring gear.



In order to assure a correct engagement between ring gear and pinion and high lifetime, both elements **MUST** be correctly **ALIGNED**.

In order to assure a correct engagement between ring gear and pinion, engine's ring gear teeth must be heat treated. To obtain suitable hardness, please contact Gali.

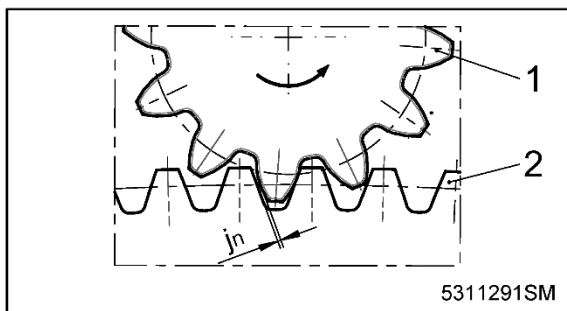
In order to obtain a suitable geometry of the ring gear and to get the best functionality, please contact Gali to assist on the design.

Ring gear and pinion lubrication with grease is recommended.

7.3. Backlash adjustment

To assure a correct mating and smooth operation between pinion and ring gear, the following normal backlash ⁽⁶⁾ (j_n) values must be adopted depending on teeth module or DP and on the pressure angle.

Module	DP	α (press. angle)	J_n (normal backlash, mm)
2.54	10 10/12	20°	0.3~0.6
2.75	-		0.7~1.0
3	-		
3.175	8 8/10		
3.5	-		
4	-		
4.233	6 6/8	14.5° – 15°	0.3~0.5
5	-		
3	-		
3.5	-		
4	-	12°	0.3~0.5
2.117	12 12/14		



1. Driving pinion.
2. Engine's ring gear

Table 4. Backlash adjustment.

⁽⁶⁾ The normal backlash is the gap or allowance between engine's ring gear and starter's pinion teeth flanks.

8. INSTALLATION REQUIREMENTS

8.1. Oil-operating fluid

The viscosity, quality and cleanliness of the operating fluid are decisive factors in determining the reliability, performance, and lifetime of the hydraulic starter.

8.1.1. Viscosity

The hydraulic starter maximum lifetime and performances are achieved within the recommended viscosity range. The recommended operating kinematic viscosity, ν , is 30~100 mm²/s (cSt). This viscosity is referred at the same time to the temperature of the fluid entering the starter and to the temperature of the fluid inside the starter housing.

In case of extreme conditions, the following limitations are applied:

$\nu_{min. abs.}$ = 10 mm²/s for instants in case of emergency, with a minimum case fluid temperature of 80°C.

ν_{min} = 18 mm²/s with reduced torque and maximum supplied power performances.

ν_{max} = 1000 mm²/s during cold start-up (-20°C).

For all applications outside these limits, please contact Gali.

Make sure that the degree of the viscosity always fulfils the values specified in the next figure.

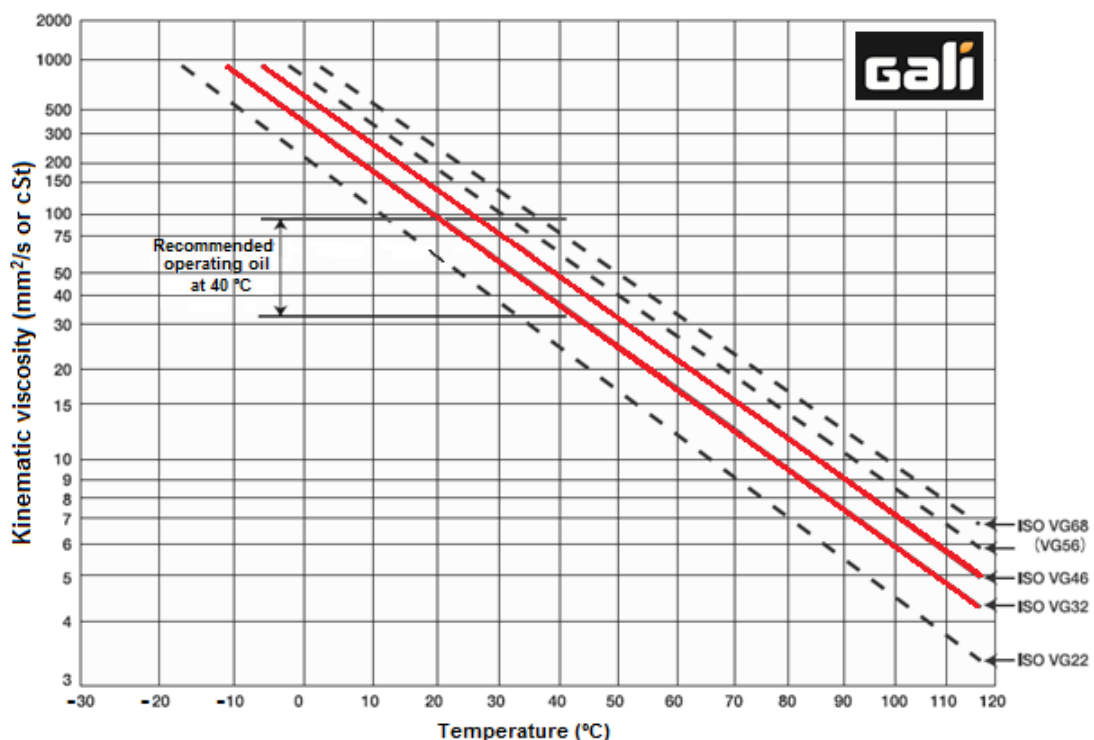


Figure 4. Recommended operating oil viscosity grade and applicable viscosity range.



