



HIGH PERFORMANCE TOOLS TO SPEED UP YOUR R&D

DSI PRODUCT RANGE :



1. MODERN TEST CENTRE FOR ENGINES & LUBRICANTS 2
Engine test centre based in Belgium



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Air-X equipment for on-line measurement of gas content in oil



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AIR-MIX to generate controlled aeration lubricants
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MODERN TEST CENTRE FOR ENGINES & LUBRICANTS



DSi offers complete services for research, development and evaluation of engines and lubricants.

A 1,300 sqm test facility based in Belgium, with modern test cells equipped with radiotracing tools.

YOUR BENEFITS

- A fully independent contract service center
- Modern engine test equipment associated to innovative radiotracing tools
- Real-time results
- A significant reduction of your development time & associated testing costs
- Our highly qualified and experienced technical staff
- Customer oriented solutions and high flexibility



STANDARD TOOLS

- Low inertia "tandem" dynamometers
- Data acquisition @ 100Hz
- ECU diagnostics (INCA, DDT, etc.)
- Standard fuels and biofuels
- Fuel flow meters
- Blow-by meters
- Regulated oil/water heating systems (up to 150°C)
- Combustion analysis system
- Oil/fuel analysis services
- Measurement of friction losses
- 400V power supply unit for hybrid engines

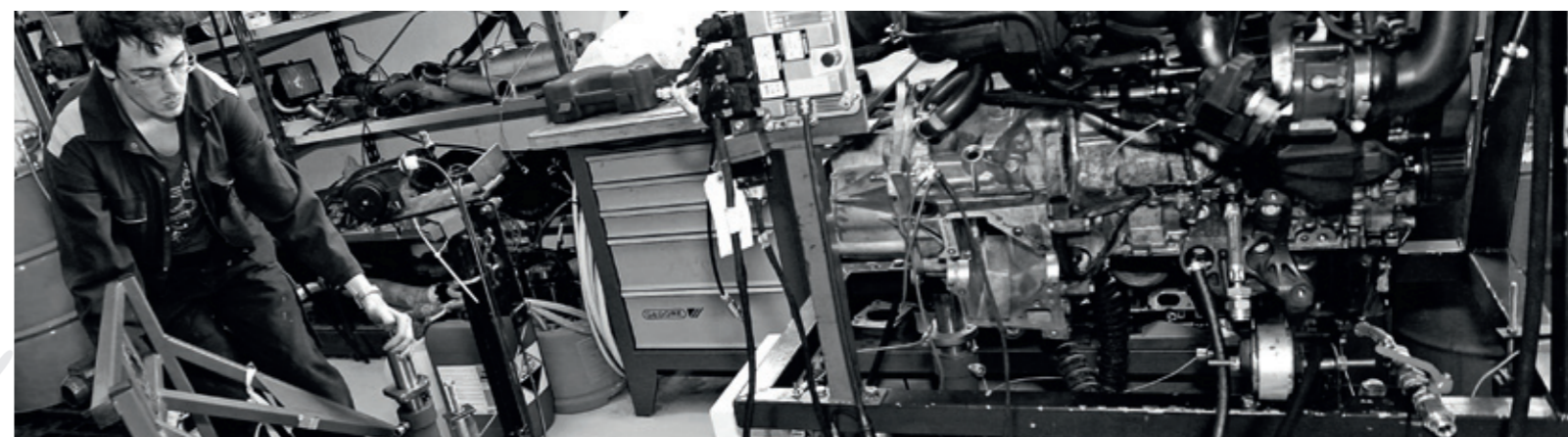
DSI CUSTOMER REFERENCES

- | | | | |
|-----------------------|-------------------|---|---|
| • PSA | • SK Corp | • Prodrive (UK) | • Federal Mogul |
| • Renault SAS | • Lubrizol | • Magna Powertrains | • HMC (KIA-Hyundai) |
| • Renault Sport F1 | • Ricardo | • I.F.P. (Institut Français du Pétrole) | • Maruti • Suzuki Group |
| • Jaguar / Land Rover | • Tickford | • Le Moteur Moderne (AVL Group) | • Massachussets Institute of Technology (MIT) |
| • Bentley | • Volvo Trucks | • Schrick (AVL Group) | • GM |
| • Daimler | • DAF Trucks | • D2t (IFP) | • John Deere |
| • Toyota (TME) | • Perkins Engines | • Sodemo Racing | • Ford |
| • TOTAL France | • Cummins Engines | • Case New Holland | • ... |
| • BP Castrol | • Cosworth (UK) | | |



SPECIAL TOOLS (RADIOTRACERS)

- On-line wear measurement
- On-line fuel dilution measurement
- On-line gas content (aeration) measurement
- On-line oil consumption measurement (engine, turbocharger and oil separator)
- External engine / turbocharger lubrication system
- Monitoring equipment for ATS





USER'S INTERFACE

All measurement data (oil temperature, oil pressure and gas content) are recorded and can be visualized on a graphic during operation of Air-X. A dedicated routine is also provided, which allows converting the results to a .csv format.

