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SAFETY FACT SHEET

TRITON SUBMARINES' SAFETY FEATURES, EQUIPMENT, CLASSIFICATION & OPERATIONS INFORMATION

CONTENTS

SAFETY: FEATURES, EQUIPMENT, CLASSIFICATION AND OPERATIONS

The following information provides an insight into the comprehensive safety related features, equipment, procedures, and operational standards that represent the foundation upon which every Triton submersible is built. Triton Submarines does not produce experimental vehicles, but series-built submersibles that are compliant and delivered with full certification by a third-party classification society.

CLASSIFICATION

Certification is an essential part of any human occupied vehicle. Certification requires significant investment in time, testing and indeed finances, but the result is a thorough independent appraisal of every aspect of the design, production, testing, and operation of a human occupied craft.

Each of Triton's submersibles, without exception, is designed, produced, and operated in compliance with the rules set by a recognized classification society (DNV, ABS, etc.). It is a certification process similar to that undertaken by the FAA in the aircraft sector.

At Triton, we fully embrace 3rd party certification by a recognized, independent team of experts as the foundation of everything we do.

Certification begins with an in-depth review of the design and engineering of the vehicle including detailed analysis of all mechanical, electrical and fluids systems. The certification extends to the selection, analysis, and approval of materials. All critical materials and hardware are tested by independent laboratories to confirm their chemical and physical properties as well as critical dimensions and tolerances on approved drawings. Pressure and strength testing of assemblies are evaluated and tested in witness of qualified, surveyors. The process continues through the testing and final certification of the completed vehicle and the craft's continued compliance through regular scheduled surveys in line with the class society rules for the entire lifetime of the vehicle.

SAFETY FEATURES

Every system on a submersible is designed, built, and tested with safety in mind.

1) The main passenger compartment is a pressure vessel (PV) designed, built, tested, certified, and annually inspected to ensure maximum safety.

The most critical safety system is the main pressure vessel (PV) and is designed to withstand twice the maximum operating pressure of the submersible and tested to a minimum of 1.2 times its rated operating depth. The hull consists of the main PV, usually constructed of acrylic or metallic components, and includes the hatch assembly and metallic penetrators. Penetrators are required to pass electrical power and air/O_2 from external tanks into the passenger compartment. Samples of all hull materials are sent to independently operated laboratories for structural and chemical analysis. Only certified hardware is used in hull assembly. Following initial certification, each pressure vessel is annually inspected and recertified by a class agency surveyor. Although still within their design life, all acrylic pressure vessels are removed from service after 20 years for safety and in compliance with the rules of PVHO (Pressure Vessel for Human Occupancy).

2) Breathing systems need to have multiple layers of redundancy for safety.

There are primary-, reserve-, backup- and secondary backup breathing systems. Primary breathing systems are designed to support approximately 12 hours of breathable air. Once exhausted, reserve oxygen banks can provide an additional 96 hours of O_2 with deployable lithium hydroxide curtains to provide the additional CO_2 scrubbing needed. Additionally, a Built-In Breathing System (BIBS) allows occupants to breathe the high-pressure air stored in the main and reserve ballast air banks. Lastly, each occupant has access to an Emergency Self-Contained Breathing Apparatus (ESCBA) unit.

3) The external chassis is built and tested to support extreme loading.

The external chassis supports the main pressure vessel and provides attachment points for lifting the submersible during launch and recovery. The chassis is designed to support eight times the weight of the total submersible and every chassis is tested to 2.2 times the safe working load. Like the hull, chassis part materials and hardware meet strict rules regarding material and structural analysis.

4) Fail safe drop weight systems are an integral part of all deep diving subs.

Deep diving (Hadal zone) Triton submersibles rely on drop weights to control buoyancy during diving operations. Drop weights in these subs are held in place by electromagnets for safety as a loss in electrical power will deenergize the system, dropping the weight and immediately bringing the sub back to the surface. Additionally, a drop of weights can be triggered by electronic commands from the surface support team. As an operational example, the surface team would trigger a drop weight release if the submersible loses comms or otherwise misses two consecutive comms checks (typically at 15 minute intervals).

5) Shallower diving subs have large main and reserve tanks for exceptional buoyancy.

Shallower diving subs rely more heavily on variable ballast systems. Once the main surface ballast tanks are vented, the sub becomes neutrally buoyant and relies on either the transfer of water or environmentally safe oil to control buoyancy. In an emergency the sub has large banks of air in redundant-, main-, and reserve high pressure air tanks to blow air into the main ballast tanks for additional buoyancy.

6) Redundant systems to return to the surface.

Every Triton submersible is equipped with numerous independent systems to achieve positive buoyancy and facilitate resurfacing. These methods include electrically powered vertical thrusters, variable ballast systems, pneumatic (main and reserve) and hydraulic systems. Moreover, a hydraulic hand-pump is available to eject drop weights specifically designed to counterbalance the influx of water into a critical pressure vessel.

