Fig. 1 – The M/S Coral Princess is powered by two 16-cylinder Wärtsilä 46 common rail engines that have already accumulated more than 30,000 running hours each.

Common rail engine – how are you today? Wärtsilä medium-speed common rail engines exceeds 540,000 running hours

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Smokeless operation has rapidly become a requirement for marine vessels, especially for cruise ships. Just prior to Christmas 2002, a new cruise ship was delivered from the Chantiers de l'Atlantique shipyard in France with the first smoke-free diesel machinery. How are the common rail engines doing today?

Smoke-free cruising

The 294 meter long M/S Coral Princess spends the winter season in the Caribbean, before sailing the waters of Alaska and the west coast of the USA from May to September. Here, environmental restrictions can be demanding, and in Alaska a smoke-free operation is mandatory.

The 1970 passenger Coral Princess has been in service for about four years. Her two 16-cylinder, Wärtsilä 46 common rail (CR) engines in V-configuration have now accumulated more than 30,000 running hours each. In addition to the M/S Coral Princess, there are today seven cruise ships in operation using Wärtsilä 46 CR engines, and one of them is the famous and elegant Queen Mary II.

Introducing new technology is always demanding. This is especially so for a cruise ship where the demand on the availability and reliability of the machinery is high. However, as a result of several years of experience with numerous installations, we can attest that both the availability and reliability are extremely high on all Wärtsilä CR engines.

Smoke-free engine operation was already achieved at the engine factory tests using both FSN and Ringelaman measurements. Nevertheless, although the engine settings had been tested and tuned to smoke-free operation on all loads during various laboratory tests, under certain operating conditions, the fuel used in the Caribbean area was still causing visible smoke.

However, thanks to the customised setting engine tuning features of the CR engine, by simply changing a few parameters within the engine control software, the problem was overcome and operation using Caribbean fuel types was also made smoke-free.

Last but not least, the reliability and the lifetime of the components are today well on a par with a conventional diesel engine.

Experiences with Wärtsilä 46 CR fuel injection equipment

The common rail is built using one accumulator per two cylinders. The accumulators are connected to each other with small-bore pipes to eliminate pressure waves in the rail. All visual leak indicators are also integrated into the accumulators. Except for some minor leakages in the beginning, the accumulators have performed very well.

The fuel injection pump is operated by a double cam. Each fuel pump feeds one common rail accumulator, while the flow to the pump is controlled by a flow control valve. Cavitation is sometimes a risk in any fuel injection pump, especially with newly-introduced designs. The simplified fuel pump element used in the common rail pump has, however, been totally free from cavitation from the very beginning. This has also been verified in all pump service inspections.

Based on our experiences so far, the service lifetime of the common rail injection pump is expected to be far longer than for a conventional pump. Figure 2 shows a pump plunger at the 24,000 hr inspection. No cavitations or any wear could be detected when making measurements and inspections. The pump tappet is of a proven design, and has been used for many years in conventional fuel injection pumps. It has also worked exceptionally well with common rail injection pumps.

The common rail fuel injection valve is perhaps the most important part of the common rail injection system. The common rail system is designed with a triple function to prevent fuel entering the combustion space when it should not. The three step function includes: 1) the nozzle seat, 2) the shuttle valve and 3) the flow fuse.

Initially, the lifetime expectancy of the shuttle valve seat gave cause for concern. The material used at that time was hardened steel, and because of that choice of material, there was a certain amount of flow erosion. Although the seat maintained its functionality, the gradual erosion of material led us to conclude that its lifetime was not acceptable. Today the seat is made of tungsten-carbide, and this design more than meets lifetime expectancy criteria.

Upon inspection following 9221 running hours, the latest design version of the shuttle valve has been found to be in excellent condition, see Figure 3. The injection nozzle is also in excellent condition with no cavitations found during inspections. The service interval and the lifetime of the nozzle are also longer than for conventional equivalents. See Figure 4.

■ Fig. 2 – A pump plunger at the 24,000 hr inspection with no detected cavitations or wear.

Experiences with engine control and automation

The automation system used for current Wärtsilä CR engines comprises an injection and rail pressure control system, which is incorporated within the standard engine alarm and monitoring system. Thus this automation package is also easy to install on existing engine retrofits, as are too the fuel injection components.

Surprisingly, the major challenges with the first versions were cable and connector problems on the so-called manufacturing friendly cable harness system. This cabling system was swiftly replaced with a more traditional point to point type of cabling that withstands oil-, heat-, and mechanical stress. This cabling uses as few connectors as possible.

