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The Changing Role of the Remotely Operated Vehicle in Offshore Operations

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ABSTRACT

The ROV's role in satisfying the requirements of the offshore production industry has been one of constant change over the years.

As technical, operational and commercial experience has been gained, new and more demanding challenges have been identified.

This paper demonstrates the capabilities of ROVs and their associated technology in meeting these new demands dictated by deepwater operations, increased safety requirements and low oil prices.

Figures at end of paper

INTRODUCTION

ROVs and their associated intervention tools have been gradually eroding the well established role of the diver.

This is clearly evident by the reduction in the number of divers to date supporting the industry compared with the increase in the number of ROV's and their associated personnel.

Historically a large quantity of equipment and numerous personnel were required to support a simple diving system whose duties on a drilling rig for example were establishing wellhead guide wires and the occasional operation of valves. The introduction of the ROV however was in itself a traumatic period and most divers have their own ROV recovery tale to tell.

These early machines had not been designed for the rigours of offshore use and were therefore generally unreliable.

The ROV's potential was recognised, however, which encouraged companies to invest in these machines and improve their performance to acceptable levels.

In addition to the machines themselves, their launch and recovery systems were also improved. Early launch systems such as articulated cranes (commonly fitted to trucks) have been replaced with purpose designed "A" frames and towers etc. to cater for the general increased weights of the modern ROV, its tether management system and to provide a contingency for intervention equipment etc.

In addition, systems are now generally designed to comply with offshore lifting regulations e.g. "DnV Code of Practice for Offshore Lifting Appliances" which ensures their ability to cope with the dynamics associated with their intended use.

CURRENT CAPABILITY

Today it is now widely recognised that the ROV is the primary support system on drilling rigs.

Recently, however, we have seen numerous instances where the ROV has been required to perform activities which may be considered beyond the ROV's commonly perceived capabilities.

Such projects highlight that ROVs can perform tasks that were previously considered unlikely and will encourage new tasks to be considered with confidence.

It also became evident that all work class ROVs do not have equal compatibility and that certain tasks will require the higher specification models to be used.

RECENT DEVELOPMENTS

Three recent projects of the type mentioned are given below:

- **ROV based flowline pull-in and connection (DMaC System)**
- **Component changeout (insert choke and subsea control pod by ROV)**
- **Power and control provision (Deepwater pipeline repair)**

DIVERLESS MAINTAINED CLUSTER (DMaC)

DMaC is a subsea production system which offers a solution based on diverless technology, and therefore involves an ROV based flowline pull-in and connection system as an integral part.

One of the first Deepwater fields currently under development in the UK West of Shetlands sector by BP and Shell led the operators to the conclusion that a system such as DMaC would be critical to the success of the project.

The field named FOINAVEN located off the West of Shetlands is in approximately 550 metres of water depth and with its associated currents and weather conditions, is considered to be one of the most hostile environments in the world.

It was recognised by BP that no suitable field proven ROV based connection system existed and therefore BP decided to accelerate the build of a DMaC system for the purpose of an offshore trial. The two key features of the offshore trial were to demonstrate the functionality of the equipment in its intended environment and also to demonstrate that the flowline pull-in and connection operations could be performed from the drilling rig without interruption to rig activities. The latter being fundamental to the economic evaluation of the operation.

PULL-IN AND CONNECTION PROCEDURE

The pull-in and connection of a flowline jumper between a manifold and subsea Christmas tree is achieved by the ROV being able to attach to the subsea structures (tree or manifold) a pair of winch wires; docking onto the ends of the flowline jumpers (laid on the seabed at an earlier time) and winching in the wires therefore pulling the jumper towards the termination mounted on tree or manifold.

Once the jumper has been pulled to its final location, the ROV would operate the clamping system associated with the DMaC terminations to secure the flowline.

The main systems associated with this operation are the ROV, the interface skid and the Pull-in tool.

UNDERWATER DOCKING (Ref Fig 1)

A key feature, of the operation is the mating of the ROV and pull-in tool underwater. The ROV fitted with the underslung interface skid would dock vertically with the Pull-in tool on the seabed (deployed in a basket) via a wet mateable electro / hydraulic / mechanical connector. The pull-in tool being approximately the same size as the ROV and weighing in the order of 3.5 Te in air. This philosophy allows a standard ROV launch and recovery system to be used to deploy the ROV together with the interface skid.