Temperature must never exceed 80°C anywhere in the system.

8.1.2. Recommended oils

Gali recommends **ISO VG32 or ISO VG46 HLP oils** (mineral oil-based) based on the standard DIN 51 524 **part 2** (with anti-wear, antioxidation and anticorrosion properties), and **part 3** (with a high viscosity index, suitable for application subject to wide temperature ranges).

Gali also recommend that the hydraulic fluids must be defined according to the standards 11158 and ISO 6743-4.



Use only the recommended oils.

8.1.3. Fluid filtration

Gali's hydraulic starter is self-lubricating. For satisfactory service life and performance of the hydraulic starter, Gali recommends changing filters, as indicated below, in order to keep the system fluid clean. The cleanliness level should be NAS 1638 Class 8, ISO 4406 Class 19/17/14 or SAE AS 4059 Class 9.

In case the above listed filtration classes cannot be respected, please contact Gali.

The filters must be changed after first 200 running hours; subsequent cleaning and/or changes must take place every 6 months or 500 running hours, whichever comes first.

8.1.4. Changing the oil-operation fluid

The frequency of oil changes depends on the working conditions of the starter, the environment and the amount of oil in circulation. Under normal operating conditions, the hydraulic oil should be changed at the following intervals:

The first oil change should be carried out after max. 80–100 hours of operation but at the latest one year after first-time operation. The second change should take place after max. 500 hours of operation but at the latest one year after the first change. Thereafter, the hydraulic oil should be changed at least every 1000 hours of operation or at least once a year.



**The suitable temperature of the hydraulic fluid draining is 40 °C due to its conditions viscosity.
Remove any residual dirt or sludge from the reservoir.**

In extremely dusty atmospheres, the intervals between oil changes must be correspondingly shortened.



**The level of cleanliness required by a system depends on the level required by the most sensitive component (e.g.: soft engagement valve).
Fluid samples must be taken from the power loop of the system.**



The life of hydraulic components is lengthened when the contamination level is low.

Gali recommends the oil be revised periodically to ensure that the characteristics described below are maintained. These analyses may also serve to determine more precisely how often to change the oil. At any case, the frequency must never exceed every 12 months. For other types of fluid, follow the manufacturer's instructions.

If the fluid becomes contaminated with any foreign material (dirt, water, solvent, grease, etc.) or has been subject to abnormal operating conditions, the fluid should be changed more frequently.

8.1.5. Mixing different oils

Mixing oils of different brands or different oils of the same brand may lead to the formation of sediment and sludge. Consequently, a fast and irreversible deterioration of the system is induced.



Mixing oils is not permitted.

To avoid mixing different oils, during an oil change, all equipment and lines (especially the tank) must be drained and the starter completely cleaned. It is also important to replace all the oil in the drainage chambers, emptying the starter completely.

9. STARTER OPERATION RECOMMENDATIONS

Typical start sequence

The starter declutching speed should be as lower as possible in order to increase as maximum the starter's lifetime and in order to reduce the oil consumption. The less the engine firing speed can be, the less the starter declutching speed will be.

The following starting sequence is commonly used to start an engine, see next figure:

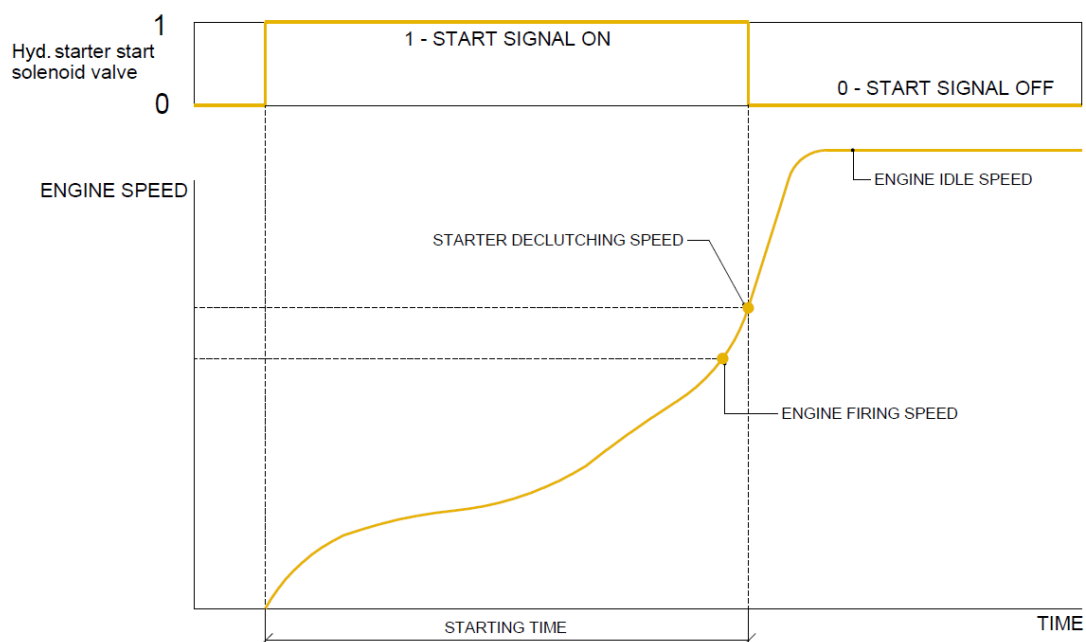


Figure 5. Normal start sequence.

