



ASSEMBLY, MAINTENANCE
& OPERATION MANUAL
ARM 5E ELECTRIC ARM
(Joystick USB Surface Controller)

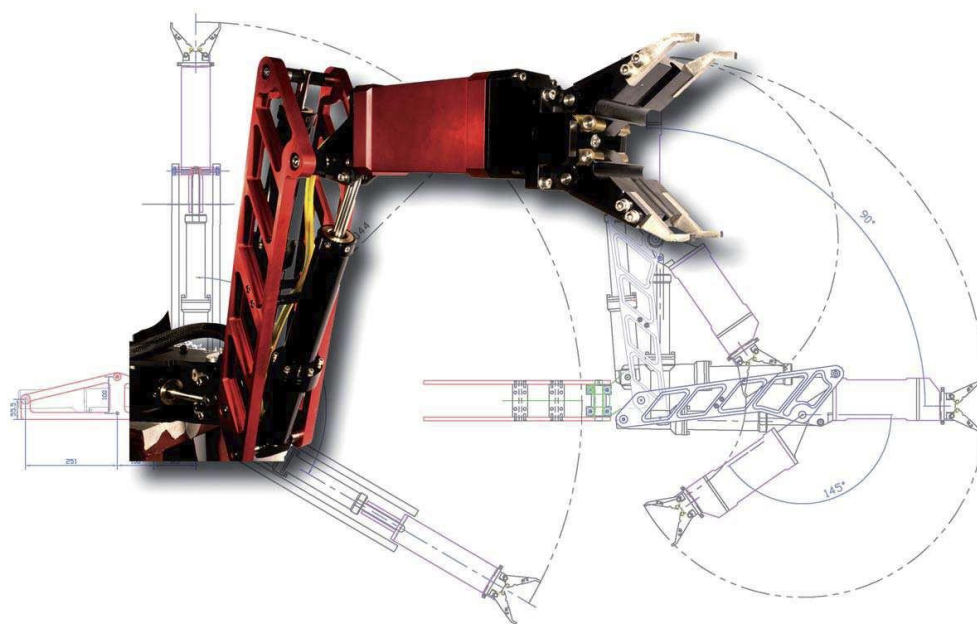
Reference :
SWI - 017



ASSEMBLY, MAINTENANCE & OPERATION MANUAL

ARM 5E

5 Function Electric Manipulator ARM
(Joystick USB Surface Controller)



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1. UP DATE CHART

ISSUE	SUBJECT	ORIGINATOR	VERIFICATION	APPROVAL
Draft A	Draft Issue	KD	MR	SB
Issue A	Original Issue	KD	MR	SB

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2. Introduction

This Equipment has been made in compliance with CE marking Standards.

This manual is written for suitably qualified personnel responsible for operation and maintenance of this equipment. Operating and maintaining must be done according to appropriate general rules.

Non-appropriate or defective use may lead to an irreversible failure of components or the equipment. If any failure occurs, the user must check that the device is safe for its environment.

Before every operation, the operator must check that the system is correctly configured in accordance with this manual.

CAUTION: REPAIRING THE EQUIPMENT WHILE SWITCHED ON IS RESERVED FOR QUALIFIED TECHNICIANS

3. Specification

SLEW	120 DEGREES
ELEVATE	85 DEGREES
ELBOW	130 DEGREES
JAW ROTATE	CONTINUOUS
JAW OPENING	140mm at the tips
REACH	1.0 METRES
LIFT	25KG AT 4 AMPS AT FULL EXTENSION
JAW ROTATE TORQUE	>25NM AT 4 AMPS
JAW ROTATE SPEED	~ 48 RPM AT 24vdc
JAW CLOSING FORCE	60Kg AT 4 AMPS
WEIGHT	18.5KG IN WATER 27KG IN AIR
SUPPLY	24 - 30vdc 240vac
DEPTH	1000 METRES

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4. Description

4.1 System Components

The five function Electric Arm 5E consists of four major components, these are:

- a) Surface Control Unit.
- b) Sub-sea Electronics Housing.
- c) The Manipulator Arm.
- d) Compensator and Manifold (0.5 Litre)

4.2 Surface Electronics

The Arm can either be controlled by the Joystick USB Surface Controller or by the netbook computer. The Joystick USB Surface Controller is powered only when plugged into the USB port of the netbook computer.

The Surface Control Unit illustrated below is the typical standard version. Custom designs can be supplied to suit customer requirements where size or configuration needs to be changed to suit the installation.



Photo 1
(Joystick USB Surface Controller)

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The Manipulator arm is controlled via the Joystick, the Joystick Toggle and the Jaw Grip / Cutter switch (Positioned above the Joystick). The following movements of the Manipulator Arm in relation to the Surface Control Unit demands will occur and are proportional to the level of demand by the operator.



Photo 2
(Joystick and Jaw controls)

4.2.1 Demands

Joystick pulled back (towards the operator) - Shoulder up.
Joystick pushed forward (away from the operator) - Shoulder down.
Joystick moved to the left - Slew left.
Joystick moved to the right - Slew right.
Toggle depressed back - Elbow up.
Toggle depressed forward - Elbow down.
Toggle depressed left - Jaw rotates to the left (counter clockwise).
Toggle depressed right - Jaw rotates to the right (clockwise).
Jaw Grip / Cutter pushed away from the operator - Jaws open.
Jaw Grip / Cutter pulled towards the operator - Jaws close.

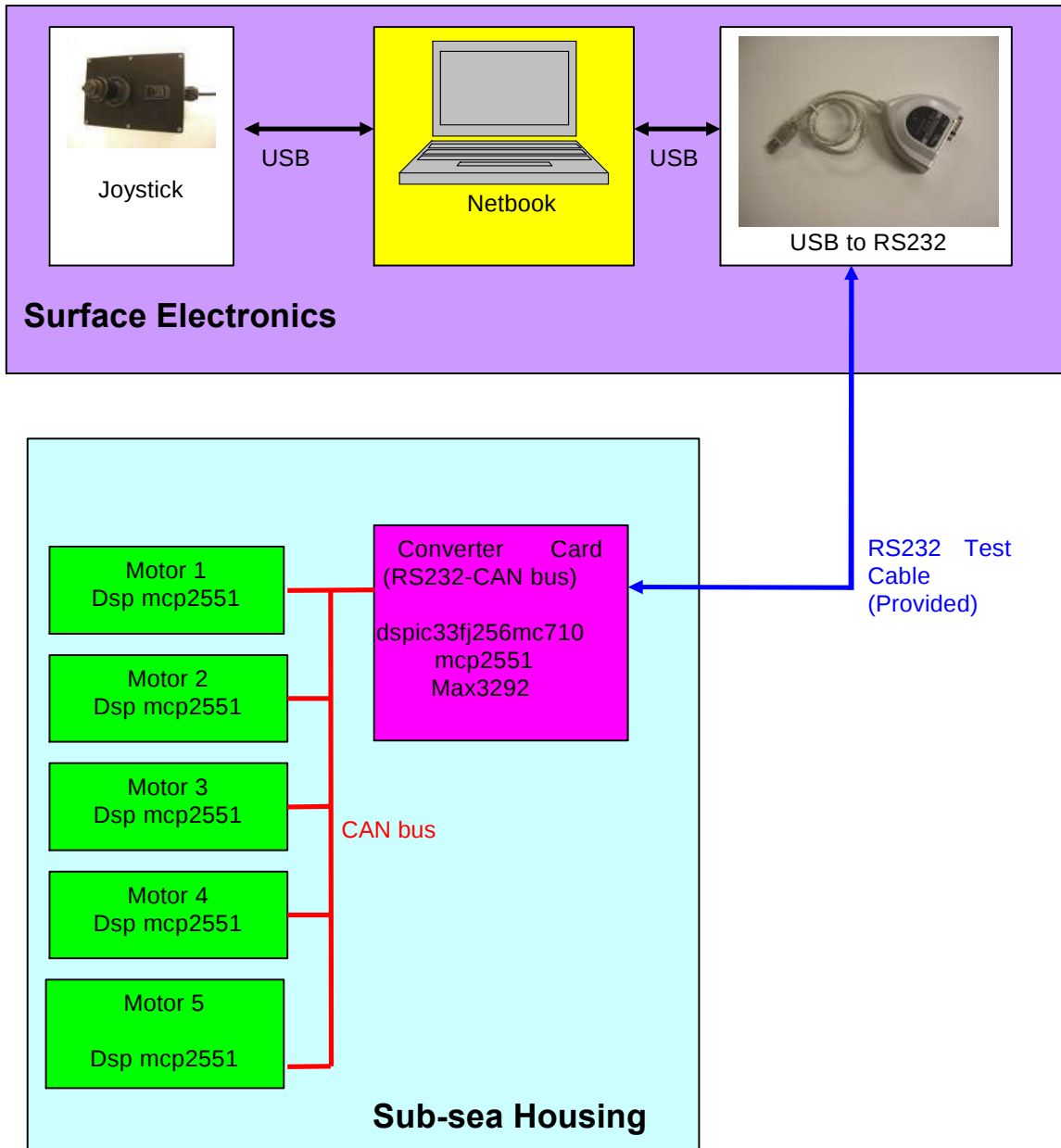
4.2.1 Netbook Controller

The netbook supplied with this system has the following Key features:-

- Intel Core 2 Duo processor
- 1.6Ghz, 2Mb Cashe
- Windows 7 operating system
- 1GB Memory
- 160GB Hard Drive
- 32 Bit

The Control System used within this netbook for driving the Arm and programming the control parameters are contained within Appendix A2.

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Communications system diagram

DSP = Digital signal processor, used as main processor in Motor driver and converter card.
MCP2551 = CAN bus transceiver used in conjunction with DSP above
MAX3292 = RS232 transceiver used in conjunction with DSP above

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4.3 SubSea Housing

This contains the Converter Card (RS232 - CAN bus) and the five Motor Driver boards within a waterproof housing that are essential for the operation of the arm. Failure of the integrity of this Housing will render the system inoperative and probably cause irreparable damage. Connections are made through the seven Sub-Con type underwater matable connectors, the connector function and pin connections are shown in Section 5, Electrical Connections.



4.4 Manipulator Arm

The manipulator supplied is the versatile 5 function version, and although it is tolerant to everyday use care should be exercised with regard to the oil filled cables as these form part of the overall compensation system integrity. The mounting arrangements for this Arm can be found at the rear of the manual



(Manipulator Arm)

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4.5 Compensator

The Compensator supplied is of the 0.5 litre size. This unit has been supplied fully charged and ready to use. When connecting to the manifold with the length of 0.25" tubing (As supplied) it must be ensured that the piston rod is held in position whilst the hose connections are made. Also supplied is a self-sealing Quick Connect coupling for easy refilling / topping up of the system

4.6 Manifold

The Manifold supplied is the 4 way unit. The hoses are already fitted to the unit and once the Manipulator has been fitted to the vehicle can be connected to each of the Actuators. Connections are made by simply pushing the tube into the connector and are of the 'Push Fit' type. To remove a tube, depress the locking ring and remove the tube by pulling.

5. Electrical Connections

5.1 Electrical connections are made to the Sub-sea Housing via Sub-Con type connectors for each of the arm functions, power and communications. These have been orientated and identified so that the possibility of incorrect connection has been reduced.