7) External air and O_2 tanks are preferred in most situations.

In all but the deepest diving subs, the high-pressure air and O_2 tanks are located outside the main pressure vessel for safety. Hulls stops and multiple valve shutoff locations ensure safety in the event of a leak. For deeper diving subs, due to the immense pressure, the oxygen tanks are located on the interior. Once again for safety, the internal O_2 tank size is minimized so that a tank leak into the passenger compartment would not cause an overall O_2 rise to an unsafe level. O_2 and CO_2 levels in the submersible are constantly monitored using multiple redundant systems in case of electrical failure.

8) High-voltage is kept out of the main PV for safety.

Electrical power is also stored in batteries located in pods outside the main pressure vessel. High-voltage DC power is fed to multiple external systems, thrusters, lights, pumps, etc. though external electrical junction bottles. However, only low-voltage DC (typically 24V) is passed into the main PV for safety.

9) Multiple redundant power sources help prevent total loss of electrical power.

The electrical system relies on the combination of dual, redundant external battery banks as well as backup emergency batteries located inside the main PV. Batteries used in Triton subs are certified by use by the major class agencies. Triton most commonly relies on the use of Lithium Iron Phosphate ($LiFePO_4$) due their proven safety record and inability to support thermal runaway that may be seen in some other advanced battery chemistries.

10) High-reliability communication equipment is essential in emergency situations.

Triton submersibles feature an underwater telephone (UWT) system and uses acoustic transmission of signals between the surface and sub for voice and text communication. UWT systems are typically dual frequency (10 and 27 kHz) and feature dual redundant, external transducers in case of failure or damage. The UWT is compatible with NATO emergency underwater telephones, ensuring maximum compatibility for mutual rescue capabilities. All submersibles also have external VHF or UFF communication equipment for surface communication.

11) Navigation and tracking are requirements for safe undersea operation.

During a dive the submersible is continuously tracked via USBL system. The USBL system can also provide data communication with surface support vessels for assistance with navigation. Externally mounted USBL tracking beacons can operate on independent internal rechargeable batteries in case of internal power failure. Most models also offer optional releasable marker buoys that reveal the position of the submersible in an emergency and can be used to pull it back to the surface.

The SONAR systems mounted on all subs are very helpful with navigation and collision avoidance in low visibility situations. An optional DVL can also help with pinpoint navigation during the dive. Most Triton models offer autopilot feature that will provide auto heading and auto altitude for assist in safe piloting.

All Triton subs are equipped with between 6 and 12 external lights for visibility, observation, and navigation. Most commonly 20,000 lumen light used provide extreme visibility at night or at depth.

12) Being visible at the surface aids in rescue.

Being able to locate a sub on the surface is important when other systems are inoperable. Externally mounted Iridium or radio beacons greatly assist in surface tracking and rely on independent satellite or RF based beacons to locate subs on the surface. Xenon strobe lights mounted to the external chassis help locate the sub. The surface VHF system can also support AIS for location from surface ships or low flying aircraft. Most Triton models have a large freeboard making it highly visible on the surface.

13) Being able to escape the sub is necessary in extreme situations.

All Triton subs rely on dual-hatch dogging mechanism that can secure a hatch from either the inside or the outside. The additional freeboard mentioned in the previous section makes it safer to open the hatch in rough seas without swamping the sub. In some models there is sufficient deck space to allow occupants to get out and gather on the deck if the atmosphere in the submersible is contaminated. In addition, there are life jackets, rations, thermal blankets, multiple fire extinguishers, along with a medical kit, toolbox, reverse osmosis pump for freshwater and numerous atmospheric sampling kits for monitoring CO_2 and O_2.

14) The ability of a sub to assist in getting itself free of entanglement is critical.

Many Triton subs delivered to date feature a manipulator arm that incorporates a wire-cutter. Should the submersible become entangled, the manipulator can be used to free itself from entanglement. Should the manipulator become entangled, it is jettisonable, and all electrical and hydraulic lines can be cut using a guillotine system from inside the main pressure hull. The manipulator and in some models the external battery pods can also be ejected in the case of emergency to provide additional positive buoyancy. This is just one simple example of the multitudinous redundancy systems built into every Triton submersible. However, the main safety measure against entanglement is the unparalleled visibility provided by the acrylic pressure vessels.

The above represents just a minute sample of the highlight safety features included in each Triton submersible.

OPERATIONAL PROCEDURES

PILOT TRAINING

Included in the purchase of each Triton submersible is comprehensive training for Technical, Surface Officer and Pilot crew. Our policy is to never hand over a unit until we are completely satisfied the unit will be serviced, maintained, and operated to the highest standards. The content of Triton's training programs is reviewed and approved as part of the third-party class certification process.

