SEAmagine Submersible Integration

Designer’s Package for Integration of a SEAmagine Submersible onto a Yacht

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Introduction

This general overview is intended to help yacht designers and shipyards obtain general information on the various SEAmagine submersible models, their sizes and weights, as well as some of the various aspects to be considered when integrating a submersible onto a yacht.

SEAmagine can accommodate some changes on its submersible configuration to help the integration on a specific yacht and we strongly recommend contacting SEAmagine’s engineering department to help you with the process.

For all technical questions, please contact SEAmagine’s headquarters in California:

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**Ocean Pearl Model**

*2 Person Model*  
+ A1 ABS Class, CISR Certification, IMO

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**SEAmagine’s Smallest Submersible**

Engineering drawings found in the appendix on page 22 at the end of this document

<table>
<thead>
<tr>
<th>Model</th>
<th>Depth Rating</th>
<th>Delivery</th>
<th>Description</th>
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</thead>
</table>
| Ocean Pearl (2 Person) | 500 ft (152 m) | 14 - 18 months | Standard proposed model:  
  - Smallest configuration  
  - Basic dimensions  
    - Length: 4.53 m (14.9 ft)  
    - Height: 2.25 m (7.4 ft)  
    - Width: 2.44 m (8.0 ft)  
  - Weight: 7,100 lbs (3,200 Kg)  
  - Accepts all available options regarding peripherals |
| 1250 ft (380 m)        | 14-18 months |          | Deep 2-Person model:  
  - Larger dimension  
    - Length: 4.60 m (15.1 ft)  
    - Height: 2.25 m (7.4 ft)  
    - Width: 2.56 m (8.4 ft)  
  - Weight: 8,300 lbs (3,770 Kg)  
  - Accepts all available options regarding peripherals |
| 3000 ft (915 m)        | 24 months    |          | Deepest 2-Person model:  
  - Larger dimension  
    - Length: 4.79 m (15.7 ft)  
    - Height: 2.44 m (8.0 ft)  
    - Width: 2.55 m (8.4 ft)  
  - Weight is 9,040 lbs (4,100 Kg)  
  - Accepts all available options regarding peripherals |
Trinity Model
3 Person Model +A1 ABS Class, CISR Certification

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**SEAmagine’s Largest Submersible**

Engineering drawings found in the appendix on page 22 at the end of this document

<table>
<thead>
<tr>
<th>TRIUMPH (3 Person)</th>
<th>1500 ft (457 m)</th>
<th>24 months</th>
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<tbody>
<tr>
<td><strong>Standard three-person model:</strong></td>
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<tr>
<td>• Basic Dimensions</td>
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<tr>
<td>- Length: 5.33 m (17.5 ft)</td>
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<td>- Height: 3.05 m (10.0 ft)</td>
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<tr>
<td>- Width: 3.11 m (10.2 ft)</td>
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<tr>
<td>• Weight is 13,850 lbs (6,282 Kg)</td>
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<td>• Accepts all available options</td>
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<table>
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<tr>
<th>3000 ft (915 m)</th>
<th>28 months</th>
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<tr>
<td><strong>Deep three-person model:</strong></td>
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<tr>
<td>• Wider than Standard Triumph</td>
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<tr>
<td>- Length: 5.33 m (17.5 ft)</td>
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<td>- Height: 3.05 m (10.0 ft)</td>
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<tr>
<td>- Width: 3.25 m (10.7 ft)</td>
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<tr>
<td>• Heavier than Standard Triumph</td>
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<tr>
<td>Weight = 19,000 lbs (8,650 Kg)</td>
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<tr>
<td>• Accepts all available options</td>
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SEAmagine Submersibles’ Launch & Recovery Considerations

Overview

SEAmagine’s submersibles feature a special design from the more traditional concepts, which make them ideally suited for yacht operations. Traditional submersibles tend to be neutrally buoyant vessels that need to be boarded by the occupants while the craft still sits on deck before being hoisted into the water to go diving. Similarly, the submersibles then need to be hoisted back on deck after each dive for the occupants to disembark. This inherent need of the traditional submersibles, requiring a launch and recovery process for each single dive, makes their operation logistically complex, difficult and time consuming.