5.1.1 PL1 8 way Power and Communications

PIN	FUNCTION
1	24 Volt
2	24 Volt
3	0 Volt
4	0 Volt
5	RS232
6	RS232
7	RS232 Screen
8	Not defined

5.1.2 SKT3 8 way Slew

PIN	FUNCTION
1	Slew Phase A
2	Slew Phase B
3	Slew Phase C
4	Slew Hall Power
5	Slew Hall A
6	Slew Hall B
7	Slew Hall C
8	Slew Hall Ground

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5.1.3 SKT4 8 way Elbow

PIN	FUNCTION
1	Elbow Phase A
2	Elbow Phase B
3	Elbow Phase C
4	Elbow Hall Power
5	Elbow Hall A
6	Elbow Hall B
7	Elbow Hall C
8	Elbow Hall Ground

5.1.4 SKT1 16 way Jaw Rotate and Jaw Close

PIN	FUNCTION
1	Jaw Rotate Phase A
2	Jaw Rotate Phase B
3	Jaw Rotate Phase C
4	Jaw Rotate Hall Power
5	Jaw Rotate Hall A
6	Jaw Rotate Hall B
7	Jaw Rotate Hall C
8	Jaw Rotate Hall Ground
9	Jaw Close Phase A
10	Jaw Close Phase B
11	Jaw Close Phase C
12	Jaw Close Hall Power
13	Jaw Close Hall A
14	Jaw Close Hall B
15	Jaw Close Hall C
16	Jaw Close Hall Ground

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5.1.5 SKT2 16 way Shoulder and Auxiliary

PIN	FUNCTION
1	Shoulder Phase A
2	Shoulder Phase B
3	Shoulder Phase C
4	Shoulder Hall Power
5	Shoulder Hall A
6	Shoulder Hall B
7	Shoulder Hall C
8	Shoulder Hall Ground
9	Not defined
10	Not defined
11	Not defined
12	Not defined
13	Not defined
14	Not defined
15	Not defined
16	Not defined

The colour coding for each of the actuators follows a common theme and are as follows:-

FUNCTION	COLOUR
Phase A	Green
Phase B	Red
Phase C	Black
Hall Power	Yellow
Hall A	Blue
Hall B	Orange
Hall C	Brown
Hall Ground	White

5.2 Surface Electronics

Electrical connections from the Joystick USB Surface Controller to the computer are made via its own USB cable. The drivers for this require to be set up from the Start menu via the Control Panel - Games controllers. Connection of the netbook to the customer supplied underwater umbilical is made from the USB to RS 232 interface cable. The software for this has been supplied on the USB pen; EasySync USB serial Converter.

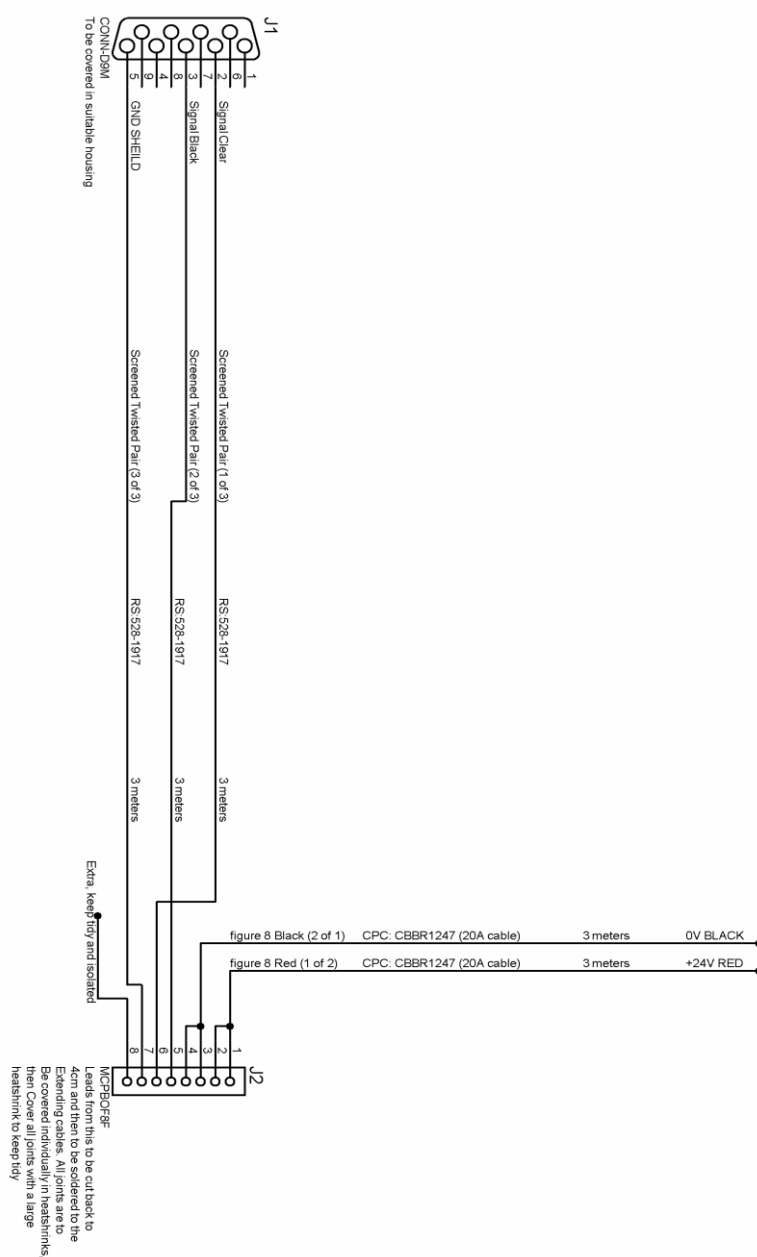
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6. Operating Procedure

6.1 Electrical Connection (Test)

Connect the Arm to the Sub-sea housing as detailed in section 5.1 above. Connect the Power / Communications test cable (As supplied) to the Sub-sea housing. Connect a suitable 24Vdc supply to the Red (positive) and Black (negative) cables. A DC supply that is able to supply 10amps will be sufficient to operate all of the Arms functions simultaneously. A schematic of the test cable is shown below.

TEST CABLE FOR IN-AIR USE ONLY



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6.2 General Safety

Before applying power to the system, ensure that all personnel and equipments are clear from the working parameters of the Arm. Ensure that when the Arm is in operation, all persons are not physically close to the moving Arm as serious injury may occur.

6.3 Operation

Detailed operation functions of the Joystick USB Surface Controller are set out in Para 4.2.1. For detailed computer operation please see Appendix A2.

7. Assembly and Maintenance

7.1 General Caution

The 5E Electric Arm has been designed for ease of maintenance by a competent engineer. The information contained in the sections below is for the individual assemblies i.e. Shoulder, Elbow, Slew and Jaw Unit. When dis-assembling the units care must be taken with sub-assemblies such as the Ballscrews, it is recommended that if possible the Actuator be retracted to its minimum length to avoid the Nut from becoming unwound from the Ballscrew.

After each use, wash the Arm with fresh water liberally and dry if possible. Check for tightness of fixtures and fittings adjusting if necessary. Check for galvanic corrosion of the arm, the first signs of which may appear upon sharp edges or corners. Touch up any scratches, marks or damage with black enamel paint as required, then spray with a water dispersant e.g. WD40. Finally check the condition of any anodes if fitted and replace if required. It is recommended that Magnesium anodes are used.

If water ingress into the compensation system has taken place, all units must be cleaned and checked. Absolute cleanliness is paramount when disassembling / reassembling the actuators.

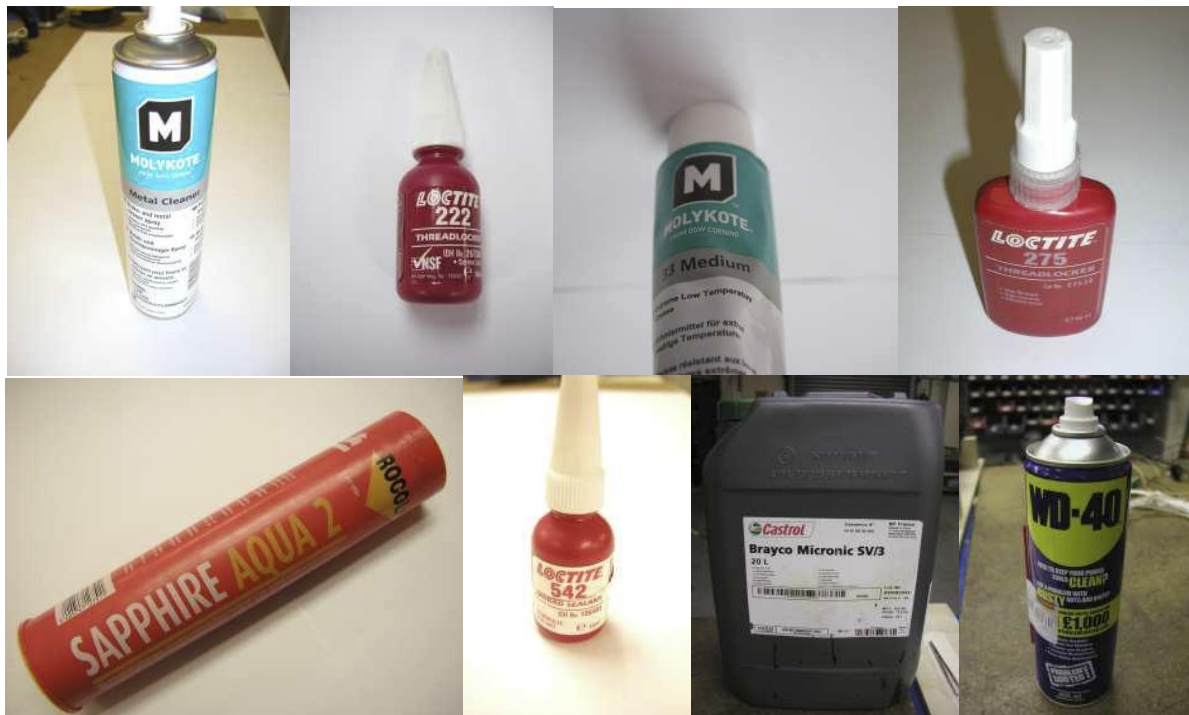
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7.2 ACTUATOR ASSEMBLY CONSUMABLES

Several typical items are used to assemble the manipulator. These are:-

- Molykote Solvent Metal Cleaner
- Loctite 222 Threadlocker
- Molykote 33Medium Silicone grease ('O' Rings)
- Loctite 275 Threadlocker
- Rocol Sapphire Aqua 2 (Underwater grease for nuts bolts etc)
- Loctite 542 Thread Sealent
- Castrol Brayco Micronic SV/3 Oil
- WD40 water dispersant
- Loctite 401 SuperGlue (Not shown)

As shown below.



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7.3 SLEW ACTUATOR ASSEMBLY

7.3.1 Bearing Retainer

Assemble the polyurethane 'O' Ring into the recess of the Bearing Retainer using Loctite 401 Superglue after increasing the surface roughness of the side to be glued with abrasive paper and cleaning thoroughly with a Solvent Cleaner.



7.3.2 Actuator Housing

The Actuator Housing and the Guide Insert are manufactured in such a way that no serviceable parts are within.



7.3.3 Seal Insert

Using a suitable tool that has no sharp edges, carefully push in the Wyclip outer scraper into the Seal Insert. Lightly grease with Silicone grease the PTFE backup ring and press gently into the Seal Insert, followed by the Quad ring after also being greased. Finally with a small amount Silicone grease, grease the outer 'O' Ring and assemble to the outer 'O' Ring groove of the Seal Insert.



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7.3.4 Gear Housing

In the unlikely event that the Gear Support Pin has to be replaced, the following method should be followed.

Clean thoroughly with a Solvent Cleaner the area of the Gear Housing where the Gear Support Pin is to be fitted and the Gear Support Pin. Then assemble using Loctite 275. Ensure that the Gear Support Pin is held fully in until all of the air has been expelled. If there is a requirement to remove this Gear Support Pin from the Gear Housing, gentle heating will be required using a hot air gun to degrade the Loctite 275 to aid removal.



Clean thoroughly with a Solvent Cleaner the area of the Gear Housing where the Pivot Bush is to be fitted and the Pivot Bush. Then assemble using Loctite 275. Ensure that the Pivot Bush is aligned correctly with the outer edges of the Gear Housing. If there is a requirement to remove this Pivot Bush from the Gear Housing, gentle heating will be required using a hot air gun to degrade the Loctite 275 to aid removal. The Pivot Bush still may require pressing out.



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7.3.5 Rod

Assemble the polyurethane 'O' Ring into the recess of the Rod using Loctite 401 Superglue after increasing the surface roughness of the side to be glued with abrasive paper and cleaning thoroughly with a Solvent Cleaner.

Clean the inside of the Rod as this may still have residual debris from prolonged use.



7.3.6 Ball Screw

There should be no requirement to remove the Nut from the Ballscrew under normal routine maintenance. If it is required to remove the nut, advice should be sought from the factory. Removal of the nut without advice will result in the internal balls becoming dislodged.

