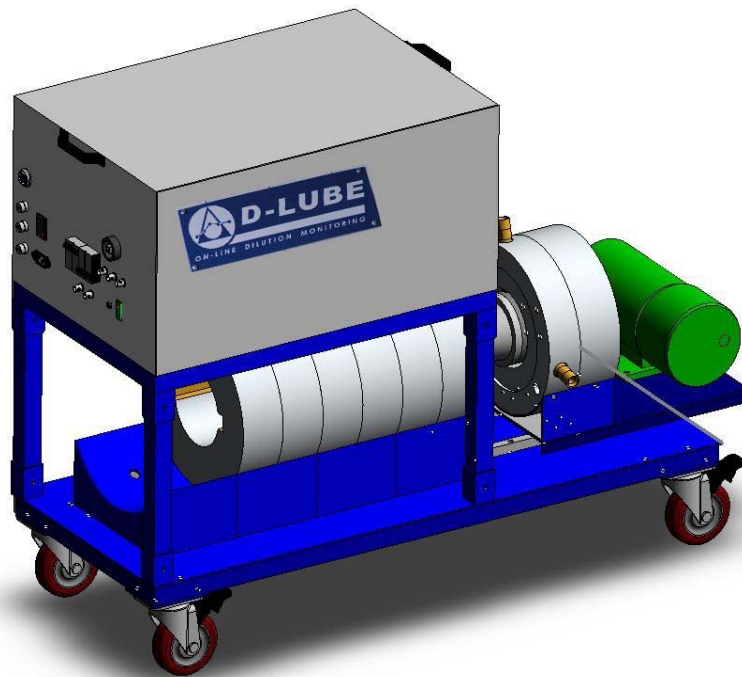


**D-LUBE :**  
**AN INNOVATIVE TOOL FOR REAL-TIME**  
**MEASUREMENT OF OIL DILUTION**  
**ON FIRED ENGINES**



**May 2006**



## INTRODUCTION

On-line measurement of oil dilution is of interest in light of new environmental regulations imposed on today's high-performance engines.

In particular, after-treatment devices such as diesel particle filters (D.P.F.) need to be periodically re-generated in order to eliminate their soot content. Such re-generation process is typically performed by using post-injection cycles that can induce a transfer of fuel to the lubricant, resulting in oil dilution.

Oil dilution has a negative impact on engine wear parts such as bearings, camshafts, cylinder sleeves, etc.

A new methodology was recently developed by D.S.I. sprl and TOTAL France for monitoring oil dilution on running engines. It is based on lubricant labelling using a new radiotracer compound, which is representative of lubricant.



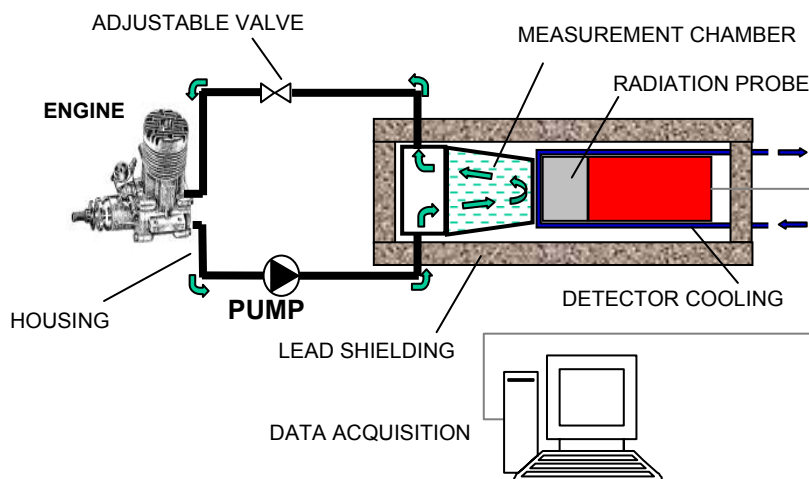
**Bearing Wear  
caused by oil dilution**

## MEASUREMENT PRINCIPLE

The new, patented method is based on lubricant labeling using an innovative radiotracer compound, which is added to the lubricant. A few ml of labeled compound is mixed to the oil when the engine is started.

During engine operation a small volume of the engine oil is circulated continuously into a measuring chamber where specific activity of the oil is monitored.

The dilution measurement consists in monitoring the signal (gamma-rays) emitted by the radiotracer and in converting any variation in terms of oil dilution. Temperature effects are corrected automatically.



**FIG.1: OPERATING PRINCIPLE OF D-LUBE**



The new methodology applies to both gasoline and diesel engines: optimisation of cold start procedures, development of post-injection strategies and of evaporation cycles.

