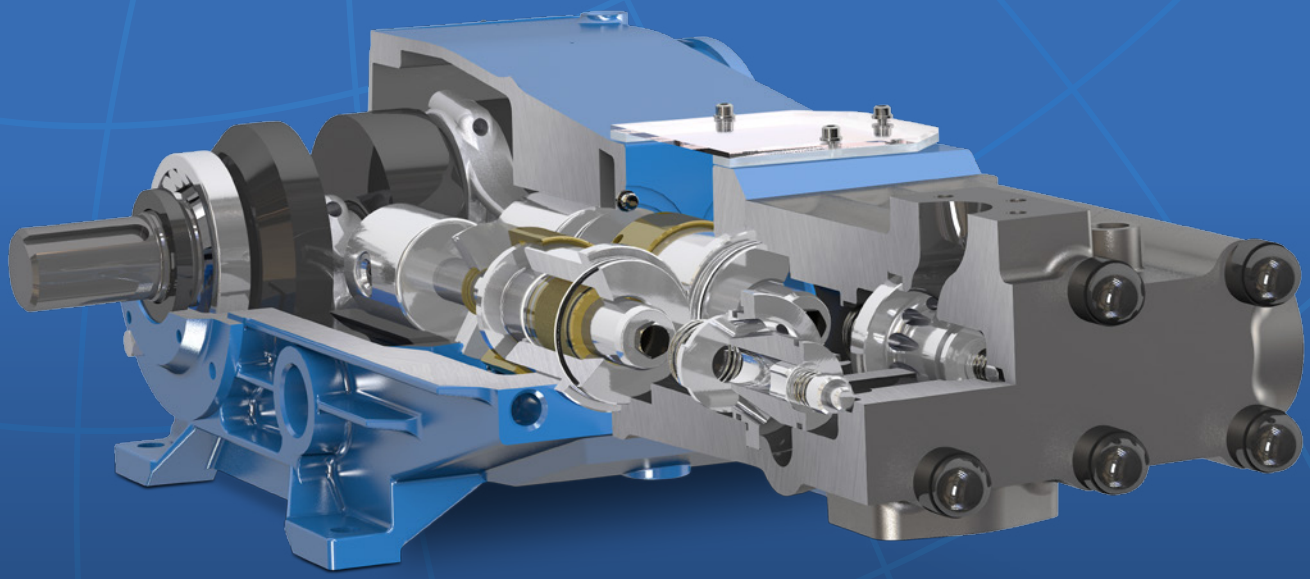
RAM PUMPS

Meeting The Toughest Challenges



VHP Series

Installation, Operation and Maintenance Manual

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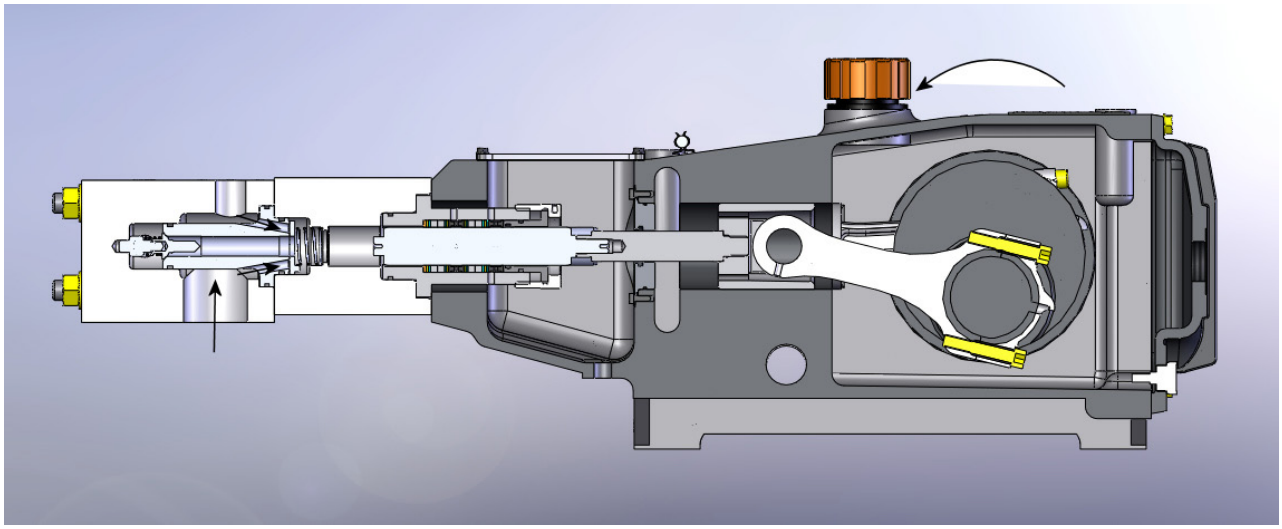
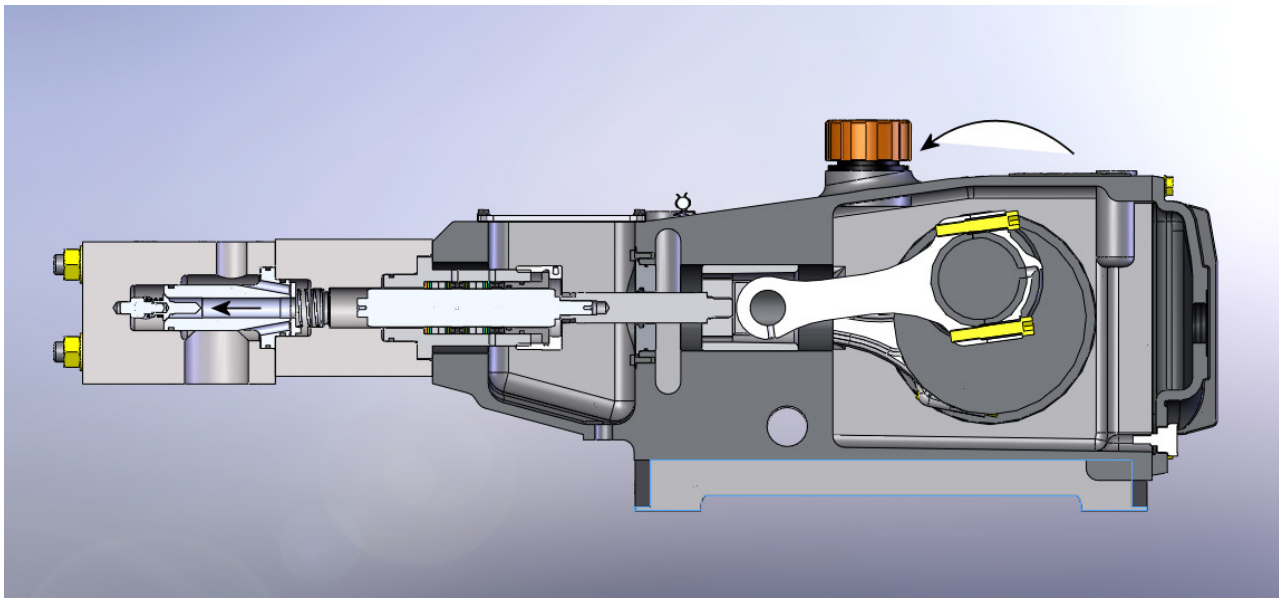
1.0 Physical Description

1.0.1 Ram pumps are horizontal single acting reciprocating piston pumps either in a Triplex (3) or Quintuplex (5) piston lay out. The basic operation of the pump can be defined in 2 steps.



Step 1: Suction Stroke.



Step 2: Discharge Stroke.

1.0.2 The difference between the suction gallery and discharge gallery along with the ram size, stroke and crankshaft RPM creates the flow.