This connector was rated for a 15 Te load capacity and was fitted with 32 hydraulic stab connections and three 12 pin electrical connectors.

Prior to the offshore trial, a number of onshore tests were performed which included the pull-in and connection of jumpers on land. The largest jumper connected was a 12" flexible type jumper approximately 60 metres in length.

OFFSHORE TRIAL

The offshore trial demonstrated the pull-in and connection system to the satisfaction of the client, who was then able to commit to the DMaC concept for the field development with confidence. The jumper installed during offshore trials was made up of two 6" and one 2" flexible flowlines combined in a single bundle. This was successfully pulled-in, then clamped in position by the ROV and a positive seal test performed on all lines.

The test was performed by the ROV onboard the drilling rig whilst drilling operations were ongoing in a water depth of 550 metres.

During the test a number of underwater dockings between the ROV and pull-in tool were performed successfully.

No interruption to drilling or normal rig duties resulted from the trial which was equally important.

COMPONENT CHANGEOUT

1994 saw the first use of ROV retrieval insert style choke valves in UK sector of the North Sea.

The valves were incorporated in a purpose designed subsea manifold built by Total for the Dunbar Ellon development.

The inserts were retrieved via a surface deployed running tool which was controlled at depth by an ROV fitted with a dedicated intervention package.

MANIFOLD DESIGN

The manifold was required to control the flow of gas from two adjacent subsea wells. The design incorporated ROV retrievable choke valves and ROV operated gate and needle valves throughout.

The operator placed such a high priority on the interfaces with the ROV, intervention system and retrieval tool that the ROV intervention contractor was commissioned to perform the preliminary manifold design which was included in the manifold tender for manufacture.

INSERT VALVE CHANGEOUT (Ref Fig 2)

Changeout of a defective valve would be performed by a guideline deployed Running Tool operated in conjunction with an ROV outfitted with the company's existing ROV Intervention System.

This ROV intervention system had been used successfully by the Company on the previous development, ALWYN NORTH EXTENSION. The system assembly, designed to interface with most work class ROV's is fitted to the front of the vehicle, providing the following:

- Docking System
- Dedicated Electronic Control System
- 3 Axis tool deployment system (manipulator)
- Suite of "bolt on" tools for various functions

This system is now extensively used by many oil companies and its associated interfaces are to be included in the API 17H standard being formulated in the UK.

A typical valve changeout sequence would be as follows:

- Remove manifold lid (hinged)/attach two guide wires

- Deploy Running Tool (shock absorption units fitted)
- Close Choke Isolation Gate Valves
- Unlock Insert Lockdown Mechanism
- Engage tool retrieval latch with valve lifting mandrel
- Retrieve Running Tool to surface
- Re-deploy tool with replacement valve
- Operate running tool to insert into valve body
- Lock Insert Lockdown Mechanism
- Flush all cavities with methanol / pressure test with ROV
- Open Choke Isolation Gate Valves
- Recover Tool to surface

The estimated duration of such an operation - 10 Hours.

TANK TRIALS

The operation to retrieve and re-install the insert choke valve was performed numerous times by the ROV with the manifold and Running Tool submerged in a Test Tank in Aberdeen.

STANDARDISATION

The intervention equipment used by the ROV as previously stated has already become an industry standard for many oil companies and has been interfaced with most types of work class ROV's to date.

The Running Tool concept has been received with interest by a number of operators in the UK and has led to standard interfaces being adopted in the UK by BP and Shell.

These interfaces have been configured to allow not only choke valves but control pods (or similar sized objects) to be retrieved either with or without guidewires and surface lift lines.

GUIDELINELESS MODE (Ref Fig 3)

The previously mentioned Foinaven development located in the West of Shetlands region of the UK sector has adopted these interfaces throughout. In addition to choke valves and control pods, valve blocks containing gate valves will be retrievable from the field's production manifold. In the case of guidelineless operations the concept adopted for Foinaven uses a transportation frame which is being placed on the seabed and which contains the replacement valve or control pod and its associated changeout tool.