Air-X, the right tool for monitoring lubricant aeration

- The reference tool in the automotive industry for gas content measurement
- Based on X-ray transmission : range from 0% to 100% gas content
- Real-time results : response time selectable from 1 sec to 1 min.
- Continuous oil sampling, at regulated flow (selectable)
- Allows measuring both dissolved and non-dissolved fractions
- Accuracy : 0.1% in terms of gas content
- Automatic temperature compensation
- Easy to calibrate and user friendly interface
- Visualisation of oil flow in the measuring chamber (video signal)
- 4 versions available, from low to high flows
- In-board model available
- Single USB connection

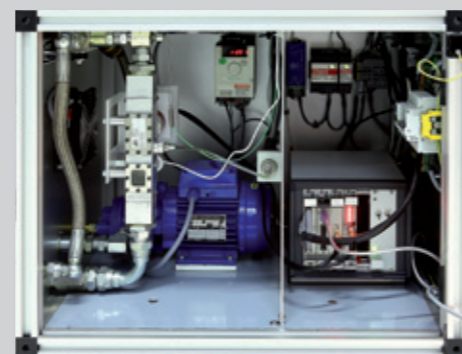
DSi EXPERTISE

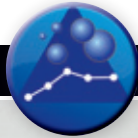
DSi team has acquired a strong expertise in assisting our customers to understand and solve aeration problems.

Our services include :

- Service measurement with AirX equipment, at your company
- Service measurement at DSi including rent of engine test tools
- Solving aeration problems by adapting the oil circuit and lubricant properties
- Training on the aeration process (theoretical and practice)
- Design and manufacturing of dedicated test rigs for aeration measurement
- Development of special configuration in the hydraulic and mechanical industries

Air-X is able to sample and evaluate oil from atmospheric or pressurized lines in an operating hydraulic system. The sampling unit of Air-X includes an internal oil pump with accurate and variable flow control.





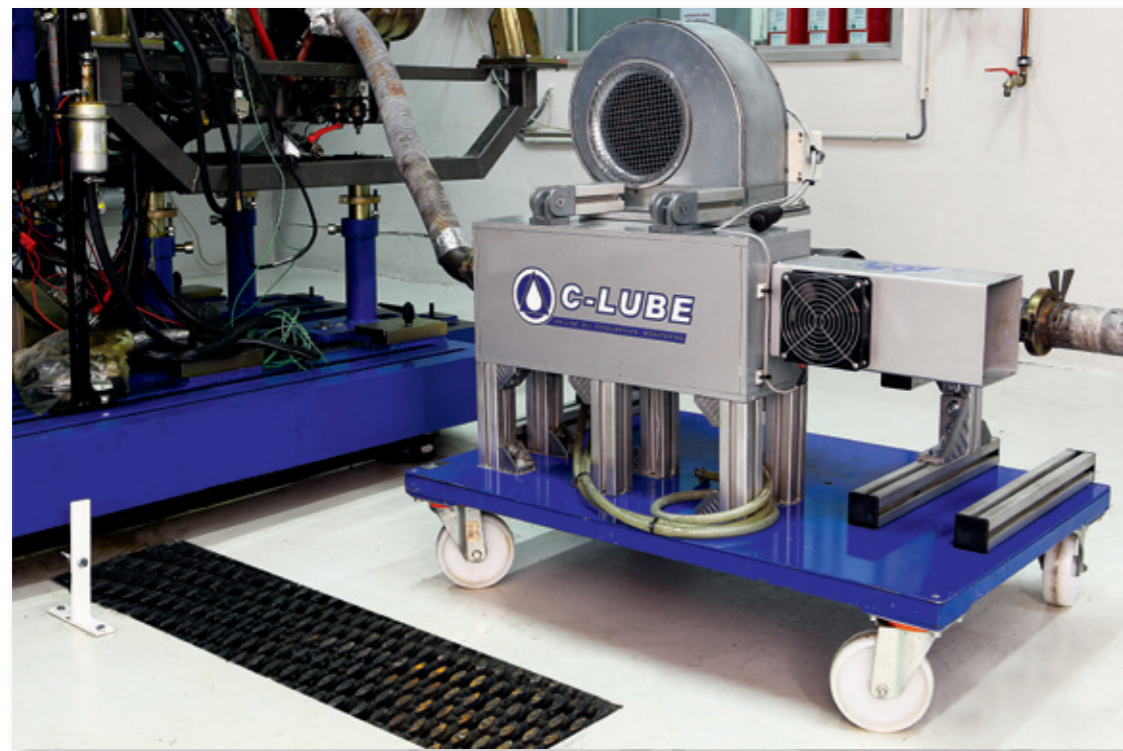
ENGINE OIL CONSUMPTION



REAL-TIME OIL CONSUMPTION MEASUREMENT ON I.C. ENGINES

DSi offers a patented methodology for on-line measurement of oil consumption on I.C. engines. The method is based on lubricant labelling using radiotracers that are representative of the distillation interval. It allows distinguishing between various sources of oil consumption : engine block ; turbocharger (turbine side and compressor side) ; and oil separator (blow-by) circuit.