To replace the end stop Acetal, the Nut must be removed and refitted to the Ball Screw.



Slide the Bearing Retainer over the Ball Screw, followed by the Bearing which should be a good push fit onto the Ball Screw shaft.

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7.3.7 Rod and Ball Screw

Using 4 off Unbrako Socket Head Cap Screws, attach the Rod to the Nut. Ensure that the Rod and the Nut are aligned such that they will freely travel up and down the Guide Insert. Remove each Unbrako Socket Head Cap Screw in turn and reassemble after cleaning thoroughly with a Solvent Cleaner using a small amount of Loctite 275.



7.3.8 Bearing Housing Assembly

Assemble the Ballscrew into the Bearing Housing. This may need gentle heat applied to the Housing using a hot air gun to enable easy assembly. Once the Bearing is fully inserted, slide the Bearing retainer up to the Bearing Housing and secure using four off Socket Head Cap Screws, Spring washers and Plain washers as shown.



7.3.9 Motor and Gears

Ensure that the Key is in position on the Ballscrew Shaft, then push the Gear onto the shaft. If this is to be removed at a later date, a small three legged puller (as shown below) may be required. If the gear is too tight to push onto the shaft by hand, gently warm the Gear using a hot air gun to enable easy assembly.

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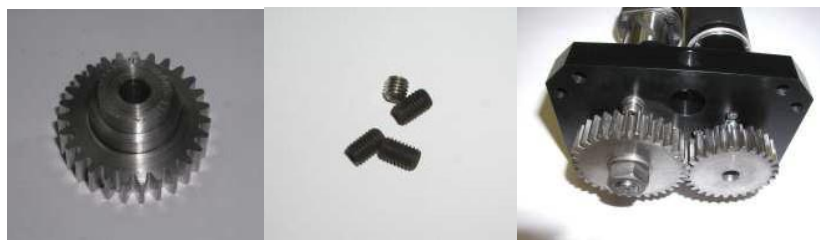


After cleaning the thread of the Ballscrew thoroughly with Solvent Cleaner, using a small amount of Loctite 275 assemble the Plain washer and the Nut onto the shaft and tighten. Note that the nut has a thread pitch of 1.25mm which is unlike a normal M10 nut.

Assemble the Motor and Gearbox into the Bearing Housing and secure using four off Socket Head Cap Screws and Spring washers, no plain washers are used in this location.



After cleaning the Gear and its four M5 tapped holes thoroughly with a Solvent Cleaner, using a small amount of Loctite 275 assemble each of the Socket Head Set Screws into the Gear, noting that there is one shorter Socket Head Set Screw than the rest. The Gearbox output shaft has a machined flat which the two longer Socket Head Set Screws locate, the other two (one long and one short) locate in the other side. Tighten these locking the Gear in a position with the gears aligned correctly.



7.3.10 Actuator Body

Utilising a 4mm Pin wrench, screw in the Seal Insert into the Actuator Housing and tighten.



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With a small amount of Silicone grease, grease the Actuator Housing body 'O' Ring and assemble to the groove of the housing. Slide the Actuator Housing over the Motor, Ball screw and Rod assembly, ensuring that the Motor wires do not become trapped and that they exit the wire outlet.



With a small amount of Silicone grease, grease the Gear Housing body 'O' Ring and assemble to the groove of the housing. Assemble the Gear Housing to the Actuator Housing as shown in the photos below. Ensure that the Socket Head Cap Screws have been well greased with Underwater grease.



Using a 4mm Pozi Panhead screw and a Bonded seal, screw in the bleed screws (one on each side) and tighten.



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7.3.11 Hose Connector

Assemble the Tube fitting to the body using a little Loctite 542 Sealer. With a small amount of Silicone grease, grease the Hose Connector body 'O' Ring and assemble to the groove of the body.



Feed the Motor wires through the Hose Connector and Tube fitting. Assemble to the Actuator Housing with the Socket Head Cap Screws, Plain and Spring washers as shown below.



7.3.12 Motor wiring and Connector

Extend the Motors wiring to the required length. Note the there are two different gauges of wires used, 22swg for the motor phases and 26swg for the hall power and sensors. Feed these wires through the 3/8inch Tygon tubing, then secure the tubing to the Tube fitting using the clip as shown. Finally slide the Braided sleeving over the Tubing and secure with a small cable tie.



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Assemble the Tube fitting to the Junction body using a little Loctite 542 sealer and then assemble the Push fit connector. This has a PTFE sealer fitted from new and requires no additional sealer.



Push the Tube fitting into the 3/8inch Tygon tubing, ensuring that the wiring protrudes beyond the end of the Junction box, then clip into place. Finally fix the braiding into place using a cable tie.

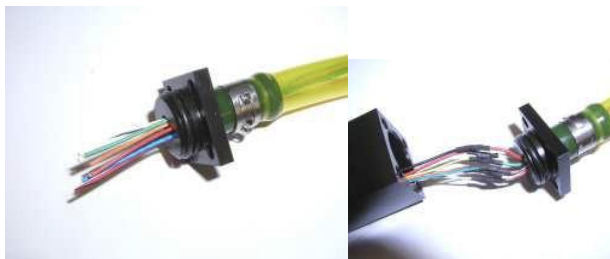


The 8 way connector supplied is of an underwater matable type. The tails of this connector are slid into a short length (~ 1foot) of 7/16inch Tygon tube and fixed with a clip. The other end of the tube is pushed over the Acetal Hose Tail of the Junction box and again fixed with a clip.



With a small amount of Silicone grease, grease the Acetal Hose Tail 'O' Ring and assemble to the groove of the body. Then make the connections between the Motor wires and the Connector wires by soldering then insulating with a heatshrink sleeve. The wiring protocol is shown in the table on the next page.

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FUNCTION	CONNECTOR COLOUR	MOTOR COLOUR
Phase A	Black	Green
Phase B	White	Red
Phase C	Red	Black
Hall Power	Green	Yellow
Hall A	Orange	Blue
Hall B	Blue	Orange
Hall C	Black / White	Brown
Hall Ground	Red / Black	White

Carefully push the Acetal Hose tail into the Junction box and secure using the with the Socket Head Cap Screws, Plain and Spring washers as shown below.



Finally, push the 6mm tube end blank into the push fit connector. Details on how to fill / purge the actuator can be found in Appendix A1



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7.4 SHOULDER ACTUATOR ASSEMBLY

7.4.1 Bearing Retainer

Assemble the polyurethane 'O' Ring into the recess of the Bearing Retainer using Loctite 401 Superglue after increasing the surface roughness of the side to be glued with abrasive paper and cleaning thoroughly with a Solvent Cleaner.



7.4.2 Actuator Housing

The Actuator Housing and the Guide Insert are manufactured in such a way that no serviceable parts are within.



7.4.3 Seal Insert

Using a suitable tool that has no sharp edges, carefully push in the Wyclip outer scraper into the Seal Insert. Lightly grease with Silicone grease the PTFE backup ring and press gently into the Seal Insert, followed by the Quad ring after also being greased. Finally with a small amount Silicone grease, grease the outer 'O' Ring and assemble to the outer 'O' Ring groove of the Seal Insert.



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Utilising a 4mm Pin wrench, screw in the Seal Insert into the Actuator Housing and tighten.



7.4.4 Motor Housing

Clean thoroughly with a Solvent Cleaner the area of the Motor Housing where the Pivot Bush is to be fitted and the Pivot Bush. Then assemble using Loctite 275. Ensure that the Pivot Bush is aligned correctly with the outer edges of the Motor Housing. If there is a requirement to remove this Pivot Bush from the Gear Housing, gentle heating will be required using a hot air gun to degrade the Loctite 275 to aid removal. The Pivot Bush still may require pressing out.



7.4.5 Rod

Assemble the polyurethane 'O' Ring into the recess of the Rod using Loctite 401 Superglue after increasing the surface roughness of the side to be glued with abrasive paper and cleaning thoroughly with a Solvent Cleaner.

Clean the inside of the Rod as this may still have residual debris from prolonged use.



7.4.6 Ball Screw

There should be no requirement to remove the Nut from the Ballscrew under normal routine maintenance. If it is required to remove the nut, advice should be sought from the factory. Removal of the nut without advice will result in the internal balls becoming dislodged.

To replace the end stop Acetal, the Nut must be removed and refitted to the Ball Screw.

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Slide the Bearing Retainer over the Ball Screw, followed by the Bearing which should be a good push fit onto the Ball Screw shaft. After cleaning the thread of the Ballscrew and Nuts thoroughly with Solvent Cleaner, using a small amount of Loctite 275 assemble the Nut onto the shaft and tighten. Note that the nut has a thread pitch of 1.25mm which is unlike a normal M10 nut. Finally assemble the locking nut and tighten.



7.4.7 Rod and Ballscrew

Using 4 off Unbrako Socket Head Cap Screws, attach the Rod to the Nut. Ensure that the Rod and the Nut are aligned such that they will freely travel up and down the Guide Insert. Remove each Unbrako Socket Head Cap Screw in turn and reassemble after cleaning thoroughly with Solvent Cleaner using a small amount of Loctite 275.



7.4.8 Motor and Ballscrew Assembly

The Drive Coupling is held onto the Gearbox Assembly shaft by one M3 x 8mm socket set screw and a 4mm by 4mm key. These are assembled using Loctite 275 Threadlocker after being cleaned thoroughly with Solvent Cleaner to ensure that the coupling remains secured to the shaft.

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Assemble the Bearing Housing to the Motor using the Socket Head Cap Screws and Spring washers as shown.



Assemble the Rod and Ballscrew to the Bearing Housing using a small amount of Loctite222 after being cleaned thoroughly with Solvent Cleaner.

With a small amount Silicone grease, grease the Bearing Housing 'O' Ring and assemble to the 'O' Ring groove of the Bearing Housing. Feed the Motor wires through the Motor housing and slide this over the Motor. Again with a small amount Silicone grease, grease the Actuator Housing 'O' Ring and assemble to the 'O' Ring groove of the Actuator Housing and slide this over the Rod.



Finally screw the Motor Housing, Bearing Retainer and Actuator Housing together with the Socket Head Cap Screws that have been well greased with good quality underwater grease, taking care that the Motor wires do not become trapped in the bottom of the Motor Housing.

With a small amount Silicone grease, grease the Cable Entry 'O' Ring and assemble to the 'O' Ring groove of the Cable Entry. Feed the Motor wires through the Cable Entry and the fix to the Motor Housing as shown below.

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Using a 4mm Pozi Panhead screw and a 4mm Bonded seal, screw in the bleed screws (one on each side) and tighten.



7.4.9 Motor wiring and Connector

Extend the Motors wiring to the required length. Note the there are two different gauges of wires used, 22swg for the motor phases and 26swg for the hall power and sensors. Feed these wires though the 3/8inch Tygon tubing, then secure the tubing to the Hose Tail using the clip as shown. Finally slide the Braided sleeving over the Tubing and secure with a small cable tie.



Assemble the Tube fitting to the Junction body using a little Loctite 542 sealer and then assemble the Push fit connector. This has a PTFE sealer fitted from new and requires no additional sealer.

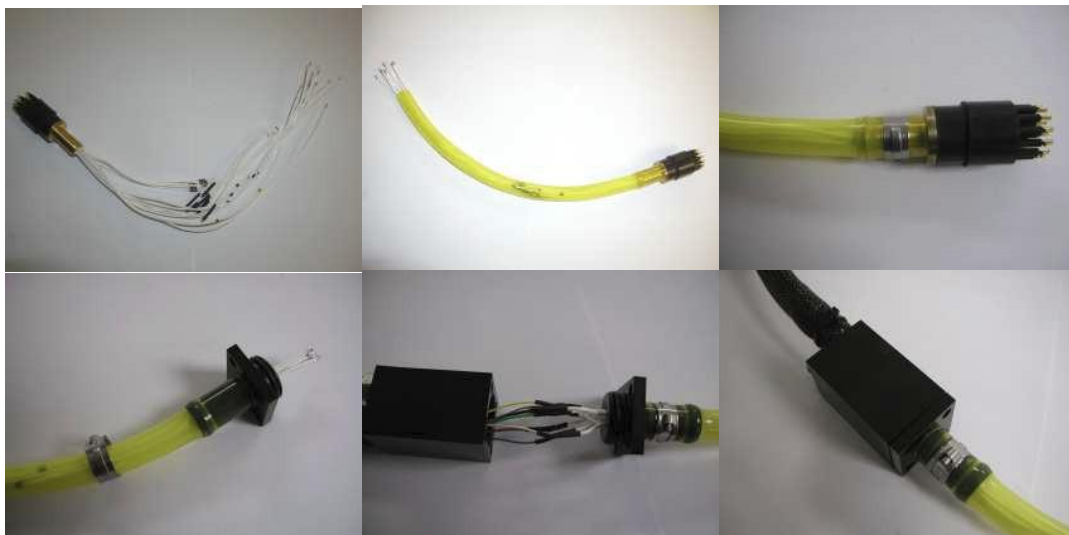


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Push the Tube fitting into the 3/8inch Tygon tubing, ensuring that the wiring protrudes beyond the end of the Junction box, then clip into place. Finally fix the braiding into place using a cable tie.



