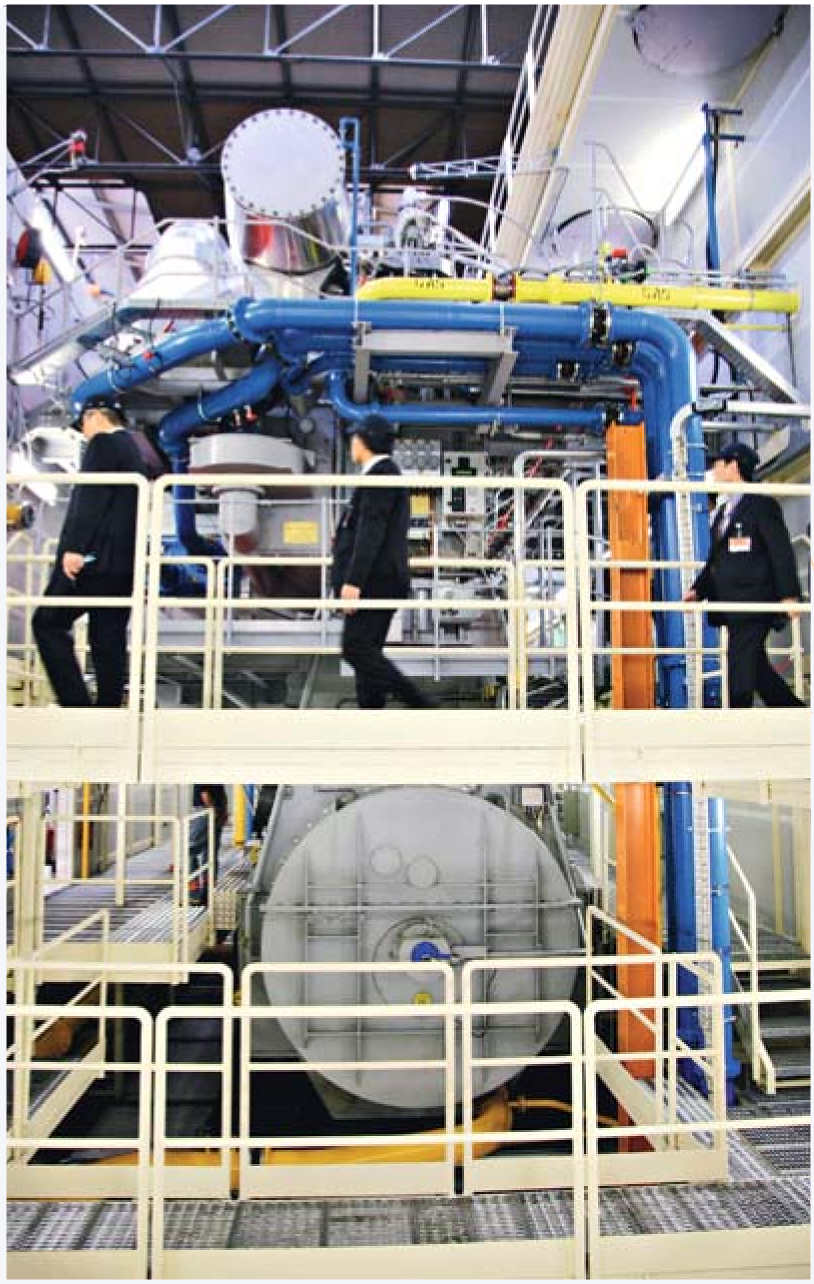

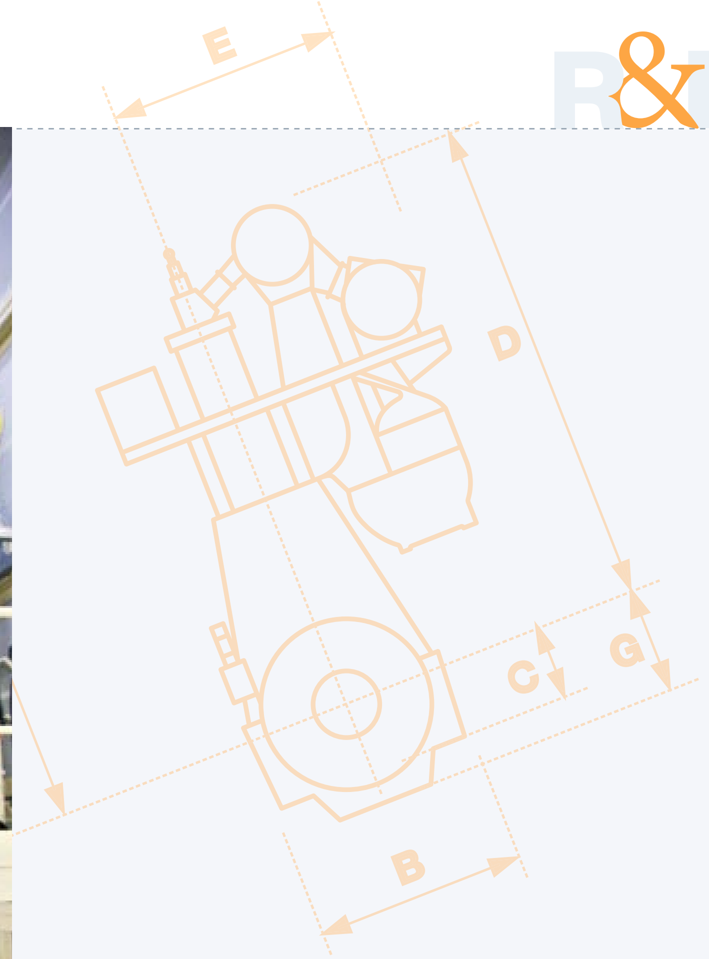

NEW TWO-STROKE GAS ENGINE
SETS NO_x EMISSIONS BENCHMARK

Wärtsilä's strategy includes offering gas-fired options in its low-speed marine engine portfolio. A new engine design currently being tested complies with the upcoming IMO Tier III emission limits on nitrogen oxides (NO_x), setting a new benchmark.

TEXT: HARRIET ÖSTER **PHOTOS:** WÄRTSILÄ

The use of liquefied natural gas (LNG) as a marine fuel is widely viewed as a realistic solution for complying with stricter environmental regulations. In the autumn of 2010, Wärtsilä initiated a development programme to expand its portfolio of gas engines to include two-stroke low-speed dual-fuel engines in addition to four-stroke medium-speed designs.

Tests on the first two-stroke Wärtsilä RT-flex50, version-D prototype at Wärtsilä's engine laboratory in Trieste in Italy have demonstrated that the new design is showing the way forward in meeting future environmental standards in the shipping sector. The IMO (International Maritime Organization) Tier III regulations on NO_x emissions that will come into force in Emission Control Areas in 2016 stipulate a reduction of 80% compared to Tier I levels.

AN ELEGANT SOLUTION

"When running on fuel oil, a low-speed two-stroke engine has to be fitted with separate selective catalyst reduction (SCR) equipment to cut NO_x emissions to the required levels," says **Ingemar Nylund**, Program Director, Wärtsilä Research & Development. "A dual-fuel engine design is a very elegant solution for meeting the new requirements: Heavy fuel oil (HFO) can be used when crossing the world's oceans and the vessel can switch to LNG within each emissions control area."

