ENERGY
ENVIRONMENT
ECONOMY

WÄRTSILÄ PULSE LUBRICATING SYSTEM

OPERATIONAL COST SAVINGS, IMPROVED MAINTENANCE FRIENDLINESS AND RELIABILITY WITH NEW PULSE LUBRICATING SYSTEM

Thanks to intensive research and development and a constant strive for product improvement, Wärtsilä has taken another step in the direction of decreasing cylinder oil consumption and increasing piston running reliability on two-stroke marine diesel engines.

Since 2007 the so-called Pulse Feed cylinder oil injection principle has been the standard on all new Wärtsilä two-stroke marine diesel engines with a minimum guide feed rate of 0.70 to 0.80 g/kWh.

In the meantime, however, the so-called Pulse Jet principle that was originally introduced with the electronically controlled Pulse Lubricating System back in 2006 has been carefully reviewed and re-designed. Comprehensive testing both in the laboratory and in the field has shown good and convincing results, and the Pulse Jet principle will be re-introduced on new engines.

When compared to the standard Pulse Feed-based system, tests with the new Pulse Jet-based lubricating system have shown improved performance regarding both cylinder lubrication and component reliability, and hence a minimum guide feed rate of 0.60 g/kWh is feasible for the new system.

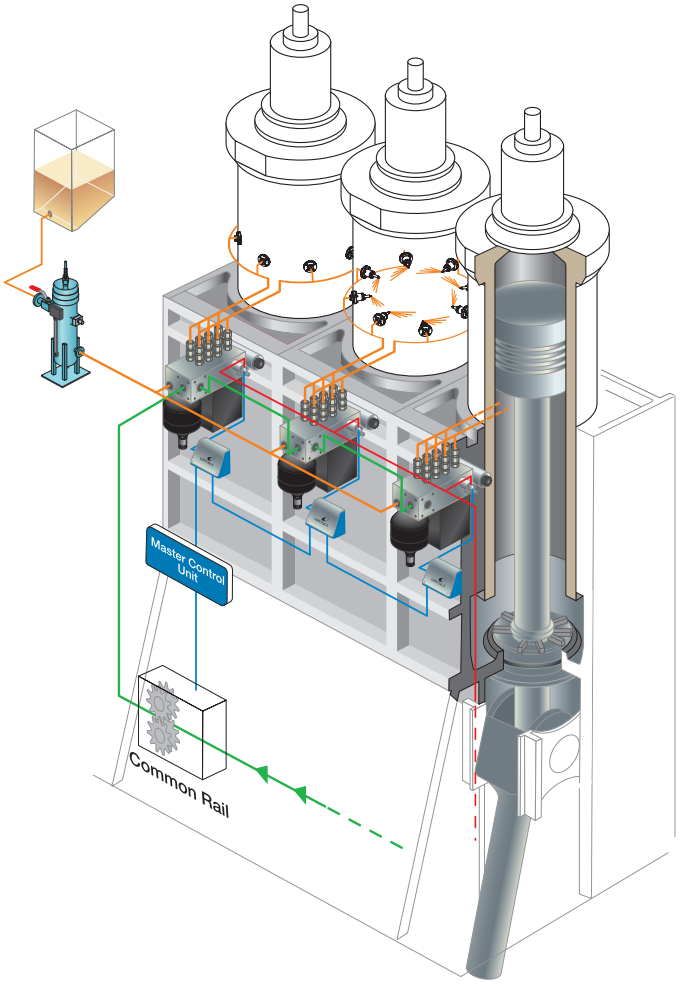

Figure 1. Arrangement of Pulse Lubricating System on RT-flex engine

BENEFITS

The major benefits of the new Pulse Lubricating System are:

- Lower guide feed rate* than the current standard for the benefit of operational costs and the environment, i.e. less particulate emissions from the funnel and less sludge from the piston underside space
- Reliable piston running at low load operation* over longer periods
- Improved maintenance friendliness
- Improved component reliability

*) In order to safeguard piston running in all operational conditions, it is highly recommended to follow Wärstilä's guidelines regarding the sulphur content in the fuel and low load operation over longer periods.

