Brown Brothers

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A Vickers Marine Engineering company

Project Title:	Swivel for Petrojarl 1	Date:	12/6/95
Customer Reference:		Contract No.:	4-47-4360
Approval required by:		Your Contact:	R. Wragg

Submitted for: Information ☐ Approval ☐ Record ☑

Submittal of: Plans ☐ Manuals ☑ Reports ☐ Drawings ☐ Calculations ☐ Other ☐

Submittal type: Preliminary ☐ Final ☑ Partial ☑ Complete ☐

Item No.	Document Number	Issue No.	Title/Description	Qty.
A	A-003561	6	Interunit Connection Diagram, Swivel Control	5 1
B	SK11749	4/6	Starter Wiring Diagram INSERT 16.06.95 BRS The above drawings are to be incorporated in the manual. Previous issues should be removed and destroyed.	5 1
C	SK11749		Sticky back wiring diagram The above sticky back drawing is to be fitted inside starter unit. Previous issue should be removed and destroyed. Note:- The above updates required due to the fitting of the bypass solenoid valve during commissioning.	4

Yours faithfully

SIGNATURE: Robert J Wragg TITLE: .....

TECHNICAL MANUAL

TRIPLE PASS SWIVEL

BB CONTRACT NO.	4-47-4360/4-49-7281
GNO ORDER NO.	T94-4078
DOCUMENT NO.	R-005651
VESSEL	PETROJARL I

WHEN ORDERING SPARE PARTS
PLEASE QUOTE THE ABOVE
CONTRACT NUMBER

February 1995

HEALTH & SAFETY

AXIAL SWIVEL PASSES GAS UNDER HIGH PRESSURE

TOROIDAL SWIVEL PASSES LIVE CRUDE OIL

DO NOT WORK ON THE SWIVEL UNLESS POWER PACK MOTOR IS ISOLATED. PLACE NOTICE ON STARTER TO THE EFFECT THAT THE SWIVEL IS BEING WORKED ON.

WIPE UP ANY HYDRAULIC OR LUBRICANT SPILLAGE IMMEDIATELY TO AVOID SLIPPAGE.

ENSURE THAT HYDRAULIC RESERVOIR IS FILLED TO CORRECT LEVEL TO AVOID OVERHEATING AND FLUID DEGRADATION.

DO NOT PLACE HANDS, FEET OR LIMBS IN DANGEROUS AREAS SUCH AS SLEW DRIVE GEAR TEETH OR HARD STOP IN WAY OF TURRET AS THE FORCES GENERATED BY THESE MECHANISMS ARE LARGE.

ENSURE LEAKAGE (IF ANY) FROM SWIVEL IS PIPED TO SAFE COLLECTION POINT.

DO NOT WORK ON THE STARTER UNLESS POWER IS ISOLATED.

FAMILIARISE YOURSELF WITH THE WORKINGS OF THE SWIVEL.

ALWAYS OBTAIN PERMISSION FROM THE PETROLEUM ENGINEERING SUPERINTENDENT OR SOMEONE OF EQUAL AUTHORITY BEFORE WORKING ON ANY EQUIPMENT IN HAZARDOUS AREA.

BEFORE WORKING ON SWIVEL CHECK THE FOLLOWING:-

- PRESSURE IS NOT TRAPPED IN SWIVEL
- SWIVEL IS EMPTY OF ALL FLUIDS

- AXIAL SWIVEL IS PURGED WITH INERT GAS OR HAS BEEN BLOWN THROUGH WITH AIR

- SWIVEL IS ISOLATED FROM TURRET FLEXIBLE PIPES.

SEAL AND SEAL INSERTS SUPPLIED TO PETROJARL I IN 1986/87 DO NOT FIT AXIAL SWIVEL SUPPLIED IN 1995.

ENSURE ICE DOES NOT ACCUMULATE ON TOP OF SWIVEL OR ON SLEW GEAR TEETH. ICE TRAPPED BETWEEN SLEW GEAR AND PINION MAY CAUSE DAMAGE TO EQUIPMENT IF OPERATED WHILE ICED UP.

