U.S. Department of Transportation
Maritime Administration
Office of Shipbuilding and Marine Technology

Energy Technologies

Newsletter No. 04 Winter 2003-2004

Introduction

This issue focuses on some important developments in the effort to foster and promote energy related improvements in the maritime industry. Specifically, this Newsletter describes:

- one vessel under construction with low-emission technology;
- three demonstration projects (one completed, two planned);
- one Norwegian vessel constructed with LNG as the primary engine fuel; and
- a new U.S. research vessel with a goal to reduce the rate of engine emissions by 90 percent.

All of these efforts are directed at advancing the state-of-the-art methods to reduce air emissions while gaining experience on economical and operational factors that are critical in future decision making.

For several of these projects, the potential for using reduced marine emissions to offset larger corporate or area inventories was a prime factor in the technology decisions.

INSIDE THIS ISSUE:

New-Build Vallejo Ferry with SCR

Photo courtesy of Dakota Creek Industries

The city of Vallejo, California, operates Vallejo-Baylink, a passenger-only, fast-ferry system serving Vallejo and North Bay residents with service to and from downtown San Francisco. The city is building a fourth ferry to add to its fleet. The new build will be a low emissions ferry utilizing urea-based selective catalytic reduction (SCR).

The ferry is 131 feet (40m) in length and carries 301 passengers at a service speed of 34 knots on the one-hour trip to San Francisco.

Main propulsion will be provided by a pair of IMO-compliant MTU/DDC 16V-4000 series diesel engines producing a total driving power of 4,500 kW. The SCR equipment supplied by Steuler Industriewerke GmbH of Germany through Pacific Detroit Diesel of Kent, Washington, will reduce NOx by 50 percent, along with 10 percent reductions in total hydrocarbon (THC), carbon monoxide (CO), and particulate matter (PM).

The vessel is currently under construction at Dakota Creek Industries in Anacortes, Washington, and is scheduled for delivery to Vallejo in April 2004.

The emission reduction installation is jointly funded by the Federal Transit Administration and the state of California.

HIGH-SPEED FERRY TESTS COMPLETED WITH AIR HUMIDIFICATION AND LOW SULFUR FUEL

Through a Cooperative Research Agreement with SCX Ferries, Inc., MARAD has completed emissions testing to determine the emission reduction potential of an air humidification system and of low sulfur fuel on a hydrofoil ferry serving the San Diego, California, commuting area. The Department of Energy funded the services of West Virginia University's Mobile Source Testing Laboratory to conduct the emissions measurements.

During the testing, the ferry was conducting a commuter demonstration between Oceanside and San Diego, California, under an arrangement with the Port of San Diego and the California Department of Transportation (CALTRANS). The 149-passenger hydrofoil, the *WaveRider*, is approximately 80 feet (24m) in length and is powered by four high-speed Detroit Diesel 12V92 compression ignition engines driving two water jets. The engines are each rated at 1050 BHP at 2300 RPM.

To reduce NOx emissions, a water injection (fumigation) system was installed. The objective of the water injection system is to increase charge air humidity that reduces peak combustion temperatures and the formation of NOx. Water is injected at the turbocharger outlet. The controls on the installed system were simple on/off with no modulation in water flow rate in response to load. The system is deactivated if the manifold air pressure drops below a preset value. The water injection system was supplied and installed by M.A. Turbo/ Engine, Ltd., of Vancouver, British Columbia.

To reduce particulate matter (PM), ultra low sulfur diesel fuel was purchased (15 ppm sulfur). The standard marine fuel contained 3940 ppm sulfur while, due to some apparent cross contamination, the lower sulfur fuel was post-test sampled at 320 parts per million.

