OceanGate®

MANNED SUBMERSIBLE TITAN
OPERATIONS MANUAL

This document contains information necessary for the safe operation of Titan. It shall include the mechanical, electrical, pneumatic and associated sub systems, which relate to the submersible and provide detailed procedures to allow for the safe operation of the submersible systems.

Separate documentation will be available in the form of the Pilot Training Manual covering all titan systems information.

Amendment History

REVISION DATE	AUTHOR	APPROVED BY
5/6/2019	[redacted]	
5/21/2019	[redacted]	

Introduction

This document is issued to all pilots and Titan operations personnel and shall be made available to any outside contractors or inspecting bodies involved in the day to day running of the operation.

The contents of this manual should provide an adequate level of information of Titan operational procedures for all parties concerned. It will be assumed that the qualified pilots through to the surface personnel have had adequate training in their field; the individual training of personnel will be covered in the Pilot and Surface Ops training manuals.

Titan Command Module Checklist

Pre-Dive Checks – External

Review Maintenance Log

Portside

Thruster Anodes	Secure
Thruster Connectors	Secure
Thruster Mounts & Bolts	Secure
Prop/Blades/Bearings	Inspect
Fairing Mounts & Bolts	Secure
Cable Anti-Chaffing	Secure
Oil Compensation Lines	Inspect
J Box	No Water
Oil Compensator	Full
Landing Gear & Bolts	Secure
Ingot Hard Ballast	Secure/Weight Total
Drop Weight	Centered/Greased
Hydraulic Drop	Secure/Clear
Penetrators and Cables	Inspect

Aft

Fairing Bolts	Secure
Tow Point Shackle	Secure
DVL Protection Cap	Remove
DVL Transducer Head	Inspect
DVL X-Axis Notch	Forward Facing
Aft Camera	Secure/Orientation
Disabled Sub Line	Removed

Starboard

Thruster Anodes	Confirm Secure
Thruster Connectors	Confirm Secure
Thruster Mounts & Bolts	Confirm Secure
Prop/Blades/Bearings	Inspect
Fairing Mounts & Bolts	Confirm Secure
Cable Anti-Chaffing	Confirm Secure
Oil Compensation Lines	Inspect
HPA Cylinder	Open
VBT Motor	Confirm No Water, Lines Free
VBT Fill Line	Confirm Secure /Valve closed
Vacuum Line	Confirm Open
Landing Gear & Bolts	Confirm Secure
Ingot Hard Ballast	Secure/Weight Total
Drop Weight	Centered/Greased
Penetrators and Cables	Inspect
Belly camera	Secure
Hydraulic Drop	Secure/Clear

Forward

Viewport	Inspect
Lights & Connections	Confirm Secure
Drop Weight Motors	No Water/Lock collars removed
Disabled Sub Line	Removed
Lift Strap	Secure
Hinge	Inspect
Exo-Structure Hardware	Secure
Camera	Secure
Pan & Tilt Mounts	Secure
Fairing Mounts & Bolts	Secure
O Ring	Greased and clean
O Ring matting surface	Inspect

Topside

Sonar & Sonar Connections	Secure
Pan & Tilt Cables	Secure
Fairing Mounts & Bolts	Secure
Tracking Emergency Locator	Remove On/Off Band
Lift Strap	Secure
CB Antenna	Secure/Dive Flag Secure
Thruster Anodes	Secure
Thruster Connectors	Secure
Thruster Mounts & Bolts	Secure
Prop/Blades/Bearings	Inspect
Acoustic Comm Transducer	Inspect

Pre-Dive Checks – Internal

Internal Electrical

Aft Breaker	On
Main Power Switch	On/Green
Control Computer	Follow Prompts/Password 1
Variable Ballast	Operate - confirm motion
Thrusters	Clear/Run/Confirm Direction
DVL	On
PHINS	On
2D Sonar	On
Camera	On
Lights	Test
12V Scrubber	Test

O2 Gas System Floor Storage And Life Support

4 Reserve O2 Cylinders	Crack Open - min 2500 psi
4 Reserve O2 Cylinders	Close; Do ***NOT*** Bleed
Main Day O2 Cylinder	Open, Confirm Flow, Close
Emerg. Atmospheric Monitor	Test and off
Lithium Blankets (5 boxes)	Confirm in Place

Internal Aft

Through Hull Penetrator Wiring	Inspect
Hull Through Bolts & Seam	Inspect
Tool Kit	Confirm in Place
Emergency Life Support	Confirm in Place
O2 Masks	Confirm 5 in Place
Thermal Blankets	Confirm in Place
Barometer	Set Prior to Hatch Closure
Scrubber	Filled, Fitted and Tested
HPA Hull Stop In	Open
HPA Hull Stop Out	Closed
Cabin Vent Valve	Closed
Pressure	>5,000 psi dives <2,000 meters

	>9,500 psi dives >2,000 meters
Blow Valve	Open until flow stops
Pressure	Confirm no decrease
Blow Valve	Closed
HPA Hull Stop Out	Open slowly
Cabin Vent Valve	Open
Hydraulic Hull Stop	Closed
Pump	Pump - inspect for leaks

Final Pre-Dive Check

Oxygen	Pressure and flowing
Scrubber	On
Vacuum	Holding pressure
Vacuum valve	Closed and locked
VBT	Valve full up
Computers	Up and running
Crew	Briefed – Hoods, O2, Comms
	Surfacing, Rebreathers
Crew	Gear Stowed For Platform Decent

Post-Dive Checks – Internal

HP Gas Systems

HPA Hull Stop In	Closed - Log Pressure
HPA Hull Stop Out	Open
Vacuum Valve	Open

O2 Gas And Life Support Systems

O2 Flow Valve	Closed - Log Pressure
Main Day O2 Cylinder	Closed

System Power

Windows Computer	Log batt levels then Shutdown
Aft 24v Meter	Log 24v Level
Control Computer	Shutdown
ATM-RTM Computer	Shutdown
Power	Off-Red
Aft Breaker	Off

Post-Dive Checks – External

Portside

Thruster Connectors	Secure
Thruster Mounts & Bolts	Secure
Prop/Blades/Bearings	Inspect
Oil Comp Line	Inspect

Aft

Tow Point Shackle	Secure
DVL Transducer Head	Inspect - install cover

Starboard

Thruster Connectors	Secure
Thruster Mounts & Bolts	Secure
Prop/Blades/Bearings	Inspect
Oil Comp Line	Inspect
HPA Cylinder	Shut

Forward

Viewport	Inspect
Dome matting surfaces	Inspect

Topside

Tracking Emergency Locator	Confirm Off Band Installed
Thruster Connectors	Secure
Thruster Mounts & Bolts	Secure
Prop/Blades/Bearings	Inspect
Oil Comp Line	Inspect

Titan Emergency Procedures

Power Failure of Internal Batteries

1.	All Electrical System Breakers	Off
2.	Main Breaker	On
3.	Main Power Button	On
4.	Essential Bus Breaker	On
5.	Aux Bus	On
6.	If Systems Fail	Repeat 1-4 and surface

Power Failure External Batteries

1. Shutdown and the reboot system

Deballasting/Jettisoning

Drop Weight Tray Release Procedure

1.	Weight tray hull stop	Open
2.	Hand pump selector	Closed
3.	Pump handle until weight drops	

CO2 Scrubber failure/excessive CO2

1. Notify surface of condition
2. Open a Lithium Hydroxide cannister and hang sheets as needed to keep CO_2 below 1%
3. Surface immediately

Uncontrolled Internal HP Air Release

1. Turn off the air supply valve at the through hull to the VBT system.
2. If VBT is needed, only open HP air hull stop long enough to blow VBT and then shut supply off.
3. Continue normal surfacing procedure.