STORE THE HAND CRANK IN A SECURE AREA. DO NOT LEAVE IT ATTACHED TO GEAR BOX.

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1. SPECIFICATION

1.1 SWIVEL

BB Drg No. B-003 682

Triple pass swivel comprising two low pressure toroidal passes and one high pressure axial swivel complete with slew gear drive arrangement.

1.1.1 GENERAL

BB Drg. No. B-003 682

Location		In way of moonpool above splash zone.
Environment		-10% to +45°C 0% to 95% RH
Acceleration:	longitudinal	0.5g
	Athwartship	0,5g
	Vertical	0.5g (1.3g transit)
External loads:	Axial	50,000 Kg
	Radial	10,000 Kg
Gear wheel/pinion ratio		7.5:1.0
Speed of Rotation		3°/sec max (0.5 rpm)

1.1.2 TOROIDAL SWIVEL

BB Drg. No. B-002 091

No of passes	2
Flow path size (NPS)	6" & 8"
Design pressure	650 psi
Test Pressure	975 psi
Fluid type	produced fluids
Fluid temperature	0°C to 90°C
Flanges	ANSI. Class 300
Geostationary element	Core
Weathervaning element	Casing

1.1.3 AXIAL SWIVEL

BB Drg. No. B-002 904

No of passes	1
Flow path size	4.125"
Design Pressure	5000 psi
Test Pressure	7500 psi
Fluid type	Gas Injection
Fluid temperature	0°C to 90°C
Flanges	API 5000/10000 psi
Geostationary element	lower body
Weathervaning element	upper body

1.2 TORQUE DRIVE

Hydraulically driven planetary gearbox with an output pinion meshing with a spur slew gear on inner race of slew bearing attached to swivel core. Hand operated back up gearbox is fitted.

1.2.1 GENERAL

BB Drg.No. B-003 747

Location: Motor & G/B	Mounted on swivel
Power Pack	Safe area between decks.
Swivel starting torque	120 KN-m
Swivel running torque	60 KN-m
Environment	-10% to +45°C 0% to 95% RH

1.2.2 SLEW GEAR

TYPE: External Spur Gear

No of teeth	90
Module	10.00
Face width	85.0
Addendum Modification	+5.00
Dedendum Modification	-1.00
Pressure Angle	20°

1.2.3 PINION

TYPE: External Spur Gear

No of teeth	12
Module	10.00
Face width	90
Addendum Modification	+8.00
Dedendum Modification	-1.00
Pressure Angle	20°

1.2.4 GEARBOX

TYPE: Planetary

Reduction Ratio:	Hydraulic	29.4:1
	Manual	92.8:1
No. of stages:	Hydraulic	2
	Manual	2+1

1.2.5 HYDRAULIC MOTOR

TYPE: Gerotor Gear

Displacement	315 cc/rev
Max Speed Rating	240 rpm
Max Pressure Rating	210 Bar
Required output pressure	140 Bar

1.2.6	HYDRAULIC PUMP	TYPE: Gear
	Displacement	20 cc/rev
	Max Speed Rating	3000 rpm
	Max Pressure Rating	210 Bar
	Required output pressure	160 Bar
1.2.7	CONTROL VALVE	TYPE: D.C. Solenoid Valve
	Control Voltage	24V.dc
	Control Current	0.33A
	Maxflow rating	100l/min
	Max pressure rating	250 Bar Cont.
	Time: Neutral to max	200 ms
	Time: Max to neutral	115 ms
	Filtration (ISO 4406)	17/14
1.2.8	ELECTRIC MOTOR	TYPE: foot mounted squirrel cage synchronous T.E.F.C
	Supply	440v/3/60
	Speed (synchronous)	1800 rpm
	Continuous Power	11 Kw c/w 120V. AC. Heater
1.2.9	HYDRAULIC RESERVOIR	TYPE: Deck mounted
	Capacity	150 litre
	Filtration (ISO 4406)	17/14
	Low level Switch	Float type