With the standard fuel, the brake-specific mass emissions of NOx were reduced by about 16.5 percent when the water injection system was turned on. There may also have been a slight

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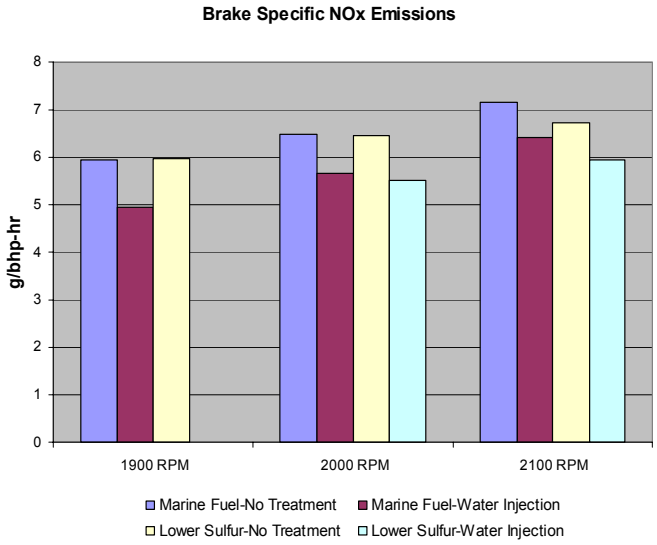

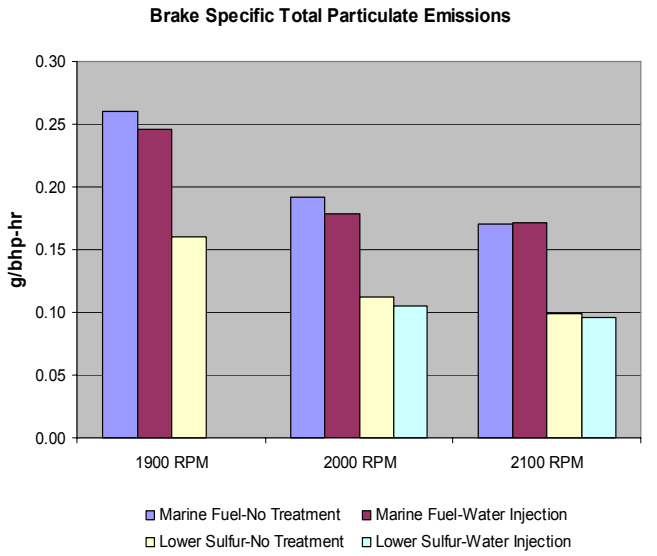

THE WORLD'S FIRST GAS-POWERED CARGO SHIP

This article was contributed by Kjell Sandaker, Project Development, Eidesvik AS, Norway

Following three years of development, the world's first gas-powered cargo ship is now in operation.

Viking Energy

The offshore supply ship, named *Viking Energy* is powered by liquefied natural gas (LNG) with dual-fuel engines.

The shipping company Eidesvik AS in Norway took the initiative and headed the development of the gas-driven ship concept in close cooperation with Statoil and the local naval architects Vik-Sandvik AS. The project comprises two ships, where Eidesvik AS and Simon Møkster Shipping AS will own and operate one ship each. *Viking Energy* was delivered from Kleven Verft in April and *Stril Pioner* in July 2003. Both ships are on a ten-year charter for Statoil.

The driving force behind this development has been the environmental issue. The project was triggered when Statoil in June 2001 obtained an agreement of intent with the Norwegian government that NOx reductions on the ships could be traded in Statoil's corporate environmental account. By this agreement Statoil could assign a defined value to the emission reductions. This compensates for the higher charter rate asked for the vessel due to the additional investments required for the gas installations.

Reduced emissions: By operating on gas, the emissions of NOx are reduced by approximately 90 percent and of CO_2 by approximately 30 percent compared with operating on diesel. For the given operational profile, the emissions of NOx is reduced by 60 kg and of CO_2 by 1175 kg for each ton of LNG consumed. The yearly consumption of LNG is estimated at 3000 – 3500 tons for each ship.

Main particulars: Ship length overall is 311 feet (94.9m), breadth is 67 feet (20.4m), and depth 32 feet (9.60m). The cargo capacity is 6000 deadweight tons with a cargo deck area 11,100 square feet (1030m²). The ship is of the all-electric type with propellers, thrusters, cargo pumps, etc., electrically driven and has an Equipment Class II dynamic positioning system. The two main propulsion units of Rolls-Royce Contaz 25 type, 4000 HP (3000 kW) each, give a maximum speed in loaded condition of about 16 knots.