Excessive O2

1. Day O2 Valve Off
2. Emergency O2 Valves Off
3. Notify surface
4. Monitor and encourage exercise of crew to burn O2 if needed and practical
5. Surface immediately if reason for high O2 is not obvious and solved
6. Open Day O2 as needed once O2 returns to normal levels

Loss of Communications

1. The submersible sends status data continuously to the surface. If connection with surface is lost for more than 60 minutes, sub will surface.

Smoke/Fire *In the event of a fire*

1. Turn OFF Main Breakers to isolate power.
2. Turn OFF Oxygen.
3. Deploy and don smoke hoods.
4. Use flashlights to determine if smoke/fire has stopped.
5. If fire has stopped, turn off all but essential bus and attempt to start systems while watching for smoke or fire.
6. Use fire extinguisher if possible and necessary.
7. If systems come up normally notify surface.
8. If fire returns turn off power system and deploy O2 masks.
9. Surface immediately.
10. After 15 minutes start O2 flow at 0.25-0.50 ltr/hr per person

Entanglement

1. Notify support vessel. "Depth is ____, investigating entanglement."
2. Pilot will survey situation

If possible use non-entangled thrusters to maneuver

1. submersible for better viewing.
2. Check for any damage.
3. Consider descending to minimize entangling tension.
4. Try reversing thrusters slowly if they are entangled.
5. Try blowing VBT.
6. Try descending and then blowing and VBT while using full thruster power.
7. Drop the weight tray only after considering possible trim attitude changes due to entanglement, which could cause the submersible to hang at an uncomfortable angle. This action is irreversible.
8. Should all efforts be unsuccessful, prepare submersible for extended bottom time.

Stranded on Bottom

EXTENDED STAY ON BOTTOM – NO ELECTRIC POWER (assumes entanglement procedure has been performed)

1. Analyze atmosphere every 30 minutes to determine trend.
2. Minimize physical exertion.
3. Bleed in oxygen at a rate to maintain proper level.
4. Unpack and deploy LiOH blankets as needed.
5. Try to keep CO_2 absorbent dry.

Flooding

1. Determine source of flooding and secure hull stops if necessary (if conducting salt water operations, taste test will determine if source is external).
2. Notify surface support unit – "X-ray, X-ray, X-ray – Flooding -Depth is ____ feet, emergency-surfacing".
3. Blow VBT.
4. Turn on vertical thrusters if needed.
5. Check ascent rate, if additional buoyancy required, drop weight tray.

1. If water level or spray reaches electrical gear, shut off all power and don smoke hoods.
2. Once on the surface, dock and surface as quickly as possible
3. Consider adding HPA into cabin to pressurize hull by closing HPA out valve and opening vacuum valve to equalize pressure and stop water intrusion.

System Descriptions

Pressure boundaries, EXO-structure and external fittings

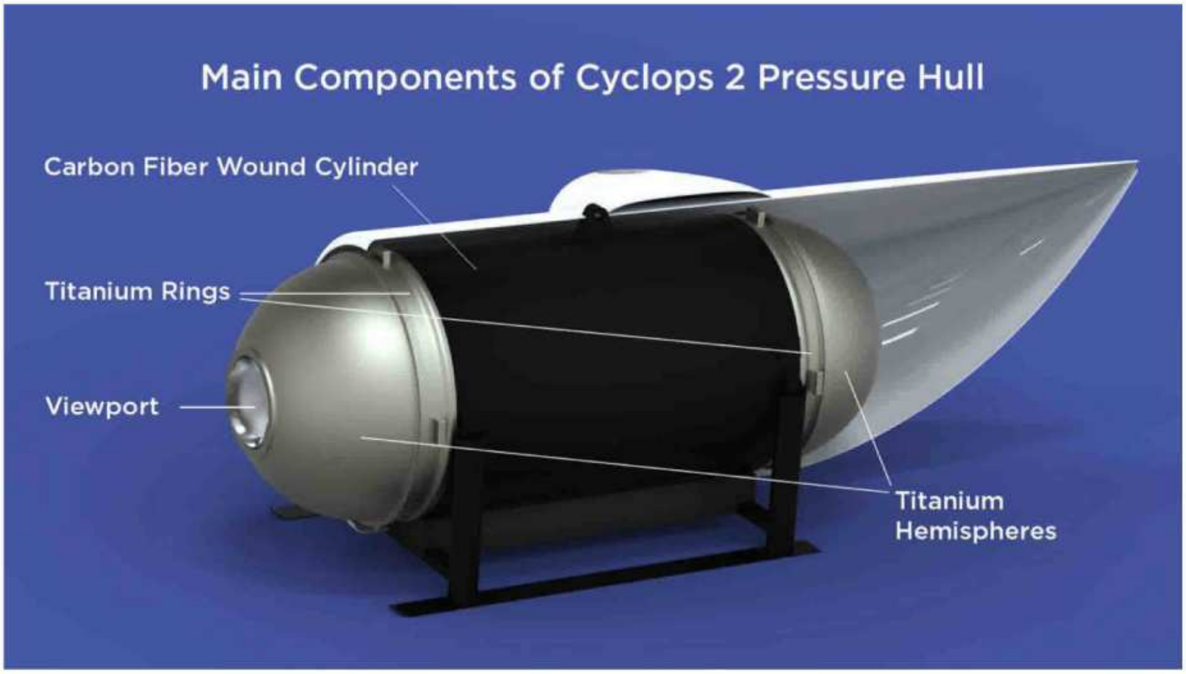
The pressure boundary maintains watertight integrity of Titan and its associated equipment to the maximum operating depth of 4,000 msw. The term "Pressure Boundary" covers the pressure hull and associated external systems. The exo-structure forms the framework enabling various fixtures and fittings to be attached to Titan outside the pressure boundary.

The pressure hull consists of a 5 inch thick carbon fiber cylinder with titanium interfacing end caps glued to the cylinder. Two 60" diameter 3.25" thick titanium hemispherical domes are bolted to the ends of the carbon fiber and titanium cylinder. The forward hemisphere is hinged to allow entry and exit it is also fitted with a 23 inch diameter view port.

A single point lift system incorporated in the hull using the four lift points on the Titanium end rings.