C-LUBE EQUIPMENT FOR ON-LINE OIL CONSUMPTION MEASUREMENT



The methodology offers the following benefits :

- Real-time results
- High sensitivity (<1 mg)
- Separate monitoring of oil consumption sources
- Fast results (21-points oil consumption map within 8 hours)
- No special fuel or lubricant required
- No change in oil properties associated to the presence of the radiotracer
- Selectable chain length to be labelled, from very light to heavy oil fractions
- Burned and unburned oil fractions are taken into account
- The method is not affected by fuel dilution

CONTRIBUTION OF TURBOCHARGERS AND OIL SEPARATOR SYSTEMS

Reducing oil consumption of turbochargers and increasing efficiency of oil separators are important issues for reducing emissions and for increasing lifetime of ATS.

CONTRIBUTION OF OIL SEPARATOR SYSTEMS

Our radiotracer method allows measuring on-line oil consumption issuing from the engine ventilation system. An absolute filter is installed downstream the oil separator to collect residual oil. It offers negligible pressure losses and it is equipped with a probe that monitors accumulation of oil with a sensitivity of less than 1 milligram.

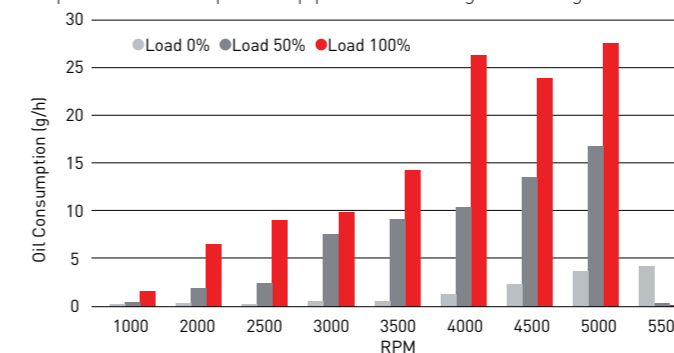
CONTRIBUTION OF TURBOCHARGERS

A separate lubrication system ("TC-Lube" see details page 13) containing labelled oil (radiotracer) is used to feed the turbocharger independently from the rest of the engine. Oil leaks issuing from the turbine bearing are monitored in the exhaust line where an absolute filter is installed. Leaks from the compressor stage are trapped in another filter installed between the compressor and the intercooler. As a consequence, oil consumption from both stages are measured independently.

EXAMPLE : OIL CONSUMPTION SOURCES IN A MODERN I.C. ENGINE

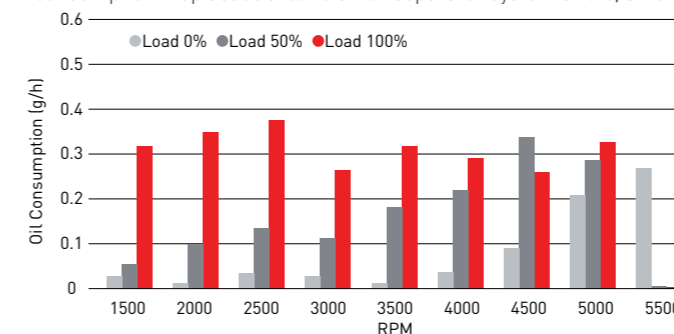
Oil consumption map : engine block

Example of oil consumption map performed on a gasoline engine.



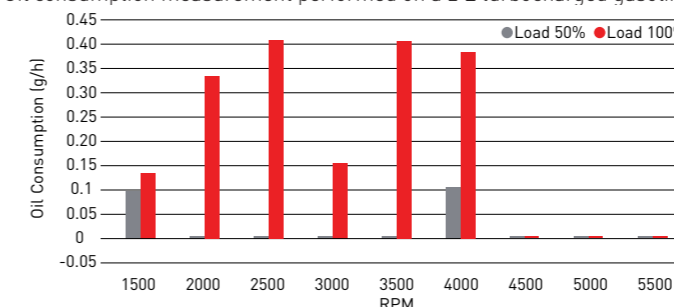
Oil Consumption Map : BBY circuit (ventilation)

Oil consumption map associated to an oil separator system at 0%, 50% and 100% load.



Oil Consumption Map for the turbine only

Oil consumption measurement performed on a 2 L turbocharged gasoline engine.



