armada TECHNOLOGIES

# Frequently Asked Questions

## About Hull Air Lubrication

**What are the primary factors contributing to the growth of the hull air lubrication system market?** The hull air lubrication system market is experiencing growth due to the implementation of the EU ETS policy, which aims to reduce carbon emissions from large ships entering EU ports. This policy went into effect on January 1st, 2024, and applies to these vessels regardless of their flag state. Additionally, EEXI and CII ratings are important metrics in assessing a ship's energy efficiency during mandatory surveys, such as the IAPP survey. Furthermore, the shipping industry has made decarbonization a top priority, with global institutions establishing the Poseidon Principles for Marine Insurance. The AER measure is used to calculate a ship's carbon emissions per tonne of cargo / mile traveled. These initiatives provide a significant market opportunity for eco-friendly technologies like the hull air lubrication system.

**What is an air lubrication system?** Air lubrication systems operate by releasing microbubbles under the hull, creating a layer of aerated water that minimizes friction between the hull and seawater, resulting in reduced fuel consumption and, therefore, lowered emissions.

**How do hull air lubrication systems work?** A hull air lubrication system is designed to reduce the drag that occurs between a ship's hull and the surrounding seawater. To achieve this, many system's use air compressors to generate a continuous flow of air.

The air is then passed beneath the ship's bottom plate surface through embedded piping and air cavities in the hull. This results in a layer of air bubbles being created that reduce the drag encountered by the ship's hull as it moves through the water.

EcoOne Marine Technologies Group

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## Hull Air Lubrication Systems (Continued)

**Why is it important to reduce drag on a ship?** A reduction in drag corresponds to a decrease in power required to propel the vessel at the ordered speed and, consequently, a reduction of fuel consumption leading to lower emissions, higher profit margins and a cleaner environment.

## First Generation Technologies

**What are some of the issues associated with 1st generation air lubrication systems?**

- Dependence on sea state: Ship rolling can render these air lubrication systems ineffective as the bubble carpet in these conditions now escapes to the side and no longer lubricates the hulls flat surface.
- Power demand: Continuous operation of air compressors requires additional auxiliary engine power supply. Particularly when an additional aux engine must be brought on line, at a sub-optimal load, to supply power for the air lubrication systems.
- Space: Installation space requirements for compressor are needed, plus extensive associated piping and higher levels of vibration and noise.
- Additional Increased Drag: Potential of increased vessel drag when a system is non-operational.

**What are the disadvantages of using air compressors?** The disadvantage of using air compressors in some present-day air lubrication systems is the use of upwards of 4 to 10 compressors depending on the size of the vessel. The power required to operate the compressors can significantly reduce net energy savings and also may require additional auxiliary engines to be brought online to power the systems, negatively impacting the ships integrated energy load balance.

Due to the active nature and high number of compressors needed to run air lubrication systems there is a higher-probabilistic breakdown risk, increased noise and vibration on the ship, and additional costs for equipment and ongoing maintenance.

**What are the potential fuel savings from current hull air lubrication systems on the market?** Some existing 1st generation air lubrication systems claim potential fuel savings of 5 – 10 % but research indicates that they have consistently realized about 0 - 7% fuel savings on ships to date.

## Armada Technologies

### Benefits

**How does Armada's "Passive Air Lubrication System" (PALS) work?** Armada Technologies' (Armada) PALS uses pods installed into the double bottom tanks and flush with the vessels baseline. The vessel's own forward motion is used to drive water through an aperture in each of the pods to a venturi. As water passes through the venturi, air is passively drawn from deck level to create an air: water mix which is then injected into the vessel's boundary layer for hull lubrication of unparalleled efficacy.

**What are the benefits of the PALS technology?** Since PALS utilizes the forward motion of the ship to draw air from the deck to create a specific air: water mixture (and not high-energy compressors) and small capacity water pumps are only used when operating in sub-optimal operational conditions, the system consumes significantly less power to achieve the lubrication effect. PALS has a performance control system with 'machine learning' for better overall bubble control and delivery. PALS runs effectively in a wide range of operating conditions (i.e., speed, draft, weather) without incurring intermittent "burps" in air carpet delivery normally associated with cavity-based air lubrications systems operating at deep drafts. The system's passive air injection mechanism design enables the match of bubble production to ship type and operating condition allowing greater bubble dynamics over a wider range of operating conditions. PALS has less equipment so needs less maintenance, inspections and overhauls.

