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# VGP Compliance:

## How the Latest EPA Marine Lubricant Requirements Affect You

By Jim Kovanda, Vice President,  
American Chemical Technologies, Inc.

The National Oceanic and Atmospheric Administration (NOAA) estimates that more than 700 million gallons of petroleum enter the environment each year, more than half of which is due to irresponsible discharges and illegal disposal. Oil leakage from stern tubes, once considered a part of normal operational consumption of oil by ocean-going vessels, has become an issue of concern and is now considered oil pollution.

In its document EPA 800-R11-002, November 2011, the U.S. Environmental Protection Agency (EPA) references a 2010 study that estimated stern tube leakages and operational discharges of lubricant oils within the world's 4,708 ports and harbors total 36.9 to 61 million liters (9.7 to 16.1 million gallons) of lubricant oil annually!

In addition to spills and stern tube leakage, continuous low-level discharges are produced by other vessel systems during vessel operations in port. Both deck machinery and submerged equipment can contribute. However systems located below the waterline are a particular problem. Stern tubes and other submerged systems are pressurized to prevent seawater from entering the oil system where it could compromise lubrication effectiveness and equipment reliability. As these systems operate, oil naturally flows into the sea. In this paper we will discuss:

- The impact of today's EPA regulations on the use of traditional mineral oil marine lubricants.
- Critical lubricant performance requirements in oil-to-sea interface applications.
- The ability of products classified by the EPA as environmentally acceptable lubricants (EALs) to meet those requirements.

### New EPA Vessel General Permit Regulations

In 2013, the EPA took action to minimize the adverse impact of lubricant discharges on the aquatic environment with its updated Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels (VGP). The EPA VGP provides vessels with "authorization to discharge under the national pollutant discharge elimination system" in compliance with provisions of the U.S. EPA Clean Water Act (CWA).

Under the new VGP regulations, effective December 19, 2013, new vessels 79 feet or longer must use EPA-recognized Environmentally Acceptable Lubricants (EALs) in all oil-to-sea interface applications. Vessels constructed before that date will have to replace mineral oil or other lubricants and adopt EALs in all oil-to-sea interfaces unless technically infeasible.

**New vessels 79 feet or longer must use EPA-recognized Environmentally Acceptable Lubricants (EALs) in all oil-to-sea interface applications.**

### EAL Selection Criteria

The 2013 EPA VGP requirements mean, to legally operate in U.S. waters, any deep draft vessel – as well as workboats and other craft covered by the regulations – must replace traditional mineral oil or other non-compliant lubricants with an EPA-defined environmentally acceptable lubricant in oil-to-sea interface applications. Even products described more generally as "environmentally friendly lubricants" must be converted if they do not meet the EPA EAL requirements.

While VGP requirements have changed, marine industry needs for protection and performance have not. Vessel operators must identify compliant lubricant solutions that deliver the same (or better) performance and reliability as traditional lubricants for equipment operating with an oil-to-sea interface.

### EPA Environmentally Acceptable Lubricants

By EPA definition an "environmentally acceptable lubricant" must be biodegradable, minimally toxic and not bioaccumulative. Because the majority of a lubricant is composed of the base stock, the EPA identifies compliant lubricants by base stock class. As mentioned earlier, the EPA identifies only four classes of lubricants that comply with the 2013 VGP EAL requirements: polyalkylene glycols (PAGs), synthetic esters, vegetable oils, and bio PAOs. Some applications have incorporated non-metallic bearings and are lubricated with seawater. In order for a lubricant to be classified as an EAL it must meet specific EPA qualifications for biodegradability, toxicity and bioaccumulation as follows:

Four Classes of lubricants are identified by the EPA as EALs:

- Polyalkylene glycols (PAGs)
- Synthetic Esters
- Vegetable Oils
- Bio-based polyalphaolefins (bio PAOs)

- "Biodegradable" – Biodegradation is the chemical breakdown

of oil caused by organisms or their enzymes into carbon dioxide and water. The EPA says several tests may be used to establish biodegradability, including tests published by the Organization for Economic Co-operation and Development (OECD). Under the OECD 301 A-F test methods, a lubricant is “readily biodegradable” if it is more than 60% biodegraded in 28 days.

- **“Minimally Toxic”** – Aquatic toxicity refers to the damaging effects of lubricants on marine life and populations. It is measured by the concentration in parts per million or milligrams per liter of lubricant that kills a specified percentage of test species. Lubricants must pass EPA prescribed tests for acute or chronic toxicity. Included are the OECD 201, 202 and 203 tests for acute toxicity or the 210 and 211 tests for chronic toxicity.
- **“Not Bioaccumulative”** – Bioaccumulation is the build-up of foreign chemicals within the tissues of a living organism over time. Chemicals with a slow or low degradation rate can accumulate in tissues, leading to adverse effects. Bioaccumulation potential is measured by establishing its partition coefficient, which is expressed as log Kow. Substances with a log Kow value below 3 or above 7 are considered non bioaccumulative. The two most common test methods for measuring bioaccumulation potential are OECD 107 and 117. The EPA also lists other characteristics of non-bioaccumulative materials in the regulations.

#### Clean Water Act Requirements

The U.S. Clean Water Act (CWA) regulates discharges of pollutants into U.S. waters and the quality standards of surface waters. CWA compliance continues to be a requirement for vessels and other marine equipment operating in U.S. waters.

Under the CWA, a lubricant cannot create a surface sheen on the surface of water in the event of a spill or other discharge. The presence of a visible sheen is one of the criteria for determining if a spill is deemed harmful to public health and welfare and subject to CWA reporting, fines and/or equipment repair and environmental remediation requirements. What’s more, the act states that dispersants, detergents, emulsifiers, chemicals or other substances may not be added to lubricant to remove the appearance of a visible sheen.

Practically speaking, in order for marine operators to avoid CWA compliance issues, a non-sheening EAL should be selected. The EPA 40 CFR 435 Static Sheen Test is an effluent test but it can be used to determine the sheening potential of a lubricant.

#### Lubrication Performance

While vessel operators, lubricant suppliers and other industry stakeholders must adapt to the environmental performance requirements prescribed by the EPA in the 2013 VGP, lubrication performance must be maintained to ensure equipment is protected and the efficiency, reliability and longevity needs of the marine industry are met.

Efficiency and reliability are especially important in deep draft ocean marine applications to support operator needs for fuel and other operational savings and to avoid unexpected equipment problems that can delay transit and put vessels and crews at risk while on the open sea.

EALs must perform acceptably under the uniquely challenging humidity and water ingress conditions present in oil-to-sea interface applications, while also providing essential anti-wear performance, corrosion protection and a high viscosity index. Reduced friction,

high load-bearing capacity and thermal stability are vital to maintain protection across all operating conditions. Oxidative stability is also important, to prevent degradation and formation of sludge or varnish in the system, which can affect change-out intervals and maintenance requirements.

In summary, EALs must meet the industry’s demanding lubrication requirements and EPA regulatory mandates to be useful to marine operators, shipyards and maintenance facilities, and equipment OEMs, as well as to the other business and societal stakeholders who benefit from efficient, reliable and responsible vessel operations.

#### Hydrolytic Stability and Water Tolerance

Lubricants used in oil-to-sea interface applications must be hydrolytically stable and tolerant of water influx. Hydrolytically unstable lubricants can form corrosive acids and insoluble contaminants that can reduce lubricant effectiveness, damage equipment and lead to premature equipment failure. What’s more, polar additives in unstable fluid formulations are attracted to water and can leach from the fluids in the event of water ingress, degrading lubrication performance and further jeopardizing equipment.

Because water ingress is an inevitable threat to lubricants used in submerged applications, purifiers are often used in larger systems – such as stern tubes, controlled pitch propellers and larger Azipods® – to spin off insoluble water. However, water ingress must be promptly detected and water removed quickly to prevent damage. All too often, water ingress can remain undetected for extended periods.

In oil-to-sea interface applications, the best way to ensure continuous, effective lubrication and safeguard against costly equipment damage is by choosing a lubricant that is tolerant of water contamination.

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***Choosing from among EAL options should be based on how the lubricants will perform in oil-to-sea interface applications.***

#### Equipment Compatibility

Equipment compatibility is a major concern of any marine operator when assessing alternative lubricant technologies, with seal compatibility usually the predominant concern. Seal failure can cause significant lubricant leakage at the oil-to-sea interface. While damage to seals can be caused by abrasive wear, contact with debris, or during installation, an incompatible lubricant can also cause seal deterioration and subsequent failure.

Data packages provided by EAL suppliers should include test results documenting compatibility with common seal materials. Equipment OEMs may also offer compatibility information as part of equipment technical specifications, or provide the information in response to specific customer requests during the fluid conversion process.

#### Comparing EAL Properties and Performance

The EPA identifies base-stock chemistries that could be classified as EALs – including PAG’s, synthetic esters, and vegetable oils and those materials have now been joined by bio PAO’s. The EPA focused on these materials because they could be made to be readily biodegradable, low in aquatic toxicity, and appreciably non-bioaccumulative.

Therefore, choosing from among EAL options should be based on how the lubricants will perform in oil-to-sea interface applications. The following data compares EAL properties and performance against important lubricant selection criteria.

## Water Limits

Because they are used at the oil-to-sea interface, the water tolerance of EALs is a primary concern. Water intrusion can break down unstable lubricants, cause corrosion inhibitors to leach out and result in accelerated wear to gears and other components. If the oil repels water and is not circulated, water can accumulate against metal causing corrosion and formation of iron oxides that can become a source of abrasive wear. Figure 1 compares the water limits of EALs as measured using the ASTM D 6304 test method. Note that water soluble PAG lubricants are far more tolerant of water and retain their performance characteristics following water influx better than other EALs. This is because water contamination is solubilized into the PAG-based lubricant. Up to 10% ingress causes no change in the viscosity of water soluble PAG lubricants and there is no change in performance up to the 40,000 ppm or 4.0% upper limit for salt water. Residual salt does not react with the PAG molecule, but should be removed via particulate filtration due to its corrosiveness and abrasiveness.

As vessel owners/operators transition to EALs, ASTM E 203 or another test should be conducted to determine if water is present in the system. A vegetable oil, bio PAO or synthetic ester should not be used if the maximum water content cannot be maintained between 200 to a maximum of 500 ppm.

FIGURE 1 – EAL WATER LIMIT COMPARISON<sup>1</sup>

EAL Product	Water Limit (%)	Notes
Polyalkylene Glycol (PAG) (Water soluble PAG)	Up to 7,500 ppm For normal operation	Inert to Water/Condensation. No change in lubricity or corrosion inhibition.  Excess water may be removed using vacuum dehydration
(Mineral Oil Vegetable Oil Synthetic Ester Bio PAO)	200 to maximum 500 ppm	Excess water removed by high speed centrifuge and must be removed promptly

<sup>1</sup> ASTM D 6304

As vessel owners/operators transition to EALs, ASTM E 203 or another test should be conducted to determine if water is present in the system. A vegetable oil, bio PAO or synthetic ester should not be used if the maximum water content cannot be maintained between 200 to a maximum of 500 ppm.

## Hydrolytic Stability

Fluids that react with water can form corrosive acidic and insoluble contaminants that are potentially harmful to equipment. Ideally, no change in the Total Acid Number (TAN) of either the fluid or the water layer will occur. The Acid Change and Total Acidity Numbers shown in Figure 2, developed using the ASTM D 2619 test method, show that PAG-based lubricants are more hydrolytically stable than other EALs.

Despite the fact that bio PAOs are inert to water, the increased pH in the water layer indicates that additives from the formulation (typically corrosion inhibitors) are being leached from the base stock creating acidity. If the acidic water remains in the cavity, it can cause corrosion and related issues until removed. Meanwhile, the base stock now must

FIGURE 2 – HYDROLYTIC STABILITY COMPARISON<sup>1</sup>

EAL Product	Change in Acid Number (mg KOH/g)	Total Acidity of Water Layer (mg KOH)
Polyalkylene Glycol (PAG)*	-0.01n	Water Solubilized
Bio PAO	-0.08	6.9
Synthetic Ester	0.83	19.37
Vegetable Oil	2.02	3.23

<sup>1</sup> ASTM D 2619 – Test conditions: 75g of fluid, 25g of water, and a polished copper strip are sealed in a bottle then placed in a 200°F (93°C) oven and rotated end-to-end at 5 rpm for 48 hrs.

\*Water soluble PAG

function in the absence of critical corrosion inhibitors.

In the case of the synthetic ester, an elevation of +0.83 indicates that the chemistry reacts with water and produces acidic byproducts. The TAN in the water layer also becomes very acidic. As with the bio PAO, this water contaminant should be removed to avoid excessive corrosion and premature wear in the system.

When vegetable oil, synthetic esters or bio PAO lubricants are used in oil-to-sea interface applications, preemptive measures are required to prevent problems caused by water contamination. Reservoirs should be outfitted with available equipment to remove water and filter particulate. Desiccant breather elements should be installed on the reservoirs to remove moisture in the air that would otherwise be breathed into the fluid during normal system function. High-speed centrifuges or vacuum dehydration systems equipped with particulate filtration are used to effectively remove water and the residual salt in larger systems but smaller systems typically operate without any means of water removal equipment.

## Wear Characteristics

In dry and cool (100°F or below) operating environments, all EPA listed EALs can provide lubricity and wear performance similar to the petroleum products they replace. However, when catalysts such as combinations of water/heat/wear or metals/debris are present, the results can change dramatically. Wear characteristics of lubricants can be compared using data from mini-traction machine (MTM) testing.

Coefficient of Friction – Figure 3 compares the coefficient of friction for EALs as well as a standard AW mineral oil. Coefficient of Friction (CoF) describes the ratio of the force of friction between two bodies and the force pressing them together, or the slipperiness of two mated surfaces. The curves depict the lubricity imparted by the lubricant. A lower friction coefficient indicates greater lubricity. To simulate real-life conditions, the tests were conducted with neat lubricants and with 10% seawater added.

The data show that the bio PAO and traditional AW hydraulic oil are displaced from the metal surface by saltwater resulting in higher upward sloping CoFs. Long-term repeated exposure to saltwater is expected to leach corrosion inhibiting additives from these fluids. The synthetic ester and vegetable esters interact with the saltwater, reducing their ability to attach to metal surfaces while slightly reducing



This photograph shows the inside of a hydraulic reservoir that contained a vegetable oil lubricant. It shows the decomposition products of vegetable oils after reaction with water. If left unattended, this contamination will affect equipment reliability and system performance. In addition, free water and residual salt in the system are corrosive to metal surfaces.

their CoFs. Long-term repeated exposure to saltwater is expected to deteriorate the esters proportional to the hydrolytic instability of the lubricants.

In contrast to the other EALs, water soluble PAGs interact with saltwater to create a true solution. While the water can displace the water soluble PAG from the metal surface, long-term repeated exposure shows good corrosion resistance because the lubricant holds the majority of the water away from the surface.

The short duration of the CoF test, cannot simulate the interaction of the saltwater with the test fluid. When interaction/reaction with this aggressive catalyst is considered, testing reveals the following order of decreasing interaction with saltwater:

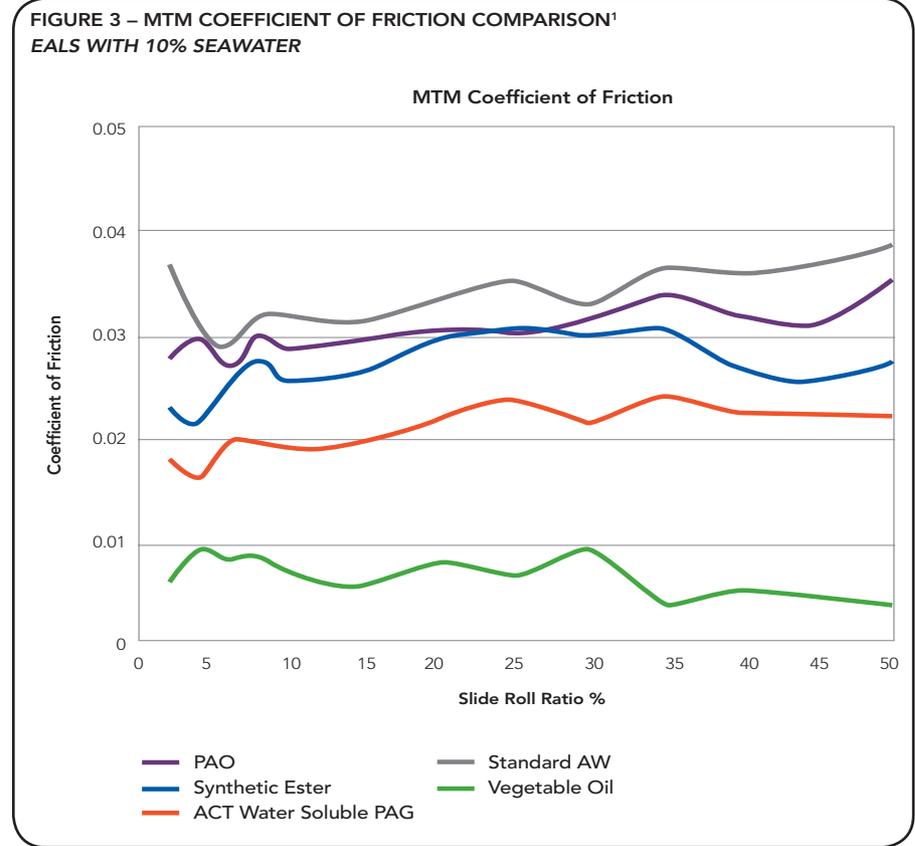
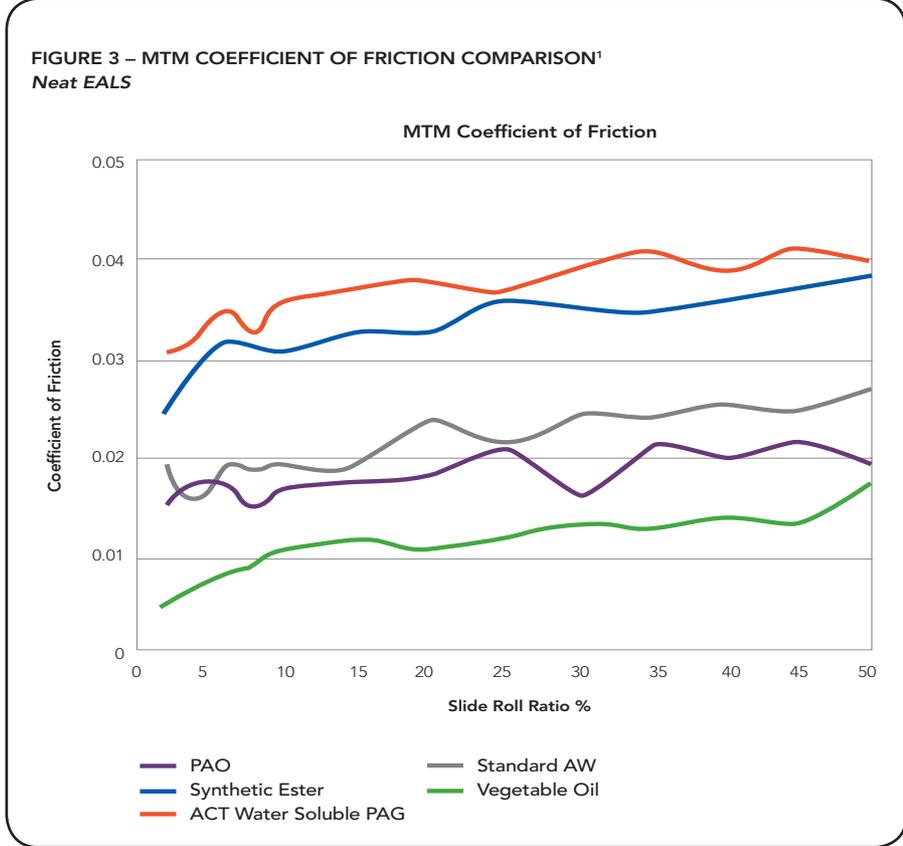
Water-Soluble PAG's > Vegetable Oils > Synthetic Ester > Petroleum Oil > Bio PAO

### Sheening

Under the U.S. EPA Clean Water Act, a lubricant cannot create a surface sheen on water in the event of a spill or other discharge. Water soluble PAG fluids are the only commercially available lubricants that pass the EPA 40 CFR 435 Static Sheen Test, which means they are the only fluid chemistry that is in full compliance with VGP and U.S. EPA Clean Water Act requirements. Results of Static Sheen testing performed on EAL hydraulic fluids are shown in Figure 4. Water soluble PAGs are heavier than water and water soluble, while other EALs are lighter and insoluble as shown in Figures 5 below and Figure 6 on the following page.

### SPCC Regional Inspection Requirements

Under 40 CFR 112, the EPA is concerned with soil and water contamination by petroleum oils and substances that behave like petroleum oils. To prevent discharges of oil to navigable waters and



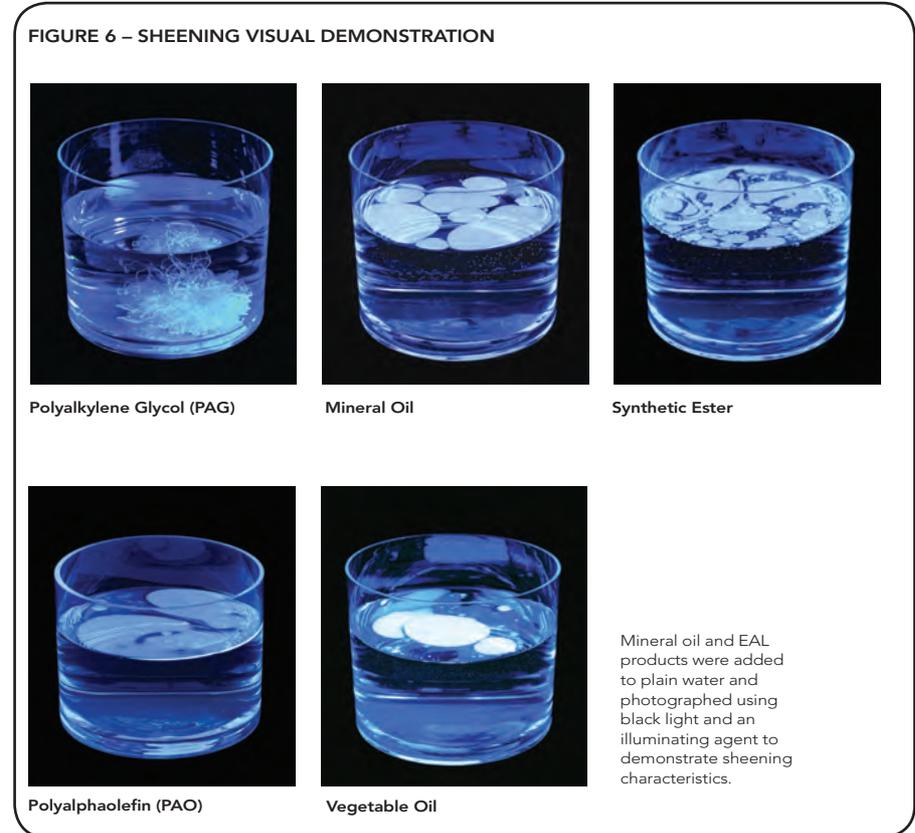
**FIGURE 4 – EAL STATIC SHEEN TEST RESULTS<sup>1</sup>**

	Water soluble PAG	Vegetable Oil	Synthetic Ester	Bio PAO	Mineral Oil
Silvery or metallic sheen	No	No	No	No	No
Increased reflectivity	No	No	Yes	Yes	No
Visual color	No	No	No	No	No
Iridescence	No	No	No	No	No
Oil slick exceeding 10% of surface area	No	Yes	Yes	Yes	Yes
Appendix I to Subpart A of 40CFR435 result	PASS	FAIL	FAIL	FAIL	FAIL

<sup>1</sup> Hydraulic fluids tested by 40 CFR 435

**FIGURE 5 – EAL SPECIFIC GRAVITY COMPARISON**

Lubricant	Typical Specific Gravity
Mineral Oil	0.876
Bio PAO	0.860
Vegetable Oil	0.923
Synthetic Ester	0.920
Water	1.000
Water-Soluble PAG	1.035



adjoining shorelines, the EPA calls for regional inspections to confirm compliance with Spill Prevention, Control, and Countermeasure (SPCC) Plans. SPCC guidance cites the U.S. Coast Guard (USCG) compiled list of substances it considers oils, based upon the CWA definition (33 U.S.C. 1251 – 1376).

Petroleum or non-petroleum “oils” falling under SPCC rules are defined as follows:

- Polyether (molecular weight 2000+)
- Olefin/alkyl ester copolymer (molecular weight 2000+)
- Vegetable oils

While some EALs may fall under these definitions and are, therefore, subject to SPCC rules, AW weight PAG-based fluids are specifically excluded from the definition of an oil because they are polyether materials with CAS# 9038-95-3 and a molecular weight of approximately 1000. However, PAG-based fluids with viscosities higher than 150 cSt are subject to SPCC rules. The exclusion of lower molecular weight polyethers from classification as petroleum or non-petroleum oils is consistent with the chemical properties that differentiate PAG’s from petroleum oils.

***AW weight PAG-based fluids are specifically excluded from the definition of an oil because they are polyether materials with CAS# 9038-95-3 and a molecular weight of approximately 1000.***

### Seal Compatibility

EALs must be compatible with equipment seals to ensure that degradation and subsequent lubricant leakage does not occur. Figure 7 compares the compatibility of EALs with common seal materials. These are general guidelines representing expected results from quality elastomers. A vessel owner or operator should submit representative seals to a prospective EAL supplier to confirm compatibility with the elastomers in actual use. ASTM D 471-10 Fluid Immersion Properties testing (or similar) should be conducted to confirm percent change in hardness, volume, and weight. The standard allowance for change in volume and hardness at 1000 hours is less than +/- 12% when exposed to fluids less than, or equal to, ISO viscosity

FIGURE 7 – SEAL COMPATIBILITY COMPARISON

	Vegetable Oil	PAO	Synthetic Ester	Water Soluble PAG
EPR (EPDM)	S	S	U	S
Viton® (FKM)	S	S	S	S
Buna- N	S	S	S	S
Butyl	S	S	S	S
Silicone	S	S	S	U
Neoprene (polychloroprene)	S	S	U	U
Teflon®	S	S	S	S
Urethane	S	S	S	S*

S = Satisfactory U = Unsatisfactory

\*Contact the supplier for specific recommendations as all formulations are not satisfactory

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grade 46, and +/- 10% when exposed to fluids that have ISO viscosity grades greater than 46. EAL suppliers can provide guidance with respect to the minimum specifications that must be met to assure that elastomers of adequate quality and integrity are used. Use of a higher durometer rated seal (minimum 90) can eliminate concerns about inferior seal quality or other potential issues associated with premature seal failure.