1.3 CONTROL SYSTEM

1.3.1 GENERAL

Cabling Diagram	BB Drg A-003 561
Starter Diagram	ACME Drg. SK11749

1.3.2 EQUIPMENT LOCATION

Proximity Switches	Turret: Hazardous Area
Isolation Amplifier (in flameproof box	Turret: Hazardous Area
Starter	Between Deck: Safe Area

1.3.3 EQUIPMENT ENVIRONMENTAL RATING

Proximity switches	-25°C to +100°C
Isolation Amplifiers (in flameproof box)	-20°C to +100°C
Starter	0°C to +40°C

1.3.4 EQUIPMENT PROTECTION RATING

Proximity Switches	IP 67
Flameproof box	IP 66 (Hylomar Sealant)
Starter	IP54

1.3.5 EQUIPMENT TYPE

Proximity Switches	Pepperl & Fuchs NJ15-30GM-N
Isolation Switches	Norcon Norrus Ltd 12365 INX
Isolation Amplifier	Pepperl & Fuchs KHD2-RW1/Ex1
Starter	ACM Ltd TA 1285

1.4 **TORQUE TUBE/HARD STOP** BB Drg. No. B-003 556

Mechanical means of ensuring that swivel's geostationary element stays in correct orientation with turret in the event of control and/or drive system malfunction.

1.4.1 TORQUE TUBE BB Drg. No. B-002 902

Type:		Two halves bolted together with mousehole for dog drive.
Size:		3000 x ø840 x ø800
Torque Capacity:	Normal	125 KN-m
	Integrity	250 KN-m

2. DESCRIPTION: EQUIPMENT

2.1 SWIVEL

2.1.1 GENERAL (Fig 1)

2.1.1.1 The triple pass swivel comprises two toroidal flow paths and one axial pass. The axial pass is accomplished by a separate in-line swivel located above and bolted to the twin pass toroidal swivel. The axial pass is for high pressure gas, the others are for low pressure liquids.

2.1.1.2 An offset angled hole connects the axial swivel with the lower face of the toroidal swivel.

2.1.1.3 The complete swivel stack is attached to the vessel via the 8" casing. Flexible risers run from the base of the core to the turret pipeline manifold. A torque tube is also attached to the base. The swivel stack is supplied completely assembled and tested with the slew drive motor and gear boxes attached.

2.1.2 TOROIDAL SWIVEL (Fig 2)

2.1.2.1 The toroidal swivel comprises a single core for the two flow paths with each path having an independent outer casing. The outer casings incorporate the exit flanges (radial flow) and the core incorporates the inlet flanges (axial flow).

2.1.2.2 A seal ring is attached to the top and bottom of each casing and houses the primary and secondary dynamic seals. A cross-drilling between the seals connects with the outside of the casing where a hand valve is fitted.. The cross drillings and hand valves allow leakage past the primary seal (if any) to be monitored.

2.1.2.3 The seals are of the elastomer energised type with PTFE utilised as the sliding dynamic element with a fabric reinforced anti-extrusion ring. The seals are radial acting in the toroidal swivel are of the radial type (Fig 9).

2.1.2.4 The 8" inlet flow path is drilled up to meet the lower circular flow path while the 6" is drilled vertically up to intercept the top circumferential cut out in the core. The core is scalloped away at the intersection of the axial and circular galleries to significantly increase the flow area in this region and thus reduce pressure drops and erosion/corrosion effects at the change in direction from vertical to radial.

2.1.2.5 The lowest seal ring incorporates a journal bush which acts as a steady bearing. A slew bearing is located at the swivel top end. The inner race is bolted to the core and the outer race is fixed to the top seal ring. The bearing allows rotation of the casing with respect to the core.

2.1.2.6 The upper case is attached to the lower case by bolts via a spacer ring. Thus the lower case rotates in sympathy with the upper case. The slew gear wheel (ref.2.2 below) is bolted to the core via the inner race of the slew bearing. The pilot on spigot location on the inner race and gear wheel ensure that they are concentric.

2.1.3 **AXIAL SWIVEL (Fig 3)**

2.1.3.1 The axial swivel (fig 3) is a modified version of that supplied to Petrojarl I in 1986. The main alteration has been to change the internal seal inserts to allow a larger seal cavity volume.