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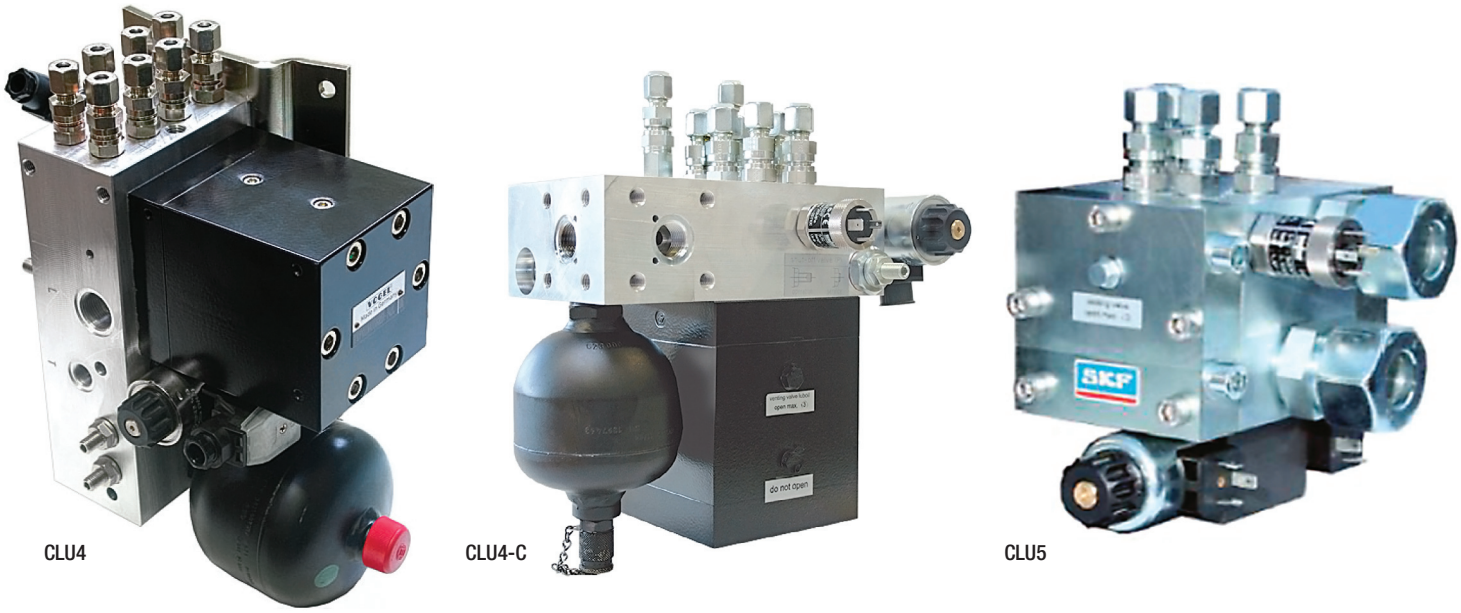

Figure 2. Dosage pumps

The savings potential can be illustrated by the following example:

Engine type:	7RT-flex82T-B
Rated power:	33,250 kW
Average load:	60%
Annual operating time:	6,000 hours
Reduction in specific cylinder oil consumption:	0.20 g/kWh

Savings in terms of cylinder oil quantity: 33,250 x 0.60 x 0.20 x 6,000 / 1,000,000 = 23.9 metric tonnes per year

With a cylinder oil price of 1,200 EUR/t, in terms of operational cost savings this represents: 23.9 x 1,200 = 28,680 EUR per year

PURPOSE AND WORKING PRINCIPLE

The purpose of the cylinder lubricating system on a two-stroke crosshead marine diesel engine is to deliver a controlled amount of cylinder lubricating oil to the cylinder liners and piston rings within a pre-defined part of the engine cycle in order to utilize the cylinder lubricating oil most efficiently.

The cylinder lubricating oil serves the following main purposes:

- Creating and maintaining an oil film
- Neutralizing sulphuric acid
- Cleaning

The new Pulse Lubricating System comprises:

- Gravity tank, filter and consumption measurement unit
- Dosage pump
- Pulse Jet quill
- Control and monitoring system

The “heart” of the Pulse Lubricating System is the dosage pump, of which there are three different types:

- CLU4: Introduced with the very first Pulse Lubricating System in 2006
- CLU4-C: Introduced as a “compact” version of CLU4 in 2009
- CLU5: Introduced with the new W-X35 and W-X40 engines in 2011

The dosage pumps are driven by a 50 bar servo oil system and electronically controlled. Each pump has a 4/2-way solenoid valve that enables cylinder oil injection when excited by the control system, and a pressure sensor on each pump provides feed-back for control system surveillance.

The pumps work according to the positive displacement principle, i.e. each quill will have exactly the same amount of cylinder oil, which is important in order to ensure a proper circumferential distribution. Each pump has either 4, 6 or 8 cylinder oil outlets for covering the entire engine range.