It offers significant advantages over other methods, including:

- **On-line / Real-time results:** Oil dilution is monitored continuously during engine operation, at a rate of 1 measurement per minute.
- **Short Test Durations:** dilution rates are accurately measured within short runs from <1 hour to max. 4 hours, depending on dilution rates. i.e. a rate of 1% per hour is accurately measured within 1 hour.
- **High sensitivity:** sensitivity is of 0.05% per hour (in terms of dilution rate).
- **No change in oil properties:** Less than 100  $\mu$ l of tracer is added to the engine oil pan. It does not interact chemically with oil and additives.
- **Measuring equipment is easy to install:** Oil is sampled directly from the sump at a rate of  $\sim$ 1 litre per min. 2 hoses are easily connected between the engine and D-Lube equipment.
- **Applicable on test beds and on vehicles.** Our standard equipment is dedicated to test bench applications. A new version will be soon available, for on-board installation on passenger cars, with local data logger for acquisition during road tests.



**FIG.2: REAL-TIME OIL DILUTION MEASURING DEVICE**



## AUTOMATIC TEMPERATURE COMPENSATION

During engine operation, temperature changes induce density variations. Without compensation, any temperature increase would increase the dilution signal since for the same lubricant activity the total volume is higher, and vice-versa (see Fig.4, yellow curve).

It is then important to take into account those density variations. A temperature measurement is performed in the measuring chamber in order to correct the dilution measurement, using the following formula:

$$D_{\text{corr}} = D(T) - c(T - T_{0\%})$$

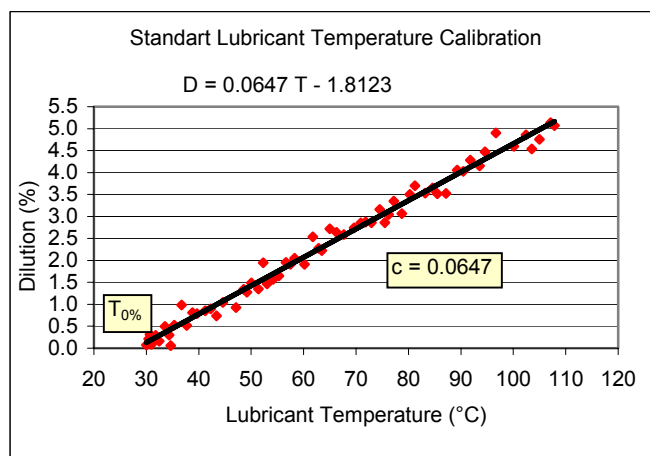
Where :

$D_{\text{corr}}$  is temperature corrected dilution

$D(T)$  is dilution at a measured temperature

$c$  is the temperature calibration coefficient

$T_{0\%}$  is a reference temperature for 0% dilution



**FIG.3: TEMPERATURE CALIBRATION CURVE**

A calibration measurement is performed in order to determine coefficient  $c$ . The calibration consists in circulating labelled but non diluted lubricant in the measuring chamber, and measuring specific activity variations associated to temperature changes.

Activity variations are expressed in terms of oil dilution and calibration results usually consist in a first order curve where angular coefficient is the above-mentioned coefficient  $c$ .

The reference temperature  $T_{0\%}$  is the start point of the curve (lowest temperature - see figure 3). Such calibration has to be performed once per type of lubricant.

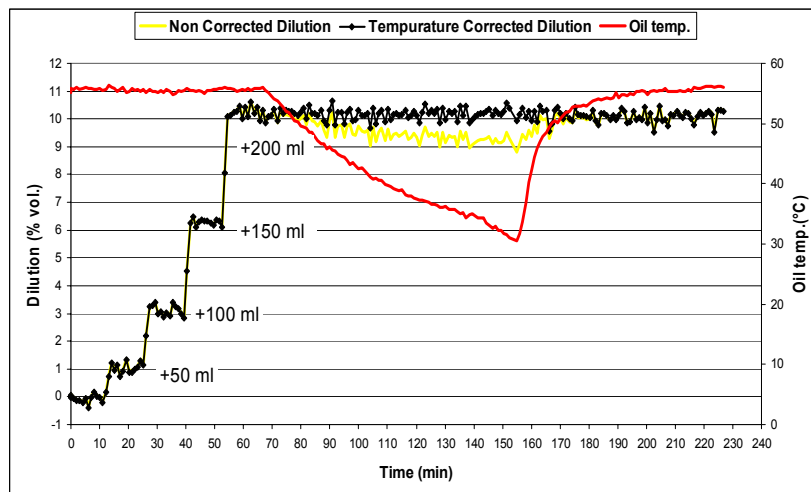


## **EXAMPLE 1 : OIL DILUTION MEASUREMENT – LABORATORY SET-UP**

This first example shows typical on-line results that can be obtained using D-Lube equipment.