The 16 way connector supplied is of an underwater matable type. The tails of this connector are slid into a short length (~ 1foot) of 7/16inch Tygon tube and fixed with a clip. The other end of the tube is pushed over the Acetal Hose Tail of the Junction box and again fixed with a clip.



With a small amount of Silicone grease, grease the Acetal Hose Tail 'O' Ring and assemble to the groove of the body.

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Then make the connections between the Motor wires and the Connector wires by soldering then insulating with a heatshrink sleeve. The wiring protocol is shown in the table below.

FUNCTION	CONNECTOR PIN NUMBER	MOTOR COLOUR
Phase A	1	Green
Phase B	2	Red
Phase C	3	Black
Hall Power	4	Yellow
Hall A	5	Blue
Hall B	6	Orange
Hall C	7	Brown
Hall Ground	8	White
Not assigned	9 to 16	

Carefully push the Acetal Hose tail into the Junction box and secure using the Socket Head Cap Screws, Plain and Spring Washers as shown.



Finally, push the 6mm tube end blank into the push fit connector. Details on how to fill / purge the actuator can be found in Appendix A1



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7.5 ELBOW ACTUATOR ASSEMBLY

7.5.1 Bearing Retainer

Assemble the polyurethane 'O' Ring into the recess of the Bearing Retainer using Loctite 401 Superglue after increasing the surface roughness of the side to be glued with abrasive paper and cleaning thoroughly with a Solvent Cleaner.



7.5.2 Actuator Housing

The Actuator Housing and the Guide Insert are manufactured in such a way that no serviceable parts are within.



7.5.3 Seal Insert

Using a suitable tool that has no sharp edges, carefully push in the Wyclip outer scraper into the Seal Insert. Lightly grease with Silicone grease the PTFE backup ring and press gently into the Seal Insert, followed by the Quad ring after also being greased. Finally with a small amount Silicone grease, grease the outer 'O' Ring and assemble to the outer 'O' Ring groove of the Seal Insert.



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Utilising a 4mm Pin wrench, screw in the Seal Insert into the Actuator Housing and tighten.



7.5.4 Motor Housing

Clean thoroughly with a Solvent Cleaner the area of the Motor Housing where the Pivot Bush is to be fitted and the Pivot Bush. Then assemble using Loctite 275. Ensure that the Pivot Bush is aligned correctly with the outer edges of the Motor Housing. If there is a requirement to remove this Pivot Bush from the Gear Housing, gentle heating will be required using a hot air gun to degrade the Loctite 275 to aid removal. The Pivot Bush still may require pressing out.



7.5.5 Rod

Assemble the polyurethane 'O' Ring into the recess of the Rod using Loctite 401 Superglue after increasing the surface roughness of the side to be glued with abrasive paper and cleaning thoroughly with a Solvent Cleaner.

Clean the inside of the Rod as this may still have residual debris from prolonged use.



7.5.6 Ball Screw

There should be no requirement to remove the Nut from the Ballscrew under normal routine maintenance. If it is required to remove the nut, advice should be sought from the factory. Removal of the nut without advice will result in the internal balls becoming dislodged.

To replace the end stop Acetal, the Nut must be removed and refitted to the Ball Screw.

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Slide the Bearing Retainer over the Ball Screw, followed by the Bearing which should be a good push fit onto the Ball Screw shaft. After cleaning the thread of the Ballscrew and Nuts thoroughly with Solvent Cleaner, using a small amount of Loctite 275 assemble the Nut onto the shaft and tighten. Note that the nut has a thread pitch of 1.25mm which is unlike a normal M10 nut. Finally assemble the locking nut and tighten.



7.5.7 Rod and Ballscrew

Using 4 off Unbrako Socket Head Cap Screws, attach the Rod to the Nut. Ensure that the Rod and the Nut are aligned such that they will freely travel up and down the Guide Insert. Remove each Unbrako Socket Head Cap Screw in turn and reassemble after cleaning thoroughly with Solvent Cleaner using a small amount of Loctite 275.



Assemble the Bearing Housing and Rod and Ballscrew assembly together after cleaning thoroughly with Solvent Cleaner using a small amount of Loctite 222.

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7.5.8 Motor and Ballscrew Assembly

The Drive Coupling is held onto the Gearbox Assembly shaft by four M5 x 8mm Socket Head Set Screws. These are assembled using Loctite 275 Threadlocker after being cleaned thoroughly with Solvent Cleaner to ensure that the coupling remains secured to the shaft.



Assemble the Motor Adaptor Plate to the Motor using the four Socket Head Cap Screws shown below. Ensure that the Socket Head Cap Screws have been cleaned with a Solvent Cleaner before assembling with Loctite 222.



Then assemble the Ball Screw and Bearing Retainer to the Motor and Adaptor Plate, again ensure that the Socket Head Cap Screws have been cleaned with a Solvent Cleaner before assembling with Loctite 222.

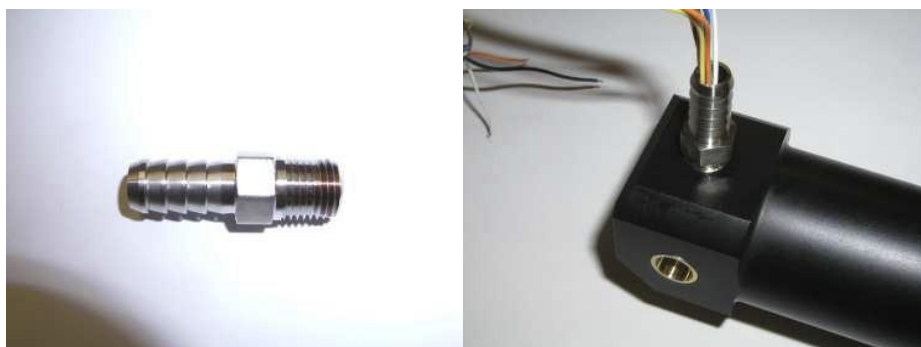
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Feed the Motor wires through the outlet of the Motor Housing and carefully slide the Motor into the Housing. Ensure that the wires do not become trapped or squeezed in the bottom of the housing. With a small amount Silicone grease, grease the Motor Housing 'O' Ring and assemble to the 'O' Ring groove of the Motor Housing. Again with a small amount Silicone grease, grease the Actuator Housing 'O' Ring and assemble to the 'O' Ring groove of the Actuator Housing and slide this over the Rod. Finally screw the Motor Housing, Bearing Retainer and Actuator Housing together with the Socket Head Cap Screws that have been well greased with underwater grease, taking care that the Motor wires do not become trapped in the bottom of the Motor Housing.



Assemble the Tube fitting to the Motor Housing after being cleaned with a Solvent Cleaner using a little Loctite 542 sealer.



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7.5.9 Motor wiring and Connector

Extend the Motors wiring to the required length. Note the there are two different gauges of wires used, 22swg for the motor phases and 26swg for the hall power and sensors. Feed these wires though the 3/8inch Tygon tubing, then secure the tubing to the Tube fitting using the clip as shown. Finally slide the Braided sleeving over the Tubing and secure with a small cable tie.



Assemble the Tube fitting to the Junction body using a little Loctite 542 sealer and then assemble the Push fit connector. This has a PTFE sealer fitted from new and requires no additional sealer.

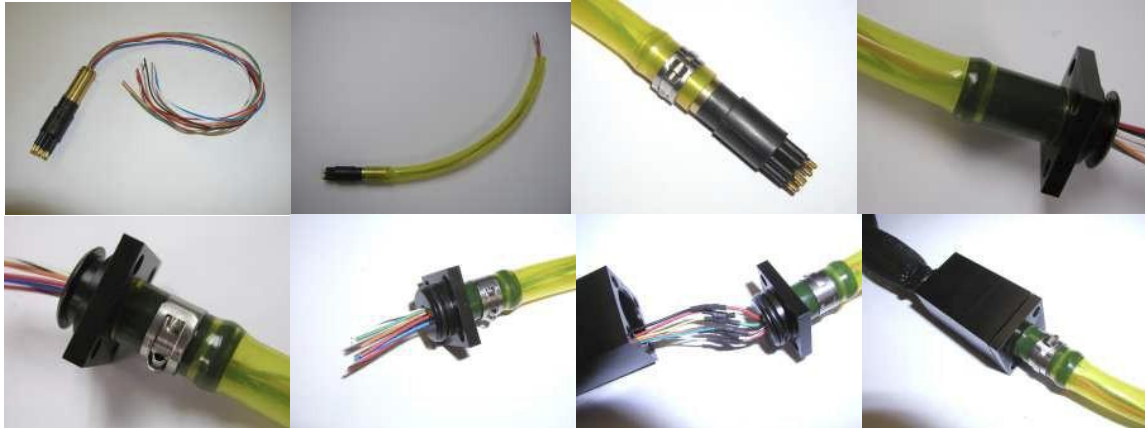


Push the Tube fitting into the 3/8inch Tygon tubing, ensuring that the wiring protrudes beyond the end of the Junction box, then clip into place. Finally fix the braiding into place using a cable tie.



The 8 way connector supplied is of an underwater matable type. The tails of this connector are slid into a short length (~ 1foot) of 7/16inch Tygon tube and fixed with a clip. The other end of the tube is pushed over the Acetal Hose Tail of the Junction box and again fixed with a clip.

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With a small amount of Silicone grease, grease the Acetal Hose Tail 'O' Ring and assemble to the groove of the body. Then make the connections between the Motor wires and the Connector wires by soldering then insulating with a heatshrink sleeve. The wiring protocol is shown in the table below.

FUNCTION	CONNECTOR COLOUR	MOTOR COLOUR
Phase A	Black	Green
Phase B	White	Red
Phase C	Red	Black
Hall Power	Green	Yellow
Hall A	Orange	Blue
Hall B	Blue	Orange
Hall C	Black / White	Brown
Hall Ground	Red / Black	White

Carefully push the Acetal Hose tail into the Junction box and secure using the Socket Head Cap Screws, Plain and Spring Washers as shown.



Finally, push the 6mm tube end blank into the push fit connector. Details on how to fill / purge the actuator can be found in Appendix A1

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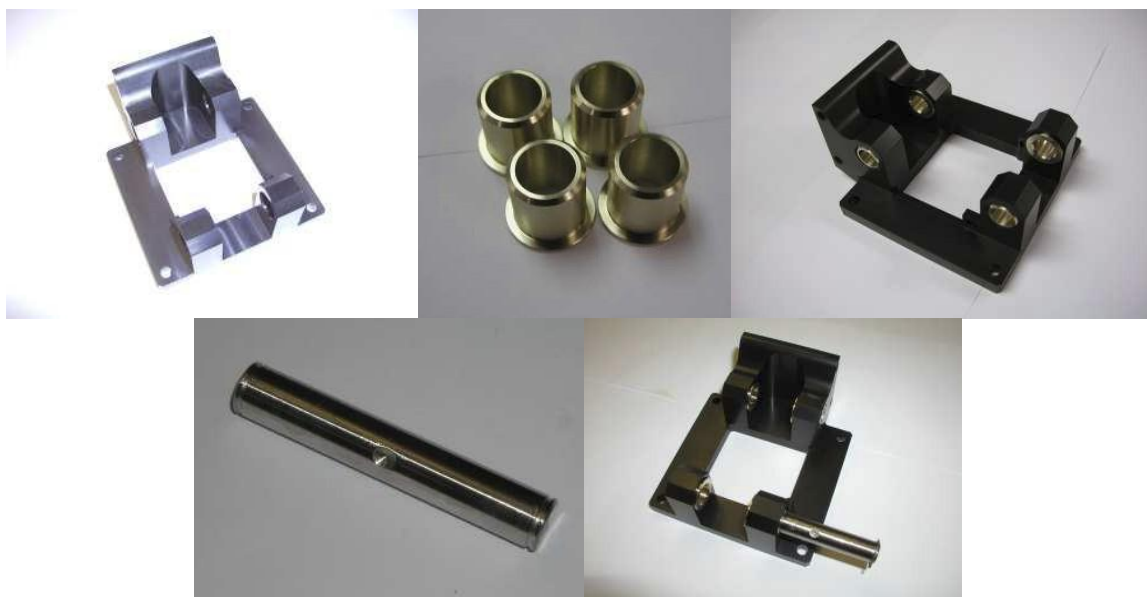


Using a 4mm Pozi Panhead screw and a 4mm Bonded seal, screw in the bleed screws (one on each side) and tighten.