Similar to the concept of DMaC the ROV interfaces to the changeout tool from above via a skid attached to its underside. The two mate together using a similar electro / hydraulic / mechanical connector.

The ROV will now perform a changeout sequence utilising a weight transfer system to compensate for the weight of the component weight during the sequence - **Ref Fig 4.**

USE OF ROV POWER AND CONTROL

The ROV in itself is a system comprising of high power and complex control capability. Many projects exist where subsea intervention systems have been fitted with dedicated electro-hydraulic power units and micro processor based control systems interfaced to the surface via dedicated control umbilicals. In such instances, if it was possible to transfer the power and control capability of the ROV subsea, there would be potential for cost savings and design simplification.

This would also eliminate the need for any surface umbilicals other than that for the ROV.

POWER/CONTROL TRANSFER

The recent technological advances related to wet mateable electrical connectors provide the opportunity to transfer power and control subsea.

PIPELINE REPAIR SYSTEM

A recent PRS project required the ROV to be able to transfer not only electrical power and control signals but also hydraulic power whilst underwater.

This was to enable the operation of subsea equipment such as pipeline handling frames, pipe cutting and concrete removal machines and a welding habitat.

This paper will not address the functionality of the repair equipment but highlight the interface between this equipment and the ROV.

Each of the pieces of subsea hardware was outfitted with a standard design of interface panel.

The ROV intervention panel is shown in **Figure 5** and provided the following functions:

- Three docking points to secure the ROV during operations.

- A single 4 pin high power electrical connector to allow 50 Amps @ 1000 volts to be transmitted by the ROV to power electric motors on the repair equipment.

- Two 12 pin electrical connectors to allow ROV control of solenoid operated directional control valves on the modules and permit video and sensor information to be relayed back to the surface.

- Two Hydraulic connectors to allow hydraulic power to be transferred by the ROV. (Water based fluid) provided by a unit fitted to the ROV.

- 30 Manual valve interfaces to allow direct control of functions in the event of an electrical system failure.

All of these functions were performed by an ROV fitted with an underslung skid. Existing designs of field proven equipment were used throughout which enabled the work to be performed quickly with low risk.

INTERFACE SKID

The design of the interface skid fitted to the ROV enabled it to be fitted to a number of different work class ROV's currently available.

The skid housed the following key assemblies:

- Docking System
- 3 Axis automated tool deployment system
- Electrical/hydraulic connection systems (2)
- Hydraulic Control system (water based)
- Dedicated multiplexer control system
- Video/sensor interface unit

In addition, the skid contained a vertical docking system and a further electro / hydraulic connector (12 pin electrical / 14 off hydraulic) to allow the subsea interface with the following specially designed tools.

- Pipeline Internal Cleaning Tool (40" pipeline)
- Inflatable bladder installation Tool (40" pipeline)

OFFSHORE TRIAL

The equipment was demonstrated to the satisfaction of the client during an offshore trial (summer 1994) in a water depth of 400 metres.

All of the listed interface panel functions were demonstrated using two different types of work class ROV.

CONCLUSIONS

FUTURE POTENTIAL

The ROV over past years has demonstrated a capability to perform tasks such as

- Survey/inspection
- Guidance
- Cleaning
- Measure
- Turning / Pushing / Pulling / Cutting etc.

The projects described in this paper demonstrate however a new exciting milestone in the use of ROVs.

The ability of the ROV to be able to interface with subsea tools of significant complexity and be able to manoeuvre them around the seabed offers huge potential.

WORKCLASS ROV'S

The performance of these tasks dictates the use of high performance work class ROVs. These "state of the art" machines are now readily available from a number of sources and offer features such as:

- High power - 100 kWatts min
- Fibre Optics
- High Payload Capacity
- Pitch and Roll control
- Multi-function control options
- Self diagnostics

COST EFFICIENCY

Simultaneous operations from the drilling rig is seen as a means of considerable cost savings.

The ROV based pull-in and connection system DMaC is a good example.

In a cluster type development it is intended that adjacent wells can be interconnected to a manifold for example whilst the rig was doing normal drilling operations.

INTERVENTION COSTS

The cost of intervention to a subsea development is often dictated by the cost of the vessel performing the work.