## Performance Verification

**How was the system performance verified?** In September 2022, Armada's PALS went through Hydrodynamic & Cavitation Tunnel (HYKAT) testing at HSVA, one of the world's leading pressurized cavitation tunnel testing facilities. The results verified that passive aeration by PALS is viable and offers credible double-digit on-plate drag reduction. Testing results showed a stable, well engaged, and high-quality rigid carpet of aerated water into the boundary layer and significant on-plate reduction was recorded.

Additionally, the Armada team documented a drag reduction "sweet spot" that could be targeted where two identified hydrodynamic phenomena were effectively balanced within every operating condition. Even in case of a technical malfunction (e.g. pumps or blowers defective) the passive operation of the system will continue to reduce vessel drag.

## Operations

**How does PALS optimize the distribution of air bubbles?** PALS uses a carefully designed venturi combined with the forward motion of the ship to passively create the optimum distribution of lubrication bubbles. The net result is an even lubrication over a wide range of speed and depth variables.

**Can PALS operate effectively under less than optimal conditions, such as deep drafts and slow operating speeds?** Yes, under these specific "off-design" operating conditions, PALS utilizes a small number of low energy pumps to supplement the air: water flow to ensure ongoing optimal performance at slow vessel speeds and higher sea states. This allows better system control and drag reduction optimization that is aligned to the vessels speed, draft and the prevailing weather conditions.

The reason why this is so important is the ongoing prevalence of slow steaming across the world merchant fleet and the uptake of Engine Power Limitation (EPL) as a means of regulatory compliance.

**Can each of the Armada Pods be independently controlled?** Yes, given the versatility of the system, PALS can tune the output from each pod independently and thus provide a significant optimization of performance over a much wider array of sea states and operating conditions.

**What influence does sea state have on PALS?** PALS drag reduction optimization is aligned to the vessel's speed, draft, and the prevailing weather conditions, so the system operation does not fluctuate as significantly as other air lubrication systems when operating in heavy or variable sea state conditions. As the sea state increases the component of wave making resistance increases and as such the frictional resistance as a component of total resistance reduces. The ability to ensure drag reduction on a smaller component of total resistance is a very attractive attribute of PALS, particularly when combine with weather routing support services.

**Is there potential for cavitation erosion around the propeller that may damage the propeller?** No, air lubrication systems have been proven not to induce increased cavitation of the ships propeller(s).

**Will air entering the vessel's pre-existing sea chests enable mass water transition to the deck through adhesion?** Depending on the design and location of sea chest(s), an aeration chamber may be required to separate air from water to prevent such adhesion suction to the deck level. This requires a very minor modification to the sea chest drop lines as part of the PALS installation.

**How will PALS impact the underwater noise produced by ship and impact wildlife migration patterns?** PALS will reduce the noise pollution emitted to the ocean as the bubbles themselves suppress the noise attenuation across the air carpet. This means that the Armada system has the potential to provide a significant benefit to marine life in this increasingly important area of environmental protection.

## Armada Technologies (Continued)

**Will the presence of a stable air carpet interrupt the accurate functioning of an echo sounder?** Depending on the number and position of the echo sounder(s), an echosounder may have to be relocated to a position clear of the air carpet coverage.

**Will the accumulation of slime and other biomatter with PALS cause reduction in efficacy?** Given the speed of flow through the system and the nature of the pod internal surface finish, slime and other organic matter buildup, whilst the vessel is moving, is not deemed a risk. Depending on the vessels operating profile and if the vessel is static for prolonged periods of time, particularly in turbid waters, Armada may recommend the installation of two ultrasonic antifoul transducers to ensure fouling does not create hydrodynamic losses across the system.

Whilst considered a low risk, the pod units are fully isolatable for mechanical cleaning in water if required.

**Will the system required additional onboard staff to operate?** No, PALS needs no additional crew or technical engineers to operate the system.

### Manufacturing

**Where is the Armada PALS manufactured?** Currently, PALS is manufactured in Turkey. However, our process and manufacturing capabilities are designed to encompass a global market supporting both initial installation and in-service needs around the world.

**What is the build lead time?** The lead time to build PALS is specific to the ship type and size but ranges from 6 to 12 months.