1.0.3 Down stream equipment from the discharge line such as regulators, un-loaders or well head create the backpressure.

1.1.1 RAM PUMPS PRODUCT CODE

RAM SERIES
50
150
170
250
500

FLUID HEAD MATERIAL
0 = Carbon Steel
1 = Stainless Steel 316
2 = 22% Cr Duplex
3 = 25% Cr Duplex
4 = Inconel 625

RAM SIZE
Dimensions (mm)
Determined by the pump series
and duty required

HEAD DESIGN
HCH = High Capacity Head
VHP = Very High Pressure

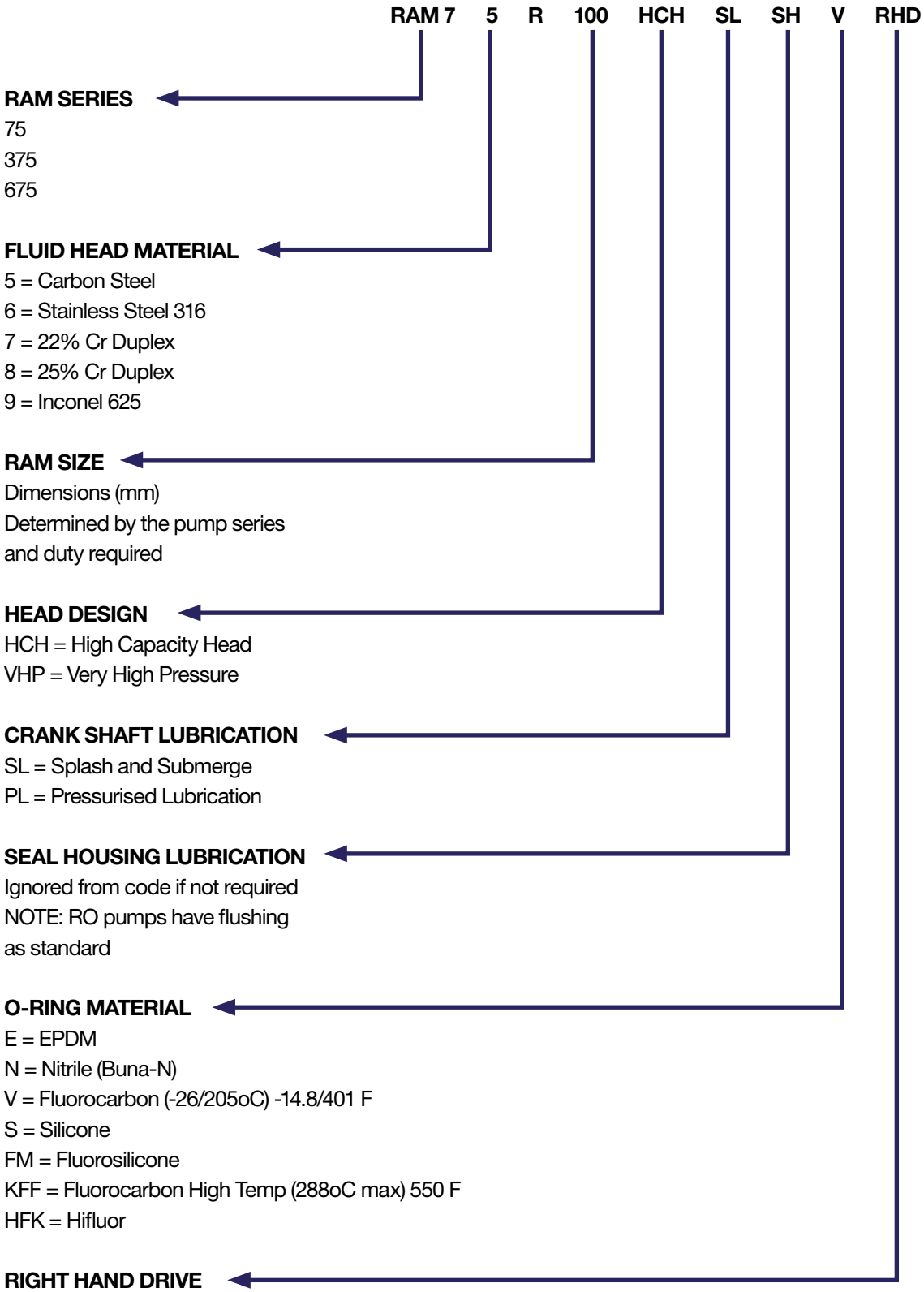
CRANK SHAFT LUBRICATION
SL= Splash and Submerge
PL= Pressurised Lubrication

SEAL HOUSING LUBRICATION
Ignored from code if not required
NOTE: RO pumps have flushing
as standard

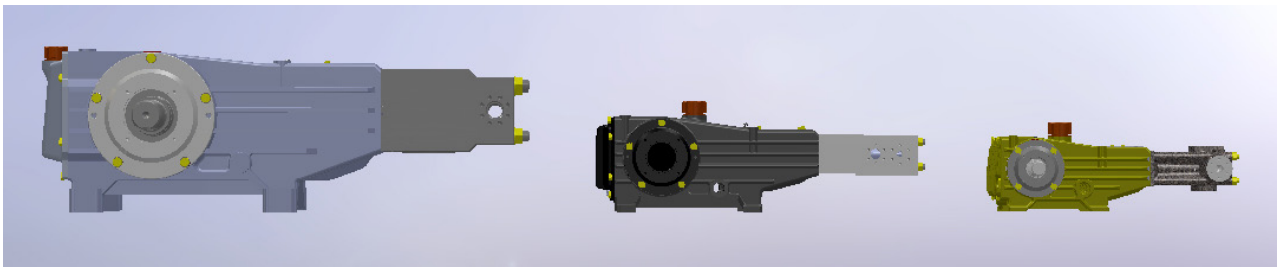
O-RING MATERIAL
E = EPDM
N = Nitrile (Buna-N)
V = Fluorocarbon (-26/205oC) -14.8/401 F
S = Silicone
FM = Fluorosilicone
KFF = Fluorocarbon High Temp (288oC max) 550 F
HFK = Hifluor

RIGHT HAND DRIVE
Standard is left hand drive looking at
the pump from the fluid head end.
Not noted unless the pump is RHD.

1.1.2 RAM PUMPS PRODUCT CODE



1.2 Capabilities



	RAM 250	RAM 75	RAM 50
Max Flow	366 l/min	48 l/min	175 l/min
Max Pressure	420 bar g	700 bar g	600 bar g
Max RPM	360	450	600
Max Inlet Pressure	30 bar g	30 bar g	30 bar g
Min RPM	75	60	60
Max kW	160	65	45
Suction Port	6"	3"	2"
Discharge Port	4"	2"	1"
Oil Capacity	85 litres	14 litres	7 litres
Weight	2400 kg	450 kg	175 kg

Note: Values are max for standard materials, grater values can be achieved with different material grades.

1.3 General Notes

1.3.1 This IOM is a guide only. Although this is detailed, Ram Pumps Ltd recommends the use of specially trained Ram Pumps Ltd personnel for commissioning, maintaining and repairing any pump or package supplied by Ram Pumps Ltd.

1.3.2 As with all reciprocating pressure pumps the most important factor concerns the way the pump is connected to the fluid supply being pumped. It is important to have the correct NPSH figures to match the pump flow rate. It is not always enough to just have a flooded suction condition or even a pressurised suction line if there is a restriction to flow caused by a badly installed filter or too many bends in an inadequate size of pipe.

1.3.3 If assistance is required please contact our Technical Department on +44 (0)1903 206622, where our technical staff will be pleased to advise.

2.0 Shipping and Handling

2.0.1 Most Ram Pump packages or bare shaft pumps are shipped on a wooden pallet type base and will be covered in a number of different ways including a solid wood box, plastic or cardboard, specification depending.