### Paint and Coating Compatibility

For non-stainless steel hydraulic power unit, piping and reservoirs, EAL compatibility with paints and coatings used on internal system surfaces is an important consideration. EAL manufacturers can provide a list of paints and coatings capable of withstanding interaction with their lubricants. In general, use of primers and acrylics should be avoided in marine environments. Cross linked two-part epoxy paints and coatings are preferred. Example compatibility information is included in Figure 8.

FIGURE 8 – PAINT AND COATING COMPATIBILITY<sup>1</sup>

Elastomer	Water Soluble Polyalkylene Glycol	Bio PAO	Vegetable Oil	Synthetic Ester
Epoxy	S	R	R	R
Oil Resistant Alkyd	NR	R	NR	NR
Baked Phenolic	NR	R	R	R
Two Component Urethane	NR	R	R	R
Moisture Cured Urethane	NR	R	R	R
Acrylic	NR	NR	NR	NR
Latex	NR	NR	NR	NR
Oil Varnish	NR	NR	NA	NA
One Component Urethane	NR	NR	R	R
Polyvinyl Chloride	NA	NR	NA	NA
Lacquer	NA	NR	NA	NA

<sup>1</sup>Radco 2012, Summit N/D, and Totten 2000

### Lubricant Conversion Guidelines

When converting an existing lubricant to an EAL, the goal is always to select an EPA compliant lubricant that will not require a sacrifice in lubrication performance. Choosing a versatile lubricant that can be used in multiple vessel systems can help reduce onboard inventory requirements. EALs are typically more expensive than traditional mineral oil lubricants. To offset this expense, compare lubricant drain interval recommendations to identify a product with extended operating life, which can reduce the overall cost of vessel lubrication, and related maintenance, over time.

To ensure compatibility prior to installation, confirm lubricant seal and system compatibility with equipment OEMs. If multiple lubricants were used when the system was originally assembled, or during operation, address each lubricant during the conversion process.

***Choosing a versatile lubricant that can be used in multiple vessel systems can help reduce onboard inventory requirements.***

### Draining and Filling the System

When draining old lubricant from the system, adhere to all applicable environmental, health and safety practices and regulatory

requirements for proper handling, storage, transport, and recycling or disposal of used lubricant. Consult Safety Data Sheets (SDS) and regulatory authorities for guidance. After the old lubricant is removed, prepare the drained system using a procedure that will adequately remove mineral oil from the system before installing the new lubricant. Petroleum oil is soluble and miscible in vegetable oil, polyalphaolefin, and synthetic ester. Any residual hydrocarbon left in the system after it is drained will mix into these EALs and the resulting mixture will be considered a pollutant in the event of a leak or spill into a sensitive waterway.

Therefore, it is critical that a thorough and well thought out drain and flush procedure be used to assure that no petroleum oil remains in the system when the EAL is installed. Because petroleum oil is lighter and insoluble in water-soluble PAG lubricants, any petroleum oil remaining in a reservoir after conversion to a water-based PAG will rise to the surface and can be removed by wet/dry vacuuming the lighter material from the surface until completely removed.

All EAL suppliers should have a method of confirming the amount of petroleum oil left in the system after conversion but the following method is useful when converting to a synthetic ester, vegetable oil or bio PAO. These EALs have different densities than petroleum oil. The approximate percentage of residual petroleum oil can be determined by determining the density of the final charge of fluid in the reservoir, and comparing it to the densities of the neat fluids. The approximate amount of the petroleum oil that remains solubilized into the vegetable oil, synthetic ester or bio PAO fluid can be calculated from this weighted average.

#### Baseline Lubricant Testing

When the fluid conversion has been completed, a control or baseline sample should be pulled and sent to a lab for testing. To obtain a representative sample, pull the sample from the unit after the system has cycled at normal operating pressure and temperature for approximately 1 week. This will allow for any residual petroleum oil in the circuits/lines to make its way back to the tank. In addition, all samples should be pulled while the equipment is operating at normal pressure and temperature to ensure the sample accurately represents the fluid circulating through the system.

Because water soluble PAG lubricants are heavier and insoluble with petroleum oil, a sample can be observed shortly after it is pulled to make a determination if residual petroleum oil exists in the system, and at what approximate percentage. A lab can be used to centrifuge the sample to provide a more accurate measurement if necessary. If petroleum oil exists, it can be removed as described above.

#### Conclusion

The US EPA's 2013 VGP mandates require vessel owners and operators to change lubricants used in oil-to-sea interface applications. Selection of an EAL requires careful thought and consideration. Just because EALs are, by definition, biodegradable, minimally toxic and non-bioaccumulative, does not mean they will not all perform acceptably at the oil-to-sea interface. Given the propensity for water/salt-water ingress at any time, end-users should favor the use of the most water tolerant and forgiving lubricants to maintain performance and protection after lubricant conversion. Failure to consider performance before EAL conversion can have a long-term impact on equipment reliability and service life and affect overall vessel operating efficiency, productivity and expense.

#### About ACT

American Chemical Technologies, Inc. (ACT) is at the forefront of synthetic lubrication technology. We create, supply, and technically support high performance solutions that extend equipment life, reduce operating expense and help protect the environment. Today, polyalkylene glycol (PAG) and other specialty lubricants from ACT are at work globally, meeting the varnish control/cleanliness, fire resistance, biodegradability, water solubility and other demands of industry leaders in energy, metals, marine, amusement, tunneling, and die casting/forging. ACT is headquartered near Detroit in Fowlerville, Michigan, USA.

## Neptune® Series Water Soluble PAGs

Polyalkylene glycol (PAG)-based lubricants are an attractive option for compliance with the 2013 EPA VGP requirements because of their high lubrication performance, tolerance of water, inherent cleanliness, longevity and versatility. The water soluble chemistry of Neptune® Series lubricants is the only fluid chemistry that is in full compliance with VGP and U.S. EPA Clean Water Act requirements. Neptune® Series products meet the U.S. Coast Guard's Technical Standard for EALs published and released in April 2014. Neptune® Series PAG-based lubricants are available globally from American Chemical Technologies, Inc. (ACT) to support compliance with EPA VGP regulations. These water soluble PAG-based lubricants conform to VGP requirements as Environmentally Acceptable Lubricants and are available exclusively from ACT.

They have been shown to be biodegradable using the OECD 301B test and are classified as "relatively harmless" or "practically non-toxic" to fish and other aquatic wildlife by the U.S. Fish and Wildlife Service. Neptune® Series lubricants have been found to be non-bioaccumulative in the tissues of living organisms using the OECD 107 and 117 test methods. Neptune® Series lubricants also support compliance with the non-sheening provisions of the U.S. EPA Clean Water Act. They are heavier than water and dissolve completely, leaving no surface sheen in the event of a leak or spill. PAGs are the only commercially available lubricants that pass the EPA 40 CFR 435 Static Sheen test.

Neptune® Series lubricants offer excellent lubricity, high viscosity index, and corrosion protection. The lubricants are especially well-suited for use in oil-to-sea interfaces because they retain their performance characteristics in the presence of humidity or upon water influx better than EALs formulated from synthetic ester, vegetable oil, and bio-PAO base oils. The hydrolytic stability of Neptune® Series lubricants reduces formation of corrosive acids and sludge due to water contamination, protecting components from damage and supporting vessel operating reliability. With excellent oxidation stability, Neptune Series lubricants are non-varnishing or sludge forming, which means they can extend lubricant change-out intervals for reduced maintenance expense. The lubricants are Factory Mutual approved.

Neptune® Series lubricants include anti-wear (AW) fluids as well as gear lubricants in a broad range of viscosity grades to meet the requirements of oil-to-sea interface, deck and other marine vessel applications, as well as requirements for dockside or other shoreline systems.

To learn more, contact ACT at [sales@americanchemtech.com](mailto:sales@americanchemtech.com) or visit [www.americanchemtech.com](http://www.americanchemtech.com)

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# Neptune® PAGs last longer and comply with EPA VGP.

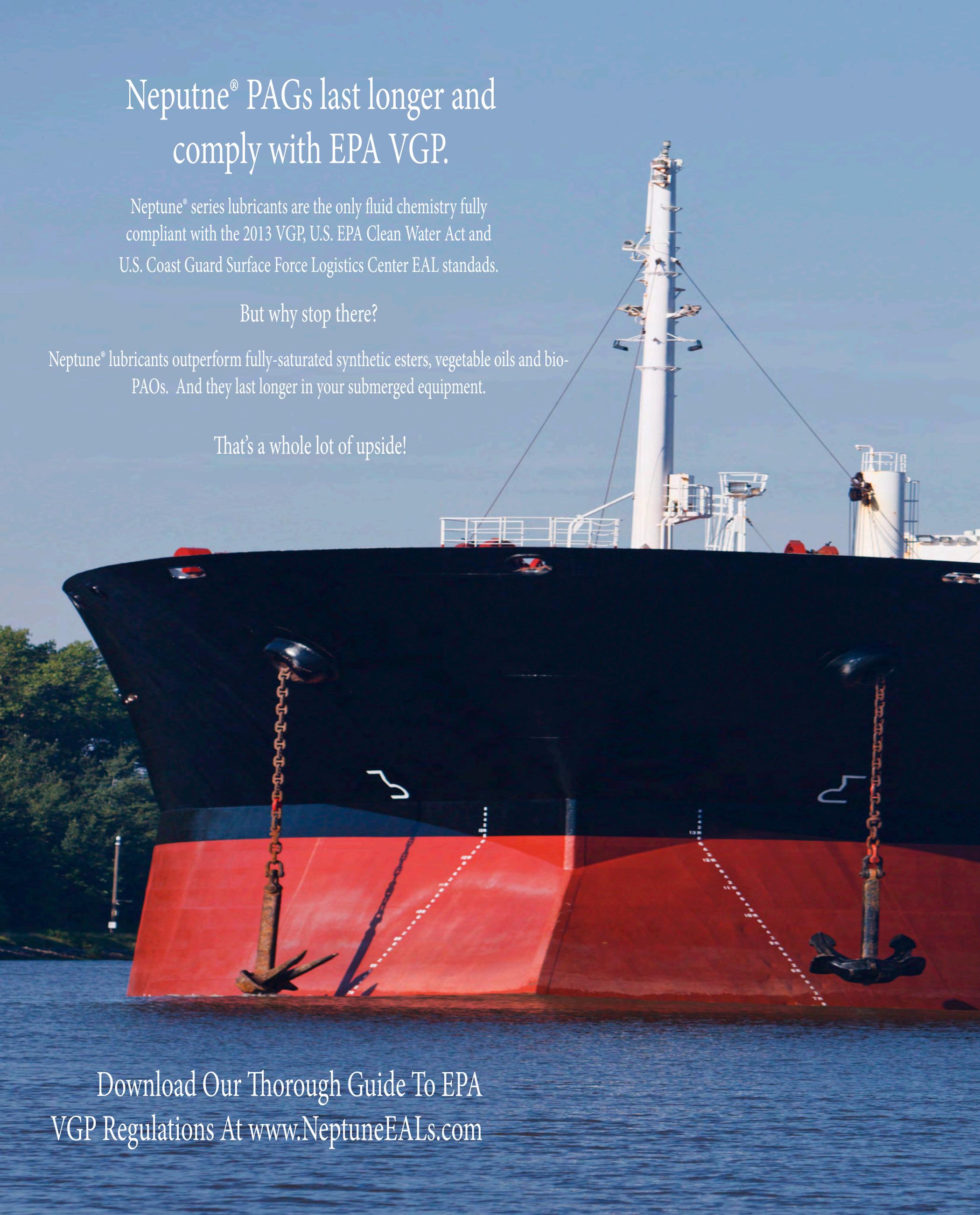
Neptune® series lubricants are the only fluid chemistry fully compliant with the 2013 VGP, U.S. EPA Clean Water Act and U.S. Coast Guard Surface Force Logistics Center EAL standards.

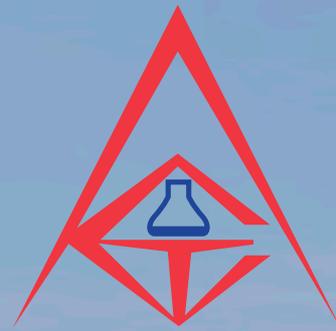
But why stop there?

Neptune® lubricants outperform fully-saturated synthetic esters, vegetable oils and bio-PAOs. And they last longer in your submerged equipment.

That's a whole lot of upside!

Download Our Thorough Guide To EPA  
VGP Regulations At [www.NeptuneEALs.com](http://www.NeptuneEALs.com)





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# GE Marine

## Efficient, Reliable Power for Military & Commercial

GE Marine is one of the world's leading manufacturers of marine propulsion products, systems and services including aeroderivative gas turbines. These highly efficient marine engines meet current and future emission regulations, and offer superior availability for various commercial and military applications. GE gas turbine propulsion systems and solutions are being used in some of the most novel projects such as to power the world's fastest commercial ship as well as the United States Navy's new LHD amphibious assault ship.

### Products and Power Ranges

GE Marine's gas turbine product portfolio is diverse, ranging in power from 6,000 to 70,275 shaft horsepower (4.5 to 52 megawatts).

Since propulsion architecture is based on the power required, the duty cycle, environmental concerns and many other factors, these are the most popular cycles used for ship propulsion:

- Combined gas turbine system mechanical drive - driving propellers (COGAG)

- Combined gas turbine and diesel mechanical drive (CODAG)
- Combined gas turbine or diesel mechanical drive (CODOG)
- Hybrid drive options: combined diesel electric or gas turbine (CODOG)
- Combined dieselelectric and gas turbine (CODLAG)
- Combined gas turbine, electric and steam system (COGES) for electric drive ... where GE's system efficiency approaches 50%

What follows is an overview of recent projects, product updates and technology infusion relevant to the commercial and military marine markets.

### World's Fastest Ship

Francisco achieved 58.21 knots on June 15, 2013 -- making it the fastest commercial ship in the world. Built by Australian shipyard Incat for Argentina's Buquebus, the ship is powered by two light-weight and compact GE LM2500 aeroderivative gas turbines. This

## GE Marine Products & Power Ranges

LM6000 PG



Weight (lb/kg) 16,180/7337  
Length (ft/m) 24/7.3  
Height (ft/m) 8.3/2.5

**Output**  
(shp) 70,275  
(kW) 52,403

**SFC**  
(lb/shp-hr) 0.332  
(g/kW-hr) 201.9

**Heat rate**  
(Btu/shp-hr) 6,117  
(Btu/kWs-hr) 8,210  
(kJ/kWs-hr) 8,660

**Exhaust gas flow**  
(lb/sec)/(kg/sec) 310/141

**Exhaust gas temperature**  
(°F)/(°C) 930/499

**Power turbine speed**  
(rpm) 3,930

LM6000 PC



Weight (lb/kg) 16,340/7411  
Length (ft/m) 24/7.3  
Height (ft/m) 8.3/2.5

**Output**  
(shp) 56,900  
(kW) 42,428

**SFC**  
(lb/shp-hr) 0.329  
(g/kW-hr) 200.1

**Heat rate**  
(Btu/shp-hr) 6,049  
(Btu/kWs-hr) 8,119  
(kJ/kWs-hr) 8,564

**Exhaust gas flow**  
(lb/sec)/(kg/sec) 273/124

**Exhaust gas temperature**  
(°F)/(°C) 853/456

**Power turbine speed**  
(rpm) 3,600

LM2500+G4



6-stage PT  
Weight (lb/kg) 11,545/5,237  
Length (ft/m) 22/6.7  
Height (ft/m) 6.7/2.04

**Output**  
(shp) 47,370  
(kW) 35,320

**SFC**  
(lb/shp-hr) 0.352  
(g/kW-hr) 214.1

**Heat rate**  
(Btu/shp-hr) 6,469  
(Btu/kWs-hr) 8,675  
(kJ/kWs-hr) 9,150

**Exhaust gas flow**  
(lb/sec)/(kg/sec) 205/93.1

**Exhaust gas temperature**  
(°F)/(°C) 1,020/549

**Power turbine speed**  
(rpm) 3,600

LM2500+



6-stage PT  
Weight (lb/kg) 11,545/5,237  
Length (ft/m) 22/6.7  
Height (ft/m) 6.7/2.04

**Output**  
(shp) 40,500  
(kW) 30,200

**SFC**  
(lb/shp-hr) 0.354  
(g/kW-hr) 215.0

**Heat rate**  
(Btu/shp-hr) 6,522  
(Btu/kWs-hr) 8,746  
(kJ/kWs-hr) 9,227

**Exhaust gas flow**  
(lb/sec)/(kg/sec) 189/85.9

**Exhaust gas temperature**  
(°F)/(°C) 965/518

**Power turbine speed**  
(rpm) 3,600

LM2500



Weight (lb/kg) 10,300/4,672  
Length (ft/m) 21.4/6.52  
Height (ft/m) 6.7/2.04

**Output**  
(shp) 33,600  
(kW) 25,060

**SFC**  
(lb/shp-hr) 0.373  
(g/kW-hr) 226.9

**Heat rate**  
(Btu/shp-hr) 6,860  
(Btu/kWs-hr) 9,200  
(kJ/kWs-hr) 9,705

**Exhaust gas flow**  
(lb/sec)/(kg/sec) 155/70.5

**Exhaust gas temperature**  
(°F)/(°C) 1,051/566

**Power turbine speed**  
(rpm) 3,600

LM500



Weight (lb/kg) 1,500/680  
Length (ft/m) 9.7/2.96  
Height (ft/m) 3.0/0.91

**Output**  
(shp) 6,130  
(kW) 4,570

**SFC**  
(lb/shp-hr) 0.443  
(g/kW-hr) 269.5

**Heat rate**  
(Btu/shp-hr) 8,140  
(Btu/kWs-hr) 10,916  
(kJ/kWs-hr) 11,520

**Exhaust gas flow**  
(lb/sec)/(kg/sec) 36/16.4

**Exhaust gas temperature**  
(°F)/(°C) 1,049/565

**Power turbine speed**  
(rpm) 7,000

Average performance, ISO (60Hz, 59°F, sea level, 60% relative humidity, no inlet/exhaust losses).

Average performance, ISO (60Hz, 59°F, sea level, 60% relative humidity, no inlet/exhaust losses).



**Francisco – the world’s fastest commercial ship –** is powered by two LM2500 gas turbines fueled by LNG

1,516-tonne displacement catamaran can operate on LNG or Marine Gas Oil (MGO).

Francisco ushers in a new era of eco-sustainability in heavy-duty transportation. Lessons learned through the design and construction phase of this novel ship will assist owners and operators who turn to LNG-powered gas turbines for future high-speed newbuild projects.

The fast ferry can service over 1,000 passengers and 150 cars on each crossing of the River Plate between Argentina and Uruguay. It is the first craft built under the International Maritime Organization’s (IMO) International Code of Safety for High-Speed Craft to be powered by gas turbines using LNG as the primary fuel and marine distillate for standby and ancillary use.

### Gas Turbine Package

GE took into consideration the fast ferry’s operating and design requirements and incorporated the following features into the LM2500 package design to address Francisco’s narrow catamaran hull:

- Lightweight design package is based on a high tensile steel base-plate and aluminum enclosure
- Control system seamlessly switches between LNG and MGO for continuous dual-fuel operation
- Package and control system meet DNV GL classification requirements
- Negative ventilation is incorporated to contain any potential gas leaks within the package
- All connection points, cables and pipes are placed on the forward part of the gas turbine packages to ease installation in the narrow catamaran hull
- The gas turbines feature a marine air filtration system
- Three modules are part of the engine room design:
  1. Enclosure with gas turbine, fuel valves, and filters
  2. Auxiliary skid with gas turbine lube tank, hydraulic start system, and coolers for both
  3. Turbine control panel features a front panel-mounted human machine interface

Pre-wired, pre-piped and factory tested for easy installation, the LM2500 module weighs just 45,500 pounds (20,639 kg), and requires only 27 x 9 x 10 feet of ship space (8.23 x 2.74 x 3.05 m).

### More Space = More Revenue

Commercial ship owners and operators can experience numerous advantages by applying GE LM gas turbines as prime movers:

- **Emissions:**

NOX emissions from GE gas turbines are inherently low compared to traditional diesels. Francisco’s LM2500s, for instance, are equipped with GE’s single annular combustion system. Adding optional water injection or Dry Low Emissions (DLE) systems would allow the LM2500 to meet Tier III IMO/Tier IV United States Environmental Protection Agency NOx requirements today with no additional exhaust treatment. Additionally, these gas turbines do not suffer from methane slip.

- **Fuels flexibility:**

GE gas turbines operate on a variety of fuels, including MGO, bio-diesel, bio-synthetic paraffinic kerosene blends and natural gas. Fuel flexibility is even more beneficial today as commercial ship operators adopt dual-fuel operating scenarios to meet new emissions regulations.

- **Reduced maintenance costs:**

Even while operating at full power, 100% of the time, combustor and hot section repair intervals are 25,000 hours or longer when burning natural gas or re-gasified LNG fuel.

- **Increased availability:**

GE gas turbines offer easy maintenance and scheduled inspections. When engine overhaul is required, the gas turbine can be changed-out in as little as 24 hours and replaced by a spare unit. This ensures the highest quality service and availability for the ship.

- **Reliability:**

Built incorporating the latest aircraft engine design technologies, quality requirements and corrosion resistant materials, each GE gas turbine provides maximum reliability and parts life along with outstanding performance.

### Other Passenger Ships

Two LM500 marine gas turbines operate onboard TurboJET’s Foilcat fast ferry. This multihull hydrofoil catamaran, which links Hong Kong to Macau, measures 35 meters long. It can carry 423 passengers, with a maximum service speed of 45 knots.

The world’s largest transatlantic liner, Queen Mary 2, sails today powered by two LM2500+ marine gas turbine-generator sets and four diesel-generator sets. This flagship of the British merchant fleet is owned by Cunard Line.

Power produced by the CODAG propulsion system is also used for shipboard service such as heating, air conditioning and laundry. Each turbine-generator set contributes 25 MW to the ship’s overall 118 MW of installed power.

GE specially designed the two gas turbine packages to be some 35 tons lighter than previous LM2500+ marine installations. This lighter



**GE's LM6000 marine gas turbine** received Lloyd's Register's Design Appraisal Document to the Marine Naval Vessel Rules.

design gave Queen Mary 2 designers greater flexibility in placing various shipboard equipment and public areas. In fact, the gas turbines are located in the top of the ship's exhaust stack, opening up space for an additional 45 state rooms in the hull below.

## Commercial Update

GE has delivered more than 90 marine gas turbines worldwide for commercial marine projects, including 17 cruise ships, five high speed yachts and 19 fast ferries. GE engines are the only gas turbines currently installed on cruise ships.

Together GE and Lloyd's Register are exploring GE gas turbine-powered commercial ship projects globally. This MOU allows GE and Lloyd's Register to work with some of the leading shipyards to approve in principle GE gas turbine-powered commercial vessels for global customers.

Separately, GE and Dalian Shipbuilding Industry Company were granted Approval in Principle by Lloyd's Register for a GE combined gas turbine electric and steam system designed by the team for LNG carriers.

### LM6000 LR Appraisal

GE recently announced that its LM6000 marine gas turbine PC and PG models have received Lloyd's Register's Design Appraisal Document to the Marine Naval Vessel Rules (NVR). The LM6000PC marine gas turbine produces 59,900 shp/42 MW and the more powerful PG model has an output of 70,275 shp/52 MW.

With the LM6000 Lloyd's Register's Design Appraisal to Marine Naval Vessel Rules obtained, GE offers customers gas turbine-based propulsion solutions for a myriad of additional marine applications including military combatants.

### LM6000 Marine Experience

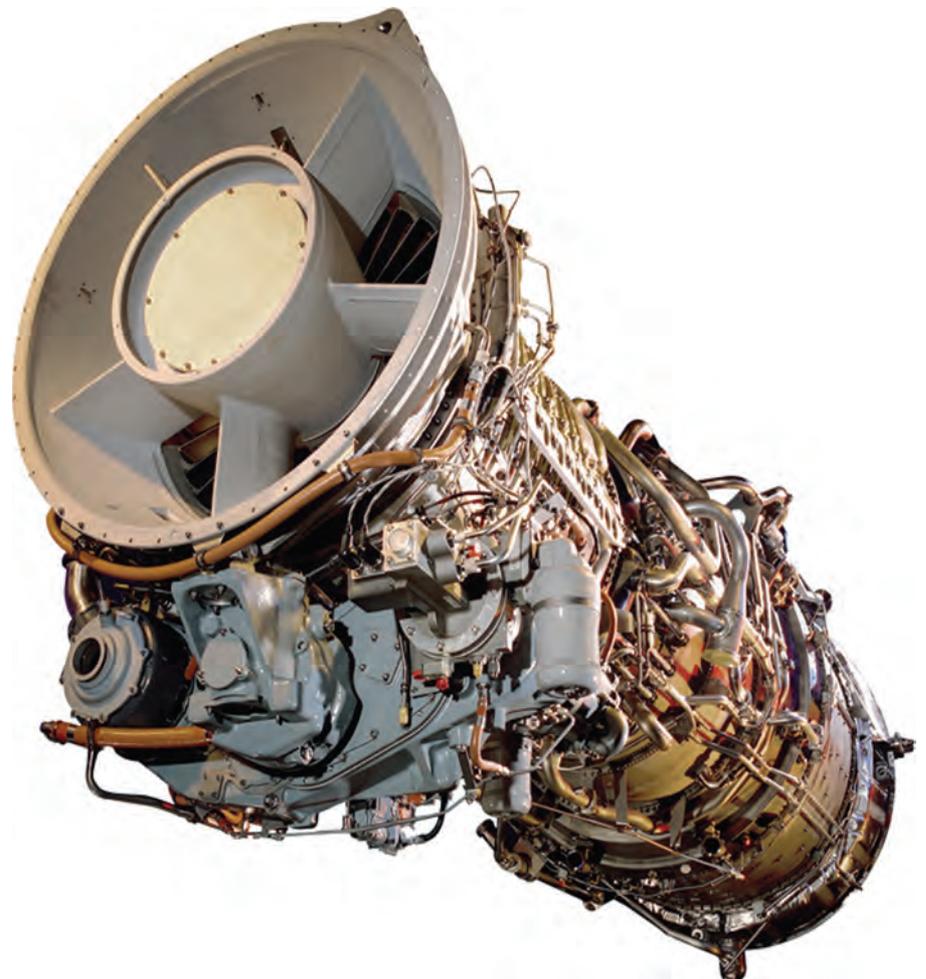
Over 1,110 LM6000 PC models are used for land-based power generation, driving LNG compressors and on marine floating production storage and offloading (FPSO) vessels, offshore platforms and power barges.