NOTE:

INSERTS FROM ORIGINAL SWIVELS (1986 SUPPLY) ARE NOT INTERCHANGEABLE WITH MODIFIED INSERTS. 1986 SEALS ARE NOT INTERCHANGEABLE WITH 1995 SEALS

2.1.3.2 The seal sleeve is attached to the lower body with the seal ring being bolted to the upper body. The two bodies are separate by a 4-point contact slew bearing. The outer race being attached to the lower body and the inner race to the upper body. The bearing allows relative rotation between the two bodies.

2.1.3.3 There are two dynamic seals located between the seal ring and the sleeve - primary seal and secondary seal. The seals are of the same type as those used in the twin pass swivel except that they are face seals with the anti-extrusion ring being to the outside (fig 9).

2.1.3.4 Cross drillings connects the region between the primary and secondary seal with a hand valve in the upper body. This valve and associated passageways through the swivel allow any leakage past the primary seal to be monitored.

2.2 TORQUE DRIVE (Fig 4)

2.2.1 The seal friction does not normally allow the swivel core to remain geostationary with the turret when the vessel weathervanes.

2.2.2 To overcome this a torque drive system is fitted and comprises a spur gear wheel attached to the slew bearings inner race (fig 8). The gearwheel mates with a spur pinion gear, on the planetary gear box. The gearbox is driven by a small hydraulic motor powered from a remote electro-hydraulic power pack.

2.2.3 A second gearbox is fitted. The gearbox is manually driven and is used as a back up to the hydraulic drive in an emergency.

NOTE:

THE TWO GEARBOXES ARE NOT INTERCHANGEABLE
THE OUTPUT PINIONS ARE INTERCHANGEABLE
THE HAND CRANK MUST NOT BE
STORED ON THE MANUAL GEARBOX

2.2.4 The gearboxes are multi-stage reduction planetary type and can be back driven.

2.2.5 The electrohydraulic power pack (fig 5) is located in a non-hazardous area remote from the swivel and is connected to the hydraulic motor with three pipe lines. The two larger pipes connect the control valve to the "A" to "B" ports on the motor, The smaller pipe connects the motor drain to the power pack reservoir.

2.2.6 The power pack is based upon a deck mounted reservoir. The fixed displacement hydraulic pump is driven by an electric motor via a flexible coupling and is supported from the motor by means of a bell-housing. The pump takes oil from the tank through a suction strainer and delivers it to the valve module.

2.2.7 The valve module is of the monobloc design and houses all the valves. The first stage contain the pump relief valve and the load compensating valve which control the pump pressure. In addition this section has the pressure reducing valve and relief valve which limits the servo pressure to 15 Bar. The second stage is mainly concerned with the directional control valve and load - sensing circuit. The circuit relief valves are in the last or output stage of the module.

2.2.8 The directional control valve is fitted with a servo solenoid (DC) which operates the valve when it receives a signal from the control system. When electric control is not available the valve can be operated by hand. A lever is fitted for this purpose.

NOTE

WHEN HAND OPERATION IS IN USE

DISCONNECT THE SOLENOID

2.2.9 The directional control valve has a closed centre spool ie in the neutral position all ports are isolated. When the power pack is inoperative hydrualic oil is trapped in the lines between the motor and the power pack. The closed centre valve allows negligible leakage from the circuit to the reservoir.

2.2.10 A by-pass valve is fitted to the circuit in close proximity to the hydraulic motor and is connected to the main system lines via non-return valves. There are 4 non-return valves, 2 allow flow from the system to the valve and 2 allow flow from the header tank to the system. The by-pass valve only allows flow in one direction, from the system to the header tank.

2.2.11 The by-pass valve is of the poppet type and is operated by an electric solenoid. The solenoid is suitable for use in a hazardous area. When the solenoid is energised it block flows through the valve. When the solenoid is de-activated it returns to the by-pass condition due to the spring. When in the blocked position a relief valve built into the main valve limits the pressure across the valve.

