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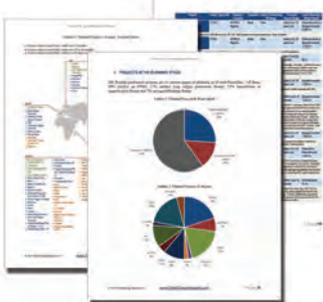
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FIVE YEAR MARKET FORECAST

Analysis of Future Business Drivers and Forecast of Floating Production System Orders between 2016/2020

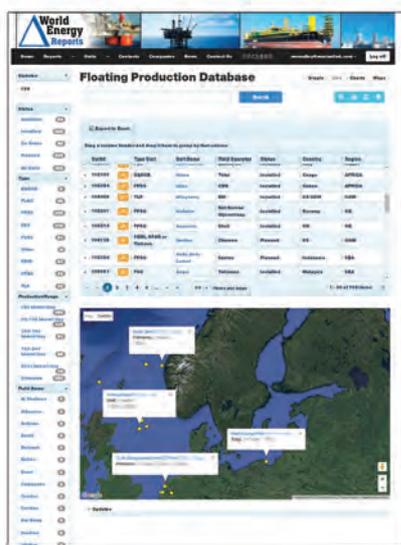
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The Lead

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Every day, industry executives turn to MarineLink.com for late breaking news and editorial. You should too.



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The Impact of Water in Your Hydraulic System

Dr. Bernard C. Roell, Jr., vice president, technology, RSC Bio Solutions

Even the smallest hydraulic system failure can be very costly in terms of lost productivity, change-out times and repairs. This is compounded in large-scale operations, such as oil rigs or dredging sites. When a hydraulic system failure occurs, it is commonly blamed on the oil or hydraulic fluid being used, and rightly so, since it is estimated that **90 percent of the time a fluid-related pump failure is due to contamination**. However, rather than simply questioning the quality or performance of the fluid itself, it is important to examine HOW the contamination occurred, what might have been done to prevent it, and to use this information to mitigate potential future problems.

According to original equipment manufacturers and tribologists, the number one cause of hydraulic system failure is water contamination. Through a series of chemical reactions, the presence of water in the system builds a corrosive environment, which shortens the life of the pump or other equipment. While it is impossible to prevent water from getting into your system, there is a series of procedures and protocols that maintenance professionals can implement to measure the amount of water in the system and work to remove it before a failure occurs.

Sources of Water Contamination

Even under the best circumstances and most controlled environments, it is virtually impossible to prevent water from entering a hydraulic system. Water can seep in through external sources (through cylinders or leaky seals, leaking into external reservoirs and even through rain or routine washdowns). Water can also come from internal sources, including condensation and heat exchangers. For example, a system run in hot, humid environments takes in air containing water vapor, which condenses as it cools and remains in the hydraulic system.

This water can be present as dissolved, emulsified or free water. The point at which the fluid cannot hold any more dissolved water is called saturation. Hydraulic fluid saturation points vary based on the fluid

base oil and the additives used, as well as operating conditions, including pressure and temperature.

Problems Associated with Water Contamination

One of the tell-tale signs of oversaturated fluid is cloudiness. However, in a closed system, the level of water in the system can be difficult to detect until there are problems.

RSC Bio Solutions' OEM Approvals - Proven in the Lab. Proven in the Field.

RSC Bio Solutions' products meet or exceed the performance of their petroleum based alternatives, both in customer and independent laboratory tests and in real-world applications. These proven products have more than 100 approvals from major OEMs listed below — successfully meeting or exceeding their extensive testing procedures.

AEGIR, Wärtsilä, SKF, MAN Diesel & Turbo, Becker Marine Systems, Rolls Royce and more.

Visit rscbio.com to access more information surrounding the specific product approvals.

Long before a failure, the following problems begin to occur when the saturation point is reached:

- Surface corrosion
- **Oxidation** –
Oxygen molecules in the water can begin chemical reactions to oxidize the fluid, reducing the fluid life
- Reduced viscosity, lubricity, compressibility and load-carrying capability
- **Bearing system damage** –
Water present in the bearing load can be especially damaging, creating super-heated steam that can cause a mini-explosion within the oil that can damage the fluid and crack bearing surfaces

- **Hydrolysis** –
Water and heat acting together can also cause the decomposition of ester-based fluids, causing acids to form which wear and corrode system components. Metal can serve as a catalyst for this type of chemical reaction
- **Crystallization** –
At low temperatures, ice crystals can form, impeding the operation of the system
- Higher operating temperatures can force the system to work harder and respond more slowly
- **Cavitization** –
Water can cause vapor pockets to form within the fluid, reducing effectiveness and fluid life

Comparison: EALs and Petroleum Oil - Marine Applications

Hydraulic Environmental Oil	Petroleum	HETG	HEPG	HEES	HEPR
Durability / Life Expectancy	●	●	●	●	●
Viscosity Index	●	●	●	●	●
Oxidative Stability	●	●	●	●	●
Hydrolytic Stability	●	●	●	●	●
Seal Compatibility	●	●	●	●	●
Frictional Characteristics	●	●	●	●	●
Mineral Oil Compatibility	●	●	●	●	●
Biodegradability	●	●	●	●	●
Ecotoxicity	●	●	●	●	●
Bioaccumulation Potential	●	●	●	●	●

- Very Good
- Good
- Fair
- Poor



Get the Water Out!

Water contamination is the leading cause of hydraulic system failure

Problems Associated with Water Contamination

Chemical



Oxidation, hydrolysis, cavitation, increased temperature, higher acidity, crystallization, premature additive depletion and sludge formation

Mechanical



Reduced system viscosity, lubricity and load-carrying capability, as well as surface corrosion, bearing system damage and excessive wear

The lubricant used can have a major impact on water contamination and removing water from a system.