2.0.2 Although there are a number of different pump coverings, all pallets or shipping boxes can be moved by fork lift or crane via the wood base.

2.0.3 Large packages will normally be shipped in an enclosed box showing the weight and centre of gravity.

2.0.4 Prior to shipping, all pumps will be completely drained of pump media and flushed.

2.0.5 Discharge and inlet ports or flanges will be blanked off using covers, fitted in place and sealed with weatherproof adhesive tape.

2.0.6 All pumps, packages, spares and ancillaries will be securely fastened to the shipping package.

2.0.7 The shipping packing must be strapped down during transit to ensure the safety of the contents.

2.0.8 All equipment must be stored on a flat even surface.

2.0.9 If there is a remote possibility of frost to a reciprocating pressure pump, precautions must be taken by the user. A split fluid head can be an expensive and unnecessary exercise.

2.0.10 Equipment should ideally be stored in a dry warehouse or if being stored outside, should be given adequate protection from the elements.

2.0.11 Equipment can be stored as preserved from 'Ex-Works' shipment for a period of up to 3 months. For extended periods please contact Ram Pumps Ltd for advice.

2.0.12 Pump drive shafts whilst being stored should be rotated by hand, once every 3 weeks to ensure that packing's and hydraulic seals are not subject to sticking and bearings are not subject to static indentation.

2.1 Installation and Alignment

If you are unclear on how to install the equipment please call our Technical Department at Ram Pumps Ltd, tel: +44 (0)1903 206622, where our technical staff will be pleased to advise.

2.1.0 It is important to remember that pump reliability is dependant on good installation of pipe-work systems, in particular the inlet/suction line.

2.1.1 All piping should be in accordance with Hydraulic Institute Standards, API 674 Section 7.6 (December 2010), and API 14E (Oct. 1991) and the system parameters such as NPSH outlined on the equipment data sheets.

2.1.2 All electrical supplies are the responsibility of the client and as a minimum should comply with IEE regulations and BASEEFA for all hazardous area environments.

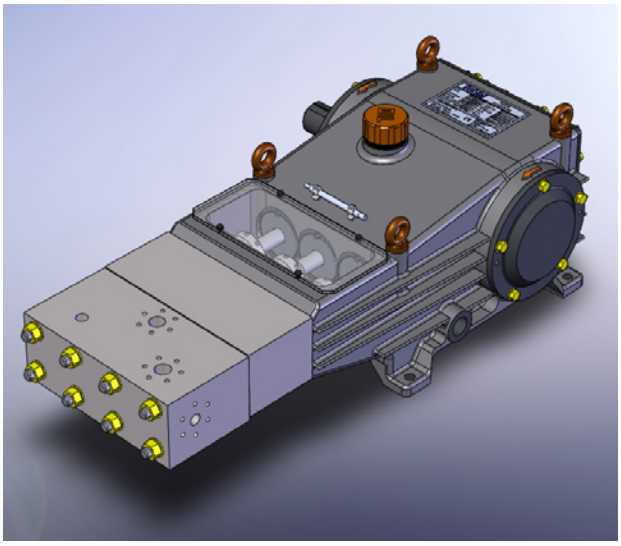
2.1.3 All terminal points on the pump package should be supported with strong pipe brackets to keep nozzle loads to a minimum.

2.1.4 Suction line filters should be avoided, but if absolutely necessary, refer to Ram Pumps technical service for advice.

2.1.5 Ensure that the Nett Positive Suction Head Required (NPSHR) by the pump IS EXCEEDED by your system with a margin of at least 2.0 meters. Smaller margins have to be formally approved by Ram Pumps Ltd.

2.1.6 When required the packaging will be removed and all loose parts (dampers, spares, flanges) removed.

2.1.7 To lift a bare shaft pump, eye bolts must be fitted to the crankcase (2.1a).



DO NOT LIFT IN ANY WAY VIA DRIVE SHAFTS, FLANGES OR COUPLINGS.

2.1.8 To lift a pump package use the eye bolts that are already attached to the baseframe.

DO NOT USE ANY AUXILIARY EQUIPMENT, PUMP LIFTING EYE BOLTS OR COUPLINGS.

2.1.9 The correct lifting procedure and equipment must be used at all times.

2.1.10 When installing a bare shaft pump the platform that the pump is being fixed to must be level within 0.25mm over all four pads, and be of suitable construction as not to move whilst executing torque down of the bolts.

2.1.11 The driveshaft of the pump must be concentric to the out put shaft of a gearbox drive and parallel with a drive belt system.

2.1.12 Check relevant coupling IOM for correct settings and tolerances.

2.1.13 Once everything is lined up, all securing bolts should be tightened up to the relevant torques and the alignment re-checked.

2.1.14 When installing a pump package, the chosen location must be secure, level and capable of supporting the entire skid.

2.1.15 The correct lifting procedure and equipment must be used at all times to ensure safe and accurate placing of the skid.

2.1.16 Ram Pumps skids can be welded or bolted in position, it is essential that the baseframe remains level and is not twisted or buckled.

2.1.17 Once the baseframe is secure the aliment of the couplings must be re-checked and adjusted where necessary.

(All Ram Pumps baseframes are fitted with jacking bolts to aid accurate adjustment).

2.2 Pulsation Dampers

CAUTION: SOME PULSATION DAMPERS CAN ONLY WORK IN THE VERTICAL PLANE! READ RELEVANT IOM'S.

2.2.0 Ram Pumps recommends fitting suction and discharge dampers to the fluid head. If this cannot be achieved a maximum distance from the fluid head of 1 meter is recommended.

2.2.1 All dampers should be pre-charged with Nitrogen at a set pressure of 80% line pressure. Some shipping regulations do not permit sending any vessel containing pressure. All pulsation dampers must be presumed empty and checked.

2.2.2 If empty, charge with Nitrogen using the correct damper charging kit and correct procedure.

2.3 Relief Valves

CAUTION: FAILURE TO INSTALL A RELIEF VALVE, OR INCORRECTLY SPECIFIED VALVES MAY CAUSE PERSONAL INJURY OR DAMAGE TO THE PUMP OR SYSTEM.

2.3.0 Time must be taken to guarantee the correct relief valve is selected to match the pressure (normally pre-set 10% above system working pressure) and flow and media type of the system.

2.3.1 Relief valves can be attached to the pump fluid head or pipe work but must be fixed to the discharge side.

2.3.2 No other equipment, valves etc, should be installed between the pump and the relief valve.

3.0 Preparing to Start

3.0.1 Open all isolation valves in the suction and discharge pipe work systems.

3.0.2 Suction filters are not normally recommended but if fitted they must be the correct size with a coarse mesh. Suction filters should be checked regularly, they are a key source of potential trouble. The differential pressure drop across a filter can force the NPSH available from a system below that required by the pump.

3.0.3 Belt drives should be checked for tension and drive couplings checked for alignment. Slack belts will slip and burn resulting in reduced pump output, over tensioned belts will reduce bearing and belt life. Coupling misalignment will lead to premature bearing and or coupling failure.

3.0.4 It is recommended that unloader valves (where fitted) should be in the 'off load' condition. Generally all pumps should be started in the 'off load' condition.

3.0.5 Check that the crankcase is filled to the centre mark on the site glass on the rear cover with the correct type of lubricating oil, refer to the Lubrication Schedule.

NOTE: OVERFILLING WITH OIL IS NEARLY AS BAD AS UNDER-FILLING, AS OIL WILL CHURN AND CAUSE OVER HEATING.