2.2.12 The header tank is located close to and above the swivel.

NOTE
THE HEADER TANK MUST BE A
MINIMUM OF 2 METRES ABOVE
THE HYDRAULIC MOTOR AND ASSOCIATED
NON-RETURN VALVES

2.2.13 The motor drain line to tank is fitted with a non-return valve. The valve is in the power pack and it ensures that the drain line is always full of oil.

2.2.14 As there is minute leakage across the directional control valve's spool there is a continuous weep of fluid from the leader tank to the power pack's reservoir. If not attended to this will eventually cause the reservoir to overflow creating a hazard. It will also allow the header tank to drain down which may allow the motor to be starved of oil.

NOTE
CHECK VOLUME OF OIL IN HEADER
TANK MAIN RESERVOIR EVERY DAY
AND ADJUST AS REQUIRED

2.3 CONTROL SYSTEM (FIG 6)

2.3.1 The control system is used to realign the swivel when the ship weathervanes. Three proximity switches and an explosion proof box housing the isolation amplifiers are mounted on the turret tower in way of the torque tube. The monitoring signals for the control system (fig 10) originate at the swtiches.

2.3.2 The control logic is located within the motor starter sited in a safe area. The promity switches communicate with the starter via the ship-turret telemetry system. The motor starter is wired to the electric motor and directional control valve in the electro-hydraulic power pack.

2.3.3 The starter incorporates safety features as listed below:-

- TIMERS: Limits the operational period of the power unit such that the swivel rotates from an extreme position to mid position but is not allowed to travel to the opposite extreme position.

- MOTOR OVERLOAD: Detects high motor current and will switch off motor if overload occurs.
- CONTROL VALVE Mutually exclusive switching

2.3.4 A centre proximity switch detects that the central position has been reached and stops the motor.

2.3.5 The starter which normally operates in automatic mode, has the option of running in manual, allowing hand operation of the control valve. The starter incorporates the indications listed on next page.

- overtravel left
- overtravel right
- centre
- motor running
- motor overload

2.3.6 In addition the system provides voltage free contacts for the above and also for a low level switch in the hydrualic tank.

NOTE

THE MINIMUM OPERATING TEMPERATURE FOR ITEMS IN THE HAZARDOUS AREA (PROXIMITY SWITCHES AND ISOLATION AMPLIFIERS) IS -20°C.

NOTE

FLAMEPROOF BOX HOUSING ISOLATION AMPLIFIERS REQUIRES TO BE SEALED AFTER ALL WIRING AND INTERFACES HAVE BEEN CHECKED OUT.

HYLOMAR SEALANT TYPE BAS 1050U IS TO BE USED ON LID. CORNING SILASTIC TYPE 732 RTV SEALANT MAY BE USED ON LID FIXING SCREW HEADS.

2.4 TORQUE TUBE/HARD STOP (Fig 7)

2.4.1 A back up system to the hydraulic torque drive is provided and comprises a torque tube attached to the bottom of the swivel (to the core) and reaches from the swivel down to the turret tower, a distance of about 3 meters. At the lower end of the hollow torque tube two mouse holes are cut out and are diametrically opposite.

2.4.2 Two dogs are bolted to an interface frame which is fixed to the turret tower. These dogs act on the torque tubes mouseholes, when the vessel has moved about 15 degrees from its mid aligned position with the geostationary turret. The proximity switches along with the isolating amplifiers are mounted in a bracket attached to the interface frame.

2.4.3 The proximity target is attached to the torque tube. The torque tube is constructed in two halves. Holes are cut in the torque tube near the top. These holes allow air to pass freely out of the tube ensuring that gas pockets are not trapped.

NOTE
HOLES MUST NOT BE ALLOWED TO
BECOME CLOGGED OR COVERED UP.
ENSURE HOLES DO NOT ICE UP

2.4.4 The proximity switches are housed on a spring energised pod. This pod is held in contact with the torque tube by the spring force. In this way the switches will follow any torque tube radial movement. Also axial movement of the torque tube will have no effect on proximity switch operation.