• **Foaming** –

An excess amount of foaming can result in a slow-responding hydraulic system, as well as cavitation

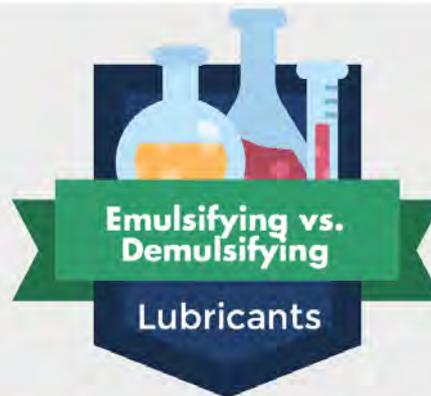
• Premature additive depletion or precipitation, reducing the effectiveness of the fluid's performance

• **Sludge formation** –

Since water is polar, it is likely to bond with other system contaminants, such as soot, resin and dirt. This can create a sludge that could overwhelm strainers and other filtration measures, restricting oil flow in the system

The Impact of Fluid Choice on Water Contamination

The type of oil or fluid used can have a major impact on water contamination and removing water from a system. Where traditional oil-based lubricants can be used on land applications, the United States Environmental Protection Agency's Vessel General Permit regulations require the use of environmentally acceptable lubricants (EALs) in marine environments. However, traditional oils and different classes of EALs react differently with water. Unlike traditional oils, which do not mix with water, some EALs, including certain hydraulic environmental synthetic esters (HEESs) and polyalkalene glycol synthetics (HEPGs) are emulsifying, which means they are intended to



While traditional oils do not mix with water, next generation Environmentally Acceptable Lubricants (EALs) react differently with water based on chemistry.

Emulsifying

Formulated to absorb water in the system
Emulsifying EALs include Hydraulic Environmental Synthetic Esters (HEESs) and Hydraulic Environmental Polyalkalene Glycol synthetics (HEPGs)

Demulsifying

Formulated to separate water from the system
Demulsifying EALs include Hydraulic Environmental Polyalphaolefin and related hydrocarbon products (HEPRs)

Advantage: Demulsifying



Most OEMs recommend draining and refilling any fluid with water content above 5 percent. As a result, the industry is trending towards wider use of demulsifying lubricants, which allow water to be easily removed through normal separating methods.

Get the Water Out and Protect Your Equipment with Demulsifying EALs from RSC Bio Solutions. Learn more at rscbio.com



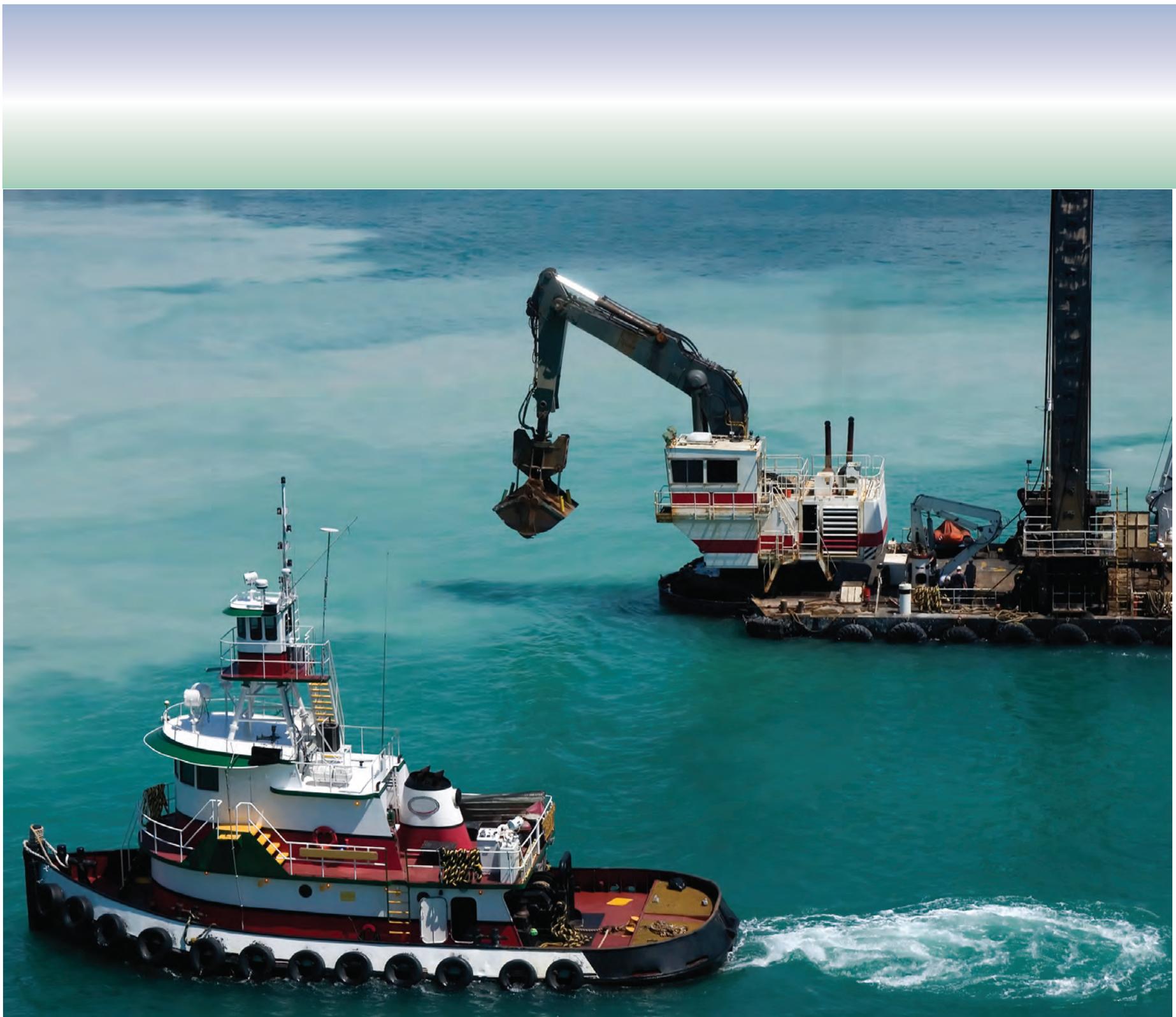
absorb water contamination. Hydraulic Environmental Polyalphaolefin and related hydrocarbon products (HEPRs), on the other hand are demulsifying, which means that they separate water out from the fluid, rather than absorbing it.