The hydraulic starter engages the ring gear and accelerates the engine until the firing speed is reached. The engine declutching signal can be performed just after.



Other starting sequences are possible according to each application. Ask Gali or one of our distributors and representatives for technical support. Gali offers the attendance to the starting tests in order to get the most efficient start sequence.



Do not engage the starter while the engine is running.

10. MAINTENANCE

Before performing any maintenance work, please follow the next instructions:



Firstly, release the oil remaining in the pipes and starter by means of the drain valve, hand pump's release hand knob or/and the starter control valve (Careful, the starter will try to work, pay attention to the movements that may happen).

Finally, check that the absence of pressure by the pressure gauge at the hydraulic stating power unit system.

Leave the drain valve opened when carrying out any kind of maintenance task on the installation.



Always use original GALI spare parts to ensure continued and reliable performance for many years. Not original Gali's spare parts can generate hazards or malfunctioning of the starter.

In order to achieve the maximum lifetime and reliability of the starter, preventive maintenance schedule should be suited as is detailed next.

10.1. Preventive maintenance

Preventive maintenance is the best way to assure correct hydraulic starter operation and longer lifetime. It is recommended to suit the following actions to take advantage of completely hydraulic starter performance.

Start sequence	TST ⁽⁷⁾ (sec)	ACTIONS FOR A 1500 STARTS / YEAR USE ⁽⁸⁾ ⁽⁹⁾	Regularity in months (starts)	
			12 (1500)	18 (2250)
NORMAL	≤ 5	Check general condition of the starter (external visual inspection). Check that there are no visually detectable damaged external parts; replace affected parts if necessary.	X ⁽¹⁰⁾	
		Check oil leakages. Replace affected parts if necessary.	X ⁽¹⁰⁾	
		Grease the pinion and ring gear with the suitable grease.	X ⁽¹⁰⁾	
		Re-grease the needle roller bearings with grease MOBIL MOBILITH SHC 100.		X ⁽⁹⁾
		Lubricate the retaining ring, all the bearings and pistons mounting surfaces (<i>ball bearing and thrust bearing</i>) with teflon lube oil (BARDAHL TEFLUBE).		X ⁽¹⁰⁾
		Replacement of all the gaskets of the starter (for spare kits refer to chapter "Spare parts").		X ⁽¹⁰⁾
		Check pistons, block cylinder or barrel and plate valve conditions (wear on faces, diameters, and piston's head).		X ⁽⁹⁾
		Check needle roller bearings conditions. Verify that the rotation is normal (not very smooth and not very hard). Check bearing sound is not squalling when rotated. Clean all the bearing mounting surfaces. Check the condition of the retainer. Replace if required (for spare parts kits refer to chapter "Spare parts").		X ⁽⁹⁾
		Clean and spray the splined shaft outer surface with teflon lube oil.		X ⁽¹⁰⁾
		ACTIONS FOR A 1500 STARTS / YEAR USE	Regularity in months (starts)	
			6 (750)	9 (1150)
LONG CRANKING CYCLE	5 ÷ 10	Check general condition of the starter (external visual inspection). Check that there are no visually detectable damaged external parts; replace affected parts if necessary.	X ⁽¹⁰⁾	
		Check oil leakages. Replace affected parts if necessary.	X ⁽¹⁰⁾	
		Grease the pinion and ring gear with the suitable grease.	X ⁽¹⁰⁾	
		Re-grease the needle roller bearings with grease MOBIL MOBILITH SHC 100.		X ⁽⁹⁾
		Lubricate the retaining ring, all the bearings and pistons mounting surfaces (<i>ball bearing and thrust bearing</i>) with teflon lube oil (BARDAHL TEFLUBE).		X ⁽¹⁰⁾
		Replacement of all the gaskets of the starter (for spare kits refer to chapter "Spare parts").		X ⁽¹⁰⁾
		Check pistons, block cylinder or barrel and plate valve conditions (wear on faces, diameters and piston's head).		X ⁽⁹⁾
		Check needle roller bearings conditions. Verify that the rotation is normal (not very smooth and not very hard). Check bearing sound is not squalling when rotated. Clean all the bearing mounting surfaces. Check the condition of the retainer. Replace if required (for spare parts kits refer to chapter "Spare parts").		X ⁽⁹⁾
		Clean and spray the splined shaft outer surface with teflon lube oil.		X ⁽¹⁰⁾

Table 5. Preventive maintenance.