The pumps deliver a fixed cylinder oil volume per stroke, and the feed rate is controlled automatically by adapting the injection frequency. The maximum injection frequency is one per engine revolution.

The cylinder oil injection is precisely timed by the control system and independent of the pressure in the cylinder.

The CLU4 and CLU4-C pumps are fitted with a nitrogen filled, membrane type hydraulic accumulator that is supposed to maintain the local servo oil pressure during the cylinder oil injection period.

In order to ensure that the hydraulic accumulators are working properly, they must

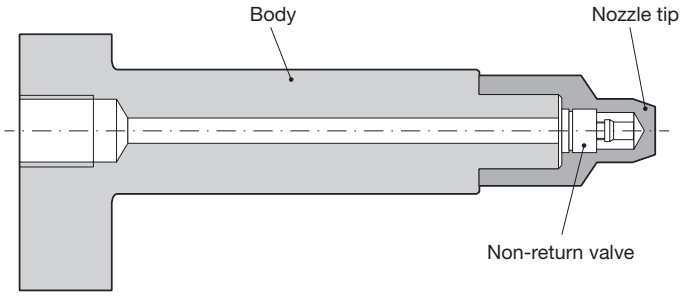

Figure 3. Cross section of Pulse Jet quill

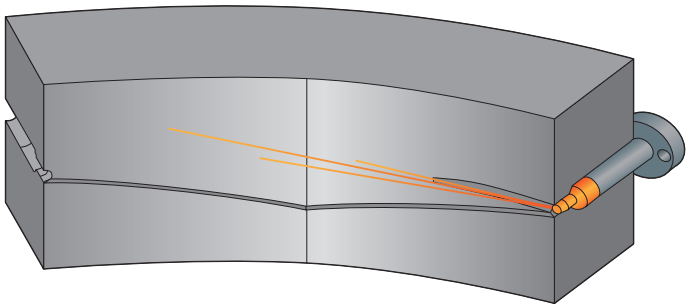

Figure 4. Pulse Jet quill with 3 jets in cylinder liner

be checked and maintained on a regular basis. To make this procedure as maintenance friendly as possible, all new CLU4 and CLU4-C pumps will have accumulators that are fitted with a nitrogen filling valve, and Wärtsilä has developed a new kit for control and maintenance of the accumulators.

The CLU5 pump has no hydraulic accumulator and is hence virtually maintenance free.

The main feature of the new Pulse Lubricating System, however, is the re-designed Pulse Jet quill.

The Pulse Jet quill generates high speed – but not atomized – "jets" of cylinder oil in the direction of the cylinder liner wall. The number of jets per quill is adapted to the engine bore size for optimal circumferential distribution of the oil.

The impact, when the jets hit the cylinder liner wall under controlled angles, is a spread of the cylinder oil reaching to the adjacent quill, which ensures that the entire cylinder liner circumference is covered.

Figure 5 illustrates at which point the cylinder oil is injected in the engine cycle. As can be seen, the injection timing varies, but regardless of injection timing, the dosage pump always performs a full stroke and delivers the same fixed volume of cylinder oil, and the injections always take place during piston upward stroke.

The major fraction (X) of the cylinder oil injections takes place above the piston. The oil is spread on the cylinder liner wall as explained above, and during the continued piston upward stroke, the piston rings will transport the oil towards the upper part of the liner, where it is needed most.

A minor fraction (Y) of the injections takes place into the piston ring pack in order to keep the piston ring pack and piston ring grooves clean and well lubricated.

A small fraction (Z) of the injections takes place below the piston. The oil is spread on the cylinder liner wall as explained above, and during the piston downward stroke the piston rings will transport the oil towards the lower part of the cylinder liner.

X, Y and Z are parameters that are set during commissioning of the engine, and they cannot be altered by the engine crew. An algorithm in the control software handles the distribution of X, Y and Z over the engine revolutions.

SERVICE EXPERIENCE

A new methodology invented and developed by Wärtsilä, the so-called "ring pack spray sampling system", has been applied in service to verify and validate the new Pulse Lubricating System.

In short, the ring pack spray sampling system collects cylinder oil samples directly from the cylinder, i.e. before the cylinder oil ends up in the piston underside space, where it gets mixed with system oil and becomes subject to pollution from other cylinder units. Hence the analysis of these samples gives a more accurate picture of the actual cylinder oil and piston running condition than the analysis of samples from the piston underside space.