Many producers of HEESs and HEPGs have claimed that, given their fluids' ability to emulsify water, there is no need to check for or remove water from the system. However, most OEMs disagree, recommending draining and refilling any fluid with water content above 5 percent. The industry generally appears to be moving toward wider use of demulsifying lubricants, which allow water to be easily removed through normal separating methods. In the field, HEPRs generally offer longer drain intervals and enhanced performance, which can result in better long-term return on investment.

Best Practices for Preventing System Failures Related to Water Contamination

Just as myriad factors contribute to the breakdown of hydraulic oils and fluids, there are many steps that can be taken to prevent failures.

- Check fluid levels at least twice a year.
- Implement an oil analysis program. It's possible to remove the guesswork from the equation by checking fluid levels and instituting a rigorous and regular oil analysis program, which can test the level of water present in your fluids, as well as key performance indicators, such as: total acid number, viscosity and lubricity. By routinely testing your fluids, you will be armed with the information to take action

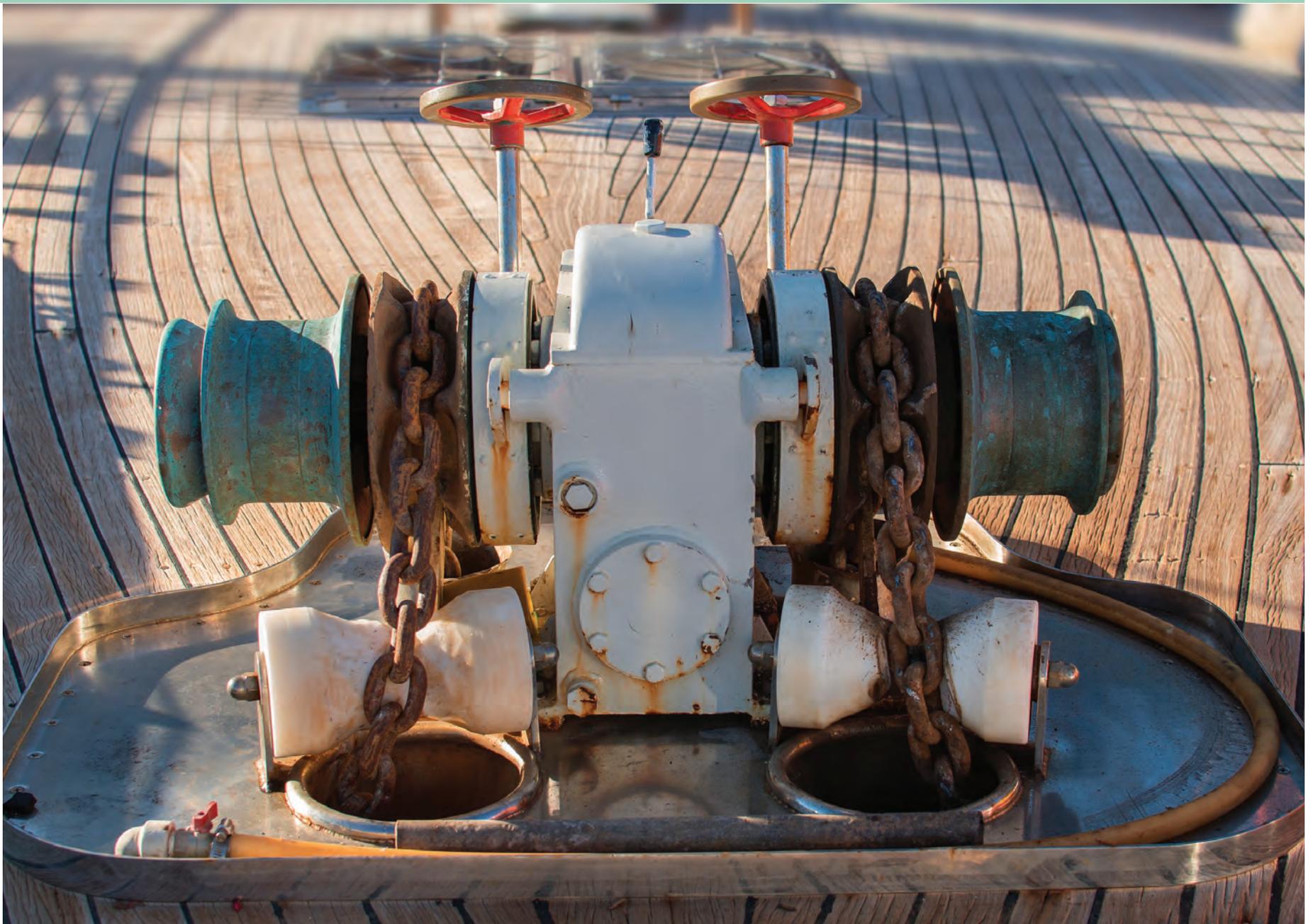


- before a failure occurs.
- Establish regular fluid change out intervals. Even the best fluids will break down over time, so use the data gained through your oil analysis to determine the optimum change out interval for your needs. While this may appear to be time-consuming or costly, the upside of doing so far outweighs the negative ramifications of a failure. Be sure to change the fluid filter when doing the oil change-out.
 - Don't ignore a perpetual leak—no matter how slow it may seem.
 - Follow equipment manufacturers' maintenance recommendations to the letter—cutting corners will cost you more in the long term.

