TEREXLIFT

TEREXLIFT

WORKSHOP MANUAL

Code 57.4400.4200 - 4th Edition 05/2007

Handler with telescopic boom

GIROLIFT 3514 - 3518

3714 SX - 5022 - 4010 Perfora

English
Edition

INDEX

WORKSHOP MANUAL

Code 57.4400.4200 - 4th Edition 05/2007

Number: .....

Consigned to: .....

DECLARATION

I, the undersigned.....

declare that I have received the ***Workshop manual for TEREXLIFT lifts series Girolift 3514 - 3518 - 3714 SX - 5022 - 4010 Perfora.***

Copies consigned: n° ..... on paper

n° ..... on CD-Rom

The undersigned is obliged to use the manual in their workshop, without disclosing the information in the same in any way, to unauthorised workshops and third parties in general, and not to photocopy or reproduce this manual or parts of the same in any way without the prior written authorisation of TEREXLIFT to do so.

If business relations between the undersigned and TEREXLIFT should come to an end, the undersigned is obliged to return the copies received without charges for TEREXLIFT.

Yours sincerely

date .....

For acceptance

The consignee

Company stamp
and signature of the Legal representative

.....

Copy to return stamped and signed for acceptance by the
Legal representative of the company receiving the copies of the manual.

WORKSHOP MANUAL

Code 57.4400.4200 - 4th Edition 05/2007

Number: .....

Consigned to: .....

DECLARATION

I, the undersigned.....

declare that I have received the ***Workshop manual for TEREXLIFT lifts series Girolift 3514 - 3518 - 3714 SX - 5022 - 4010 Perfora.***

Copies consigned: n° ..... on paper

n° ..... on CD-Rom

The undersigned is obliged to use the manual in their workshop, without disclosing the information in the same in any way, to unauthorised workshops and third parties in general, and not to photocopy or reproduce this manual or parts of the same in any way without the prior written authorisation of TEREXLIFT to do so.

If business relations between the undersigned and TEREXLIFT should come to an end, the undersigned is obliged to return the copies received without charges for TEREXLIFT.

Yours sincerely

date .....

For acceptance

The consignee

Company stamp
and signature of the Legal representative

.....

LIST OF REVISED PAGES

Revision No.	Revision date	Revised pages	Notes	Issued by
1	12-2002		Publicated	
2	12-2003		Manual revision	
3	03-2007	Sect. C, Sect. P	Manual revision	
4	05-2007	Sect. C updated with wiring diagram 5022 stage 3	Manual revision	
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				
33				
34				
35				
36				

MANUAL CONTENTS

Sect. A GENERAL INFORMATION

Sect. B SAFETY REGULATIONS

Sect. C TECHNICAL OPERATING DATA

Sect. D CHECKS AND ADJUSTMENTS

Sect. E DISMANTLING AND ASSEMBLY

Sect. F TROUBLESHOOTING

Sect. G DANA AXLE ASSEMBLY/DISASSEMBLY

Sect. H PERKINS ENGINE MAINTENANCE

Sect. I REPAIR INSTRUCTIONS - REXROTH PUMP

Sect. L REPAIR INSTRUCTIONS - REXROTH PUMP

Sect. M REPAIR INSTRUCTIONS - REXROTH MOTOR

Sect. N DANA GEARBOX ASSEMBLY/DISASSEMBLY

Sect. O ROTATION REDUCTION GEAR ASSEMBLY/DISASSEMBLY

Sect. P MAINTENANCE INSTRUCTIONS - 3B6 LOAD LIMITER

Section A
GENERAL INFORMATION

SECTION INDEX

A.01	Introduction ..... page	2
A.02	Symbols used in the manual	3
A.03	Abbreviations	4
A.04	Units of measure	5
A.05	Workshop equipment	6
A.06	Special equipment	7
A.07	Tightening torques	11
A.08	Drill diameters for threads	13
A.09	Standard tightening torques for fitting seals	14
A.10	Locking materials	16
A.11	Hoisting instructions	17
A.12	Weight list of the main parts	18
A.13	Advice to renew flexible hoses	19
A.14	Repair interventions, welds and weld materials	20
A.15	Weld material	23
A.16	Checks with liquid penetrants	24
A.17	Checks with magnetoscope	25
A.18	Refilling and product specifications	26

A.01 INTRODUCTION

This manual has been prepared to provide information about the routine and extraordinary maintenance of the main units of the machine in a safe and proper way.

STRICTLY COMPLY WITH THE INSTRUCTIONS GIVEN IN THIS MANUAL!
READ AND UNDERSTAND THIS MANUAL BEFORE CARRYING OUT ANY INTERVENTION ON THE MACHINE.

If you are unsure about anything after the reading of this manual, address to TEREXLIFT Assistance Service: addresses, phone and fax numbers are printed in the cover and in the title-page of this manual.

Keep this manual in the workshop at all times and read it before carrying out any extraordinary maintenance job.

A.02 SYMBOLS USED IN THE MANUAL

In this manual, any important information starts with a **SPECIAL SYMBOL**.
Symbols are also used to direct the reader's attention to special technical information about the tools to use, the tightening torques, etc.
There are six safety symbols in this manual, always combined with keywords that class the situations according to their degree of dangerousness.
The symbols are always followed by a text explaining the situation taken into account, the attention to be paid to such situation, the method and the behaviour to be adopted. If necessary, it stresses prohibitions or provides instructions to prevent dangers.
Sometimes, it can be followed by illustrations.

The safety symbols are the following:

DANGER

Draws the attention to situations that involve your own as well as the others' safety and that can result in serious or lethal injury.

ELECTRICAL DANGER

Draws the attention to electrical risks that involve your own as well as the others' safety and that can result in serious injury or lethal injury.

CAUTION

Draws the attention either to situations that involve your own as well as the others' safety and that can result in minor or moderate injury; or to situations that affect the machine efficiency.

ATTENTION

Draws the attention either to situations that involve your own as well as the others' safety and that can result in minor or moderate injury; or to situations that affect the machine efficiency.

IMPORTANT

Draws the attention to important technical information or practical advice that allows for a safer and more efficient use of the machine.

PROTECT THE ENVIRONMENT

Draws the attention to important environment-related information.

Indicates the number of people needed for the job

Time expected to do the intervention (except in case of troubles)

Special tools needed for the job

Weight of the unit to be handled

Tightening torque of bolts and screws

Inspection needed

A.03 ABBREVIATIONS

Abbreviation	Definition
Tab.	Table
Pag.	Page
Sect.	Section
Dwg.	Drawing
Ref.	Reference
CLS	Concrete
Mach.	Machine
Fig.	Figure
Ph.	Photo
T.O.	Technical Office
T.A.S.	Technical Assistance Service

A.04 UNITS OF MEASURE

1 FORCE

The unit of measure of force is the Newton (N)

For the conversion:

1 N	=	0.1019 kg
1 kg	=	9.81 N

2 POWER

The unit of measure of power is the kilowatt (kW). Other units of measure used are:

CV	Horsepower
HP	Horsepower

For the conversion:

1 kW	=	1.36	CV
1 kW	=	1.34	HP
1 CV	=	0.736	kW
1 CV	=	0.986	HP
1 HP	=	0.746	kW
1 HP	=	1.014	CV

3 TORQUE

The unit of measure of power is the Newton metre (Nm).

For the conversion:

1 Nm	=	0.1019	kgm
1 kgm	=	9.81	Nm
1 kgm	***=***	***10***	***Nm***

NOTE:

For simplicity, the ***Nm*** unit is converted according to the ratio 10 Nm = 1 kgm

4 SPECIFIC CONSUMPTION

The specific consumption is expressed in g/kWh (grams per kilowatt-hour). Another unit of measure used is: g/HPh (grams per horsepower-hour)

For the conversion:

1 g/kWh	=	0.736	g/HPh
1 g/HPh	=	1.36	g/kWh

5 PRESSURE

The unit of measure of pressure is the kPa (kilopascal). Other units of measure used are:

kg/cm^2	kilogram per square centimetre
Atm	Technical atmosphere
psi	Pound per square inch

For the conversion:

1 kg/cm^2	=	1	Atm
1 kg/cm^2	=	98.1	kPa
1 kg/cm^2	=	0.981	bar
1 kg/cm^2	***=***	***1***	***bar***
1 kg/cm^2	=	14.22	psi
1 bar	=	100	kPa
1 bar	=	1.02	kg/cm^2
1 bar	=	14.51	psi
1 psi	=	6.9	kPa
1 psi	=	0.069	bar
1 psi	=	0.0703	kg/cm^2
1 kPa	=	0.145	psi
1 kPa	=	0.0102	kg/cm^2
1 kPa	=	0.01	bar

NOTE:

For simplicity, the ***bar*** unit is converted according to the ratio 1 bar = 1 kg/cm^2

6 CONVERSION OF SOME METRIC UNITS OF MEASURE INTO IMPERIAL UNITS OF MEASURE

0,1 mm	=	3,937	mils
1 mm	=	0,039	inch
1 m	=	3,281	ft
1 km	=	0,621	miles
1 cm^3	=	0,061	cu. in.
1 g	=	0,035	oz.
1 kg	=	2,205	lbs.
1 t	=	1,102	short ton
1 t	=	0,9842	long ton
1 l	=	0,2642	gal
0°C	=	32°F	

Note: in case of differences of temperature 1°C = 1.8°F

A.05 WORKSHOP EQUIPMENT

IMPORTANT

The list below indicates the minimum equipment necessary for servicing the vehicle.

Standard tools
- 6 to 41 mm box wrench set
- 6 to 41 mm socket wrench set
- 2 to 10 mm Allen wrench set
- External circlip pliers - ø 10÷60 mm
- Internal circlip pliers - ø 20÷200 mm
- Two-leg pullers - ø 25÷200 mm
- Three-leg pullers - ø 50÷400 mm
- American cutters
- Scissors
- Screwdriver set
- Hammer set
- Mallets with plastic plugs
- Combination pliers
- Wire nippers
- Nylon collar pliers
- Wire cutter
- Wire strippers
- Shears
- Cutting nippers
- Hand-saw
- Cutter
- Slotted screw driver set - ø 2.5 ÷ 10 mm
- Crosshead screw driver set - ø 2.5 ÷ 10 mm
- Adjustable self-locking pliers
- Ring nut spanner
- Wrench set for hydraulic cylinders
- Drift bolt set
- Chisel set
- Punch
- Funnel
- Funnel with flexible extension
- Calibrated measuring beaker
- Crowbar
- Fluid collecting tanks
- Pliers for internal cylinder seals

Fittings for plugging disconnected pipes
- 1/4" gas male plug
- 3/8" gas male plug
- 1/2" gas male plug
- 1" gas male plug
- 1" 1/4 gas male plug
- 1" 1/2 gas male plug
- 1/4" gas female plug
- 3/8" gas female plug
- 1/2" gas female plug
- 1" gas female plug
- 1" 1/4 gas female plug
- 1" 1/2 gas female plug

Sealing material
- Teflon tape
- Loctite sealant
- Loctite threadlocker

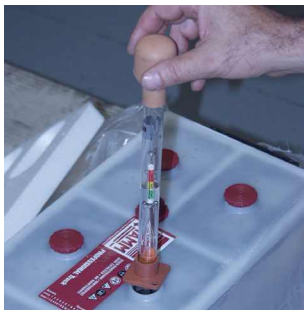
Equipment and instrumentation
- Measure instruments: metre, gauge, micrometres
- Compressor with compressed air system
- Hydraulic circuit test bench for pressures up to 400 bar
- Pressure gauges 0-60 bar / 0-240 bar / 0-600 bar
- Ammeter
- Digital tester
- Hourmeter
- Hydrometer for checking the battery charge
- Thermometer for oil temperature check
- Lamp/indicator for checking hydraulic circuit leaks
- Painting system
- Steam cleaner
- Forklift and/or pallet lift
- Stackable wooden planks and/or pallets
- Electric welding machine
- Cylinder and blowpipe
- Hoisting means with 5000 kg payload
- Textile bridles
- Two-/three-leg chains with hooks
- Pneumatic screwdriver
- Water level
- Bench drilling machine
- Portable electric drill
- Set of helical bits
- Set of screw taps and threaders
- Battery charger
- Adjustable stands