7.6 JAW ASSEMBLY

After cleaning the Jaw Support Plate and the Four Bushes with Solvent Cleaner, assemble as shown below using a small amount of Loctite 275. Use an Outer Jaw Pin to ensure that the Bushes are aligned correctly



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Assemble an Inner Jaw Pin with a Circlip and then grease with underwater grease. Slide a Jaw Link over the Pin followed by the Piston Rod End. Place a second Jaw Link over the Pin and secure these with a Circlip. Repeat this process for the second pair as shown below.



Assemble an Outer Jaw Pin with a Circlip and then grease with underwater grease, then assemble to the Jaw Support Plate the Pin and Large Jaw Block and secure these with a Circlip



Finally after greasing with underwater grease, screw in the Socket Head Set Screw fixing the Outer Pin in position within the Jaw Block

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Assemble a second Outer Jaw Pin with a Circlip and then grease with underwater grease, then assemble to the Jaw Support Plate the Pin and Small Jaw Block and secure these with a Circlip



Finally after greasing with underwater grease, screw in the Socket Head Set Screw fixing the Outer Pin in position within the Jaw Block.

Using the Socket Head Countersunk Screws shown below grease with underwater grease and assemble the Jaw Plates to the Large Jaw Block.



Using the Socket Head Countersunk Screws shown below, grease with underwater grease and assemble the Jaw Cutter Plates to the Small Jaw Block.



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Using the Socket Head Cap Screws, Plain and Spring Washers shown below, grease with underwater grease and assemble the Jaw Plate Cutters to the Jaw Support Plate.



Once this has been completed, check that the cutters mesh together. If there is to large a gap between the Jaw Plate Cutters and Jaw Cutter Plates, then the Jaw Cutter Plates will require to be shimmed. This will have been completed initially at the Factory. However, with prolonged, excessive use it may be necessary to re-shim the Cutters.



Finally assemble the Piston Ron End to the Jaw Blocks using a pair of Inner Jaw Pins and Circlips after being greased with underwater grease.



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7.7 JAW ROTATE AND OPEN/CLOSE

7.7.1 Piston Rod and Drive Housing

Clean the Cage and the Nut with Solvent Cleaner paying particular attention to the four tapped holes. Assemble the Bearing and Thrust washer onto the Piston Rod and then push through into the Cage, then position the second Bearing and Thrust Washer.



Push the Nut into the Cage noting that there is a small 'centre pop' mark to align the Nut and the Cage to the correct orientation. This is critical as the tapped holes have been manufactured in such a way so as to allow the Guide Pins to screw through the Cage into the Nut, locking the Nut into the correct position.



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Assemble the polyurethane 'O' Ring into the recess of the Drive Housing using Loctite 401 Superglue after increasing the surface roughness of the side to be glued with abrasive paper and cleaning thoroughly with a Solvent Cleaner.



Clean the Ball Screw Nut with Solvent Cleaner, then Assemble into the Cage Nut using Loctite 275. Assemble the Bearing and Thrust washer into the Drive Housing.



Assemble the Thrust Washer and Bearing onto the Ballscrew



Insert the Piston Rod and Ballscrew assembly into the Drive Housing then place the Axial Thrust Washer on top followed by the Nut. After cleaning the Guide pins with Solvent Cleaner, lightly screw them in and check for the smooth operation of the unit. If the unit functions correctly, remove the four Guide Pins and remove the nut. Withdraw the Piston Rod and Ballscrew assembly from the Drive Housing and clean the Ballscrew thread and the Nut with a solvent cleaner. Also clean the Four Guide Pins and their threads ready for reassembly.

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Insert the Piston Rod and Ballscrew assembly into the Drive Housing then place the Axial Thrust Washer on top, after applying a small amount of Loctite 275 to the Ballscrew thread put on the nut. In the side of the Drive Housing there are four M5 threaded holes, insert a pair of M5 screws into opposing holes to prevent rotation of the Ballscrew so the Nut can be tightened. Apply a small amount of Loctite 275 to each of the Guide pins, insert and tighten.

Caution Note *Extreme caution to prevent surplus Loctite 275 gaining access to sliding parts and surfaces*

With these in place now tighten the Ballscrew Nut.



Once this nut has been tightened, remove the two M5 screws from the side of the Drive Housing. Check the unit still operated smoothly.

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The Drive Coupling is held onto the Gearbox Assembly shaft by four M5 x 8mm Unbrako Socket Head Set Screws. These are assembled using Loctite 275 Threadlocker after being cleaned thoroughly with a Solvent Cleaner to ensure that the coupling remains secured to the shaft.



Assemble the Motor Adaptor Plate to the Motor using the four Socket Head Cap Screws and Spring Washers shown below. Ensure that they have been cleaned with Solvent Cleaner before assembling with Loctite 222. Then assemble the Motor and Adapter Plate to the Drive Housing, again ensure that the Socket Head Cap Screws have been cleaned with Solvent Cleaner before assembling with Loctite 222.



Insert and fix the second Motor to the Motor Mounting Plate using the using the four Socket Head Cap Screws and spring washers shown below. Ensure that they have been cleaned with Solvent Cleaner before assembling with Loctite 222.



After cleaning the Jaw Rotate Motor Spur Gear, the four Unbrako Socket Head Set Screws and the Motor Shaft with Solvent Cleaner, fit Gear to the shaft of the Motor using Loctite 275 and tighten the four Set Screws.



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7.7.3 Universal Jaw Mount

This is a difficult operation that requires the composite cap part of the seal to be deformed inwards without causing any sharp bends or kinks in the ring. The ring is then inserted into the groove and positioned on the 'O' ring energizer. A suitable tapered mandrel is then inserted into the seal to reform and size the composite cap while avoiding causing any damage or incorrect deformation. Due to the thin wall of this cap, damaging bends are easily formed! If removal of this seal is required, it is most unlikely that it will be removed in a reusable state. Using a suitable blunted tool, carefully push in the Wyclip outer scraper into the Universal Jaw Mount front face.



7.7.4 Bearing Housing

With a small amount of Silicone grease, grease the Seal Plate Quad Ring and assemble to the groove of the Seal Plate bore.

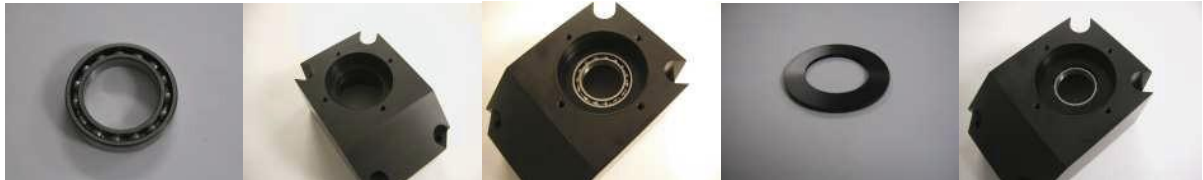


With a small amount of Silicone grease, grease the Composite Rotary Seal and assemble to the inner recess of the Seal Plate as shown below. Then also after lightly greasing with Silicone grease fit the outer 'O' ring to the Seal Plate.



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Insert the outer Bearing into the Bearing Housing then place the Seal Plate Washer on top.



Fit the Seal Plate to the Bearing Housing and fix with the four Socket Head Countersunk Screws shown after greasing them with underwater grease.



Carefully push the Universal Jaw Mount through the Seal Plate until it is fully seated. Clean the Universal Jaw Mount stub with a little Solvent Cleaner and then place the Bearing spacer over the Universal Jaw Mount spindle followed by the second Bearing.



Clean the Gear and its Locking ring with a Solvent Cleaner ensuring that all traces of grease are removed from the threads. Using a small amount of Loctite 222 assemble the Gear and Locking Ring and tighten.



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7.7.5 Jaw to Bearing Housing Assembly

Carefully align the Bearing Housing with the Piston Rod and that the Gears are going to mesh as the two are gently pushed together. Do not push fully together as a spanner may be required to be inserted onto the flats of the Piston Rod to enable the Socket Head Countersunk Screw that holds the Piston Rod End to the Piston Rod to be tightened. This Countersunk Socket Head Screw should be greased with underwater grease before assembly.



Using the four Socket Head Cap Screws with Plain and Spring washers shown below, attached the Jaw Support Plate to the Universal Jaw Mount after being greased with underwater grease.



With a small amount of Silicone grease, grease the Housing 'O' ring and fit to the Housing 'O' ring groove. Carefully slide the Housing over the assembly and fix using the four Socket Head Cap Screws with Plain and Spring washers shown below.



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Using a 4mm Pozi Panhead screw and a 4mm Bonded seal, screw in the bleed screw into the Elbow End Cap and tighten. Assemble the Hose fitting to the Elbow End Cap using a little Loctite 542 sealer and tighten.



7.7.6 Motor wiring and Connectors

The wiring connections of the Jaw Close and the Jaw Rotate Motors are set out in the table below.

16 way internal Plug	Jaw Close 8 way (a)	Jaw Rotate 8 way (c)
Pin 1	1	
Pin 2		1
Pin 3	2	
Pin 4		2
Pin 5	3	
Pin 6		3
Pin 7	4	
Pin 8		4
Pin 9	5	
Pin 10		5
Pin 11	6	
Pin 12		6
Pin 13	7	
Pin 14		7
Pin 15	8	
Pin 16		8

These are soldered to the female 16 way internal Plug then insulating with a heatshrink sleeve.

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Attach the 3/8inch Tygon tubing to the Elbow End Cap Hose fitting using the clip as shown.



Extend the male 16 way internal Socket wiring to the required length. Note that there are two different gauges of wires used, 22swg for the motor phases and 26swg for the hall power and sensors. Feed the extended wires through the 3/8inch Tygon tubing. Finally slide the Braided sleeving over the Tubing and secure with a small cable tie.

Assemble the Hose fitting to the Junction body using a little Loctite 542 sealer and then assemble the Push fit connector. This has a PTFE sealer fitted from new and requires no additional sealer.



Push the Hose fitting into the 3/8inch Tygon tubing, ensuring that the wiring protrudes beyond the end of the Junction box, then clip into place. Finally fix the braiding into place using a cable tie.

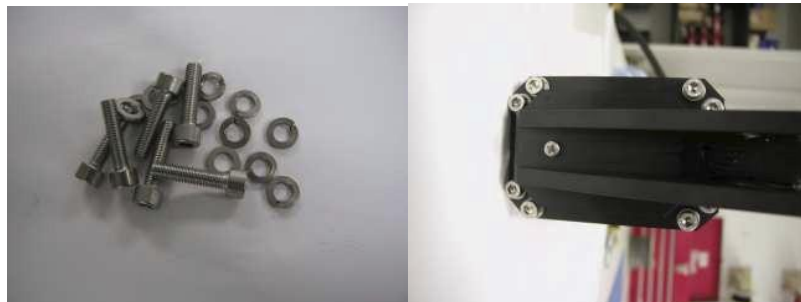
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With a small amount of Silicone grease, grease the Housing 'O' ring and fit to the Housing 'O' ring groove. Plug together the two halves of the 16way connector and secure with two small cable ties.