Oil from a thermostatic bath, which is used for temperature calibration, is circulated in a D-lube measuring device at a rate of ~1 litre/min.

Small quantities of diesel fuel are added to the lubricant in order to dilute artificially the lubricant, corresponding to dilution levels of respectively 1%, 3%, 6.25% and 10%.



**FIG.4 : LABORATORY SET-UP**

The yellow curve here above gives dilution results without temperature correction.

The dark curve corresponds to the corrected values obtained during the same experiment.

When dilution has reached ~10%, temperature of the oil bath is lowered from 55°C to 28°C in order to verify the efficiency of the automatic T° compensation routine.

This short experiment can be repeated periodically in order to check that the D-Lube equipment works properly, as part of your Quality Assurance program.

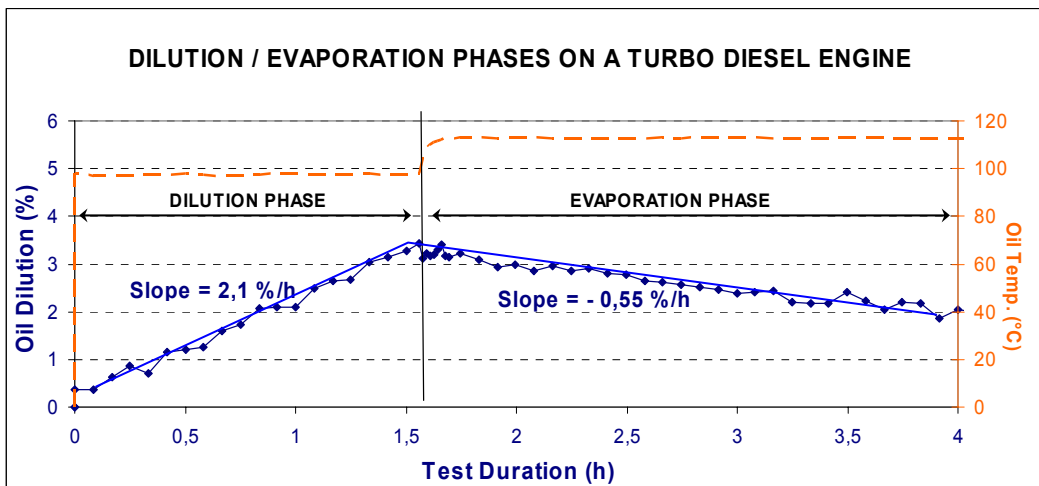


## EXAMPLE 2 : REAL-TIME DILUTION MEASUREMENT ON A FIRED ENGINE

This second example shows on-line results obtained on a diesel engine equipped with a DPF.

During a first run ( $t=0$  to  $t=1.5h$ ), the engine is operated at normal oil temperature ( $\sim 95^{\circ}C$ ) with permanent post-injection cycles for re-generating the after-treatment system. These post-injection cycles induce a high dilution rate of  $\sim 2.1$  % per hour.

During the second phase ( $t=1.6h$  to  $t=4h$ ) post-injection cycles are stopped and the engine is operated at higher temperature (oil temp  $\sim 115^{\circ}C$ ) in order to facilitate evaporation. Such operating conditions allowed to evaporate partly the of the previously diluted fuel, at a rate of  $\sim 0.55$  p.c. per hour



**FIG.5 : ON-LINE MEASUREMENT ON A FIRED ENGINE**

Similarly, other engine operating conditions can be tested in order to study their impact on dilution or evaporation rates.

The new method reduces significantly the time needed for optimizing post-injection strategies, reducing accordingly the development costs.



## Conclusion

D-Lube is an innovative tool for studying the impact of engine parameters and post-injection strategies on the dilution process.

The main benefits associated to the new method are:

- Results are available on-line, during engine operation;
- It offers an high sensitivity of ~0.05% per hour (in terms of dilution rate);
- It offers an excellent discrimination between fuel and lubricant, which is the weakness of the GC method where superposition of the heavy fuel fraction and the light oil fraction can induce uncertainties.

For more information on this product: **SAE paper ref. SAE 2005-01-2170**

### **Delta Services Industriels (DSi)**

12 rue Grande Couture,  
B-7501 Orcq,  
BELGIUM  
Tel: +32 69 64 06 04  
Fax: +32 69 78 00 79

Web site : [www.deltabeam.net](http://www.deltabeam.net)  
e-mail : [infos@deltabeam.net](mailto:infos@deltabeam.net)