Help is Available

Minimizing the risk of failures and maximizing the performance of this expensive equipment is a large responsibility; and everyone involved, from senior leadership, to engineers, to maintenance professional and field workers, must share in this responsibility. While this may seem daunting, there is a great deal of information and many resources available to help. OEMs have established product certifications, protocols and guidelines in place, and many fluid manufacturers can offer insight into choosing the right products for your needs. Some fluid manufacturers, including RSC Bio Solutions, offer oil analysis programs to help you get a solid understanding of the state of your fluids, their impact on performance, and what you can do to extend fluid and equipment lifecycles.

For more information, please visit us online at www.rscbio.com or call 1-800-639-8633.



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EQUIPMENT
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**YOU'RE THE ONE
GETTING SOAKED.**



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The Servitization Revolution Comes to Shipping

There is a new concept that is rapidly gaining traction in the world of business. It is called “servitization.” It describes a transformative process in which manufacturing companies shift from a product-centric orientation to an integrated product-services focus. While many companies around the world are adopting servitization strategies, it has so far not been widely accepted in the international maritime industry. This is changing. Danelec Marine, a Danish marine electronics manufacturer, is one of the first maritime suppliers to embrace servitization. The company is pioneering a comprehensive servitization strategy that permeates all aspects of its business, including product architecture, standardization of processes, quality control, worldwide distribution, after-sale service and repair, spare parts management and customer interface. This White Paper examines how Danelec Marine engineered this transformation and the implications for the maritime industry.

What Is Servitization?

Business schools define servitization as “the innovation of a company’s capabilities and processes to better create mutual value through a shift from selling products to selling product-service systems.” This is not a completely new concept. In its most elementary form, it is what happens when your mobile network carrier sells you a phone or tablet bundled with a monthly service plan. That is servitization. When an HVAC contractor sells you a maintenance agreement or an alarm company installs a system in your home with a monitoring service, that is also servitization.

Companies today are broadening the concept in creative ways as a tool to strengthen customer relationships, add value and reduce cost of ownership across the full product lifespan, while gaining competitive edge and creating recurring streams of revenues and profits.

Rolls Royce, for example, is often cited as a servitization pioneer. Instead of selling aircraft jet engines, Rolls Royce now sells “power by the hour.” The customer buys power, not engines. Rolls Royce guarantees the engines will work and provides technical support and service as part of the transaction. Likewise, Alstom, a manufacturer of diesel engines for railroads, provides a guaranteed level of performance. If an Alstom-powered train is late due to an engine failure, Alstom incurs penalties of nearly a thousand dollars per minute for the delay.

Consider also the example of Microsoft. In the past the software giant sold its MS Office suite as a “product,” with a one-time purchase price for the license. The latest version, Office 365, is being marketed as a “collaborative cloud-based service” in which customers pay for access to the software on a monthly or yearly subscription basis. This makes it easier for Microsoft to introduce upgrades and new features and ensures that all users are standardized on the same version, simplifying service calls and troubleshooting problems. It also ensures a recurring revenue stream from the product. From these definitions and examples, it is easy to see that servitization embraces a wide range of possibilities

– from extended warranty programs to complete solutions like availability contracting, performance contracting and managed services.

Maritime Manufacturers Slow to Adopt Servitization

While the servitization concept, often going hand in hand with cloud technology and the Internet of Things, is being implemented across many industry sectors, it has been slow to penetrate the international maritime industry for a variety of reasons. Most manufacturers of ship-board systems today still follow a traditional “silo” approach in which the product development, engineering, manufacturing, marketing and sales functions are separated from the service department.

Adopting a servitization strategy for products on commercial ships sailing global routes across 24 time zones presents unique challenges. Ships spend most of their time at sea, and commercial pressures mandate fast turnaround in port with a minimum of downtime. Thus, when an item of equipment needs to be repaired or upgraded, it is critically important to have the service team readily available at the port of call with technicians fully trained and equipped with the necessary parts to repair the equipment without holding up the ship’s sailing schedule. It would be prohibitively expensive for marine manufacturers to have their own factory technicians in hundreds of ports around the world, since the number of seagoing vessels is relatively small when compared with other industrial sectors, and there would not be a sufficient volume of business to keep them productively employed. So manufacturers normally contract with third-party service representatives who must be trained and certified on their products. They must also maintain depots of spare parts where they can rapidly be deployed as needed. In most cases, it is impractical to remove the system from the ship, so normally repairs have to be made while the ship is in port, or in some cases the service technicians may ride the ship to the next port and make repairs at sea.

Creating a Servitized Maritime Manufacturing Company

Danelec Marine is one of the first marine manufacturers to undertake a comprehensive servitization strategy. The company, based in Denmark,



SOLID

PRODUCT DESIGN

- **Dependable operation** | *Equipment that is built to be at sea*
Danelec products are based on an application-specific design to ensure extreme reliability. Fewer components mean fewer points of failure, resulting in the highest MTBF in the industry.
- **Future proof** | *Never obsolete, always supported*
We guarantee serviceability of our products during their lifetime for a minimum of 10 years. Since our products are developed in-house, we have full control over all components.