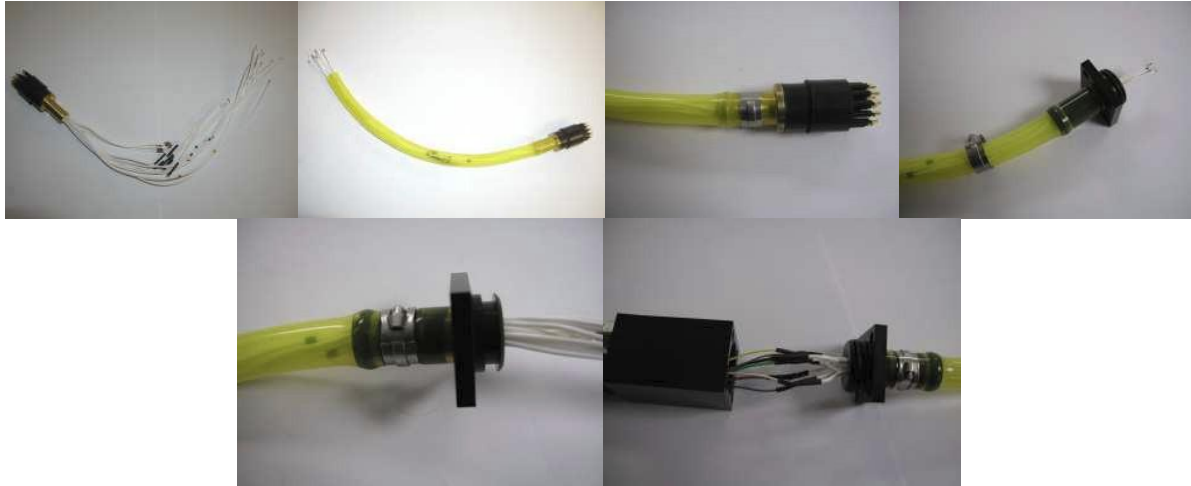


Using the eight Socket Head Cap Screws with Plain and Spring washers shown below, greased with underwater grease, assemble the Elbow End Cap to the Body.



The 16 way connector supplied is of an underwater matable type. The tails of this connector are slid into a short length (~ 1foot) of 7/16inch Tygon tube and fixed with a clip. The other end of the tube is pushed over the Acetal Hose Tail of the Junction box and again fixed with a clip.

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With a small amount of Silicone grease, grease the Acetal Hose Tail 'O' Ring and assemble to the groove of the body. Then make the connections between the Motor wires and the Connector wires by soldering then insulating with a heatshrink sleeve. The wiring protocol is shown in the table below.

16 way External Plug	Jaw Close 8 way	Jaw Rotate 8 way
Pin 1	1	
Pin 2		1
Pin 3	2	
Pin 4		2
Pin 5	3	
Pin 6		3
Pin 7	4	
Pin 8		4
Pin 9	5	
Pin 10		5
Pin 11	6	
Pin 12		6
Pin 13	7	
Pin 14		7
Pin 15	8	
Pin 16		8

Carefully push the Acetal Hose tail into the Junction box and secure using the Socket Head Cap Screws, Plain and Spring Washers as shown.

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Finally, push the 6mm tube end blank into the push fit connector. Details on how to fill / purge the actuator can be found in Appendix A1



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8. MANIPULATOR ASSEMBLY

Assemble the Upper and Lower Shoulder Plates to the Spacer Block using the eight Socket Head Countersunk Screws. Ensure that these have been greased with underwater grease.



After lightly greasing with underwater grease, assemble the two Slew Bushes into the Slew Block



After lightly greasing the Slew Pin with underwater grease, push the Pin through the Upper Shoulder Plate, Slew Bushes and Lower Shoulder Plate. Ensure that the threaded end is lowermost.



After lightly greasing the Slew Pin with underwater grease, push the Pin through the Upper Shoulder Plate, Slew Bushes and Lower Shoulder Plate. Ensure that the threaded end is lowermost.
Assemble the Retaining Disc to the Lower Shoulder Plate with two Socket Head Countersunk Screws, and the Slew pin to the retaining disc with a single Socket Head Cap Screw. Ensure that these have been greased with underwater grease before being finally tightened.

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Assemble the Cable Protector Disc to the Upper Shoulder Plate with two Socket Head Countersunk Screws. Ensure that these have been greased with underwater grease before being finally tightened.



After greasing with underwater grease, screw in the retaining Socket Head Cap Screw into both the Left hand and Right hand Slew Plates.



Fit the Shoulder Bush to the Left hand Slew Plate after greasing with underwater grease. Then assemble the Shoulder Bush and the Left hand Slew Plate to the Slew Block with two Socket Head Countersunk Screws.



Assemble the Slew Bracket to the Left hand Slew Plate with two Socket Head Cap Screws as shown below.

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Grease with underwater grease the Actuator Bush and Actuator Pin. Assemble these to the Slew Actuator along with the two Acetal washers as shown below. Carefully position the Slew Actuator between the Upper and Lower Shoulder plates and then insert the Actuator Pin. Tighten the assembly and check for correct operation. (Actuator not pinched between the plates and little sideways movement).



Grease the Slew Pin (Actuator Rod) with underwater grease, and assemble the Slew Pin (Actuator Rod), Acetal Washers, Slew Actuator Rod and the Slew Bracket together as shown below. Fit the third Socket Head Cap Screw after greasing with underwater grease and tighten the assembly. Grease the Socket Head Set Screw with underwater grease, and insert and tighten onto the Slew Pin (Actuator Rod) locating this in place.



Grease the Shoulder Pin and Shoulder Stud with underwater grease, and assemble the Shoulder Pin, Shoulder Stud and Acetal washer to the Shoulder Bush as shown below.

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Fit the Left Hand Plate to the Shoulder Stud with its Nut, Plain and Spring Washers. Support the Left Hand Plate in a suitable manor so as not to damage it upon the Slew Bracket.



Grease with underwater grease the Elbow Actuator Bushes, Elbow Actuator Stud and Elbow Actuator Pin. Assemble these to the Elbow Actuator along with the two Acetal washers as shown below. Fit this assembly to the Left Hand Plate with its Nut, Plain and Spring Washers. Support the Elbow Actuator taking care not to damage its cable outlet tubing against the Shoulder Bush.



Grease with underwater grease the male end of the Pin Assembly (Shoulder) and fix this to the Left Hand Plate with a greased Socket Head Cap Screw, Plain and Spring washers. Fit the Shoulder Actuator using a greased Shoulder Pin and the Acetal Washers shown below.

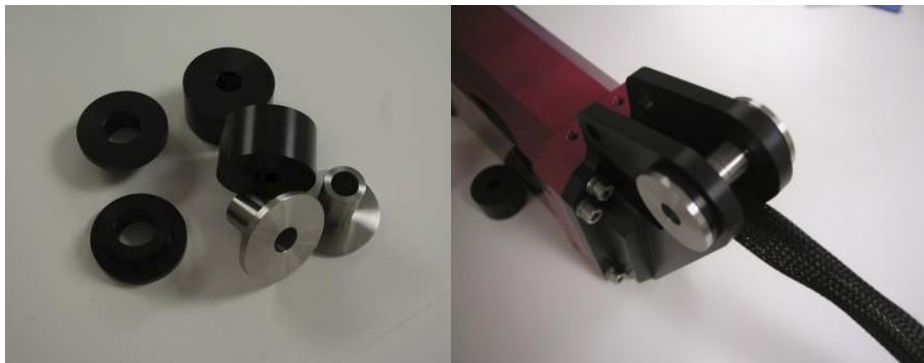


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Ensure that the Acetal Spacers have been fitted to the Shoulder Actuator Rod and are of the correct thickness to allow the Pin Assembly (Shoulder) to be tightened fully.



Assemble the Elbow Pivot Bush and Elbow Acetal Bush into the Elbow End Cap. Support the Jaw Rotate and Close Assembly within close proximity its final mounting position and feed the Actuator cable around the Shoulder Bush ensuring that it is routed correctly.



Assemble Right Hand Slew Plate with two greased Socket Head Cap Screws and two greased Socket Head Countersunk Screws as shown below. Ensure that the Shoulder Actuator Acetal washer is in place and the three Actuator Cables have the correct route through the pivot area. After Greasing with underwater grease insert and tighten the two Socket Head Set Screws locking the Shoulder Pin in place, then finally fill the heads of the two Socket Head Set Screws with grease.



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After Greasing with underwater grease, screw a Nut onto the Pivot Pin and place a Spring, then a Plain washer over the Pivot Pin. Pass the Elbow Pivot Pin through the Left Hand Plate and then Slide the Acetal Spacer over the Pin. Slide onto the Pivot Pin the Jaw Rotate and Close Assembly followed by the second Acetal Spacer.



Ensuring that the mounting points of the Right Hand Plate have been greased with underwater grease, assemble the Right Hand Plate to the Manipulator Arm and fix with the required fixings.

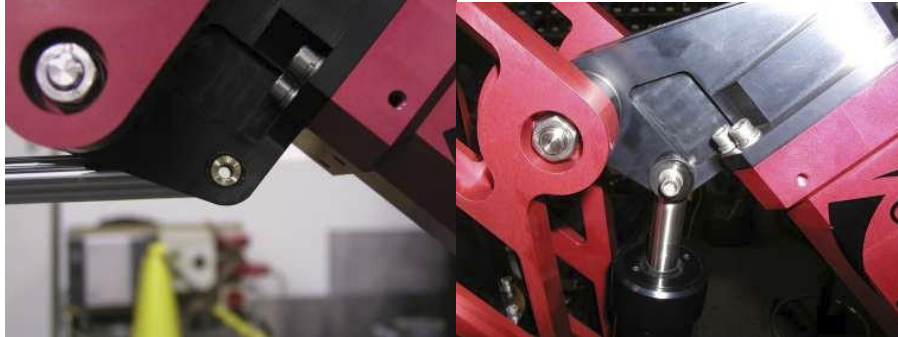


Lightly grease the ends of the Side Plate Spacers with underwater grease, and assemble using the Socket Head Cap Screws, Plain and Spring washers shown below. Ensure that the Jaw Rotate and Close Assembly cable runs between the spacers.



After Greasing with underwater grease, push the Elbow Pivot Pin into the End Cap, capturing the Acetal spacer, the Actuator Rod and the second Acetal Spacer. Lock the Elbow Pivot Pin in place by using a Socket Head Cap Screw, plain washer and an Acetal washer at each end of the Pin. Again assemble these with underwater grease.

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Finally tidy the Actuator cables and secure to the Slew Assembly ensuring that they have sufficient room to flex and move.



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9. TROUBLESHOOTING

9.1 The Manipulator appears disconnected

Check that the correct Port is being used.
Check that the power is present and at the correct level.
Check that the Communication cable is correctly attached and undamaged.
Check the Windows Port settings

9.2 Software Connectivity

This situation is unusual but can happen when an incorrect port number is selected. See device manager in windows for more information.

9.3 Slow Manipulators response

This usually happens when windows is busy, we suggest you uninstall all products not supplied with your windows installation. Please also check task manager to ensure no miscellaneous processes are stealing memory.