To greatly simplify the launch and recovery operation of a submersible from a yacht, SEAmagine’s design offers a unique patented buoyancy system that permits the small craft to float high above the water line, providing superior stability with no drag penalty once underwater. This feature allows the submersible to be operated as surface vessel and be handled or docked as a regular tender once launched. The advantages of this feature are wide-ranging and immediate:

1) The submersibles are hoisted without occupants on board. Not only is this simpler and safer, it also allows the use of simpler cranes, eliminating the burden of having the cranes "man-rated".

2) Once launched, the submersible remains in the water as a surface vessel and is docked at the dive platform. Passengers simply step into the vessel when the pilot has it ready and step out when the submersible returns to the docking position. This allows multiple dives to be performed without having to struggle with crane launch and recovery operations for each dive. This greatly simplifies the logistics of operation, safety, enjoyment, and provides more dive time in a day.
3) The launching operation can be performed by crew members only, without the guests being present. Similarly, recovery of the submersible at the end of the day involves the crew members only, leaving the guests to revel in the day’s discoveries liberated from such technical operations.

4) The location of the crane on the ship where launch and recovery operations need to be performed does not need to be the same area as where the passengers are entertained. Since the submersible can be driven anywhere on surface after launch, it is easily taken to its docking station near the recreational platform area. This separation between hoisting arrangements and diving operations allows much greater flexibility for submersible storage location on the yacht and still ensure the best practical and safe operational plan.

SEAmagine’s External Controls

To further simplify surface logistics during launch and recovery operations, SEAmagine’s submersibles are equipped with external joystick controls that allow the operator to maneuver the craft on the water’s surface without having to open the cabin or be sitting in the cabin. This feature allows keeping all aspects of the submersible sealed and closed during launch or recovery rendering the operation safer in more pronounced sea-states. It also allows easier ship management with the pilot standing on the submersible’s deck instead of sitting in the cabin.

SEAmagine’s Cabin

Another great advantage regarding launch and recovery and loading passengers with SEAmagine’s submersibles is the clamshell design of its cabin. Traditionally, passengers need to enter a submersible through a small hatch located on top of the craft. SEAmagine’s cabin design opens fully at the equator of the sphere, creating a large entry and exit point, making it far simpler and more convenient for passengers. Once the submersible is docked, and the crew has completed the required checklist, passengers simply step into the cabin without having to struggle through a small hatch.

Hoisting Arrangements

SEAmagine submersibles have a four point hoisting arrangement for launching. SEAmagine’s Triumph 3-person model also has the option for a single point hoist. Typically, a spreader bar is used with the four-point hoisting to shorten the required height of the crane and the length of the hoisting slings.

Boat Ramp Launch

Since SEAmagine’s submersibles float on surface as any tender the smaller Ocean Pearl and SEAmobile models can also be launched from a regular boat ramp and be driven off the trailer as any tender. This feature can be useful to launch the submersible from mainland at locations that do not have an adequate crane setup.
Launch & Recovery Process in Pictures

Ocean Pearl Hoisted in the water with overhead crane and spreader bar.

Ocean Pearl docked by the pier for systems check prior to boarding.
Ocean Pearl traveling to dive site with passenger on board.
Ocean Pearl proceeding to initiate a dive at the selected site.
Ocean Pearl being hoisted aboard a yacht with a boom crane.

Ocean Pearl tied down on the deck of a yacht ready of Launch.
Ocean Pearl recovered on deck
Ocean Pearl being washed on the deck of a yacht after recovery
Ocean Pearl being stowed in the hangar

TRIUMPH Submersible docked in its protective bay at the aft dive platform of a yacht.
Submersible Installation Considerations

Submersible Storage Area

SEAmagine submersibles can be stored on an open deck or in a tender storage area. If stored on an open deck, the submersible must be covered and protected from the sun. As mentioned earlier, the storage area on the ship as well as the launch and recovery area do not need to accommodate the diving operations since once launched the submersibles can be docked anywhere like any other tender.