"Wärtsilä two-stroke engines operate on the lean-burn principle, and running on LNG cuts NO_x emissions by some 80% compared to operation using HFO," he says. "NO_x levels can in fact be cut even further, but there is some additional cost in terms of higher fuel consumption."

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As gas fuel contains no sulphur, the restrictions on emissions of sulphur oxides (SO_x) in emissions control areas are automatically met. Carbon dioxide emissions are also reduced and emissions of particulates are almost eliminated.

THE TIME IS NOW RIGHT

Attempts to use LNG as fuel in low-speed two-stroke engines have been made previously, but the idea was ahead of its time and the market was not ready. Wärtsilä's breakthrough in using gas in marine applications came with a series of medium-speed dual-fuel engines introduced in the 1990s.

This time the timing was right, but the availability of suitable gas supplies was limited. The large dual-fuel propulsion solutions used in LNG tankers provide them with flexibility as they can choose the fuel they use according to the cargo they are transporting. Medium-sized dual-fuel engines are also used by offshore supply vessels operating in Norwegian waters.

"To date, all the dual-fuel marine solutions use four-stroke engines," says Nylund. "The upcoming restrictions on emissions mean the time is now right for two-stroke engines to move in the same direction. This will serve all types of merchant vessels transporting goods within SO_x emissions control areas."