2.4.5 The pod engages the torque tube via a "castor ball" which runs on a non-metallic-strip.

DOCUMENT NO. R-005651

NOTE

MECHANISM MUST NOT BE ALLOWED TO BECOME CLOGGED/STICKY/RUSTY OR ICED UP AS THESE CONDITIONS MAY PREVENT CORRECT SWITCH OPERATION

3. FUNCTIONAL DESCRIPTION

3.1 SWIVEL

The swivel acts as a rotary fluid coupling between the turret and the vessel. Flexible pipes from the turret manifold pass through the torque tube to the lower face of the swivel core. The 8" and 6" line, carrying well liquids enter the toroidal swivel (fig 2). The 4" line carries gas from the axial swivel (fig 3) down through the toroidal swivel to the turret manifold.

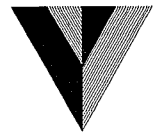
3.1.2 The outer casings of the toroidal swivel are connected with flexible pipes to the ship mounted manifold and on to the petrochemical plant on the vessel. The axial swivel's upper body receives high pressure gas from the vessel. The outer casings and axial upper body are fixed to the vessel with the toroidal core and axial lower body being supported from them via slew bearings. These bearings allow relative rotation in the swivel assembly (fig 1).

3.1.3 As the vessel weathervanes around the geostationary turret the toroidal casings and the axial upper body rotate in sympathy with the vessel. The inner core is forced to remain substantially in phase with the turret by means of the torque drive system or torque tube mechanism.

3.1.4 In this way a rotary connection is made between the turret and the vessel allowing free flow of fluid (liquid and gas) from the well in the sea bed to the vessel via the turret and swivel.

3.2 TORQUE DRIVE

3.2.1 The seal friction tends to drag the swivel core (and lower axial body) around with the outer casings and the ship. If this was allowed to continue, eventually the flexible pipes from the swivel to the turret manifold



would twist and become damaged. To overcome this a torque drive mechanism is fitted.

3.2.2 The gearboxes are fixed to the outer casing and thus remain in a fixed position relative to the ship. The primary gearbox is driven by a hydraulic motor, the secondary gearbox is furnished with a hand crank. Both boxes are capable of being back driven by the other box.

3.2.3 When the ship weathervanes by a certain amount a switch is triggered on the turret. This activates the power-pack which sends pressurised fluid to the hydraulic motor causing it to rotate. The hydraulic motor drives the gearbox and the output pinion rotates.

3.2.4 The pinion being meshed with the slew gear induces the gear to revolve. The slew gear being connected to the swivel core induces the core (and axial lower body) to revolve. When it reaches its original position another signal stops the power pack.

3.3 CONTROL SYSTEM

3.3.1 The swivel body and its angular relationship to the turret is controlled by the hydro-mechanical arrangement (described above) which limits the angular displacement relative to the turret. The swivel is automatically realigned by the torque drive which drives the inner swivel body or core back to initial central position.

3.3.2 The position of the swivel core, relative to the turret, is monitored by three proximity switches mounted on a bracket fixed to the turret. These monitor the central location and extreme travel left and extreme travel right positions.

3.3.3. The switches which are intrinsically safe are fed into an EEx'd flameproof enclosure which must be within 2 metres of the switches. This box contains three isolation amplifers which allows the proximity switches to be mounted in the hazardous area. The box is fixed to an interface frame on the turret tower.

3.3.4 The isolation amplifers provide the signal (via voltage free contacts) to the turret telemetry system which communicates the signal to voltage free contacts in the safe area, representing proximity switch functions. These safe area contacts are used to control the motor starter and hydraulic power pack.

3.3.5 When the vessel weathervanes around the turret, the swivel rotating with the ship, moves from its initial central position to the maximum permissible angle; where an extreme position proximity switches is activated. The switch when activated causes the electric motor in the power pack to be started and at the same time sends a signal to the power pack's control valve.

3.3.6 The control valve directs the flow from the power pack pump to the hydraulic motor which turns the swivel by means of the gearbox. The swivel is driven back to its initial position when the central proximity switch is activated. Activation of the central proximity switch cuts the signal to the control valve stopping hydraulic flow to the motor. The electric motor is also stopped.

