



HJ Smartlube 4.0



Introducing the future of cylinder lubrication

- Cope with any future lubrication scenario
- Accurately timed and placed cylinder lube oil
- Multiple injections during every engine revolution

Cylinder lubrication with complete endless control

Patented



INNOVATION THROUGH GENERATIONS

HJ Smartlube 4.0

HJ Smartlube 4.0 is the newest solution in advanced lubrication technology for 2-stroke marine engines.

Ensuring good cylinder and piston ring condition on 2 stroke marine engines is more demanding and more complex than ever before.

Combine this with a customer need to operate engines with lowest possible cylinder oil consumptions and we are dealing with quite a challenge.

At Hans Jensen Lubricators we appreciate a good challenge and with the introduction of our latest generation of cylinder lubrication systems, HJ Smartlube 4.0, we have created the world's best cylinder lubrication system.

The system is engineered to simultaneously, be flexible to accommodate different engine designs and operation conditions, ensure optimal lubrication no matter the type of fuel in use, have a high degree of flexibility, offer large savings in cylinder oil consumption, have a high level of safety to ensure smooth sailing whilst still being simple to use for the crew.

Advantages:

- Reduce your cylinder lube oil consumptions to levels below anything seen before- no lubricator is present.
- Introducing new intelligent algorithms.
- Less components installed.
- Improve your cylinder condition to the highest possible level.
- Extended life-time of parts associated with lubrication oil, from lower deposit build up and less wear.
- Simplified system design.
- User friendly.

The HJ Smartlube 4.0 potential:

- Enable your fleet to cope with any future lubrication scenario.
- Accurately time and place cylinder lube oil for a perfect cylinder condition.
- Give you complete endless control of when & where cylinder oil is injected and how much oil is injected.
- Perfectly suited for the 2020 S Cap, whether using LSFO or Scrubbers.
- The ability to respond to bad liner conditions.
- Reduced total cost of ownership.

HJ Smartlube 4.0 is designed for both mechanically and electronically controlled engines, and is characterized by:

- Full electronic system control by use of Hans Jensen load regulation algorithms.
- Simple view and logging of data.
- Data integration & analysis.
- Redundancy of key functions on all levels.
- Can be installed on all engine designs.

HJ Smartlube 4.0 operates without a lubricator through a single high pressure cylinder lube oil line.

By supplying high pressure oil to all lube points simultaneously, the ability to inject lube oil has been moved up-stream into the cylinder lubricator injection valves. The valve, is now able to open and close the flow of oil according to the specific operation pattern chosen.

The system can use two methods for lube oil injection:

- The patented Swirl Injection Principle, whereby lube oil is injected into the swirl creating an optimum utilization of the injected cylinder oil and a uniform oil film on the upper liner wall of the cylinder.
- Piston ring injection, where the detergency of the oil will function as cleaning.

The ability to choose when and where to inject lube oil is combined with the ability to inject multiple time per engine revolution.

This enables the lubrication system to inject via the SIP principle *and* into the piston ring pack on the up or down stroke - all during the same engine revolution.

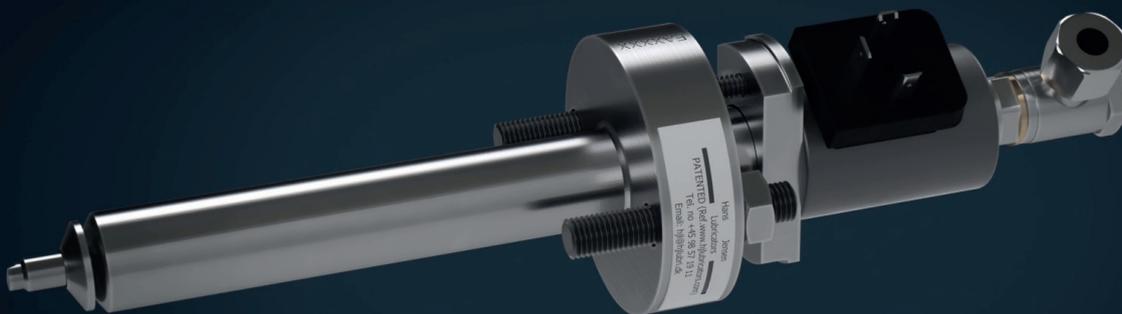
HJ Smartlube 4.0 Algorithms

Endless possibilities for regulation and injection are present for the HJ Smartlube 4.0 lubrication system.

Based on the well known principle of load dependent feed rate regulation, we have introduced methods for revolutionary control of cylinder liner conditions.

These new control methods, enable the worlds fleet to reach new levels of cleanliness, reduced feed rate and and reduced liner wear rate, providing the best cylinder condition available.