**Two LM2500 gas turbines provided by IHI** will power the Japanese Maritime Self-Defense Force's new 26DD destroyer.

**GE signed an in-service support agreement** with the Royal Australian Navy for its fleet of 16 LM2500 gas turbines.

For example, two LM6000 dual fuel gas turbines power the Triton FPSO, which produces oil and gas from six fields in the North Sea east of Aberdeen. Including Triton, there are a total of 17 LM6000 gas turbines delivered or operating on the following FPSOs or power barges:

- Åsgard FPSO
- Douglas Platform
- PLN Power Barge
- Schiehallion
- Tanir Bavi Power Barge
- ZADCO Platform



## International Naval Programs

GE's marine gas turbines offer superior availability for various military applications, ranging from patrol boats, corvettes, frigates, destroyers and cruisers, to supply and amphibious ships and aircraft carriers. What follows are a list of recent naval projects, listed alphabetically by country.

### • Australia •

GE will provide in-service support for the Royal Australian Navy's LM2500 marine gas turbines that power Adelaide- and AN-ZAC-class frigates. GE will be backed by GE Marine and Air New Zealand Gas Turbines for this multi-year contract.

In addition to repair and overhaul of the RAN's 16 LM2500s and associated accessories, GE will provide depot level maintenance to be performed by Air New Zealand Gas Turbines, an authorized LM2500 service center and longtime RAN service provider.

GE will provide program management and on-site field service support, and will handle warehouse and inventory management including spare parts and inventory replenishment throughout the life of the contract. The RAN will now have predictable LM2500 gas turbine maintenance costs and lower total cost of ownership -- all with the aim of ensuring optimum fleet readiness.

The LM2500 gas turbine will power five new RAN ships:

- HMAS Canberra Landing Helicopter Dock (LHD) is the largest ship commissioned into RAN's fleet; sister LHD HMAS Adelaide is currently under construction.
- Three Hobart-class Air Warfare Destroyers each will feature LM2500s. These RAN destroyers are based on the design developed and used by Navantia of Spain for the Spanish Navy's F100 frigate program.

### GE Marine provides maintenance and logistic support services

for the Royal Canadian Navy's fleet of LM2500 marine gas turbines



### GE's LM2500+G4 marine gas turbine

will power eight ships for the Italian, French and Moroccan Navy FREMM frigate program, including the Italian Navy's Bergamini (shown).

### • Canada •

For more than 20 years, GE Marine has been a proud supplier of the main gas turbine engines of the Royal Canadian Navy's (RCN) Halifax-class frigates. To date, GE has provided 24 LM2500 gas turbines for 12 frigates.

GE also provides maintenance and logistics support services for the RCN's fleet of LM2500 gas turbines. This contract includes immediate onsite technical support 24-hours-a-day, 7-days-a-week, as well as:

- Repair, overhaul and engineering support
- Parts warehousing and inventory management (including spare engines, supply of spare parts and replenishment of inventory)
- Field service representative support (home port and deployed)



- Support of RCN naval engineering school training curriculum for on-engine and equipment maintenance
- Operational level maintenance
- Configuration management
- Supply and distribution of technical manuals

### • Germany •

The German Navy's Baden-Württemberg (F125-class) frigate, christened in December 2013, is powered by one LM2500 gas turbine, two electric motors and four diesel generator-sets in a CODLAG propulsion arrangement. The christening ceremony was held at ThyssenKrupp Marine Systems in Hamburg, Germany. GE will provide LM2500 gas turbines for the four new CODLAG-configured F125 frigates that will replace the German Navy's eight Bremen-class F122 frigates. GE LM2500s also power the German Navy's Bremen-, Brandenburg- (F123) and Sachsen-class (F124) frigates.

### • Italy •

One LM2500+G4 marine gas turbine supplied by Avio Aero will power the Italian Navy's eighth FREMM frigate. Through Avio Aero, at least 17 LM2500+G4 gas turbines are expected to provide propulsion for the Italian-French-Moroccan FREMM program, which includes eight ships each for the Italian and French navies and one ship for the Royal Moroccan Navy. Avio Aero assembles the gas turbines into propulsion modules and services the engines for the FREMM program – all at its Brindisi facility. Avio Aero also services the LM2500 modules that power Italy's Cavour aircraft carrier. In total, GE LM2500 gas turbines power seven Italian Navy ship classes.

GE is a longstanding partner in Italy, employing more than 12,000 individuals. In Brindisi, Avio Aero produces 20% of the worldwide LM2500 engine components. The facility also serves as GE's Center of Excellence for the overhaul and repair of GE's LM2500 engine family, and will soon offer global marine and industrial customers overhaul capabilities for GE's LM6000 gas turbine.

### • Japan •

Two LM2500 gas turbines provided by IHI will power the Japanese Maritime Self-Defense Force's (JMSDF) new 26DD destroyer. The GE LM2500s will be equipped with integrated electronic controls, and will be arranged in a COmbined Gas turbine-eLectric And Gas turbine (COGLAG) configuration. IHI will deliver the LM2500 propulsion modules to MHI's Nagasaki Shipyard & Machinery Works in 2017. Separately, during a March 25, 2015, the JMSDF commissioned JS Izumo (DDH-183) in Yokohama. This is the first of two helicopter carriers for the JMSDF, and it includes LM2500 gas turbines for propulsion and LM500 electrical generator-sets for onboard ship service electrical power. This ship marks the first LM500 generator set application for military ships. The LM2500 and LM500 modules were built by IHI. The current global LM2500 fleet totals more than 2,500 engines operating in diverse marine and industrial applications. Including the 26DD program, the JMSDF uses LM2500 and LM500 gas turbines for its Kongou-, Murasame-, Atago-, Hyuga- and Izumo-class ships. To date, IHI has packaged, tested and delivered over 70 LM2500 and more than 30 LM500 marine gas turbines.

### • Republic of Korea •

GE's LM500 gas turbines will soon power the Republic of Korea

Navy's PKX-B patrol boat program. The PKX-B program is planned for 34 ships and each ship uses two LM500s. The existing 18 ships in the PKX-A program also are powered by two LM500s per ship in a CODAG arrangement. Continuing PKX-A program capabilities into the PKX-B program, Samsung Techwin locally manufactures selected parts of the LM500s, and assembles and tests the completed engines. GE will provide support of the gas turbine, control, and reduction gear system to Samsung Techwin, shipyard Hanjin Heavy Industries and Construction, and the ROK Navy throughout installation, sea trials, and commissioning.

### • Turkey •

GE will provide Savunma Teknolojileri Mühendislik Ve Ticaret A.Ş. (STM), Ankara, Turkey, with LM2500 gas turbines to power the Turkish Navy's third and fourth MILGEM multi-purpose corvettes.

STM is the program manager for these two new ships, and will provide platform systems, construction materials, design services and the main propulsion systems, as well as integration of the propulsion system. In addition to the services provided to the Turkish Navy, STM has export responsibility of the MILGEM corvettes with the endorsement of the country's Undersecretariat for Defence Industries (Savunma Sanayii Müsteşarlığı or SSM). In accordance with export targets, STM is expected to have further collaboration opportunities with GE Marine. The propulsion system for the new MILGEM ships will be the same as sisters TCG Heybeliada (F-511) and TCG Büyükada (F-512), consisting of an LM2500 gas turbine-based CODAG system with two diesel engines. Total propulsion power is 31,000 kilowatts, allowing the ship to reach maximum speed in excess of 29 knots. The corvettes have an overall length of 99 meters with a displacement of 2,300 tons.

The initial two MILGEM corvettes entered naval service in September 2011 and September 2013, respectively. Additionally 24 LM2500s operate aboard the Turkish Navy's Barbaros- and Gabya-class frigates.

The LM2500s for the MILGEM program are manufactured at GE's Evendale facility. Tusas Engine Industries Inc. (TEI), a joint venture between GE and Turkish Aerospace Industries Inc., manufactures parts for LM2500 gas turbines as well as other GE Aviation engines at their facility in Eskisehir, Turkey.

The MILGEM program is managed by SSM, and similar to the first two ships, the Turkish Navy will undertake design and performance responsibilities for the new corvettes. The new MILGEM ships will be constructed at the Istanbul Naval Shipyard; GE will deliver the engines in 2015 and 2016.

### • United States •

The United States Coast Guard's eighth National Security Cutter Midgett (WMSL 757), will be powered by an LM2500-based CODAG propulsion system. All eight ships in the U.S. Coast Guard's Legend-class cutter program feature the same LM2500-based CODAG propulsion arrangement. Similar to its sister NSCs, Huntington Ingalls Industries' Ingalls Shipbuilding division will construct the 418-foot-long Midgett at its Pascagoula, Mississippi, shipyard.

Four NSCs Bertholf, Waesche, Stratton and Hamilton, are fully operational and executing Coast Guard missions in the field. The fifth James, is scheduled for delivery and commissioning in 2015. The sixth cutter, Munro is expected to be delivered in 2016. Fabrication of the seventh NSC, Kimball, began earlier this year and delivery is scheduled for 2018.

## Exhaust Heat Recovery Technology

Increasing fuel costs and stricter emissions requirements in the marine industry are compelling owners and operators to reevaluate the impacts and economics of ship power plants. These trends set the stage for expanded use of energy efficient technologies on commercial and military vessels. One promising solution is Exhaust Heat Recovery (EHR) using carbon dioxide (CO<sub>2</sub>) as the working fluid. This technology offers the desired benefits of increased fuel efficiency coupled with marine-friendly features such as compactness and low maintenance requirements.

Using similar thermodynamic cycle principles that have been in practice for over 100 years, but replacing traditionally used steam with CO<sub>2</sub>, these systems improve upon the many benefits of a proven technology. Together, Echogen Power Systems and GE Marine are bringing CO<sub>2</sub>-based exhaust heat recovery to commercial marine and naval applications for integration with diesels and gas turbines.

GE is the exclusive provider of Echogen Power Systems' exhaust heat-to-power products that enhance GE's mechanical, hybrid and all-electric propulsion system solutions, boosting system efficiency to nearly 50%.

## Benefits of CO<sub>2</sub> Power Cycle

Heat recovery has traditionally been performed using a steam system. Three primary drawbacks with steam systems are the large footprint, high maintenance requirements, and the difficulties operating and managing water chemistry. The system size results in only large prime movers being economical heat sources. Additionally, the number of components necessary, especially in the dual-pressure steam system configuration, is daunting enough to keep steam from being widely adopted on medium and small prime movers.

A heat recovery system using CO<sub>2</sub> as the working fluid captures inherent benefits of an exhaust energy bottoming cycle while addressing the shortcomings of the more prevalent steam option. Some of the benefits that CO<sub>2</sub>-based Rankine Cycle technology offers versus steam include:

- **Simple operation:**

The CO<sub>2</sub> system is a fully automated, closed-loop cycle with no prime mover operating restrictions. Operation can be integrated with the ship power management system.

- **Non-corrosive working fluid:**

CO<sub>2</sub> can remain in the system, including the exhaust heat exchanger, without risk of rust or corrosion.

- **Scalable and adaptable:**

The CO<sub>2</sub> system is scalable from 200 kilowatts to more than 50 megawatts, and can be used on a wide range of heat sources from 240°C/464°F (e.g., low-speed diesel) to 600°C/1112°F (i.e., gas turbine).

- **Competitive efficiencies:**

Similar thermal-to-electric power conversion efficiency as steam or ORC systems.

- **Compact turbomachinery:**

The thermodynamic properties of sCO<sub>2</sub> allow for significant reductions in turbomachinery weight and volume over steam systems (see Figure 8). CO<sub>2</sub> systems typically use a single-stage turbine.

- **Closed-loop architecture:**

The CO<sub>2</sub> system does not require make-up water or strict water chemistry requirements. This simplifies operation and eliminates the need for licensed marine steam operators.

- **Lower maintenance costs:**

The use of CO<sub>2</sub> eliminates the need for steam system equipment such as the condensate system, water treatment and chemistry, and steam system specific maintenance efforts. The closed-loop, sealed design simplifies operation and maintenance of the bottoming cycle.

- **Integrated power and cooling cycle:**

Because CO<sub>2</sub> can also be used as a refrigerant, recovered energy can be easily transferred between generating electricity and cooling systems such as chilled-water production, air conditioning, electrical equipment cooling, and gas turbine inlet air cooling for hot-day power augmentation.

## Echogen Update

In December 2014, Echogen Power Systems announced the commercial availability of its EPS100 heat engine system as a turnkey solution that satisfies energy demand, environmental requirements and bottom line cost savings for industrial, power generation, oil & gas, and marine customers. The compact, packaged power system, with up to 50 megawatt (MW) capabilities, reduces the overall cost of ownership with lower transportation and installation costs. The cycle also can operate water-free – a key advantage in many parts of the world.

## Gas Turbine Services and Support

As witnessed with the service agreements in place with military customers such as Canada's and Australia's Navy and fast ferry operator Buquebus, GE Marine is more than an equipment supplier. GE can provide customized agreements to match the needs of customers in providing care and maintenance of their propulsion systems.

By shipping hundreds of new gas turbines each year into long-term marine and industrial projects, GE Marine assures speedy parts and services now, and ongoing support well into the future.

Visit [www.ge.com/marine](http://www.ge.com/marine) for additional information or contact:

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Greater power density in a compact package. Flexible engine placement for a more efficient hull line. Clean-burning fuel for lower emissions. GE's marine gas turbines are a smart alternative to diesels. And a brilliantly designed solution for greater profitability and performance in the shipping industry.

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# Get a greater capacity for possibility.

Compact engines that offer greater power density. Reliable gas turbines with lower emissions. Engines that allow more room for passengers and cargo. GE Marine gas turbines represent a lot of things to the shipping industry – especially opportunity.

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# Hawboldt

## From Local Roots Grows a Global Power

Hawboldt Industries was founded in 1906 in Chester, a small town in rural Nova Scotia, Canada. After more than 100 years, the company still resides in the same town but its business and product focus has changed dramatically. From its humble beginnings primarily servicing the local Nova Scotia marine and fishing market, Hawboldt products now reach a global customer base and serve a dynamic group of market segments.

In 2005, Hawboldt Industries became a member of the Timberland Group of companies. As a member company, Hawboldt contributes to and is supported by a wealth of engineering design experience, state-of-the-art manufacturing facilities, and an impressive history of successfully completing several major projects around the world.

Supported by a diverse group of companies and being able to provide a diverse product offering has been important to Hawboldt's success.

However, no matter the market segment they are serving, Hawboldt

products share the same theme; they get their customers equipment in and out of the water safely and efficiently whatever the sea state. Whether the application requires a hydraulic or an electric driven solution, Hawboldt is able to provide the best option in each particular situation based on the strength of its business unit teams.

Hawboldt strives to hire skilled, highly qualified and enthusiastic personnel with varied and diverse backgrounds. Business development professionals and sales application engineers look to ask the right questions early on in the discovery process to ensure complete understanding of the particular customer application. It doesn't matter if the customer is a naval architect, the vessel builder or an operator / end user, care and attention will be taken to ensure their needs have been heard before suggesting a product solution. It is a very collaborative and iterative process, sometimes with many touch points before the proper solution is provided.

"I am very proud to be a part of our technical sales and marketing team here at Hawboldt" says Paul Phillips, General Sales Manager. "Over the past two years, we have added key staff members that have improved our response time, increased our market presence and strengthened our customer facing team. Our customers have shown their approval and we appreciate their trust by giving us new and repeat orders."

"Quality of Equipment is an important aspect of why we choose to do business

	<ul style="list-style-type: none"> <li>ROV, AUV and Subsea Drill LARS and Handling Systems, Offshore Service Vessel Equipment, Oceanographic Winches, Deck Machinery, Fishing Winches, Propellers</li> </ul>
	<ul style="list-style-type: none"> <li>Offshore Mooring and Marine Equipment, Construction and Mine Hoists, Derricks, Conductor &amp; Cable Handling Equipment, Right-of-Way Equipment, Trenchless</li> </ul>
	<ul style="list-style-type: none"> <li>Underground Utility Vehicles, Personnel Carriers, Underground Conductor Handling Equipment</li> </ul>
	<ul style="list-style-type: none"> <li>Conductor Handling Equipment, Trenchless Cable-Laying Equipment, Right-of-Way Equipment</li> </ul>

**“Quality of Equipment is an important aspect of why we choose to do business with Hawboldt. However in my opinion what positively differentiates Hawboldt to us is the prompt service and attention we receive from the team there”**

**Dany Jabbour, Operations Manager, Clearwater Seafood**

with Hawboldt. However in my opinion what positively differentiates Hawboldt to us is the prompt service and attention we receive from the team there,” says Dany Jabbour, Operations Manager at Clearwater Seafood.

### **Ocean Science**

Hawboldt has been successful in securing significant contracts in the new Research Vessel markets both in Canada, the United States and Asia over the past two years. Hawboldt has been awarded two contracts from Seaspan – Vancouver Shipyards (VSY) for the deck equipment on the Offshore Fisheries and Science Vessels (OFSV) for the Canadian Coast Guard. Hawboldt Industries will be responsible for the entire scope of deck equipment for the fisheries and science missions, which includes deck cranes, all fishing winches and controls, the science winches along with specialized CTD and Side Scientific area launch and recovery systems. In total, Hawboldt is supplying over 25 unique pieces of custom designed electric winch and handling systems for the each of the three vessels. The OFSV are the first vessels to be built under the \$8 billion NSPS program for Non-Combat vessels, awarded to VSY in 2011. “This is a significant order for Hawboldt and demonstrates the confidence and trust shown by Seaspan’s Vancouver Shipyards and the Canadian Coast Guard in our ability to meet the schedule and technical requirements for these modern vessels,” says John Huxtable, General Manager of Hawboldt Industries. “This is another step in reinforcing Hawboldt as a total solutions provider in the global market for Research Vessel deck machinery.”

Hawboldt is not only interested in supporting the larger vessel projects. The USGS Research Vessel (R/V) Arcticus, based at its homeport, the Cheboygan Vessel Base in Cheboygan, Michigan is used for science and fishing research in the Great Lakes. Its primary field-sampling capabilities include bottom trawling, plankton and benthic invertebrate sampling, hydroacoustics, gill netting, and collection of environmen-

tal data. Hawboldt delivered a complete deck equipment package to the R/V Arcticus (built by Burger Boat Company) and although it was much smaller in scope and complexity than some of other recent projects, the R/V Arcticus equipment package still required the same attention to design and manufacturing as the larger projects to ensure the vessel operational capabilities could be met.

As a matter of fact, all of Hawboldt’s products receive the same attention. “Great products, great service” says Todd Langley, Science Technical with Lake Simcoe Fisheries Assessment Unit a division of the Ontario Ministry of Natural Resources with regarding his new research fishing winch delivered in early 2015. “The winch and HPU are a great improvement over our previous system, and everything is work-





ing great.”

### Marine Cranes for Any Application

Today and for the foreseeable future, the global research market will be an area of focus for Hawboldt. However in keeping with the diversification theme, Hawboldt realized that it needed to continue to add to its product offering. It was at that time that the management team looked at acquiring a marine crane company. Although attempts to purchase an existing product line or company never materialized, it did cement Hawboldt’s aspiration to enter into the marine crane market.

Hawboldt decided to hire an experienced crane sales and product manager to lead their entry into the market, and Reed Okawa came onboard in 2014. Reed has more than 37 years in the marine crane industry and there are not many applications that he has not seen before.

Leveraging Hawboldt’s extensive engineering experience, and efficient production capabilities, the company developed an extensive Marine Crane line to complement its other product offerings. Having sold over 1000 cranes in his career, Reed has secured contracts for numerous cranes already. Using state-of-the-art, 3D modeling techniques and the American Petroleum Institute guidelines for its designs, Hawboldt’s cranes are designed and built to the highest standards of quality. Hawboldt can supply marine cranes for almost any market, including workboats, fishing boats, offshore platforms, oil terminals,

barges, docks, military and research vessels. Fixed, Telescopic and Knuckle boom models are available between 2 and 150 tonne capacities with multiple winch and rigging arrangements.

“Our customers seem particularly interested in knowing that we have the full line of marine cranes they need as well as many specialized accessory packages are available to enhance safety and explosion proof ratings for applications such as LNG, Oil, and chemical barges”, says Reed Okawa, Business Development Manager - Cranes. “We are being responsive to the market needs on that front as well as offering many other special accessory packages that will also enable Hawboldt marine cranes to do side tow work of sampling nets, side scan

sonar fish or deploy and retrieve scientific packages, CTD, ROV’s and various bottom coring devices if they so desire.”

As with many of its other products, Hawboldt has experience working with most regulatory groups to provide certifications if they are required and customize any standard design to fit almost any application. ABS, DNV, Lloyds, ZC, BV, and many other certifications are well known to their design teams and available for purchase.

The same is true for a suite of other options including wired or wireless remote controls, full operator stations, operator cabs, hydraulic power units, lighting, multiple winches, custom rigging, electronic load monitoring, maintenance platforms, hydraulic grapples, and other accessories.

Hawboldt identifies the Marine Crane market as a vital part of their future business and are investing in the engineering designs and dedicated manufacturing infrastructure to keep up with the anticipated demand. Having a dedicated and experienced marine crane product leader helped Hawboldt enter the market by differentiating themselves in a very competitive marketplace.

### International Markets

The same can be said for another of Hawboldt’s markets, Asia. Hawboldt recently hired Jackie Guo as Business Development Manager for the Asian market. Based out of the Chester facility, Jackie works closely

### Hawboldt Industries Market Segments

**Ocean Sciences/ Research:** CTD winches, CTD Launch and Recovery systems, Towed Array winches, Scientific winches, Acoustic winches, Traction winches, Traction winch systems, A-Frames and Hydraulic Power Units

**Offshore Oil and Gas:** ROV, AUV and Subsea Drill Launch and Recovery Systems, Umbilical Docking Heads, Tether Management Systems, Hydraulic Power Units and Active Heave Compensation (Scantrol)

**Commercial and Fishing Equipment:** Trawl Winches, Net Reels, Fishing Winches, Crab Haulers, Fishing Systems (Scantrol), Steering Gear, Planetary Winches and Hydraulic Power Packs

**Marine Cranes:** 2-150 tonne Fixed Boom, Knuckle Boom and Telescopic Boom cranes

**Commercial Deck Equipment:** Anchor Windlasses, Capstans, Mooring winches, Anchor winches for Offshore Supply Vessels, commercial ships, workboats, barges and diving support vessels

**Propeller and Underwater Gear:** Propeller and Propeller Repairs, Nozzles, Shaft replacement



with Hawboldt's distributor network to service and support current business efforts while also developing future opportunities. The Asian market has played an integral part of Hawboldt's recent success and Hawboldt is currently manufacturing three different winch systems for the first of four research vessels due to ship this year into the market. Customers in Asia have come to trust Hawboldt for their complex traction winch systems used for ocean science applications. The complex integration and arrangement of these traction winch systems into the overall vessel design ensures the systems work flawlessly. The equipment is placed in dedicated winch rooms below the vessel main deck and hold between 8,000-10,000m of electro-mechanical (EM), electro-optical-mechanical (EOM), wire or synthetic rope on a storage drum. The systems are custom designed to meet the various requirements of the different end users mission profiles. Feedback that Hawboldt has been getting from the market has been tremendous. Adding a dedicated sales professional from the region to support their in-market partners further demonstrates the commitment of the market to their existing and future customers.

Finding the right valued added reseller or distributor partner has been crucial to ensuring Hawboldt can support its customers globally. Hawboldt looks to partner with companies that are already working in the ocean sector but does a lot of research and due diligence before working with any company. John Millett, responsible for Hawboldt's Ocean Science and Latin American markets and their other Business Development Managers invest heavily in using experienced, highly technical and customer oriented companies represent them in each market. In the past few years Hawboldt has signed on numerous partners in South America, Europe and the UK to care for customers in their home markets. Companies like DefenSea / Intelligent Maritime Solutions and RS Aqua represent Hawboldt and many other trusted maritime brands in the Brazilian and UK Oil and Gas and ocean science markets respectively with a great

track record in customer service and support. Hawboldt's unique product offering and after sales service and support is what attracted each company to want to represent Hawboldt's products.

#### After Sales Support and Service

Hawboldt's customers are very pleased with the high quality products Hawboldt manufactures and the skilled personnel leading the installation and technical service teams. Hawboldt Industries has built a reputation for having a highly responsive and knowledgeable technical services group. Besides leading the variety of factory acceptance tests, they are also support commissioning and installation services at customer sites. Whether the service or support requires a quick response or an extended stay onboard the customer vessel, Hawboldt is equipped to handle Hawboldt offers many types of service contracts that meet the needs of our customers which ultimately safeguard the operation of our products throughout years of operation. Detailed manuals and technical training during commissioning ensure proper operation and maintenance of the systems. Led by Service Manager John Baxter, an



# LAUNCH & RECOVERY SYSTEMS

## AUV • ROV • SUBSEA DRILL



### AUV LARS

Ramp style

Designed for different AUV models

Increased vessel operation time

Designed for different AUV model sizes and weights

Crane based deployment options available

### ROV LARS

Available in 27mT, 15mT, 10mT, and 6mT configurations

Subsea Drill Compatible

Hydraulic and Electric Models

Active Heave Compensation Option

Custom Engineered Solutions

CTD and Ocean Science LARS available

Proven Designs

Global Service Network

STOCK SYSTEM MODELS AVAILABLE



## MARINE CRANES FOR ANY APPLICATION

2-150 tonne capacity



Fixed, Telescopic and Knuckle Boom models

Electric, diesel, & other power options

Remote, operator cab, walk around, & fixed control options

Weld / bolt down, insert through deck, various pedestal heights

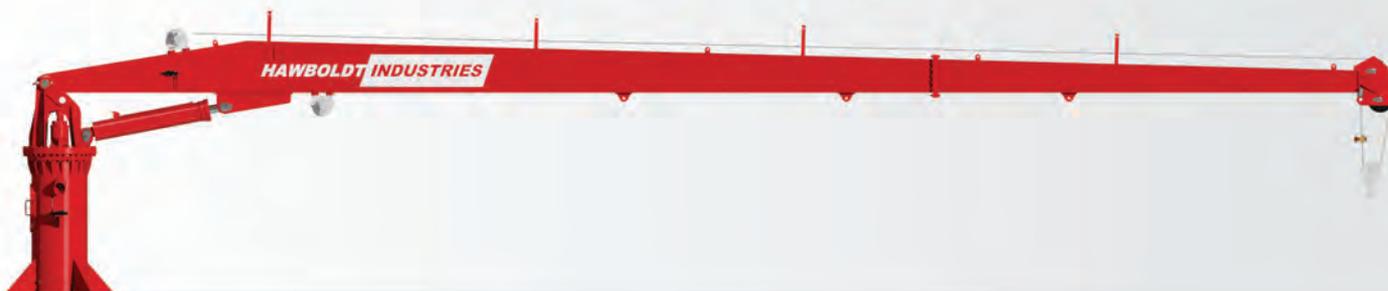
Enhanced safety package for LNG transfer fuel barge cranes

Meets API Specification 2C guidelines  
(cert. fr. ABS, DNV, Lloyds, ZC, and others)

Load Moment Indicator systems & safety devices available

Hazardous Zone ratings available for  
NEC, IEC, and ATEX

Offshore, onshore, and shipboard ratings available



experienced mix of hydraulic technicians, electricians and mechanical and electrical engineers take great pride in offering “best in class” installation, commissioning and technical support services for all the products they manufacture globally.