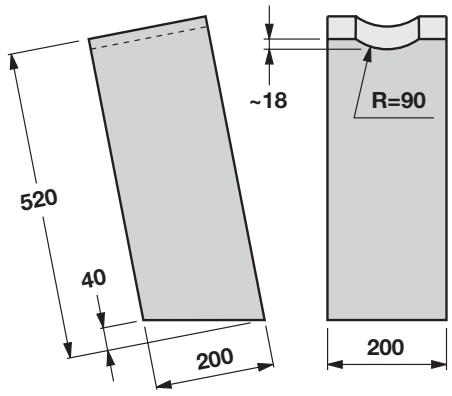
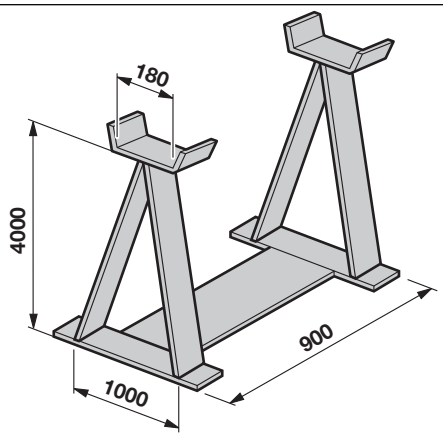
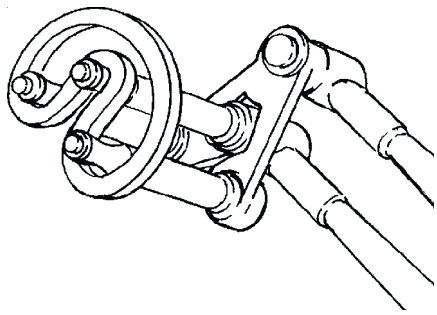
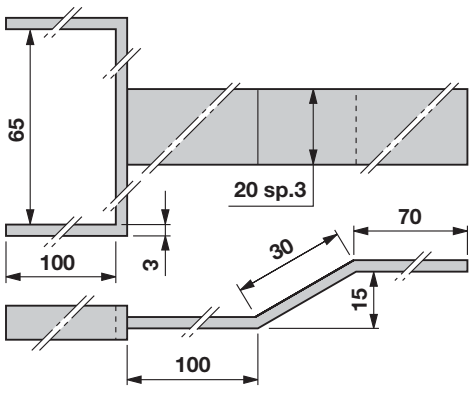
Consumable material
- Oils
- Greases
- Rags for cleaning

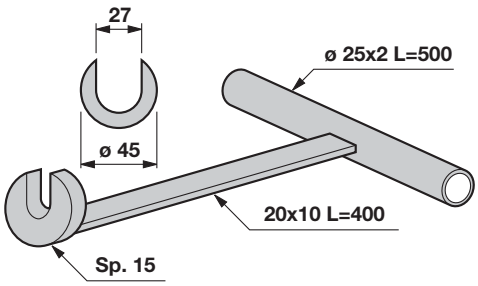
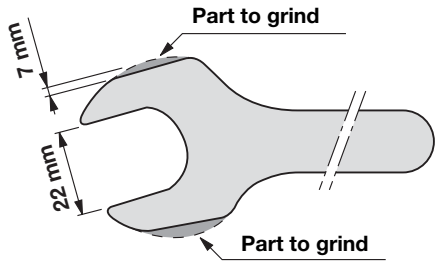
Personal protection equipment
- Goggles
- Gloves
- Ear-protectors
- Shoes
- Overall

A.06 SPECIAL EQUIPMENT

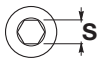
	PART#	DESCRIPTION
		Pressure gauge for checking the hydraulic oil low pressure - 0÷60 bar Pressure gauge for checking the hydraulic oil medium pressure 0÷240 bar Pressure gauge for checking the hydraulic oil high pressure 0÷600 bar
		Amperometric detector
		Electronic hourmeter
		Tester for electric values

	PART#	DESCRIPTION
		Clock / chronometer
		Hydrometer for battery charge
		Lamp/indicator for hydraulic circuit leaks
		Lamp/indicator for electric circuit
		Thermometer for checking the freezing point of the radiator coolant

	PART#	DESCRIPTION
	**Dwg.01**	Wooden block for supporting the lifting jack
	**Dwg.02**	Fixed supporting stands for boom
		Wrench for internal seals
	**Dwg.03**	Wrench for boom sliding blocks

	PART#	DESCRIPTION
		**Dwg.04** Wrench for assembling flexible hoses valve of the 3rd telescope extension c
		Tester -pressurizer for accumulators
		**Dwg.05** Wrench for Hydromatic pumps fixing enter the seat)

A.07 TIGHTENING TORQUES

Thread diameter	Pitch	Wrench measure mm				Tightening torques Material class					
						8.8		10.9		12.9	
			UNI	UNI	UNI	Normal	Galvanized	Normal	Galvanized	Normal	Galvanized
mmmm	5931/32		5933÷36	5923÷30	Nm	Nm	Nm	Nm	Nm	Nm	
4	0,7	7	3	2,5	2	3,2	2,8	4,4	3,9	5,3	4,8
5	0,8	8	4	3	2,5	6,1	5,5	8,7	7,8	10,3	9,3
6	1	10	5	4	3	10,6	9,5	14,8	13,3	17,8	16,0
8	1,25	13	6	5	4	25,1	22,5	35,4	31,8	42,5	30,2
	1	13	6	5	4	26,5	23,8	37,3	33,5	44,7	40,3
10	1,5	17	8	6	5	51,1	46,0	71,9	64,7	86,3	77,6
	1,25	17	8	6	5	53,4	48,1	75,1	67,5	90,2	81,1
12	1,75	19	10	8	6	86,5	77,8	121,4	109,2	145,9	131,3
	1,25	19	10	8	6	92,4	83,2	129,5	116,6	156,1	140,5
14	2	22	12	10	6	137,7	123,9	193,8	174,4	232,6	209,3
	1,5	22	12	10	6	145,9	131,3	206,1	185,5	246,9	222,0
16	2	24	14	10	8	209,1	188,2	293,8	264,4	353,0	317,7
	1,5	24	14	10	8	218,3	196,5	308,1	277,3	369,3	332,4
18	2,5	27	14	12	8	288,7	259,8	406,1	365,5	487,7	436,9
	1,5	27	14	12	8	314,2	282,8	442,8	398,5	530,6	477,5
20	2,5	30	17	12	10	408,1	367,3	573,4	516,1	687,7	618,9
	1,5	30	17	12	10	439,7	395,8	619,3	557,4	742,8	662,5
22	2,5	32	17	-	12	542,3	488,5	763,2	686,9	915,3	823,7
	1,5	32	17	-	12	582,6	524,3	819,3	737,4	983,6	885,3
24	3	36	19	-	12	705,1	634,5	990,8	891,7	1193,3	1074,4
	2	36	19	-	12	745,3	671,3	1051,0	945,9	1255,1	1129,5
27	3	41	19	-	-	1036,0	927,5	1448,9	1304,0	1734,6	1561,2
	2	41	19	-	-	1091,8	982,6	1530,6	1377,5	1836,7	1653,0
30	3,5	46	22	-	-	1307,9	1258,1	1989,3	1772,4	2357,1	2121,4
	2	46	22	-	-	1510,2	1359,1	2122,4	1910,2	2540,8	2286,7
33	3,5	50	24	-	-	2000,0	1800,0	2800,0	2520,0	3400,0	3060,0
	2	50	24	-	-	1610,0	1450,0	2300,0	2070,0	2690,0	2420,0
36	4	55	27	-	-	2600,0	2340,0	3700,0	3330,0	4300,0	3870,0
	3	55	27	-	-	2800,0	2520,0	3900,0	3510,0	4600,0	4140,0
39	4	60	27	-	-	3400,0	3060,0	4800,0	4320,0	5600,0	5040,0
	3	60	27	-	-	3600,0	3240,0	5100,0	4590,0	5900,0	5310,0

Thread diameter	Pitch	Standard nuts		Low nuts	
		5S Nm	8G Nm	5S Nm	8G Nm
4	0,7	5,5		3,5	
5	0,8	5,5		3,5	
6	1	9,5	13,0	6,0	8,0
8	1,25	23,0	32,0	14,0	20,0
	1	25,0	35,0	16,0	22,0
10	1,5	46,0	64,0	29,0	40,0
	1,25	49,0	68,0	31,0	42,0
12	1,75	80,0	110,0	50,0	69,0
	1,25	88,0	125,0	55,0	78,0
14	2	125,0	180,0	78,0	110,0
	1,5	140,0	195,0	88,0	120,0
16	2	195,0	275,0	120,0	170,0
	1,5	210,0	295,0	130,0	185,0
18	2,5	270,0	390,0	170,0	245,0
	1,5	305,0	425,0	190,0	265,0
20	2,5	305,0	540,0	190,0	340,0
	1,5	425,0	600,0	260,0	375,0
22	2,5	510,0	720,0	320,0	450,0
	1,5	570,0	800,0	360,0	500,0
24	3	660,0	930,0	410,0	580,0
	2	720,0	1000,0	450,0	630,0
27	3	980,0	1400,0	610,0	880,0
	2	1050,0	1500,0	660,0	940,0
30	3,5	1350,0	1850,0	850,0	1160,0
	2	1450,0	2050,0	910,0	1280,0
33	3,5	1650,0	2310,0	1050,0	1470,0
	2	1980,0	2770,0	1270,0	1780,0
36	4	2120,0	2970,0	1360,0	1900,0
	3	2550,0	3570,0	1630,0	2280,0
39	4	2730,0	3820,0	1750,0	2450,0
	3	3250,0	4550,0	2080,0	2910,0

A.08 DRILL DIAMETERS FOR THREADS

Thread x pitch	DRILL DIAMETER LIMITS max	min	DRILL BIT DIAMETER
M 4 x 0,7	3,42	3,24	3,30
x 0,5	3,60	3,46	3,50
M 5 x 0,8	4,33	4,13	4,20
x 0,5	4,60	4,46	4,50
M 6 x 1	5,15	4,92	5,00
x 0,75	5,38	5,19	5,20
M 8 x 1,25	6,91	6,65	6,80
x 1	7,15	6,92	7,00
M 10 x 1,5	8,87	8,38	8,50
x 1,25	9,38	9,19	9,20
M 12 x 1,75	10,44	10,10	10,20
x 1,5	10,68	10,38	10,50
M 14 x 2	12,21	11,83	12,00
x 1,5	12,68	12,38	12,50
M 16 x 2	14,21	13,84	14,00
x 1,5	14,68	14,38	14,50
M 18 x 2,5	15,74	15,29	15,50
x 1,5	16,68	16,38	16,50
M 20 x 2,5	17,74	17,29	17,50
x 1,5	18,68	18,38	18,50
M 22 x 2,5	19,74	19,29	19,50
x 1,5	20,68	20,38	20,50
M 24 x 3	21,25	20,75	21,00
x 2	22,21	21,83	22,00
M 27 x 3	24,25	23,75	24,00
x 2	25,21	24,83	25,00
M 30 x 3,5	26,77	26,21	26,50
x 3	27,25	26,75	27,00
M 33 x 3,5	27,77	29,21	29,50
x 2	31,21	30,83	31,00
M 36 x 4	32,27	31,65	32,00
x 3	33,25	32,75	33,00
M 39 x 4	35,27	34,67	35,00
x 3	36,25	35,75	36,00

A.09 STANDARD TIGHTENING TORQUES FOR FITTING SEALS

■ 60° CONICAL SEALS

Thread diameter		TIGHTENING TORQUES (0+10%)
inc.	mm	60° CONICAL SEALS Nm
G 1/8"		15
G 1/4"	M 10 x 1	20
9/16"-18		25
11/16"-16		40
13/16"-16		55
3/4"-16		62
1"-14		80
7/8"-14		80
1.1/16"-12		110
1.3/16"-12		115
1.5/16"-12		160
1.7/16"-12		130
1.11/16"-12		190
1.5/8"-12		225
1.7/8"-12		270
2"-12		245
2.1/4"-12		360

■ FRONT O-LOK (Parker) SEALS

Thread diameter		TIGHTENING TORQUES (0+10%)
inc.	mm	FRONT O-LOK (Parker) SEALS Nm
9/16"-18		25
11/16"-16		40
13/16"-16		55
1"-14		80
1.3/16"-12		115
1.7/16"-12		130
1.11/16"-12		190
2"-12		245

■ 37° COUNTER-SUNK CONICAL SEALS (JIC)

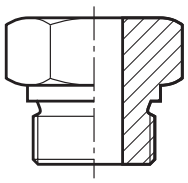
Thread diameter		TIGHTENING TORQUES (0+10%)
inc.	mm	37° CONICAL SEALS (JIC) Nm
7/16"-20	M10x1	15
1/2"-20	M12x1.5	20
9/16"-18	M14x1.5	28
	M16x1.5	62
3/4"-16	M18x1.5	62
7/8"-14	M22x1.5	80
1.1/16"-12	M27x2	110
1.3/16"-12		141
1.5/16"-12	M33x2	160
1.5/8"-12	M42x2	225
1.7/8"-12	M48x2	270
2.1/4"-12	M10x1	360