The physical dimensions and weights of the various models are presented in pages 3 and 4 above. One aspect that must be taken into consideration is that the height of the submersible is increased when the cabin is opened.

The submersible cabin can remain closed when in storage but the operator should be able to open the cabin when needed for maintenance without launching the submersible on the water. If the submersible is stationed on an open deck or if the storage area is sufficiently high this is not a problem, otherwise the ship should be able, on a need basis, to reposition the submersible in an open area or accommodate a hatch on the storage area ceiling that could be opened when the cabin must be opened.

**Note:** Designers should contact SEAmagine’s engineering department if the height of the submersible seems to be difficult since variations to the standard configuration can be accommodated to help.
Battery Charger Installation

The submersibles are electric vehicles powered by batteries that need to be recharged at the end of a full day of diving. There are two battery chargers that need to be installed on the ship.

**108V Charger:**
- Model: ERB-C 120/25R
- Size: 17”W x 17”D x 20”H
- Weight: 156 lbs
- Mounting: Wall Mountable or on floor
- Power requirement: 208VAC to 256VAC, 50-60 HZ Single Phase

**24V Charger:**
- Model: ERB-C 24/30
- Size: 17.75”W x 8.5”D x 9.75”H
- Weight: 55.2 lbs
- Mounting: Wall Mountable or on floor
- Power requirement: 208VAC to 256VAC, 50-60 HZ Single Phase

**INPUT/ OUTPUT Arrangement**
- The two battery chargers are connected together by an 8 ft cable.
- There is only one AC input power cable for both chargers
- There is only one DC output cable for both chargers to go to the submersible

![Diagram showing battery charger installation and connections](image)
Electrical Installation

The ship needs to provide the following power outlet

Voltage: 208VAC to 256VAC 50Hz-60Hz, SINGLE PHASE

Breaker Requirement: Need to have a 50 AMP Breaker Outlet to Connect Single Phase AC Power Input Line

AC Cable Length: Installed on the Charger is a 12 ft, 6 AWG, 3 Conductor Cable, for the AC Power Input. If longer cable needed verify cable capable of 50 Amps.

DC Charging Cable: Installed on the charger is a custom 30ft charging cable that connects to the submersible when charging.

Comment: The operator needs to identify a dry storage location for the battery chargers and determine the cable length required between the location of the chargers to the AC Power 50 Amp rated breaker and the available 30ft DC Charger cable output that goes to the submersible

Battery Pod Venting During Charging

The submersible’s battery pods need to be air vented during the charging of the batteries. This is achieved by connecting any low-pressure air compressor source into the submersible’s quick-connect. It must be connected with the provided fittings, which incorporate a 10psi safety relief valve.

Battery Pod Venting Air Source Requirement:

- Pressure: Adjustable to less then 10psi
- Air Flow: Minimum 2 CFM
**Air Ballast Requirement**

For the air ballast system, the Ocean Pearl model uses regular scuba tanks that can be simply swapped out in between dives. The larger Triumph model has mounted air tanks that need refilled in between dives by connecting a high-pressure compressor’s whip to the submersible’s air connection.

### 2 Person Ocean Pearl Model

The Ocean Pearl holds the following air tanks:

- 2 x 120 cuft Air Steel Scuba Tanks that need to be filled to 2400psi max
- 1 x 80 cuft Air Aluminum Scuba Tank that needs to be filled to 3000psi max

The 80cuft Scuba Tank filled to 3000 psi is only used in case of emergency and therefore does not need refilling in normal operations. Two 120cuft tanks filled to 2400psi are used for the flotation system. One full tank is used per dive while the other one is for backup and should always be full prior to a dive. After each dive one tank is removed from the submersible and swapped out with a full one.

The operator must arrange to have an air compressor capable of filling scuba tanks to 3000psi and should arrange to have sufficient scuba tanks available to perform multiple dives per day without having to wait for the compressor to refill each tank.