The 7" thick acrylic viewport is seated in a machined titanium cutout in the forward hemisphere of the hull, the acrylic viewport is then secured by a retaining ring and single O-ring.

The hull is fitted with 4 penetration plates that accommodate electrical, air and hydraulic systems.



Hull Materials:

The materials used in fabricating the hull consist of carbon fiber and epoxy resin for the composite cylinder, grade 3 titanium for the end fittings and domes and a paste adhesive bond between the composite cylinder and end fittings.

Main View Port

The forward main viewport has an inner diameter of 12.5 inches and an external diameter of 23 inches by center thickness of 7 inches and is manufactured acrylic. The viewport is held in place by means of a clamp ring bolted to the dome. Sealing is achieved by an O-ring at the outside surface pressed in place by the clamping ring. Proper care is to be taken when servicing or repairing acrylic.

Trim and Ballast System

The trim and ballast system on Titan utilize elements of the HP Air system, and electric system used for dropping trim weight and adjusting the vent line of the soft variable ballast tank. Lead "bricks" are added to the landing gear skids as appropriate to achieve the desired in water buoyancy before commencing a dive.

There is an open bottom bladder installed on the upper section of the hull on Titan, which acts as a ballast tank, this in conjunction with the HP air system, assists with the desired submerged state of Positive-Neutral-Negative. The fill point is on the top of the bladder to allow for the system to be filled with air by turning a needle blow valve internal of titan. The venting is done by an electric motor activated on the control computer to run a vent line up or down depending on what buoyancy trying to be achieved.


Trim drop weights can be dropped one at a time by way of electric drop actuators, rotating port and starboard. Up to 12 drop weights can be loaded into the drop tray, 6 port and 6 starboard each weighing 37lbs for a total of 444lbs or 34lbs in water for total in water weight 408lbs.

The entire drop tray in an emergency may be jettisoned by way of an Enerpac manual hydraulic hand pump.

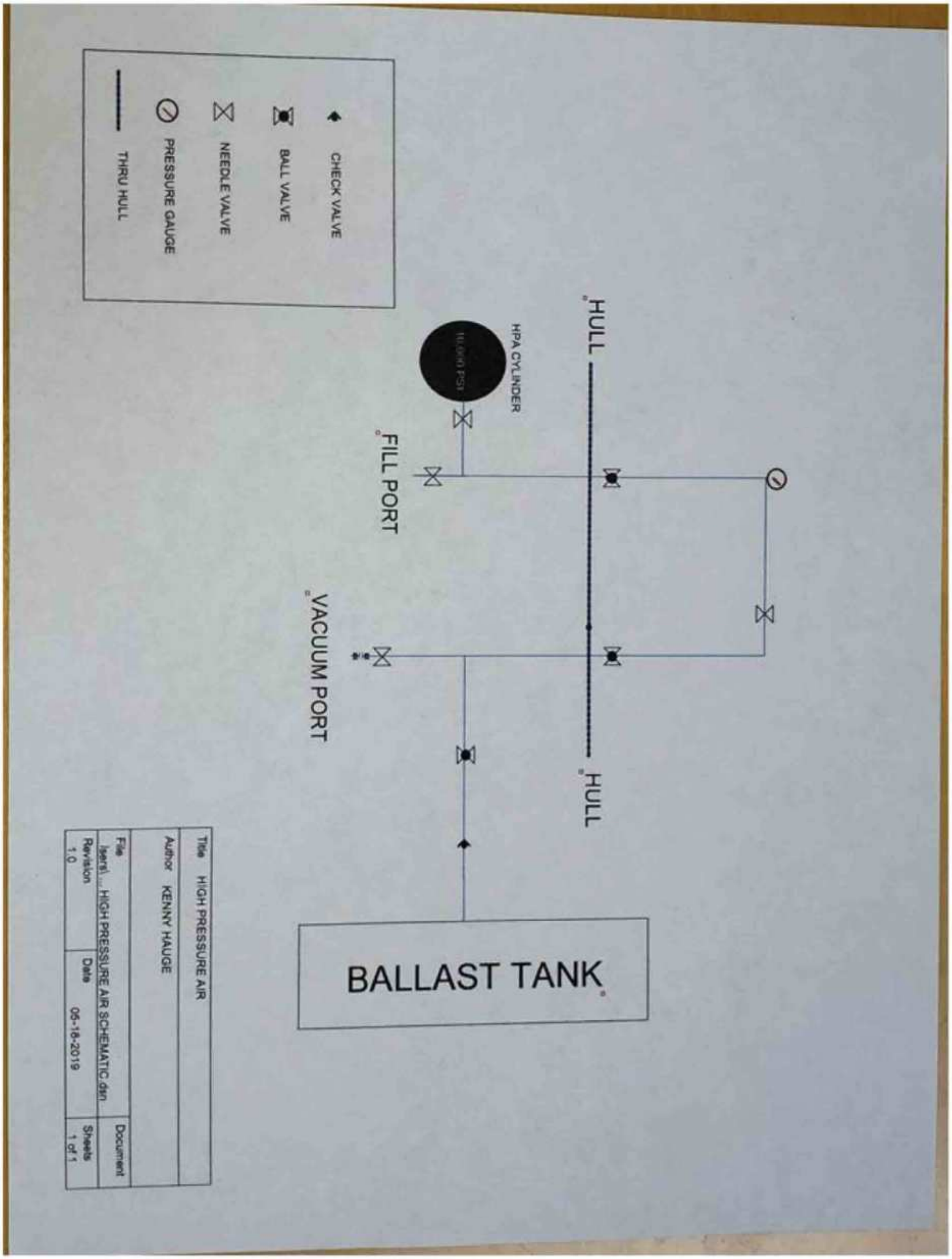
HP Air System

The HP Air system on Titan has a maximum working pressure of 10,000 psi.

The HPA tank has a volume of 40 liters.

The HPA supply enters Titan through a 10,000 psi ¼ turn valve and is gauged and runs to a needle supply valve. It then exits Titan and goes to the ballast tank.

The pressure supplied to the blow lines is not regulated and is exposed to outside water pressure. An internal pneumatic air exit valve and an internal vent valve must be configured properly and locked in position to avoid water entering the hull. The external blow lines see minimal differential pressure as the ballast system is open to the water (a soft ballast tank).