- (7) TST=total starting time= cranking start (if any) + start stage until starter declutching.
- (8) Maintenance plan for maximum hydraulic starter speed of 3500 rpm. For higher disengagement speed, please ask Gali for a special maintenance plan.
- (9) For different number of annual starts, regularity R' can be calculated as (only for **RED** items): $R' = R \times 1500 / S$ (R= table regularity; S= real starts per year).
- (10) Maintenance to be done at the limit number of starts for the corresponding regularity or at the indicated regularity (what happens first).



Use the table attached in chapter "Annex - Preventive maintenance control sheet" for preventive maintenance control.

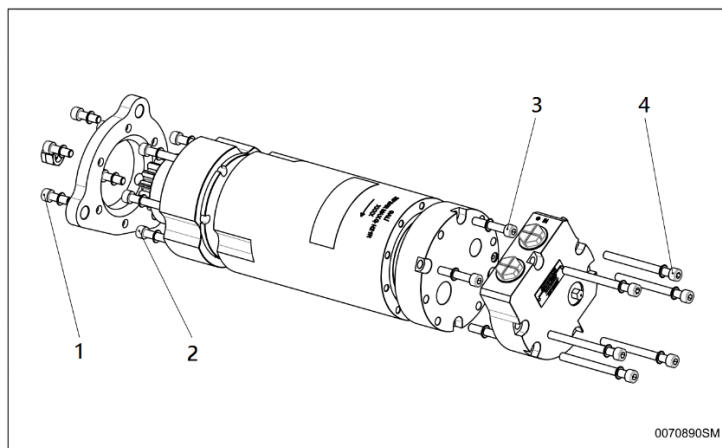
10.2. Lubrication

	Always use the greases and oils shown below	
	O-rings, Pistons and Springs (Teflon lube or oil)	• TEFLON LUBE: <i>BARDAHL SUPER TEFLUBE LDS (or equivalent)</i> • OILS: <i>SHELL OMALA S4 GX (or equivalent)</i>
	Splined shaft	<i>BARDAHL SUPER TEFLUBE LDS (or equivalent)</i>
	Needle roller bearing (grease)	• <i>MOBIL MOBILITH SHC 100 GREASE</i> • <i>KLUBERPLEX BEM 34-132 GREASE (alternative grease)</i>

Table 6. Lubrication: greases and oils.

10.3. Tightening torques

Use a torque wrench to tighten the screws to the specified torque indicated below:



Item	Size	Type	Additive	Value/Standard	Qty.
1. Coupling flange screws Allen screw DIN 912 (8.8)	M8x25	Tightening torque	Loctite 243	11 Nm	6
2. Front cover screws Allen screw DIN 912 (8.8)	M8x45	Tightening torque	Loctite 243	11 Nm	5
3. Distributor screws Allen screw DIN 912 (8.8)	M8x45	Tightening torque	Loctite 243	11 Nm	4
4. Soft eng. valve screws Allen screw DIN 912 (8.8)	M8x90	Tightening torque	Loctite 243	11 Nm	6

Table 7. Tightening torque screws.

Use a torque wrench to tighten the pinion nut to the specified torque below:

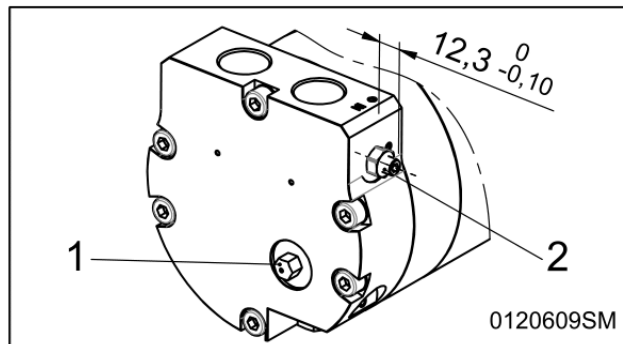
Item	Size	Type	Additive	Value/Standard	Qty.
Special NUT (nut + counter-nut)	M12	Tightening torque	Loctite 243	59 Nm (nut) 49 Nm (counter-nut)	1

Table 8. Tightening torque coupling pinion.



For correct operation of Apply Loctite 243 or equivalent product to increase the unions resistance against loosening due to vibrations. Let the union dry or 24h before installation.

Use a torque wrench to tighten the soft engagement valve nuts to the specified torque below:



Item	Size	Type	Additive	Value/Standard	Qty.
1. Soft eng. valve's nut Hexagonal nut DIN 917	M6	Tightening torque	Loctite 542	5 Nm	1
2. Soft eng. valve's special Standard nut style AJ6-SS 912 (8.8)	M8	Tightening torque	Loctite 542	11 Nm	1

Table 9. Tightening torque screws.



For correct operation of the soft engagement valve ensure that the length of the flow regulator stud is $12,3^{0}_{-0,1}$, see Figure 0120609SM.

11. TROUBLESHOOTING

Refer to chapter "Annex - Troubleshooting checklist".



Please, send the failure checklist report filled to Gali in case technical assistance is required.