■ SEALS WITH GRIP-RING

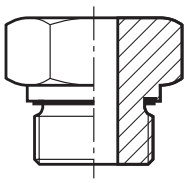
Thread diameter				TIGHTENING TORQUE (0+10%) SEALS WITH GRIP-RING
inc.	mm	Fitting Series	Pipe ø mm	Nm
G 1/8"	M10x1	LL	4	10
G 1/8"	M10x1	LL	6	10
G 1/8"	M10x1	L	6	25
G 1/4"	M12x1.5	L	8	50
G 1/4"	M14x1.5	L	10	50
G 1/8"	M20x1.5	L	12	130
G 1/8"	M20x1.5	L	15	190
G 1/8"	M20x1.5	L	18	245
G 1/8"	M20x1.5	L	22	130
G 1/8"	M20x1.5	L	28	190
G 1/8"	M20x1.5	L	35	245
G 1/8"	M20x1.5	L	42	245
G 1/4"	M12x1.5	S	6	50
G 1/4"	M14x1.5	S	8	50
G 3/8"	M16x1.5	S	10	80
G 3/8"	M18x1.5	S	12	80
G 1/2"	M22x1.5	S	16	105
G 3/4"	M27x2	S	20	220
G 1"	M33x2	S	25	370
G 1.1/4"	M42x2	S	30	500
G 1.1/2"	M48x2	S	38	600

■ FITTING ASSEMBLY

Thread diameter		TIGHTENING TORQUES (0+10%) JOINTS	
		A	B
inc.	mm	Nm	Nm
G 1/8"	M10x1	25	12
	M12x1.5	30	18
G 1/4"		40	18
	M14x1.5	50	20
	M16x1.5	60	35
	M18x1.5	80	50
G 3/8"		95	40
	M20x1.5	140	60
G 1/2"	M22x1.5	140	75
	M26x1.5	220	85
G 3/4"		250	110
	M27x2	250	100
G 1"		400	190
	M33x2	400	150
G 1.1/4"		600	240
	M42x2	600	260
G 1.1/2"		800	300
	M48x2	800	350



A



B

A Male face
Mechanical seal or copper washer

B Male face
Soft seal with O-ring

A.10 LOCKING MATERIALS

THREADLOCKERS

Product	*APPLICATION*	*Characteristics Temp. °C*	*Thread*	*Locking speed*	*Resistance*
Loctite 290	Thread locking	to 150°	M 12	Rapid	Medium
Loctite 222	Thread locking	to 150°	M 20	Moderate	Low
Loctite 243	Thread locking	to 150°	M 20	Rapid	Medium
Loctite 262	Thread locking	to 150°	M 20	Moderate	High
Loctite 270	Thread locking	to 150°	M 20	Moderate	Very high
Loctite 277	Thread locking	to 150°	M 36	Slow	High
Loctite 272	Thread locking	to 200°	M 36	Slow	High

THREAD SEALANT *For hermetic sealing. Non suitable for thermoplastic materials*

Product	*APPLICATION*	*Characteristics max °C*	*Thread max*	*type*	*Locking speed*	*Disassembly difficulty*
Loctite 511	Fitting sealant	150°	M80	Con./Cyl.	Rapid	Low
Loctite 542	Fitting sealant	150°	M36	Con./Cyl.	Rapid	Moderate
Loctite 545	Fitting sealant	150°	M36	Con./Con.	Moderate	Low
Loctite 565	Fitting sealant	150°	M80	Con./Cyl.	Instantaneous	Low
Loctite 572	Fitting sealant	150°	M80	Con./Cyl.	Moderate	Low
Loctite 577	Fitting sealant	150°	M80	Con./Cyl.	Rapid	Moderate

GASKETS *Total sealing in 24-72 hours*

Product	*APPLICATION*	*Characteristics max °C*	*Play max mm*	*Formation time*	*Resistance to fluids*
Loctite 518	Formed-in-place gasket	150°	0,5	Moderate	Excellent
Loctite 509	Formed-in-place gasket	150°	0,2	Moderate	Excellent
Loctite 573	Formed-in-place gasket	150°	0,2	Slow	Excellent
Loctite 574	Formed-in-place gasket	150°	0,5	Rapid	Excellent
Loctite 510	Formed-in-place gasket	200°	0,2	Moderate	Excellent
Loctite 5699	Formed-in-place gasket	200°	6,0	Rapid	Excellent
Loctite 5999	Formed-in-place gasket	200°	6,0	Instantaneous	Excellent
Loctite 5910	Formed-in-place gasket	200°	6,0	Rapid	Excellent
Loctite 5900	Formed-in-place gasket	200°	6,0	Instantaneous	Excellent
Loctite 5920	Formed-in-place gasket	250°	M 36	Slow	Good

A.11 HOISTING INSTRUCTIONS

DANGER

All parts weighing more than 25 kg MUST COMPULSORILY be handled with suitable hoisting means.
In the Disassembly and Assembly section there is a clear indication of the weight of the part to handle, while chapter A.12 contains a summary table with the weight of the single components.

Before removing parts of the machine, make sure that:
- all fixing bolts have been removed
- all hydraulic and electrical parts have been disconnected
- the part to be removed is not blocked.

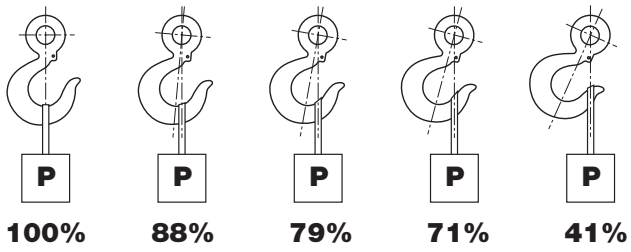
STRANDED ROPES

- Use ropes or other hoisting accessories suitable to the weight of the part to be handled. For ropes, refer to the following table:

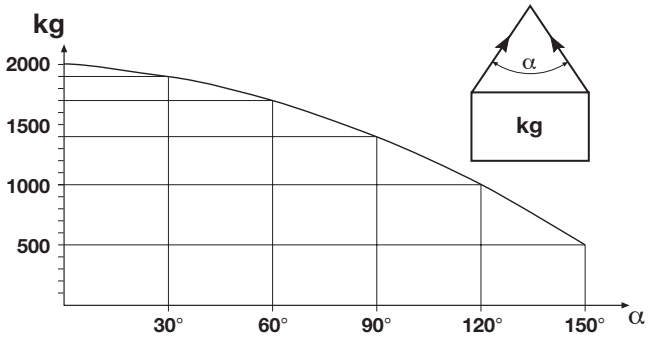
STRANDED ROPES	
Rope diameter mm	Max admissible load kg
10	1000
11.2	1400
12.5	1600
14	2200
16	2800
18	3600
20	4400
22.4	5600
30	10000
40	18000
50	28000
60	40000

The value of the admissible load has been considered as equal to 1/6 the rope breaking load.

- Attach the load to the natural seat of the hook. Attacching a load to an end can cause the load to fall down during raising and result in serious injury.



- Do not attach a heavy load to ropes forming a wide suspension angle. The total capacity of the ropes reduces proportionally to the amplitude of the angle as shown in the following chart.



A.12 WEIGHT LIST OF THE MAIN PARTS

Part	Weight kg Girolift 3514	Girolift 3518	Girolift 5022
❑ Complete cab	450	450	450
❑ Base frame without turret	1470	1470	2548
❑ Turret	1080	1080	2498
❑ 1st boom element	710	970	1420
❑ 2nd boom element	430	740	995
❑ 3rd boom element	490	480	655
❑ 4th boom element	-	500	740
❑ Complete boom	2300	3588	5600
❑ Oil-fuel tank	204	204	197
❑ Boom raising cylinder	278	283	398
❑ 2nd telescope extension cylinder	235	328	328
❑ 3rd telescope extension cylinder	146	-	-
❑ Fork balance cylinder	40	40	36
❑ Fork movement cylinderc	80	100	108
❑ Outrigger up/down cylinder	51,5	51,5	46
❑ Outrigger extension cylinder	-	-	32
❑ Front axle	700	700	694
❑ Rear axle	700	700	412
❑ Drive pump	63	63	80
❑ Service pump	35	35	45
❑ Perkins engine	550	550	600
❑ Distributor	30	30	30
❑ Gearbox	73	73	90
❑ Hydraulic joint	100	100	100
❑ Cooler	35	35	35
❑ Complete wheel (n° 1)	120	120	140
❑ Wheel rim (n° 1)	40	40	50
❑ Stabilising foot (n° 1)	50	50	18
❑ Turret rotation reduction gear	69	69	72
❑ Turret slewring	132	132	132

DANGER

All parts weighing more than 25 kg MUST COMPULSORILY be handled with suitable hoisting means.

A.13 ADVICE TO RENEW FLEXIBLE HOSES

PROTECT THE ENVIRONMENT

Before disconnecting the hydraulic piping, place containers of suitable size underneath to prevent oil spillage.

IMPORTANT

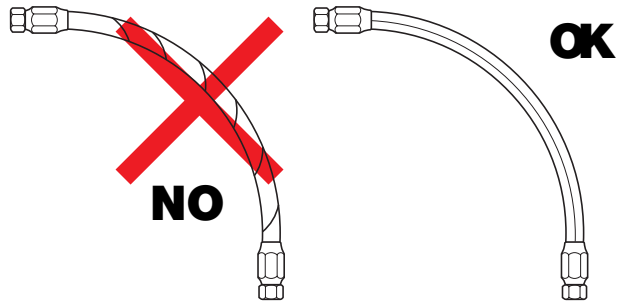
Plug all disconnected parts to prevent dust or impurities from entering the circuit. They can cause serious damage.

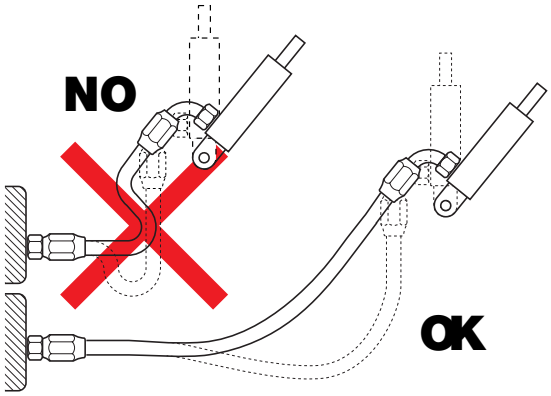
DANGER

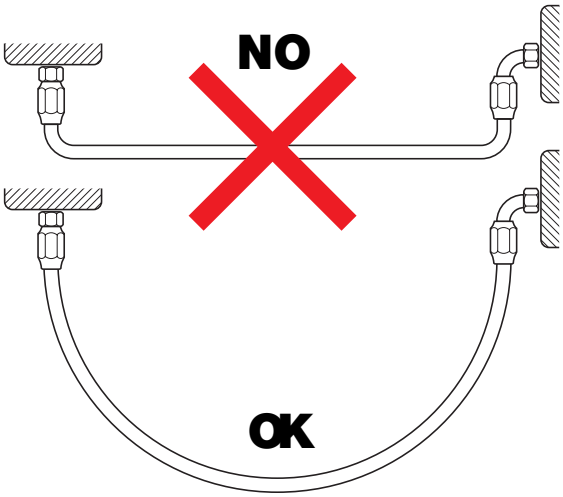
Before disconnecting the hydraulic piping, ensure there is no pressure in the line. In case, release the pressure by operating the control levers with the engine stopped.
In any case, disconnect the hydraulic piping with extreme caution and always wear suitable personal protection equipment -e.g. goggles, gloves, facial screen, etc.
Wrap up the end of the pipe to be disconnected with some rags and slowly loosen the pipe connector so that air comes out as slow as possible.

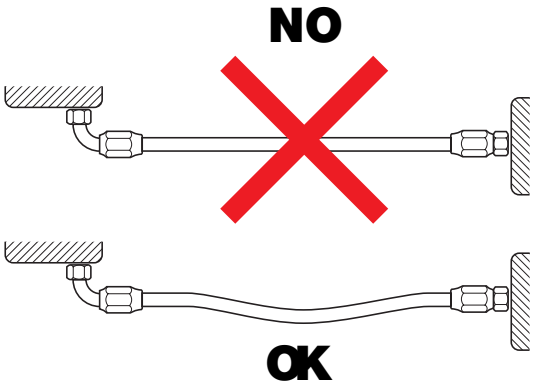
1. Before disconnecting or refitting a flexible hose, carefully clean the area all around.
2. Blow some compressed air to remove any impurity.
3. For an easier renewal of the hoses, whose run is not clearly visible, proceed as follows:
   - disconnect the hose to be replaced from both sides
   - tie a cord to one end of the hose
   - remove the hose pulling the cord until it comes out completely
   - untie the cord and tie it to the new hose
   - pull the cord from the other side to refit the hose until reaching the connecting point to the line.