- Multi-timing
- Automatic Cleaning Sequence
- Delta-timing



HJ Smartlube 4.0 Injection Valve

Multi-timing

Multi-timing is the concept of injecting fresh cylinder oil into a cylinder at multiple time each engine revolution.

The system supports multiple injections of up to four times per revolution. It is therefore possible to divide the total quantity into certain distribution keys.

The total volume of the distribution keys add up the current feed rate, thus allowing the system keep the feed rate very low.

By using Multi-timing the system ensures that cylinder oil is introduced exactly where it is needed at each engine revolution. With control of placement and injection, optimum cylinder lubrication is achievable.

The typical injection placements of interest are:

- According to Swirl Injection Principle (SIP)
- Ring pack lubrication of compression stroke
- Ring pack lubrication of combustion stroke

See the figure 1 below for a graphical illustration of the windows available.

When injecting according to SIP during the compression stroke, the window is relatively large when comparing with ring pack lubrication. A timing precision and injection duration, which HJ Smartlube 4.0 enables.

Distribution keys

An example of distribution keys can be given as below.

The feed rate will be set to 0.55 g/kWh with the below distribution keys. The example is given for operation on both HSFO & VLSFO.

- Multi-timing example

Feed rate [g/kWh]	Distribution key	
	Quantity [%]	Timing
0.55	80	According to SIP
	10	Ring-pack compression stroke
	10	Ring-pack combustion stroke

- Multi-timing example for HSFO (>0.5%)

Feed rate adjustment	Distribution key	
	Quantity [%]	Timing
-10 %	80	According to SIP
	10	Ring-pack compression stroke
	10	Ring-pack combustion stroke

- Multi-timing example for VLSFO (<0.5%)

Feed rate adjustment	Distribution key	
	Quantity [%]	Timing
-10 %	60	According to SIP
	20	Ring-pack compression stroke
	20	Ring-pack combustion stroke

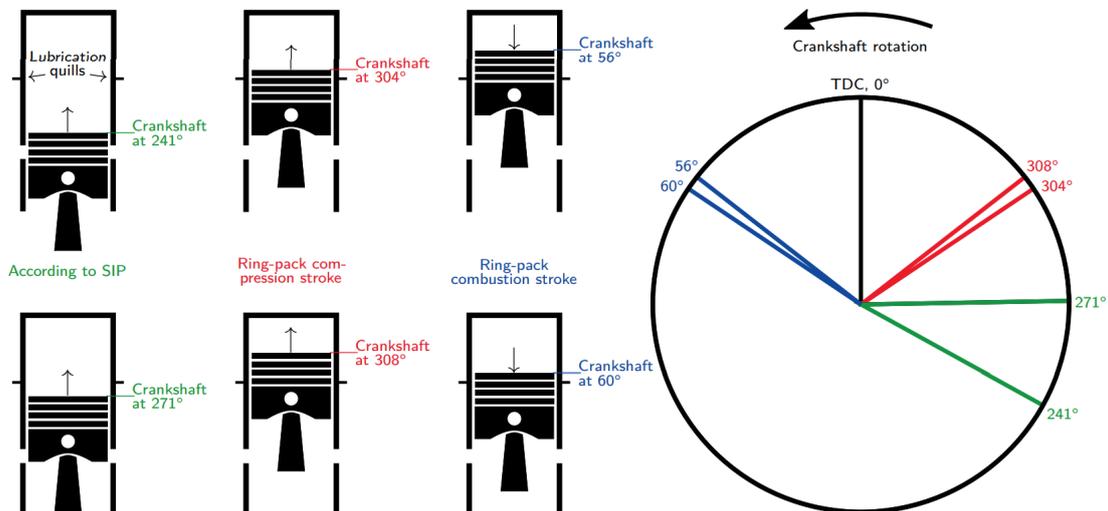


Figure 1. Engine specific injection angles

Operation on low or very low feed rates means that certain advantages and functions of the cylinder oil may not perform as intended.

Cleanliness of the cylinder liner, piston and piston rings will become an issue when realizing low cylinder oil feed rates, especially when using low Base Number (BN) cylinder oils.

When lowering the BN, the detergency of the cylinder oil will also be lowered. This compromises the cylinder oils ability to clean combustion residue and wear particles of the cylinder liner, piston and piston rings.

The detergency of cylinder lube oil is not needed continuously, whereby the Automatic Cleaning Sequence can achieve good results with intermittent cleaning.

Periodically increasing the cylinder oil feed rate to introduce cleaning, will ensure low feed rates with positive results on cylinder condition.

Multiple intervals can be set up with various durations.

Cleaning challenges

Typically when cleaning challenges arise, vessels may not be able to acquire a lower feed rate than i.e. 0.65 g/kWh.

By using the Automatic Cleaning Sequence the feed rate can be reduced to 0.55 g/kWh during normal operation and while cleaning, the feed rate will be increased to 0.90 g/kWh for two half hour cycles every 24 hours. This produces an average feed rate of 0.56 g/kWh.