12. SPARE PARTS

Gali spare parts are described in the following table:

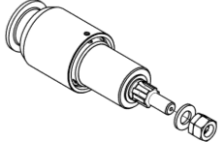
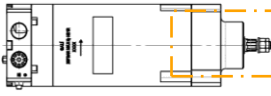
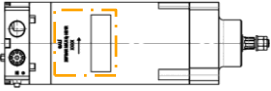
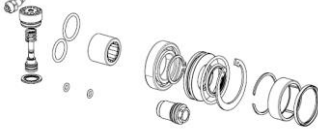
Description	Reference	Content	Maintenance required tool	Location on starter
Positork drive assembly	5290266		-	
Pistons repair kit	5290257		-	
Seals & Bearings repair kit	5290267		5907231 5907232 5907235 5907236 5907237	
Thrust bearing subassembly	5290263		5907233 5907234	

Table 10. Main spare parts.

12.1. Maintenance tools

	Reference	Maintenance operation	Content
Maintenance bracket	5907230	General maintenance	
Seals & Bearings repair kit	5907231	Needle roller bearing disassembly (ref. 0921925)	
	5907232	Needle roller bearing assembly (ref. 0921925)	

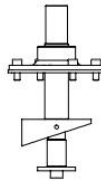
	5907235	Needle roller bearing disassembly (ref. 0974047)	
	5907236	Needle roller bearing assembly (ref. 0974047)	
	5907237	Check valve assembly / disassembly (ref. 1520130)	
Thrust bearing subassembly	5907233	Thrust bearing support disassembly	
	5907234	Thrust bearing support assembly	

Table 11. Maintenance tools.



Maintenance required tools are not included in the spare parts kits.
Galí offers other optional tools for maintenance operations, refer to chapter "Maintenance tools".

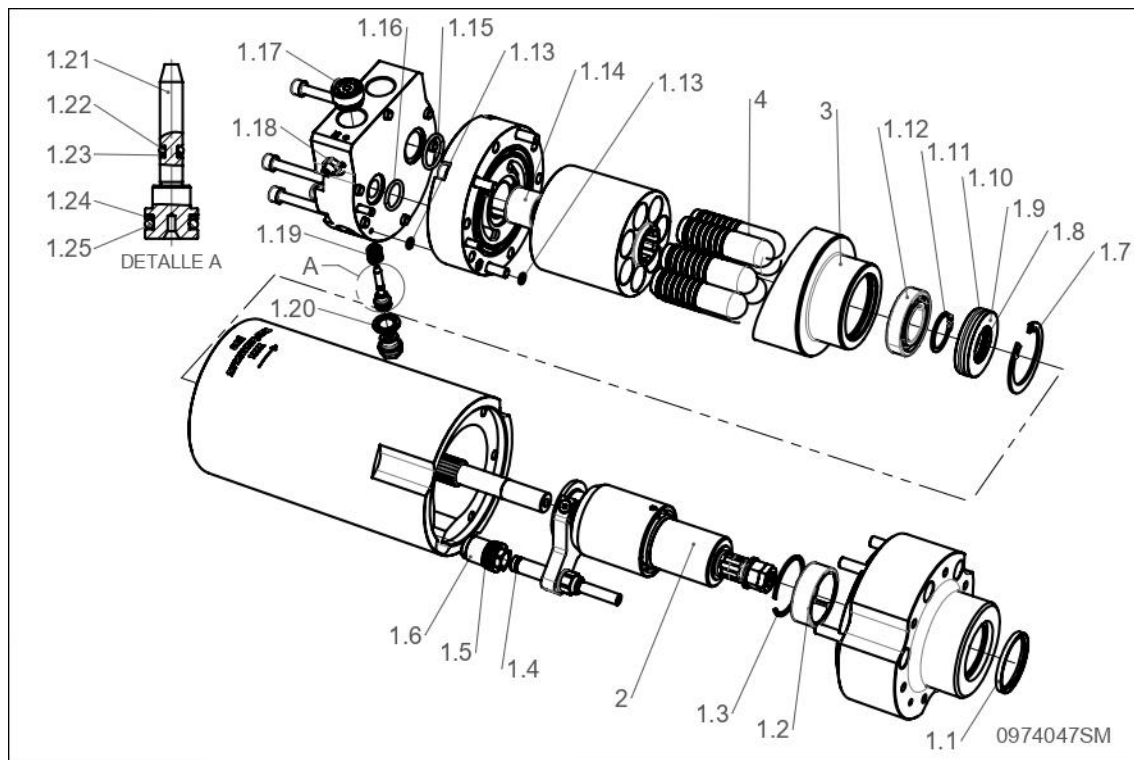


The spare parts are delivered lubricated. However, please check that lubrication has not disappeared during transport and lubricate if necessary.
Refer to chapter "Maintenance".



Maintenance required tools are not included in the spare parts kits.

12.2. Spare parts location



ID	Reference	Spare parts kit reference
1	1.1	0384004
	1.2	0974047
	1.3	0284715
	1.4	0300915
	1.5	0301902
	1.6	H21015
	1.7	0265502
	1.8	0323038
	1.9	H15004
	1.10	0305003
	1.11	0252715
	1.12	0933013
	1.13	0300602
	1.14	0921925
	1.15	0302603
	1.16	0302103.20
	1.17	1520130
	1.18	0120806
	1.19	033121315
	1.20	1410116
	1.21	H30044
	1.22	0302918.20
	1.23	0893301
	1.24	0899901
	1.25	0309324.20
		5290267

Table 12. Spare parts location.