Today, our policy is also that military type connectors should be used only where service friendliness is seen as being as important as reliability. Therefore, engine speed and engine phase detection sensors, the flow control valve-solenoid, common rail pressure sensors, and the common rail pressure relief/safety valve solenoid are connected directly to the input/output in the control modules. Hence there are no vulnerable connection points, and the Electromagnetic Compatibility (EMC) type of metal cable glands at each cable provide excellent disturbance protection. Sensor reliability has been influenced by problems related to previously used connectors. In short, very few common rail related sensors have failed.

The most vulnerable part in the electronic system has, as expected, been the drive electronics, i.e. the injector solenoid control module that uses high current/high voltage. The high electrical current required by the first generation injector solenoids as used on the Wärtsilä 32, decreased the lifetime of the drive electronics. The cylinder control module that we use today is performing well. This we achieved after lowering both current levels of the Wärtsilä 32 injectors, and increasing the current limits of the output stage electronics.

Engine operators are provided with a high performance tuning and troubleshooting tool: the WECSplorer. With WECSplorer, engine parameters are →

Fig. 3 – The latest design version of the shuttle valve is in excellent condition after more than 9220 running hours.

made accessible for performance tuning, as for example, in exhaust temperature and cylinder pressure balancing. If there is a need for troubleshooting, a parameter trending capability down to millisecond level can be made, which facilitates tracking of fast events.

The tool also provides full control over software/parameter backup. Since the latest and most accurate software is downloaded to a new onboard spare part module, flexible spare part handling is made possible. If technical assistance is needed, WECSplorer recorded data packages can easily be exported and sent to Wärtsilä for evaluation and remote troubleshooting. Remote online connection is also possible over Ethernet/LAN connection.

The flexibility of the computer control system allows easy use of different running parameters for different fuels, and for operation in different 'multiple map' areas.

Engine availability and performance

Cruise ships operate in very demanding environments, regardless of whether we look at it from an availability and reliability point of view, or from an exhaust gas emission point of view.

With twin diesel electric machinery and one gas turbine, the cruise ship Coral Princess, like its sister ship the Island Princess, requires high reliability and availability of the diesel engines, especially with rising fuel prices. The diesel engines are used for all cruising operations, and are supplemented by gas turbine power when high cruising speeds are required. Typically the diesel engines accumulate more than 7000 running hours a year.

The engines are operating well below the primary target of the exhaust gas smoke level, ensuring a smokeless start-up and operation under all loads.

Wärtsilä common rail engine portfolio in service

Today the common rail technology is available in both medium- and low-speed Wärtsilä engines, with the medium-speed engines being the Wärtsilä 20, Wärtsilä 32, Wärtsilä 38, and the Wärtsilä 46 types.

Wärtsilä 32 CR engines are installed in different types of ships, for propulsion in smaller vessels and as auxiliary engines in the large ships such as containerships, tankers and others. The first Wärtsilä 32 CR engine was installed as an auxiliary engine in the containership M/S Axel Maersk in 2003. This auxiliary engine has today logged more than 13,000 running hours. The Wärtsilä 38 CR can be found as main engines in cruise ships and yacht carriers. The latest addition to the Wärtsilä CR engine portfolio is the Wärtsilä 20 engine, the first of which will begin operating as an auxiliary engine, parallel to the Wärtsilä 38 CR main engines, in a yacht carrier later this year.

Altogether, 42 Wärtsilä common rail medium-speed engines are currently in operation, and have accumulated more than 540,000 cumulative running hours.

Reliable technology supported by a dedicated service network

The common rail technology is now well established on the marine market. Wärtsilä CR engines have also been selected in the building of a number of new vessels during recent years. While most have been cruise ships, other types of vessel are also increasingly turning to this technology. Special tools and test benches have been developed to facilitate common rail maintenance.

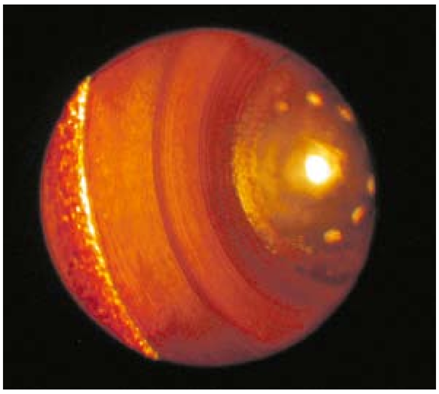

Fig. 4 – The service interval and lifetime of the CR nozzle are longer than for conventional equivalents.