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### Re-Classing Existing SAT Diving Systems

In the current low oil cost environment, dive contractors are exploring the possibility of reactivating existing systems rather than building new. In addition to classing ships and platforms, the American Bureau of Shipping (ABS) also classes saturation diving systems. In this paper, the Author describes the basic division of ABS into Engineering and Survey sides, and provides background on the ABS Underwater Rules and the ASME PVHO Standard. The author discusses obtaining a class certificate for a SAT system and then outlines the process for returning a previously classed system to class, and the process for classing an existing unclassed system.

Since being spun off from research originally conducted by the US Navy, saturation diving, with its high cost and significant risks to divers, has found a home in the offshore oil and gas industries. As such, the economic fortunes of saturation diving operators and the fabricators that supply them with equipment are tied to the health of the oil companies, and thus to the price of crude itself. After an unprecedented spike and crash in the price of oil from 2007 to 2008, oil prices gradually recovered through 2014 and then fell again, generally remaining below \$50/barrel. In this environment, diving contractors are being forced to economize their operations to the greatest extent possible. As a class society serving both the offshore fuel and shipping industries, ABS is sensitive to the needs of our clients and their customers. One option for operators is to obtain existing equipment of fairly recent construction and still in good condition. To satisfy contractual and statutory obligations, saturation diving systems usually must be classed. In some cases, ABS is able to class existing equipment and systems, with resulting cost savings to all involved.

The American Bureau of Shipping (ABS) was founded as a non-profit organization in 1862 in New York City. As a class society, ABS promotes the safety of life, property and the marine environment by establishing and applying technical standards relating to the design, construction and survey of marine related facilities including ships and offshore structures. ABS published their first set of Rules, applicable to wooden vessels, in 1870 and in 1890 the Rules that have become the backbone of their classification program, the Rules for Building and Classing Steel Vessels. As a class society, ABS has no commercial interest related to ship design, shipbuilding, ship ownership, ship management, ship operation, insurance or chartering.

ABS and 11 other class societies make up the International Association of Class Societies (IACS), an organization dedicated to establishing and maintaining unified requirements for ships, platforms and other marine systems and equipment. Together, IACS member class societies class over 90% of the world's tonnage.

ABS has been involved in the classification of underwater vehicles and systems since the first edition of the Rules for Building and Classing Underwater Vehicles, Systems and Hyperbaric Facilities (Underwater Rules) was published in 1979.

ABS currently has approximately two dozen manned submersibles in active class, as well as roughly 70 diving systems, made up of a mix of surface supplied systems, saturation diving systems, and hyperbaric rescue facilities. ABS also certifies individual components of diving systems such as deck decompression chambers, diving bells and handling systems.

ABS is divided into Engineering and Survey offices. Engineers perform review of submitted plans against our published Rules and Guides, as well as recognized national and international standards. Technical deficiencies in submitted plans may be addressed by issuance of technical or survey comments, as well as by making amendments to the plans directly. ABS Engineering offices stamp submitted drawings and issue review letters upon successful completion of review.

Surveyors attend vessels during construction at the shipyard to witness construction and testing in accordance with the applicable Rules, and verify compliance with previously approved design requirements as indicated on stamped drawings. Surveyors are also involved in certification of materials and principal equipment supplied for the vessel from vendor facilities.

Responsibility for classing of equipment begins and ends with the Survey office. When all reviews for a vessel are satisfactorily completed, the Survey office will issue an Interim Class Certificate, which is then ratified by the ABS Class Committee when they meet several times per year.

Once a vessel is classed, it is subject to ongoing survey requirements that must be maintained in order for the vessel to maintain its class status. For most vessels these are the annual survey and the special periodical survey. Both of these surveys involve review by a qualified ABS Surveyor of the records and logs, hull, propulsion systems, equipment and other critical systems, but the special periodical survey has more detailed and extensive requirements.

The ABS Underwater Rules cover a wide variety of underwater and hyperbaric equipment. The Rules are divided into general sections applicable to any vehicle or system, along with sections

specific to manned submersibles, diving systems, ROVs, AUVs and more. There is also a section applicable to handling systems for manned or unmanned underwater vehicles.

Because of the highly critical nature of diving systems they are subject to a high level of scrutiny. For engineering review of a SAT diving system, details of all equipment and systems must be submitted for review. Most crucially, pressure boundaries of Pressure Vessels for Human Occupancy (PVHOs) are reviewed for compliance with either the pressure vessel requirements of the ABS Underwater Rules (for external pressure), the ABS Steel Vessel Rules (for internal pressure) or another recognized code or standard such as ASME Boiler and Pressure Vessel Code, Section VIII Division 1, or the European Standard for Unfired Pressure Vessels (EN 13445). This includes all openings and attachments, like manways, medlocks, viewports and fluid or electrical penetrators. Acrylic windows are reviewed for compliance with the Underwater Rules as well as the ASME PVHO-1 standard. We would also review strength of structural supports and attachments, including lifting lugs where these are intended to be used during normal operation of the system. Life support systems, including piping systems, are reviewed for capacity and fitness for purpose. Handling systems are reviewed in accordance with specified dynamic factors and safety factors, including winches, wire ropes, hydraulic cylinders, and hydraulic power systems. Hyperbaric evacuation is required for ABS classed SAT diving systems and must comply with all applicable Rules. Hyperbaric rescue chambers (HRC) and self-propelled hyperbaric lifeboats (SPHL) are both acceptable according to the Rules, but a diving bell working in the water is not acceptable as a means of hyperbaric evacuation for divers in deck chambers.