CHECK VALVE
BALL VALVE
NEEDLE VALVE
PRESSURE GAUGE
THRU HULL
HULL
HPA CYLINDER
FILL PORT
VACUUM PORT
HULL
BALLAST TANK
Title HIGH PRESSURE AIR
Author KENNY HAUGE
File
HIGH PRESSURE AIR SCHEMATIC.dsn
Document
Revision
1.0
Date
Sheets
1 of 1

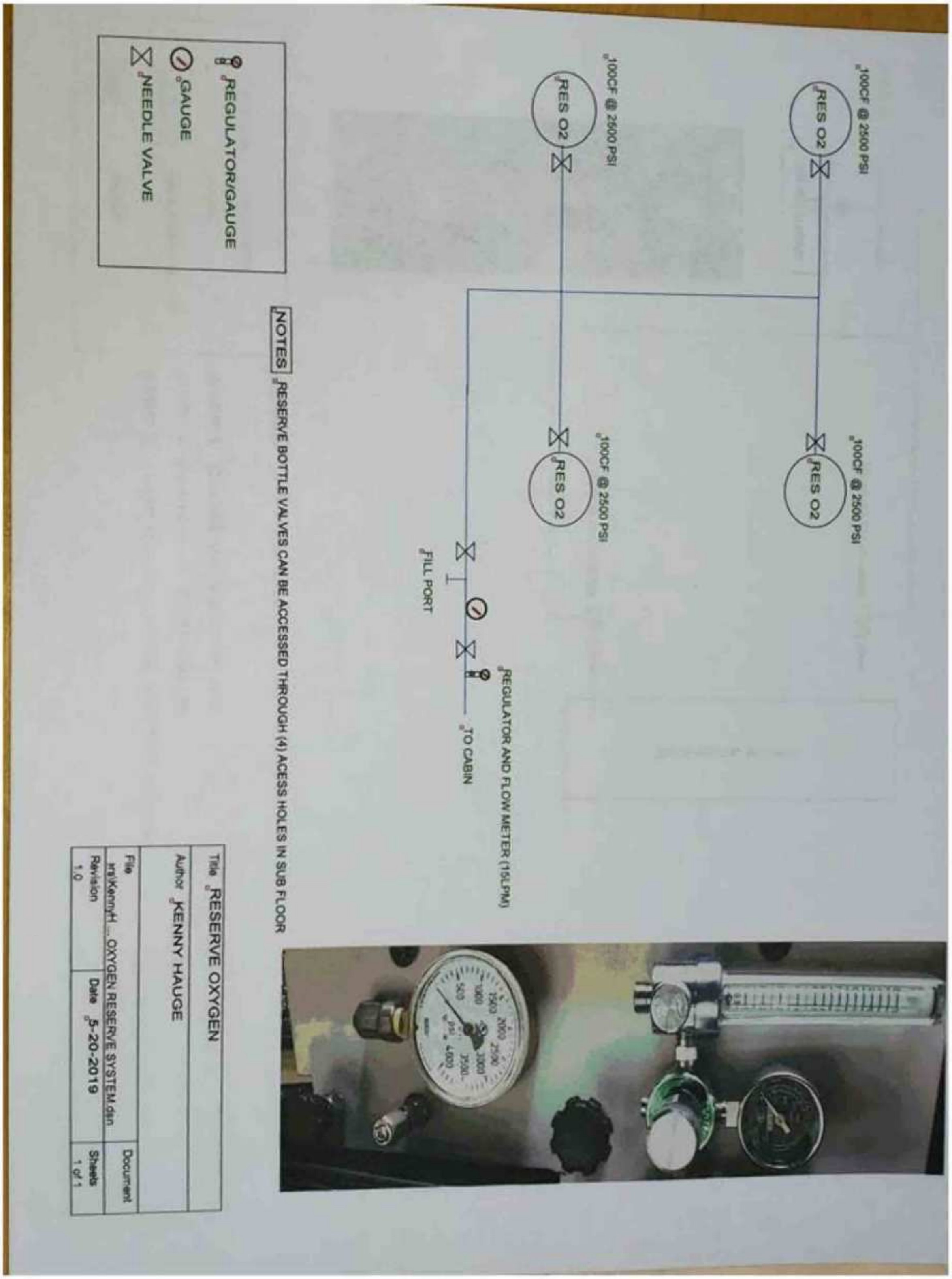
HP Oxygen System

The HP Oxygen system consists of 1 main and 4 emergency reserve cylinders. These cylinders are carried internal of Titan.

The main (day) O2 cylinder is situated in the aft equipment bay section of the hull and has a maximum charge pressure of 2,500psi. The remaining reserve cylinders are located under the floor, 2 forward and 2 midship port and starboard. The reserve cylinders are charged to 2,500 psi. Each cylinder has its own individual isolating valve at the neck of the bottle.

Once the main cylinder has been opened the flow of oxygen will pass to the flow meter. The flow meter shall be set manually using the needle valve to supply a flow of ½ltr per minute per man into the compartment. The pilot monitors the oxygen levels inside Titan with use of electronic oxygen sensors and adjusts the flow rate as required throughout the dive.

Reserve bottle under floor.



Life Support and Atmospheric Monitoring

Oxygen and CO2 are monitored by the Titan control system and emergency monitors are carried in in Titan for monitoring those gases in case of a control system failure.

There is 1 CO2 scrubber unit installed within Titan behind the Pilot seating area. This is filled with Sofnalime CO2 absorbent high performance diving grade or equivalent.

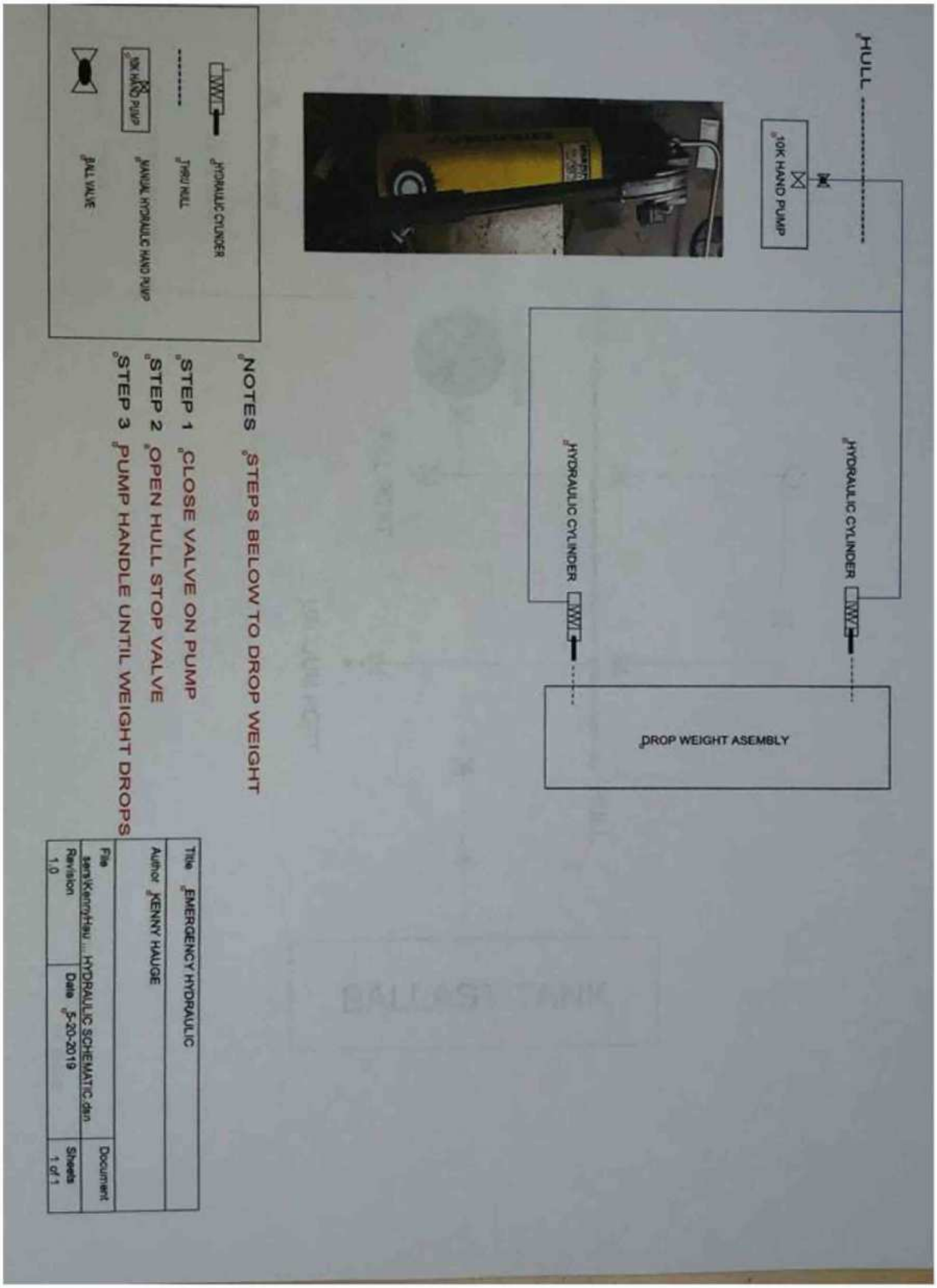
The scrubber fan unit is powered via a switch in the 24v system.