SAFE

SERVICE & SUPPORT

- **Immediate support anywhere** | *There is always a service tech near your ship*
Our extensive global network of service centers carry spare parts and provide service repairs 24/7 with 500+ factory-certified techs in 50+ countries.
- **World class service** | *Consistent, efficient and transparent*
Danelec eService platform™ automates and streamlines traditional manual processes, bringing unprecedented levels of consistency and efficiency to shipboard service.



SIMPLE

OPERATION & MAINTENANCE

- **Information at your fingertips** | *Capture shipboard data and put it to use*
Our range of remote access solutions enable instant and cost-optimized access from shore to ship, so that you can harness the power of big data for informed decisions and more efficient asset management.
- **Maximize uptime** | *Rest assured your ship sails on schedule*
Our exclusive SWAP technology™ enables fast and easy replacement of equipment in case of failure, without reinstalling software and reconfiguring the system.



is a leading manufacturer of Voyage Data Recorders (VDRs). Similar to an aircraft's Flight Data Recorder (sometimes referred to as the "black box"), a ship's VDR records data from onboard systems and sensors as well as voice recordings from the bridge and radio communications for playback by accident investigators in the event of an incident.

VDRs are required by international convention on virtually all ocean-going cargo ships. Like many items of mandatory ship equipment, the VDR is often treated as a commodity. Shipowners tend to purchase the least expensive minimally compliant product. In operation, it is "out of sight, out of mind." It functions in the background, silently capturing and storing data and audio recordings for retrieval later. VDRs are required to be inspected and tested at least annually. Because the VDR is a critical safety system, if it is not functioning correctly, the ship may be detained in port and not be allowed to sail until it is repaired and passes the Annual Performance Test.

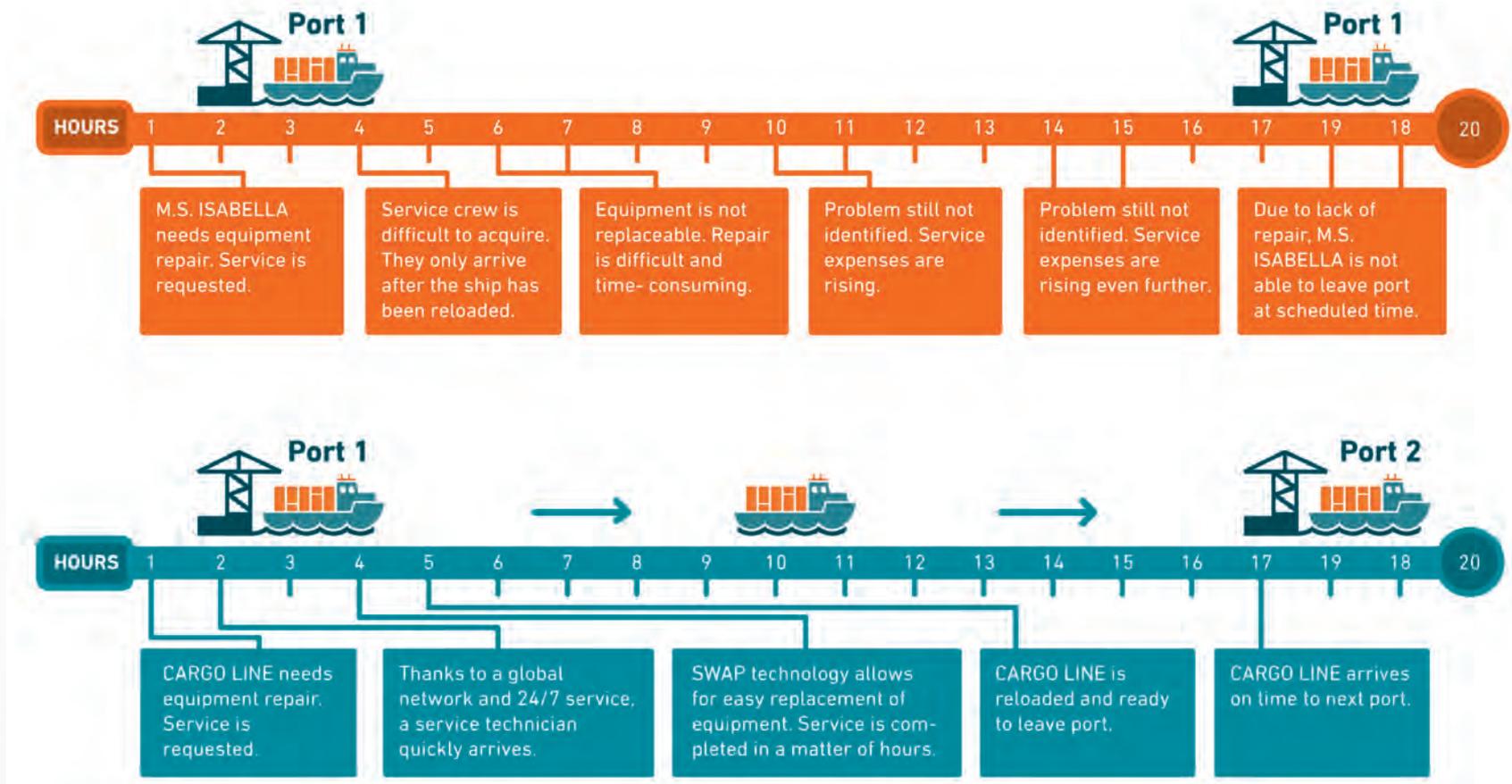
Danelec Marine was one of the first companies to develop and bring

to market ship VDRs in the 1990s, when the initial carriage requirement was adopted by the International Maritime Organization (IMO). Building on 20 years of experience with application specific product design for maritime use, Danelec Marine launched its Electronic Chart Display and Information System (ECDIS) product category in 2010, applying the same design principles known from the VDR platform. Today more than 6,000 ships are fitted with Danelec Marine equipment. As an agile organization, Danelec Marine constantly strives to find new ways to provide the most efficient product and service solutions to the maritime industry in terms of safety, optimization and total cost of ownership.