Component changeout in a guidelineless mode highlighted that no surface guide wires or control umbilicals were required to perform the operation, other than the standard ROV umbilical and a lift line to deploy the equipment to the seabed.

This method does not require heave compensated guide/lift wires and can be operated from a simple vessel with minimum DP capability therefore ensuring operational costs are minimised.

EQUIPMENT RENTAL

The standardisation of simple interfaces is allowing operators to hire equipment to perform a variety of intervention tasks.

In the UK sector this is now becoming the desired option.

Examples of equipment now available on a rental basis are:

- ROV based flowline pull-in and Connection Tools
- ROV based Umbilical Connection Tools
- Component changeout Tools i.e. insert valve / control pod
- Standard Intervention Systems i.e. torque tools, hydraulic hot stabs etc.

ACKNOWLEDGEMENT

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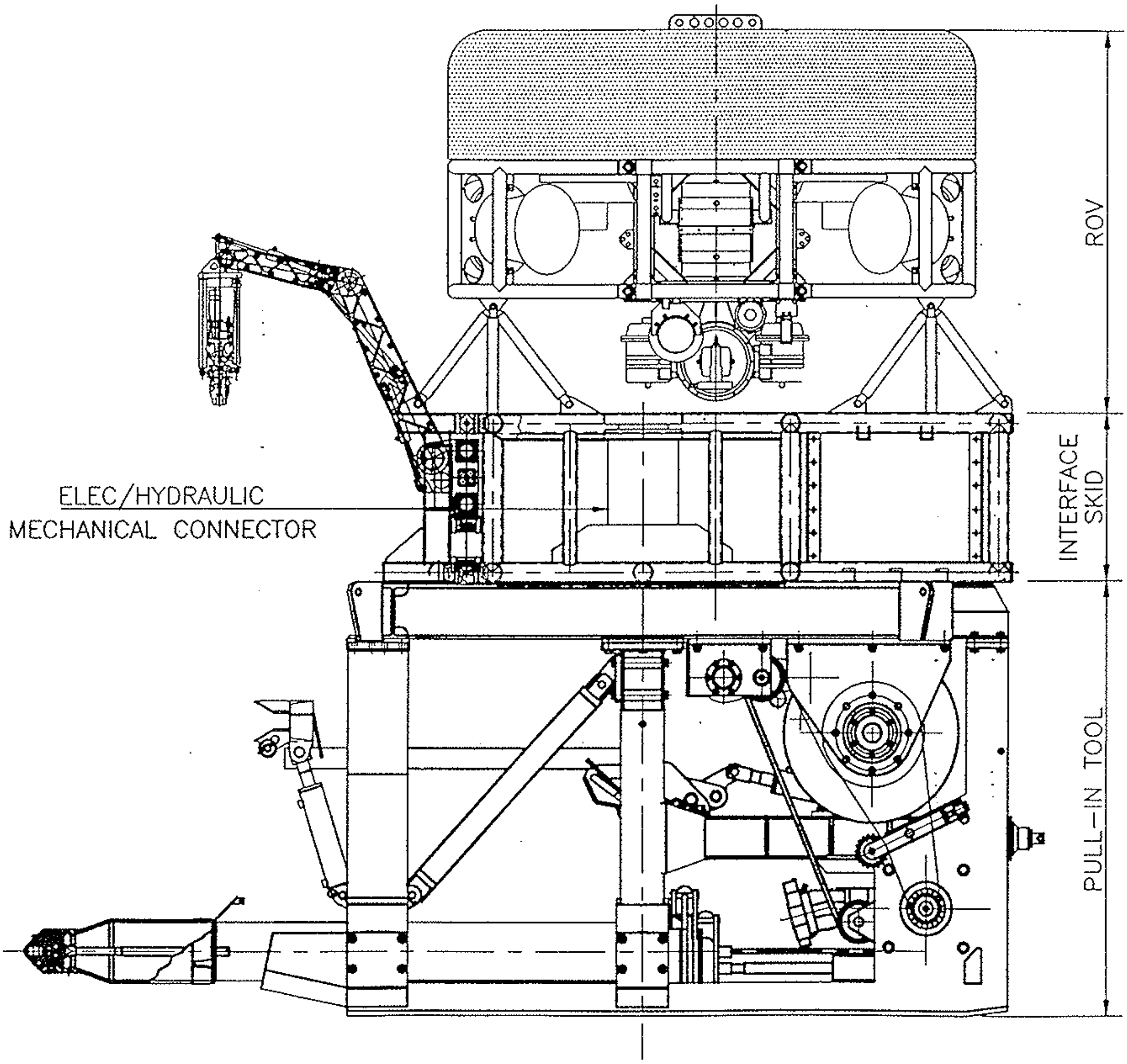