### Launch and Recovery Systems

There is not a market segment that requires a greater level of support combined with robust reliable design than the highly competitive ROV Launch and Recovery market. With a wide range of experience, Hawboldt is one of the industries trusted suppliers and has been providing Launch and Recovery Systems for the fleet of Work Class ROV's for the past number of years. Their customers trust Hawboldt to provide reliable, robust products and Hawboldt offers quick delivery to meet the demands of tight mobilization schedules. Despite the recent downturn in the oil and gas market, Hawboldt has seen only a modest decline in sales of their dependable range of Launch and Recovery products. Although Hawboldt's most popular LARS system is comprised of a 15mT A-frame, 4500m umbilical winch and a 250hp HPU, they can provide LARS systems in various sizes and configurations, including 6, 10 and 27 metric tonne, hydraulic or electric and with heave compensated winches. They can also manufacture a variety of ROV LARS crane based solutions. Hawboldt has experience deploying ROV's from various points on the vessel including port, starboard and stern and are familiar with moon pool deployments. To meet the demand of the industry Hawboldt stocks 15mT LARS for Work Class ROV's.

ROV LARS is not the only LARS product the company makes. Besides the aforementioned CTD and SSOA LARS for the ocean research market, Hawboldt has successfully designed and delivered LARS for the emerging AUV market. As deep sea exploration grows, companies and organizations that work in this space are looking for safer ways to operate. Hawboldt designed with their client's guidance, a lightweight self-articulating ramp to launch and recover an AUV. It allows customers to get the AUV on and off the vessel in various sea states. Deploy the ramp, winch it up and recover it; simple and easy. Hawboldt can supply a standard system for a variety of different AUV's but can modify the system to meet various sizes of AUV's with different weights and dimensions.

The AUV LARS is a great example of Hawboldt's product development process. As is the case with most of Hawboldt's products, they are developed based on a close relationship with a customer that becomes more like a partner. Within the partnership, they develop a concept for a particular application and then Hawboldt designs, manufactures and test the product to meet the desired application. The product development process works so well in large part due to the great customers Hawboldt works with.

### Heart of the Business

One thing is for certain, Hawboldt Industries would not be successful without its dedicated and diverse group of people. Hawboldt currently employs over 55 dedicated customer-service orientated, highly technical and experienced labour force. Hawboldt's modern and recently updated



40,000 square foot facility is ISO 9001 registered and has the capacity to handle both large and small projects, as well as repairs and maintenance. The facility includes a comprehensive machine shop featuring CNC cutting, milling and lathe equipment, a CWB certified welding facility with certifications for both steel and aluminum, a fully equipped hydraulic shop and modern blast and painting facilities. The manufacturing team consists of various highly skilled tradespeople. Welders, machinists, pipefitters, hydraulic and electrical technicians form the basis of a solid professional workforce. A robust trades program in the local area and a historical shipbuilding industry in the province give Hawboldt a pool of talented workers to choose from as the company expands.

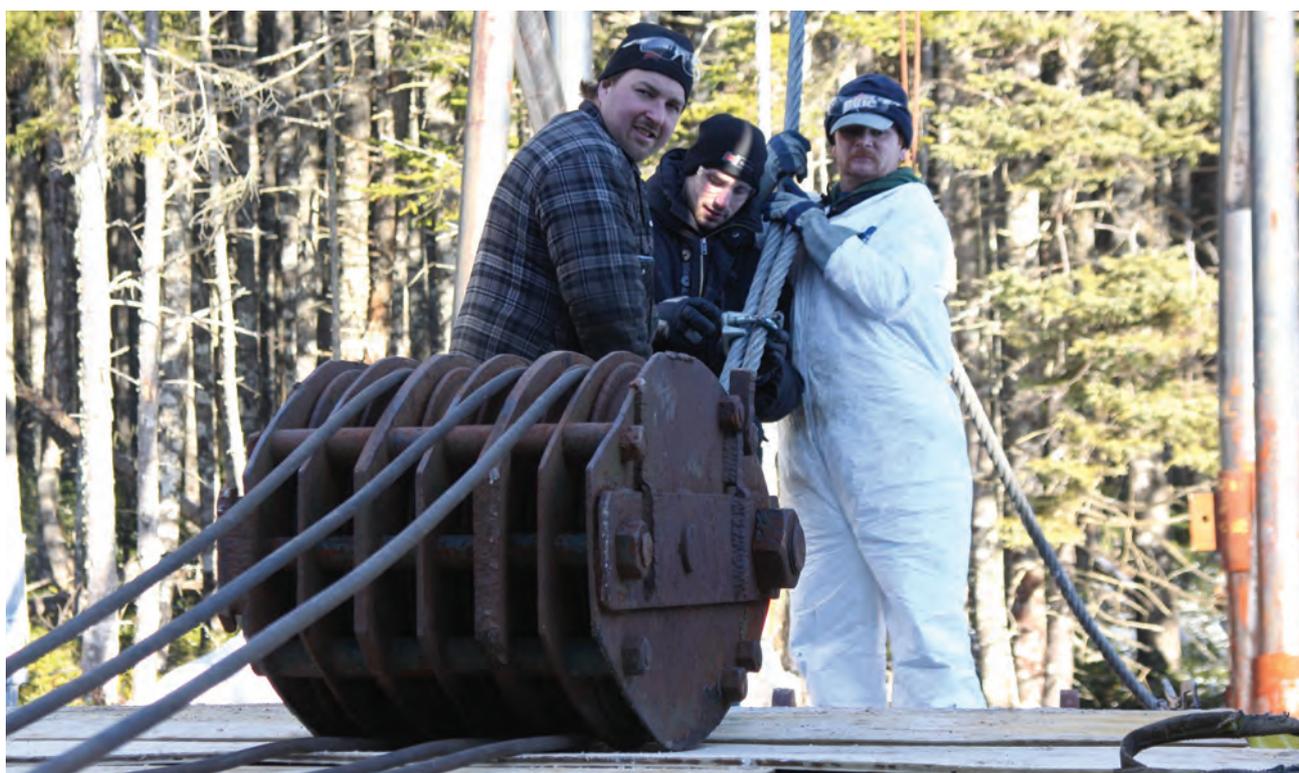
The company has embraced modern project management methodologies and has project managers on staff to oversee project plan development and execution. Whether the project is big or small, Hawboldt Project Managers interface with a client's to ensure successful program completion. To ensure a great customer experience the project management team coordinates with all of the Hawboldt departments including sales, applications, engineering, production and service support based on the specific equipment, commissioning and installation provided. Communicating with the customer and meeting the project overall schedule is critical as Hawboldt strives to meet or exceed their customers' expectations for quality, performance and delivery on-time.

Hawboldt ensures this by having a project kick-off meeting (customer attended if possible) after receiving a contract / purchase order. This is the opportunity for the specific project manager to establish the contract deliverables to the various teams responsible for each deliverable and set aggressive goals to keep the project on time. Prior to the project kick-off, the Hawboldt project manager develops a project schedule and Gantt chart in order to visually monitor the activities and milestones. The Gantt chart becomes the visible indicator that is used to monitor progress for the customer and internal stakeholders. Further to this, Hawboldt has a weekly production schedule meeting, where each project and key project timelines are discussed and the necessary adjustments are made to ensure on time delivery of projects.

Customers have come to trust and rely on Hawboldt designs and a



large reason for this is the dynamic group of experienced engineering staff the company employs. The design team consists of professional engineers, junior engineers, designers, technologists and draftspeople are capable of designing a variety of custom deck equipment. Hawboldt uses modern design techniques and software including Autocad, Inventor, ALGOR Finite Element Analysis and MasterCAM to meet the needs of their customers and specializes in advanced mechanical, electrical and hydraulic engineering design. The team produces all of the required drawings, calculations, test procedures, and engineering documents necessary to confirm the application engineering designs developed and the release to the manufacturing group. For each contract requiring substantial design activities, a Design & Development Plan is created for the customer, which is approved during final design review.



### Trusted Advisors

Hawboldt strives to be a trusted advisor to its customers. At the end of each project, Hawboldt holds a lessons learned meeting with key stakeholders of the project, in which customers are invited to attend. These meetings along with the feedback from our customers (received both directly and via our customer satisfaction surveys) ensure continuous improvement of their product and service offering. The continuous feedback is critical to their continued support of their customers. Its modest beginnings in a small town have ensured that Hawboldt stays humble and committed to the needs of its customers. No matter how big they get, they know their customers are the reason they exist.



# Choosing the Right Equipment Saves More Than Money

**A**

According to Bureau of Labor Statistics, a total of 717 work injuries occurred as a result of contact with objects and equipment in 2013. Roughly, 245 of them were struck by falling objects and another 105 workers were fatally injured after being caught in running equipment or machinery. Needless to say, anything can happen on a jobsite. Your equipment could malfunction or the weather might cause a whirlwind of unexpected issues, or even worse, someone could get hurt. Unfortunately, not much can be done when circumstances such as those arise, which is why developing preventive strategies is crucial to having a successful and safe project. One of those strategies is always choosing safe and reliable lifting equipment.

But the question that remains is: is it safer to rent or to buy?



## To Rent or To Buy

After you've examined your infrastructure and determined your lifting challenges, now it's time to determine your equipment needs. Often times, you'll find yourself wondering: Should I buy my equipment or is it more sensible to rent?

In reality, it depends on your circumstances. In industries such as shipbuilding and ship repair, the answer is never easy to decipher. Start by considering as to whether you can handle repairs or certifications in-house?

We're starting on the topic of repairs first because it's often one of the biggest concerns of not just shipbuilders, but of all construction industries. One poorly maintained hoist could break and cause that propeller you're lifting to fall. So, not only is it best to anticipate things of this nature to occur, you also need to consider if you can handle repairing the equipment on your own or if you'll have to outsource the repairs to another company.

Our research shows that hard costs such as rental fees and lease payments are only a small part of total costs.

Among the most frequently overlooked costs are those of maintenance and certifications.

As you know, all equipment, eventually, requires maintenance, wears out or breaks down. It's just a matter of when or where. While repairing some equipment can be easy, heavy lifting equipment is a much more complicated matter. In fact, the repairing and certifying heavy lifting equipment is regulated by a specific set of guidelines. For instance, the equipment usually needs to be:

- OSHA and ANSI compliant
  - Maintained by specially licensed and trained technicians
  - Tested on specialized horizontal or vertical testing equipment
- So, if you're looking to make a purchase, make sure you have access to the specialized labor and testing equipment you'll need in the event of repairing your equipment.

When making the decision to buy or rent equipment, the next thing you should consider is what's at stake if the equipment breaks. Shipbuilding is a tough market and it's just as competitive as every other construction-related industry. By missing a deadline or a budget target, it could mean the end of your relationship with your customer. So, when considering to buy or rent, ask yourself what I am really losing if my equipment fails?

For some projects, it might not be a big deal. When the project at hand is a "lynch-pin" task, one which must be completed before further work can continue, you must carefully weigh your options. When renting equipment, some vendors will send a certified, trained technician to repair the equipment, the same day an issue occurs. They

might replace the equipment, too, mitigating the risk of equipment failure and time loss. However, these are not guarantees.

When purchasing, you must make sure you have access to back-up equipment and technicians in case of incident because when you purchase equipment, you are not getting a technician with it.

Something else you should be thinking about is how risky do you want to be. Heavy lifting equipment requires a specific kind of knowledge and training to operate, maintain, and certify safely. It is also the culprit behind some of the most dangerous tasks on a job-site.

When purchasing equipment, you may have some peace-of-mind knowing you have direct access to that equipment at any given time. That being said, purchasing means you have to accept any and all responsibility for the on-going upkeep, maintenance, warehouse expenses, and certification of that equipment. To put it simply, you're accepting total liability for it.

Don't fret, however.

Owning equipment is not inherently a risky decision because with the appropriate maintenance and upkeep, it can be very safe. It's just a responsibility you have to be ready to take on because in construction, anything can happen and it will. Just weigh the risks and decisions carefully and you'll see what tips the scale.

Once you've measured your risks, now you should wonder when your equipment could become outdated. You probably purchase your equipment because you see a long-term benefit for your company and with consistent use, it will produce a positive ROI. If that is your belief, then you need to ensure your purchase will last long enough to see it through.

When purchasing, keep in mind a few things:

- Is the equipment consumable?
- Will access to the "latest & greatest" help me meet the needs of my customers?
- Will the equipment last long enough so that I will make a reasonable return on the funds invested?

Next, ask yourself if the equipment is going to remain in one location or be repositioned around the country. The answer to this largely depends on whether you're a regionally focused company or if you have a geographically distributed customer base. A regionally focused company has little need to transport equipment, and has an on-going need for the equipment, which makes owning more sensible.

A firm that services a geographically distributed customer base, even







across a major metropolitan area, the cost of freight and the headache of logistics can make renting a better option. You might not want the burden of shipping heavy equipment all over the country. It makes more sense to partner with locations and warehouses that are near your jobsite to avoid these additional and needless costs.

Now is the nature of your work consistent or do your requirements and job tasks change? Depending on your customers and core capabilities, your on-going equipment needs may be largely predictable. However, customer demands can be ever-changing, which mean your capabilities need to be readily-adaptable to give yourself a competitive advantage. So, are you a utility contractor that requires your scissor lift every day? Well, it makes more sense to own the equipment then. If you're uncertain as to how long or how often you'll need the equipment for a single job, you might want to rent your heavy lifting equipment instead. Just to be on the safe side.

When you purchase your equipment, you're doing it for the long term. If you don't use it all the time, it becomes your total liability. It can be easier to rent even for long-term purposes and cheaper, as well, to know the equipment is modern, new and already inspected.

Just weigh the long-term needs of your company to understand what makes the most sense for you. The truth is, there is no one-size fits all answer. There are many factors to consider when evaluating what's best for your company. A careful analysis of each of these factors will help you make the best possible decision.

### What Renting Can Save

According to OSHA, in 2013, 828 workers died on the job at construction sites and 302 of those were falls. Another 84 were struck by objects. Electrocutions took 71 lives and 21 were caught-in or between something. It's imperative to every worker in the shipbuilding and ship repair industries to always adhere to and practice the upmost safety procedures. When it comes to heavy lifting equipment, not having the right capacity, type, or a Plan B in the case of emergencies can be quite exasperating and dangerous. Delays in getting the equipment can challenge the schedule of your project and its cost effectiveness, too. As with purchasing your equipment, there are benefits that are exclusive to renting. Advantages that can save you time, money, energy, your project, and perhaps, even your life.

### Control

If you're a shipbuilder, you've probably asked yourself, 'what do I do with the equipment after the job is over?' or 'what if it's broken?' Well, wonder less and build more.

Keeping control of your lifting project can be challenging, especially when you add the possibilities of the equipment breaking and enduring possible injury, which might cause hindrances in the scheduling. And in the world of shipbuilding, the scheduling is everything.

Most cargo or military ships have a two week turnaround. This means, the ship has to dock, obtain needed repairs, and leave the harbor, so that the next vessel may dock. One day off schedule can cause a major disruption in the flow of ship repair.

And any rigging superintendent can tell you that their hands are tied by procurement of the equipment. They need to have the right equipment, and a variety of it available at all times.

Luckily, renting means you needn't wonder as to what to do with your equipment after the project is over or having to be behind sched-

ule because you experienced equipment failure. The equipment is up-to-date, never obsolete, and available at a moment's notice.

### Productivity

When you purchase equipment, you can't always be sure of what you're buying. By not having the right tool or quantity or type, you're sacrificing time, money, and energy. It's not a fair trade. Also, operating conditions can be severe at times, so your equipment needs to be tough in order to survive and thrive in all oceanic, atmospheric, and workplace conditions.

Unfortunately, purchasing equipment doesn't always guarantee you're getting the exact piece or quantity that's needed. In the shipbuilding and ship repair industry, you have to know what you need, when you need it and how much of it in order to stay on schedule. This leaves the productivity of your job hanging in the balance. Equipment failure means more downtime for employees, which means less productivity on the job.

For shipbuilding and ship repair, equipment that is not tested to survive oceanic and atmospheric weather conditions could result in delays and money loss.

Renting means you will get exactly what's needed at the right time, place, and quantity. You can feel safe in knowing you won't receive broken or obsolete equipment, removing the worry of being behind schedule and succeeding the budget allotment.

### Inventory

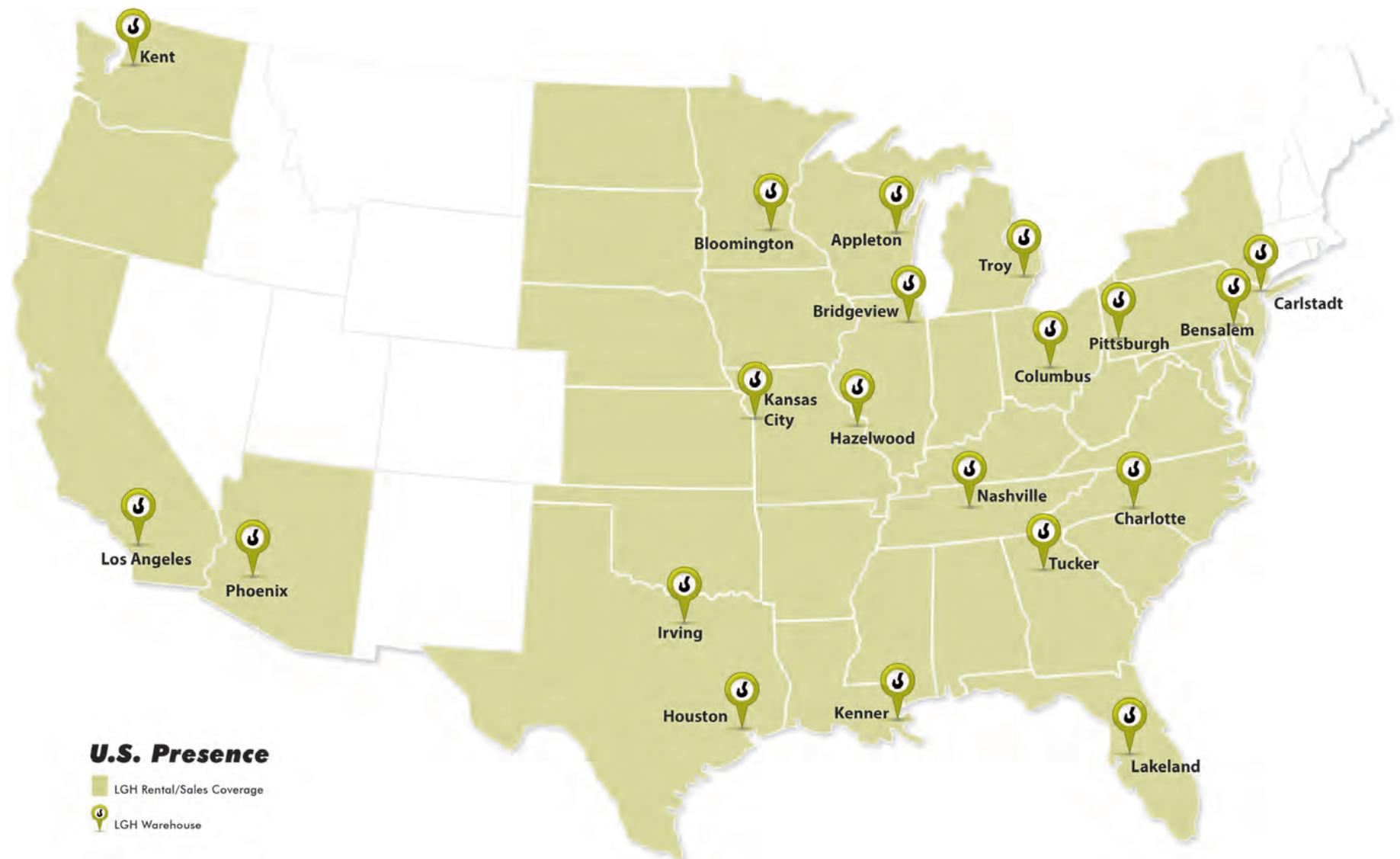
Speaking of which, staying within budget is yet another challenge to overcome. From extra storage costs to house your unused equipment to maintenance expenses to repair broken tools, any number of additional charges can spring up to challenge your efforts to control costs. Not to mention, you can experience additional problems or extra expenses that typically come from not having the right quantity of the equipment needed. Shipbuilders and maintenance crews are more concerned about the low prices and efficiency of the equipment more than anything else. However, they also are plagued with concerns over getting the right equipment and excessive costs.

With renting, you can hoist easier when you know you received the exact amount of the equipment you need because rented equipment is delivered when and where it's needed and retrieved immediately after the project is ended. Also, renting removes the constant need for service and certification for it's already taken care of for you. Plus, it doesn't lock you into a long-term decision, which often doesn't yield cost effective results.

### Capital

You probably weren't aware that property taxes are reduced on rental equipment. You also might not have considered that renting would help you conserve capital. Well, it's true.

You can spend a lot of additional money on the property taxes of purchased equipment, which is money that could've been used elsewhere. Renting can help you there. It reduces your expenses, reduces property taxes and increases your borrowing capacity. Not to mention that renting is just an overall easier and more convenient process than purchasing. All that additional capital can be conserved and used elsewhere within your project instead of being used on purchased equipment that you might never use again.



## What Tested and Inspected Equipment Can Save

There are many concerns construction workers have to think about before a job begins. Choosing the right equipment is always number one. However, the timing of your project doesn't always allow for extra time to be spent on contacting multiple places in an effort to find the best equipment for the most affordable prices. Which is why, no matter whether you're purchasing or buying your equipment, a primary focus should be placed on lifting equipment that has been tested and inspected first.

## Budget

Equipment that is tested and inspected saves you money. If you bought or rented equipment that wasn't tested beforehand, you'd have to delay the usage of the equipment to test it first. Otherwise, without testing or inspecting it, you're leaving the safety of your workers and the success of your project to chance. Plus, you'd have to spend additional money to have it tested and inspected, as well. Money that could've been saved and used elsewhere had you bought or rented equipment that was previously tested before being given to you.

## Stress

Using untested and uninspected equipment is very risky. You could

be putting your workers in danger by using cheap, broken or obsolete equipment that hasn't been proven to still retain its full functionality. Save yourself the stress and worry of whether or not your equipment will fail or survive by just buying or renting equipment that's proved to be safe and ready for immediate use.

## Efficiency

The efficiency of your project is truly dependent upon the survivability of your equipment. Tested and certified equipment is physically proven to withstand your project's challenges. If your equipment should fail during a lift, you'll have to put the project on hold until the equipment is repaired or another one has been purchased or rented. This means more downtime for your employees and more money that was needlessly spent when you could've purchased trusted equipment in the first place.

## Lives

With the amount of injuries and deaths that occur on construction sites ever year, protecting workers from harm is of the upmost importance. Equipment that is not tested, inspected, and certified is a risky decision and could put your workers in danger. Always ensure the protection of workers by renting or purchasing equipment that is new, modern, and above all, safe and ready for immediate use.



# **Lifting Gear Hire**

Lifting Equipment Rental Specialists

Hoisting | Pulling | Jacking | Rigging | Material Handling | Safety

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## LIFTING EQUIPMENT RENTAL SPECIALIA

Due to the limited timing of shipbuilding and ship repairs, we know the success of your project depends greatly on equipment availability and variety. By not having the right capacity or type or a Plan B, you're losing out on time, productivity and money. Not to mention, unsafe and untested equipment could put you, your workers, and the success of the project at risk.

Don't leave things to chance and start renting your equipment from Lifting Gear Hire. Renting from LGH means you'll never have to deal with:

- Obsolete or Broken Equipment
- Unserved or Untested Tools
- Needless Downtime on Project Site
- Loss of Productivity

Because at LGH, we stock only the most reliable equipment from the most trusted bands in the industry and guarantee to always supply you the exact tools you need, the exact amount you need, when it's needed and at your exact specifications.

With LGH, we promise to provide:

- Safe & Ready-to-Use Equipment
- A Stocked Warehouse Near Your Job-Site
- Local Rental Representatives To Assist You
- A Variety of Equipment With Over 50,000 Pieces Available

So, you can conduct a safe operation without having to worry about costly lifting equipment failure.

Because at LGH, we put safety first.



# **WATER PROCESSES IN COMMERCIAL SHIPPING FOR WASTE MANAGEMENT**

**A** Chief Engineer is responsible for all operations and maintenance that has to do with any and all engineering equipment throughout the entire ship; taking responsibility for engine room and maintenance. However, his main concern regarding sewage is secondary. The last thing to contend with is making sure the marine sanitation device works properly.

Sewage is defined under the US EPA Clean Water Act as: “human body wastes and the waste from toilets and other receptacles intended to receive or retain body wastes”, and includes greywater discharges from commercial vessels (as defined at 33 U.S.C. 1322.a.10) operating on the Great Lakes.

Per the US Coast Guard (USCG) MEPC.115(51) regulations, “Sewage” means all the drainage and other wastes in any form from toilets and urinals; medical premises (dispensary, sick bay, etc.) via wash basins, wash tubs and scuppers located in such premises; spaces containing living animals; or other waste waters when mixed with the drainages defined above.

## **GREYWATER IS A DIFFERENT MATTER**

Per USCG MEPC.159.55 definition, greywater (also spelled graywater, grey water, gray water) is the “drainage from dishwasher, shower, laundry, bath and washbasin drains.” Which is why, when asked, “Why treat greywater?” We answer, “because it may be required for commercial vessels operating in

certain International waters and that the greywater could be used as a dilution medium for processes per USCG MEPC.227(64).”

Greywater can also contain certain biological pollutants and be required to meet the same standards as applied to wastewater on land. These are certain US-based offshore platforms and rigs operating under special contractual sewage treatment specifications that are subjected to total wastewater (blackwater/greywater) treatment.

Even though offshore platforms and drilling rigs may or may not be “vessels” many operators specify USCG 33CFR159 and MEPC.159.55, probably to ensure the construction, safety and performance of the purchased equipment. Another reason to treat greywater is because certain vessels may be operating in territorial or other environmentally sensitive areas that specifically require such treatment.

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Flow: 100-800 GPD (378-3026 LPD) | 1-44 crew

MarineFAST® LX-Series are lightweight, certified, biological, flow-through systems to treat all wastewater generated on board small vessels.



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“

With the [other system] we would have been running everything in the holding tank and getting it pumped out the best way we could...