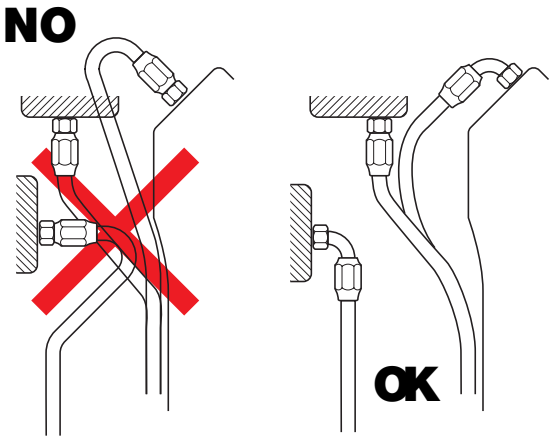
Useful advice for mounting flexible hoses:











A.14 REPAIR INTERVENTIONS WELDS AND WELD MATERIALS

ATTENTION

Before any weld on the machine, disconnect and isolate the battery cables and all the connections to positive and negative poles reaching the alternator. The ground cable of the machine must be directly connected to a metal part to be welded.

IMPORTANT

According to following specifications, repairable cracks are those with a maximum development of 100 mm which have not altered the normal deformability of the structure (crack edges open).

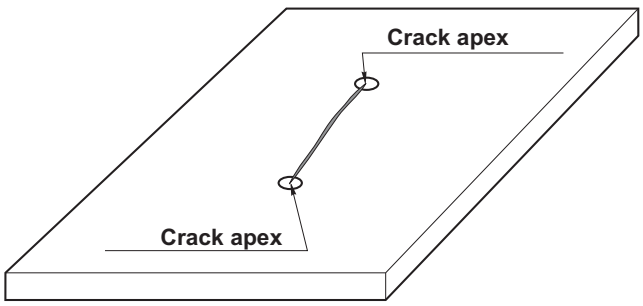
OPERATION PROCEDURE

1 Clean the area where the crack has been found thoroughly.

Remove paint, concrete or grease residues from the area.

To this end use traditional thinners.

2 Using a liquid penetrant (or another non-destructive method) inspect the areas to find the apices of the crack.



ATTENTION

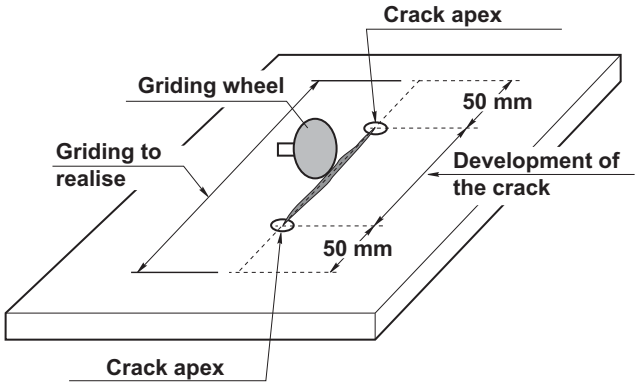
Warning: the visible apex of the crack is not the real apex. This is usually under the material skin and needs non-destructive methods to be found (liquid penetrants, magnetoscopy or ultrasounds).

IMPORTANT

It is also necessary that the operator charged of the checks is authorised to use the inspection instrumentation in accordance to UNI EN 473 standard or equivalent.

3 After inspection and once found the position of the two apices of the crack, grind the material for the entire development of the crack - see **2**.

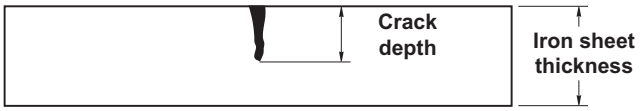
Grind 50 mm more than the development of the crack on both sides.



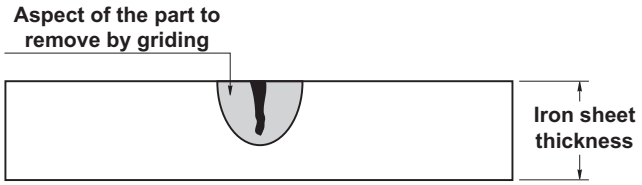
4 Check the ground area with a liquid penetrant - see **3**.

The result of this check can provide useful information on the depth of the crack:

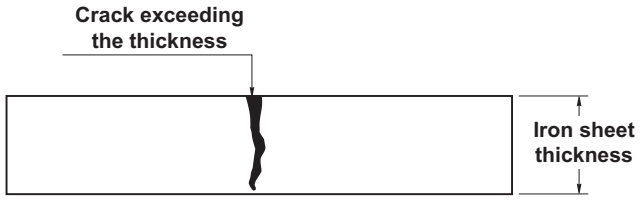
Type A *The crack does not exceed to the thickness of the iron sheet*



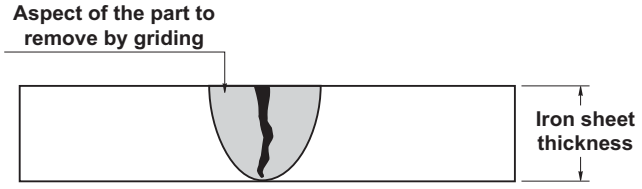
In this case, further grind the crack and check again with a liquid penetrant until the crack has been removed.



Type B *The crack exceeds the thickness of the iron sheet*



In this case grind in depth without removing too much material as this would complicate subsequent welding.



5 Grind as explained below:

a- Use electrodes compatible with the structure material.

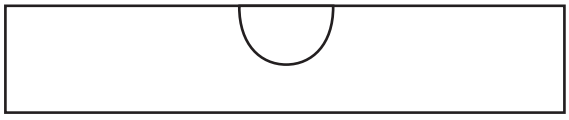
b- Create a seam with low voltage (V) and current (A) parameters so as not to alter the structure in the vicinity of the weld. The materials used for the structural elements of the machine have a fine grain structure which, if subject to high thermal loads, can result in a coarsening and, consequently, in a decay of the mechanical characteristics of the base material.

IMPORTANT

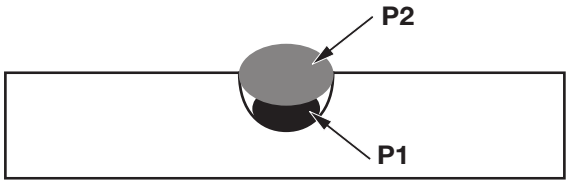
It is better to foresee an multi-pass welding with moderate parameters rather than a weld with less passes and high parameters.

Preparation after grinding

Crack not exceeding the thickness



WELDING PROCEDURE

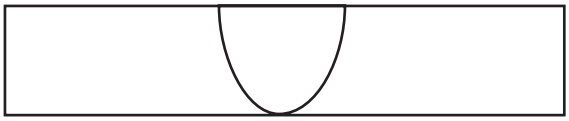


P1: Bottom pass

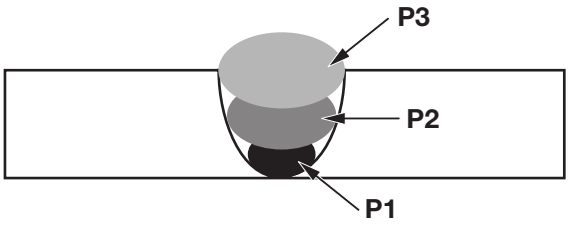
P2: Filling pass

PRE-HEAT AT 120°
BEFORE PASS P1

Preparation after grinding
Crack exceeding the thickness



WELDING PROCEDURE



P1: Pass at the root
P2: Intermediate pass
P3: Filling pass

PRE-HEAT AT 120°
BEFORE PASS P1

IMPORTANT

For reduced thickness values (3-5 mm) the operation can be carried out in two passes eliminated pass P2.

c- The welder must be qualified and use specific materials for the structural elements in accordance with UNI EN 287 or equivalent.

6 After cooling of the welded parts, do a final check with a liquid penetrant to be sure no surface cuts or cracks have been produced during welding.

Do a magnetoscopic or ultrasound inspection to be sure there are no internal defects in the material.

If, during this last check, defects in the seams or other defects such as burns or cuts are found:

a- Grind away the defect.
b- Check again to be sure the defect has been eliminated with a non-destructive test.
c- Re-weld the defective section as indicated in point **5**.

A.15 WELD MATERIAL

For material S690 (CNR 10029-87)

Wire ø 1.2
Class ER100S-G AWS A5.28-79
Protection gas
80% Argon mixture
20% CO_2

IMPORTANT

To weld couplings S690-S690 or S690 with other material, pre-heat:

- **Recommended**: for thickness up to 7.5 mm at 100-120°C
- **Compulsory**: for thickness from 8 mm and more at 150°C

For material S490 (CNR 10029-87)

Wire ø 1.2
Class DIN 8559-84 SG3
Protection gas
80% Argon mixture
20% CO_2

A.16 CHECKS WITH LIQUID PENETRANTS

Procedure to check welds or material cracks:

1. Thoroughly clean the part to be checked making sure there are no fluids or anything else which can prevent a good penetration of the fluid; to this end, use sand paper, grinding wheel, dry rags or paper.
2. Use a red liquid and let it dry for about 5 ÷ 8 minutes
3. Thoroughly clean with a rag and some water or a sponge, then dry with a clean and dry rag
4. Spray a white liquid (detector) onto the part to be checked and let dry for about 5 ÷ 6 minutes. If after this treatment the red colour comes to surface decidedly there is a crack. Pay extreme attention as, in presence of a deep but close crack, the red colour could hardly come to surface.
5. Pay attention to the area thermally altered by welding since cracks usually appear in this area and not in the middle of the weld.
6. This check can detect any surface crack.

A.17 CHECKS WITH MAGNETOSCOPE

Scope:

The checks with magnescope allow to find surface and sub-surface cracks down to 2 mm to guarantee the integrity of the structure

Equipment:

Magnetoscope

Detection method:

Black magnetic powder diluted in water. Spray the mixture onto the part to be checked during the magnetisation of the examined part.

Preparation of the surface:

The surface must be as regular as possible - e.g. absence of weld drops. The check can also be done on painted surfaces provided they are uniform.

Magnetisation mode:

The magnetisation of the area to be examined shall be done so that the lines of the magnetic field are perpendicular to the profile (course) of the defect.

Reading of the magnetoscopic image:

After magnetising the part and applied the detecting liquid, examine the area to find any indications. Indications of presence of a crack can be found on the edges and in the crack fissure with accumulation of magnetic particles.

IMPORTANT

Note all the defects with their position, length and type of indication on the drawing of the examined part to evaluate the damage.

A.18 REFILLING AND PRODUCT SPECIFICATIONS

Part	*Product*	*Girolift 3514 Girolift 3518 Capacity (litres)*	*Girolift 5022 Capacity (litres)*
Diesel engine	Shell Myrina D SAE 15W-40	10.5	13.5
Engine cooling system	Caltex Polar Antifreeze (ASTM D3306-74)	30	35
Fuel tank	Diesel fuel	125	125
Oil tank	Shell Tellus T46 DENISON HF-1	200	200
Gearbox	Shell Super Gear 90 LS SAE 90W	2.7	2.2
Differential gears	Shell Super Gear 90 LS SAE 90W	8.5	7 + 7
Wheel reduction gears	Shell Super Gear 90 LS SAE 90W	0.6 + 0.6	1.5 + 1.5
Turret rotation reduction gear	Shell Super Gear 90 LS SAE 90W	2.8	2.8

Section B
SAFETY INFORMATION

SECTION INDEX

B.01 General considerations ..... page 2
B.02 Requisites of the servicemen 2
B.02-1 Personal protective equipment 3
B.03 General safety precautions 3
B.03-1 Working area 3
B.03-2 Precautions during work 3

B.01 GENERAL CONSIDERATIONS

Most accidents occurring while working, servicing or maintaining operation machines, are caused by not complying with the basic safety precautions. Therefore, it is necessary to pay steady attention to the potential hazards and the effects that may come of operations carried out on the machine.

IMPORTANT

***If you recognise hazardous situations, you can prevent accidents*!**

For instance, this handbook makes use of special ***safety symbols*** to highlight potentially hazardous situations.