FIGURE 1

DMAC ROV BASED PULL-IN AND CONNECTION

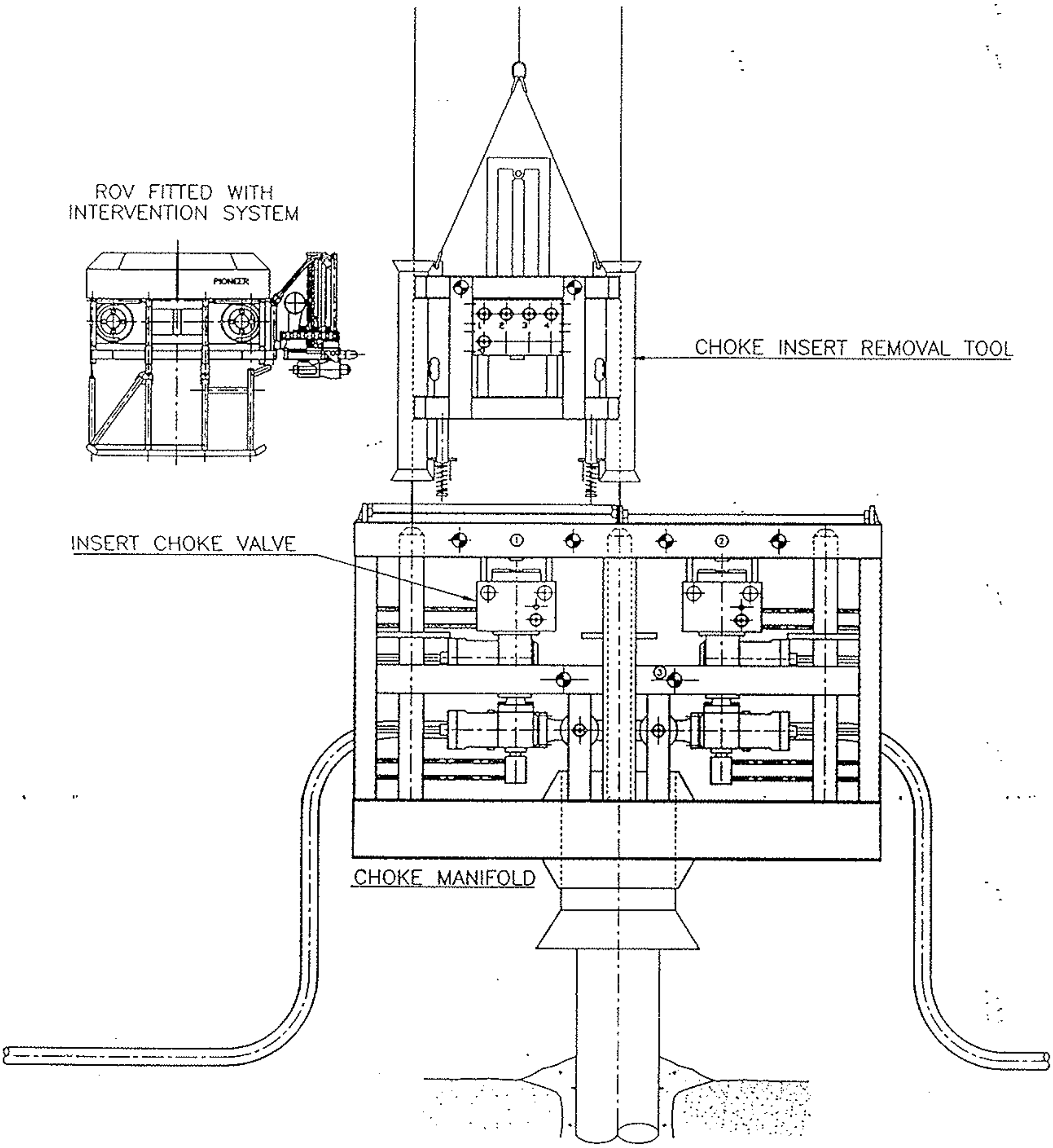

FIGURE 2

TOTAL - DUNBAR ELLON DEVELOPMENT