3.3.7 In addition there is a timer in the starter which limits the time the valve is energised, thus limiting the maximum swivel movement. The timer is set such that it allows the swivel to be driven from an extreme position to the central position but switches off before the opposite extreme position is reached.

3.3.8 The starter provides the following voltage free contacts for alarm or monitoring by external system.

- OVERTRAVEL LEFT	Closing contact which stays closed for about 5 seconds when the appropriate switch detects that the swivel has moved to the extreme left position.
- OVERTRAVEL RIGHT	Similar to the above except being for the extreme right position.
- CENTRE	Closing contact when the central proximity switch detects that the swivel has moved to the centre.
- MOTOR RUNNING	Closing contact when motor is running.
- MOTOR OVERLOAD	Opening contact to represent this fault condition.
- AUTO	Closing contact when the starter is set to operate in the automatic mode.

- All above contacts are rated at 220V 2A ac/dc resistive load.

3.4 TORQUE TUBE/HARD STOP

3.4.1 When there is a failure in the control or torque drive system the swivel will weathervane with the vessel and travel past the extreme travel proximity switches. The torque tube and hardstop limit the total amount of travel.

3.4.2 The swivel continues to rotate with the vessel while the vessel is weathervaning. The torque tube rotates with the swivel until it hits the hard stop. Any further weathervaning of the vessel will not affect the swivel due to the hard stop. The torque tube is capable of driving the swivel when all passes are at design pressure as well as back driving the two gearboxes.

4. MAINTENANCE

4.1 GENERAL

4.1.1 The swivel stack with its associated electrical, hydraulic and mechanical equipment are of simple and rugged design requiring the minimum input to ensure good working order. The main activities are in lubricating the moving parts and ensuring that the oil level in the tank is kept at the correct level.

4.2 LUBRICATION

4.2.1 The lubricants required are tabulated in the LUBRICATION CHART at the end of this chapter.

4.2.2 Hydraulic oil is fed into the reservoir through the breather/filter on the tank top. Gear teeth lubricant is applied by a stiff brush. Gearbox lubricating oil is fed into the box via a removable threaded plug.

4.2.3 The slew bearing is grease lubricated via the grease points on the external race.

4.3 MAINTENANCE SCHEDULE

4.3.1 DAILY

Check fluid level in header tank and power pack reservoir and adjust volumes as required to ensure that reservoir does not overflow.

4.3.2 MONTHLY

Carry out maintenance as per 4.3.1 above.

(i) Check swivel stack, torque tube and hard stop bolts - tighten if necessary

(ii) Check hydraulic connection for leaks - tighten or replace as necessary

(iii) Check hydraulic connection for leaks - tighten or replace as necessary

(iv) Check gear box lubricant level - top up as required

4.3.3 3 MONTHS

(i) Carry out maintenance as per 4.3.2 above.

(ii) Lubricate slew bearing

(iii) Lubricate gear teeth and gearbox pinion.

(iv) Lubricate sensor castor belt and spring.

4.3.4 12 MONTHS

(i) Carry out maintenance as per 4.3.3 above.

(ii) Lubricate electric motor bearings.

4.3.5 24 MONTHS

(i) Carry out maintenance as per 4.3.4 above.

(ii) Replace filter elements in reservoir.

(iii) Check quality of hydraulic oil (send sample to laboratory to check for water, metallic and general contamination/degradation). Change out oil as required and flush system if contamination level is outwith specification.

4.4 SPARE GEAR

4.4.1 ELECTRICAL SPARES

Starter Spares	1 set	P-002640
Proximity Switches	2	P-002618
Isolation Amplifier	1	P-002639
Control System	1 set	P-002746

4.4.2 SWIVEL SPARES

Seal: Lotork Elastolion	8	JW 172 514
Seal: Lotork Elastolion	1	ø108.5 x ø142.5 x ø12
Seal: Lotork Elastolion	1	ø141.5 x ø176.5 x ø12
Seal: Endless lip	1	JW.TA 14405A-2
Seal: Endless lip	2	JW.TA 14405A-1
Seal: o-ring Elastolion	1	JW 50-248
Seal: o-ring Elastolion	1	JW50-214
Seal: o-ring Elastolion	8	ø840 ID & ø5.7
Slew Brg: 4-point contact	1	B-002287
Valve: Needle	1	P-002762
Valve: Cartridge	1	P-003593