Emergency long duration CO2 scrubbing is accomplished with Lithium Hydroxide blankets, which are dry stored in Ammo boxes and deployed during emergency dived operations. Within Titan we carry enough Lithium blankets to allow for 96 hours of atmospheric scrubbing capability.

Emergency Hydraulic System

The Emergency Hydraulic System consists of a hydraulic hand pump that can activate a drop tray release mechanism and detach all of the trim weight at once. The system can also detach the entire landing gear and all lead bricks attached to it in case of emergency.

The pump itself has a maximum working pressure of 15,000 psi and is filled with oil via the fill point atop the unit.


HULL
10K HAND PUMP
HYDRAULIC CYLINDER
HYDRAULIC CYLINDER
DROP WEIGHT ASEMBLY
HYDRAULIC CYLINDER
THRU HULL
10K HAND PUMP
MANUAL HYDRAULIC HAND PUMP
BALL VALVE
NOTES STEPS BELOW TO DROP WEIGHT
STEP 1 CLOSE VALVE ON PUMP
STEP 2 OPEN HULL STOP VALVE
STEP 3 PUMP HANDLE UNTIL WEIGHT DROPS
Title EMERGENCY HYDRAULIC
Author KENNY HAUGE
File
HYDRAULIC SCHEMATIC.dsn
Document
Revision 1.0
Date 5-20-2019
Sheets 1 of 1

Electrical Systems

150volt:

Main power for the submersible propulsion is provided by two 150 volt lithium polymer external batteries that are rated to full ocean depth. One battery runs vertical thrust and another runs horizontal thrust.

The house and all auxiliary systems are run by way of 24 volt internal battery bank.

This bank consists of (4) 6 volt sealed lead acid batteries installed below the flooring of Titan.

The 6 volt batteries are run in series to make 24 volt bank and accommodate all required systems.

There is a voltage indicator on the control panel to show system voltage.

24V:

The meter on the control screen shows available voltages and battery percentages.

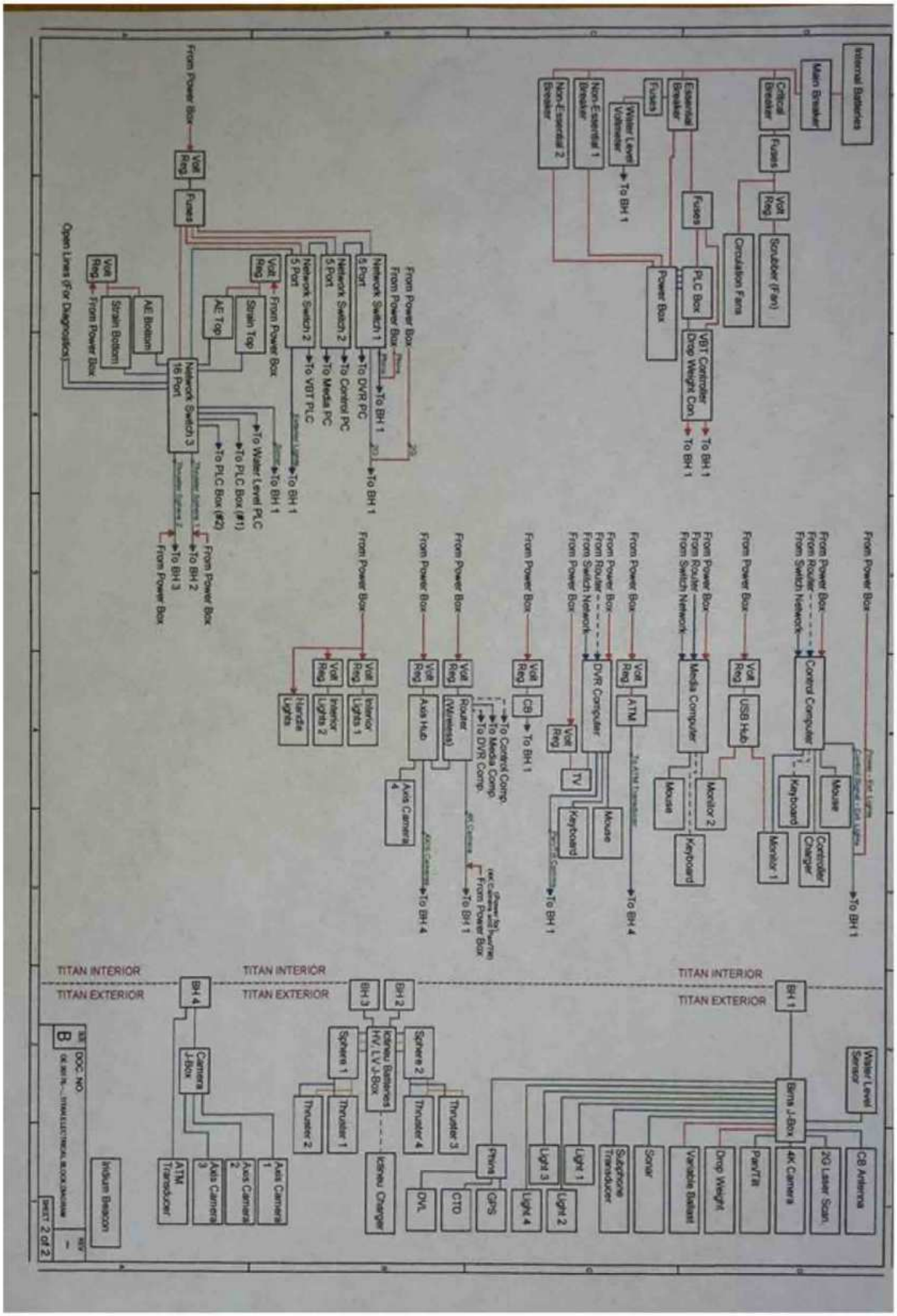
The 150V system provides power to the 4 thrusters.