INSERT VALVE CHANGE-OUT

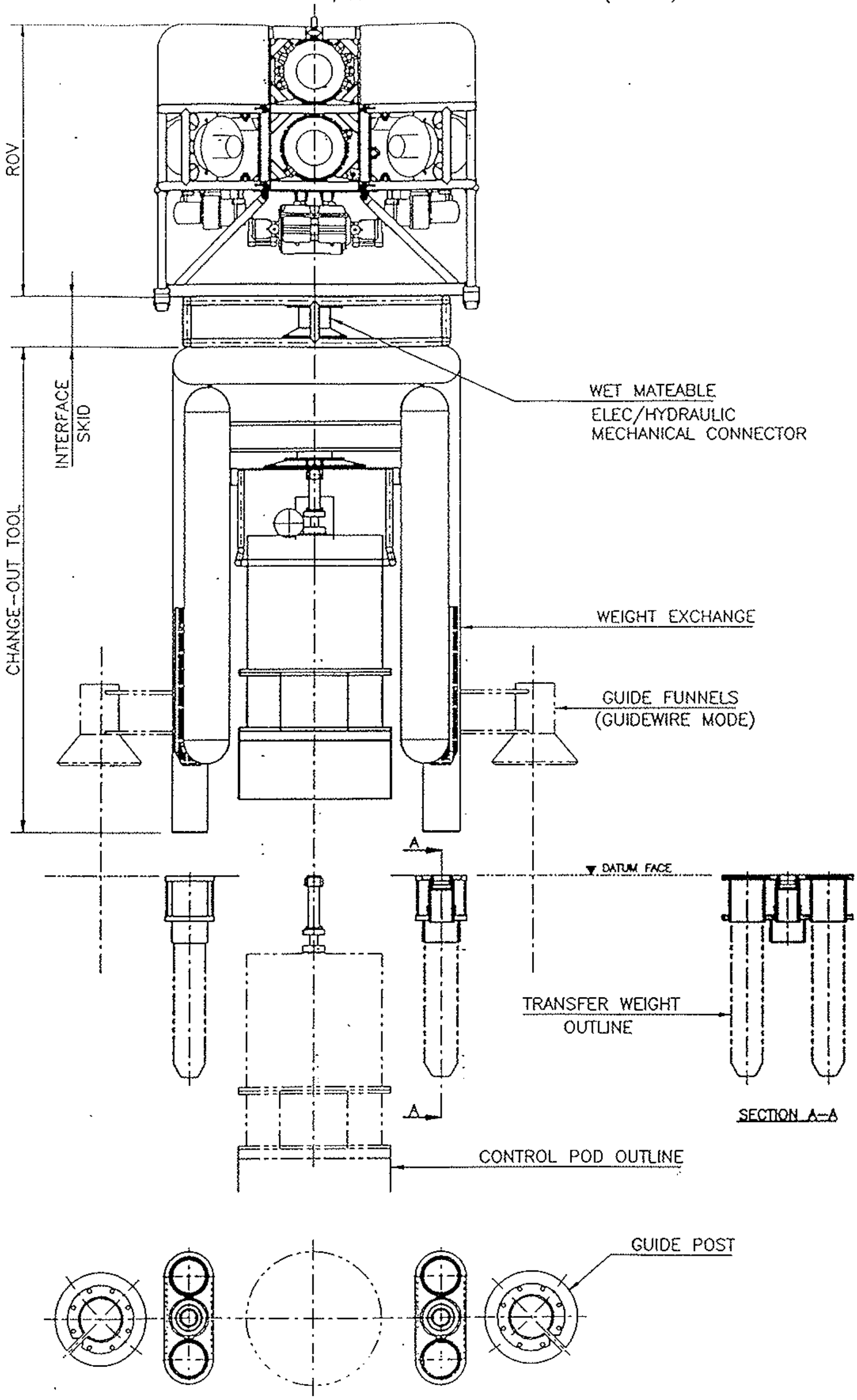

FIGURE 3

ROV DEPLOYED CHANGE-OUT TOOL COMPONENT
(GUIDELINELESS MODE)