3.1 Start Up

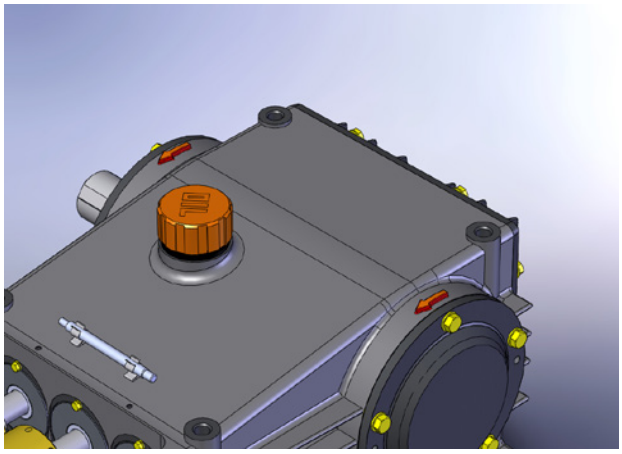
3.1.0 Where possible, it is useful to rotate the pump by hand via the belt pulleys or drive coupling for one or two revolutions.

3.1.1 Open the suction and discharge line isolation.

Note: Leaking from pump packings should not be considered a problem at this stage. Many packing arrangements are designed to pass a minimal leak rate. This has the effect of lubricating the packing's. Some pumps are fitted with a high integrity sealing arrangement within the packing/seal housing. This system does not stop the packings from leaking but diverts it to a drain-line to be piped to waste.

3.1.2 If the Pump is fitted with a bleed valve or valves, open and wait until all air is purged.

3.1.3 Give the pump an initial 2-3 second start to check for the correct direction of rotation. This is very important. Refer to the directional arrows situated on top of the pump crankcase (3.1a).



3.1a

3.1.4 The pump can now be started with initial monitoring of flow rate and pressure. Check pump for air entrapment, if this is apparent, purge the fluid end.

3.1.5 If possible it is good practice to run new pumps with either no discharge or very little discharge pressure i.e. 'off load' for 30 minutes to bed in the packings and power end assembly and remove trapped air from with the pipe work. The pump can be brought to duty point and a check on motor full load current should be made at this stage.

3.1.6 Pumps fitted with pressure lubrication on the crankshaft should be checked for function pressure. Pumps fitted with packing lubrication are pre-set at the factory. However, one to two drips every minute is sufficient (viewed from the sight glass on top of the packing Lubricator pump). Do not over lubricate the packings as this may cause carburisation and ultimately packing failure.

3.2 Shut Down

3.2.1 Where possible 'OFF LOAD' the running condition of the pump. Pump unloader valves (where fitted) should be in the off load position.

3.2.2 Shut down the pump.

3.2.3 Isolate inlet and discharge lines as required.

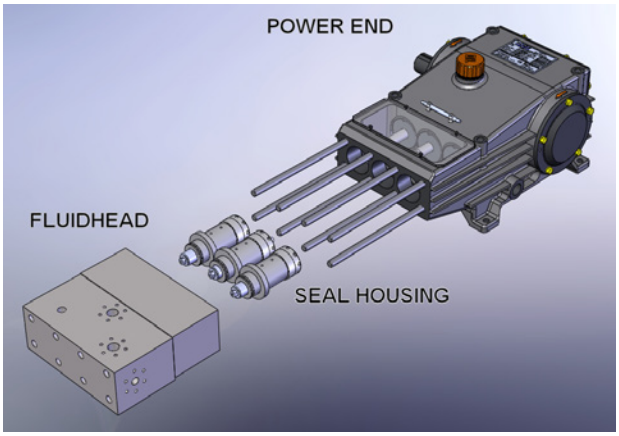
3.2.4 Release any residual line pressure.

4.0 Maintenance

CAUTION: BEFORE COMMENCING WITH ANY MAINTENANCE WORK, SHUT OFF AND ISOLATE ALL DRIVE SYSTEMS AND MEDIA GOING TO THE PUMP. RELIEVE ALL DISCHARGE PRESSURE AND ISOLATE.

4.0.1 All pump models are designed to different build specifications to suit various duties and pumped media. For this reason when ordering spare parts, the pump serial number must be quoted. This can be found on the pump nameplate, which is normally situated on the top of the pump crankcase.

4.0.2 All VHP pump packages can be split into three sections (4.0a).

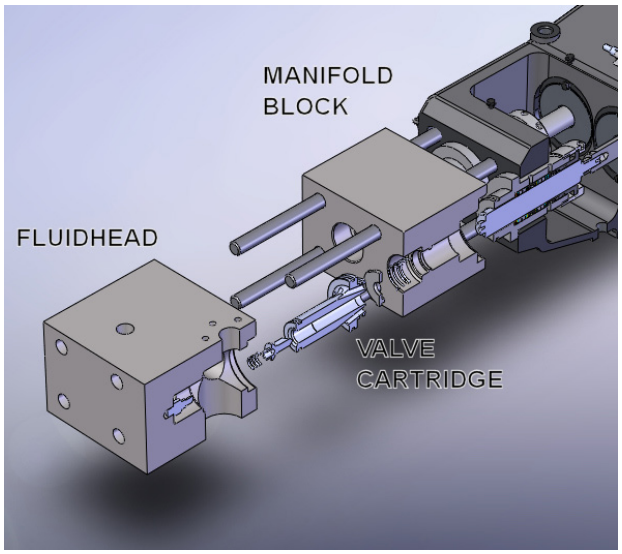


4.0a

4.1 Maintenance Schedule

ITEM	SCHEDULE
Seal Housing, Nut Packing Adjuster	Check at commissioning and every month after.
Crank Case, oil	First oil change after 20 operating hours. Every 3000 operating hours there after. Daily check for colour and leakage
Fluidhead, valves	Weekly (check pump performance)

4.2 Fluidhead

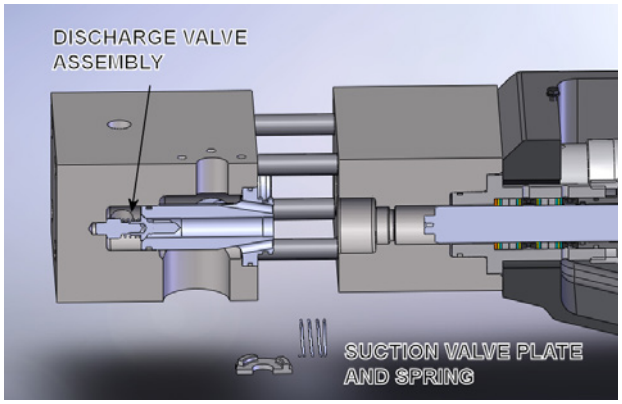


4.2a

4.2.1 To gain access to the valves the fluidhead must be removed.

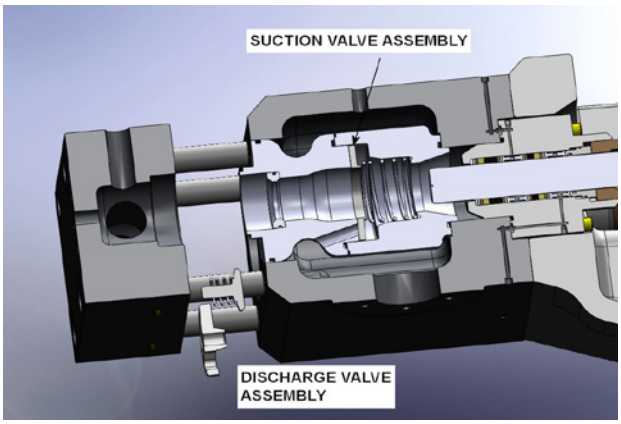
4.2.2 Remove any piping to the seal housings and fluidhead.

4.2.3 Remove the nuts from the front of the fluidhead and slide the fluidhead along the retaining studs until the valve plates and springs can be accessed and removed (4.2b, 4.2c).