9.4 COMMUNICATIONS

The following section describes the Comms/software details

- RS232
- 115200 baud rate.
- USB link, appears as COM port on PC, for details see windows device manger (control panel/System/hardware/Device Manager/Ports(COM&LPT))

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10 CONTACTS

For Product and Technical Support please contact in the first instance:

Email : info@ecagroup.com

Telephone: +33 4 67636400

Address : ECA Robotics
501 rue de la Croix de Lavit
BP 4403
34197 Montpellier Cedex 5
FRANCE

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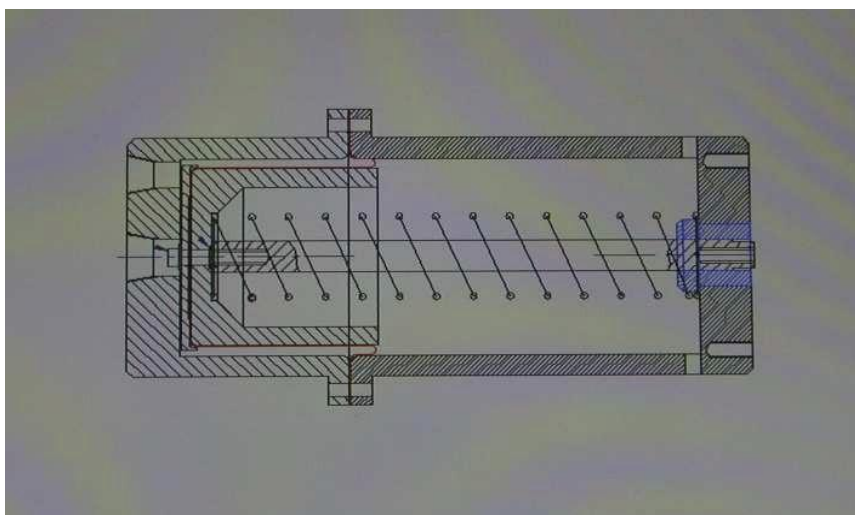
A1 COMPENSATION SYSTEM

A1.1 System Description

The Electric 5E Manipulator has been designed to operate in deep water and is therefore oil filled with a Pressure Compensation system. This comprises of three major assemblies, the Manipulator and its actuators, the Four Way Manifold and the 0.5litre Compensator. Each of the actuators are connected to the Four Way Manifold which in turn is connected to the Compensator.

A1.1.1 Compensator

The Compensator capacity is 0.5 litre. Its design is a rolling diaphragm type; free flooding on one side of the diaphragm with the oil chamber on the other. A compression spring provides a positive pressure to the oil chamber at all times at any depths.



The construction and materials are such that it requires little maintenance, and has been designed for easy replacement of the Diaphragm when required. The Compensator is to be connected to the Manifold with the length of 0.25" tubing, (as supplied). The tubing is pushed into the coupling and the Ferrule nut tightened by hand. Finally the nut is tightened by one complete rotation. Also supplied is a self-sealing 'Quick Connect' coupling for easy refilling / purging of the system

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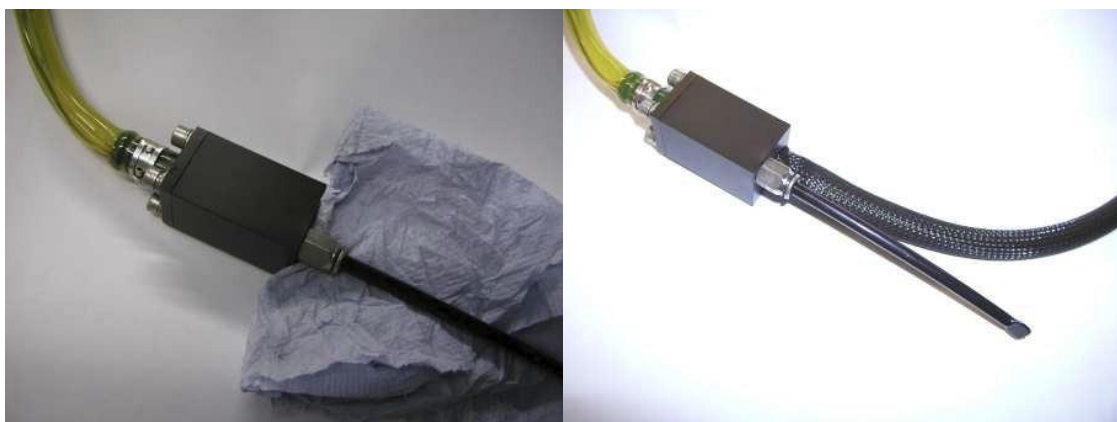


A1.1.2 Manifold

The Manifold supplied is a 4 way unit, pre-assembled and ready for use. After the Manipulator has been fitted to the vehicle, the Manifold outlet hoses can be connected to each of the Actuators, then secured to suit the installation.

A1.1.3 Manipulator Actuators

Each of the four actuators are pressure compensated. Connections are made by simply pushing the 6mm tube into the 'Push Fit' type connector. When performing this operation ensure that the Actuator being connected is extended fully. This has the effect of reducing the slightly raised pressure within the actuator as it will have been filled at the factory in this state. The Actuator has a small swept volume, the diameter of the Actuator Rod and the length of stroke. Ensure that the Junction Box where this connection is made is held above the actuator. Finally position a small amount of tissue between the compensation tube and the hose. This will collect any spillage when conducting this operation. To remove a tube from the 6mm fitting, hold back the locking ring and remove the tube by pulling firmly.



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A1.2 System Purging

To remove air from any part of the system, position the compensator so that it is the uppermost component of the oil system, this will allow any trapped air to migrate to the top of the system. Using a proprietary pressure spray bottle (See below example shown), fit the male end of the 'Quick Connect' connector to the pressure spray bottle output hose.



Fill the pressure spray bottle with a sufficient quantity of Castrol Brayco Micronic SV/3 oil. Next connect the male Quick Connect to the compensator.



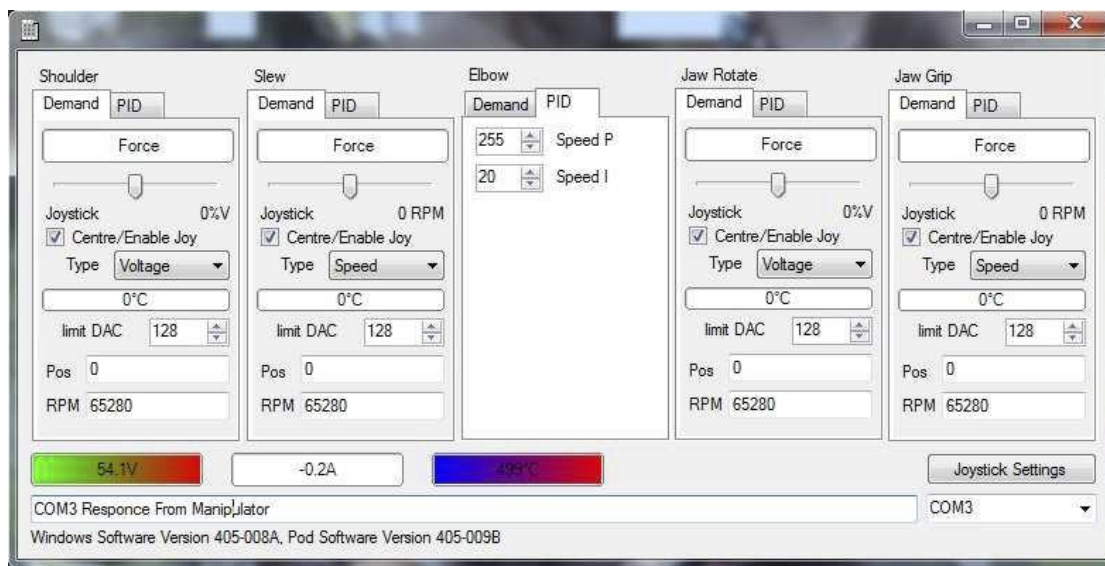
By operating the each of the arms functions it can be noted that oil is moved from the Actuator to the Compensator and finally back into the pressure bottle by utilising the swept volume of the Actuator. By pressurising the Compensator with the pressure spray bottle oil can be reintroduced back into the system and cycled by operating the Actuator and pressurising / de-pressurising the compensator. By using this method the air can be removed from each of the Actuators and finally the Manifold and Compensator. When the operator is satisfied that all of the air has been removed, fill the compensator fully then disconnect the pressure spray bottle.

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A2 Software Details

The software can be split into 4 main sections

- Motor control panel
- Master Feedback
- COMS settings
- Joystick Settings



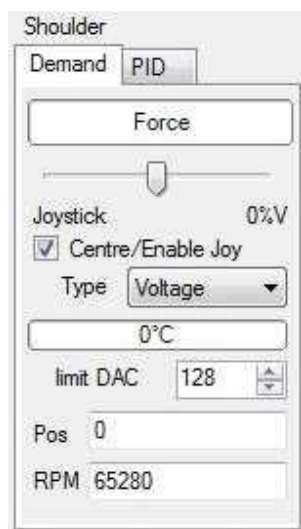
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A2.1 Motor Control Panel

The motor control panel has 2 pages; Demand and PID.

A2.1.1 Demand Page

The demand page is the main control page, from this page the operator can see the feedback from the motor driver as well as adjust the controls. The various parts are described below.



A2.1.2 Force

Force is a display of the power consumed by the motor; it is for indication only and not calibrated to any meaningful units.

A2.1.3 Joystick bar and centre/enable joy

This functionality allows operation with or without a joystick attached to the PC. The user can use the on screen track bar to command the joint; the on screen track bar always has priority over the handheld joystick. The Centre/Enable Joy makes the Joystick USB Surface Controller active if connected and causes the track bar to always return centre, should you not want the Joystick USB Surface Controller active then disconnect it.

A2.1.4 Demand Type

In this mode you set the type of demand. Voltage mode sets the average voltage to the motor depending on joystick deflection (desired by human operators). Speed mode sets the Speed in RPM of the motor in a closed loop operation depending on joystick deflection (the end result is dependant on the gearbox ratios).

A2.1.5 Temperature

If the temperature on any sensor reaches more than 60° continue with caution especially if the underwater electronics housing is not in water to provide cooling.

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A2.1.6 Current Limit DAC

This value is not scaled to any meaningful terms. It however allows a way to adjust the current supplied to any motor function, if the current needs to be limited to a given value, connect a calibrated amp meter to the manipulator, (carefully drive the actuator to the end of travel) and trim the DAC until you are within your power supply requirements.

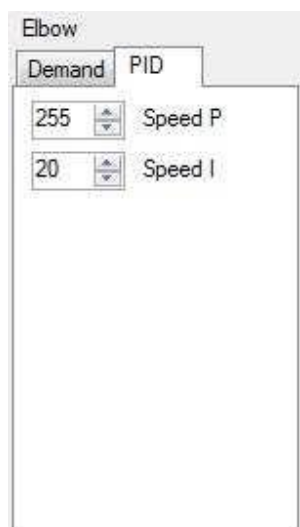
A2.1.7 Position

This display outputs the motor rotation pulse count derived by the motors hall effect sensors. At power up all the motor drivers are set to zero.

A2.1.8 RPM

This area displays the current speed in RPM of the motor before any gearbox ratios.

A2.1.9 PID Page



Some of the PID features are still in development, if you are not familiar with PID control theory please do not operate this section.

A2.2 Master Feedback

The master feedback displays sensors from the master card. These parts contain Master voltage, master Current and master temperature. These sensors are for approximation troubleshooting and are not calibrated for power supply setup.

If the temperature on any sensor reaches more than 60° continue with caution especially if the underwater electronics housing is not in water to provide cooling.

A2.3 COMs Settings

The COMs settings and feedback are used to select the PC comport for manipulator communication. In most cases the manipulators USB to RS232 converter will be sensed at start-up if it is plugged in however if this does not happen, please locate the manipulators port in the list.

Note the display area will show diagnostic messages which can be helpful.

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A2.4 Joystick Settings

A2.4.1 5E software calibration

This settings box can be used to remove a proportion of the centre of the joystick so that the arm cannot be moved in error.

To check the joystick is ok, slowly move up and down and release each joystick. If any joystick functions do not fall to the centre position on release then increase the Dead band percentage so that the onscreen joysticks fall centre. Note that setting the value higher than necessary will decrease the joystick accuracy.