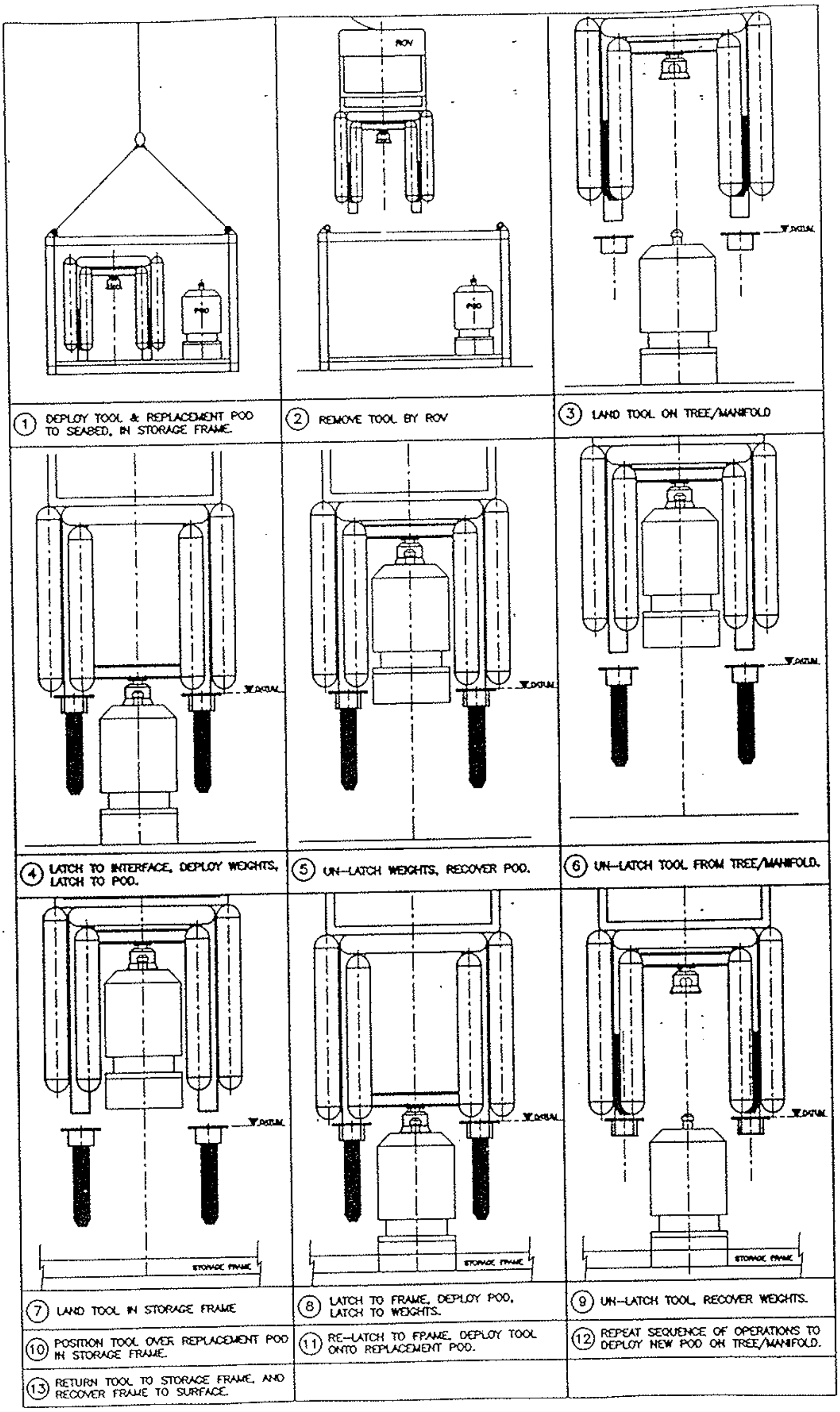

FIGURE 4

CONTROL POD CHANGE-OUT SEQUENCE