4.2b

4.2.4 For RAM50 and 75 pumps the valve cartridge will remain in the fluid head (4.2b)



4.2c

4.2.5 For the RAM250 the valve cartridge will remain in the manifold block (4.2c)

4.2.6 To access the cartridge withdraw from assembly by pulling free.

4.2.7 Clean and inspect all parts of the valve assemblies. Replace or repair as necessary.

4.2.8 To repair valves, apply a fine lapping compound to the valve and place into the valve cartridge. Gently twist the valve backward and forward.

4.2.9 To test valve seating, clean off compound from all parts and apply engineers blue to the valve and place gently in cartridge. Remove valve and check for a continuous witness mark around the valve seat.

4.2.10 If the manifold block seals require changing, slide the block forward until the seal housings are exposed and change the seals.

Note: Manifold block seals should last the lifetime of the pump.

4.2.11 The cause of the leak must be investigated as the most likely cause of a fluidhead seal leak is by the o-ring being damaged by the pump media.

4.2.12 Refitting is the reverse of the above instructions. To fit the suction valve plate wrung it to the valve cartridge before assembly.

4.2.13 Use of heavy waterproof grease on studs and faces will assist in later removal if required. Tighten the head Bolts in accordance with the pump torque settings.

O-ring Grease Table

O-ring	Grease
Viton	Tufshield (Hydrocarbon Base)
Nitrile	Molybdenum Grease (Lithium Base)
EPDM	Molybdenum Grease (Lithium Base)
Silicone	Silicone Grease

Note: For RO or Food preparation applications use FOODLUBE or other NSF H1 registered grease.

NOTE: DO NOT USE PETROLEUM BASED GREASE (VASELINE ETC) ON EPDM, NITRILE OR SILICONE O-RINGS.

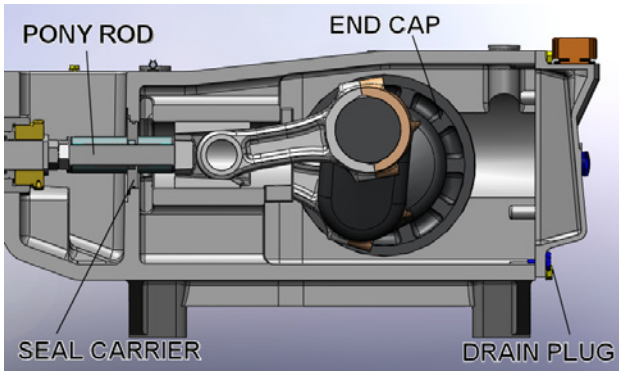
NOTE: USE OF THE WRONG O-RING OR PACKING GREASE MAY CAUSE THE O-RING TO BRAKE DOWN AND FAIL.

Fluidhead Bolt Torque

Ram	Torque Nm (ft-lbs)
50	220
75	250 (185)
250	RotaBolt*

*Tighten bolt until the cap becomes tight.

4.3 Power End



4.3a

4.3.0 Maintenance of the power end will be limited to oil changes and checking for leaks on the pony rod seal carrier.

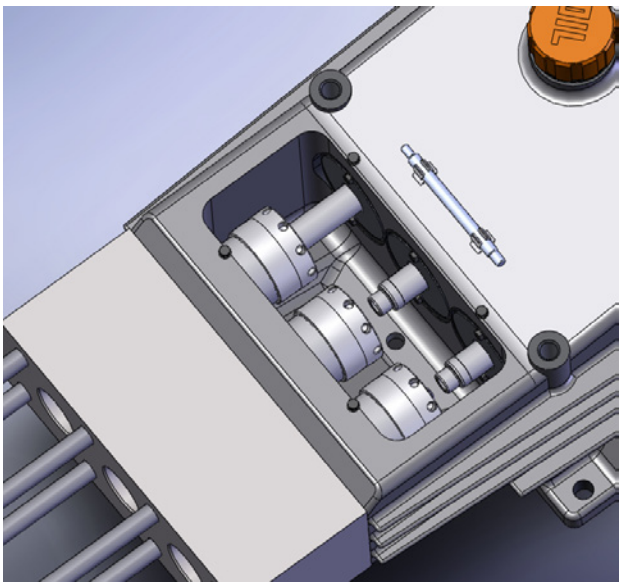
4.3.1 If crankcase pressure lubrication is fitted, check pressure; refer to the Crankcase Pressure Lubrication servicing instructions. Remember to change any pressure lube system oil filters!

If any problems are encountered please refer to our Technical Department on +44 (0)1903 206622 for advice.

4.3.2 To change pony rod seals, remove drain plug and half empty crankcase.

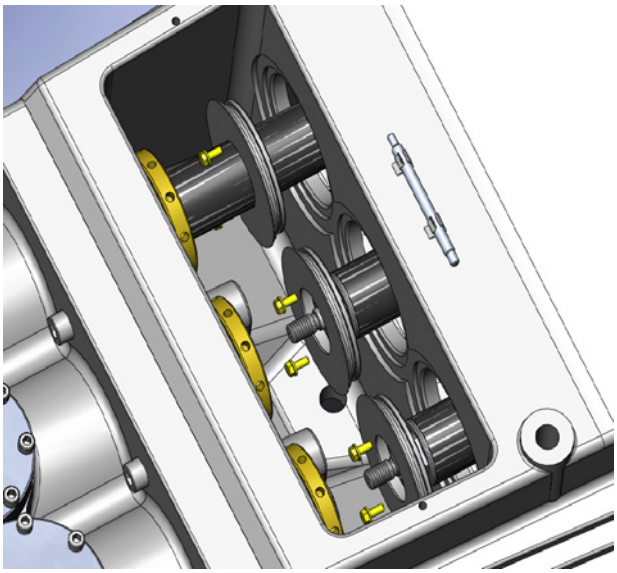
4.3.3 For Ram 50 and 75 the fluid head must be removed as described in section 4.2

4.3.4 Loosen rams and push forward to create a gap between the pony rod and ram (4.3b).



4.3b

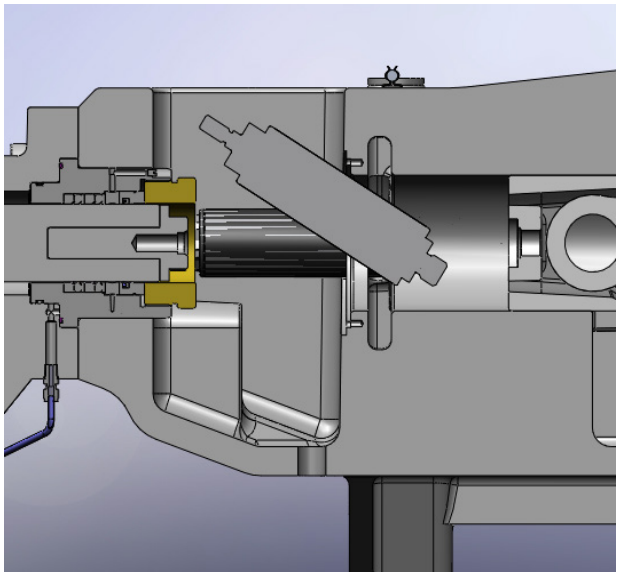
4.3.5 Undo seal housing bolts. Lever out seal housing with a wide flat bladed screwdriver and slide along pony rods until free (4.3c).



4.3c

4.3.6 With the seal housings out the seal can be replaced. Always replace like for like and note the orientation of the seals.

4.3.7 If the pony rod is scored it must be replaced or repaired. The pony rod of the RAM250 can be removed with the pump fully assembled (4.3d). RAM50 and RAM75 will require the head and seal housing removed as per section 4.2.