- Automatic Cleaning Sequence example

Cycle	Feed rate [g/kWh]
0-11.5 hours	0.55
11.5-12 hours	0.90
12-23.5 hours	0.55
23.5-24 hours	0.90

Average feed rate	0.56
--------------------------	-------------

Delta-timing combines multi-timing and the Automatic Cleaning Sequence, providing the ultimate flexibility.

The option of changing quantity and distribution key at each engine revolution is thus possible. By using Delta-timing, the system will ensure overall optimal distribution of the cylinder lubrication oil. The full and automated control of oil distribution and quantity enables this lower oil feed rate with:

- Optimal top liner lubrication
- Optimal sulphuric acid neutralisation (for HFO)
- Optimal ring pack lubrication
- Optimal piston ring cleaning

The Delta-timing algorithm can be set to change according to fuel oil sulphur level as well as normal engine operating parameters. This results in the Delta-timing algorithm allowing any quantity and distribution key to be used.

HSFO Delta-timing

It is important to consider the high S content in the fuel oil, and the need to neutralize this.

By changing the injection placements, the amount and when to inject - a low feed rate may be obtained together with a good cylinder condition.

Cycle	Feed rate [g/kWh]	Distribution key		
		Quantity [%]	Frequency [Inj./rev.]	Timing
0-11 hours	0.50	80 % 10 % 10 %	1/1 1/10 1/10	According to SIP Ring-pack compression stroke Ring-pack combustion stroke
11-12 hours	0.50	40 % 30 % 30 %	1/1 1/3 1/3	According to SIP Ring-pack compression stroke Ring-pack combustion stroke
12-23.5 hours	0.50	80 % 10 % 10 %	1/1 1/10 1/10	According to SIP Ring-pack compression stroke Ring-pack combustion stroke
23.5-24 hours	0.70	60 % 20 % 20 %	1/1 1/5 1/5	According to SIP Ring-pack compression stroke Ring-pack combustion stroke

Figure 3. Delta-timing - HSFO example

VLSFO Delta-timing

The build up deposits is the determining factor, when obtaining a low feed rate with good cylinder condition. Care must also be taking to the placement, the amount and when to inject cylinder lube oil, to avoid scuffing and bore polishing.

Cycle	Feed rate [g/kWh]	Distribution key		
		Quantity [%]	Frequency [Inj./rev.]	Timing
0-11 hours	0.45	60 20 20	1/1 1/5 1/5	According to SIP Ring-pack compression stroke Ring-pack combustion stroke
11-12 hours	0.55	40 30 30	1/1 1/3 1/3	According to SIP Ring-pack compression stroke Ring-pack combustion stroke
12-23.5 hours	0.45	60 20 20	1/1 1/5 1/5	According to SIP Ring-pack compression stroke Ring-pack combustion stroke
23.5-24 hours	0.70	40 30 30	1/1 1/3 1/3	According to SIP Ring-pack compression stroke Ring-pack combustion stroke

Figure 4. Delta-timing - VLSFO example

Delta-timing on HSFO & VLSFO

If a vessel running on HSFO is not able to reduce feed rate below 0.65 g/kWh, the Delta-timing algorithm is applicable. A low feed rate of 0.504 g/kWh may be realized when combining the distribution keys of Multi-timing and the washing of the Automatic Cleaning Sequence. In this example, it is possible to reduce the feed rate by combing the two algorithms into the Delta-timing algorithm.

Please see figure 3 for illustration of the distribution keys as well as the quantity for operation on HSFO.

When running on VLSFO the feed rate can be reduced even further from 0.65 g/kWh, to 0.459 g/kWh. This is due to the lower sulphur % of the FO, with less BN needed for neutralization.

Please see figure 4 for illustration of the distribution keys as well as the quantity for operation on VLSFO.

HJ Smartlube 4.0 Technology

HJ Smartlube 4.0 works on the well-known common-rail principle with high-pressure oil distributed to all parts of the system.

There are four essential parts of the system:

- High pressure unit
- Cylinder oil manifold
- Electronic SIP nozzle
- Electronic control system

Two high pressure units are present at each installation in order to ensure redundancy as well as switching capability between cylinder lube oil BN values. Each unit ensures a pressure of 70 bars is always present on the cylinder oil rail.

Cylinder oil is delivered at 70 bars to each cylinder oil manifolds of which there is one per cylinder. The manifold functions as measuring control unit as well as ensuring a functioning hydraulic line with an accumulator.

The electronic SIP valve is fitted with an electric valve actuator, which determines the flow of the cylinder oil.

The electronic control system is redundant on all levels and receives & sends the required signals from all parts. This ensures the actual main engine load as well as the timing of the engines are accurate. The system controls when and for how long flow is permitted in the electronic SIP valves.