ATTENTION

The instructions given in this handbook are the ones established by TEREXLIFT. They do not exclude other safe and most convenient ways for the machine commissioning, operation and maintenance that take into account the available spaces and means.

If you decide to follow instructions other than those given in this manual, you must:

- be sure that the operations you are going to carry out are not explicitly forbidden;
- be sure that the methods are safe and in compliance with the indications given in this section;
- be sure that the methods cannot damage the machine directly or indirectly or make it unsafe;
- contact TEREXLIFT Assistance Service for any suggestion and the necessary written permission.

IMPORTANT

Do not hesitate to pose questions if you are in doubt! Contact TEREXLIFT: the assistance service is at your disposal. Addresses, phone and fax numbers are given in the cover and in the title-page of this manual.

B.02 REQUISITES OF THE SERVICEMEN

The operators who use the machine regularly or occasionally (e.g. for maintenance or transport) shall have the following requisites:

health:
before and during any operation, operators shall never take alcoholic beverages, medicines or other substances that may alter their psycho-physical conditions and, consequently, their working abilities.

physical:
good eyesight, acute hearing, good co-ordination and ability to carry out all required operations in a safe way, according to the instructions of this manual.

mental:
ability to understand and apply the rules, regulations and safety precautions. They shall be careful and sensible for their own as well as for the others' safety and shall desire to carry out the work correctly and in a responsible way.

emotional:
they shall keep calm and always be able to evaluate their own physical and mental conditions.

training:
they shall read and familiarise with this handbook, its enclosed graphs and diagrams, the identification and hazard warning plates. They shall be skilled and trained about the machine use.

IMPORTANT

It is recommended to take part in at least one technical training course organised by TEREXLIFT Assistance Office.

IMPORTANT

Ordinary and extraordinary maintenance of the machineare quite complex from a technical point of view and should be performed by an authoirsed service centre.

B.02-1 PERSONAL PROTECTIVE EQUIPMENT

During work, but especially when maintaining or repairing the machine, operators must wear suitable protective clothing and equipment:

- Overalls or any other comfortable garments. Operators should wear neither clothes with large sleeves nor objects that can get stuck in moving parts of the machine
- Protective helmet when working under or in the vicinity of suspended load
- Protective gloves
- Working shoes
- Breathing set (or dust mask)
- Ear-protectors or equivalent equipment
- Goggles or facial screen.

IMPORTANT

Use only type-approved protective equipment in good condition.

B.03 SAFETY PRECAUTIONS

DANGER

Read and understand the following safety instructions before servicing the machine.
The following list contains safety rules which must absolutely be obeyed to prevent accidents and injuries.

B.03-1 WORKING AREA

- Make sure the area all around the machine is safe. Always be aware of potential risks.
- During work, keep the working area in order. Never leave objects scattered: they could hinder the machine movements and represent a danger for personnel.

B.03-2 PRECAUTIONS DURING WORK

- Do not walk or stop under raised loads or machine parts supported by hydraulic cylinders or ropes only.
- Keep the machine handholds and access steps always clean from oil, grease or dirt to prevent falls or slips.
- When entering/leaving the cab or other raised parts, always face the machine; never turn the back.
- When carrying out operations at hazardous heights (over **3 meters** from the ground), always use type-approved safety belts or fall preventing devices.
- Do not enter/leave the machine when it is running.
- Before servicing the engine, let its parts cool down.
- Do not leave the driving place when the machine is running.
- Neither stop nor carry out interventions under or between the machine wheels when engine is running. When maintenance in this area is needed, stop the engine, engage the parking brake and chock the wheels to prevent accidental movements.
- Do not carry out maintenance or repair works without a sufficient lighting.
- When using the machine lights, the beam should be oriented in order not to blind the personnel at work.

- Before applying voltage to electric cables or components, ensure they are properly connected and efficient.
- Do not carry out interventions on electric components with voltage over 48V.
- Do not connect wet plugs or sockets.
- Signs and stickers shall never be removed, hidden or become unreadable.
- Except for maintenance purposes, do not remove safety devices, covers, guards,. Should their removal be necessary, stop the engine, remove them with the greatest care and always remember to refit them before starting the engine and using the machine again.
- Aleays stop the engine and disconnect the batteries before maintenance or service.
- Do not lubricate, clean or adjust moving parts.
- Do not carry out operations manually when specific tools are provided for this purpose.
- Absolutely avoid to use tools in bad conditions or in an improper way.
- Before carrying out operations on hydraulic lines under pressure (hydraulic oil, compressed air) and/or before disconnecting hydraulic components, ensure the relevant line has been previously depressurised and does not contain any hot fluid.

Any intervention on the hydraulic or pneumatic circuit must be carried out by authorised personnel.
Before any operation on lines under pressure, release any residual pressure from the circuit.
Do not use your fingers to check for pressure leaks. Fine jets of air, oil or fuel can injure you.

- Neither smoke nor use open flames if there is a risk of fire or close to fuel, oil or batteries.
- Do not leave fuel cans or bottles in unsuitable places.
- Do not empty catalytic mufflers or other vessels containing burning materials without taking the necessary precautions.
- Carefully handle all flammable or dangerous substances.
- After any maintenance or repair work, make sure that no tool, cloth or other object has been left within compartments with moving parts or in which suction and cooling air circulates.
- Never give orders to several people at a ime. Instructions and signs must be given by one person only.
- Always pay the due attention to the instructions given by the foreman.
- Never distract the operator during working phases or crucial manoeuvres.
- Do not call an operator suddenly, if unnecessary.
- Do not frighten an operator or throw objects by no means.
- After work, never leave the machine under potentially dangerous conditions.

Treatment and disposal of used oils is subject to federal, national and local laws and regulations. Collect and deliver these wastes to authorised centres.

- Use the assistance of a second person to handle loads weighing 30 to 50 kg.
- For loads over 50 kg, the use of special hoisting equipment in good condition and equipped as per enforced regulations is mandatory.

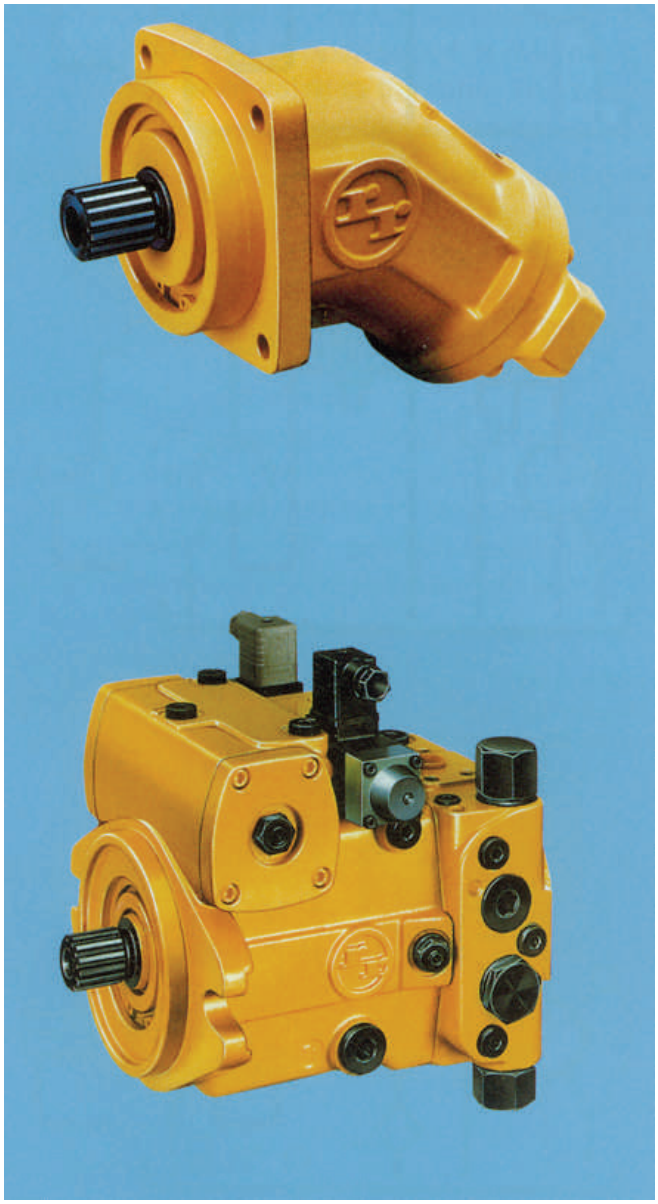
Section C
TECHNICAL OPERATING DATA

SECTION INDEX

C.01	Principles of hydraulics ..... page	3
C.02	Hydraulic symbols	31
C.03	Hydraulic schemes	33
C.03.01	Hydraulic scheme - machines	33
C.03.02	Hydraulic scheme - aerial man-platform	47
C.03.03	Hydraulic scheme - winch	48
C.03.04	Hydraulic scheme - robot	49
C.04	Electrical symbols	53
C.05	Wiring diagrams	55
C.05.01	Wiring diagrams 3514-3518 (up to serial no. 9261) 5022 (up to serial no. 9410)	55
C.05.02	Wiring diagrams 3514-3518 (from serial no. 9262 to serial no. 10188) 5022 (from serial no. 9411 to serial no. 10078)	78
C.05.03	Wiring diagrams 3514-3518 (Girolift 3514: from serial no. 10189 to serial no. 14740 - Girolift 3518: from serial no. 10189 to serial no. 14749)	103
C.05.04	Wiring diagrams 5022 (from serial no. 10079 to serial no. 16757)	139
C.05.05	Wiring diagrams 5022 (from serial no. 16758)	177
C.05.06	Wiring diagrams 3514-3518 (from serial no. 9262 to serial no. 10188) 5022 (from serial no. 9411 to serial no. 10078) - RADIO version	192
C.05.07	Wiring diagrams 3514-3518 (Girolift 3514: from serial no. 14741 - Girolift 3518: from serial no. 14750)	212
C.05.08	Wiring diagrams 3714 SX	227
C.05.09	Wiring diagrams 4010 Perfora	242
C.05.10	Wiring diagrams - AERIAL PLATFORM	258
C.05.11	Wiring diagrams - 3B6 load limiter	261
C.05.12	Wiring diagram - Platform/boom connection	265
C.05.13	Wiring diagram - Mixing buckets	266
C.05.14	Wiring diagram - Extension jibs and winches	267
C.05.15	Wiring diagram - Robot	268
C.06	Cylinder size	274
C.07	Pumps and motors	294
C.08	Hydraulic distributor	301
C.09	Valves	302

Intentionally blank page

Axial Piston Units



1 Basic Principles

1.1 Types of Hydraulic Circuit

1.1.1 Open circuit
1.1.2 Closed Circuit

2 Principles of Function

2.1 Bent-Axis

2.1.1 Bent-Axis Principle
2.1.2 Description of Function
2.1.3 Principles of Calculation
2.1.4 Rotary Group Forces
2.1.5 40°-Tapered Piston, Bent-Axis Rotary Group
2.1.6 Examples of Types
2.1.7 Symbols

2.2 Swashplate

2.2.1 Swashplate Principle
2.2.2 Description of Function
2.2.3 Principles of Calculation
2.2.4 Rotary Group Forces
2.2.5 Swashplate Rotary Group
2.2.6 Examples of Types
2.2.7 Symbols

3 Components

A Selection of Typical Models from the individual Product Groups

3.1 to 3.10 Standard Models of Bent-Axis and Swashplate Design

3.11 Summary of Control Devices

1 Basic Principles

1.1 Types of Hydraulic Circuit

For the hydraulic engineer, there are three basic types of circuit to consider:

open circuit
closed circuit
semi-closed circuit

In the following we look at open and closed circuits in some detai ls. The semi-closed circuit is a mixture of these two types of circuit and is used in applications where volume compensation via prefill valves is necessary (e.g. when using a single rod cylinder).

1.1.1 Open Circuit

Open circuit normally means the case where the pump suction line leads below a fluid level whose surface is **open** to atmospheric pressure. Maintenance of a pressure balance between the air in the hydraulic tank and the air in the atmosphere guarantees good pump suction characteristics. There must be no resistance in the inlet line which might cause pressure to drop below the so-called suction head/suction limit.

Axial piston units are self-priming; in certain special cases, however, a low pressure is applied to the suction side.

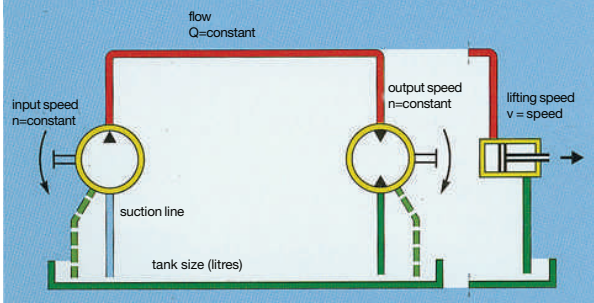
In **open** circuit hydraulic fluid is fed to the user via directional control valves and returned to the tank in the seme way.