4.3d

4.3.8 Repair or replace items were necessary making sure all parts are clean and grit free before reassembly.

4.3.9 Replace pony rods in reverse order.

4.3.10 Lubricate the seal housing outside diameter and seal before reassembly.

4.3.11 Reassemble seal housings and tighten bolts to torque shown.

Seal Housing Bolt Torque

Ram	Torque Nm (ft-lbs)
50	10 (7)
75	10 (7)
150, 170, 250	20 (15)

Ram Torque

Ram	Torque Nm (ft-lbs)
50	35 (26)
75	60 (45)
150, 170, 250	120 (88)

Note: Torque may differ from drawing in section 5 if a non standard assembly is used.

4.4 Power End Overhaul

4.4.0 In the unlikely event that a complete overhaul is required these procedures must be followed.

CAUTION: IF A COMPLETE OVERHAUL IS REQUIRED THE PUMP MUST FIRST BE REMOVED FROM ANY SKID AND DRIVE TRAIN. REFERENCE TO ALL RELEVANT COUPLING IOM'S AND LIFTING PROCEDURES MUST BE MADE.

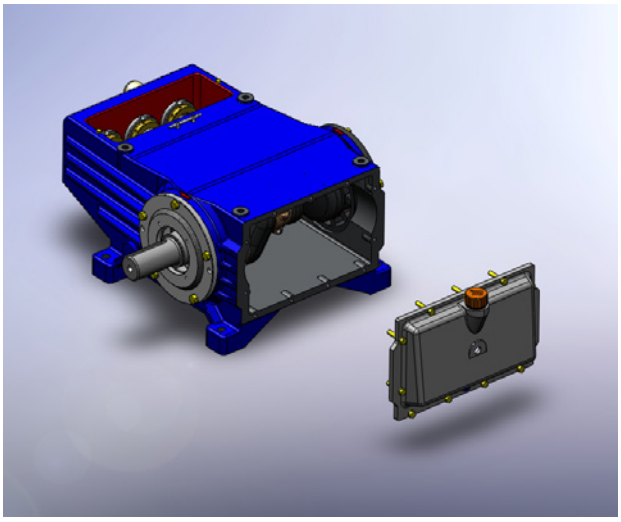
CAUTION: THE POWER END MUST BE STRIPPED, ASSESSED AND RE-ASSEMBLED BY A COMPETENT PERSON. ANY DAMAGED CAUSED BY THIS PROCESS MAY PUT THE ENTIRE PUMP OUT OF COMMISSION COMPLETELY.

4.4.1 Remove magnetic drain plug and drain crankcase completely.

4.4.2 Remove fluid head and pony rods as described in section 4.2 and 4.5

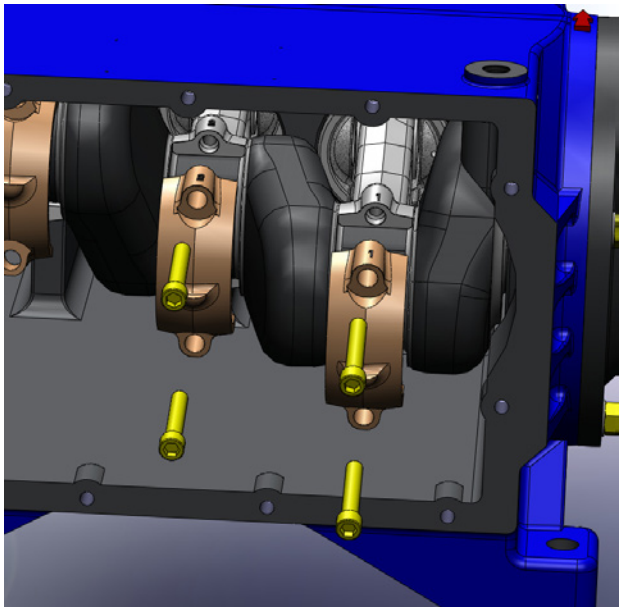
4.4.3 Remove seal housings.

4.4.4 Remove rear cover using jacking screws at each side of the casting. The sealing medium is silicone rubber, therefore a gasket is not required (4.4a).



4.4a

4.4.5 Note the positions of the bolts, washers and connecting rod end caps for re-assembly. Remove bolts from the connecting rods (4.4b).

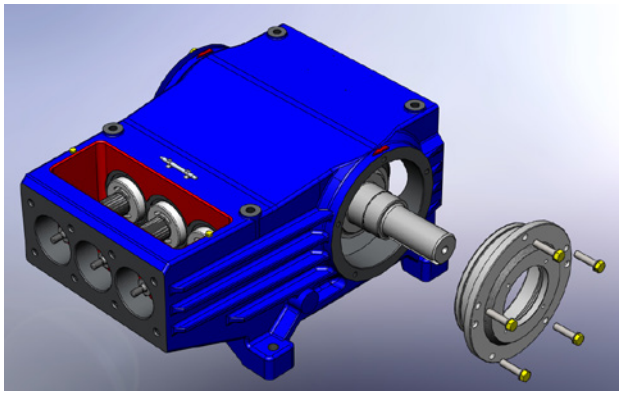


4.4b

4.4.6 Push all three connecting rods fully forward.

4.4.7 Support the crankshaft under each end.

4.4.8 Detach Crankshaft Bearing Housing Bolts from drive end and withdraw the housing and bearing. Note the positions of these items for re-assembly. (4.4c)

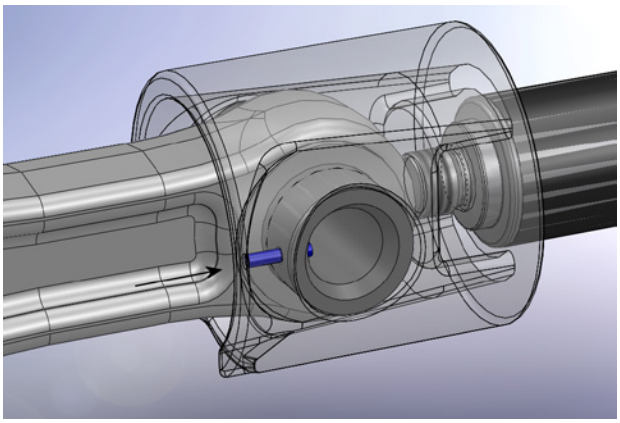


4.4c

4.4.9 The crankshaft can then be removed.

4.4.10 If required the Connecting Rod / Cross-Head / Pony Rod assemblies may be withdrawn.

4.4.11 To separate the connecting rod from the cross head the roll pin will have to be removed using a suitable sized punch and hammer pushing the pin through to the Wrist Pin Centre. On re-assembly align the roll pinholes in the wrist pin and crosshead and replace the pin. (4.4d)



4.4d

4.4.12 Clean all parts and check all parts for wear. Repair or replace were necessary.

4.4.13 Re-assemble, in reverse order, taking care to replace in the same positions as removed. Take care to maintain the crankshaft bearing shimming issued in the same position as removed. Tighten the connecting rod bolts in accordance with the pump torque settings.