Aside from the Underwater Rules, other applicable standards include the PVHO standard, recognized pressure vessel codes, the IMO Code of Safety for Diving Systems and the IMO Guidelines and Specifications for Hyperbaric Evacuation Systems. Crucially, the key requirements for standard geometries, short term critical pressure, dimensional ratios and sealing arrangements for acrylic windows are only found in the ASME PVHO-1 standard.

In addition to Engineering review, a SAT system must be built and tested under Survey in order to be classed. The Surveyor will verify Material Test Reports and qualify or verify Welding Procedure Specifications and Weld Procedure Qualification Records, witness fit-up prior to welding, verify dimensions, witness NDT for welds and witness hydrotesting for PVHO chambers. Acrylic windows and electrical penetrators must be build and tested under Survey. The Surveyor will witness fabrication and testing of associated piping systems and equipment. Once all system components are delivered to the fabricator for final assembly, the Surveyor will conduct an integration survey of steel structures, PVHOs, piping systems and associated equipment. Final testing of the system under survey includes load test of handling systems, stability test of diving bells and hyperbaric evacuation units (HEU), manned life support testing

of PVHO chambers, and finally a test dive once all other Engineering and Survey requirements are satisfied.

Should an owner or their representative wish to submit existing un-classed or previously classed equipment for review, they would first need to contact their local ABS Survey office. The local Survey office will contact the divisional Survey department for initial guidance, and will arrange with the owner to conduct a Pre-Condition Survey of the system.

The pre-condition survey consists of an internal and external examination. The condition of the equipment is carefully documented with photographs, and the Surveyor reviews the service history and dive records. They will review the available viewport documentation, and conduct any additional examinations that they see fit or were requested by the divisional Survey Office. This survey is undertaken with no charge to the owner.

The Surveyor will then make a recommendation to the divisional and corporate Survey department as to whether or not to class the system. If there are any areas of concern, they may contact the appropriate Engineering office for their input. The corporate survey office, based on input from the attending surveyor and the divisional survey office, makes the final decision to proceed with re-classing.

Assuming the response is favorable, the divisional survey department will issue instructions for re-classing the dive system. The local survey office presents the owner with a list of requirements as well as a fee quote. Any modifications to the system must be submitted for Engineering review. This specifically includes modifications or repairs performed while out of class, as well as modifications required to comply with the Rules. The Surveyor will need to witness any required repairs or tests, which typically includes a special periodical survey based on the age of the system. Any due or overdue surveys as well as previous recommendations will need to be complied with.

A special periodical survey is required by Section 7-11-4 of the ABS Rules for Survey After Construction for classed diving systems three years after class is granted, and at three year intervals thereafter. This is required of formerly ABS classed systems if the due date has passed. This includes pressure testing of hydraulic systems, life support piping systems and gas storage containers. Viewports must be removed and inspected, or replaced if the service life (chronological life or cyclic life) have been exceeded. Gauges and monitoring instruments must be shown to have been calibrated recently. Electrical systems are examined for condition of cables and proper operation of ground fault and/or stray current detection systems is verified. PVHO pressure boundaries are inspected by removal of protective and insulating coatings in selected areas, and NDT is performed in highly stressed areas such as lifting lug connections.

Internal and external exam is carried out for other pressure retaining components. Finally, a test dive is required in accordance with the requirements of the Underwater Rules.

For SAT diving systems less than 20 years old but not previously classed, the process is similar to that for a previously ABS classed system. A preliminary condition survey is conducted as described above. One important point is that per the Underwater Rules, PVHO hulls and acrylic windows can only be accepted when built under survey by an IACS member class society or a recognized Flag Administration. Once the preliminary condition survey is conducted, and a favorable decision made, the corporate Survey department will issue instructions for the requirements for classing the system. These instructions will be based on the quality and completeness of the documentation demonstrating that the submersible was built under survey. Documentation should include, but not be limited to, welding procedures and performance qualification records, NDT records, and material mill test reports. A special periodical survey is required.

ABS will apply the edition of the Underwater Rules that is agreed to between the owner, the Corporate Survey department and the Engineering Office in each case. For formerly ABS classed systems, the same edition of the Rules in place when the SAT system was classed will typically be applied. For non-ABS classed systems, the current edition of the Rules would typically apply.

The responsibilities of the owner of an existing system submitted for classification include agreeing to the ABS fee quote, completing a Request for Class (RFC) form provided by local survey office, provide a signed affidavit detailing the system's class status, modifications or repairs, and any other anomalies requiring Surveyor attention, and providing all required documentation for the subject system, including class certificates, stamped drawings, survey reports, viewport PVHO documentation, and operating and maintenance manuals. The owner is also to submit details of any modifications for review by the engineering office and complete all required repairs and/or modifications to the satisfaction of the attending Surveyor.

The ABS Underwater Rules, along with recognized national and international standards, provide detailed and comprehensive guidance for classing saturation diving systems. ABS engineers and surveyors work together to provide a high level of technical service in a timely manner. Although more complicated, ABS is also able to class existing diving systems or reclass formerly classed diving systems provided that they are in satisfactory starting condition and the owner is willing to comply with all required repairs, modifications and tests.