”

## GREYWATER CONTAINS MORE THAN WATER

There are two aspects to sewage treatment: organic and hydraulic loading. The addition of greywater adds substantially to both.

The very best data that has been assembled during the past forty years shows the expected per person of hydraulic and organic loadings for blackwater (service factor 1:1) and from all the sources of greywater, i.e. laundry, sinks, etc. (service factor 1:2.5). The loadings are stated in terms of conventional units of measure to illustrate the effect of adding greywater to blackwater. That is, the treatment capacity of a plant designed to handle blackwater plus all greywater must have roughly 2-1/2 times than that of treating blackwater only. It will be bigger, heavier and add to the cost.

However, there are several reasons not to treat greywater. The most important one is the obvious reason – it may not be required by governing law or regulations. That is, the only purpose of sewage treatment aboard ships and offshore structures is to satisfy the requirements of regulatory agencies and applicable authorities.

## BLACKWATER IS EASIER TO TREAT THAN GREYWATER

Although a common perception is that blackwater is difficult to treat and adding greywater will help, the opposite is the case. Blackwater is more treatable than greywater and the reason is that the biodegradable material in blackwater is pre-digested.

Greywater may contain higher amounts of inorganic (non-biodegradable) material and cleaning compounds that do not break down, which hinders the treatment process with antibacterial substances.

“

I just wanted to give everyone an update on the [Marine]FAST<sup>®</sup> Sewage Treatment System. It has been 9 months since we put this system onboard it has worked so well!

We never have to get our hands in any waste like we had to do all the time with the [other] system. We have had 8 men onboard this trip, the most we have ever had and this FAST System has handled it like it was nothing!! With the [other] we would have been running everything in the holding tank and getting it pumped out the best way we could, and that was with just 5 to 6 men onboard.

I would recommend this FAST System for all our boats. I have been on tugs for 25 years in the engine room and this is the best system I have ever had onboard!

Thanks to all that got this system put onboard. It has been a blessing!”

Tug Duty Chief David Harris

”

### WHAT ABOUT GREASE FROM THE GALLEY?

Although it is generally known that grease traps will reduce problems with drainage piping, removal of cooking grease from wastewater is particularly important for most, if not all, sewage treatment systems. Most sewage treatment processes can deal with small amounts of grease in human waste and grease from dishwashing.

However, larger amounts of grease will coat the system components and the microorganisms necessary for treatment. It will interfere with the transfer of oxygen into the wastewater. Properly sized and maintained grease traps are essential if wastewater from the galley is to be treated.

### WHAT ABOUT GROUND FOOD WASTE?

Under current marine regulations, ground food waste is not greywater or sewage. It is considered to be garbage and is covered under a different set of regulations.

If this organic garbage is added to the wastewater, then the sewage treatment system must be able to handle the additional loading. Treating all domestic sewage to include ground food waste (service factor 1:3.54) is more than triple the loading of the blackwater treatment only.

### WATER TEMPERATURE IS A FACTOR

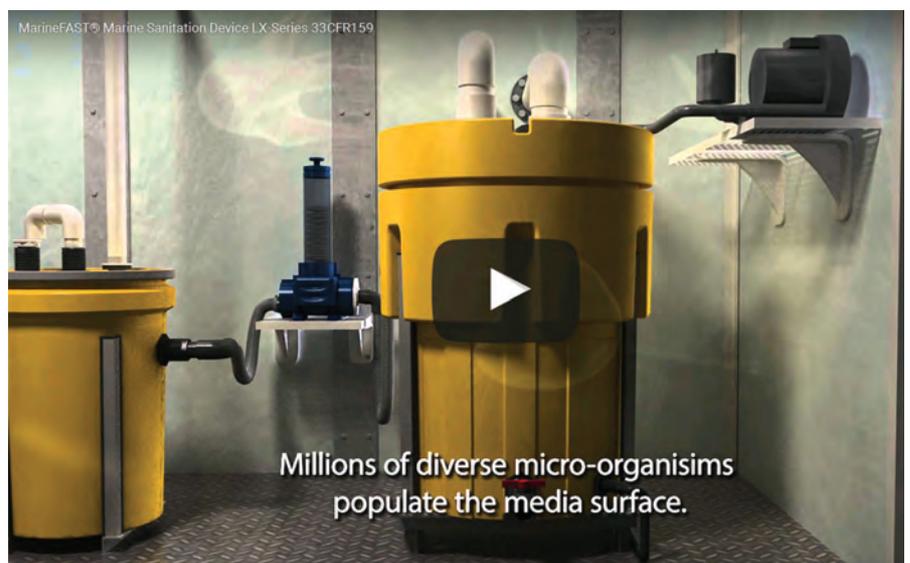
The great majority of treatment systems capable of meeting MEPC.159.55 or other secondary treatment requirements employ biological processes. In general, the performance of these processes

deteriorates rapidly as water temperatures rise above 98.4° F; even though the treatment unit might be installed in a machinery space with an ambient temperature of up to 122°F.

Naturally occurring microbes in sewage originate in the human intestine, which is at the temperature that they thrive. Microbes that can survive at substantially higher temperatures are not nearly as effective in the removal of contaminants from wastewater.

When treating blackwater only, whether using conventional or low-flow toilets, freshwater or seawater, the temperature inside the wastewater treatment system is usually moderate the volume of cooler fresh wastewater flowing into the system limits the temperature in the bio-reactor (treatment tank).

However, the addition of greywater can change that situation, particularly as low-flush toilets come into greater use. Personal washwater from showers and hand sinks is not a problem as those water temperatures are limited by the effects of hot water on human skin.



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Type II Marine Sanitation Devices (MSDs)

Flow: 200-1500 GPD (600-5700 LPD) | 1-78 crew

MarineFAST® M- & MX-Series designed to treat all blackwater/greywater generated on board and ideal where access can be extremely limited.



Consider the effects of relatively large volumes of very hot water from automatic dishwashers and laundry being mixed with relatively small volumes of cooler water from toilets and urinals. In the examples below, the exact volumes and temperatures are not significant as the results won't change very much with different assumptions.

Example: Consider conventional toilets, flushing water at 70°F, personal washwater at 90°F, dishwasher and laundry at 140°F. Using the volumes, the combined temperature will be about  $(11 \times 70^\circ + 13 \times 90^\circ + 11 \times 140^\circ + 9 \times 140^\circ) / 44 = 108^\circ\text{F}$ . With vacuum toilets, it will be about  $(3 \times 70^\circ + 13 \times 90^\circ + 11 \times 140^\circ + 9 \times 140^\circ) / 33 = 127^\circ\text{F}$ .

Some vessels use higher laundry and dishwashing temperatures for sanitary, as well as, cleaning purposes. 160° F. is a reasonable choice as it is the temperature required to kill bacteria and the numbers above change to 117° F. for conventional toilets and 139° for vacuum toilets. We are aware of at least one instance where 195° F. water is

employed in shipboard dishwashers and laundry.

Depending upon the details, performance in terms of removing BOD5 and TSS from the wastewater will suffer. Certain certification testing typically takes place at land facilities where wastewater is determined by a groundwater temperature of 68° F., as municipal sewers can run for miles underground before reaching treatment facilities.

What that means is that there is a real question whether the results from official testing on land can be achieved in practice aboard ship when greywater is added to blackwater. This is not rocket science – it is a simple heat balance calculation.

### **CAN THIS BE COUNTERED?**

Of course, one way to do this is to discharge the wastewater from dishwashers and laundry into a separate holding tank, perhaps even a skin tank where the water can cool before being pumped to the sewage treatment system. However, this will require a dedicated tank, extra machinery, extra weight and extra cost.

### **WHAT IF THE REGULATIONS CHANGE?**

This is a common question asked by vessel operators and naval architects. Since the US Coast Guard, which is based upon the Water Pollution Control Act of 1970 amended 1972, issued 33CFR159 in 1975. Very little has changed in 40 years for the vessels operating United States waterways. Perhaps the major change is that greywater is now considered sewage on the Great Lakes.

## Water & Wastewater Treatment

**IMO / MARPOL:** IMO issued its first regulations in 1973. The major differences between those and the corresponding limits in MEPC.159.55 after 42 years are:

1. Effluent BOD5 has been reduced from 50 mg/l to 25 mg/l.
2. TSS has been reduced from 50 mg/l to 35 mg/l.
3. Fecal coliform count has been reduced from 250 MPN/100 ml to 100 MPN/100 ml.
4. Chlorine residuals have been limited.

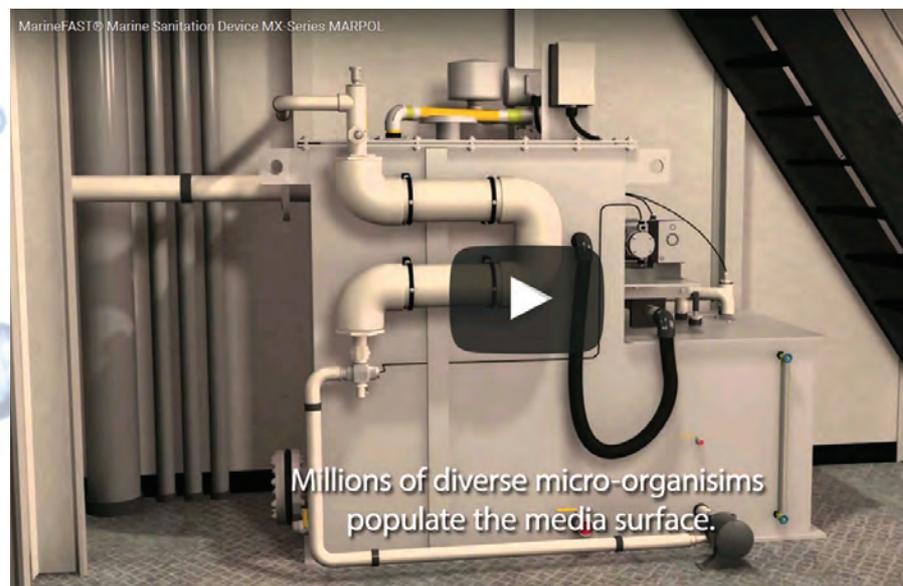
All of these pertain to the certification test that may be performed on land, and all are more a matter of degree rather than substantial change.

The most significant change has been the regulation of dilution in MEPC.227.64 that will take effect in 2016. It is unfortunate, but true that earlier marine regulations do not regulate the use of dilution to meet effluent standards.

Implementation of this standard should have no effect upon legitimate wastewater treatment systems designed to remove pollutants from the wastewater. However, it will certainly affect “dilution machines” and other systems that use dilution in order to achieve specified concentrations of pollutants.

**EPA Final 2013 Vessel General Permit:** Section 1.2.3.2 on page 10 of the VGP states “Discharge of sewage from vessels...are not required to obtain NPDES permits. Instead, these vessels are regulated under...33 CFR Part 159.”

Much of the authorities concern seems focused on large cruise ships. Despite a great deal of speculation, the regulations have changed very little for other commercial vessels and offshore platforms over that time span.



### CONCLUSIONS AND RECOMMENDATIONS

With the addition of treating greywater -- which contains more inorganic and organic material than realized -- as sewage, it is only required in certain specific areas. The treatment of all greywater adds about 150% to the organic loading; and treatment of all greywater plus ground food waste adds about 350% associated with properly sizing Marine Sanitation Devices.

If your operation does not specifically require treatment of greywater, don't do it. If you treat wastewater from the galley, you need to properly size and maintain the grease traps. Properly sized and maintained grease traps are required for galley sinks discharging to sewage treatment systems. Moreover, the wastewater temperature is

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an important and generally unknown factor in the treatment of greywater. Always check the flow and control the temperature of the wastewater.

The treatment standards for most commercial vessels and offshore structures are less stringent than those for large cruise ships. The “special” higher per person sewage loadings from cruise ships are under different regulations and may require more advanced treatment technologies (like membranes and RO systems that require more maintenance).

The regulations for vessels other than large cruise ships have changed very little during the past forty years or so. That exception is MEPC.227.64, which may prove to be a very significant change in its regulation of dilution in the treatment of wastewater from vessels.

Whatever is used for meeting the regulations, don't install “dilution machines.” Or, any other unit that perform so poorly it requires dilution in order to meet effluent standards; these systems would be unlikely to survive future updates in requirements and end up costing more in maintenance, upgrades, and fines during the life of the vessel. 

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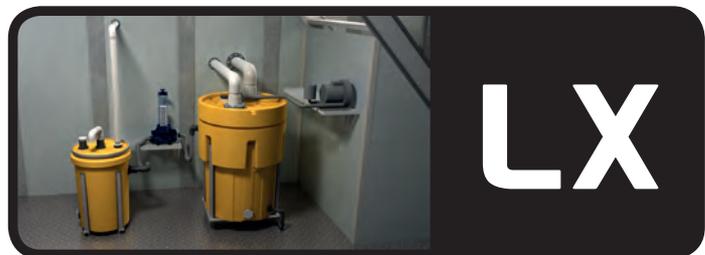
## Just ask your Chief Engineer or Ours!

Vessel Owners, Naval Architects and Marine Engineers consider how their marine operations impact the environment.

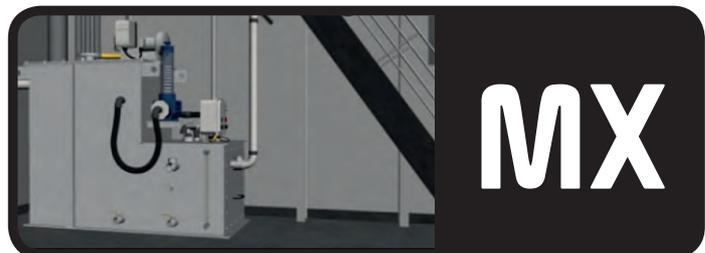
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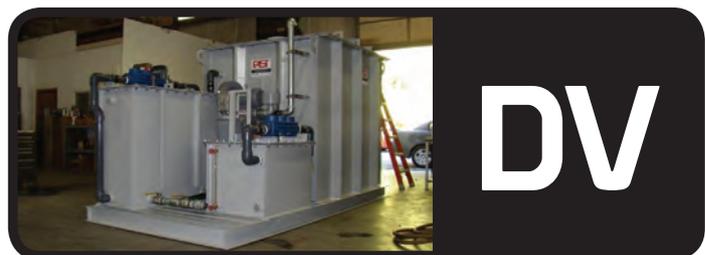
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LX



MX



DV

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## Services & Solutions

Scienco/FAST is dedicated to delivering the highest quality support to provide assistance with marine engineering knowledge, solutions for projects, and applications to improve system performance, safety, equipment reliability, treatment quality, and environmental impact of operations.

## Engineering/Technical Services

Scienco/FAST experts offer sewage treatment system and industrial water treatment solutions. We provide CAD services and tailor the manual to the specific needs of your system for proper maintenance and operation to ensure years of reliable service.

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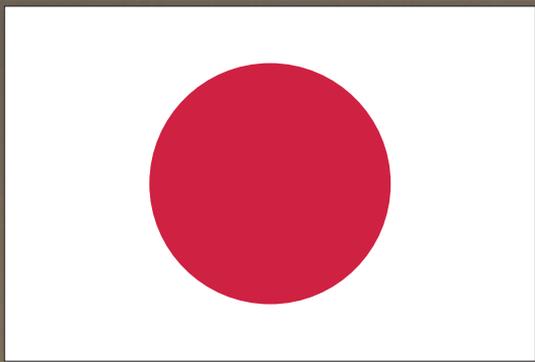
We offer a full after sales support service for the wide range of water (Scienco<sup>®</sup>) and wastewater (FAST<sup>®</sup>) Treatment equipment. This includes servicing, planned preventative maintenance, operator training and spares. On-site repair service available through Engineering and/or associate representative companies. Training can be provided either at client's site or at our factory covering aspects of operation, maintenance and so on.

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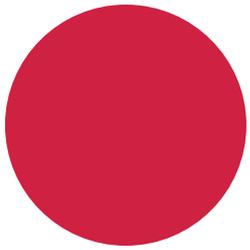
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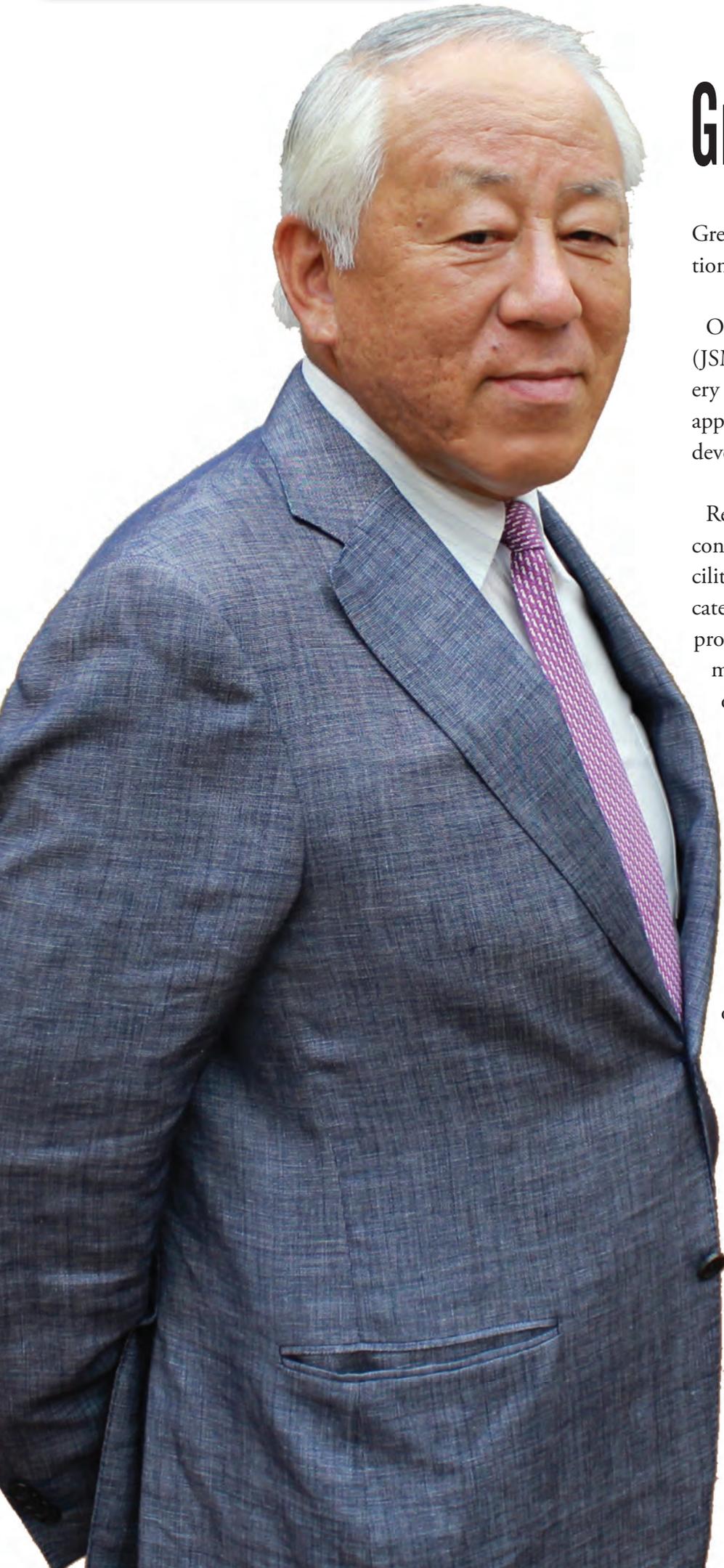
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## Greetings from JSMEA's Chairman

Greeting from the Chairman of Japan Ship Machinery and Equipment Association (JSMEA)

Our organization, the Japan Ship Machinery and Equipment Association (JSMEA), mainly consists of enterprises that primarily manufacture ship machinery and equipment installed aboard vessels. It currently boasts a membership of approximately 240 manufacturers, some of which supply products for offshore development facilities.

Recently, Japanese shipbuilding companies have been increasing the number of contracts from both compatriot and overseas customers for the production of facilities for offshore development projects. For its part, the JSMEA set up a dedicated in-house organization, called the Offshore Working Group, in 2013 to study products and services for and to exchange information on the offshore development business. We are now working with the government of Japan together with other parties.

The JSMEA has been present at the Offshore Technology Conference (OTC) since 2013 to promote its member companies' ship machinery and equipment.

Global energy demand is growing every year, though it is vulnerable to economic changes, as with the recent decline in crude oil prices.

We, Japanese ship machinery and equipment manufacturers, hope to not only supply safe and efficient products of high quality, but also to provide professional and thorough after-sales services so that each oil and gas drilling, production and transport project can be carried out safely and efficiently.

This year, the JSMEA introduced many Japanese ship machinery and equipment products at its **booth at the OTC**.

Signed  
***Motoyoshi Nakashima***  
*Chairman*

**Japan Ship Machinery and Equipment Association**  
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# Achieving New Heights in TECHNOLOGY

## High-End Offshore Service Vessel Ordered

Kawasaki recently received a shipbuilding contract from Island Offshore Shipholding LP (Island Offshore) for one vessel to be built according to the Mobile Offshore Unit (MOU) regulations. Island Offshore, based in Norway, is a company offering a range of complex services to the offshore industry, including light well intervention, subsea installation and maintenance, anchor handling and logistics and supply. The vessel is a UT 777 designed by Rolls-Royce and Island Offshore in close cooperation.

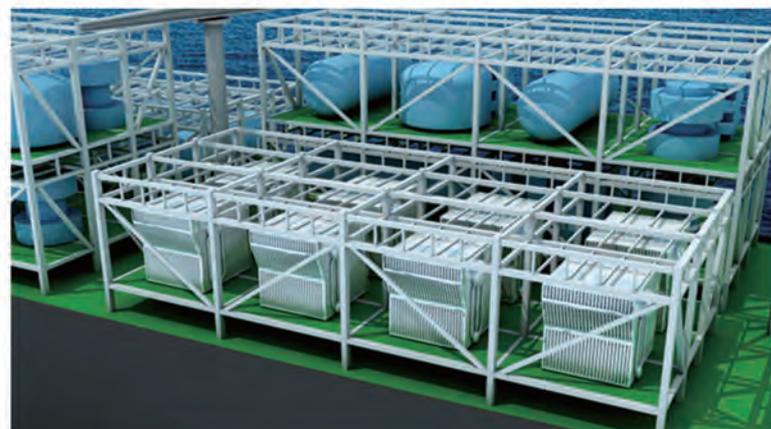
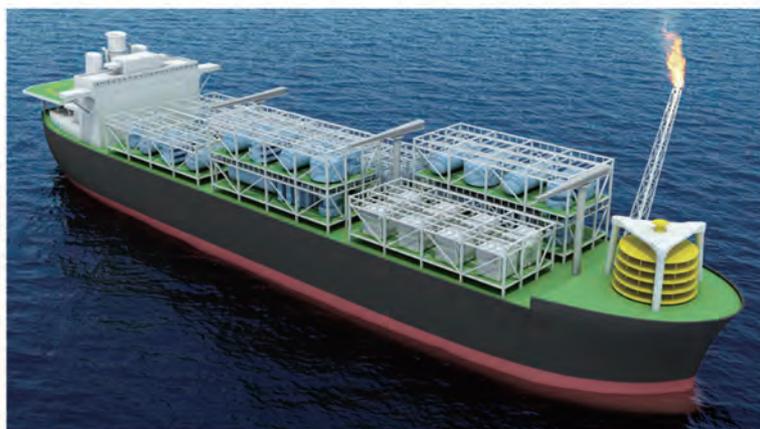
Kawasaki will build the vessel at its Kobe shipyard and carry out the necessary engineering work for construction together with Rolls-Royce. The vessel is scheduled for delivery in the first quarter of 2017. The topside handling equipment will be delivered by National Oilwell Varco. Emphasis has been placed on designing and outfitting the vessel for optimal subsea operations, and Island Offshore has experience from operating equivalent units over the last 10 years. The vessel will be equipped for tophole drilling and may also be adapted for light well intervention services.



It will feature an enclosed module handling tower to secure a safe and comfortable working environment when operating in harsh conditions, and the highest level of positioning capability, powered by the seven thrusters, which will secure more redundancy than similar offshore service vessels. It will also be of the highest comfort class and will be larger (approximately 169 m long, 28 m wide and 11.7 m deep) than similar vessels owned by Island Offshore. Kawasaki will actively pursue its shipbuilding operations in light of the expected rise in demand from the offshore industry, including various offshore service vessels and offshore structures.

For more information on Offshore Service Vessel, please contact: [khi\\_brochure@khi.co.jp](mailto:khi_brochure@khi.co.jp)

## Marine boiler for FPSO



Kawasaki supplies boiler(s) to be installed to floating facilities such as Floating Production Storage and Offloading (FPSO) and/or Floating LNG (FLNG).

The boiler can produce the steam upto 220 tonnes per hour with high temperature and high pressure.

The steam produced by boiler(s) will be used for power generation and Oil/LNG production processes in the offshore facility.

Kawasaki has supplied more than 1,200 boiler units, not only for land use for firing various kinds of fuel but also for marine use including LNG carriers. Integration of these technologies based on Kawasaki's proven track record and technical capability will realize reliable and robust boiler(s) that can operate under severe offshore conditions.

For more information on Marine boiler for FPSO, please contact: [energy\\_power@khi.co.jp](mailto:energy_power@khi.co.jp)

# MARINE MACHINERY

With its history and performance of delivering various marine machinery starting with the marine steam turbine in 1907, Kawasaki continues to develop and supply high-performance marine products.



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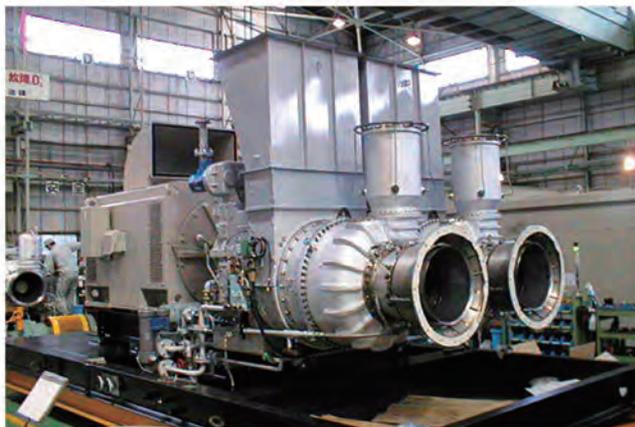


**SIDE THRUSTER**



For more information on Marine Machinery, please contact: [marine-machinery-sales-e@khi.co.jp](mailto:marine-machinery-sales-e@khi.co.jp)

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Kawasaki lines up from 1.5MW (Model M1A) to 30MW (Model L30A) for power generation, and the L30A is also available for mechanical drive application.

For more information on Gas Turbine, please contact: [webh6ov@khi.co.jp](mailto:webh6ov@khi.co.jp)

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# TAIKO KIKAI INDUSTRIES CO., LTD.