Connecting Rod Bolt Torque

Ram	Torque Nm (ft-lbs)
50	50 (37)
75	80 (60)
150, 170, 250	120 (88)

End Cap Bolt Torque

Ram	Torque Nm (ft-lbs)
50	50 (37)
75	80 (60)
150, 170, 250	300 (220)

Rear Cover Bolt Torque

Ram	Torque Nm (ft-lbs)
50	50 (37)
75	50 (37)
150, 170, 250	120 (88)

RECOMMENDED LUBRICANTS FOR RAM MODELS (TO SPECIFICATION API CF-4/SG)

Applications with normal running temperatures:

- Shell Rimula R3 X 15W/40
- Mobil Delvac Super 1300 15W/40
- BP Vanellus 15W/40 C3 Multigrade
- Elf Tecnic Super 15W/40

Or any other 15W/40 lubricant meeting the requirements of Specification API CF-4/SG

Applications with running temperatures between 100 and 120 °C:

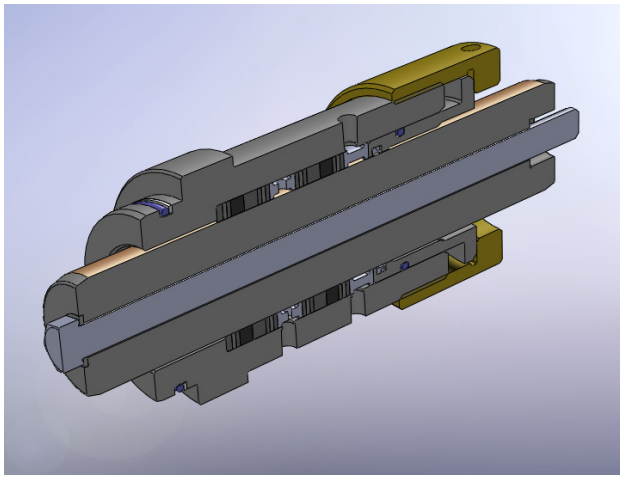
- BP Vanellus M20/50.

Applications with running temperatures greater than 120°C:

Contact Ram Pumps Ltd. Technical Department on +44 (0)1903 206622.

4.5 Seal Housing

4.5.0 Ram Pumps use several different configurations of Seal Housing but the two main types are chevron 'V' packing's packing's (4.5a)



4.5a

Please see the unique drawings and parts list in the IOM pack for the Seal Housing supplied with your order.

4.5.1 The nut packing adjuster should be checked periodically and tightened if required. The packing's should not require regular attention and over tightening will cause damage.

Their are two procedures for tightening the packing glands.

4.5.1a Procedure One – Pump Static: The packing's can be tightened in a static condition without the pump running.

Using the special tool clipped to the crankcase, (TST4585.4) tighten the gland nut until the nut does not move. Back off the nut 1/8 of a turn. Monitor the packing temperature during running, if the temperature exceeds 60 deg C within an hour, slacken a further 1/8 turn until the temperature stabilises. Note! Ambient temperatures above 45 deg C should be taken into account.

4.5.1b Procedure Two – Pump Running:

EXTREME CARE MUST BE TAKEN WHEN CARRYING OUT THIS PROCEDURE AND MUST BE PERFORMED BY A COMPETENT PERSON.

Using the packing adjuster tool, tighten packings in a clockwise direction. During this operation the packing nut will vibrate, this will decrease to virtually zero at maximum pre-tension. At this point back the nut off 1/8 turn and monitor packing temperature. If the temperature exceeds 60 deg C stop, back off 1/8 turn. Repeat process until the packing temperature stabilises.

4.5.2 If the packing's are required to be replaced the following procedures must be followed.

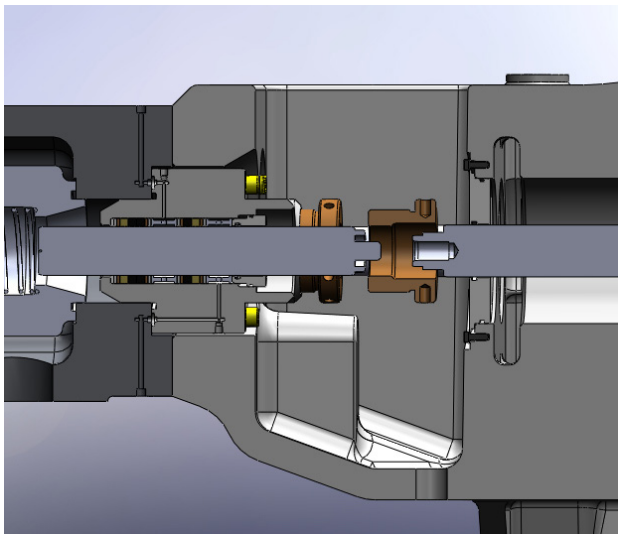
4.5.3 Shut down and isolate the pump as per section 3.2

4.5.4 For Ram 50 and 75 remove the fluid head as per section 4.2. The Rams can be released from the pony rods allowing the seal housings to be removed, stripped, assessed, and repaired as necessary.

4.5.5 For RAM250 Loosen and remove the Nut Packing Adjuster and Thrust Ring.

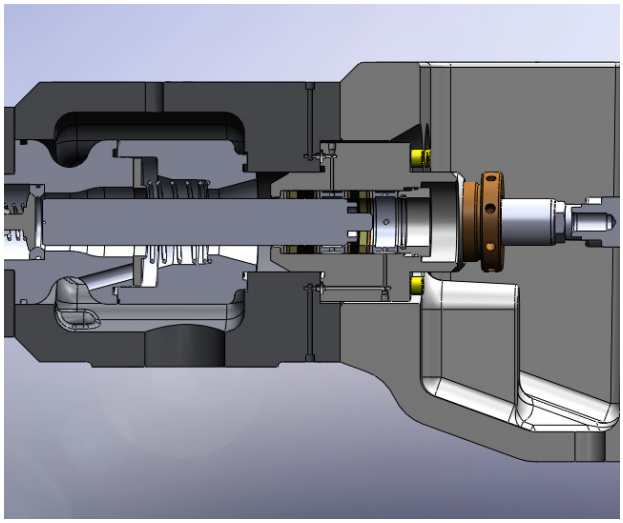
4.5.7 Cycle the pump and the packing arrangement may withdraw from the seal housing (4.5b).

4.5.8 Disconnect the Ram from the Pony Rod as per paragraphs 4.3.2 to 4.3.3. Push the Ram forward removing the Thrust Ring, Nut Packing Adjuster and any packing.



4.5b

4.5.9 Continue pushing the Ram forward into the Fluidhead until it clears the Seal Housing 4.5c.



4.5c

4.5.10 Remove any remaining packing's.

4.5.11 Re-build seal housing as shown in drawing included in section 4.

NOTE: TAKE CARE NOT TO DAMAGE THE RAMS DURING THE ASSEMBLY/DISASSEMBLY PROCESS.

4.5.12 Re-assemble pump and run packing's in as per initial start up procedure.

Seal Housing Bolt Torque

Ram	Torque Nm (ft-lbs)
250	100 (74)

4.6 Fault Finding

SYMPTOM	POSSIBLE CAUSE	REMEDY
Incorrect Pressure or flow from pump	No liquid in reservoir or tank	Ensure lines are connected and valves are open
	Inlet line valve closed	Ensure lines are connected and fill tank
	Crankshaft is not turning	Check for power to drive and drive connections
	Inlet strainer is totally clogged with debris	Clean or replace strainer
	Pump speed is too low	Check belt tightness or power to motor
	Pump speed it to fast	Correct drive speed
	Relief valve improperly adjusted or worn	Check relief valve and adjust setting
	Pump not filling	Prime pump. Increase suction pressure. Allow pump to operate at low pressure through a bypass valve
	Excessive leakage from pump seals	Adjust or replace packing or damaged parts
	Insufficient system back pressure	Check system
	Worn valves	Inspect valves and repair or replace
	Pump valve stuck open	Remove debris beneath valve
	Air/gas entrapment	Purge gas/air
	Air leaking into pump	Check pipe and pump seals
	Capacity of booster pump less than displacement of power pump	Use larger booster pump
Pump runs rough, knocks, or vibrates	Pump not filling	Prime all chambers, Increase suction pressure.
	Pump cavitation	Increase suction size or NPSH
	Insufficient NPSHA	Provide more NPSHA
	Excessive acceleration head in suction line	Install suction stabilizer
	Pulsation dampener improperly charged	Charge to proper pressure
	By-pass or relief is piped back to suction	Pipe back to reservoir (tank)
	Inlet line too long or too small in diameter	Increase suction pipe size
	Air leaks in suction line or fittings	Correct installation to stop leaks
	Vortex in tank near inlet pipe opening	Increase submergence or baffle to stop vortex
	Air entering booster pump	Correct installation of booster pump
	Broken or weak valve spring	Replace valve spring
	Valve damaged	Repair/replace valve
	Loose plunger, piston, or rod	Tighten loose components
	Low oil level in power end	Fill to proper level
	Excessive main bearing clearance	Adjust end-play
	Worn wrist pin	Replace worn components
	Pump running backward	Correct rotation
	Loose bushes (v-belt drive)	Tighten loose components
	Worn packing allows air ingress	Replace packing
	Excessive pressure variation in discharge	Install discharge pulsation dampener
	Piping inadequately supported	Install supports at proper locations
	Excessive short-radius elbows or tees	Correct installation to minimize turns and short-radius fittings
	Water in Power End crankcase	Drain. Refill with clean oil