Typical features of the **open** circuit are:

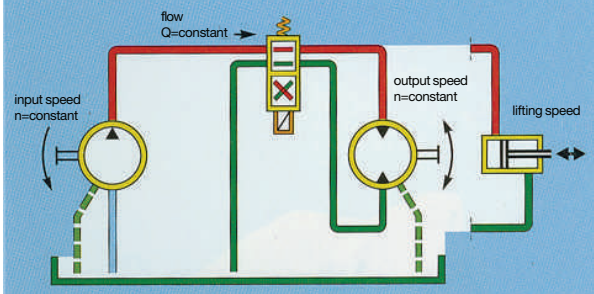
- suction lines - short length, large diameter
- directional control valves - flow-related sizes
- filter / cooler - flow-related sizes
- tank size - a multiple of the max. pump flow in litres
- pump arrangement - adjacent to or below the tank
- drive speeds - limited by the suction head
- load maintained in return by valves

The open circuit is standard in many industrial and mobile applications - from machine tools, through press drives to winches and mobile transmissions.

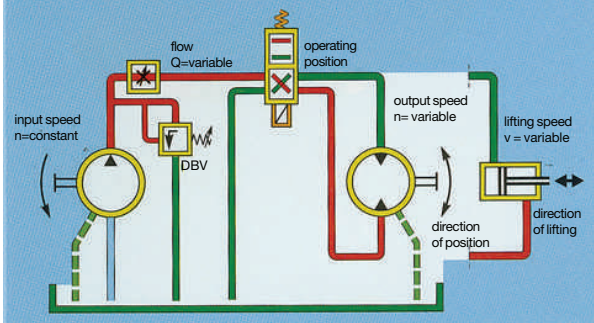
Open Circuit
The way to the complete hydraulic system:
(explanation of symbols, see page 3)



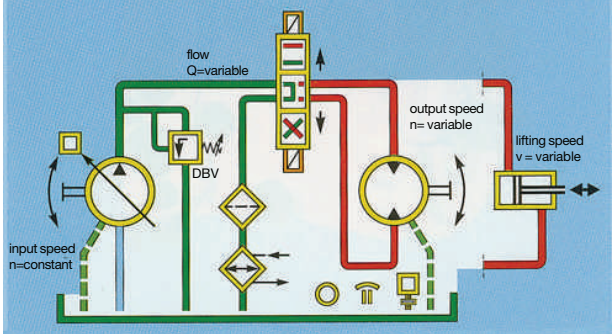
Basic system with hydraulic pump and hydraulic motor (or cylinder). **Single** direction of input, output and lift.



The directional control valve allows **reversal** of the direction of rotation or of movement at the user.



Variable output speed is achieved by installation of a flow controller for variable flow. the pressure relief valve (DBV) protects the system from overload.



Here, the fixed pump and flow controller have been replaced by a variable pump. Further valve functions have been added, e.g. free-whelling of the user. Filter, cooler and other accessories are also fitted.

1.1.2 Closed Circuit

A hydraulic system is described as **closed** when the hydraulic fluid is returned from the user direct to the pump.

There is a high pressure and a low pressure side, depending on the direction of load (take-off torque at the user).

The high pressure side is protected by pressure relief valves which unload to the low pressure side. The hydraulic fluid remains in the circuit.

Only the continuous leakage from pump and motor (dependent on operating data) must be replaced.

This fluid is normally replenished by an auxiliary pump flanged direct onto the main pump which delivers a continuous, adequate supply of fluid (boost fluid) from a small tank via a check valve into the low pressure side of the **closed** circuit. Any surplus flow of the boost pump, which operates in open circuit, is returned via a boost-pressure relief valve to the tank. The boosting of the low pressu re side en hances the pu m p-operati ng characteristics.

Typical features of the **closed** circuit for axial piston units are:

- directional control valves - small sizes for pilot operation
- filter/cooler - small sizes
- tank size - small, dimensioned to suit boost pump flow and volume of system
- speed - high limiting values through boost
- arrangement/mounting - position-flexible/optional
- drive - completely reversible through centre position
- load maintained - via the drive motor
- feedback of braking power

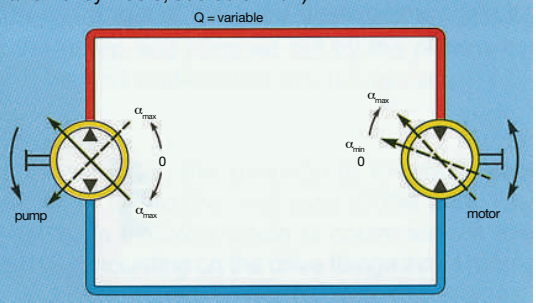
Explanation of Symbols / Colour Code for Open and Closed Circuits

red		(high) pressure line
blue		(low, boost) pressure line
blue		suction line
green		(low, boost) pressure line
blue		suction line
yellow		hydraulic components (pump, motor cylinder, valves accessories)
orange		control element (solenoids, springs)

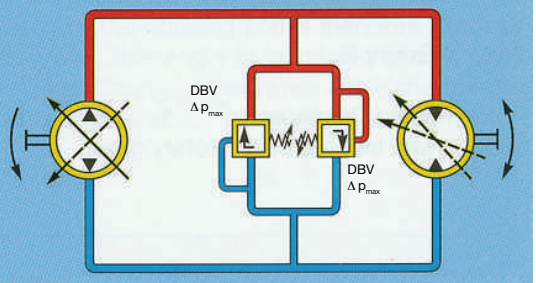
Closed Circuit

A step-by-step guide

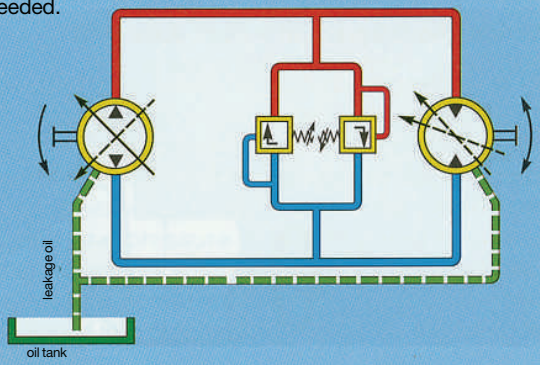
(explanation of symbols, see below left)



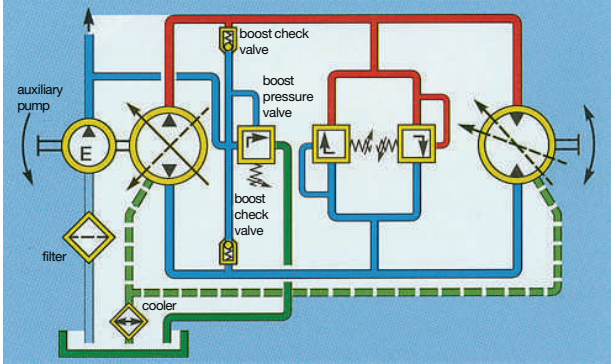
Basic system with variable pump and variable motor. Single pump input drive direction. Motor power take-off in both directions. The pump can be swivelled smoothly over centre, i.e. the direction of flow is reversible.



pressure relief valves , one each for the high and low pressure sides, prevent the maximum permissible pressure from being exceeded.



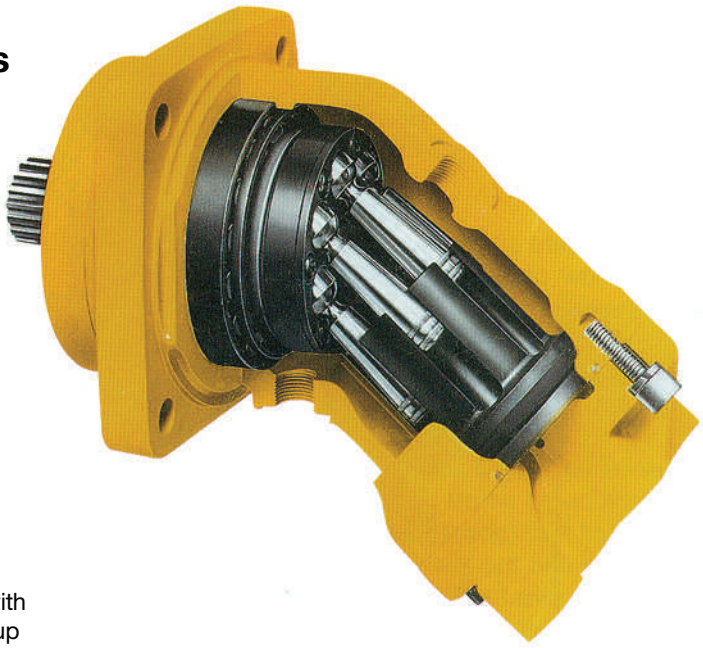
The leakage from pump and motor is led back to a small tank and must be replenished!



An auxiliary pump for replenishment of leakage oil and control of the pump. Boost check valve RV. Boost pressure relief valve DBV. Fitted filter, cooler and accessories.

2 Principles of Function

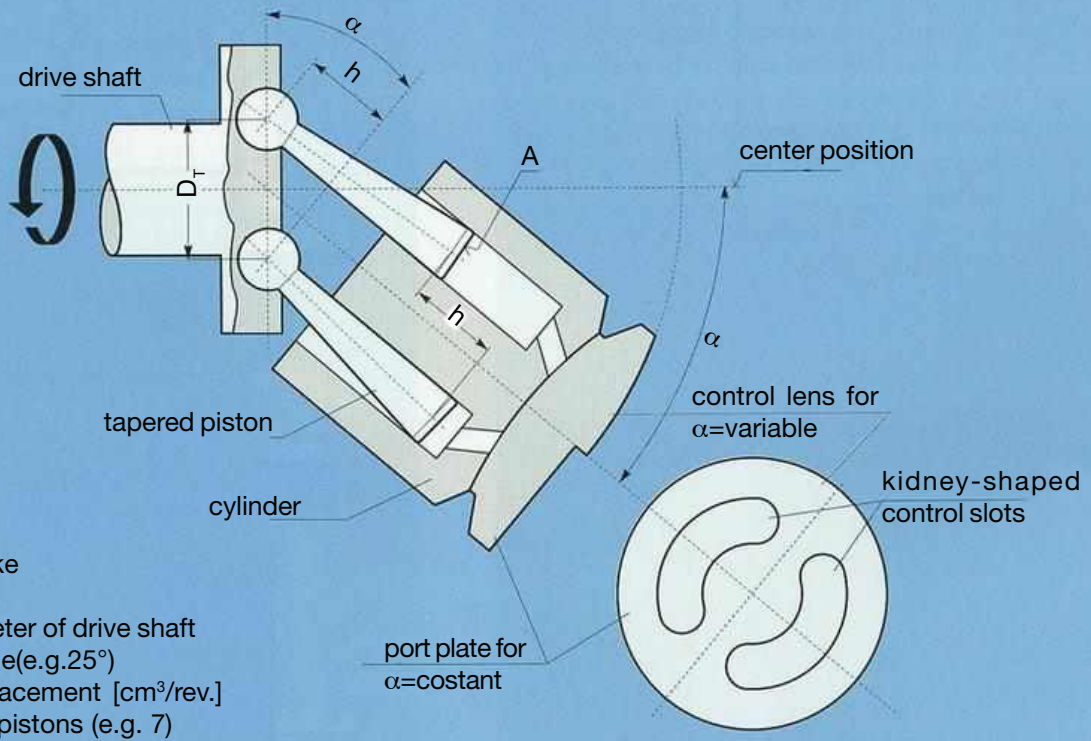
2.1 Bent Axis



Example:

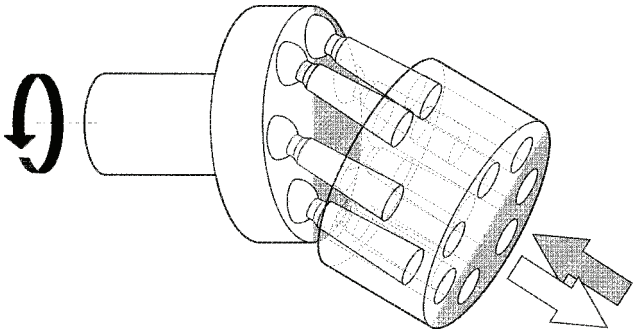
Fixed Displacement Unit with tapered piston rotary group

Schematic Diagram of a Bent-Axis Units
with fixed or variable swivel angle α



h = piston stroke
A = piston area
D_T = pitch diameter of drive shaft
α = swivel angle(e.g.25°)
V_g = geom.displacement [cm^3/rev.]
x = number of pistons (e.g. 7)
h = D_T • sin α
V_g = x•A•h
V_g = x•A•D_T•sin α

2.1.1 Bent-Axis Principle



The bent-axis rotary group is a displacement unit whose displacement pistone are arranged at an angle to the drive shaft.