EXTENSIVE LNG BUNKERING PLANS

While the 'chicken-and-egg' problem - whether bunkering facilities for LNG or vessels using LNG as fuel should be constructed first - remains, the situation is now opening up. There are extensive plans for building LNG bunkering stations in locations in northern Europe, the United States and Canada. Plans for distributing fuel using small LNG tankers which enable bunkering at sea are also being made.

In the ship construction sector, developments towards employing dual-fuel solutions means that vessel designs will have to incorporate space for onboard LNG tanks. As the energy content of gas per unit volume is lower than for HFO, the amount of space required for fuel will be larger.

NEW SOLUTIONS REQUIRED

"Developing the first two-stroke gas engine prototype took about a year of intensive effort," says Nylund. "Wärtsilä has extensive knowledge and experience with four-stroke gas engines, but the technology in two-stroke engines is completely different. Many of the challenges we met demanded new solutions. The technological decisions we eventually made were not self-evident."

The most significant difference between four-stroke and two-strokes engines is that the rotational speed in the latter is much slower, about one-fifth. The combustion process must therefore be efficiently moderated and controlled to ensure that everything remains synchronised. In a four-stroke engine no corresponding special measures are required.

The new two-stroke gas engine design was developed within Wärtsilä's global R&D function. The design was carried out jointly at Winterthur in Switzerland and Vaasa in Finland. The Wärtsilä engine laboratory located in Trieste in Italy was the site for test installation as it has gas supplies.

A FULL RANGE OF ENGINE SIZES IS PLANNED

"In addition to exhibiting major reductions in NO_x emissions, the prototype design has worked well," says Nylund. "We are now studying how much power it can develop when running on gas. Our target is to achieve the same output as when running on HFO."

Tests carried out so far have been part of a feasibility study to evaluate the technological concepts. An industrial engine design is the next step. During the summer, the prototype engine will be rebuilt to enable tests at full scale and further tuning. New two-stroke dual-fuel engines could be offered to the market in mid 2013, with the first engines in operation in 2014.

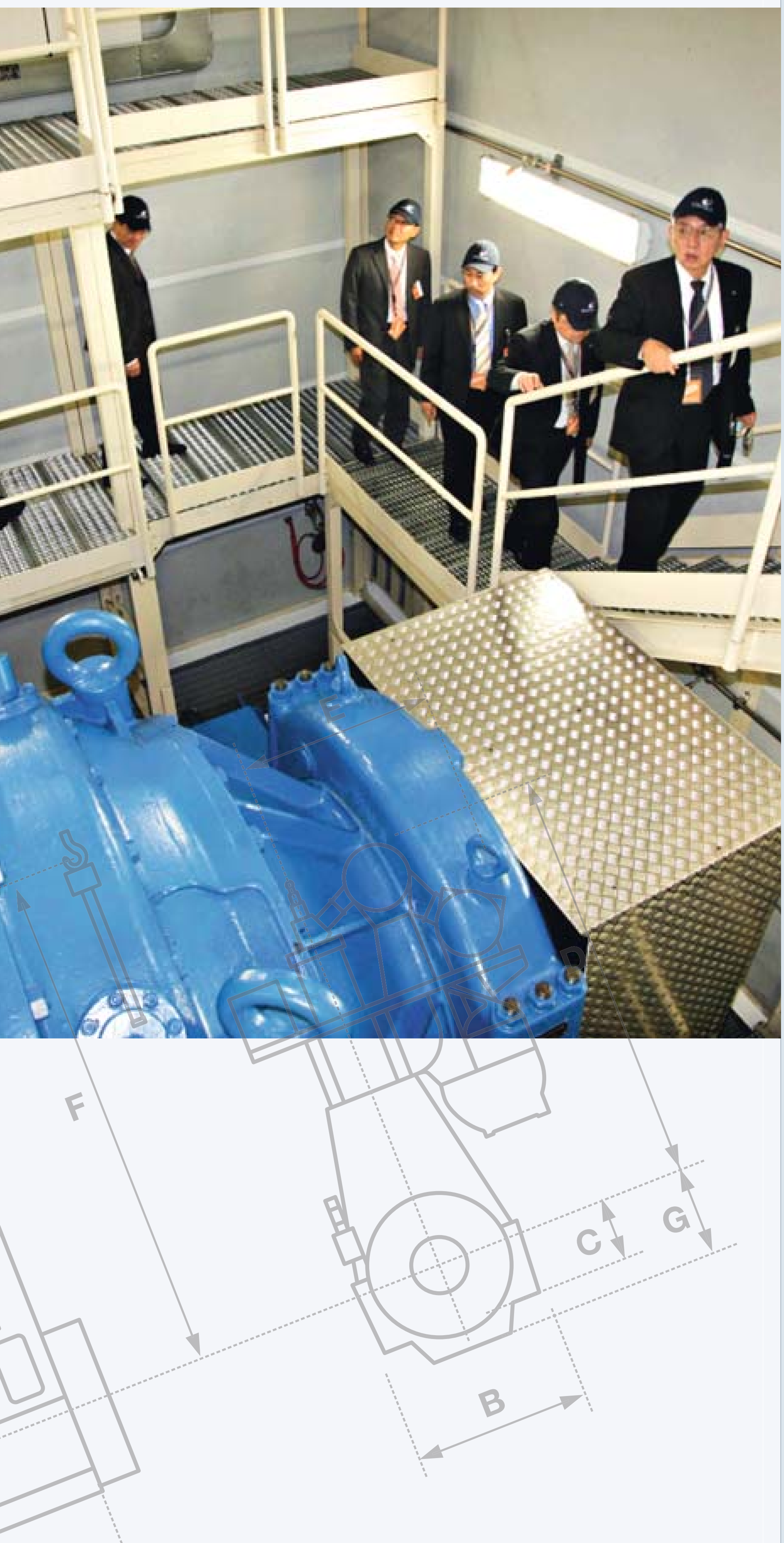
"This first two-stroke gas engine has a bore size of 50 cm," says Nylund. "We plan to apply the new technology to a complete range of engine sizes. Developing and testing these new configurations will require plenty of work, and Wärtsilä's normal customer support and service functions will be developed in parallel."