(Continued on page 8)

OWNERS ASSIST NYSERDA ON A NEW YORK CITY HARBOR PRIVATE FERRY EMISSIONS REDUCTION PROGRAM

Increasing traffic congestion and the demonstrated flexibility of ferries during the aftermath of "9/11", has stimulated a resurgence of ferry ridership in the New York City harbor area. Currently, a fleet of approximately 50 private passenger ferries operates in the harbor. However, the region's designation as a Nitrogen Oxide (NOx) Non-attainment Area, is causing pressure to be applied on ferry operators to reduce air emissions. Accordingly, the New York State Energy Research and Development Authority (NYSERDA) has recently initiated a $6.8 million program to work with private ferry operators to demonstrate emission reduction technologies.


New York City Harbor

In September 2003, Seaworthy Systems, Inc., was awarded a prime contract to oversee implementation of the program. Environment Canada, Northeast States Coordinated Air Use Management (NESCAUM), and ESI International are assisting.

The Seaworthy team has been tasked to:

- conduct an inventory of all area ferries and types,
- data log the operations of four candidate vessels,
- evaluate suitable emission reduction technologies,
- work with ferry operators to install selected systems, and
- demonstrate the equipment and measure the emissions reduced.

Three local ferry companies are participating: New York Waterways, Inc. *(2 vessels)*; Seastreak, Inc. *(1 vessel);* and New York Water Taxi, Inc. *(1 vessel).* All have already offered recently constructed ferries with electronically controlled four stroke engines for the operational data logging phase. This spring, each vessel will also undergo emissions testing while first using a baseline diesel fuel and then an ultra low sulfur diesel fuel. By the summer of 2004, the outfitting of new emissions control devices and further testing will begin.

The Federal Transit Administration (FTA) is providing $5 million to NYSERDA as part of an overall NYC ferry system development program. The New York City Department of Transportation (NYC DOT) is partnering and providing the balance of funds, $1.8 million. The Environmental Protection Agency (EPA) and the New York State Department of Environmental Conservation (NYSDEC) have been integrally involved in program planning, and the Maritime Administration (MARAD) is providing technical assistance. During the program, NYSERDA will be seeking methods to deploy successfully demonstrated technologies throughout the New York harbor ferry fleet.

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STATEN ISLAND FERRY EMISSIONS REDUCTION DEMONSTRATION PROJECT

The Port Authority of New York and New Jersey (PANYNJ) has combined forces with the New York City Department of Transportation (NYC DOT) to initiate an innovative pilot project demonstrating emissions reduction technologies aboard a Staten Island Ferry.

The *MV Alice Austen* will be retrofitted with selective catalytic reduction (SCR) and diesel oxidation catalyst (DOC) systems. Over the full range of vessel operations, these systems should provide a conservative 70 percent reduction in nitrogen oxides (NOx) and a substantial reduction in particulate matter (PM), respectively. The two Caterpillar 3516 main engines will receive both systems. If funding is available, the Caterpillar 3406 auxiliary generator engines may receive DOC systems. It is also anticipated that the NYC DOT will eventually operate the ferry with an ultra-low sulfur diesel fuel.

MV Alice Austen

M.J. Bradley, an engineering consultant firm, was awarded a prime contract for program management, survey of all vessels, equipping each with data loggers, developing the initial system requirement specifications, and developing a ferry emissions measurement protocol. Emissions measurement and data logging specialists from West Virginia University are assisting. NAVSEA, Philadelphia, is performing Coast Guard liaison functions.

The Environmental Protection Agency (EPA), the New Jersey Department of Environmental Protection, and the New York State Department of Environmental Conservation have been creative forces in the program development. Each is also reviewing the emissions measurement protocol for approval. NYC DOT has requested that the Port Authority share the approved protocol with the concurrent New York City Harbor Private Ferry Emissions Reduction Program (see article page 4).