<http://www.taiko-kk.co.jp>

209-1, Shimotabuse, Tabuse-Cho, Kumage-Gun, Yamaguchi Pref. 742-1598, Japan

## Create & Challenge

A painter creates an artwork on a canvas using his brush, paint and special talent. Similarly, TAIKO innovates from scratch in the pump manufacturing industry, our "canvas" ; with water, oil and air serving as our "artist's utensils". We aim to contribute to the world's development through our innovative technologies as a fluid handling equipment manufacturer, and to continue growing as humane company with progressive vision.

## About Us

TAIKO was established in Tabuse town, Yamaguchi Prefecture, Japan, in April 1956. Since then, we have developed our efforts to developing new, and improving existing technologies to meet the diversified needs of the industry and our customers. Our expertise and unique technological know-how in the pump manufacturing field is the fruit of such endeavors. We are developing projects focusing on the following themes: 'from oil to water, water to air, air to vacuum.' Preserving the environment is our company's mission. We encourage our workers also to improve their own individual sense of environmental issues and to develop new products that include protecting the environment.

## Please Contact Me!



**Mr. Hideki Umeno**  
h-umeno@taiko-kk.com  
Tel : +81-820-52-3211



### Our Products

- ▶ Gear Pump
- ▶ Screw Pump
  - One Rotor Screw Pump
  - Two Rotor Screw Pump
  - Three Rotor Screw Pump
- ▶ Centrifugal Pump
- ▶ Oily Water Separator (15 ppm Bilge Separator)
- ▶ Sewage Treatment Plant
- ▶ Rotary Blower
- ▶ Vacuum Pump
- ▶ Diaphragm Blower



# NITTO CHEMICAL INDUSTRY CO., LTD.

<http://www.nitto-kasei.co.jp/>

24-24, Harima-cho 1chome, Abeno-ku, Osaka, 545-0022, Japan / Tel: +81-6-6693-3561

## FIRE-TIGHT SEALING FOR CABLE TRANSIT APPROVED IN ACCORDANCE WITH 2010 FTP CODE



### Record

Delivery record: Drillship , FPSO , AHTS , PSV and any kinds of commercial vessels. Since 1981, we have supplied Japan shipyards. Now, we have supplied All Japan Shipyards and almost every Korea Shipyards, China Shipyards and Singapore Shipyards.

## Please Contact Me! Mr. Tetsuya Yamasaki

t.yamasaki@nitto-kasei.co.jp  
Tel: +81-6-6693-3561



### About Our Products

- 1 PLASEAL NF-23 is the highest level of fire-tight compound for ships.**  
PLASEAL NF-23 passed IMO Resolution MSC.307(88) - 2010 FTP Code for A-class cable transits.
- 2 It is very easy to construct with PLASEAL NF-23.**  
PLASEAL NF-23 is an one component type of sealing compound. You need ONLY itself to construct, so this product makes construction easy.
- 3 PLASEAL NF-23 has comparatively low specific gravity.**  
Specific gravity of PLASEAL NF-23 is Approx.0.8, so with this product you can reduce ship body weight and save the cost of energy.
- 4 PLASEAL NF-23 will shorten working hours.**  
One cable can contact with other cables when you construct with PLASEAL NF-23, which means that every cable can be arranged freely, so PLASEAL NF-23 makes working hours shorter.
- 5 PLASEAL NF-23 is free from hazardous materials.**  
The main component of PLASEAL NF-23 is safe inorganic material, so this product does not contain any hazardous materials.

Experience...

The right solutions, the right results

FPSO/FSOs and SOFEC Mooring Solutions



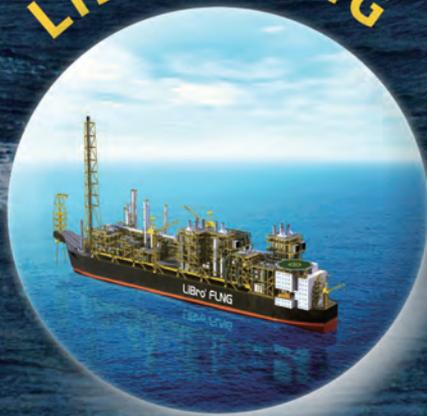
SOFEC Marine Terminals



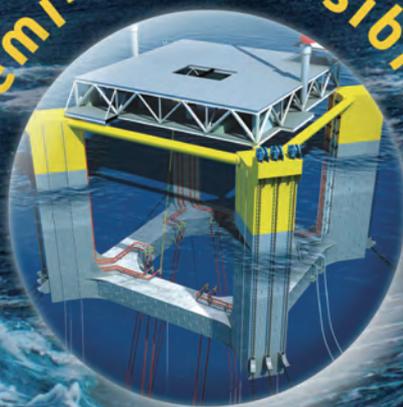
Tension Leg Platforms



Libro® FLNG



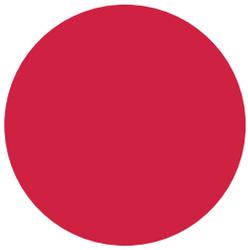
Semi-Submersibles



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# Hamanaka Chain Experts in Offshore Chain



## Mooring Chain & Anchor Chain

- Stud Link Mooring Chain & Studless Link Mooring Chain Grade R3, R3S, R4, R4S & R5 for Offshore
- Stud Link Anchor Chain Grade G2 & G3 for Ships

**HAMANAKA CHAIN** was the first in Asia to introduce a Swedish flash butt welder in 1957 and today we are one of the world's foremost manufacturers of not only R4 and R5 grade ultra-strong chain for offshore applications, but also chain that surpasses these standards and is designed for use in even harsher environments.

The many years of chain manufacturing experience and the feedback that **HAMANAKA CHAIN** is constantly receiving from customers have been invaluable in the research and development of the steel materials used in chain manufacturing that has been carried out in conjunction with Nippon

Steel & Sumitomo Metal Corp., which has many years of steel-manufacturing expertise. The resulting steel, which is used in the manufacture of R5 chain, is the fruit of much hard work carried out by researchers in both companies.

## Record

Hamanaka Offshore Chains have been supplied for nearly 300 occasions as well as enormous number for marine.

<http://www.hamanaka-chain.co.jp>

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# AlphaBridge coming to America

Houston (TX) office open for business



Merchant bridge



Offshore bridge



Tugboat/Ferry bridge



One man bridge

# Pioneering FLNG



In 1994–1997, JGC completed the study of a prototype floating LNG for a Japanese governmental oil and gas organization. Through participation in the world's first LPG FPSO projects, and with its experience in onshore LNG and gas processing topsides, JGC is uniquely positioned in pioneering FLNG.

Working together with clients, JGC has conducted numerous studies on concept, constructability and feasibility, as well as preliminary front-end designs, which led to the company being awarded contracts for FLNG front end engineering design work for Petrobras in 2010, Petronas in 2012, Inpex in 2013 and ENI in 2014.

In-house, JGC has developed concept models for FLNG for clients planning to monetize stranded offshore gas fields.

And in 2014 JGC won a lump-sum turnkey EPCIC contract from Petronas for one of the very first FLNG projects: a facility having a production capacity of 1.5 mtpa of LNG for deep offshore gas fields off the Malaysian coast.

**JGC**

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# A Guide to Fixed and Portable Gas Detection For Shipbuilding and Ship Maintenance from Scott Safety

## NEXT-GENERATION GAS DETECTION

*Protecting your people and your physical structure, while ensuring business continuity, are the most important functions of a fixed gas detection solution. Engineering a reliable, high-performance system that makes it easier and more cost effective to meet this challenge is the driving force behind a truly universal approach to gas detection.*

*Based on the model of “universal truths,” Scott Safety Gas and Flame Detection R&D Engineering Manager, Dan Munson offers direction on how to evaluate current systems, and project the impact of next-generation gas detection on companies’ safety and productivity in a global economy. Munson discusses the evolution and benefits of designing, implementing and maintaining a truly universal approach to gas detection.*

In a global economy, the challenges to personal safety, productivity, and business continuity are magnified. Companies in a wide range of industries, where the presence of combustible and toxic gases are a way of life, must continue to evaluate their gas detection systems or pay the price on many levels. This evaluation must consider a number of factors that can enhance safety, while streamlining installation and minimizing maintenance – in the present and the future. That’s what constitutes a truly universal solution.

## FIXED GAS DETECTION

Before we look ahead and evaluate a truly universal approach, it’s important to take a look at how gas detection is done with fixed gas detection technology today:

- *A single detector is paired and tested with a single sensor, detecting only a single combustible or toxic gas;*
- *adopting new, advanced digital communication protocols necessitates replacing existing systems with new detectors and/or new sensors;*
- *unique certification requirements for different devices and regions complicate the ability to engage in business as a company expands its operations globally;*
- *more points mean more maintenance and associated costs;*
- *a field technician’s toolbox is packed with multiple sensors, detector heads and accessories from multiple manufacturers, requiring major inventory investment; and*
- *a large workforce with specialized knowledge is needed to address specific installation and service requirements; and multiple manuals, covering many different product lines, only complicate installation and impede productivity.*

## ENGINEERING, INSTALLATION AND MAINTENANCE FOR A UNIVERSAL WORLD

Call it a paradigm shift in response to customer needs. Today, there is an increasing call for higher levels of safety, performance, standardization, economies of scale, ease of use, and overall accountability. Meeting these needs and adding value to the customer experience begins with re-thinking fixed gas detection engineering.

Engineering a universal gas detection system provides its own set of

challenges. But these challenges are being met and needs are being fulfilled. As you position your company to leverage a truly universal gas detection solution, you must evaluate where you are and where you need to be. The following exploration of legacy systems used in the field today and truly universal characteristics of next-generation gas detection instruments should aid in your evaluation.

## ONE TOO MANY

In a fixed gas detection system, a single detector is paired with – and tested with – a single sensor, accommodating only a small number of combustible or toxic gases, whereas a universal system allows for a single gas detector to accommodate multiple sensors, so multiple types of gases can be detected in one location. Working within the same device footprint the transmitter is designed to support different sensing technologies: combustible gas sensing with infrared and catalytic bead sensors and electrochemical and metal oxide semiconductor sensors for toxic gases. Using equally smart sensor technology allows the construction of sensors with multiple ranges in the same package which in turn enables range invariant calibration. One instrument that can provide the capabilities of multiple instruments, and one sensor that can support multiple gas ranges provides valuable flexibility not available in legacy gas detection devices.

## COMMUNICATION PROTOCOLS

Fixed gas detection systems have traditionally relied on analog signals for communication. This limits the transmission of advanced diagnostics data that ensures a safe environment. Adopting digital communication protocols necessitates installing new detectors and/or new sensors.

A universal system is engineered to accept new plug-and-play communication boards, as needs change and new communications protocols are required. This multiprotocol innovation – wired or wireless (when industry appropriate) – means protocols can be added without replacing the transmitter as communication requirements change. Companies will want to make sure their transmitter accommodates a wide range of communication protocols, including MODBUS®, HART®, wireless HART and wireless ISA100.11A. This kind of flexibility is a key to a futureproof gas detection solution, and the transition from rigid, proprietary systems to standards-based, secure systems that accommodate growth and change.

## CALIBRATION AND MAINTENANCE

Due to engineering constraints, sensor calibration in a fixed gas detection system must be performed in the field, where conditions are less than ideal and both safety and performance may be compromised.

Accurate calibration is critical to satisfying both safety and performance requirements. It also impacts productivity when false alarms, due to inaccurate calibration, slow down – or even shut down – production. Next-generation universal gas detection enables a calibration-in-the-lab scenario, providing a more controlled and safe environment for establishing gas sensor parameters. This is a significant innovation, especially with legacy cat bead sensors which required proper volt-

age adjustments at the point of detection. Additionally, the flexibility to calibrate an electrochemical sensor to a particular gas level and then make simple adjustments to the range later—without recalibrating the sensor to the new range—can offer significant efficiencies in sensor maintenance.

Through advanced engineering, a transmitter's microprocessor can remember the type of sensor installed, as well as all calibration values. This built-in system of checks and balances virtually eliminates duplication of effort and the possibility of installing the wrong sensor.

### GLOBAL STANDARDS

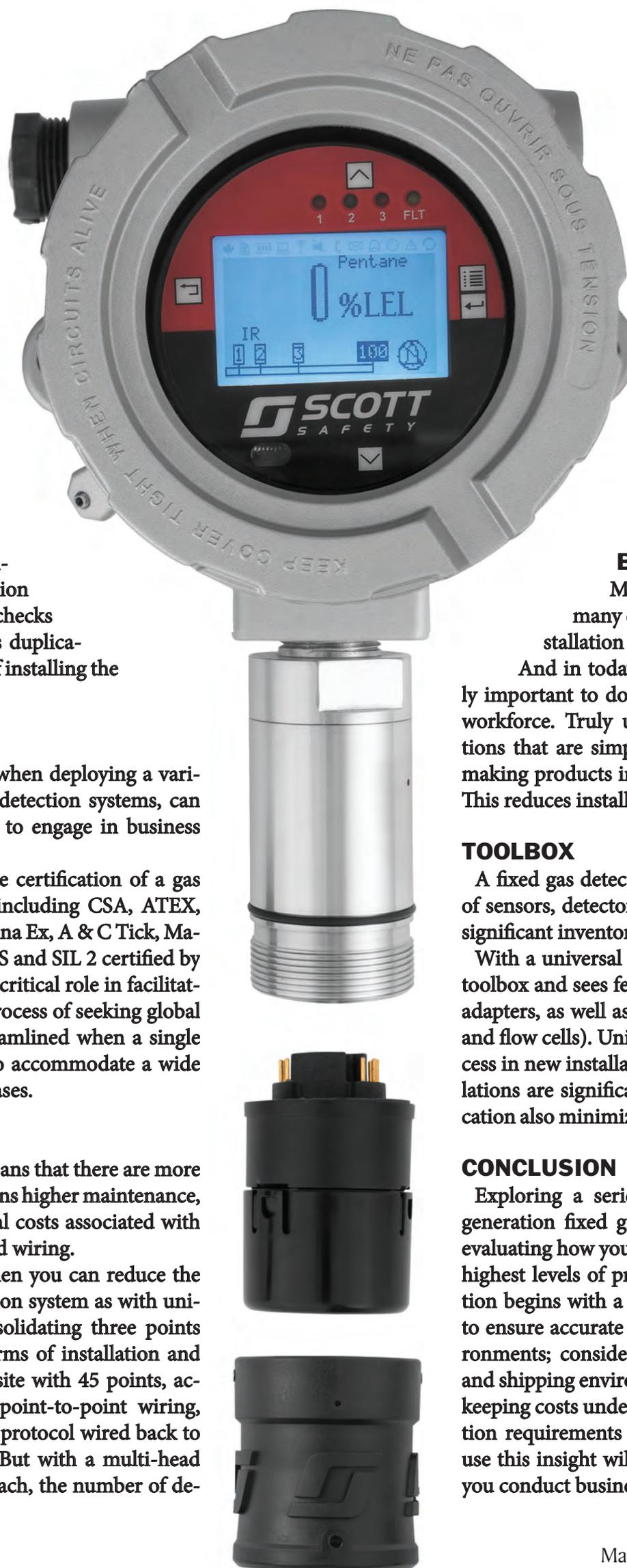
Global certification, especially when deploying a variety of detectors, as in fixed gas detection systems, can complicate and delay the ability to engage in business around the world.

A universal system expands the certification of a gas detector for global acceptance (including CSA, ATEX, IECEx, INMETRO, GOST-R, China Ex, A & C Tick, Marine Directive - Ship's Wheel/ ABS and SIL 2 certified by a third party agency) and plays a critical role in facilitating quick global adoption. The process of seeking global certifications can be further streamlined when a single gas detector is flexible enough to accommodate a wide range of toxic and combustible gases.

### COST OF OWNERSHIP

A fixed gas detection system means that there are more points (i.e., detectors), which means higher maintenance, more complexity and incremental costs associated with added cabling, junction boxes and wiring.

Less is more – and better – when you can reduce the number of points in a gas detection system as with universal systems. One device consolidating three points has a positive ripple effect in terms of installation and maintenance. For instance, at a site with 45 points, accepted practice would include point-to-point wiring, using a Modbus communication protocol wired back to a central location or controller. But with a multi-head scenario, handling three points each, the number of de-



### Meridian Universal Gas Detector

tectors is reduced to 15 devices. This approach represents significant cost savings. In fact, using a single detector that consolidates three points, with a single relay board to control three alarms, totally eliminates a costly controller. Multiply this configuration times three for every three-head detector/ multiple sensor configuration, and your cost of ownership is further reduced.

### WORKFORCE KNOWLEDGE BASE

Multiple manuals or the knowledge of many different product lines can slow the installation process and impede productivity.

And in today's climate, it is becoming increasingly important to do more with a smaller, less specialized workforce. Truly universal engineering produces solutions that are simple to use with consistency in design making products intuitive, easy to learn and easy to use. This reduces installation time and increases productivity.

### TOOLBOX

A fixed gas detection system includes large inventories of sensors, detector heads and accessories, demanding a significant inventory investment.

With a universal system, a field technician looks in his toolbox and sees fewer sensors, detectors and calibration adapters, as well as fewer accessories (like deluge guards and flow cells). Universal mounting kits simplify the process in new installations, while retrofits to existing installations are significantly more manageable. This simplification also minimizes lapses in safety due to human error.

### CONCLUSION

Exploring a series of "universal truths" about next-generation fixed gas detection is a critical first step in evaluating how you protect your people and maintain the highest levels of productivity. Truly universal gas detection begins with a singularly flexible system, engineered to ensure accurate performance in a wide range of environments; considers current and future manufacturing and shipping environments; and plays a significant role in keeping costs under control in the face of global certification requirements and a changing workforce. How you use this insight will impact where, and how successfully you conduct business.

### SCOTT SAFETY FIXED GAS DETECTION PRODUCTS

Combining advanced sensor technology and simple operation, Scott Safety offers a comprehensive range of gas detectors, flame detectors and controllers flexible enough to handle the harshest conditions while helping customers minimize their overall cost of ownership.

#### MERIDIAN UNIVERSAL GAS DETECTOR

The Meridian Universal Gas Detector is an innovative next generation gas detection solution. The Meridian single detector head supports combustible and toxic sensors. Designed for ease-of-use, Meridian significantly reduces upfront investment and ongoing maintenance costs. With global approvals and SIL2 certification from TÜV-Rheinland, Meridian provides best-in-class performance and safety, offering the following features:

- *Single detector head for all sensor types – whether electrochemical, catalytic bead, infrared, or solid state MOS*
- *Full range of combustible and toxic sensors including Scott Rock Solid sensors*
- *Supports up to three sensors per transmitter*
- *Multiple communication protocols – 4-20mA, and Modbus are standard; options include HART, Wireless HART, Wireless ISA100.11a*

The Meridian Universal Gas Detector accepts all sensor types in one detector. Whether you need an infrared or catalytic bead sensor to detect combustible gases or an electrochemical or Metal Oxide Semiconductor (MOS) sensor for a toxic environment, the Meridian gas detector utilizes a single detector head to easily accept all sensor types. Simply attach the specific toxic or combustible sensor to the detector head and the Meridian gas detector will automatically determine the type of gas to be detected. Installation of the sensor is a simple plug-and-play action. The Meridian platform is designed to be future proof, allowing you to take advantage of new sensing technologies from Scott Safety while maintaining ease-of-use and peace of mind.

### GAS DETECTION IN CONFINED SPACES

*The Scott Safety global marketing team defines a confined space, and discusses ways to successfully recognize and diagnose the most common atmospheric hazards found within.*

A confined space is defined as an area large enough for an employee to enter and perform work. These spaces have limited or restricted means of entry or exit and are not designed for continuous human occupancy. According to the National Institute for Occupational Safety and Health (NIOSH), investigations of confined space injuries and fatalities indicate that workers usually do not recognize they are working in a confined space, and they may encounter unforeseen hazards. Testing and monitoring of the atmosphere is not performed, and rescue procedures are seldom planned.

Recognition of potential hazards is not always easy. Confined spaces such as manholes, sewers, boilers, silos, vessels, vats, pipelines, tunnels, storage tanks, ship compartments and underground vaults are often easily identified. However, often overlooked are potential confined space hazards such as open-topped water and degreaser tanks, open pits and enclosures with bottom access.

Confined spaces alone may not be hazardous, but they can become so

quickly. And, when coupled with common atmospheric hazards, they can be life threatening. Before entry, a confined space should be monitored for all atmospheric hazards suspected to be present. Common hazards found in the work environment include:

- *Oxygen deficiency*
- *Hydrogen sulfide exposure*
- *Carbon monoxide exposure*
- *Combustible gases within the LEL (lower explosive limit) and UEL (upper explosive limit)*

Fixed and portable gas detection instruments are used to identify the presence of atmospheric hazards. Instruments are typically used to detect the presence of toxic gases such as H<sub>2</sub>S and CO. For combustible gases such as methane or propane, instruments are used to detect concentrations of gas up to the LEL. A gas-air mixture becomes explosive at the LEL, but the monitoring range of most instruments is below this limit to provide advanced warning. Common sources of atmospheric hazards include:

- *leaking gases and liquids*
- *decomposing organic matter*
- *combustion (welding, cutting, brazing) or oxidation (rusting)*
- *cleaning processes*
- *oxygen enrichment*
- *oxygen absorption*
- *combustible dust concentrations*

After checking for gases the space should be properly ventilated to reduce the hazard level as much as possible. Proper attendants and rescue equipment should be in place before making any confined space entry. If the space is or has the potential to be Immediately Dangerous to Life and Health (IDLH), workers must wear a tight-fitting positive pressure, air supplied respirator. A NIOSH-approved self-containing breathing apparatus (SCBA) or supplied-air respirator (SAR) with egress cylinder are the most appropriate respiratory protection options.

Grade D breathing air is provided to a worker wearing a supplied-air respirator (SAR) via a portable air cart, remote cylinders in a trailer or stored as plant breathing air, a Grade D breathing air compressor or filtered air from an industrial air compressor. The duration of a supplied-air respirator is limited to the capacity of the supplied air source. Because of the design of extended duration airlines, the possibility of the air source being interrupted requires that all supplied-air respirators used in IDLH situations include an egress cylinder providing enough Grade D breathing air to escape to a safe environment.

Scott Safety Product Line Manager, Tony Pickett, suggests that “preparing to deal successfully with any emergency situation requires careful planning and training. All personnel on board need to know how to behave in an emergency and those responsible for carrying out life-saving tasks must be familiar with the equipment they need and know how to use it safely and effectively. This, together with working with a reputable manufacturer will help reduce unnecessary deaths and serious injury in this demanding industry.”

### PORTABLE GAS DETECTION PRODUCTS

With simple, intuitive operation and automated functionality, our

# TRULY UNIVERSAL



Introducing  
**MERIDIAN**  
UNIVERSAL GAS DETECTOR



From the plant floor to the executive suite, a single device is now capable of protecting your people and impacting the operations and economics of your entire organization. The Meridian gas detector does just that, detecting both combustible and toxic gas. A single detector head easily accepts all sensor types - it's simply plug and play. Learn how **Scott's Meridian Universal Gas Detector** is redefining "universal." Visit [www.UniversalByScott.com](http://www.UniversalByScott.com)

**LET'S WORK.**



PS200

portable gas detection solutions reduce the likelihood of user error and provide greater peace of mind, so the focus is on the job, not on the equipment.

### PS200

The PS200 is a rugged, easy to use portable multi-gas detector ideal for use in confined spaces and hotworks. Both lightweight and durable the instrument monitors and displays up to four hazardous gas conditions simultaneously using catalytic bead sensor technology for a wide range of combustible gases, and electrochemical sensors for carbon monoxide, hydrogen sulfide, and oxygen deficiency. Operator interface and calibration are intuitive and easy by toggling between simple one-button functions. During hazardous conditions users are alerted via three alarm functions: vibration, red flashing LEDs, and audible buzzer. To ensure the highest level of personal safety, the PS200 is also fitted with an optional man down/motion sensor that activates alarms if the instrument is not moved at a pre-set time. The instrument is also fitted with an optional built in remote sampling pump making it ideal for use

in confined spaces. The PS200 features a screen backlight that can be manually switched on in poor lighting conditions. Additional features include: customized user identification code setup, calibration due date display, and standard data logging that can be downloaded to a docking station via USB connection to a computer. Also available is a auto bump and cal station, 5-way charger and PC data logging software.

### Electrical Classification

IEC Ex ia d IIC T4 Gb

### Safety Approvals

ATEX  
cCSAus

CE  
CSA

MED

### A COMMITMENT TO SAFETY, GAS DETECTION

Rooted in more than 75 years of heritage and dedication to safety, Scott Safety has constantly expanded to provide safety solutions for new markets and challenges. Today, we work with dozens of global industries, including general industry, petrochemical oil and gas, marine, asbestos, first responders and military and civil defense. With five manufacturing facilities and a customer base that spans more than 50 countries, Scott Safety has a broad, global offering of innovative safety products, with a premium portfolio of SCBA, air purifying respirators, gas detection systems, compressors, PPE, and thermal imaging products.

Scott Safety is committed to becoming a world leader in gas detection as demonstrated by the recent acquisition of Industrial Safety Technologies (IST). The advanced products manufactured by Detcon, Simtronics, Oldham, and Gas Measurement Instruments (GMI) together with the Scott Safety offerings provide holistic gas detection solutions, with some of the most advanced technologies in the market for the marine industry.

IST holds a technology leadership position in the gas and flame detection industry and is strongly committed to innovating in industrial safety solutions. From groundbreaking wireless gas-detection technology to the first SIL3 certified triple IR flame detector, IST provides among the most advanced and reliable solutions, protecting lives and workplaces around the world. IST brings strong market presence in Europe, the Middle East, and the Gulf Coast U.S. region and will complement the Scott Safety Flame and Gas Detection business.