The 24V system provides power to the following:

- Control PC
- 4k media PC
- AE PC / ATM – RTM
- Internal relays
- Scrubber / life-support
- External lights
- External cameras
- External junction box
- Thruster control sphere 24V Power
- Acoustic data modem
- Drop weight motors
- CB Radio
- Phins inertial navigation
- VBT motor
- Sonar pan and tilt
- 4k camera
- 2G Laser scanning system

Items in blue route through the external J-Box.

All external systems with pressure boundaries are either oil compensated, gel filled, or epoxy sealed.



Alarm Systems

Titan is equipped with various alarm systems to alert the pilot to possible issues with the equipment.

The alarm control is located on the pilot control program screen and is also fitted with analog water alarms for any water ingress to the PVHO.

Water Detection Alarm

There are two water detection alarms located within Titan.

One sensor is located under the forward crew floor panel and the second sensor is located under the flooring just aft of the pilot seating area. Both alarms are suspended approximately 1" above the lowest point on the curvature of the hull. The sensors have two contact points, which, when connected via submergence in water, will create a closed circuit and activate the flashing LED on the control box. Each sensor will activate a separate LED on the control box.

There are also alarm systems installed within the external Control Spheres monitoring temperature, humidity, water detection and pressure. The Pilot has visual indication of these alarms on the control screen and monitored throughout the dive.

Communication Systems

For topside communications, Titan employs an acoustic data system.

The data system sends speed, heading and depth information ever ten minutes as well as receiving text messages from the surface and sending message from the submersible that are manually entered on the control computer.

Navigation, Video and External Lighting

Tracking

When Titan is submerged it is tracked by the topside support vessel via an USBL acoustic system consisting of a transceiver and a transponder in addition to the acoustic data position reports.

Video

An external video camera is mounted in the top of the viewport alongside the sonar to give the pilot in the rear of the submersible a view outside the dome. There is also a belly camera which play a few roles. It is used for navigation near the bottom, and to monitor visually the dropping of trim weights. It also serves as a visual for landing and taking off from the launch and retrieval platform.

There is also an aft camera, which allows the pilot to reverse and maneuver with confidence of not running into any form of complication and an internal camera that looks out the viewport for additional forward visibility.

Lighting

The source for external lighting on Titan consists of four 9,000 lumen LED lights two on the port the other two on the starboard for a total of 38,000 lumens.

Sonar

Titan uses a Blueview sonar for detection of underwater objects.

The sonar is mounted to an electric pan and tilt unit, which is controlled via the Blueview controls.

The specifications of the available sonar's for Titan are as follows:

M450

- 90 degree field of view
- Range 300m
- Frequency 450khz
- Update rate up to 25Hz
- Power consumption 24W
- Depth 4000m

PHINS Inertial Navigation System

A fiber optic gryo inertial navigation system provides heading, position and velocity data using a fully self-contained system. Once a GPS position is established and the system aligns it is independent of any surface input and is used for primary navigation.

Doppler Velocity Logger (DVL)

Titan uses a Teledyne RDI DVL that provides, over-ground and altitude information to the PHINS inertial navigation system. This system helps the PHINS compensate for internal sensor drift.

Propulsion

Titan Spherical Glass Housings

Titan makes use of two 17" glass spheres for multiplexing propulsion power and data outside of the life space pressure hull.

The glass (1/2" thick) is manufactured by Nautilus Marine of Germany and is rated to 6000-meter depth. Holes are precision drilled to allow communications and power cable access.

One sphere controls the vertical thrusters and on controls the horizontal thrusters

The basic components contained in the spheres are:

- Motor controllers for the thrusters, which are brushless DC motors operating at 150V. Each sphere controls 2 thrusters and thus contains 2 controllers.
- A motor control unit that handles signals to and from the thrusters as well as supplying 150V power as required.
- Temperature and pressure sensors for monitoring the sphere internal environment. These are also routed to the DAC device in each sphere.
- Ethernet switch/router for communicating with sensors and control computer

Sphere connectors/penetrators are all from SubConn/MacCartney Inc. These include:

- High-power connectors for thruster power.
- Low-power connectors for auxiliary power.
- Standard Ethernet connectors for cross-sphere data and low power transfer.

The spheres are mostly filled with mineral oil. This helps conduct heat generated by the motor drives to the walls of the sphere and then into the ocean. It also reduces risk of implosion should the spheres fail by reducing entrained air. To maintain sphere integrity at low external pressures (e.g. in air or near surface) the sphere internal pressure is drawn down by a vacuum pump after oil filling.

Thrusters

Titan has 4 Innerspace 1002HL Hexscreen Electric Thrusters.

Both Ictineu batteries power this system. Power is routed out of the external batteries and into a high power junction box, where it is then routed to both spheres and into individual thrusters. The control and operating system is customized and discussed more in detail in the sphere parameters.