4.6 Fault Finding continued

SYMPTOM	POSSIBLE CAUSE	REMEDY
Rapid suction pressure fluctuation	Pump cavitation	Increase suction size or NPSH
	Air is entering suction line	Correct installation to stop leaks
Pump requires excessive power	Discharge pressure too high	Reduce system back-pressure or relief valve
	Speed too high	Reduce speed
	Packing too tight	Loosen nut packing adjuster
	Misaligned coupling	Correct alignment
	Belts too tight	Correctly adjust belt tension
	Power end bearings too tight	Increase end-play
	Low motor voltage	Supply correct voltage
Power end overheats (above 85°C)	Discharge and/or suction pressure too high	Reduce pressure or reduce plunger size
	Oil level too high or too low	Adjust to correct oil level
	Contaminated power end oil	Refill with clean oil and eliminate contamination
	Incorrect oil viscosity or grade	Fill with correct oil
	Misaligned coupling	Correct alignment
	Belts too tight	Correctly adjust belt tension
	Pump running backward	Correct rotation
	Pump located too close to heat source	Remove heat source or install crank case cooler
	Worn or damaged power end bearings	Replace damaged bearings
	Tight main bearings	Correct clearance
	Pump speed too low	Increase speed
Crankshaft jerks or starts and stops rotation	Drive belts loose and slipping (if equipped)	Correctly adjust belt tension
	System relief valve pressure set too high	Reduce relief valve pressure setting
	Discharge line blocked or partially blocked	Clear obstructions from piping system
Fluid leaking from pump	Packing leaking	Replace packing
	Fluid cylinder bolts not properly tightened	Properly tighten and torque bolts
	Fluid head o-rings damaged	Replace damaged o-rings
Reduced packing life	Highly abrasive particles in fluid	Install strainer or filter
	Incorrect packing or fluid type	Change to correct packing or cup
	Inadequate packing lubrication	Increase lubrication rate and replace packing
	Pump was run dry for extended time	Correct problem and replace packing
	Nut Packing Adjuster too tight	Properly adjust Nut Packing Adjuster
	Nut Packing Adjuster too loose	Properly adjust Nut Packing Adjuster
	Too much packing in box	Correct installation problem

4.6 Fault Finding continued

Reduce system back pressure or relief valve	POSSIBLE CAUSE	REMEDY
Reduce suction pressure or plunger diameter	Highly abrasive particles in fluid	Install strainer or filter
	Change procedure to drain fluid when cold	Change to correct packing or cup
	Correct piping system problems	Increase lubrication rate and replace packing
	Pump was run dry for extended time	Correct problem and replace packing
	Nut Packing Adjuster too tight	Properly adjust Nut Packing Adjuster
	Nut Packing Adjuster too loose	Properly adjust Nut Packing Adjuster
	Too much packing in box	Correct installation problem
	Highly abrasive particles in fluid	Install strainer or filter
	Cavitation damage	Correct problem and replace damaged valves
	Air leaking into suction line or packing	Correct problem and replace damaged valves
	Suction inlet insufficiently submerged	Increase submergence or baffle to stop vortex
	Relief valve or bypass piped to suction	Pipe back to reservoir tank
	Valve damaged by improper installation	Replace damaged components
Broken crankshaft or connecting rod	Discharge pressure too high	Reduce system back pressure or relief valve
	Suction pressure too high	Reduce suction pressure or plunger diameter
	Fluid freezing in fluid end	Change procedure to drain fluid when cold
	Hydraulic shock due to cavitation	Correct piping system problems
Excessive wear of Power End parts.	Poor lubrication.	Replace oil as recommended instructions. Keep oil clean and at correct temperature. Be sure oil is reaching all bearings.
	Liquid in Power End.	Drain Power End. Check seal housing and filler breather for damage or wear.

These notes are only a guide! Contact Ram Pumps Ltd. on +44 (0)1903 206622 for confirmation or advice.

4.6.1 Appendix

Auxiliary Equipment

Other items either attached or packed with the pump, ie gear box or pulsation dampers.

NPSH (Net Positive Suction Head)

The required NPSH by a pump (NPSHR) is the minimum capacity the suction line has to supply without causing the media to boil or cavitation within the pump. Ideally the available NPSH (NPSHA) should be grater then the NPSHR of the pump. Many factors can influence the NPSH of a suction line and ideally a pump should be within 1.5 meters of a tank holding 6-10 times the capacity of the pump suction. All sharp bends and pipe reductions should be avoided as much as possible. Contact Ram Pumps Ltd for advise.

Cavitation

The formation of vapour bubbles in a flowing liquid in a region where the pressure of the liquid falls below its vapour pressure. The bubbles or cavities will collapse when they pass into the higher regions of pressure, causing noise, vibration, and damage to many of the components. Cavitation will be formed on the suction stroke only. The main cause is the NPSAA is lower then the NPSAR. Cavitation can generate massive forces capable of causing serious damage to pumps and must be avoided at all cost. Other signs will be loss of capacity, pressure and efficiency.

Acceleration Head

Pressure pulsations generated by a system resisting flow fluctuation from the pump. This depends on the mass of the liquid that has to follow the variations in velocity from the pump (the flow fluctuations). For triplex pumps the flow can come to a near halt creating big peeks. For Quintuplex pumps there is a pulse overlap so the pulsations do not peek as high as a quintuplex.

The pump creates the flow but the system creates the pressure and therefore the pressure pulsations.

This can also cause a suction pressure loss that will prevent the pump from filling. Before initial start up or after any maintenance work on the pump fluid end, be certain to bleed out any entrained gasses from the fluid head.

5.0 Limited Warranty

Ram Pumps Ltd will repair or replace any component of its own manufacture which, in the opinion of Ram Pumps Ltd, is defective in workmanship or material under normal or proper use provided the same is returned at the customer's risk and expense to Ram Pumps' works within 12 months or 1000 running hours (whichever is the sooner) from acceptance.

Product failure due to any other reason including, but not limited to misuse, negligence, accident, normal wear and usage, or improper installation and operation, will not be remedied under the warranty.

The warranty is valid only if Ram Pumps Ltd Personnel performs the repairs. No claim for labor or consequential damages will be allowed.

Ram Pumps Limited does not accept any liability whatsoever for the consequential loss or damage, which may in anyway arise out of defective material or workmanship or operational malfunction.

Equipment not of Ram Pumps' manufacture will not be covered by any warranty other then that supplied to Ram Pumps by the equipments manufacturer.

Sealing elements, packing's, 'O' rings and elastomers are not the subject of warranty cover.

If equipment can not be returned to Ram Pumps works for whatever reason, a Ram Pumps technician can visit the site where the equipment is located but cost of the trip will not be covered by Ram Pumps.

The warranty is invalidated by:

- Misuse of the unit.
- Unauthorized alteration to the unit or the introduction of non-standard parts.
- Failure to comply with the measures laid out in this document.

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