  
*A Tyco Business*

ISSUE	EDITORIAL	BONUS DISTRIBUTION
<b>JANUARY</b> Ad Close: Dec 19	<b>Ship Repair &amp; Conversion Edition</b> Market: Maritime Propulsion: Gears, Thrusters, Waterjets & Propellers Technical: Marine Salvage & Recovery Product: Marine Electronics Equipment & Supplier Guide Country Report: France & Poland	<b>PVA MariTrends 2015</b> January 31 - February 3 Long Beach, CA <b>EuroMaritime</b> February 3 - 5 Paris, France
<b>FEBRUARY</b> Ad Close: Jan 21	<b>Cruise Shipping Edition</b> Market: Ships of War: Evolution and Future of U.S. Navy Technology Technical: Marine Telematics: Data, Tracking and Communications Product: Marine Coatings & Corrosion Control Country Report: Denmark, Finland & Sweden	<b>Cruise Shipping Miami</b> - Mar 16-19, Miami, FL <b>ASNE DAY</b> - March 4 - 5, Crystal City, VA <b>NACE Corrosion</b> - March 15 - 19, Dallas, TX <b>Arctic Technology Conference</b> - March 23-25 Copenhagen, Denmark
<b>MARCH</b> Ad Close: Feb 20	<b>U.S. Coast Guard Annual</b> Market: Training & Education: From Simulation to Distance Learning Technical: Oil Spill Response & Recovery Product: Marine Propulsion: Green Marine Fuels & Lubricants and Emission Technologies Country Report: Greece & Turkey	<b>CMA Shipping 2014</b> March 23-25, Stamford, CT <b>Sea-Air-Space</b> April 13-15, National Harbor, MD
<b>APRIL</b> Ad Close: Mar 20	<b>Offshore Edition</b> Market: Modern OSV Design & Technology Technical: Workboat Fleet Maintenance & Repair Product: Deck Machinery, Winches and Ropes Country Report: The German Maritime Cluster	<b>Offshore Technology Conference (OTC)</b> May 4-7, Houston, TX <b>Workboat Maintenance &amp; Repair</b> April 14 - 16, New Orleans, LA <b>Marine Money Houston</b> Houston, TX
<b>MAY</b> Ad Close: Apr 21	<b>The Marine Propulsion Edition</b> Market: RIB & Patrol Boat Report Technical: Workboat Design & Construction Product: Satellite Communication Technologies Country Report: The Norwegian Maritime Cluster	<b>Norshipping</b> - June 2 - 5, Oslo, Norway <b>Inland Marine Expo</b> - June 15 - 17, St. Louis, MO <b>MACC 2015</b> - May/June, USA <b>Seawork</b> - June 16-18, Southampton, UK
<b>JUNE</b> Ad Close: May 22	<b>Annual World Yearbook</b> Market: Maritime Simulation & Training Centers Technical: Dredging: Deepening the Channels of Trade Product: Pumps, Valves, Pipes & Insulation Country Report: U.K. & Ireland	<b>Marine Money Week</b> June 16-18, New York, NY
<b>JULY</b> Ad Close: Jun 21	<b>Marine Communications Edition</b> Market: Classification & Ship Registry Technical: ECDIS System Review & Report Product: Maritime Tools: Welding & Cutting Country Report: Italy	
<b>AUGUST</b> Ad Close: Jul 21	<b>Shipyard Edition</b> Market: Offshore Deepwater: Structures and Systems Technical: Heavy Lifting Solutions: Maritime Cranes Product: Ballast Water Technology Country Report: Russia, Lithuania, Latvia & Estonia	<b>Offshore Europe</b> September 8 -11, Aberdeen, UK <b>NEVA</b> September 22 - 25, St. Petersburg, Russia
<b>SEPTEMBER</b> Ad Close: Aug 21	<b>Offshore Energy Technologies</b> Market: Maritime Security Technology & Technique Technical: Maritime Propulsion: Efficient Drivers Product: Clean Water Technologies Country Report: Spain, Portugal & Brazil	<b>OTC Brazil</b> October 26 -29, Rio de Janeiro <b>GasTech</b> October 27 - 30, Singapore
<b>OCTOBER</b> Ad Close: Sep 21	<b>Marine Design Annual</b> Market: Ship Classification Societies Technical: Marine Firefighting, Safety & Salvage Product: CAD/CAM Country Report: The Netherlands & Belgium	<b>SNAME</b> November 4-6, Providence, RI <b>Europort</b> November 3-6, Rotterdam, Holland <b>Clean Gulf</b> November 10-12, New Orleans, LA
<b>NOVEMBER</b> Ad Close: Oct 20	<b>Workboat Edition</b> Market: LNG Handling and Transportation Technical: Deck Machinery, Winches & Ropes Product: Fuels, Lubricants & Additives Special Report: Gulf of Mexico Builder & Supplier Guide	<b>International Workboat Show</b> December 2-4, New Orleans, LA <b>Marintec China</b> December 1-4 Shanghai, China
<b>DECEMBER</b> Ad Close: Nov 20	<b>Great Ships of 2015</b> Market: The Automated Ship: Command & Control Technical: Shipyard Automation Product: Marine Engine Guide Special Report: Korea/Singapore/Vietnam	<b>Surface Navy Association 2016</b> January, Crystal City, VA



## PMC timeline

1973

First major PMC designed and built product. Pneumatically controlled hydro-mechanical pitch controller with proportional positioning and integral automatic load control.

1979

PMC delivers first solid state Navigation Light Panel and Engine Order Telegraphs. Several hundred of these units are currently in service worldwide.

1986

PMC began manufacturing microprocessor based alarm and monitoring equipment.

1987

PMC installed our first unmanned machinery space alarm and watch keeping/cabin system.

1987

PMC launched a new "Electric Shaft" Bridge control system which was installed on 8 vessels in first year of manufacturing.



# Prime Mover Controls

Prime Mover Controls (PMC), based in Burnaby, B.C., Canada, began in 1969 as a small governor service shop, servicing virtually all types of Woodward governors. Over the years, PMC has kept up with new developments in governor technology and has maintained a dedicated and experienced staff of service technicians, as well as extensive test equipment. Servicing and adapting new Woodward governors to a wide variety of applications, both on and offshore, continues to be a significant part of PMC's business.

In 1973, PMC began design and manufacture of remote control components, instrumentation and system for marine applications. These systems have been refined and proven through years of dependable operation. PMC marine control systems include propulsion controls for controllable and fixed-pitch propeller systems as well as thruster and winch controls. These control systems have been installed on hundreds of vessels world-wide.

## Custom Control Consoles

PMC started making control consoles in 1978. These consoles are completely pre-wired, tubed and tested before leaving the factory. The company's level of integration of control and navigation equipment has evolved through the years. PMC in partnership with other manufacturers and subcontractors now have the ability to supply complete turnkey packages for all types of commercial vessels. To date nearly 100 ship sets of consoles have been designed, manufactured and commissioned by PMC.

## Company Overview

### Product and System Engineering

Today's marine industry requires more than high quality control components. It demands comprehensive interaction between customer and supplier in a relationship built on extensive knowledge and experience. The high performance and reliability found in our integrated propul-

sion control systems are the products of that partnership.

### From Concept to Final Design

If your projects require a committed team effort, we are prepared to meet the challenge. Our in house design team works closely with you to convert your specialized requirements into a complete integrated system.

### Research and Development

Every product developed by PMC originated from an application need. We have environmental testing facilities to enhance the development of products for the harsh marine environment. These facilities also assist in the testing required to obtain approvals from marine regulatory and classification bodies.

### Software Development

For software development PMC maintains the latest computers, operating systems, and software development tools. A state-of-the-art Integrated Development Environment (IDE) allows rapid software development and thorough testing of all hardware and software components.

### Component and System Manufacturing

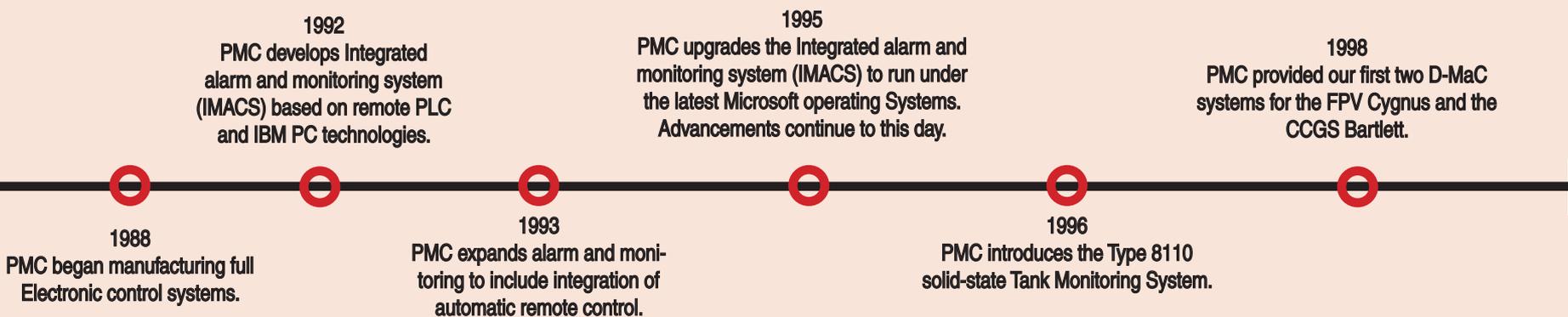
Our highly qualified personnel are committed to details. All components and systems are manufactured to the ISO 9002 quality standard and all components are put through two complete test cycles.

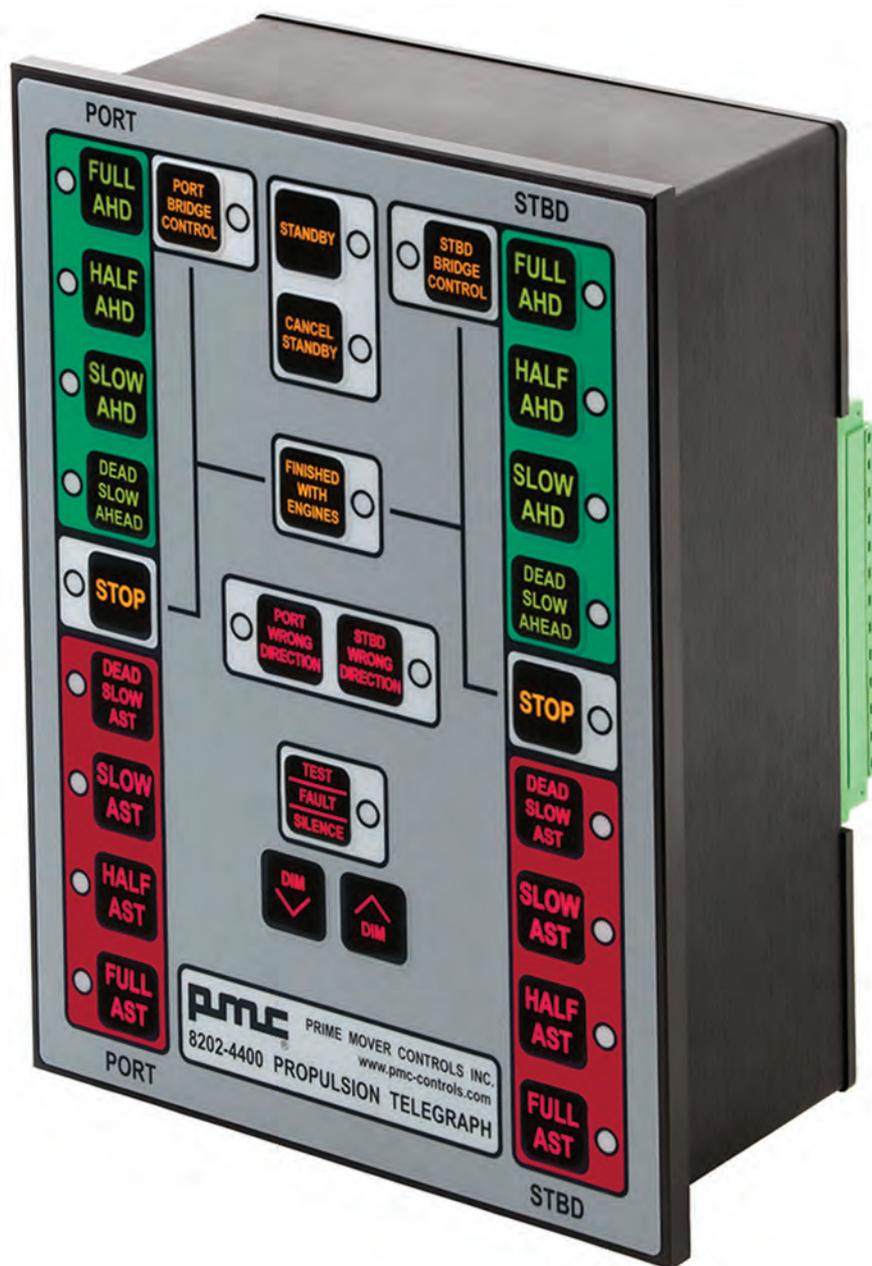
### System Testing

Your system is fully tested and verified before shipment. This includes; documentation, programming, regulatory approvals and factory testing as a complete system.

### Commissioning

Our dedicated, trained and experienced staff of service technicians are





## The PMC Series 8202 Engine Order Telegraph

This is a compact marine telegraph for single or twin screw systems. It operates as a stand-alone or back-up system, and functions independently of the ship's main propulsion controls and allows emergency operation when primary remote controls fail.

available for installation assistance and start up. This commissioning can include PMC equipment, system interfaces or complete integration and verification to ensure smooth trials.

- **Training**

Customer training for the operation and maintenance of control systems is a service provided by PMC. Our customers may take advantage of our shop facilities, for hands-on training, or arrange to have one of our technicians visit your location.

- **Preventative Maintenance**

PMC offers preventative maintenance and consulting services. Other services include sensor calibration and assistance with periodic automation safety tests. PMC also offers service kits and system spare parts.

- **Service**

If trouble arises with a system, be it with PMC components or an integrated component, PMC offers complete field services and comprehensive maintenance programs.

- **Repair**

PMC maintains a staff of repair technicians, an extensive parts inventory, as well as up to date test equipment. If you cannot afford down time, PMC can offer exchange units during repair.

### Product Overview

As a true engineered solutions company, PMC's product and service offering is as broad as its customer's needs. **Literally!** PMC designs, develops, manufactures and services a wide range of products, and every product developed by PMC originated from an application need. Some of the product highlights include:

- **Alarm Annunciators**
- **Drop-in Propulsion Control and Instrumentation Plates**
- **IMACS Integrated Machinery Alarm & Control**  
Distributed analog and digital inputs or outputs  
Industry standard inputs  
Galvanically isolated inputs and outputs  
Stand alone alarm display  
Single or dual high speed network

2004

PMC expands the line of electric shaft control heads with the new MCH-ES2 and added electric shaft functionality to the DCH digital control head.

2001

PMC established a fully-equipped laboratory to perform Electromagnetic Compatibility (EMC) tests.

2001

PMC installed the first digital electric shaft system and the first digital lever telegraph system.

2002

PMC introduces the MPC-D Digital Marine Control system.

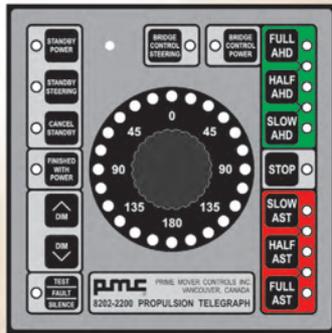
2007

PMC introduces the MPC-CP (Marine Propulsion Control – Controllable Pitch) propulsion control system.



# Propulsion Control, Telegraph, and Machinery Alarm & Monitoring

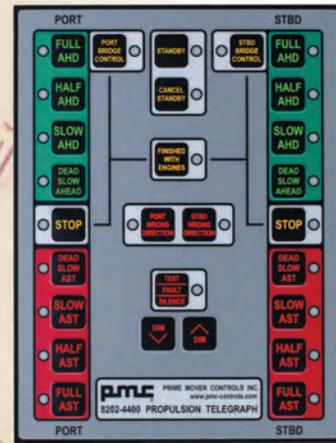
## AZIMUTH TELEGRAPH



## DCH



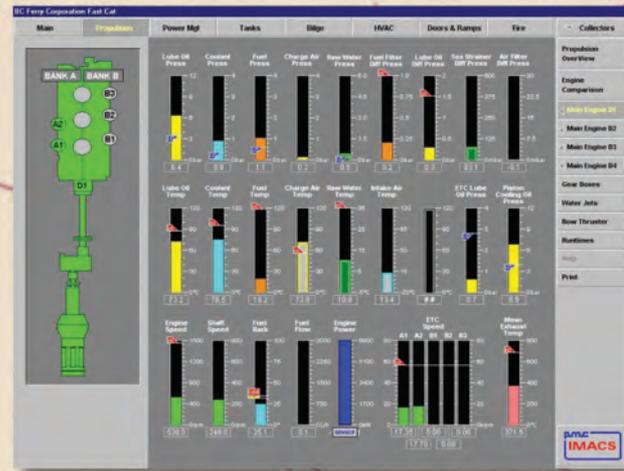
## PUSHBUTTON TELEGRAPH



## MPC-FP



## IMACS



## PCH



## MCH



## SCH



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On-line self diagnostics  
Ship to shore data transfer and remote diagnostics

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- **Mimics**

- **MPC-CP Marine Propulsion Control**

Digital System for Vessels with Controllable Pitch Propellers.  
Load sharing, Load control, Safety interlocks, Redundant, and Fault tolerant.

- **MPC-D/MPC-FP Marine Propulsion Control**

Digital System for Vessels with Fixed Pitch Propellers.  
Safety interlocks, Redundant, and Fault tolerant.

- **MPC-U Azimuth Propulsion Control**

- **Navigation Light Controls**

Bulb, fuse, and wire monitoring  
Dual fused input power source  
Auto transfer  
Group transfer  
Modular construction

- **Propulsion Control Heads**

Standard designs  
Custom configurations  
Electric Shaft operation  
Suitable for a wide range of marine applications

- **Propulsion (Engine Order) Telegraphs**

Lever, Pushbutton, Azimuth, Single or twin screw, Separate standby group, Wrong direction alarms, Compact, Watertight, Serial network link, Data logging, Self diagnostics

- **Tank Level Monitoring and Alarm**

## PROJECTS

PMC provides innovative control and monitoring solutions for a wide variety of applications. Its dependable leading edge marine control and monitoring systems are based on proven technologies with innovative functionality and versatility. Today's sophisticated marine industry demands comprehensive interaction between vessel owners, designers, builders, operators and suppliers in a relationship built on extensive knowledge and experience. PMC is committed to that relationship. The high standards of ergonomics, performance and reliability found in our consoles and integrated systems, are the product of that partnership.

We offer design, manufacture, installation assistance, start-up assistance, service and training to fill your requirements.

### Commercial

Freighters  
Supply Vessels  
Tug Boats  
Work Boats

### Passenger

Cruise Ships  
Ferries  
Casino River Boats  
Sternwheelers

### Military/Government

Navy  
Offshore Patrol  
Coast Guard  
Hydrographic Survey

### Yachts

Expedition Yachts  
Motor Yachts  
Sailing Yachts

### Consoles & Integrated Systems

Integrated Bridge Design  
Bridge Consoles  
Engine Control Room  
Consoles  
Drop-in Console Plates

### Industrial Steam Turbine Control Retrofits

Steam Turbine Control  
Systems  
Explosion Proof Enclosures  
Custom Bracketing

<http://pmc-controls.com/>

2009

Produce Multi-Function Graphical Display for Tachometer signal conditioning and display.

2012

Updated Series 8202 telegraph design. Add latest sunlight readable LEDs, redundant communication, and NMEA 0183 VDR output.

2010

Launch MPC-U Azimuth Propulsion Control for 360 degree Z-Drives.

4th Q 2015

Launching PMC's latest product. Series 8014 Navigation Light Control Panel for LED lamp fixtures.

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# How Ester-Based Oils Handle Hydrolysis to Remain the Top EAL for VGP

## Introduction

When the Environmental Protection Agency (EPA) issued the new Vessel General Permit (VGP) in December 2013, lubricant and fluid manufacturers were prepared to give vessel owners a number of environmentally acceptable lubricants (EAL) to work with. EAL usage is now essentially required for any application on vessels where incidental lubricant discharge could occur in the marine environment. Those applications include stern tubes, thrusters, stabilizers, CPP propellers, and wire rope and mechanical equipment immersed in water during normal operation.

Today, with so many EAL choices available, vessel owner/operators and equipment manufacturers are looking to understand the performance characteristics of these different lubricants. Other than water lubricated applications, EALs attain their environmental qualities by using either an ester oil, a polyalkylene glycol (PAG) oil, or a combi-

nation of ester and synthetic hydrocarbon oils (PAO) as the base oil of the lubricant. Considering that the vast majority of EALs that have been approved by seal system manufacturers contain ester oils, it is likely that most vessels will use an ester-based EAL. It is important for users to have an accurate understanding of ester oil performance characteristics to assist in their selection of EALs and to ensure they receive the most benefit from their investment.

## Evaluating environmentally acceptable ester-based lubricants

As a mainstay of marine lubrication, ester-based oils and greases continue to offer value and versatility in a majority of situations. As a class, ester-based oils exhibit excellent environmentally-friendly properties in terms of biodegradation, non-bioaccumulation and minimal toxicity. Concern over lubricant effects in these three envi-



ronmental areas was the basis for issuing the changes to the oil-to-sea interface section of the VGP, which specifically targets mineral oil as unacceptable. Esters used in lubricant formulations fall into one of two categories: either naturally produced triglycerides from vegetable or animal sources, or synthesized esters developed by combining acids and alcohols in a manufacturing process. Triglyceride esters have found acceptance for use in hydraulic oils and as a base for biodegradable greases. However for marine use, where the influence of water and operational temperatures can affect the lubricant's performance, synthetic esters generally perform better.

Triglyceride esters do have a high viscosity index to minimize thinning at high temperatures, and they exhibit high lubricity. Furthermore, reaction with paints and varnishes is not a problem. However, they exhibit poor temperature stability and poor flow behavior at cold temperatures. At high temperatures, oxidation readily occurs, requiring more frequent oil changes. They also exhibit poor hydrolytic stability, readily breaking down in water to form carboxylic acid and other acids that can damage machinery and seals. It is these negative traits of triglyceride esters that lead to the often repeated claim that ester based products have poor hydrolytic stability.

Synthetic ester oils, on the other hand, can be used with a wider range of applications, because their properties can be tailored for specific performance conditions. They handle a wide range of temperatures and exhibit high viscosity, lubricity, corrosion protection and oxidative stability — the latter feature contributing to longer lubricant life, an advantage in hydraulic fluids, and stern tube and thruster oils where vegetable or mineral oil based lubricants need to be changed more frequently.

### Hydrolysis resistance in ester-oil chemistry

To answer the question, "What about the hydrolysis of ester oils?" it helps to understand the basics of ester chemistry.

Synthetic ester oils are derived from an inorganic acid or an organic acid in reaction with an alcohol. The *esterification* reaction produces the ester, plus water. The reverse reaction, called *hydrolysis*, consumes water while producing acid and alcohol. Like all chemical reactions, the process depends on temperature.

Although all esters can be hydrolyzed, it does not mean all esters have poor hydrolytic stability. Again, the difference is in the formula.

When using vegetable resources, the esters produced have simple, linear molecular shapes with double carbon-hydrogen bonds. They are referred to as "unsaturated esters," because the molecule is not "fully saturated" with hydrogen atoms. These structures are relatively weak, and in the presence of water and heat, poor hydrolytic stability can be expected.

But when saturated esters with branched acids – known as polyolesters – are utilized, hydrolytic stability is improved. In fact, for these complex polyolester molecule shapes (technically known as sterically hindered esters), hydrolytic stability is very good. Field experience with saturated synthetic polyolesters with branched acids show that even when mixed in 300 to 500 ppm water, acid content does not increase over years.

Ultimately, the speed of hydrolysis reactions are influenced by several factors:

- The chemistry of the base oil
- Percent of water in the oil
- Oil temperature (higher temperatures speed up the



#### hydrolysis reaction)

- Formation of reaction products that support further hydrolysis (acids that act like catalysts)
- Use of additives that support hydrolysis
- Presence of copper, which can also support hydrolysis

Of these factors, ensuring a low percentage of water in the oil is the ultimate deterrent against hydrolysis. For thrusters, the amount of free water in gear oil should not exceed 200 – 1000 ppm depending on manufacturer specifications. Typically, a maximum of 200 – 300 ppm is recommended. In stern tube oil, the water content should generally not exceed five percent. By maintaining seal integrity and monitoring the condition of the oil, ester oils used in stern tubes should last for years.

In addition, due to the low water percentage recommended in these applications, using an emulsifier to disperse the water in oil will increase the tendency towards hydrolysis. Oils without emulsifiers can have free water removed with conventional oil filters containing water separators. Oil with an emulsifier will yield a stable emulsion; however, water cannot be easily removed. Using an emulsifier in stern tube oil is a viable emergency measure that will require prompt oil replacement.

### Bottom line benefits of ester-based oils

VGP environmental standards for EALs are being met by a number of alternatives: triglyceride vegetable oils, ester-based oils and PAG oils. Environmentally, ester-based oils exhibit excellent biodegradation, non-bioaccumulation and low-toxicity characteristics. Operationally, they handle a wide range of temperatures, exhibit high viscosity, lubricity, corrosion protection and oxidative stability. While there are several types of natural and synthetic ester base oils, concerns about ester oils' susceptibility to hydrolysis can be addressed by selecting the right formulation, namely saturated synthetic polyolesters with branched acids. When environmental friendliness, operational performance and resistance to hydrolysis are all considered, synthetic polyolester oils are an excellent choice for hydraulic oil and grease, stern tube oil, thruster oil, and gear lubricants.

[www.klubersolutions.com/ester-based-oils](http://www.klubersolutions.com/ester-based-oils)

# Shear Stability Is Key To Proper EAL Gear Oil Selection



## Introduction

Selecting a gear oil for use in marine thrusters or a stern tube lubricant for use with propeller shaft bearings is typically based on analyzing price/performance characteristics of the lubricant and its availability. Now with the implementation of the 2013 VGP, this analysis must be expanded to include EALs that meet the new EPA standards. To meet environmental requirements, EALs are blended from base oils other than mineral oil. They still meet the same lubricant objective: To provide long-term equipment protection. It is worthwhile, however, to focus on how the new EALs meet one particular criterion for analysis: Their ability to resist shearing under load.

## Lubricant performance factors

In general, a complete performance analysis of an EAL gear oil or stern tube lubricant should include an assessment of thermal, oxidative, and hydrolytic stability to estimate the projected life of the oil under operating conditions. These results can be compared to the initial purchase price of the lubricant for a total cost of ownership value. Other measures include its ability to protect the equipment from wear, scuffing, pitting, and corrosion. A high performance lubricant will extend equipment service life and reduce unplanned downtime, therefore contributing to your bottom line profits.

Evaluation of lubricant viscosity is imperative to protect all the components in a system. The kinematic viscosity of an oil is affected by a number of factors. One inherent physical property of a lubricant is its tendency to thicken in cooler temperatures and thin at higher temperatures. This change in viscosity as a function of temperature is called Viscosity Index, or VI. As a general rule, the higher the VI, the less the oil is affected by temperature change.

When formulating a lubricant, viscosity improvers (which are often polymer based) can be used to increase the VI. Viscosity modifiers are used in some EALs to push the viscosity of a low viscosity biodegradable oil to a higher viscosity value. Using viscosity modifiers with a low viscosity base oil to manufacture a lubricant can be more cost effective than to use a high viscosity base stock.