Pump Function:
Through the flexible piston/piston rod arrangement, rotation of the drive shaft also causes the cylinder to rotate without the need for a Cardan coupling. The pistone execute a stroke within the cylinder bores dependent on the angle of inclination of the bent axis. The hydraulic medium is fed to the low pressure (inlet) side of the pump and pumped out by the pistone on the high pressure (outlet) side into the system.

Motor Function:

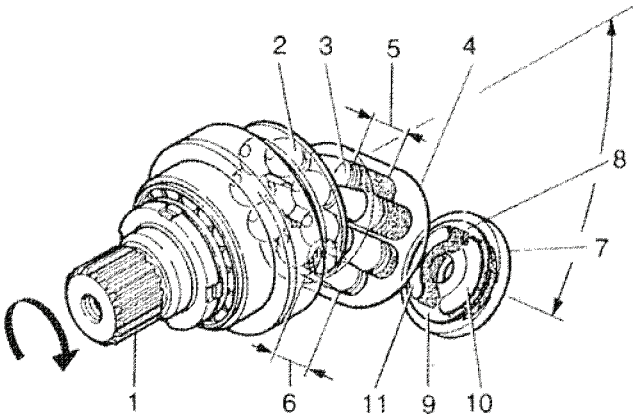
In motor operation, the process is reversed and pressure oil is fed to the inlet side of the unit. The pistone perform a stroke which is converted via the flexible piston mounting on the drive flange into a rotary movement. The cylinder rotates with the pistone, generating an output torque on the drive shaft. Oil exiting on the outlet side flows back into the system.

Swivel Angle:

The ti lt/swivel ang le of the fixed d isplacement u n it is determined by the housing and is therefore fixed. On a variable unit, this angle is infinitely variable within specific limite. Changing the swivel angle changes the piston stroke, thus allowing variable displacement.

2.1.2 Description of Function

Example: Fixed Displacement Unit



1 = drive shaft
2 = piston
3 = piston area
4 = cylinder
5 = pressure stroke
6 = suction stroke
7 = port piate
8 = upperdead pointOT
9 = lower dead point UT
10 =control slot, pressure side (for direction of rotation shown)
11 = control slot, suction side (for direction of rotation shown)

Description

The axial piston units of bent-axis design with fixed or variable displacement can operate as hydraulic pumps or hydraulic motore.

When used as a pump, the flow is proportional to the input speed and the swivel angle. If the unit is used as a motor, the output speed is proportional to the flow through the unit. The input (pump) or output (motor) torque increases with the pressure drop between the high and low pressure sides. In pump operation, mechanical energy is converted into hydrostatic power, while in motor operation, inversely, hydrostatic power is converted into mechanical energy. By adjusting the swivel angle of a variable pump or motor it is possible to vary the displacement and thus the flow.

Function
... as a pump in open circuit:

On rotation of the drive shaft, the cylinder is caused to rotate by seven pistone flexibly mounted in a circular arrangement on the drive shaft. The cylinder slides on the spherical port piate which has two kidney-shaped control slots. As the cylinder rotates, each of the seven pistone moves from the upper dead point OT to the lower dead point UT and back, thereby executing a stroke dependent on the swivel angle. The piston movement from the lower to the upper dead point in the cylinder bore produces the suction stroke, whereby a quantity of oil relative to the piston area and piston stroke is sucked in through the control slot on the suction side.

On further rotation of the drive shaft, as the pistone move from the upper to the lower dead point, oil is pushed out through the other control slot (pressure side). The pistone are held against the drive shaft by hydraulic pressure.

... as a motor:

The motor function is the reverse of the pump function. In this case, hydraulic oil is fed via the connection piate through a control slot to the cylinder bores. 3 or 4 cylinder bores are located over the pressure side control slot, 4 or 3 over the return-line side, with one bore possibly being covered by part of the port piate directly at the dead point. The force generated as a product of pressure and piston area acts on the drive shaft to produce the output torque.

Control Function: (with control devices fitted)
The swivel angle of the bent axis can be changed, for example, mechanically via an adjusting spinale or hydraulically via an adjusting piston. The hydraulic section of the rotary group cylinder complete with control lens (port piate) is swivelled out and, depending on the type of circuit and function, is held in the zero or starting position by either mechanical or hydraulic means. Increasing the swivel angle increases displacement and torque; decreasing the angle gives a corresponding reduction in these values. If the swivel angle is zero, the displacement is also zero.

Mechanical or hydraulic control devices are normally fitted, which can themselves be controlled and regulated by mechanical, hydraulic or electrical means. Well-known types of control are: handwheel contro!, electro-proportional contro!, constant horsepower contro!.

General
Because of the bent-axis design, in both pump and motor operation, the torque is generated direct at the drive shaft. The radiai loading of the pistone on the cylinder is very low, giving low wear, high efficiency and good starting torque. The spherical design of the port piate means a torque-free cylinder bearing since all forces acting on the cylinder pass through one point. Axial movement caused by elastic deformation does not increase the leakage losses between cylinder and port piate. When idling and during the start-tip process, the cylinder is held against the port piate by the builtin cup springs. As pressure increases, hydraulic forces balance the cylinder so that, even with high loading on the control face between cylinder and port piate, a permanent oil film is maintained and leakage is kept to a minimum. Mounted on the drive shaft is the bearing set which absorbs axial and radiai forces. External sealing of the rotary group is by means of radiai seal and O-rings. A retaining ring holds the complete rotary group in the housing.

2.1.3 Principles of Calculation

Calculating pump size

	Fixed displacement bent-axis pump	Variable displacement bent-axis pump
Flow	$Q=\frac{V_g \bullet n \bullet \eta_{vol}}{1000}$ (l/min)	$Q=\frac{V_g\ max \bullet n \bullet \sin\alpha \bullet \eta_{vol}}{1000 \bullet \sin\alpha_{max}}$ (l/min)
Drive speed	$n=\frac{Q \bullet 1000}{V_g \bullet \eta_{vol}}$ (rpm)	$n=\frac{Q \bullet 1000 \bullet \sin\alpha_{max}}{V_{g\ max} \bullet \eta_{vol} \bullet \sin\alpha}$ (rpm)
Drive torque	$M=\frac{V_g \bullet \Delta p}{20\pi \bullet \eta_{mh}} = \frac{1{,}59 \bullet V_g \bullet \Delta p}{100 \bullet \eta_{mh}}$ (Nm)	$M=\frac{V_{g\ max} \bullet \Delta p \bullet \sin\alpha}{20\pi \bullet \eta_{mh} \bullet \sin\alpha_{max}} = \frac{1{,}59 \bullet V_{g\ max} \bullet \Delta p \bullet \sin\alpha}{100 \bullet \eta_{mh} \bullet \sin\alpha_{max}}$ (Nm)
Drive power	$P=\frac{2\pi \bullet M \bullet n}{60000} = \frac{M \bullet n}{9549}$ (kW) $P=\frac{Q \bullet \Delta p}{600 \bullet \eta_{vol} \bullet \eta_{mh}} = \frac{Q \bullet \Delta p}{600 \bullet \eta_t}$ (kW)	$P=\frac{2\pi \bullet M \bullet n}{60000} = \frac{M \bullet n}{9549}$ (kW) $P=\frac{Q \bullet \Delta p}{600 \bullet \eta_{vol} \bullet \eta_{mh}} = \frac{Q \bullet \Delta p}{600 \bullet \eta_t}$ (kW)

Where:

Q	= flow	(l/min)	α_{max}	= max. swivel angle (varies according to design)
M	= drive torque	(Nm)	α	= set swivel angle (between 0 and α_{max})
P	= drive power	(kW)	η_{vol}	= volumetrie efficiency
V_g	= geometrie displacement per rev.	(cm3)	η_{mh}	= mechanical - hydraulic efficiency
$V_{g\ max}$	= max. geom. displacement per rev.	(cm3)	η_t	= overall efficiency ($\eta_t = \eta_{vol} \bullet \eta_{mh}$)
n	= speed	(rpm)	Δp	= differential pressure (bar)

Calculating motor size		
	Fixed displacement bent-axis pump	**Variable displacement bent-axis pump**
Consumption (Flow)	$Q=\frac{V_g \bullet n}{1000 \bullet \eta_{vol}}$ (l/min)	$Q=\frac{V_g\ max \bullet n \bullet \sin\alpha}{1000 \bullet \sin\alpha_{max} \bullet \eta_{vol}}$ (l/min)
Drive speed	$n=\frac{Q \bullet 1000 \bullet \eta_{vol}}{V_g}$ (rpm)	$n=\frac{Q \bullet 1000 \bullet \eta_{vol} \bullet \sin\alpha_{max}}{V_{g\ max} \bullet \sin\alpha}$ (rpm)
Drive torque	$M=\frac{V_g \bullet \Delta p \bullet \eta_{mh}}{20\pi}=\frac{1{,}59 \bullet V_g \bullet \Delta p \bullet \eta_{mh}}{100}$ (Nm)	$M=\frac{V_{g\ max} \bullet \Delta p \bullet \sin\alpha \bullet \eta_{mh}}{20\pi \bullet \sin\alpha_{max}}=\frac{1{,}59 \bullet V_{g\ max} \bullet \Delta p \bullet \sin\alpha \bullet \eta_{mh}}{100 \bullet \sin\alpha_{max}}$ (Nm)
Drive power	$P=\frac{2\pi \bullet M \bullet n}{60000}=\frac{M \bullet n}{9549}$ (kW) $P=\frac{Q \bullet \Delta p}{600} \bullet \eta_{vol} \bullet \eta_{mh}=\frac{Q \bullet \Delta p \bullet \eta_t}{600}$ (kW)	$P=\frac{2\pi \bullet M \bullet n}{60000}=\frac{M \bullet n}{9549}$ (kW) $P=\frac{Q \bullet \Delta p}{600} \bullet \eta_{vol} \bullet \eta_m=\frac{Q \bullet \Delta p \bullet \eta_t}{600}$ (kW)

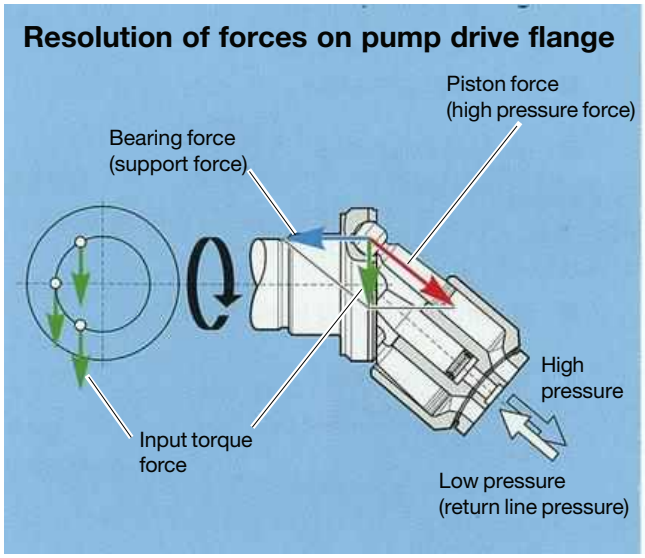
Where:

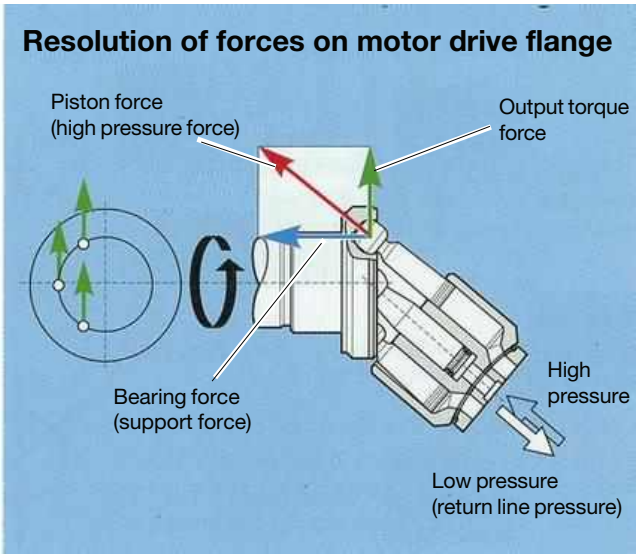
Q	=	consumption (flow) (l/min)	α_{max}	=	max. swivel angle (varies according to design)
M	=	output torque (Nm)	α	=	set swivel angle (between 0 and α_{max})
P	=	output power (kW)	η_{vol}	=	volumetrie efficiency
V_g	=	geometrie displacement per rev. (cm3)	η_{mh}	=	mechanical - hydraulic efficiency
$V_{g\ max}$	=	max. geom. displacement per rev. (cm3)	η_t	=	overall efficiency ($\eta_t = \eta_{vol} \bullet \eta_{mh}$)
n	=	speed (rpm)	Δp	=	differential pressure (bar)