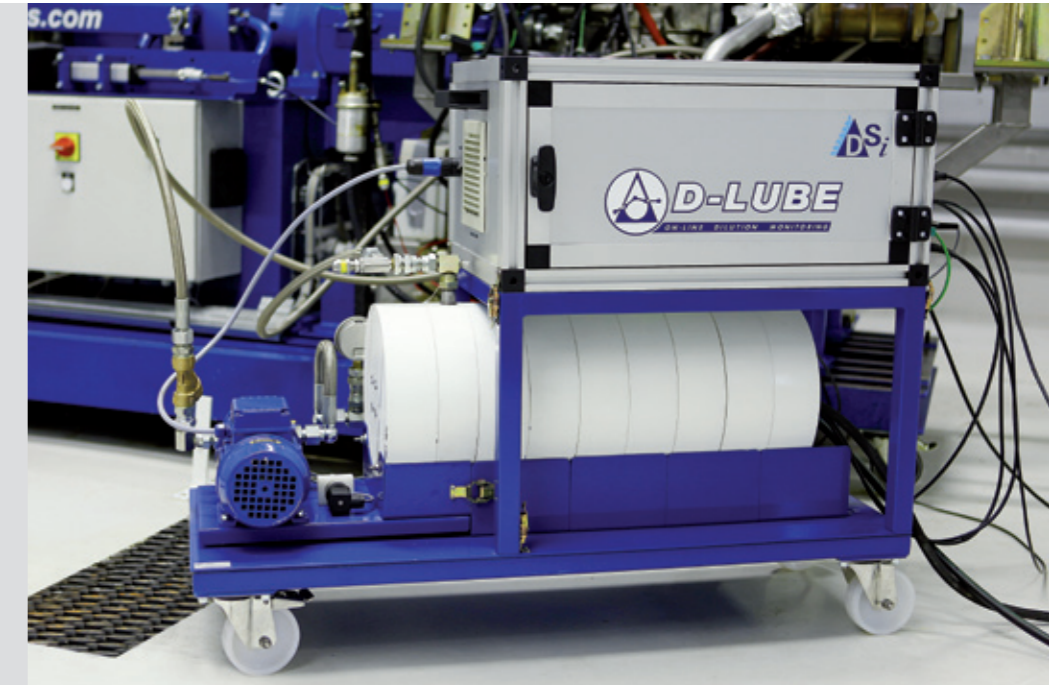


FUEL DILUTION MEASUREMENT



Fuel dilution measurement is of particular interest in light of new environmental regulations imposed on today's passenger car and heavy duty engines. Our innovative methodology offers on-line and accurate results. It is based on lubricant labelling using a new radiotracer compound, which is representative of the lubricant.

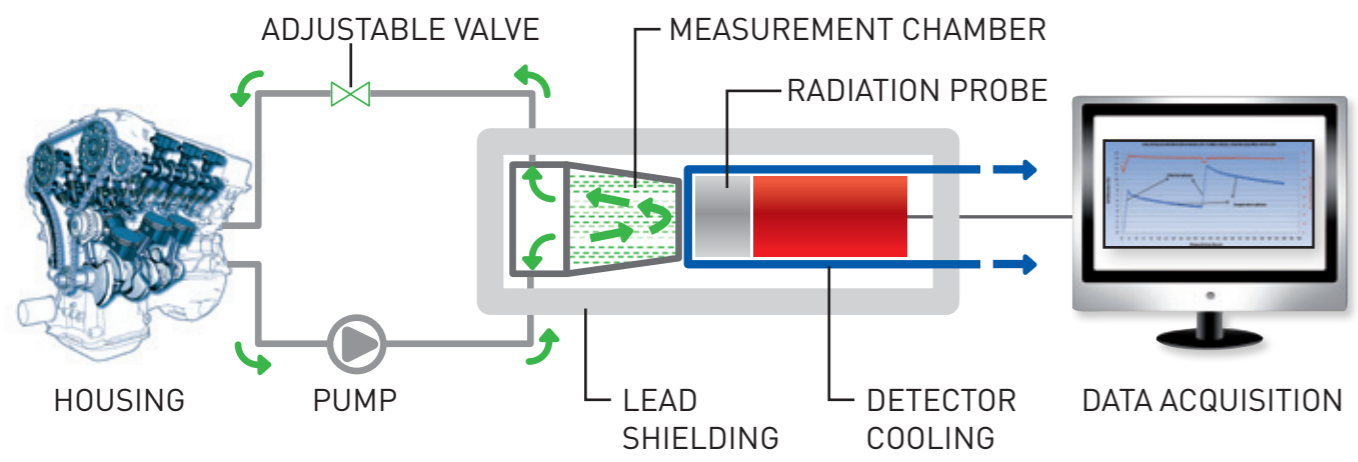
- **No change in oil properties :** Less than 100 µl of tracer is added to the engine oil pan. It does not interact chemically with oil and additives.
- **Equipment is easy to install :** Oil is sampled directly from the sump at a rate of ~1 litre per min. 2 hoses are easily connected between the engine and D-Lube equipment.
- **Applicable on test beds and on vehicles.** Our standard equipment is dedicated to test bench applications. A compact version is available for in-board installation on passenger cars and HD vehicles. It includes a data logger for acquisition during road tests.



Standard D-Lube equipment for test rigs and laboratories.

MEASUREMENT PRINCIPLE

As first step, a radiotracer compound is mixed to the lubricant. During engine operation oil is circulated continuously into a measuring chamber where the signal (gamma-rays) emitted by the radiotracer is monitored. This signal is representative of the dilution process. Temperature / density effects are corrected automatically.