When the IMO implemented a new upgraded VDR standard, which came into effect in 2014, Danelec Marine's management team seized the opportunity to radically redesign their VDR product and – more importantly – to transform the company and its business through an integrated servitization strategy. This process took place on several different levels:

1. Designing serviceability into the product

TRADITIONAL WAY: REPAIR ON BOARD



2. Upgrading and establishing quality controls and standardized procedures across the service network
3. Using cloud technology to create a fully connected highly automated global service network
4. Redefining the role of VDR from a static product to an integrated product-service system

1. Designing for Serviceability

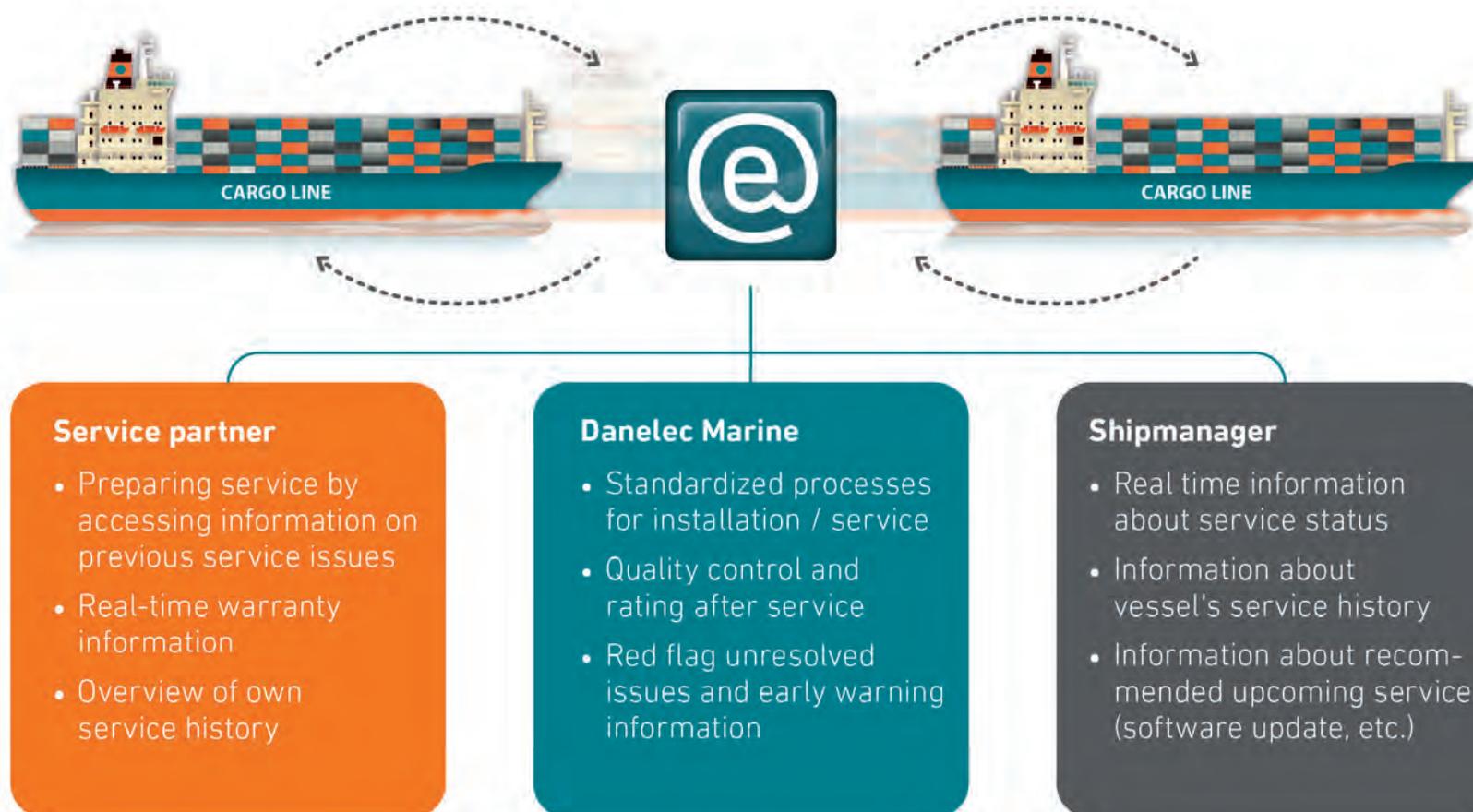
The first step in Danelec Marine's transformation was a total redesign of the VDR product with an eye toward greater reliability (fewer failures and less downtime) and easier serviceability. The company's new VDR has a purpose-built Linux-based computer rather than an off-the-shelf PC, with fewer parts and less electronics for better reliability. Since Danelec designs and manufactures its own products, the company guarantees that they can be serviced for a minimum of ten years after the end of life of the product line. In addition, with the next-generation VDR product Danelec pioneered a revolutionary new approach to shipboard service with its proprietary SWAP technology (Software Advanced Protection), in which all of the VDR's system programming and configurations are contained on a hot-swappable memory card that plugs into the front of the unit.