ID	Reference	Spare parts kit reference
2	-	5290266
3	-	5290263
4	-	5290257



Gali recommends changing all the seals and bearings when any part of the starter is disassembled for a maintenance job.

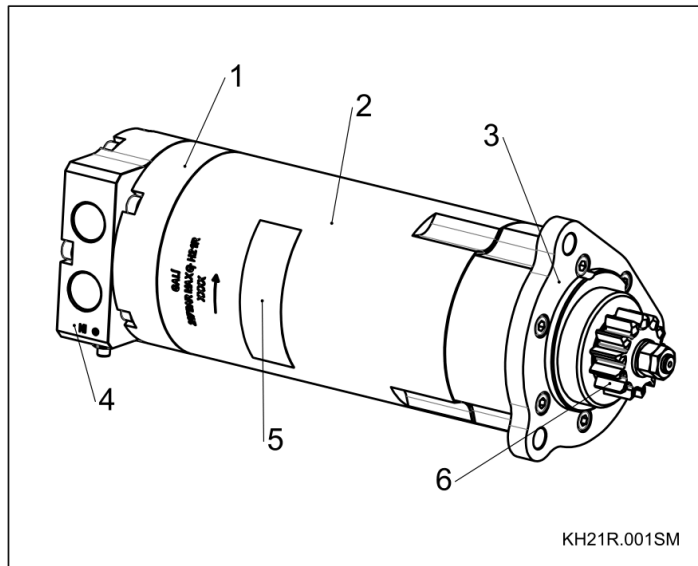


Request the spare part drawing in case of need detailed assembly instructions.

12.3. Main parts identification

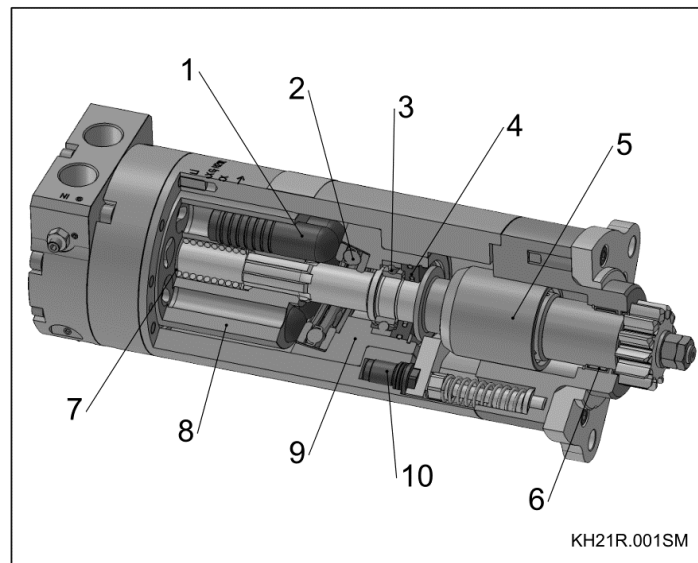
Outer parts

1. Distributor (valve plate).
2. Main body.
3. Coupling flange.
4. Soft engagement valve.
5. Sticker.
6. Driving pinion.



Internal parts

1. Piston.
2. Thrust bearing.
3. Ball bearing.
4. Retaining ring.
5. Drive assembly.
6. Needle bearing.
7. Needle bearing.
8. Block cylinder.
9. Swashplate.
10. Pusher.



13. DISTRIBUTORS AND SERVICE

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Table 13. Distributors and service.

14. APPENDIX

14.1. Preventive maintenance control sheet

Start sequence used	☐ Normal (<5 sec)
	☐ Long cranking cycle (> 5 sec)
	☐ Hydraulic starter over speed (> 3500 rpm). Ask Gali for maintenance program.

Maintenance work	1 st preventive maintenance		2 nd preventive maintenance		3 rd preventive maintenance	
	Date: N° of starts:		Date: N° of starts:		Date: N° of starts:	
	Done	Not done	Done	Not done	Done	Not done
Check general condition of the starter (external visual inspection). Check that there are no visually detectable damaged external parts; replace affected parts if necessary.						
Check oil leakages. Replace affected parts if necessary.						
Grease the pinion and ring gear with the suitable grease.						
Re-grease the needle roller bearings with grease MOBIL MOBILITH SHC 100.						
Lubricate the retaining ring, all the bearings and pistons mounting surfaces (<i>ball bearing and thrust bearing</i>) with Teflon lube oil (BARDAHL TEFLUBE).						
Replacement of all the gaskets of the starter (for spare kits refer to chapter "Spare parts").						
Check pistons, block cylinder or barrel and plate valve conditions (wear on faces, diameters, and piston's head).						
Check needle roller bearings conditions. Verify that the rotation is normal (not very smooth and not very hard). Check bearing sound is not squalling when rotated. Clean all the bearing mounting surfaces. Check the condition of the retainer. Replace if required (for spare parts kits refer to chapter "Spare parts").						
Clean and spray the splined shaft outer surface with Teflon lube oil.						

Table 14. Preventive maintenance control sheet.