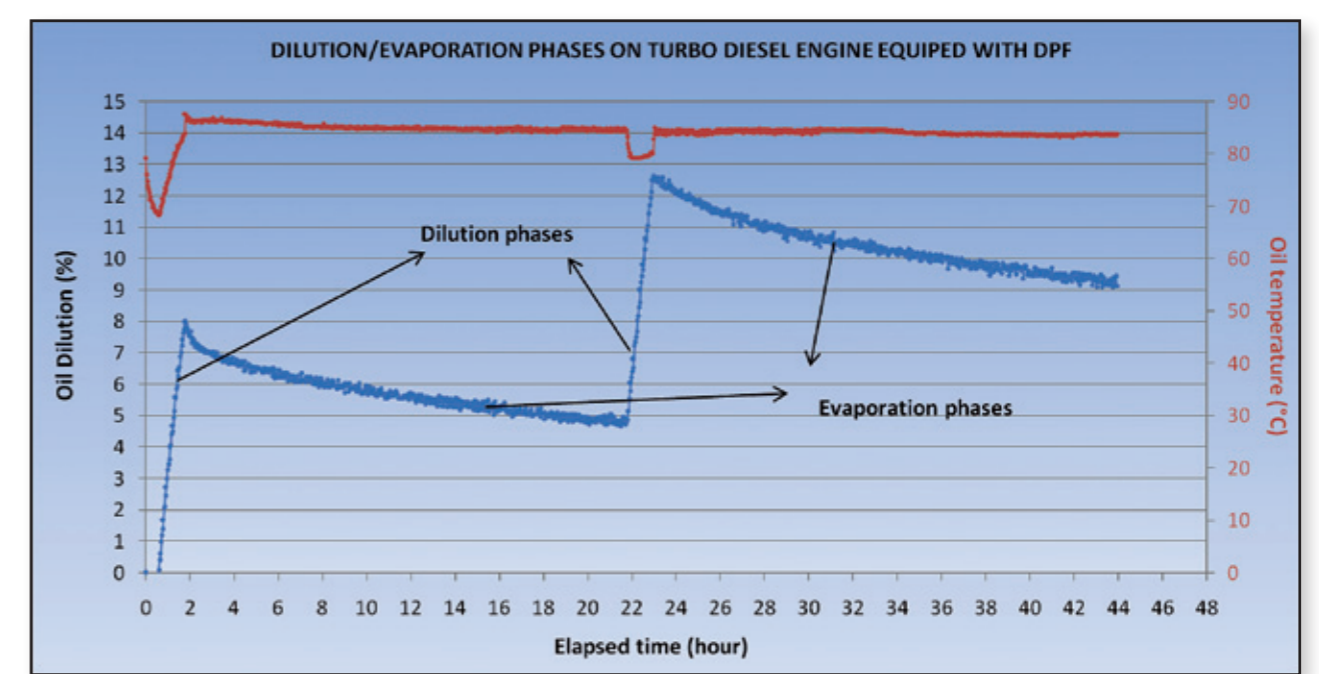


The methodology applies to gasoline, diesel and bio-fuel engines for optimisation of cold start procedures, for the development of post-injection strategies and of evaporation cycles.

D-Lube 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 4 hours, depending on dilution rates.
- **High sensitivity :** sensitivity is of 0.05% per hour (in terms of dilution rate).

The graph hereunder shows typical results obtained during successive dilution and evaporation phases performed on a passenger car diesel engine. Oil temperature is shown (red signal) and fuel content in oil (volumic, in %) is displayed on-line.



On-line fuel dilution and evaporation measurement on a diesel engine : fuel content is precisely known at any time during engine operation.

D-Lube equipment **reduces significantly** the time needed for **optimizing fuel injection** strategies on I.C. engines.



WEAR MEASUREMENT (TLA/RNT)



For more than 15 years, DSi has applied **radiotracer techniques** to offer accurate and **real-time wear measurements**

TLA (Thin Layer Activation) is our key product. The method allows performing on-line wear measurements on running engines without dismantling parts (i.e. camshafts, cylinder sleeves, piston rings, valves & seats, bearings, turbocharger bearings, etc.). TLA is also convenient for studying the impact of lubricant formulation, fuel dilution and soot content on wear.

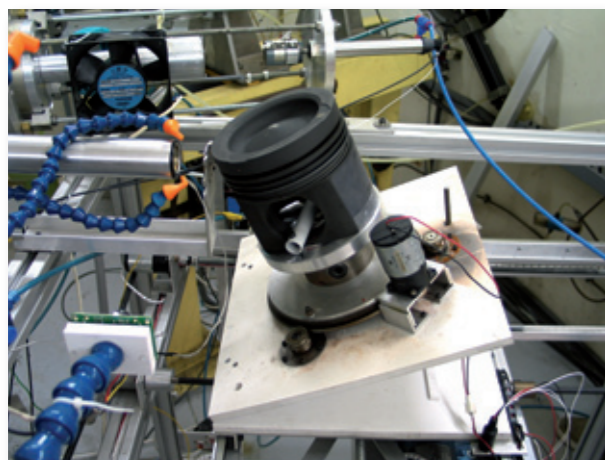
DSi provides TLA-RNT measurement services as a full package that includes activation services, equipment sales & renting and qualified manpower. Wear measurements services can be performed either at your site or at our engine test centre in Belgium.