However, a lubricant containing viscosity improvers may not be as effective in high shear, high pressure, and extreme temperatures. In these conditions the oil can exhibit a temporary loss of viscosity. When shearing continues or if the forces are high enough, the polymers can break down, eventually causing a permanent loss of viscosity.

## Shear stability factors

One measure of a lubricant's protective value is its ability to withstand shearing under pressure. Shear stability describes a lubricant's ability to resist a decrease in viscosity due to exposure to mechanical loads. Maintaining the appropriate and OEM recommended viscosity is critically important to both protect the equipment and to extend the time between oil change intervals.

Lubricant thinning under stress is the result of the breakdown of viscosity modifiers. Under stress, viscosity modifiers can either align at the molecular level causing a temporary loss of viscosity – or they can break apart causing a permanent loss in viscosity. Either scenario reduces their effectiveness in service. Increasing viscosity through the use of high viscosity base stocks – without the use or only moderate use of viscosity modifiers – tend to have better shear stability.

## Lubricant effects on stern tube bearings/shaft and on thrusters

Stern tube systems and thrusters stress the lubricant due to high loads, speed of rotation, and heat. In a stern tube system, the weight of the propeller shaft and high thrust forces, combined with the speed of rotation and surface area create significant shear stress on the lubricant.

Of course, the function of a lubricant is to protect the components it is lubricating, improve efficiency by reducing friction, and reduce heat generation. But to properly protect the components, an oil relies on two main properties, viscosity and additives.

Determining proper viscosity is necessary to ensure a proper elastohydrodynamic (EHD) lubrication film. This film is essentially a wedge of oil that builds up between two moving surfaces and provides a separation. It is this separation that helps protect the surfaces from wear, pitting, and scuffing. EHD film thickness is a function of speed, pressure, surface condition, temperature, and viscosity.

A reduction in viscosity, either temporarily or permanently will reduce the lubricant's ability to create a fluid film to separate the shaft from the bearing. Thrusters operate under extreme loads as they transfer power generated by the vessel's engines, through the bevel gears of the z-drive and on to the propeller. When the correct viscosity is not maintained, an increase in micro-pitting and gear wear may occur. The lubricant selected to protect shafts, bearings, and gears must be able to withstand high shearing forces.

## Maintaining oil viscosity to protect against shearing

In practice, a good oil sampling program can be used to monitor the condition of the oil. Tracking the viscosity over time will detect loss of viscosity due to shearing.

That's why monitoring trending data is part of a successful oil analysis program. The condition of oil should always be checked against a representative baseline. A baseline can be established by directly sampling the sump soon after filling with a fresh oil and after a short duration of operation. The frequency of sampling is typically established by the OEM, or depending on the application and operating conditions, an appropriate schedule of resampling can be established. An adequate interval is typically based on the number of service hours or at set intervals to check for viscosity stability. If one of the tested parameters ever falls out of the OEM recommended range for the equipment, it should be replaced and a new baseline should be established.



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While an oil analysis program will help accurately measure how the current oil is performing, there are numerous tests that a manufacturer can perform in the lab to characterize the oil performance to help the OEM or end user make an informed purchasing decision prior to filling the system/gearbox.

A preferred method is the standard test method CEC L-45-A-99, also known as the KRL Tapered Roller Bearing test. Used by OEMs and lubricant manufacturers, this test simulates lubricant performance under shear stress in actual gear and bearing applications. It is considered the most severe of the available shear stability tests and offers the best correlation to actual field performance. The CEC L-45-A-99 test simulates a high shear condition to accelerate the breakdown of oil viscosity. To accomplish this, tapered roller bearings are used because the large surface area of the roller exposes the oil to a high percentage of shear. The test bearings are run at 1,450 rpms for 20 or 100 hours under a load equal to 5,000 N, at 60° C. The results are calculated by measuring the percentage of viscosity change between the oil viscosity pretest and the oil viscosity posttest. A small value indicates a high shear stability, while a high value indicates poor shear stability.

### Results of testing shear stability

Internal testing of various EALs using the test method CEC L-45-A-99 has produced a wide range of results among the sample lubricants. Synthetic ester-based products that did not use viscosity modifiers produced the best results. Even after a short test duration of 100 hours, two of the samples with viscosity modifiers showed a minimum of 50% loss in viscosity.

However the two oils that were formulated without viscosity improvers maintained a consistent viscosity. Even a small drop in viscosity can drop the ISO viscosity grade down into the next VI category permanently. Running too light of an oil viscosity can reduce the lubricant's ability to provide a sufficient oil film. If this occurs, lubri-

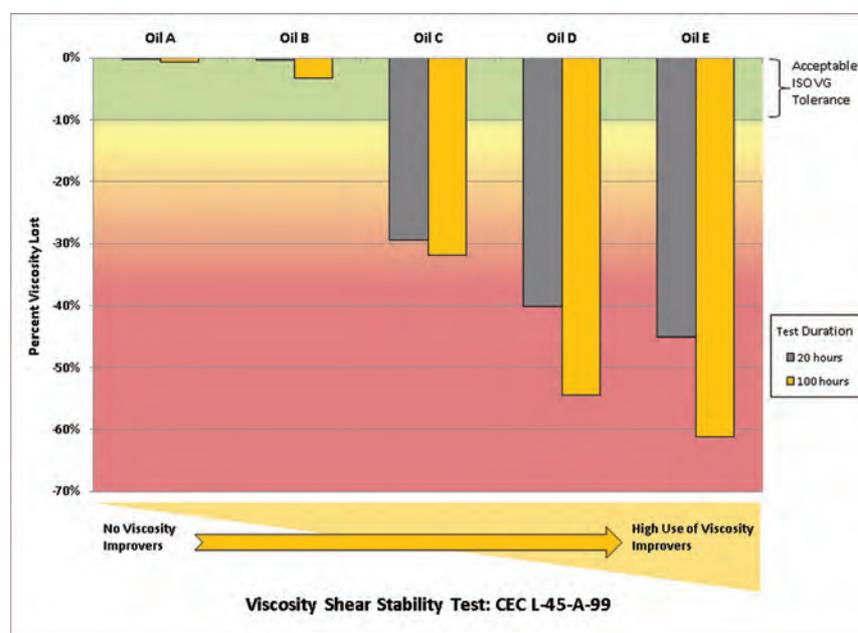
cant protection is compromised, which leads to a higher probability of premature wear, scuffing, and pitting.

### Conclusion

EALs are formulated to protect the environment. But there is no need to select an EAL that compromises the protection of thrusters or shaft bearings.

Careful selection of EALs is necessary to prevent failures of bearings and gears. Protecting against shearing stresses is achieved by selecting EALs with a high VI. But lubricants that employ viscosity modifiers to raise VI can compromise shear stability. Selecting an EAL using a base oil with an inherently high VI – assisted by a good oil sampling program – will ensure the high level of shear protection that meets today's environmental and equipment requirements.

[www.klubersolutions.com/shear-stability](http://www.klubersolutions.com/shear-stability)

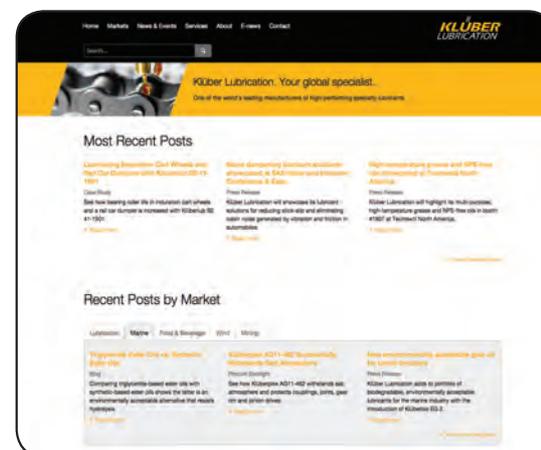


## New Klüber Lubrication Website

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See the new website from Klüber Lubrication – [www.klubersolutions.com](http://www.klubersolutions.com) – for insights into lubrication solutions and industry expertise aimed at helping you save energy, protect equipment and enhance processes. This unique ‘content hub’ gives users a wide range of reliable, convenient information about market trends and best practices, as well as oils and greases from Klüber Lubrication. For the marine market, topics include:

- **Product spotlights** that describe lubricant properties and applications – such as Klüberplex AG11-462, which is specially formulated to withstand salt atmosphere in lubricating couplings, joints and gear rim/pinion drives.
- **Blog overviews** from a Klüber Lubrication expert about special application issues – such as whether triglyceride ester oils or synthetic ester oils provide better performance in marine applications.
- **Whitepapers** that provide in-depth information about test procedures, lubricant properties and application techniques.
- **Case histories** that detail successful application in commercial vessels and deck/dock cranes.
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# New Software Requirements for Tankers & Bulkers

## Increase the Need for Software Solutions

### Tankers

IMO/adopted guidelines for the mandatory carriage of damage stability verification instruments (software, computers, etc.) onboard all (new and existing) tankers beginning in January 2016.

### IMO

IMO has adopted guidelines and applicable IMO Code amendments for the mandatory carriage of damage stability verification instruments onboard new and existing tankers. Amendments to MARPOL Annex I, BCH Code, IBC Code, IGC Code and to the Survey Guidelines under HSSC to mandate the provision of a computer program capable of calculating the applicable damage stability requirements were agreed. The approval generally applies to the software, but may include hardware, for example, when the instrument receives input from sensors for the contents of tanks.

New tankers will need to comply on delivery and existing tankers will need to comply at the first scheduled renewal survey after 1 January 2016 (1 July 2016 for Gas Carriers) but no later than 1 January 2021.

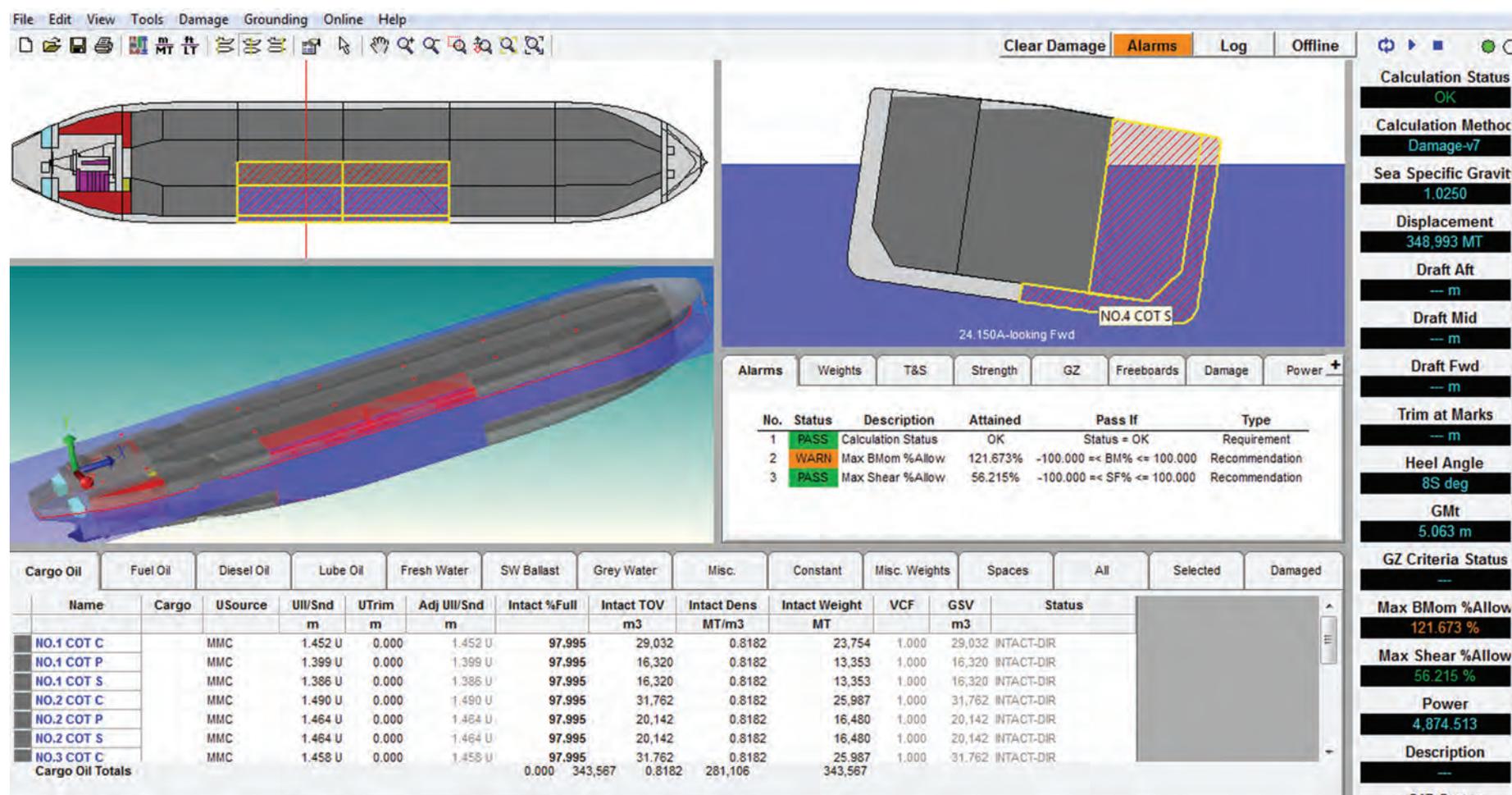
### The Issue

All tank vessels on international voyages must meet the International Maritime Organization's (IMO) requirements for damage stability. These regulations are contained in the MARPOL Convention for general purpose tankers, the IBC and BCH Codes for bulk chemical carriers,

and the GC and IGC for gas carriers.

In 2005 several Port States, led primarily by the UK's Maritime and Coast Guard Agency (MCA), recognized that many tank vessels had onboard documentation to demonstrate compliance with these damage stability requirements only when the ships were loaded in accordance with the ships standard loading conditions in the approved Stability Booklet or Loading Manual. However, during actual operations many tank ships are loaded to conditions which significantly differ from these standard loading conditions. A survey by the MCA indicated that "more than 50% of vessels are operating in conditions which are not in the approved Stability Information Booklet."

In 2010 the Paris Memorandum on Port State Control carried out a Concentrated Inspection Campaign to verify correct damage stability on oil tankers, chemical tankers and gas carriers. The reasons for this Concentrated Inspection Campaign included that inspections showed tankers frequently sailing when not complying with damage stability requirements or had no means of assessing damage stability or were sailing in a loading condition not covered by the approved Stability Booklet or Loading Manual. The Concentrated Inspection Campaign Report stated; that a significant number of tankers during a "spot check" could not show compliance with stability requirements and thus may pose a risk to the environment. It is generally understood that since most tank vessels use computer programs to evaluate stability and strength for any loading condition, there no longer is a practical incentive to stay with the standard loading conditions.



## Special Dispensation

The Flag Administration may give special dispensation from the provisions of a stability instrument in the following instances:

- *tankers where stability is remotely verified by a means approved by the Administration;*
- *tankers on a dedicated service, with a limited number of permutations of loading such that all anticipated conditions have been approved;*
- *tankers which are loaded within an approved range of loading conditions; and*
- *existing tankers provided with approved limiting KG/GM curves covering all applicable intact and damage stability requirements.*

The Administration should take into account the Guidelines for the approval of stability instruments (MSC.1/Circ.1229) when reviewing them. Stability software should be approved, but hardware approval is not mandatory and can be covered by national standards.

## Commentary on Compliance

Limiting the number of loading permutations or range of loading is not a practical operational restriction for many, if not most, tank ships. Practical reliance on gaining voyage specific approvals on a timely basis may also be a burden to both the operator as well as the national administration, and may limit operational flexibility.

Many ships are currently operating effectively and safely, using approved limiting KG/GM curves, covering all applicable intact and damage stability requirements. For this type of system the limiting KG (or required GM) curves vs. draft are pre-developed and pre-approved, and would typically be added to both the Stability Booklet and the loading computer. This would normally insure compliance with both the damage stability and intact stability requirements. However, in practice, these curves are complicated and expensive to produce, and also have other application and enforcement concerns as noted in MSC 82/18/3, "because of the need to consider all possible loading and damage combinations and any associated limiting provisions such as tank filling ratios. The resulting stability books may be complex and not easily applied by ships' officers and Port State control inspectors". For these reasons Herbert-ABS Software Solutions LLC (Herbert-ABS), generally does not recommend this approach.

The best practical solution is to fit onboard damage stability verification instruments on all tank vessels as required. A direct damage stability loading instrument provides a solution that will make it easy to demonstrate compliance with the damage stability requirements to the Port State authorities for any cargo or ballast distribution.

## The Solution

The use of an approved computer program, to verify that the non-standard loading condition complies with the damage stability requirements, can be readily applied to new ship loading computers or implemented as an upgrade to existing loading computer programs.

Loading computer programs with this feature are generally referred to as "IACS Type 3 Loading Instruments" as specified in IACS URL 5 (applicable for new buildings since July 2005), which define Type 3 as "software calculating intact stability and damage stability by direct application of preprogrammed damage cases for each loading condition."

Herbert-ABS' CargoMax™ loading computer with the Direct Damage Stability (DDS) module fully meets the requirements of IACS URL

5, Type 3, for any type of tank vessel. It demonstrates compliance with the damage stability requirements for any of the relevant regulations from IMO and national administration for any type of loading or ballast loading. It can also be used to demonstrate this compliance to Port State inspectors or vetting surveyors.

## Pre-existing Onboard Software

Loading computer software previously approved for stability can be classified as one of three types as defined by IACS UR L5:

*Type 1 software calculates intact stability only through the use of an intact required Max GM/ KG curve.*

*Type 2 software calculates intact stability and checks damage stability using a combined intact and damage stability required GM/Max KG curve.*

*Type 3 software calculates intact stability and damage stability by direct application of preprogrammed damage cases for each loading condition (DDS). Determining which software type an existing CargoMax™ falls under may not be clear through the existing approval documentation.*

It is not always straight forward to determine the URL5 type. The first place to check is the software's class approval letter. If the approval letter states that the approval is for 'intact strength only' then the software was not previously approved for stability and is not classified as a URL5 type software. While the loading program likely has either an intact only or intact/damage required GM curve, the stability portion of the program was not reviewed or approved by the classification society. If the approval letter mentions stability approval, then the software can be classified as one of the three types.

Most recent approvals mention the software type in the approval letter. However for software delivered prior to 2004 as well as for some more recent deliveries, the approval letters do not mention the type. If this is the case, the software type can be determined by review of the loading program and the vessel's Trim and Stability booklet or Loading Manual. In the loading program documentation, an inspection of the Required GM curves and calculation options could reveal the type. If the option to 'Calculate Direct Damage Required GMr' is available, then this software has Direct Damage Stability calculations enabled (DDS) and is considered Type 3. If not, then the software likely utilizes either an intact only or intact/damage required GM (or max KG) curve. The name of the curve can sometimes be taken from the program by looking at the Trim and Stability summary. If the curve is labeled 'Damage' then this program is a Type 2. The type of Required GM curve used can usually be found in the ship's Trim and Stability Booklet. If the Required GM curve is derived based on intact stability criteria only, the software is Type 1, but if the Required GM curve incorporates both intact and damaged stability, then the software is Type 2.

## Bulkers: Damage Stability Requirements for Bulk Carriers

### Introduction:

The great majority of bulk carriers are designed to the reduced B-60 freeboard, Type B freeboard, minus 60% of the distance to the Type A freeboard. With this reduced freeboard, the ICLL66 convention, Reg, 27, requires compliance with a fairly conservative damage stability standard only at the summer loadline draft. These regulations specify a

# Software Solutions

1-compartment damage, with the holds loaded at their 100% homogeneous load VCG, and a permeability of 0.90. This is usually considered by a 'design only' requirement and once the damage analysis for all 1-compartment damage is met for this design case, operationally, the ship is not required to meet any damage stability requirements.

There are two other interesting cases where other damage stability regulations apply:

## Bulk Carriers with Type B Freeboards

Type B ships constructed before February 1992 were not required to meet any damage stability standards. However, all Type B ships constructed after February 1992 are required to meet the SOLAS Ch. II-1, Part B-1 probabilistic regulations, unless they are covered by other regulations (such as Reg. 27 of the ICLL).

New retroactive requirements for bulk carriers came into force as part of SOLAS Ch. XXI. Regulation 4 of this chapter covers the new damage stability requirements, which must be met for bulk carriers constructed after July 1999, flooding each individual cargo hold. This can be considered the damage stability equivalent of the S17 hold flooding structural requirements.

It should be noted that ships meeting ICLL Reg. 27, the B-60 freeboard ships, are exempt from the new Reg. 4 requirements, so this essentially only applies to the minority of bulk carriers with only Type B freeboards.

The Reg. 4 requirements were originally considered to be a 'design only' requirement, in order to fulfill the obligation of producing a design study to demonstrate compliance with Reg. 4, which included damage of each individual cargo hold (at a permeability at 0.90), at the loadline draft, at a GM of 0.40m, and a range of trims. This was not recommended by class and they commented as follows:

*“Separate design calculations in accordance with SOLAS Reg. XII/4 are not recommended as it may introduce trim limits not defined by the designer/shipyard. Please note that the underlying principle is that the loading computer software shall reflect the required onboard documentation.”*

In compliance with classification society recommendations, the “Bulk Carrier DDS” was put to use, which includes a direct damage stability simple run through damage cases for each bulk cargo hold to

verify compliance with Reg. 4 damage stability, thereby meeting the ICLL Reg. 27 stability standard. This procedure has been implemented in CargoMax™ and when required done simultaneously with the S17 hold flooded strength calculations.

## Bulk Carriers with Type B-60 Freeboards and Deckloads

Since bulk carriers with deckloads can have a VCG even higher than the conservative 100% full homogeneous CG required by ICLL Reg. 27, these damage requirements are considered to be inadequate and need to be supplemented by the SOLAS B-1 probabilistic requirements, see IACS LL65.

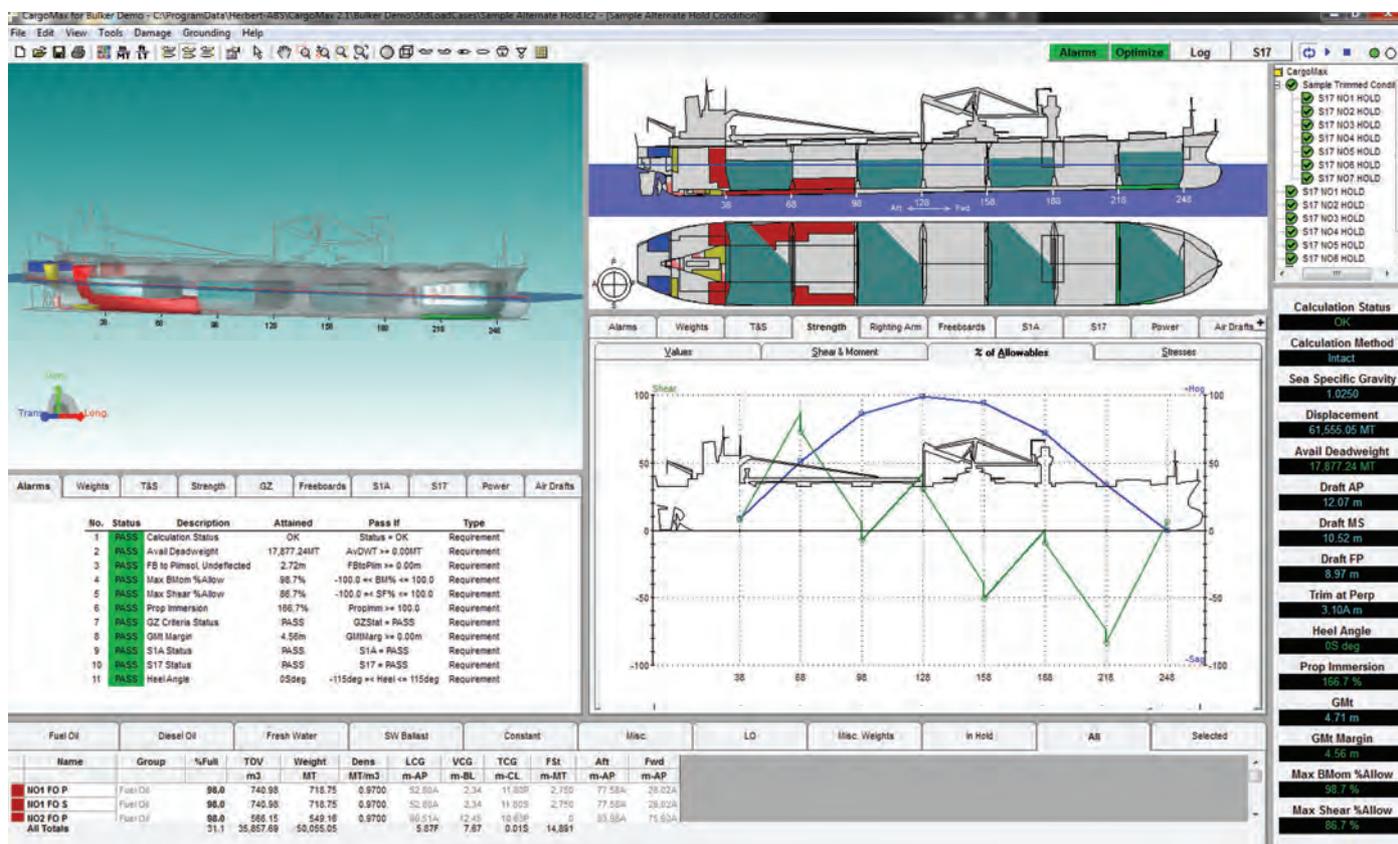
The B-1 probabilistic requirements are generally considered less conservative than the Reg. 27 deterministic requirements. Nonetheless, attention needs to be paid to provision 4 of IACS LL65, which states:

*“The KG used for demonstrating compliance with the criteria in 3a (the ICLL Reg. 27 calculations) shall be the same as that used for the criteria in 3b (probabilistic B-1 calculations) at the subdivision loadline.”*

This means that even if the B-1 calculations with a higher VCG (lower Req. GM) are met, the relatively conservative VCG (high GM) from the Reg. 27 calculations at the deep waterline must still be used. In essence this stipulates that since ships cannot have cargo with a VCG higher than the homogeneous cargo hold, they are prevented from having any significant deckload at the deep waterline. Depending on the Partial Draft Req. GM to meet the B-1 damage requirements, ships can get progressively more deckload at lighter and lighter drafts.

Class has conceded that the Reg. 27 calculations might be easily met for some ships, and the ship in question could meet the ICLL damage stability criteria with a cargo VCG even higher than the homogeneous fully loaded holds. In this case class states:

*“Redoing the ICLL Reg. 27 calculation with a lower GM (higher VCG) than required by the standard initial condition in order to use this lower GM for the subdivision draft GM in the probabilistic calculations is an acceptable solution.”*



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