To fully understand the importance of the SWAP technology, consider a typical service scenario. A ship's VDR fails while at sea. The ship's master notifies the shipping agent at the next port that a service call is needed. Arrangements are made with the VDR manufacturer to have the local representative visit the ship as soon as it arrives. The techni-

cians, armed with service manuals, go aboard the ship and begin troubleshooting the problem. They discover that a component has failed, and a new circuit board must be installed, but they do not have it in stock locally. They arrange to have it shipped by air express, and return to the ship a day or two later to install the new board, reinstall software programs and perform numerous tests to ensure it is performing to specifications. Meanwhile the ship is not allowed to leave port because the VDR is a critical safety system. The ship manager incurs tens of thousands of dollars in fees and losses from the in-port delay.

Now consider the servitized scenario with SWAP technology. The service technician arrives at the ship bringing with him a replacement VDR processing unit. He extracts the memory card from its front panel slot, disconnects and removes the old unit, slides the replacement unit into the rack and re-inserts the memory card from the old VDR into the slot on the front of the new one. There is no need for reprogramming or software uploads. The VDR is immediately fully functional as soon as it is switched on. The faulty unit can then be taken ashore for repair in a Danelec-certified repair facility and if possible put back into inventory. The service call is completed in a matter of hours instead of days. The ship sails on schedule.





2. Upgrading the Service Network

At the same time, Danelec took measures to strengthen its worldwide service network, establishing the industry's most rigorous standards for service partners to ensure standardized policies and procedures. All service technicians must undergo an extensive training curriculum to become certified to perform installations and Annual Performance Tests (APTs).

Danelec cancelled agreements with underperforming service partners and appointed new stronger companies. The company also established more than 20 Certified Service Centers in strategic locations, augmenting the service coverage in over 50 countries. The Certified Service Centers are required to maintain a substantial inventory of replacement units and spares to ensure availability at short notice to ships anywhere in the world. Danelec monitors and analyzes every installation and APT to make sure they conform to quality standards. Any below-standard report triggers a requirement for remediation training for the service technician.

3. Automating the Service Process

The third phase of Danelec's servitization transformation was the launch of the Danelec eService platform, an initiative aimed at automating and streamlining shipboard service for its products around the world.

Danelec eService is an internet cloud-based solution designed to provide seamless integration of the ship service process by connecting the equipment manufacturer, the local service company and the shipmanager to ensure fast, efficient and high-quality service for ships anywhere in the world.

The eService platform uses a cloud-based portal to automate many of the traditional manual processes involved in planning and executing a service call. When a request for service is received from a shipmanager, the service company logs onto Danelec eService and retrieves information about previous service issues. The service company plans the service

call and pre-alerts the shipmanager with potential issues to be addressed, assuring that service technicians are fully prepared with the proper tools and parts, minimizing their time aboard the ship. At the end of the service call, the technician uses the Danelec eService tool to perform an automated error check procedure, to verify product performance before leaving the ship. The tool also extracts a data sample from the VDR.

Once ashore, the service technician connects to the Internet and sends the data sample to Danelec. The Danelec technical team reviews the data as part of the quality control procedure and rates the quality of the service job. If the vessel has had more than one service call recently regarding the same issue, it initiates a "red flag" warning, and the Danelec team develops a plan for solving the issue and monitoring for repeat occurrences. Reports are automatically generated to the service company's and shipmanager's eService accounts.

The eService platform and Danelec's rigorous in-house quality procedures bring unprecedented levels of consistency and efficiency to shipboard service. For the manufacturer, it ensures standardized procedures are followed in installing the system, performing Annual Performance Tests (APTs) and servicing. It also provides consistent quality control, rates the work performed by the service technicians and "red flags" any unresolved issues or early warning signs of potential points of failure. For the service company, it helps prepare for the service call by accessing information on previous service issues, real-time warranty information and an overview of the service history. For the shipmanager, Danelec eService yields information about the service status of the equipment, the ship's service history and recommendations for upcoming service.

4. Remote Access Solutions

The final phase in Danelec's transformation into a fully servitized company was the launch of VDRConnect, a remote access service that provides selective transmission of data from the Danelec VDR via satellite to the home office. The ship manager ashore can log into a portal