Best of both worlds

With the possibility to inject lube oil into the ring pack as well as according to SIP, the system can acquire the advantages of both methods. The traditional piston ring injection methods means that accumulated particles can be cleaned while significantly reducing the consumption via SIP.



Piston Ring Injection

Traditional injection is inefficient when lubricating, but necessary when cleaning.

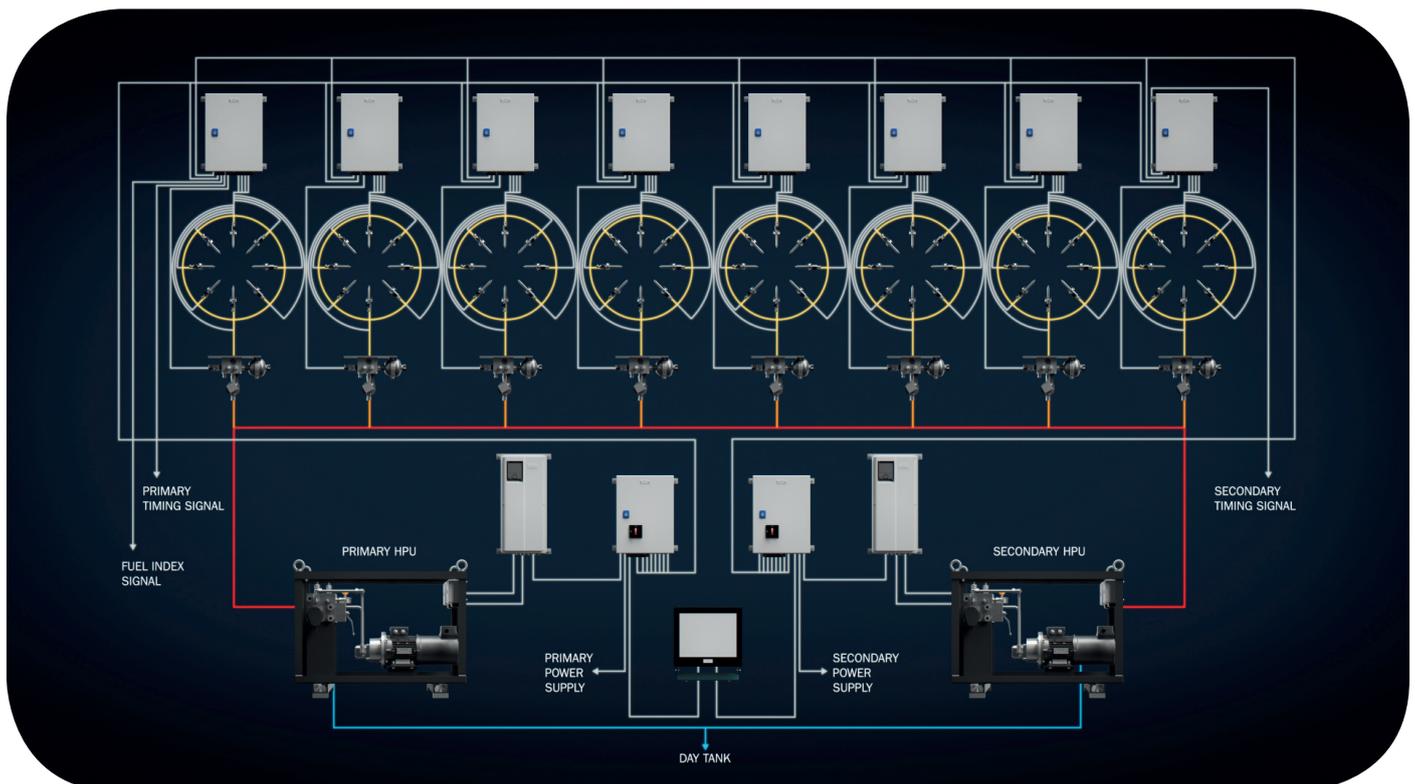


SIP Injection

Swirl injection ensures lubrication oil exactly where most wear occurs.

Piston Ring Injection

SIP Injection



HJ Smartlube 4.0 System Layout



Hans Jensen Lubricators



Hans Jensen Lubricators A/S

Smedevænget 1-3
DK-9560 Hadsund

Phone: +45 98 57 19 11
Fax: +45 98 57 13 87
Mail: hjl@hjlubri.dk

www: hjlubri.com

Hans Jensen Lubricators China

DI Asia Base Business Services Ltd
3/F, #139 Ruijin Rd.(No.1),
Shanghai 200020,
China

Phone: +86 21 6289 6661

Hans Jensen Lubricators Singapore Pte Ltd

15 Jalan Kilang Barat
Frontech Centre #06-07
Singapore 159357

Phone: +65 6274 1911

Patented



INNOVATION THROUGH GENERATIONS