MARAD is a member of the program's Staten Island Ferry Advisory Group (SIFAG). Meetings are held monthly to help guide program activities. In December 2003, the PANYNJ issued an Invitation For Bid for the pilot vessel SCR and DOC systems. The current schedule anticipates contract award by April 2004 and system testing by July 2004.

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NEW POLAR RESEARCH VESSEL HAS LOW EMISSIONS GOAL

The National Science Foundation (NSF) has initiated a project for a New Generation Polar Research Vessel (PRV) to support year-round science in the Antarctic. This vessel has a wide range of missions including geotechnical drilling, bottom mapping, towing of nets and instrumentation in ice, a need for excellent seakeeping, and an icebreaking capability.

Artist Rendition of the Polar Research Vessel (PRV)

The Maritime Administration (MARAD) has been asked by NSF to conduct a series of technical studies related to the vessel including a study to evaluate technologies available to reduce diesel engine exhaust emissions. In particular, NSF is seeking to achieve a lower rate of nitrogen oxides (NOx) and particulate matter (PM) emissions from the power plant.

Currently, the PRV technical studies and feasibility design show that a diesel-electric propulsion plant best satisfies the scientific and operational requirements of the vessel. The power plant consists of four main diesel-generator sets, two of approximately 8,000 HP (5900 MW) and two of 6,800 HP (5100 MW) for a total of 29,600 HP (22MW). This configuration was selected because it provides great flexibility as it relates to the physical arrangement and varying electrical load. All electrical service loads including propulsors, bow thruster, winches, cranes, lights and other general ship service needs are powered from a common bus/integrated electrical system.

Diesel engines aboard existing U.S. research vessels were not subject to any emissions regulations at the time they were built. However, the new engines to be installed on the PRV must comply with recent regulatory requirements of the Environmental Protection Agency (EPA) that limits exhaust emissions, particularly lower NOx. Further reduction of NOx may be achieved by employing optional emission reduction equipment.

Several optional emission reduction technologies are currently available and more are in the developmental stage. These technologies can be divided into two broad categories. The first

(Continued on page 7)

(Continued from page 6) New Polar Research Vessel has Low-Emission Goal

Emission Estimates for Various Engine Configurations	NOx + THC (g/kW-hr)	PM (g/kW-hr)
NBP-1990 engines	20	0.50
PRV-2007 engines without optional treatment	9	0.50
PRV-2007 engines with 2003 optional technology	4	0.06
PRV-2007 engines with 2007 optional technology	2	0.03

category affects the basic combustion process and prevents the formation of undesirable air emissions in the engine. These technologies include fuel selection or treatment, electronic control of fuel injection and valve timing, ceramic coating of combustion parts, exhaust gas recirculation, and the injection of water into the combustion chamber, to name a few. The second category focuses on the removal of undesirable emissions from the exhaust after they form in the engine. These include the use of catalyzed reaction and filtration processes including selective catalytic reduction, diesel oxidation catalysts, and particulate traps.

Emissions estimates have been made for diesel engines based on various technologies and treatments for nitrogen oxides (NOx), total hydrocarbons (THC), and particulate matter (PM). These estimates are for the "off-the-shelf" regulatory compliant engines after 2007 without optional treatment, with 2003 optional technology; and with 2007 optional technology. These levels are all compared with the likely emission levels from engines on vessels of the *Nathaniel B. Palmer (NBP)* vintage.

In summary, it is clear that the new generation Polar Research Vessel provides an opportunity to capture available technology to significantly reduce diesel engine emissions. Hence, the goal of achieving a 90 percent reduction in the rate of diesel exhaust emissions has been established for the research vessel.