4.4.3 MECHANICAL SPARES

Slew Brg: 4-point contact	1	B-001835
Gearbox: 92.8:1 Ratio	1	P-002958
Splined Shaft: Input Coupling	1	P-003424
Handle: Detachable	1	B-003740
Guide Block: Assembly	1	B-003724

5. FIGURES

Fig 1: Triple Pass Swivel
Fig 2: Toroidal Swivel
Fig 3: Axial Swivel
Fig 4: Torque Drive
Fig 5: Electro-Hydraulic Power Pack
Fig 6: Control System
Fig 7: Torque Tube
Fig 8: Slew Bearing and Gearwheel
Fig 9: Swivel Seals
Fig 10: Proximity Sensors
Fig 11: Hydraulic System

6. EQUIPMENT DATA

6.1 DRAWINGS

Triple Pass Swivel	BB. Drg No.	B-003 682
Toroidal Swivel	BB. Drg No.	B-002 091
Axial Swivel	BB. Drg No.	B-002 904
Torque Drive	BB. Drg No.	B-003 747
Cabling Diagram	BB. Drg No.	A-003 561
Starter Diagram	ACME Drg No.	SK 117 49
	" " "	SK 117 84
Torque Tube/Hard Stop	BB. Drg No.	B-003 556
Torque Tube	BB. Drg No.	B-002 902
Sensor Assembly	BB. Drg No.	B-005 204
		B-005 205
Hydraulic Circuit	BB. Drg No.	B-005 266
Power Pack	Bewick Drg No.	010-01851
Solenoid DC Valve	Danfoss Drg No.	94105BRO

MULTI-PASS SWIVEL : PETROJARL I

LUBRICATION CHART

EQUIPMENT OR SYSTEM	LUBRICANT TYPE	SHELL	BP	ESSO	CASTROL	TEXACO	MOBIL	CHEVRON	ROCOL
HYDRAULIC SYSTEM	MINERAL OIL TO ISO VG32/46	TELLUS 32 OR TELLUS 46	HLP-HM32 OR HLP-HM46	NUTO H32 OR NUTO H46	HYSPIN AWS32D	RANDO OIL HD 32 OR HD 46	D.T.E. 13M OR D.T.E. 15M	MECHANISM LPS32 OR LPS46	
ELECTRIC MOTOR	LITHIUM BASED GREASE HIGH TEMPERATURE	ALVANIA GREASE R3	ENERGREASE LS-EP2	BEACON EP2	SPEEROIL GREASE AP3	MULTIFAX EP2	MOBILUX EP2	DURA-LITH GREASE EP2	
SLEW BEARING	MOLYGREASE WITH E.P. ADDITIVES	CALITHIA GREASE HDX		MULTI-PURPOSE GREASE (MOLY)	SPHEEROL LMM	MOLYTEX EP2	MOBILTAC 81	MOLY GREASE EP2	MTS 1000
SLEW GEAR TEETH	OPEN GEAR LUBRICANT WITH CORROSION INHIBITOR	MALLEUS GL95	ENERGOL GR3000-2 OR ENERGREASE GG	SURETT N5K OR SURETT FLUID 4K	SPHEEROL SX2	CRATER 2X FLUID	MOBILTAC C	OPEN GEAR LUBRICANT 250CB	TUFGEAR ALL-WEATHER LUBRICANT
GEARBOX	TRANSMISSION OIL TO MIL-L-2105B API GL4/5	DONAX TT	HYPOGREAR EP OIL 80WEP	IL 2082	AGRICASTROL A5	ETL 2039	MOBILUBE HD80	GULF GEAR LUBRICANT 80W	
SENSOR BALL CASTOR	GREASE WITH CORROSION INHIBITOR								ANTI-SCUFFING SPRAY
SENSOR SPRING PISTON	LIGHTOIL WITH CORROSION INHIBITOR								PTFE SILICONE OIL SPRAY