THE **METHODOLOGY** IS APPLIED IN **2 STEPS** :

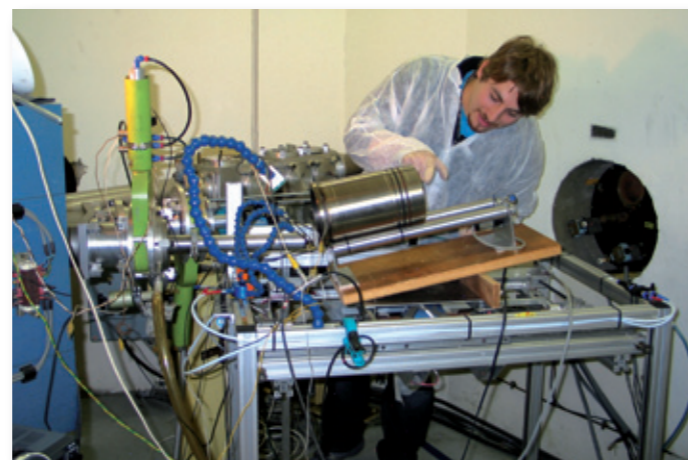
STEP 1

Labelling of wear parts :

A particle accelerator is used to produce a thin layer of radiotracers at the surface of wear parts.



Treatment of a piston groove to produce radiotracers superficially.

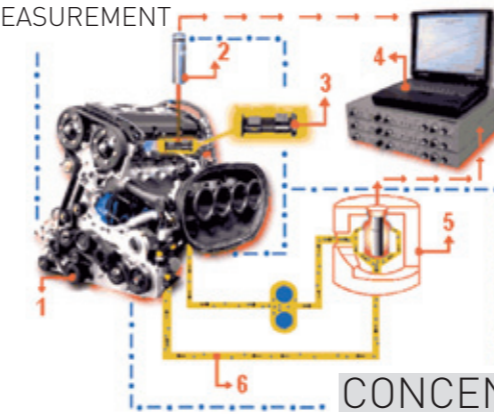


Labeling of a cylinder sleeve.

STEP 2

On-line measurement during engine operation : "direct" and "flow-through" methods.

DIRECT MEASUREMENT



1. Running engine
2. Detector for "direct" or "residual" measurement
3. Activated wear part (camshaft)
4. Signal processing, data acquisition and software
5. Chamber for flow-through or "concentration" measurement
6. Circulating oil

CONCENTRATION MEASUREMENT

DIRECT MEASUREMENT

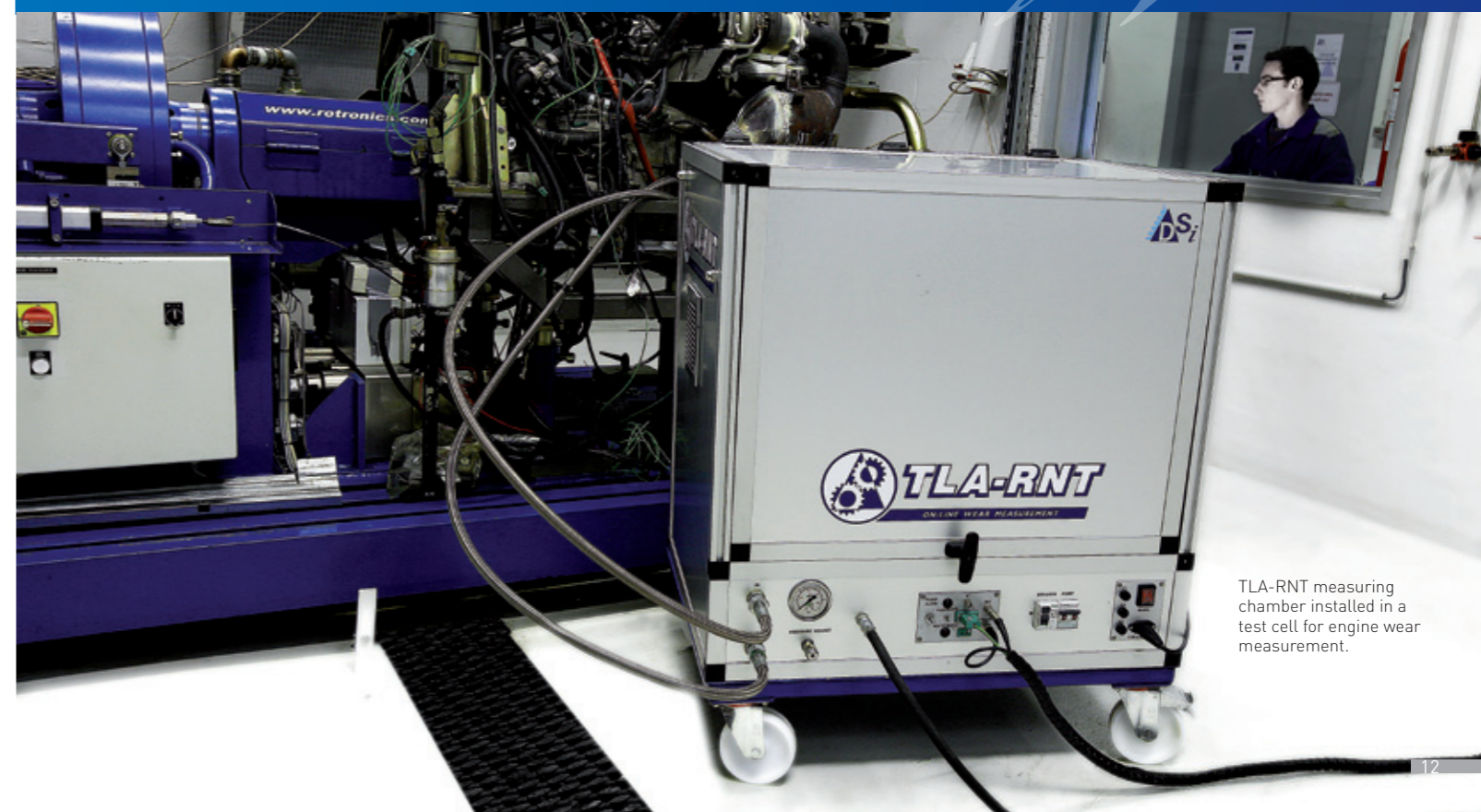
A probe is installed externally to the engine for monitoring of the gamma-ray signal emitted by the labelled area. Any loss of signal is automatically converted in material loss.