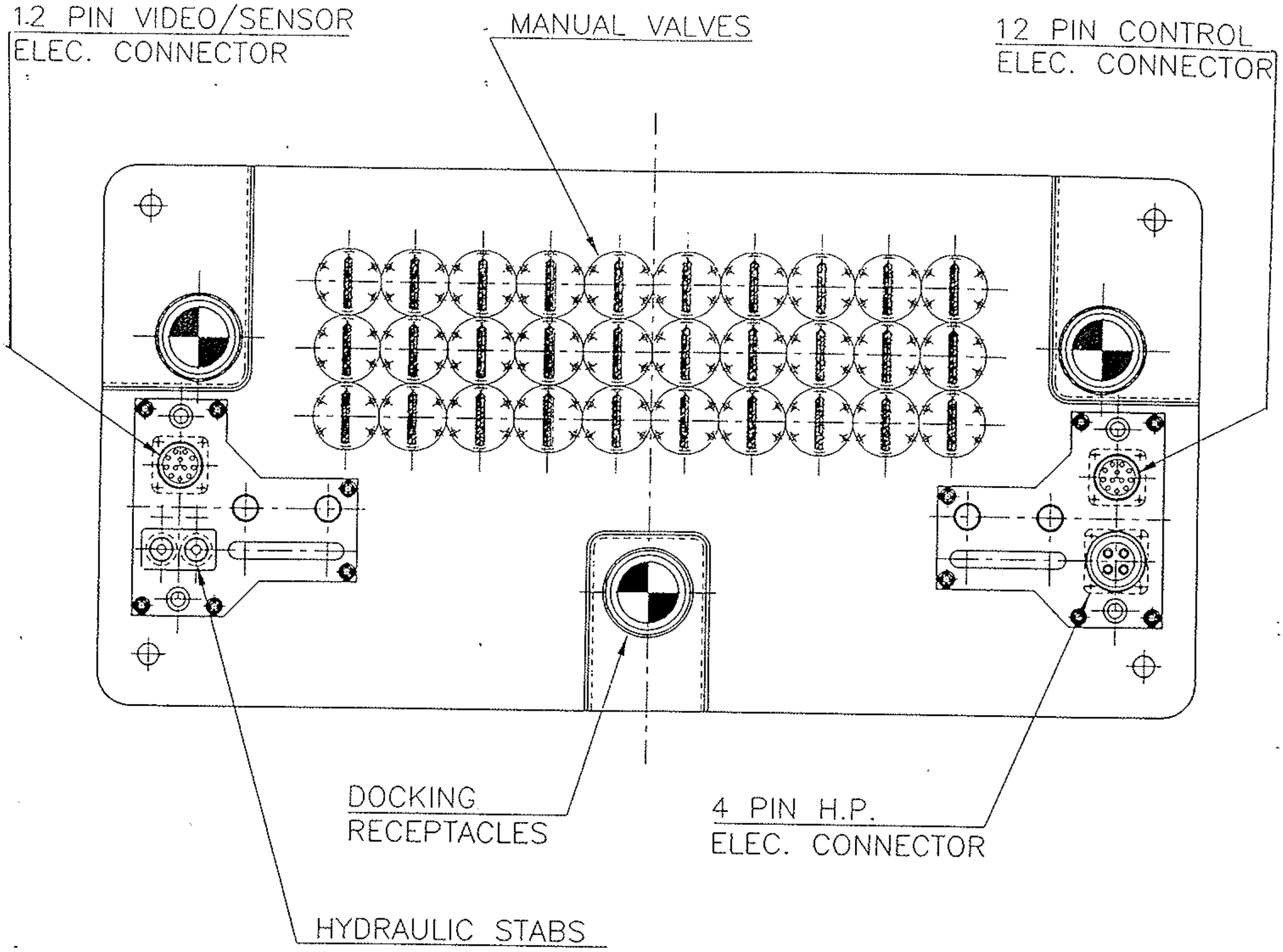

FIGURE 5

POWER AND CONTROL ROV INTERFACE PANEL