THE SPREAD OF ECAS

IMO Tier III levels for NO_x emissions will apply in NO_x Emission Control Areas (also called NECA) and enter into force at the beginning of 2016. Emissions reductions of some 80% compared to Tier I levels will be required.

The North American NO_x ECA along the US and Canadian coastlines is the only one currently in force. New NO_x ECAs are being evaluated include the Baltic Sea, the North Sea and the English Channel. An NO_x ECA in Tokyo Bay is also under discussion.

New low levels for sulphur oxide (SO_x) emissions in IMO Emission Control Areas (also called SECA) come in force in 2015. SO_x ECAs already defined are the Baltic Sea, the North Sea, the English Channel and coastal waters surrounding the US and Canada.



ACHIEVING BALANCED COMBUSTION IS THE KEY

THE VERY LOW levels of NO_x emissions created by Wärtsilä's two-stroke RT-flex50, version-D engine are a result of operating on the lean-burn principle. In this context, "lean-burn" means that the quantity of air in the mixture of gas and air fed to the engine's combustion chambers is more than is required for all the fuel to be fully burnt.

Lean combustion technology reduces the peak temperatures achieved and less nitrogen oxides are then created. The higher the air-fuel ratio, the lower the resulting temperatures and levels of NO_x emissions. As a two-stroke engine works relatively slowly, with a rotational speed only some 20% of that in a four-stroke engine, fuel combustion must be kept under complete control.

"If the combustion process is not efficiently controlled it could accelerate at too high a rate," says Ingemar Nylund. "If that happens, the resulting pressure could exceed the engine design parameters and knocking would occur."

EXCESS AIR TO CONTROL THE PROCESS

The speed at which combustion occurs is moderated and controlled through the ignition technology employed and by mixing air with the gas fuel. Higher amounts of air result in lower combustion speeds but also reduce engine efficiency. The key is achieving the right balance.

In four-stroke gas engines, the gas fuel is injected before the gas-air mixture enters the combustion chamber. In the Wärtsilä two-stroke gas engine design, gas is injected directly into the cylinder. The total greenhouse gases from a dual-fuel engine clearly stay below the greenhouse gases of an engine running on HFO.

"THE DUAL-FUEL ENGINE IS AN ELEGANT SOLUTION **FOR MEETING EMISSION REQUIREMENTS EFFICIENTLY.**"