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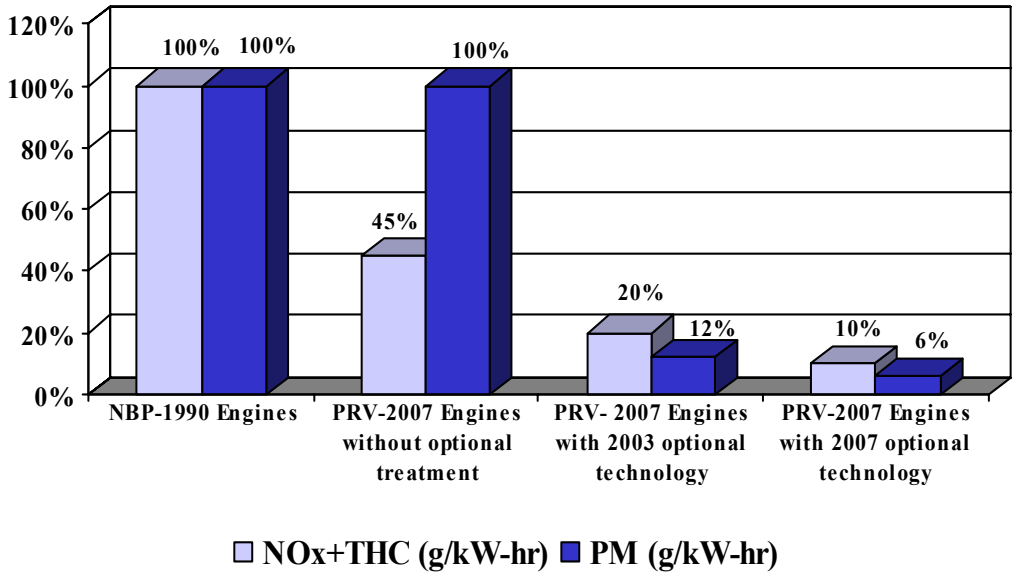
90% lower rate of diesel exhaust emissions compared to existing research vessels

Emission Reduction Per Horsepower



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FYI

CNG — compressed natural gas
CO — carbon monoxide
CO_2 — carbon dioxide
HC— hydrocarbons
LNG —liquefied natural gas
NOx — nitrogen oxides
O_2 — oxygen
PM — particulate matter
SOx — sulfur oxides
THC — total hydrocarbons
TPM — total particulate matter

ENERGY TECHNOLOGIES NEWSLETTER ...

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(Continued from page 2) ## High-Speed Ferry Tests Completed with Air Humidification and Low Sulfur Fuel

reduction in total particulate matter (TPM), but the drop was not significant. The lower sulfur fuel reduced PM by approximately 40 percent compared to the standard marine fuel while underway and 70 percent while at idle.

Using water injection in conjunction with the lower sulfur fuel also resulted in a NOx reduction of similar magnitude to that experienced with the standard higher sulfur fuel. There was no measured fuel penalty associated with using the low sulfur fuel or the water injection system.

Since there is no feedback or control on the amount of water injected into the intake, there was a larger NOx reduction at lower engine speeds, because there is a higher percentage of water injected at those conditions.

A copy of the complete report is available by contacting either: robert.behr@marad.dot.gov or daniel.gore@marad.dot.gov

(Continued from page 3) ## The World's First Gas-Powered Cargo Ship

LNG is contained in a 220m³ stainless steel vacuum insulated thermo tank with a design pressure of 9 bar delivered by AGA-CRYO AB in Gotenburg. From the tank, gas is led through a vaporiser to four Wärtsilä 6L32DF engines, each of 2010 kW and each driving a 690 V AC generator.

The concept with dual fuel was chosen for reasons of operational flexibility. Normally operation on diesel is back-up in case of abnormalities in the gas system. The dual-fuel concept, however, also allows the ship to operate on diesel fuel whenever necessary. As the infrastructure for delivery of LNG bunker to ships is limited, diesel operation may be necessary if the ship should be delayed or directed to ports where LNG is not available.

The regular operation program is for three roundtrips per week from the shore base to the offshore fields, refuelling LNG once a week. Operation on gas has appeared reliable in calm as well as stormy weather in the entire power range of 12 – 100 percent of engine load. Regular operation on diesel is only during refuelling of LNG.

Risk analyses have been used systematically and extensively as part of the development. It has been a prerequisite that safety, for this ship, was to be at least as good as for similar new, conventional ships. The ship is classed with Det Norske Veritas and complies with the newly developed regulations and requirements of The Norwegian Maritime Directorate.

The web site for Eidesvik may be found at www.eidesvik.no

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