### 3 Person Triumph Model

The Triumph model’s large air tanks can be refilled in between dives while the submersible is still docked, tied off, and floating on the water. The air inlets are located above the water line and allow the operator to connect the line from a high-pressure compressor to refill the tanks without having to take the submersible out of the water in between dives.

The operator must arrange to have air compressor capable of 3000psi.
**Oxygen Requirements**

The submersibles do not consume large quantities of oxygen in their life support system. SEAmagine submersibles all have a main oxygen supply and a reserve oxygen supply as backup. The main oxygen tank must be replaced after 30 to 32 hours of cumulative diving. The oxygen tanks are regular 120cuft (15L) oxygen cleaned SCUBA tanks that are certified for transport and are easily stored. The ship can carry a number of oxygen filled 120cuft (15L) tanks that can be swapped out when at sea and refilled at the next harbor stop over. As an example, for an ABS classed submersible, 6 full spare tanks will provide in excess of 180 hours of cumulative diving before they need to be refilled.

**ICE Freezer Requirements**

Our simple AC system on the submersible consist of putting ice in a cooling metal enclosure which has a fan that blows air through a small radiator. The reason we use ice is to not only condensate humidity in the air and prevent any fogging up of the windows but also to meet the ABS regulatory code requiring us to have a dictated amount of drinking water for each occupant. So the ice used to cool down the cabin also becomes the drinking water and thereby satisfies the regulatory rules.

The system is simple; ice or frozen water bottles are placed in the cooler reservoir through a large opening of the container along with some water. A pump circulates the iced water through a radiator, which has a fan that blows through it. The metal enclosure does have a bilge pump inside so that at the end of the dive the melted ice is simply bilged out and new ice can be poured in.

The Ocean pearl requires around 10Kg of ice prior to each dive. It does not matter if it is crushed ice or cubes of ice. Some of our clients freeze small containers and put the frozen bottles in the ice box instead of directly the ice.

The size/capacity of the ship-board freezer depends on the number of dives planned per day. As an example, for an operational plan to perform three dives as day, with a dive duration of 2 hours each, the freezer would need to produce 30Kg of ice or frozen small containers. The cooling is most important when the submersible is on surface exposed to the sun. Once underwater the cabin remains very comfortable and the cooling demand is a lot lower.

*The coller ice-box is filled with ice or frozen water bottles that can be refrozen.*
CO2 Scrubber Sodasorb Requirement

The submersible’s life support system is based on scrubbers filtering out the CO2 and oxygen tanks replenishing the consumed oxygen at a rate that maintains the air in the cabin at normal concentration levels.

The scrubbers are filled with a CO2 absorbent powder called Sodasorb or Softnalime which is another brand name. This absorbent material needs to be replaced after hours of running. This filter material is regularly available since it is the same as recreational divers use in the new rebreather diving gear sold worldwide.

The submersible has two Scrubber canisters each with a capacity of 12lbs of Sodasorb. One Scrubber canister is the Main while the other Canister is for Reserve. In normal operation the main canister needs to be replenished after 10 hours of cumulative running. The Sodasorb is normally procured in 5 Gallon containers holding 40 lbs of material. One 5-gallon container will provide 30-35 hours of cumulative diving hours. Many larger SCUBA diving shops around the world sell Sodasorb or Softnalime. For larger quantities the following organizations can be contacted to supply Sodasorb.

**Steam Machines Inc**
Contact: Sharon Ready  
Tel: +1 (615) 374-0202  
Tennessee, USA  
www.steammachines.com  
Type: SODASORB 6-12 mesh or 4-8 mesh

**Molecular Products Inc.**
Contact: Mike Clarke  
Tel. +44 (0)1371 830676  
England, UK  
www.molprod.com  
Type: SOFTNALIME
Other Frequently asked Questions

1. **How is the submersible launched?**
   SEAmagine’s submersibles have a four point hoisting arrangement for launching. SEAmagine’s Triumph model also has the option for a single point hoist.
   