A2.4.2 Windows calibration

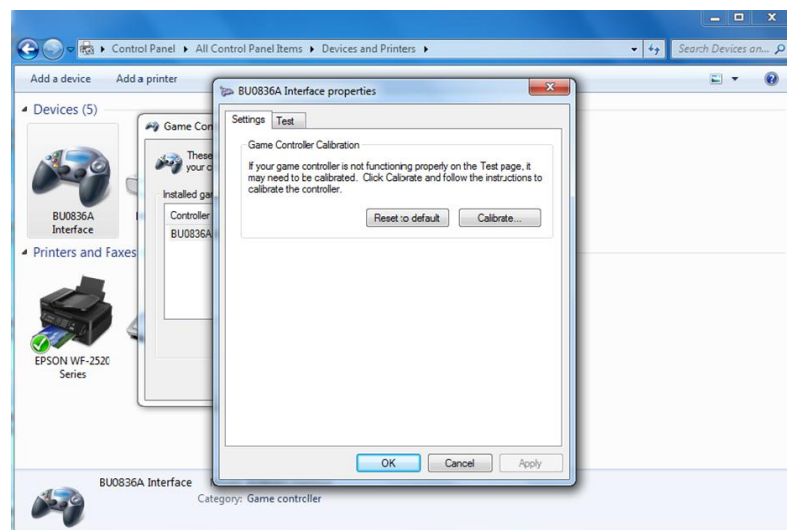
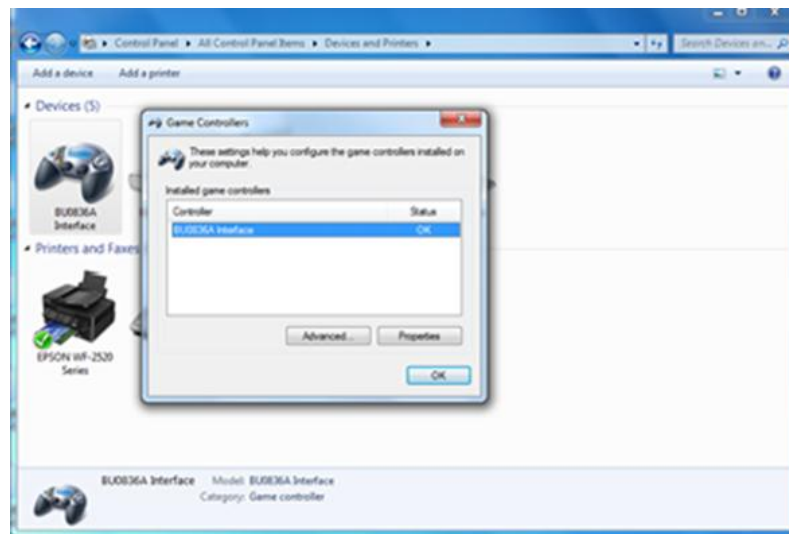
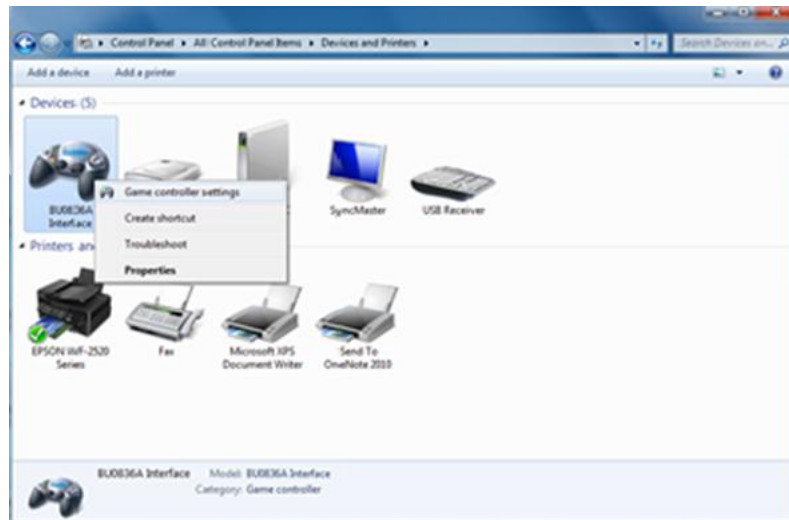
Windows 7 provides calibration for games controllers under its control panel. A calibration wizard is available. This calibration is not always required unless the joystick becomes problematic. Please follow windows help files for more information.

From your start icon go to the control panel and choose devices and printers. You will see your controller as an option, right click on its icon and choose game controller settings from the drop down list. Click on the properties button and then the settings tab. Click on the calibrate button, which will take you to the Calibration Wizard. Follow the on screen instructions to calibrate your controller. (find screen print guide on the next page)

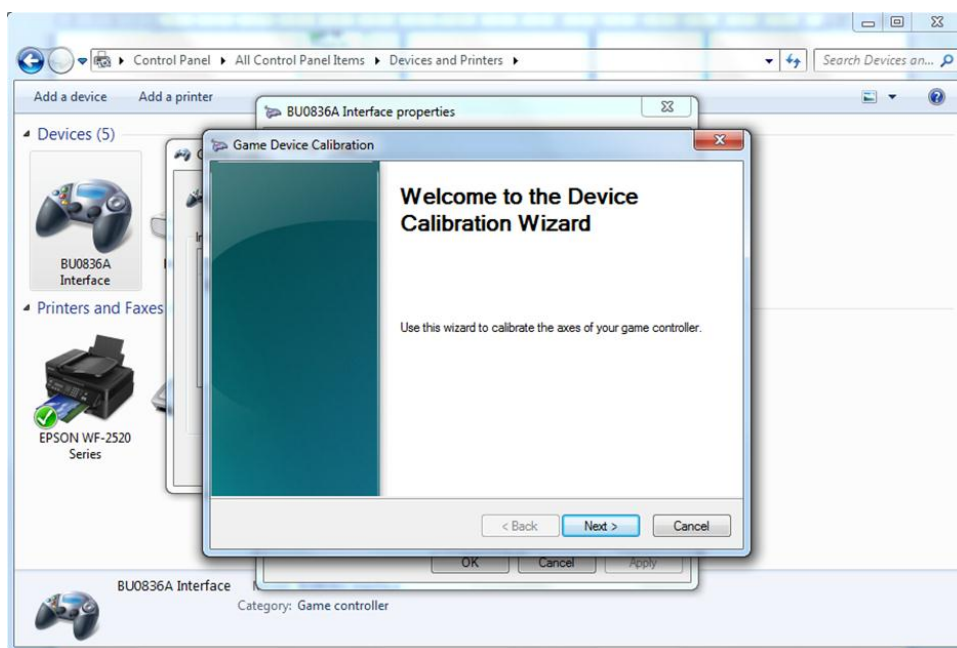


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A2.5 COMMS

The following section describes the Comms/software details

- RS 232
- 115200 baud rate.
- USB link, appears as COM port on PC, for details see windows device manger (control panel/System/hardware/Device Manager/Ports(COM&LPT))

A2.6 Installation Notes

Note the software has been designed to run on a 32 bit windows 7 machine, it may however run on other windows operating systems but has not been extensively tested.

- Disable screen savers and all power management on target machine.
- Install software from the USB pen (setup.msi or setup.exe) provided
- Install the device driver from the USB pen provided.

[illegible]

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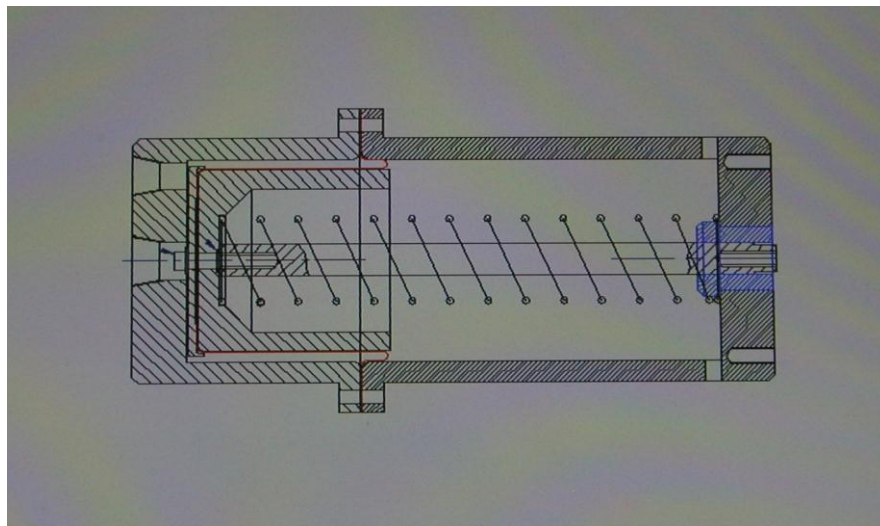
A4 COMPENSATION SYSTEM

A4.1 System Description

The Electric 5E Manipulator has been designed to operate in deep water and is therefore oil filled with a Pressure Compensation system. This comprises of three major assemblies, the Manipulator and its actuators, the Four Way Manifold and the 0.5litre Compensator. Each of the actuators are connected to the Four Way Manifold which in turn is connected to the Compensator.

A4.1.1 Compensator

The Compensator capacity is 0.5 litre. Its design is a rolling diaphragm type; freeflooding on one side of the diaphragm with the oil chamber on the other. A compression spring provides a positive pressure to the oil chamber at all times at any depths.



The construction and materials are such that it requires little maintenance, and has been designed for easy replacement of the Diaphragm when required. The Compensator is to be connected to the Manifold with the length of 0.25" tubing, (as supplied). The tubing is pushed into the coupling and the Ferrule nut tightened by hand. Finally the nut is tightened by one complete rotation. Also supplied is a self-sealing 'Quick Connect' coupling for easy refilling / purging of the system

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A4.1.2 Manifold

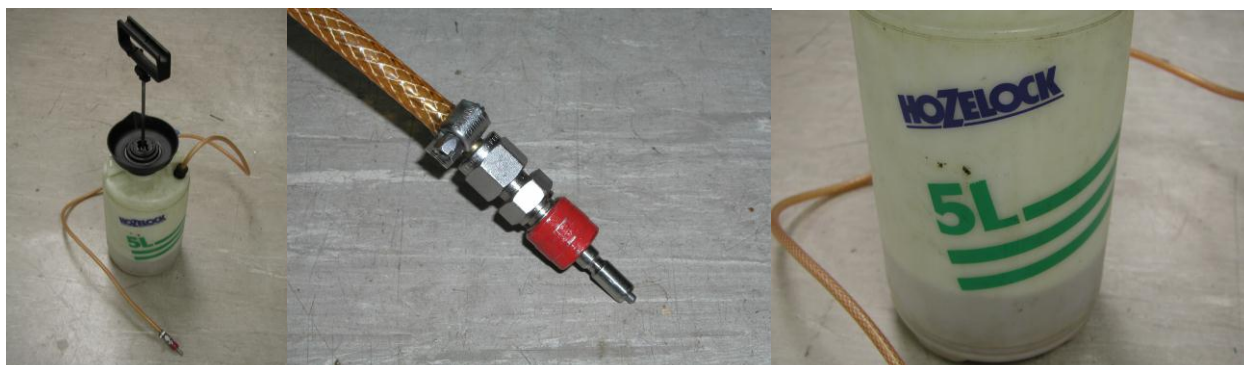
The Manifold supplied is a 4 way unit, pre-assembled and ready for use. After the Manipulator has been fitted to the vehicle, the Manifold outlet hoses can be connected to each of the Actuators, then secured to suit the installation.

A4.1.3 Manipulator Actuators

Each of the four actuators are pressure compensated. Connections are made by simply pushing the tube into the 'Push Fit' type connector. This has the effect of reducing the slightly raised pressure within the actuator as it will have been filled at the factory in this state. The Actuator has a small swept volume, the diameter of the Actuator Rod and the length of stroke. To remove a tube from the fitting, hold back the locking ring and remove the tube by pulling firmly.

A4.2 System Purging

To remove air from any part of the system, position the compensator so that it is the uppermost component of the oil system, this will allow any trapped air to migrate to the top of the system. Using a proprietary pressure spray bottle (See below example shown) (not supplied), fit the male end of the 'Quick Connect' connector to the pressure spray bottle output hose.



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Fill the pressure spray bottle with a sufficient quantity of Castrol Brayco Micronic SV/3 oil. Next connect the male Quick Connect to the compensator.



By operating the each of the arms functions it can be noted that oil is moved from the Actuator to the Compensator and finally back into the pressure bottle by utilising the swept volume of the Actuator. By pressurising the Compensator with the pressure spray bottle oil can be reintroduced back into the system and cycled by operating the Actuator and pressurising / de-pressurising the compensator. By using this method the air can be removed from each of the Actuators and finally the Manifold and Compensator. When the operator is satisfied that all of the air has been removed, fill the compensator fully then disconnect the pressure spray bottle.

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A5 Spares Packages

A5.1 A full range of spares are available upon request from the company, for example:

Seal Kits
Hose kits and clips
Actuators