Training comprises of three phases and commences during the final weeks of the unit's assembly when the candidates spend several weeks at the Triton facility. This phase involves the trainee participating in the final assembly of the submersible, gaining hands-on familiarity with every component and system of their submersible. In addition, classroom time and reading material are used to hone the trainee's knowledge.

Phase two of the training focusses on dive theory, using the submersible as a simulator, and provides the trainee the opportunity to make repeated dives, practice drills and simulate emergency scenarios, in a benign environment. During instructed simulator time, the pilot trainee will learn everything required to conduct safe diving operations including:

· Pre-dive checklist;

· Pre-dive guest briefing;

· Diving and surfacing procedures;

· Pilot and Surface Officer communication protocols;

· Control & monitoring systems;

· Life support systems;

· Navigation & positioning systems;

· Emergency procedures;

· Touch screen interface;

· Backup and mechanical systems;

· Troubleshooting using Phase 1 knowledge.

The third and final phase of training takes board upon delivery aboard the client's vessel. Conducted at sea the trainee pilot will conduct a minimum of 20 dives as pilot-in-command alongside a Triton instructor. Open water training gives the trainee the opportunity to fine-tune the skills acquired during the previous phases in a real-world environment. The same elements covered in simulator training will be combined with launch and recovery, support vessel crew interaction, daily maintenance, and in-mission troubleshooting.

On conclusion of Phase 3, the trainee will be issued a certificate of completion (signed by the instructor and one of our senior pilots) and is considered fully qualified to operate the specific Triton submersible.

TRACKING / COMMS

Throughout a dive, the submersible's position remains under constant surveillance by the Surface Officer using the USBL system. This system enables monitoring of the underwater vehicle's location from a chase boat, the main vessel's bridge, or it can be shared with other nearby vessels to ensure they maintain a safe distance from the underwater operation. By employing an acoustic modem, the calculated position data is relayed back to the pilot, facilitating navigation towards the dive targets. For submersibles not equipped with a marker buoy, any failure of the USBL system requires aborting the dive.

For seamless communication even at maximum diving depth, the analogue underwater telephone serves as a reliable means of contact. The Surface Officer and the pilot must engage in regular communication checks, with intervals no longer than 15 minutes. If two consecutive communication checks are missed, the dive must be aborted. Since the system is analogue, the Surface Officer can actively listen to the various sounds produced by the vehicle, such as thrusters or pumps in motion.

RESCUE PLAN

Prior to every dive operation, it is imperative to establish a comprehensive rescue plan that outlines the available rescue assets both on board and external. The depth at which the dive can take place is restricted by the capabilities of the rescue assets accessible in the vicinity. Shallower diving submersibles can rely on the immediate assistance of divers. However, for submersibles operating at greater depths, it is crucial to have an ROV either present on board or readily available on standby, prepared to promptly respond to any emergencies.

Triton Submarines maintains a round-the-clock hotline and actively monitors all submersibles and ROVs that can offer support in the event of an emergency declaration. Clients check in with Triton to validate a rescue plan before operating in remote regions.

SAFETY EQUIPMENT

All Triton submersibles are fitted with the following equipment as standard:

Life Support

- Standard metabolic oxygen make-up system with soda lime CO_2 scrubber.
- Full redundancy Oxygen system with capacity to deliver 15-hours main + 96 hours reserve.
- Emergency CO_2 scrubbing using Lithium Hydroxide curtains for more than 96 hours.
- Air conditioning – Freon-based dual, high-output AC systems. For deep diving subs, heating system powered by an independent set of batteries.
- Digital Atmospheric Monitors - O_2, CO_2, freon, temperature, humidity, cabin pressure.
- Backup, analogue atmospheric monitoring using a sample pump and reaction tubes and analogue gauges.
- Ration packs.
- Reverse osmosis pump for unlimited supply of drinkable water.
- Unisex, personal waste disposal kits.

Safety Equipment

- Bilge pump.
- Life Jackets.
- Thermal protection blankets.
- First aid & sub tool kit.
- Jettisonable ‘drop weights’.
- Built in breathing system (BIBS).
- Self-contained breathing apparatus (ESCBA).
- Emergency 24 Volt batteries located inside main pressure hull.
- Emergency light.
- Novec 1230 and water mist fire extinguishers.
- Analogue, backup compass.

Communication

- Submerged - Dual frequency UWT system*.
- Surfaced - VHF radio*, satellite Iridium beacon.
- Wireless Ethernet to surface vessel or RIB* (supporting Voice, Text and Data).