**Has the Armada PALS been approved by any classification societies?** Armada is engaged with DNV, ABS and Lloyd's Register (LR). In addition, Armada is currently developing an Approval in Principle (AiP) with RINA.

### Installation

**Does Armada provide 3D scanning and system integration engineering services?** Yes, Armada offers its clients vessel 3D scanning and system integration engineering services through third-party integration marine engineering firms that are highly experienced with PALS and skilled in providing these services.

**What is the complexity of an Armada PALS installation?** A PALS installation is relatively easy with costs anticipated to be lower than many other air lubrication systems. This is due to the footprint of the system as it is designed to fit cleanly between the longitudinal and transverse structure of most merchant vessels and because it does not use compressors. In comparison, many other air lubrication systems use multiple air compressors to create and distribute the lubricating bubbles, therefore, the installation process is encumbered by the integration of these compressors, which can create uncertain dry dock timelines along with the ability to manage unforeseen costs.

**Can PALS be fitted on existing ships?** Yes, the Armada pod system can be retrofitted to an existing vessel or be installed as part of a new design and construction project.

**Can any part of the Armada system be installed underway?** Yes. It is possible to prepare the installation location (double bottom spaces) and install certain parts of the Armada system underway, but it may not be the most technically ideal approach. Such an approach can be considered on a project-by-project basis, but generally it is recommended that all Armada systems be installed during dry dock for safety and optimal performance and cost outcomes.

**Can the Armada team provide supervision through the installation and commissioning phases of the system?** Yes. Our team of highly skilled technicians can oversee the installation and commissioning of PALS. Furthermore, we have access to a network of expert service partners who are well-versed in working with class and flag state, installation project management, and any regulatory requirements that ensure compliance with all applicable standards and regulations.

## Armada Technologies (Continued)

**How long does it take to install the Armada PALS system?** Duration is project specific, however, PALS can generally be installed during a standard dry-docking window.

### Maintenance

**What is the risk of the water intake blocking and if it does, how can this be fixed?** The water intake system used in PALS is designed to minimize the likelihood of any blockages. The hydrodynamic longitudinally-orientated bars are positioned at the inlet opening to prevent any large debris entering the pod unit. Similarly, the smallest bore diameter across the length of the system is sufficient to allow any smaller debris to pass right though the system. In the unlikely event that a blockage does occur, each pod can be easily and independently isolated to allow a quick and effective resolution. Blockage or disruption on an individual pod does not affect the system as a whole and the remaining pods remain fully operational.

**What are the annual maintenance costs associated with PALS?** Annual maintenance costs are ship-specific, but because there are no compressors to maintain and fewer equipment parts to service, PALS requires less maintenance than other air lubrication systems on the market.

### Return on Investment

**What are the CAPEX and OPEX cost of PALS?** The cost of PALS is ship-specific, but has relatively low capital investment and operating costs due to the elimination of the compressors. Its unique design uses less power than other hull lubrication technologies, decouples speed from drag reduction and is easier to maintain. This provides economic payback to the shipowner within a very short period of time.

**Would PALS still provide fuel savings and $CO_2$ reductions on ships operating on short duration with multi-port trade routes?** Yes, even for ships operating on short-duration multi-port trade routes, PALS can provide significant fuel savings and $CO_2$ reductions. It is worth noting that PALS technology not only positively impacts main engine power and corresponding fuel consumption reduction but can also be used as a means of achieving higher speeds for the same main engine power delivery.

For example, air lubrication systems reduce frictional resistance and therefore ensures the vessel requires less power to achieve an ordered speed. The owner can materialize this benefit by reducing power (and therefore fuel) to achieve the ordered speed, or alternatively, achieve a higher speed for the same power delivery. This speed increase benefit is generally attractive to liner trades with vessels operating on tight schedules. Time saved on passage provides more time in port and/ or more round trips per annum and therefore offers more tangible financial benefits.

**How are my fuels savings measured and reported?** There are a few ways to measure fuel savings. Maritime software solutions that can provide in-depth vessel performance metrics to track and manage the data of a ship's carbon emissions footprint.

Additionally, a simple method of measuring PALS performance, is by doing an initial baseline performance test that is conducted with the system turned off. This baseline test provides a benchmark for fuel and power consumption against which the savings achieved, by utilizing the PALS system, can be independently measured and reported in line with industry accepted ITTC standards and protocols.