"FLOW THROUGH" METHOD

It consists in monitoring the increase of gamma-ray signal in the lubricant where worn particles are released. A probe is installed in a measuring chamber where the fluid is circulated. A particle trap (a filter or a magnet) can also be installed in the chamber to collect worn particles.

YOUR BENEFITS

- On-line results
- Significant reduction of test duration
- Extremely high sensitivity : 1 nanometer
- Real-operating conditions without dismantling parts
- Non-destructive measurement
- Full package service measurement at DSi or at your test facility



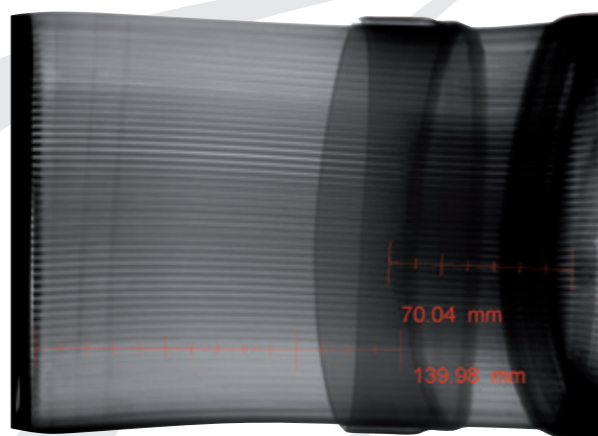
TLA-RNT measuring chamber installed in a test cell for engine wear measurement.



INNOVATIVE TOOLS FOR THE DEVELOPMENT OF AFTER-TREATMENT DEVICES (ATS)

Poisoning and clogging of ATS by soot and by ash residues affects their performances.

DSi has developed a non-destructive technique based on radiotracer labelling of additive compounds contained in the fuel or in the lubricant (e.g. zinc, calcium, molybdenum...). The methodology allows monitoring ash deposits during engine operation.



X-ray radiograph of a Diesel Particulate Filter (DPF).

YOUR BENEFITS

- **On-line results** : ash accumulation in the ATS is measured in real-time during engine operation
- **Real Operating Conditions** : no change in oil properties
- **Very high sensitivity** : <1 mg ash deposit
- **Selectivity** : several organic compounds can be labelled simultaneously in the lubricant to evaluate their respective impact on ATS poisoning and clogging
- **2D-3D map of ash deposits** : X-ray radiography combined to a dedicated ATS scanning system allows monitoring ash deposit profiles
- **Non Destructive Measurement** : no need to open the casing or destroy the ceramics

DSi has also specialised in the development of industrial cleaning procedures for soot and ash removal from ATS, for Passenger Cars and Heavy Duty vehicles. Combination of our radiotracer techniques with X-Ray radiography allows optimising the cleaning process for 99% efficiency in terms of soot & ash removal.

DEVELOPMENT OF TEST RIGS AND ANCILLARY SYSTEMS

DSi has acquired a strong expertise in the development, manufacturing and installation of dedicated test tools for engines and lubricants. Amongst several of our recent projects :

- Development, manufacturing and installation of wear and aeration test rigs
- Development and manufacturing of oil and water conditioners for test beds with very accurate flow and temperature control (engine test facility)
- Development of test rigs for friction losses measurement
- Development of test procedures to compare the impact of lubricant formulation and oil aging on engine wear