Navigation

- Depth gauge and transducer.
- Echo sounder.
- Fluxgate compass.
- Magnetic compass.
- Mechanical clinometers.
- Motion sensor (pitch and roll).
- RF beacon with pressure sensor*.
- Digital Oceanographic Thermometer*.
- Xenon strobe with pressure and light sensor.
- USBL Tracking System with acoustic modem and Triton's exclusive WorldView Navigation System*.
- MultiBeam Imaging Sonar*.
- Autopilot.
- PLC-controlled and PLC-bypass redundant control modes.

Operational Equipment

- Acoustic modem*.
- Jettisonable Manipulator.
- Emergency buoy with manual release (Optional)*.
- RF beacon with RDF tracking system*.
- Doppler Velocity Log (DVL).
- Situational awareness cameras.

*INCLUDED EQUIPMENT

Below is further information on the significant Standard Safety Equipment included in the Triton submersible:

DUAL FREQUENCY UNDERWATER TELEPHONE

With an operational depth of 3,500m the Subsea UWT communication system fitted to all Triton submersibles is a wireless, dual channel, long-range communication system designed specifically for communications between submarines, submersibles, surface vessels and divers.

The Subphone has high and low power capabilities enabling the user to conserve battery life and reduce the acoustic footprint for shorter range communications. The option of dual frequency also offers a Subphone operator the capability of choosing the best frequency for communicating under various ocean conditions.

SURFACE VHF (x6 Units)

To facilitate surface communication between the submersible pilot, surface officer and primary vessel crew, six hand-held VHF units are included with each Triton submersible. The units delivers a high 6W RF output and 700mW audio output, its current saving circuit offers 8-hours of operating time with the supplied 980mAh (typ.) Lithium-Ion battery pack.

WIRELESS ETHERNET TO SURFACE SUPPORT

The wireless ethernet connection included in Triton's submersibles can operate at temperatures ranging from 0° to 60°C and are rugged enough for any harsh industrial environment. The unit supports IEEE 802.11a/b/g standards. Included are two 1 dbi dipole antennas, with a range up to 300'.

RADIO LOCATION BEACON

All Triton submersibles are fitted with a self-contained submersible Radio Beacon, designed to assist in the location and recovery of the submersible upon return to surface if communication has been lost. It may be submerged for long periods of time in ocean depths to 7,300m (24,000feet). The activation is completely automatic as it utilizes a pressure switch that automatically turns the beacon OFF below 10m, effectively isolating the power source, and ON when it returns above the 10m threshold.

USBL TRACKING SYSTEM WITH ACOUSTIC MODEM AND TRITON'S EXCLUSIVE WORLDVIEW NAVIGATION SYSTEM

Utilizing an Ultra Short Base Line (USBL) tracking system uses two-way acoustic communication to calculate the relative position of a surface vessel-mounted transceiver to an underwater vehicle-mounted beacon and allows the submersible to be tracked underwater. The USBL is synced with Triton's proprietary 'WorldView' navigation system to maintain live tracking and positional data of the submersible, host vessel and other points of interest.

Using GPS from the host vessel and USBL tracking, pilots can monitor the submersible's position, dive repeatedly to a point of interest and even track other vehicles. Triton Worldview consists of both hardware and software. The hardware consists of three components: a chart plotter, a Toughbook, and a hard case containing proprietary hardware components.

MULTI-BEAM IMAGING SONAR

The imaging sonar included in Triton's standard equipment is a dual-frequency 900 kHz and 2250 kHz system with a 130-degree imaging field. The 900 kHz offers high-resolution long range navigation, object detection, and obstacle avoidance, while the 2250 kHz provides ultra-high resolution at close range. Fitted aboard Triton submersibles it enhances the pilot's situational awareness, assists in locating hazards and aids orientation when supplementing the onboard chart plotter.

HYDROPHONE

The fitted hydrophone is a reliable rugged hydrophone which is integrated into instrumentation for research and professional systems. The usable response (+3/-12dB) is good to better than 50kHz. The official "Flat" frequency response (±1dB) is rated to 28kHz. The models integrated by Triton are professional quality hydrophones rated to the appropriate depth capacity.

OPTIONAL EMERGENCY RELEASE BUOY

In the extremely unlikely event that the submersible is unable to return to the surface, Triton submersibles can be fitted with a release buoy which can be deployed in an emergency to aid location and recovery. Custom designed for each model, the system consists of an exterior mounted unit containing both the marker buoy and Dyneema line 1.5x the max rated depth and with the capacity to raise the submersible.

DIGITAL OCEANOGRAPHIC THERMOMETER

Unaffected by shock and vibration, the Oceanographic Thermometer has high accuracy and stability, and is easy to use. It has a rugged, corrosion-proof, 10,500m rated titanium housing. Real-time temperature data is transmitted via the serial interface in ASCII characters (°C or raw counts) to the Triton pilot's display.

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