14.2. Troubleshooting checklist

HYD. STARTER STATE (mark as it happened)	FAILURE	POSSIBLE CAUSE (Mark actions carried out to solve the problem)	ACTIONS TO SOLVE THE PROBLEM (Mark actions carried out to solve the problem. Start again after each action)	WHAT HAPPENED AFTER THE ACTION
PINION NOT ENGAGED TO THE RING GEAR	Pinion is not engaging or moving the engine ring gear.	Not enough oil pressure at starter's inlet (the accumulator(s) is discharge or no oil at starting system).	Increase system oil pressure until 20.7 MPa (3000 psi).	
		Hydraulic starting system drain valve opened.	Close oil valve of hydraulic starting system.	
		Flow control valve is completely closed.	Re-adjust flow control valve.	
		Damaged soft engagement valve.	Check that the soft engagement valve is not stuck. Replace if necessary.	
		High pressure filter installed on the hyd. starting system is blocked.	Remove and clean filter. Replace if necessary.	
		System overload relief valve adjustment not set high enough.	Check system pressure (20.7 MPa / 3000 psi) and reset relief valve.	
		Starter's oil control circuit completely blocked.	Check starter's control pipes and clean out.	
	On opening starter control valve, starter does not respond although oil flows through control circuit (noise is heard).	Oil leakages from rigid or flexible control pipes or from tube fittings or adapters.	Fix or replace them.	
		Not enough oil pressure at starter's inlet (at accumulator(s) or at hydraulic starting system).	Increase system oil pressure until 20.7 MPa (3000 psi).	
		Flow control valve is completely closed.	Re-adjust flow control valve.	
		Damaged soft engagement valve.	Check that the soft engagement valve is not stuck. Replace if necessary.	
		High pressure filter installed on the hyd. starting system is blocked.	Remove and clean filter. Replace if necessary.	
		System overload relief valve adjustment not set high enough.	Check system pressure (20.7 MPa) and reset relief valve.	
	Pinion revolves and advances but does not engage the ring gear.	Engine's ring gear and/or starter's pinion have burrs or are damaged.	Clean burrs or replace if necessary.	
		Lack of normal backlash between starter's pinion and engine's ring gear.	Check and correct.	
		Lack of frontal gap between starter's pinion and engine's ring gear.	Check and correct.	
		Not enough hardness of engine's ring gear teeth profile and front surface ($\approx <40$ HRc).	Gali soft engagement system is required.	
		Bad alignment between starter's pinion and engine's ring gear.	Check and correct.	
		The starter drive assembly (engagement system) is blocked or damaged.	Replace if necessary.	
	Pinion rotates but does not advance.	Not enough oil pressure at starter's inlet (at accumulator(s) or at hydraulic starting system) to exceed the engagement of drive assembly.	Increase system oil pressure until 20.7 MPa (3000 psi).	
		Splined shaft stuck.	Disassemble and clean. Lubricate shaft with Teflon lube oil spray and reassemble.	
		The starter drive assembly (engagement system) is blocked or damaged.	Replace if necessary.	
	Pressure loss (system does not maintain pressure).	External oil leaks.	Inspect all system connections and piping for external leaks and tighten or replace them by new ones, if necessary.	
	Oil emerges from the hydraulic starter motor.	Incorrect hydraulic hoses connections.	Check that the inlet and outlet connections are correctly connected to the pressure and return lines of the hydraulic station.	
		OUT port strangulated due to wrong size connection.	Check that the inlet and outlet fittings and hoses connections are 3/4" BSPP (DN19) during all pressurized and return lines.	
		Perspiration between the coupling surfaces on the starter.	Clean the starter and see whether the problem persists.	
		Shaft sealing ring leaks.	Replace shaft sealing ring.	
		Porous castings.	Please contact Gali.	