   Since SEAmagine’s submersibles have a patented buoyancy system that permits them to float high above the water line when on surface, the operator launches the vessel with no occupants on board. The launch and recovery of SEAmagine submersibles is performed unmanned, reducing the cost of the handling system since the cranes are not required to be “man-rated” which would involve far greater safety factors and larger equipment. Once launched, the external controls on the submersible allow a pilot to drive the submersible on surface as any tender and dock the craft to the dive deck where it is tied off and then prepared to receive its crew.

2. **Are the submersibles classed?**
   Yes, all SEAmagine submersibles are classed +A1 by the American Bureau of Shipping (ABS) and can also be certified by US Coast Guard or by the Cayman Island Shipping Registry (CISR). During the construction of each submersible, ABS surveyors inspect all key aspects of the construction, survey all functional test of the various systems and witness the sea trials, which include the final test dive to the submersible’s maximum operating depth.

3. **Are there special Flag-State requirements for submersibles?**
   Yes, most Flag State agencies will require some proof that the submersible will be operated safely in their waters. Most state flags do not have special submersible requirements but will generally require that the submersibles be classed by an internationally recognized classing society such as ABS (American Bureau of Shipping). Other Class societies include Lloyds Registry (LR – United Kingdom), Det Norske Veritas (DNV - Scandinavia), Germanischer Lloyd (GL - Germany), Bureau Veritas (BV - France), (RINA – Italy), which all belong to the International Association of Classing Societies (IACS).

   The Cayman Islands Shipping Registry (CISR) is one of the exceptions and they do have additional requirements regarding the submersible operation in addition to those of the classing societies. These additional CISR requirements are readily addressed during the construction of the submersibles. US Flag State have specific requirements if the submersible is to be used for “passengers for hire” in which case the US Coast Guard requires additional vessel inspections and technical reviews above ABS or other classing societies. For private use, the US territory does not have specific requirements. French flag state also has specific submersible requirements in addition to the classing societies.
4. **How much oxygen must be carried and how is it stored?**

   The submersibles do not consume large quantities of oxygen in their life support system. SEAmagine submersibles all have a main oxygen supply and a reserve oxygen supply as backup. The main oxygen tank must be replaced after 30 to 32 hours of cumulative diving. The oxygen tanks are regular 120cuft (15L) oxygen cleaned SCUBA tanks that are certified for transport and are easily stored. The ship can carry a number of oxygen filled 120cuft (15L) tanks that can be swapped out when at sea and refilled at the next harbor stop over. As an example, for an ABS classed submersible, 6 full spare tanks will provide in excess of 180 hours of cumulative diving before they need to be refilled. The oxygen used on the submersibles is medical oxygen and the tanks are stored in a protected environment as any medial oxygen.

5. **What do I need to organize on the ship to accommodate a submersible?**

   There are a number of aspects that need to be taken into account for integrating the submersible onto a ship.
   - Proper Electrical AC power for the submersible’s battery charger
   - Proper rated crane/handling system for launch and recovery
   - Sufficient storage area for spare parts
   - High-pressure air compressor for refilling the submersible air tanks
   - Storage area for high pressure air and oxygen tanks

   Every ship has some differences. SEAmagine’s engineering department is highly experienced and will assist to provide the necessary support for helping determine each ship’s integration requirements.

6. **How Can I best refit or redesign the ship to accommodate the submersible?**

   The best first step when looking into the redesign or refit of an existing ship is to first contact SEAmagine’s engineering department. There are a number of aspects to consider and SEAmagine’s extensive technical knowledge is an important source of knowledge on available options. In many cases some adjustments on the submersible is possible to simplify the integration on an existing ship design.
Appendix

Engineering Drawings of Standard Ocean Pearl 2 Person Model

Note: Slight variations on the dimensions to the standard models depending on maximum depth rating selected are described on pages 3 and 4 above.
Engineering Drawing for 3 Person
Triumph Model Submersible Depth
Rated to 1500ft (460m)