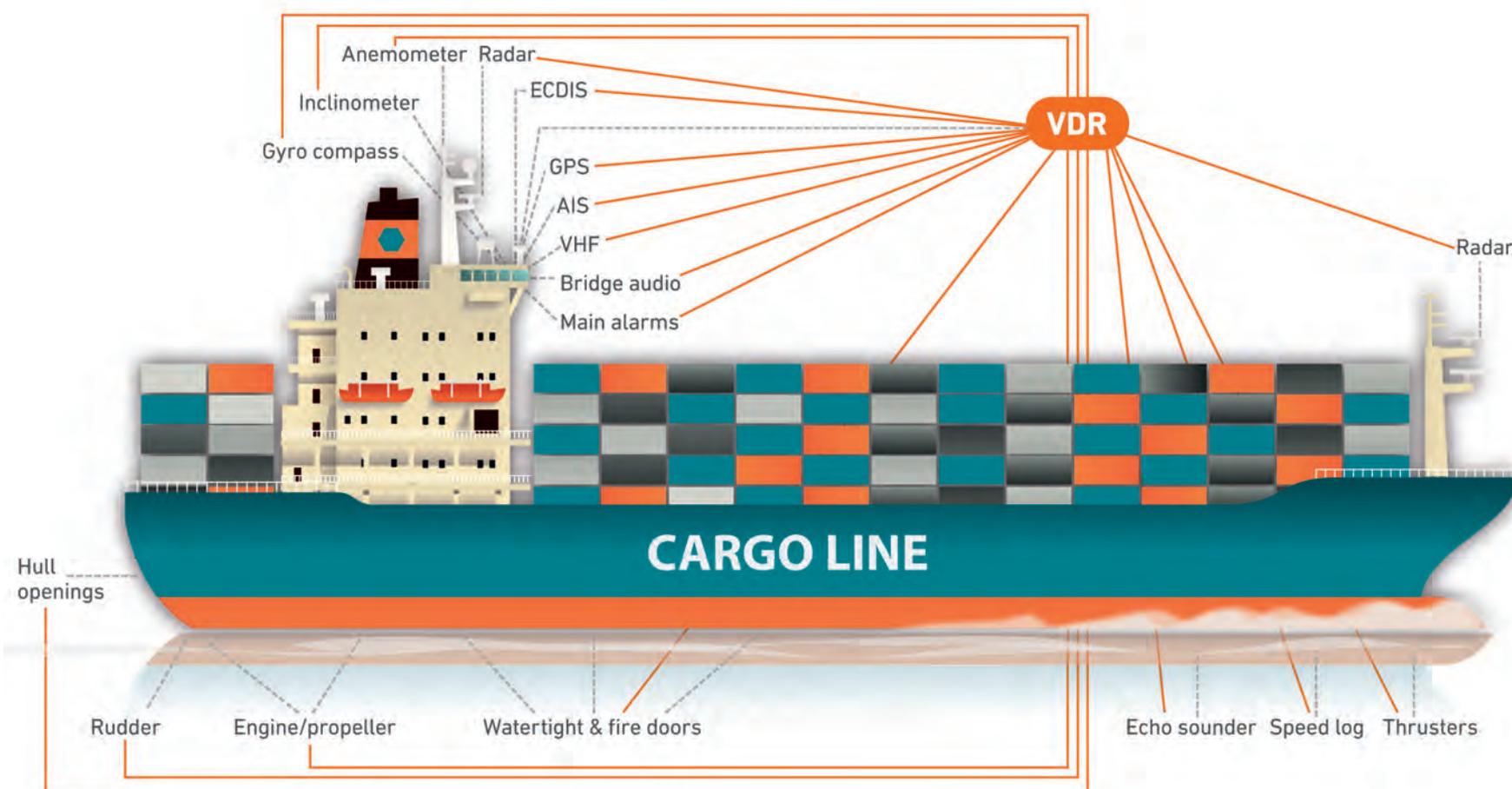
using a convenient dashboard on a computer to request specific data files to be downloaded from the Danelec VDR and select intervals for automatic transmission.

Danelec's remote access capability allows "push-through" and "pull-through" of data sets from the VDR. The ship operations team can query the VDR at any time requesting data from specific sensors or set up a schedule of downloads from each sensor, under dynamic control from the computer. The VDRConnect service is optimized for narrowband satellite channels for ship-shore transmission for additional cost savings.

There are a number of potential uses for the remote access solution. It can provide a useful tool for detecting unsafe practices, analyzing incidents and correcting navigational mistakes. Using data from the VDR, the ship manager can set up remedial crew training, correct poor

practices and create event-driven roles for parameters for automatic reporting from ship to shore. It also provides a portal for remote configuration of the VDR, reviewing mandatory data for the APT or troubleshooting a problem with the VDR prior to a service call. It can provide an immediate warning to the ship manager ashore if any devices sending data to the VDR should malfunction.

Thus, the VDR continues to fulfill its primary role of recording data for accident investigation, while also assuming a secondary role as the data hub for a ship telematics system. Using the VDR as a central data collection point and clearing house greatly reduces the cost of installing and maintaining a dedicated data network aboard ship, with serial and analog cables and/or wi-fi connections with numerous items of equipment throughout the ship.



Summary

Servitization as a business strategy is sweeping through most industrial sectors. It has benefits for all parties on the sell side and buy side. For the manufacturer it provides competitive differentiation, deeper relationships with customers, enhanced customer satisfaction and loyalty, and a source of recurring revenues. For the customer it provides more value for the money and lower cost of ownership, as well as faster and better after-sale service and support. It is clearly the wave of the future in business relationships, and the time is right for the maritime industry to climb aboard.

For more information, visit www.danelec-marine.com.

WE PROVIDE THE MOST EFFICIENT PRODUCT AND SERVICE SOLUTION TO THE MARITIME INDUSTRY



**SAFETY
FIRST**

Safety at sea is priority #1



**OPTIMIZATION
OF OPERATIONS**

Enhance fleet operational efficiency



**TOTAL COST
OF OWNERSHIP**

Maximize return on investment

SOLID

PRODUCT DESIGN

- **Dependable operation** | *Equipment that is built to be at sea*

Danelec products are based on an application-specific design to ensure extreme reliability. Fewer components mean fewer points of failure, resulting in the highest MTBF in the industry.

- **Future proof** | *Never obsolete, always supported*

We guarantee serviceability of our products during their lifetime for a minimum of 10 years. Since our products are developed in-house, we have full control over all components.



High quality Danish design
10+ years service guarantee

SAFE

SERVICE & SUPPORT

- **Immediate support anywhere** | *There is always a service tech near your ship*

Our extensive global network of service centers carry spare parts and provide service repairs 24/7 with 500+ factory-certified techs in 50+ countries.

- **World class service** | *Consistent, efficient and transparent*

Danelec eService platform™ automates and streamlines traditional manual processes, bringing unprecedented levels of consistency and efficiency to shipboard service.



24/7 worldwide service & parts
Danelec eService platform™

SIMPLE

OPERATION & MAINTENANCE

- **Information at your fingertips** | *Capture shipboard data and put it to use*

Our range of remote access solutions enable instant and cost-optimized access from shore to ship, so that you can harness the power of big data for informed decisions and more efficient asset management.

- **Maximize uptime** | *Rest assured your ship sails on schedule*

Our exclusive SWAP technology™ enables fast and easy replacement of equipment in case of failure, without reinstalling software and reconfiguring the system.



Remote access solutions
SWAP technology™

MAXIMIZE YOUR POTENTIAL.



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