2.1.4 Rotary Group Forces

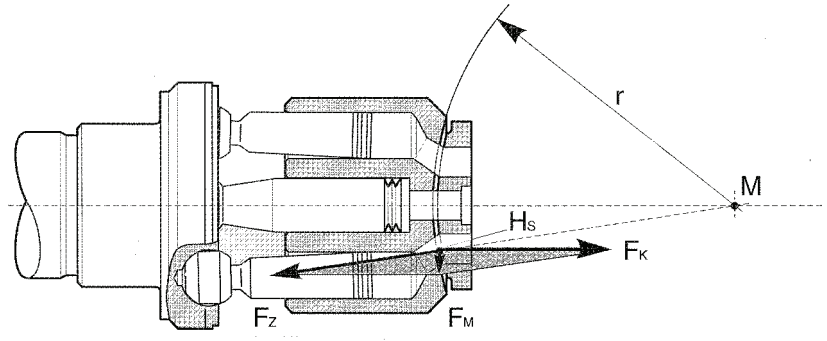
Parallelogram illustrating forces in a Fixed Displacement Unit.

The resolution of forces takes piace on the drive flange, ite. direct on the drive shaft. This conversion from torque into piston force in the pump, and in reverse in the motor, guarantees the best possible efficiency. A single resolution means a single efficiency loss!





Resolution of Forces on Port Plate with Spherical Control Face



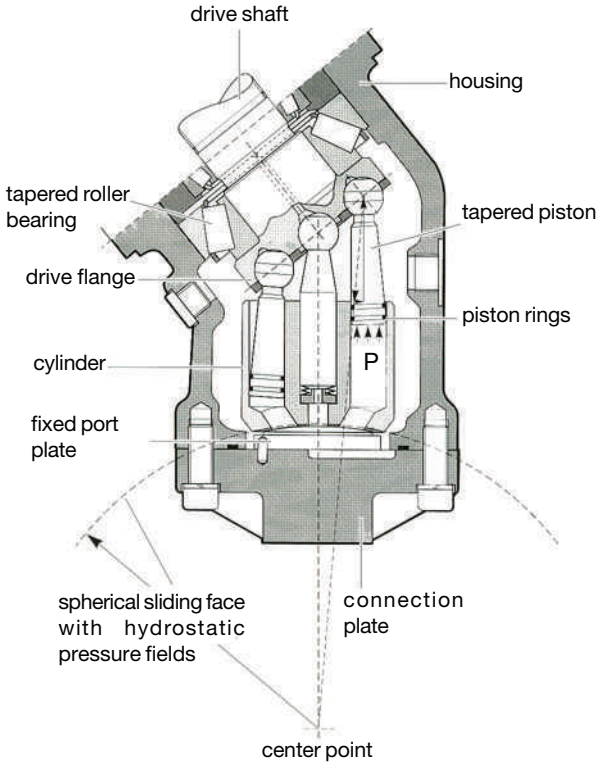
For this torque illustration, a segment of the hydraulic rotary group has been cut out and shown in simplified form in pure static condition with swivel angle 0°.

In practice, when the rotary group is swivelled out, dynamic loading is present since 3 or 4 of the piston areas are always under high pressure.

M	=	centre of assumed (theoretical) sphere
r	=	radius of this sphere
Hs	=	focal point of hydrostatic bearing pressure field
FK	=	sum of the force of 3 or 4 pistone
Fz	=	force of hydrostatic pressure field of cylinder
FM	=	resulting force on centre pin

2.1.5 40° Tapered Piston, Bent-Axis Rotary Group

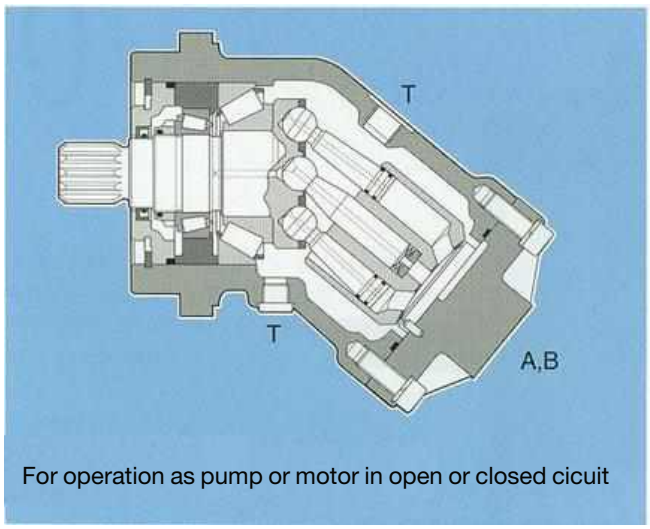
Shown here in housing with fixed swivel angle



- central swivel point
- cardanless cylinder drive
- torque-free cylinder bearing
- self-centring rotary group
- spherical port piate
- tapered roller bearings
- one-piece tapered piston with 2 piston rings
- automatic bearing lubrication
- piston-force resolution direct on drive flange

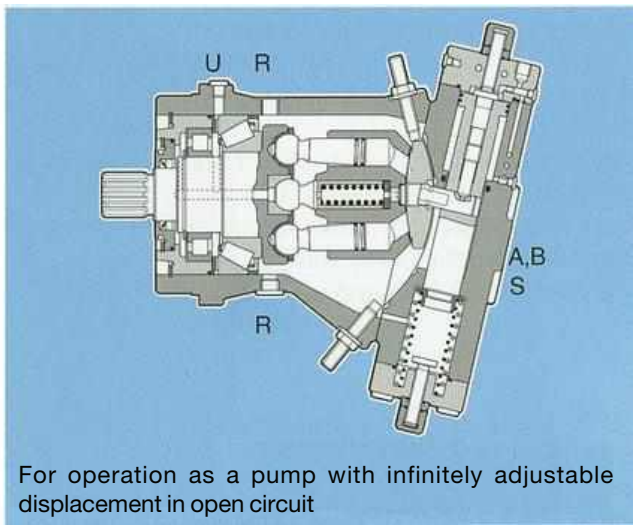
2.1.6 Examples of Types

Fixed Displacement Unit A2F (fixed swivel angle)



For operation as pump or motor in open or closed cicuit

Variable Displacement Unit A7VO (variable swivel angle)



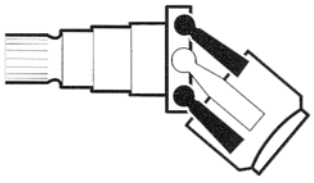
For operation as a pump with infinitely adjustable displacement in open circuit

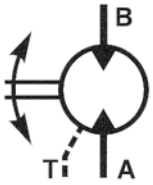
2.1.7 Symbols

Symbolic illustration of the best-known types

A,B Pressure ports
S Suction port
T,R Case drain ports
U Flushing port

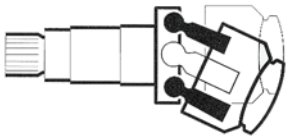
A2FM
Fixed motor





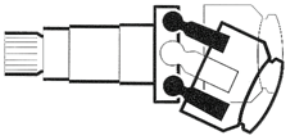
Fixed displacement motor for open or closed circuits; fixed swivel angle; both directions of rotation of power take-off.

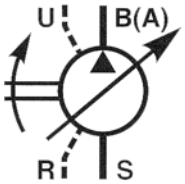
A6VM
Variable motor



Variable displacement motor for open and closed circuits, swivel to one side only; infinitely variable swivel angle; both directions of rotation of power take-off.

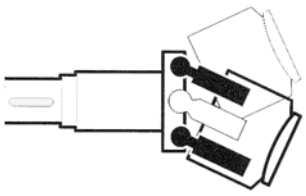
A7VO
Variable pump





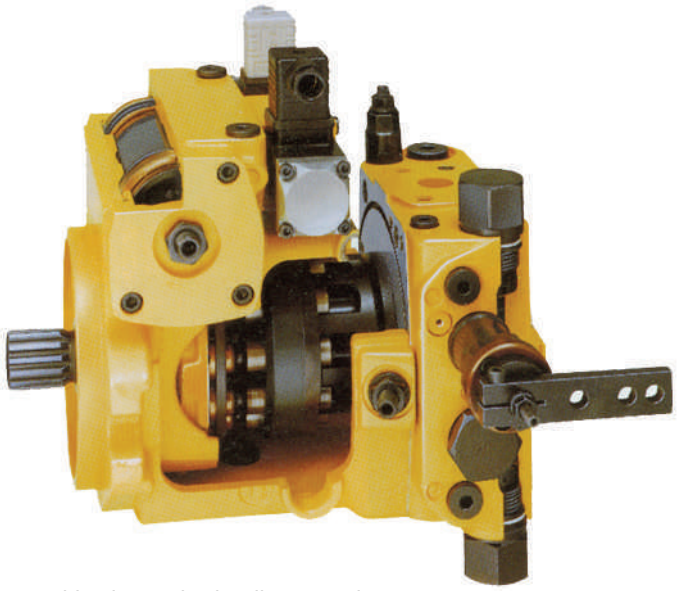
Variable displacement pump for open circuits, swivel to one side only; infinitely variable swivel angle; single direction of rotation of drive.

A2V
Variable pump



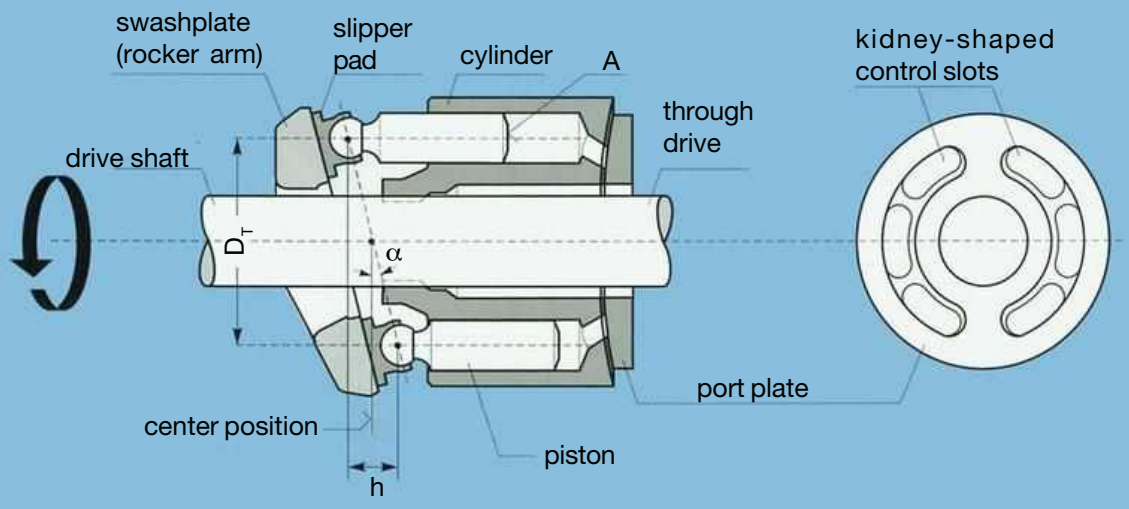
Variable displacement pump for closed circuits, swivel to both sides; swivel angle infinitely variable over centre; both directions of rotation of drive.

2.2 Swashplate



Example:
Variable Displacement Pump with electro-hydraulic control, speed-related closed loop control and built-on auxiliary pump

Schematic Diagram of a swashplate unit (with pistons parallel to axis)
with fixed or variable swivel angle α



h = piston stroke
A = piston area
D_T = pitch diameter when α=0
α = swivel angle (e.g. 20°)
V_g = geom.displacement [cm^3/rev.]

x = number of pistons (e.g. 9)
h = $D_T \bullet \tan \alpha$
V_g = $x \bullet A \bullet h$
V_g = $x \bullet A \bullet D_T \bullet \tan\alpha$