Image above showing 1 of the Control Spheres

Launch Tow and Recovery Procedures

LARS

LARS Launch

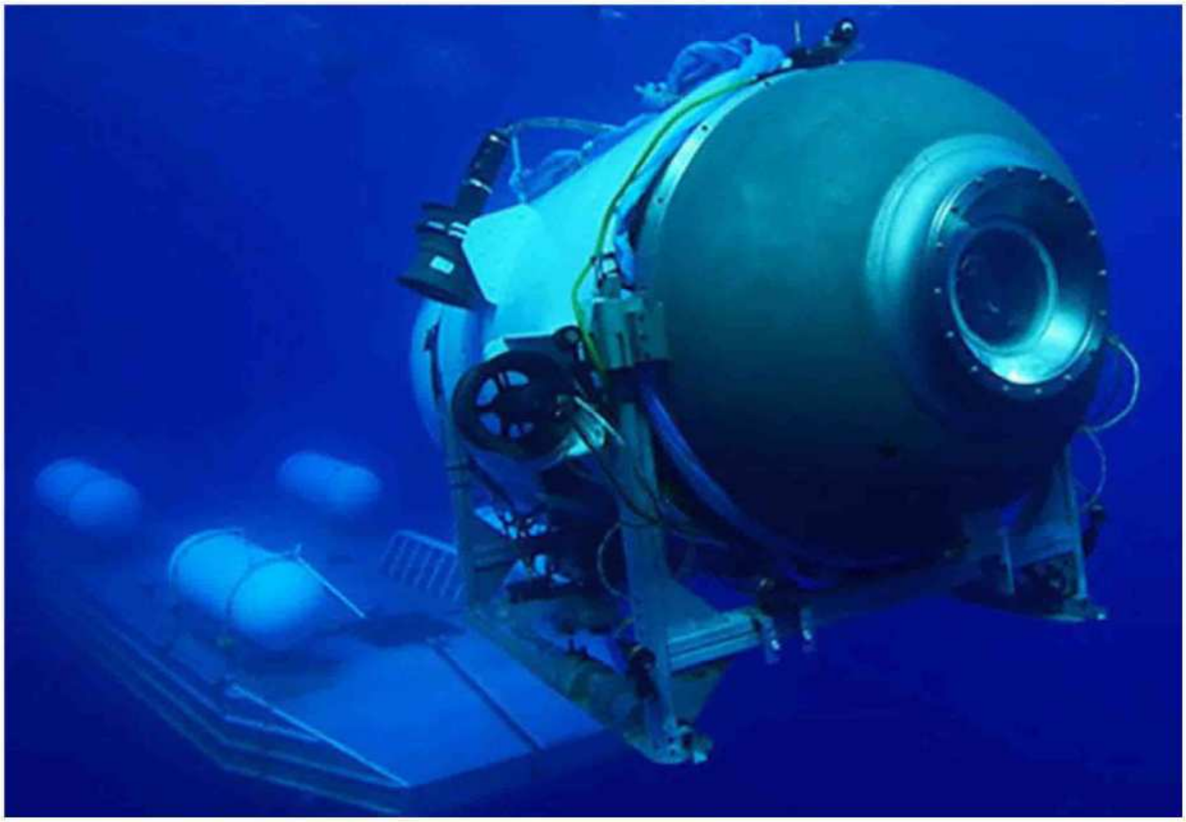
Before commencing with the launch sequence, the Mission Director will ensure that the following conditions are satisfied: -

- A pre-dive brief of Pilot, marine crew and all key personnel has been carried out as required.
- All stations are manned, equipment is operational and pre-dive checks are completed.

- If working in the vicinity of platforms or other vessels, clearance shall be obtained from the respective platform manager or vessel master.
- Mission director and captain of tow vessel shall determine once near site the set and drift accompanied by estimated time necessary to do final dive and platform checks, in order to successfully dive on desired location. At this point the tow vessel will run with predominant swells to minimize motion on platform. When not transferring personnel tow speed shall be as close to swell speed as possible.
- Vessel master and Mission Director will place the vessel and towed LARS in idle forward to ensure that the sub remains locked in place during the descent.
- If no communications are available within five minutes of sinking. The Titan pilot will make one long blast of air into the ballast systems with the vent open to show the surface all conditions are OK. If the sub needs to be raised the submersible pilot will do four long air blasts.
- If no communications can be made in 15 minutes the Mission Director shall terminate the dive and lift the LARS unless prior dive plans outline a different procedure.
- Upon confirmation the Pilot will clear the LARS and commence with the Dive mission.
- The Support boat will clear from the LARS dived station no less than 5m away.
- Typically the LARS will be blown to deck wash depth for ease of towing.

LARS Recovery

- Vessel master and Mission Director will confirm the MOSHIP is clear of the recovery area and all towlines to the LARS have enough slack prior to commencement of the recovery.
- All way of tow vessel and platform shall stop.
- The Titan pilot will be informed: "Clear to land on the LARS".
- The submersible pilot will land on the platform and confirmed locked in place by filling the ballast tank.
- Once locked in the pilot shall confirm ready for surfacing.
- The tow vessel will go to minimum forward idle to keep the sub locked in during surfacing
- The LARS operator shall then be directed to raise the vessel.
- Once surfaced the platform crew will take necessary normal operating steps to open Titan and get pilot and crew transferred off of platform.



Once sub-leaves platform:

- VBT is vented.
- ATM communications check carried out with topside coms and tracking personnel.
- CB volume turned down to prevent interference.
- External lights switched on as necessary.
- Internal lights on or off as necessary.
- Through-hull penetrators, viewports and bilges checked regularly for ingress of water.
- Sonar working and pan and tilt facing towards the seabed.
- Depth reported every 350 metres.
- Thrusters may be used in the vertical mode to vary the descent rate.
- Atmospheric conditions monitored
- At 50-75 metres from bottom thrusters will be used to gauge negative buoyancy and give an estimate of how many weights will be dropped to achieve neutral buoyancy.
- At a suitable distance from the seabed, the main propulsion can be used to further slow the rate of movement and, weights will be dropped one at a time until neutral just off bottom.
- Notes will be taken in order to log squawks and or modification/ maintenance requirements for following dives.

All Dives

Once on the bottom the Pilot reports to the topside 'on bottom' or ' near bottom'2 and notes in the Dive Log, the following:

- Depth
- Heading
- Life support
- Visibility lights on and off
- Bottom conditions
- Tide/current direction and strength
- Whether or not instruction as to range and bearing will be necessary to locate target if applicable.
- The Pilot then proceeds with his Work Task as instructed at the pre-dive brief.

Surfacing Procedures

Upon completion or termination of the Titan mission and initial ascent to required safety stop and coms before surfacing depth (20 meters), the Mission Director will order 'stand by for recovery'.

The Mission Director shall ensure that the following conditions are satisfied: -

1. No other vessels are in the area hazarding the operation.
2. Required deck personnel are ready and standing by.
3. Location of Titan is known.
4. The MOSHIP is on station.
5. The Mission Director shall then give the instruction to Titan 'clear to dock platform'.
6. Once locked in, and necessary steps are complete, platform will be ordered to surface with Titan.

Underwater Communications

An underwater communications log is to be constantly maintained between the MOSHIP and Titan when in water. Communications are to be kept to an absolute minimum to enable the Titan crew to devote their full attention to the designated work task.

In the absence of any other traffic, a communications check is to be initiated from the MOSHIP every 15 minutes. The Mission Director may extend this interval if communications are bad or when tasks would be hindered by the 15-minute rule. However, an extension of the interval must be considered the exception rather than the rule, and agreed upon by pilot and coms persons. The interval may, of course, be shortened.

In the event of no surface communication via acoustic modem of more than 1 hour, the submersible pilot will initiate surfacing procedure in accordance with the Loss of Communications Procedure.

Emergency Procedures

Emergency Surfacing Procedure

The decision to make an emergency XRAY ascent must take into account the following:

If working in or around platforms, structures or vessels, a clear ascent may not be possible and an attempt could severely aggravate the situation. In this instance Titan will have to be moved clear before the ascent by the use of thrusters, if operational, or by becoming neutrally buoyant and drifting.

In the event of an emergency, which necessitates Titan surfacing immediately, the following action is to be taken: -

- Blow HP air into ballast tank to obtain lift.
- Drop trim weights as necessary, keeping in mind that the drop of all weight may lengthen the surface interval before being able to land on platform and ascend.
- Broadcast XRAY, XRAY, XRAY clearly on ATM.
- Check CB switched on.
- If emergency is of an electrical nature, take power off all circuits, and secure oxygen as necessary.