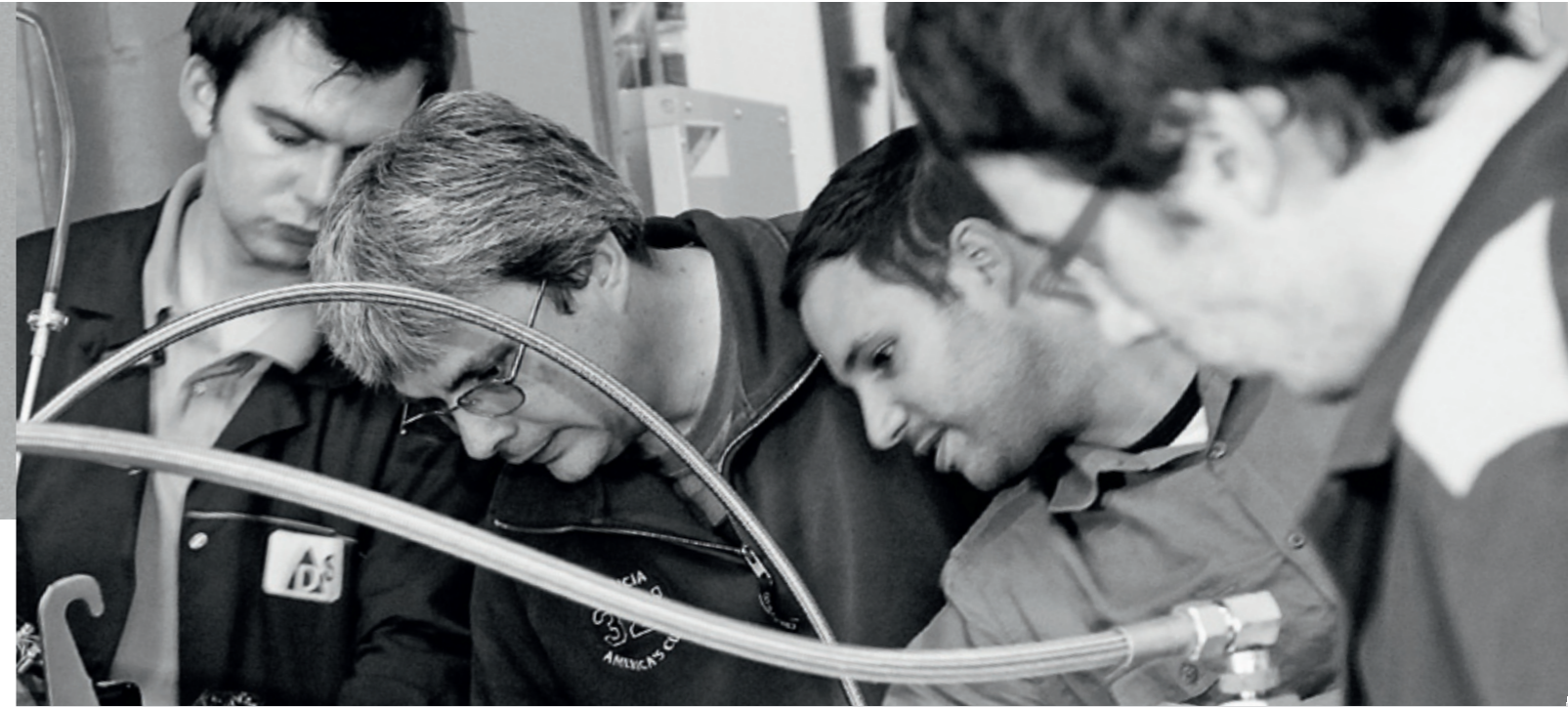
TC-Lube is a separate lubrication system for turbochargers. It provides very fast response and includes programmable and accurate control of oil temperature and oil pressure.

RANGE OF APPLICATIONS :

- Investigation of lubrication limits
- Study of the impact of oil aging (soot content, wear particles, dilution)
- On-line measurement of oil consumption of the TC only
- On-line wear measurement (axial and radial wear of bearings)



TRIBOLOGY / NEW MATERIALS & AERONAUTICS



Plasma assisted chemical vapour deposition unit.

DSi contributes to the development of new materials and new coatings that are more extensively used to reduce wear and friction losses in modern powertrains. Our contribution in this field includes the development of on-line wear monitoring tools dedicated to tribology machines and the development of new radiotracer techniques for labelling thin coatings such as chromium and bismuth-based coatings, tin-aluminium coatings, DLCs, etc.

New TLA (Thin Layer Activation - see details page 10) equipment have been developed for on-line wear measurement on tribology test rigs such as pin-on-disc machines, Plint machines, block-on-ring simulators, piston simulator machines, and Vickers vane pump test rigs.



Pin-on-disc tribology equipment.



Our field of expertise also covers the development of fast screening tools for analyzing crude oil corrosivity in refineries.

R&D partnerships exist between DSi and local (Liège, Namur and Louvain-la-Neuve) and foreign universities (University of Birmingham). In the industry, DSi cooperates closely with R&D centres of major oil and car companies. A partnership exists for more than 12 years between DSi and a major Formula 1 engine supplier. The reason for this long-lasting cooperation is that radio-tracer techniques combine real-time results with unequalled sensitivity. This is the reason why we can also speed-up your R&D programs !



INNOVATIVE TOOLS PROPOSED BY DSI ALLOW SPEEDING-UP THE DEVELOPMENT OF JET ENGINES AND ANCILLARY SYSTEMS.

Our services in this field include the development of oil/fuel de-aeration systems; on-line wear measurement of critical parts (bearings, gears, carbon seals,...) ; and optimisation of oil separator systems to reduce oil releases in the environment.



WHY SELECTING DSI



MOTIVATION



CUSTOMER ORIENTED SERVICES



EXPERTISE



FLEXIBILITY



TECHNOLOGY



INNOVATION

SAE® AWARD FOR DSI

Our methodology for oil consumption measurement is the fruit of a cooperative research program between DSI and TOTAL. It is described in SAE paper 2005-01-2178, which received a "SAE Award for Research on Automotive Lubricants". This paper is entitled "An Innovative On-Line measurement Method for Studying the Impact of Lubricant Formulations on Poisoning and Clogging of After-Treatment Devices."



DSI offers industrial products for engine and lubricant testing



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