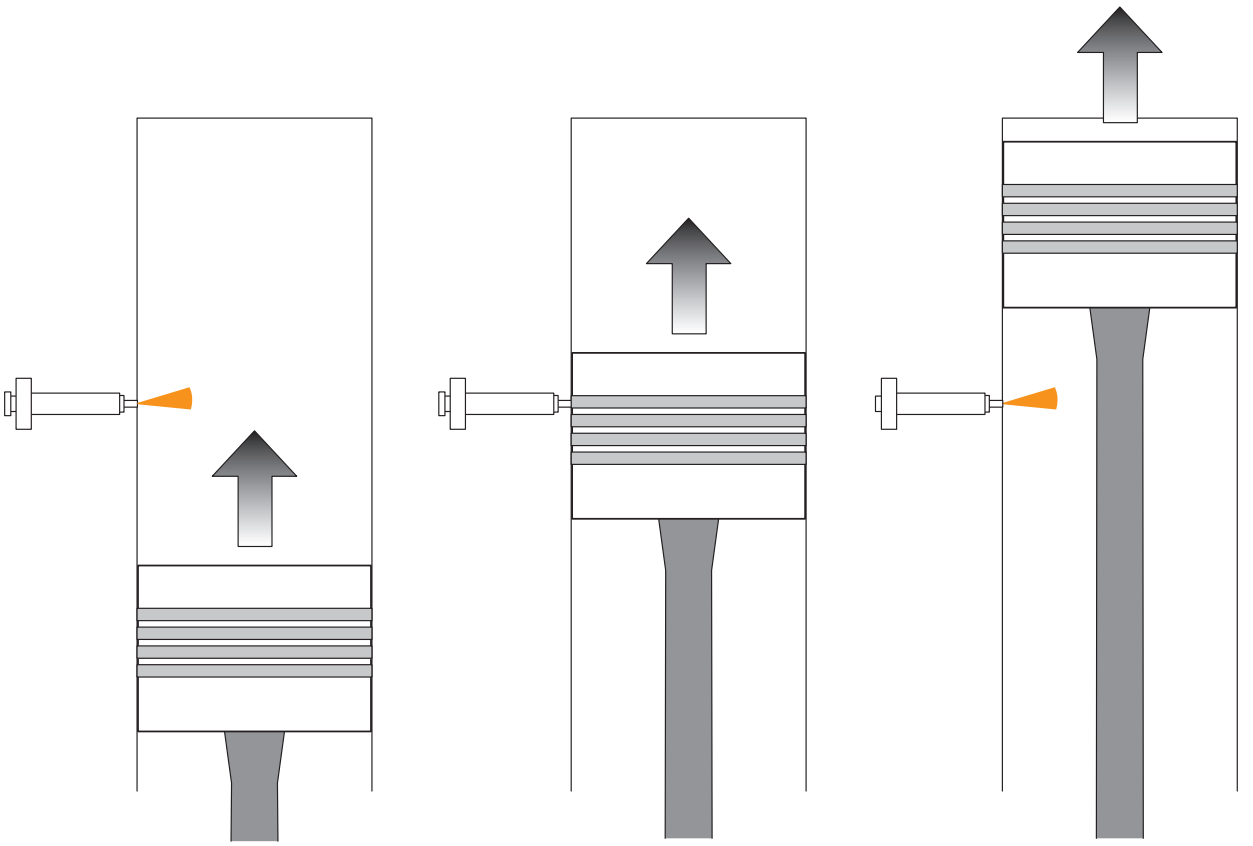

Figure 5. Stroke dependent cylinder oil injection

The verification and validation in service have been carried out on two different engine types:

- 6RT-flex50B for more than 10,000 running hours
- 12RT-flex96C-B for more than 25,000 running hours

The trend from both engine types was clear in comparison with similar engines equipped with the standard lubricating system:

- Higher base number (BN) in oil samples from cylinder
- Reduced BN in oil samples from piston underside space
- Less iron in oil samples from cylinder
- Improved circumferential distribution of the oil in the cylinder liner
- Reduced depletion of the cylinder oil

SUMMARY

With the new Pulse Lubricating System based on Wärtsilä's patented Pulse Jet principle it is now possible to achieve a better and more efficient utilization of the cylinder oil, which has been verified and validated in service on engine types from both the small bore and the large bore segment.

The outcome of this cylinder lubrication performance improvement will be better and more reliable piston running with less cylinder oil consumption for the benefit of ship owners and operators as well as for the environment.

The CLU4 and CLU4-C dosage pumps applied until now have proven to be most reliable. The recently introduced CLU5 pump type looks promising, and maintenance friendliness has been improved for the benefit of the engine crews.

Thanks to its simple and robust design, the reliability of the Pulse Jet quill has also been demonstrated during the above mentioned validation tests.