When on the surface

- Attempt communication with the MOSHIP and support boat and pass continual reports on CB/VHF.
- Platform crew will take all necessary emergency steps in order to open Titan and assist pilot and crew in disembarking.
- Don life jackets (do not inflate while in the submersible).
- Pilot follows the crew into the water or support boat.
- Stay within vicinity of Titan until rescued by the support boat if necessary to enter water.

Action by Mission Director on receiving XRAY, XRAY, XRAY

- Dispatch support boat to expected Titan surfacing position.
- Prepare MOSHIP for full recovery.
- Standby near expected location with platform for immediate tow into recovery position.
- Deploy any additional workboats along with the support boat.
- Standby and log all updates given by Titan. (life support, Location, Depth, Heading, and all surface conditions/midwater conditions reported on initial descent)

Distressed Submersible

A distressed submersible is one, which is unable to surface without external assistance. The circumstances that would prevent Titan from attaining positive buoyancy and therefore being unable to surface are:

- Entanglement to seabed or subsea obstruction.
- Flooding to the Titan compartment.
- Loss of air ballast system and thruster control.
- Loss of trim weight drop capability.
- Loss of hydraulic drop function.

Should an incident arise where Titan cannot attain positive buoyancy and therefore be unable to surface, an emergency situation, but not necessarily a rescue situation, will exist.
The factors effecting any given emergency situation and, consequently the action thought necessary to rectify any given situation will vary according to the nature and severity of the incident.

Action in Titan

In the event of an ballast system failure, Titan should be able to thrust to the surface where the surface support should be able to connect and lift sufficiently to maneuver platform into location or lift sub on deck.

Titan has the ability to jettison a drop weight. If the entire weight is dropped with all trim weights intact, the result of this action would be to increase positive buoyancy by 420 lbs.

Should these jettisoning measures not be appropriate or not work, Titan will inform the Mission Director and await assistance, maintaining constant atmospheric, ATM watch, and make plans for an extended wait for rescue.

LARS

In the event of a malfunction with the LARS buoyancy while under Tow, the option to add additional buoyancy in the form of 2 Flotation bags will assist in maintaining the stability of the Launch platform until the necessary repairs have been carried out.

The LARS has various attachment points on the upper deck, which will allow for the surface support personnel to attach and secure the bags to the hull. Once the bags are attached a fill line shall be ran from the support vessel and then they will subsequently be filled.

If the LARS has an issue which results in the slow sinking while under tow then an attempt to release the tie down points and deploy Titan will be carried out at the discretion of the Mission Director.

Titan Recovery to LARS

In the event that Titan loses all power and is unable to navigate into position on the LARS the following procedure will ensure it is secured to the LARS.

1. Submersible will inform the Director of Marine Operations that she is on her final ascent if possible.
2. LARS support vessel will be launched with 2 divers dressed for a Recovery to MSLARS.
3. With the use of the tow boat, MSLARS will be towed into position for landing of submersible.
4. Divers will deploy above LARS and go down to get dead sub recovery lines, located in center trough of platform.
5. Submersible will be towed into position above the LARS with support vessel
6. Divers will ascend and attach dead sub recovery lines (FORE AND AFT)

7. If the submersible is too light, divers will lock submersible off and get lead from support vessel.
8. Lead weight will be added by divers via. Lift bag, supported by LARS tender vessel.
9. Once the submersible is correctly weighted, she will then vent or be pulled down by way of ratchets on dead sub recovery lines.
10. Final positioning shall be carried out by divers.
11. Once in position the submersible pilot will blow a small amount of air into the ballast tank to ensure she is locked
12. If necessary, divers will lock down submersible with ratchet straps and fully locate submersible in the locked position
13. Divers will clear away from LARS and recover to LARS support vessel.
14. LARS will be put under tow and brought to the surface once divers communicate to topside that she is ready to surface.

Upon the surfacing of Submersible from dive with excessive positive buoyancy, the following procedure is to be carried out:

1. Submersible will inform the Director of Marine Operations that she is on her final ascent.
2. LARS support vessel will be launched with 2 divers dressed for a Recovery to MSLARS.
3. With the use of the tow boat, MSLARS will be towed into position for landing of submersible.
4. Submersible will position herself above the LARS and vent ballast tanks if buoyancy is unknown
5. Submersible pilot will inform topside whether lead is necessary or not.
6. If the submersible is too light, pilot will inform topside as to desired amount of lead.
7. Lead weight will be added by divers via. Lift bag, supported by LARS tender vessel.
   a. Once the submersible is correctly weighted, she will then vent and descend to the platform.
8. Final positioning shall be carried out by the pilot and verified by divers
9. Once in position the submersible pilot will blow a small amount of air into the ballast tank to ensure she is locked
10. If necessary, the divers shall use dead sub recovery winches or ratchet straps to fully locate submersible in the locked position
11. Divers will clear away from LARS and recover to LARS support vessel.
12. LARS will be put under tow and brought to the surface once pilot and topside have clear communication.

Appendices

Glossary of Terms

Payload	Weight which can be carried and remain within standard emergency operating parameters.
PHS	Portable handling system " A-Frame"
LARS	Launch and Recovery Transportation
RTM	Real Time Monitor
ATM	Acoustic Telemetry Modem
CB	Citizens band
VHF	Very High Frequency
DISSUB	Distressed Submersible
Fsw	Feet Sea Water
Msw	Meters Sea Water
Psi	Pounds per Square Inch
VBT	Variable ballast tank
MOSHIP	Mother Ship
Titan	5 manned submersible rated to 4,000 meters

Unit Convertor

Imperial and metric measurements

1 centimeter (cm)	= 0.3937 in
1 meter (m)	= 3.28084 ft
1 kilometer (km)	= 0.6214 mile
1 inch (in)	= 2.54 cm
1 feet (ft)	= 0.3048 m
1 mile	= 1.6093 km
1 mile	= 0.868976 nm
1 nautical mile	= 1.150779 mile
1 nautical mile	= 10.126859 cables
1 cable	= 0.098747 nm
1 fathom	= 1.8288 m

Surface or Area

1 sq cm (cm2)	= 0.1550 in2
1 sq meter (m2)	= 1.1960 yd2
1 sq km (km2)	= 0.3861 mile2
1 sq in (in2)	= 6.4516 cm2
1 sq yard (yd2)	= 0.8361 m2
1 sq mile (mile2)	= 2.59 km2

Volume and Capacity

1 cu cm (cm3)	= 0.0610 in3
1 cu meter (m3)	= 1.3080 yd3
1 litre (l)	= 0.2200 gal
1 cu inch (in3)	= 16.387 cm3
1 cu yard (yd3)	= 0.7646 m3

Weight

1 gram (g)	= 0.0353 oz
1 kilogram (kg)	= 2.2046 lb
1 tonne (t)	= 0.9842 ton
1 ounce (oz)	= 28.35 g
1 pound (lb)	= 0.4536 kg
1 ton	= 1.016 t

Pressure

1 bar	= 14.503774 psi

1 psi = 0.068948 bar

10 msw = 1 bMorse Code