PINION ENGAGED TO THE RING GEAR	Pinion engages ring gear but will not crank the engine.	Highly worn internal power transmission parts or defective (pistons' head and pistons' bore, distributor's face and block cylinder's face). Internal leakages or reduction in efficiency due to wear.	Replace internal power transmissions parts if necessary.	
		Not enough oil pressure at starter's inlet (at accumulator(s) or at hydraulic starting system). In this situation, oil pressure may be below minimum starting pressure.	Increase system oil pressure until 20.7 MPa (3000 psi).	
		Oil starting pipe restricted, high pressure filter saturated or not enough diameter of oil starting pipe.	Check and replace or modify. Check for hose damage, deformed hoses or piping or obstructions inside the hoses.	
		Starter's oil control circuit partially blocked.	Check starter's control pipes and clean out.	
		There is an appreciable counter-pressure in the return control pipe line.	Check and correct.	
		Lack of normal backlash between starter's pinion and engine's ring gear.	Check and correct.	
	Lack of starter power. The starter rotates the engine during a time but declutches before the start signal is OFF (not cranked engine).	Oil starting pipe restricted, high pressure filter saturated or not enough diameter of oil starting pipe.	Check and replace or modify.	
		Not enough oil pressure at starter's inlet (at accumulator(s) or at hydraulic starting system). In this situation, oil pressure may be below minimum starting pressure.	Check the pressure in the hydraulic system. If the pressure has exceeded the setting value of the safety valve. Check the pressure level in the system and correct the setting of the pressure limit valve. Increase system oil pressure until 20.7 MPa (3000 psi).	
		Highly worn internal power transmission parts or defective (pistons' head and pistons' bore, distributor's face and block cylinder's face). Internal leakage or excessive internal friction (low efficiency) due to wear. Internal leakages or reduction in efficiency due to wear.	Replace internal power transmissions parts if necessary.	
		Pressure filter blocked.	Replace.	
		Excessive resistance (starter motor overload).	Check for engine problems (e.g. wrong lubricant viscosity, excessive parasitic load ⁽¹¹⁾, partial seizure of engine ⁽¹²⁾...). Refer to engine manufacturer's handbook).	
		Leakages.	Replace the starter.	
	The starter is noisy (excessive noises)	Viscosity too high (temperature too low), excessive flow resistance or viscosity too low, excessive leakages (internal leakages).	Check and correct.	
		Too much wear on running surfaces.	Replace if necessary.	
		Bearings.	Replace if necessary.	
	Short starting cycle (initially the full system pressure is enough to rotate the load, but as the pressure drops the output torque of the starter drops to the point where it can no longer rotate the load).	Hydraulic fluid contaminated and dirty, leading to damage and blockage of equipment.	Change the oil-operating fluid.	
		The flow control valve is not completely opened, or the soft engagement valve is not well adjusted.	Check and correct.	
	Oil emerges from the hydraulic starter motor.	Incorrect hydraulic hoses connections.	Check that the inlet and outlet connections are correctly connected to the pressure and return lines of the hydraulic station.	
		OUT port strangulated due to wrong size connection.	Check that the inlet and outlet fittings and hoses connections are 3/4" BSPP (DN19) during all pressurized and return lines.	

□ AFTER ENGINE GOT STARTED UP	□ After starting the engine, pinion tries to reengage and hits the ring gear.	The start signal is still switched ON when the engine gets started up. Switch wrongly set or defective, limit switch not contacted.	□ Close the starter control valve (in case of manually operated valves) or check that the switch is set correctly (in case of solenoid starter control valve).	
	□ Slow cranking of engine (cranking cycle is low and extended).	The starter motor is not receiving enough pressure.	□ Check system pressure (20.7 MPa).	
		Viscosity too high (temperature too low), excessive flow resistance or viscosity too low, excessive leakages (internal leakages).	□ Check and correct. Refer to chapter “Oil-operating fluid” for oil viscosity requirements.	
		The flow control valve is not completely opened, or the soft engagement valve is not well adjusted.	□ Check and correct.	
		Oil starting pipe restricted, high pressure filter saturated or not enough diameter of oil starting pipe.	□ Check and replace or modify.	
		There is an appreciable counter-pressure in the return control pipeline.	□ Check and correct.	

Table 15. Troubleshooting checklist.

(11) Could be caused by transmission or main hydraulic circuit failure (e.g. the failure of the components driven by the engine...).

(12) Engine seizure essentially means that engine has locked or is frozen. It is normally the result of a failure of the lubrication system.



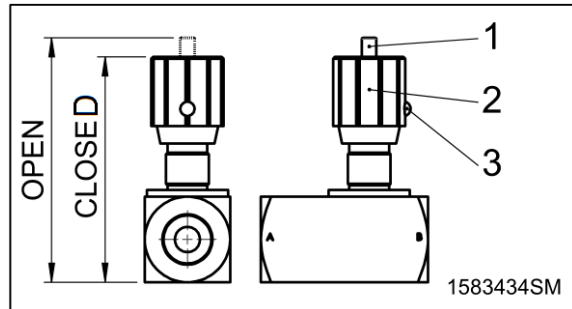
If the proposed solutions do not solve the malfunction, or in case of doubt or problems not listed in the table: please contact Gali.

14.3. Additional hydraulic station components

14.3.1. Flow control valve

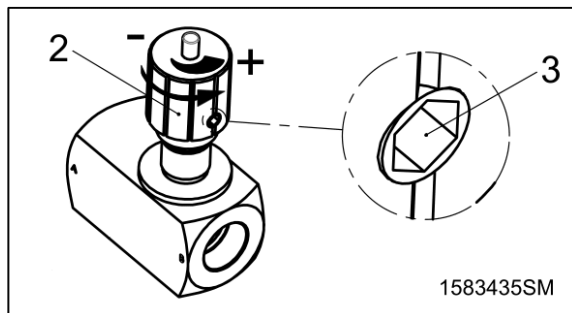
The flow control valve is used to optimize the oil consumption and to set the hydraulic starter motor's maximum speed.

1. Coded spindle.
2. Graduated turning knob.
3. Setscrew.



14.3.1.1. Flow regulation

To increase the hydraulic starter motor's speed, rotate the graduated turning knob (2) **counter-clockwise** (open the flow control valve) and to reduce it, rotate the graduated turning knob **clockwise** (close the flow control valve), see Figures 1583434SM and 1583435SM.



Once the start sequence and the hydraulic starter motor's speed desired is adjusted according to the requirements, the flow control valve must be locked by the set screw (3), see Figure 1583435SM.