TLA-RNT

Real-time Wear Monitoring for hard coatings development

TECHNICAL BROCHURE

2018

INTRODUCTION

TLA-RNT equipment is a wear monitoring probe especially designed for continuous wear measurement on engines. It offers **on-line wear results** with very **high sensitivity** in the range of one nanometer per hour (1 nanometer = 1/1000 of a micron).

TLA-RNT equipment can be adapted to any engines or mechanical devices. It is equipped with an internal pump that allows circulating a fluid (oil, fuel, coolant…) at very controlled conditions.

TLA-RNT equipment combines real-time results with very short response times in the range of several seconds. Its extreme sensitivity and accuracy allows shortening significantly test durations compared to conventional wear measurement procedures.

TLA-RNT equipment operating principle is based on the use of the Thin Layer Activation (TLA) technology (also called RNT for Radio Nuclide Technique). The methodology is based on the production of radiotracers on the surface of wear parts.

The heart of TLA is a high sensitivity measuring chamber combined with a MCA (Multi Channel Analysis) data acquisition system and a powerful and user-friendly software that offers real-time wear results.

TLA is also convenient for real-time wear measurement on very hard coatings (such as DLCs), for which very low wear rates are usually involved as well as very low thicknesses in the range of several microns.

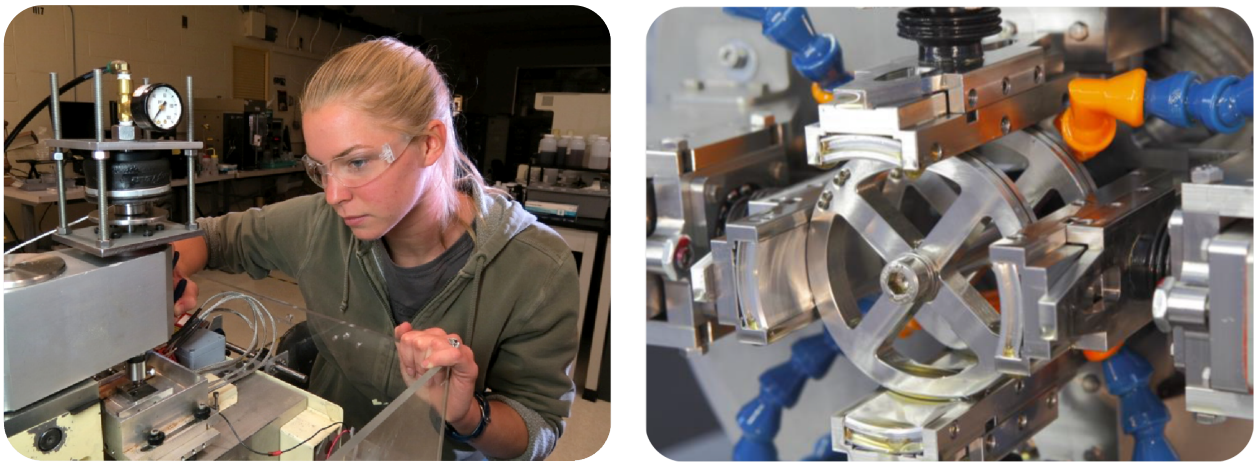


Figure 1 : By Courtesy of Tetra Ilmenau GmbH - Piston simulator machine

OPERATING PRINCIPLE?

WHAT IS THE TLA-RNT METHOD? The TLA (Thin Layer Activation) / RNT (Radio Nuclide Technique) method is applied for many decades in the automotive industry for testing engines and lubricants. It allows performing online wear measurements on running engines without dismantling parts (i.e. camshafts, cylinder sleeves, piston rings, valves & seats, bearings, turbocharger bearings, etc.).

The methodology is applied in 2 steps:

- ✓ **Step 1**: Labelling (activation) of wear parts

A particle accelerator is used to produce a thin layer of radiotracers at the surface of wear parts. After treatment, labeled areas emit gamma rays that allow monitoring the wear process during engine tests.

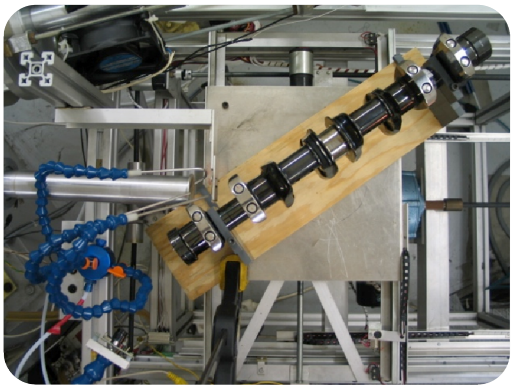
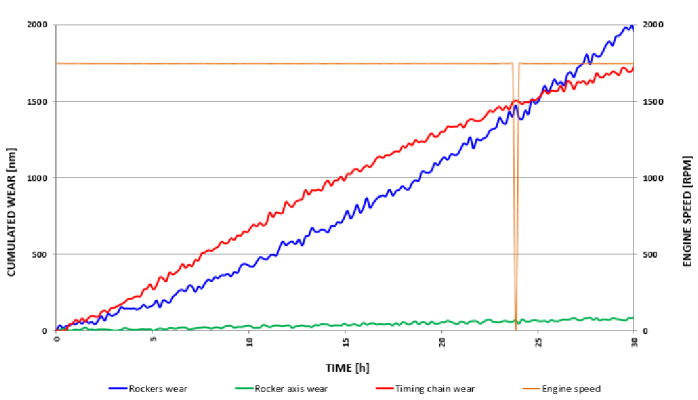
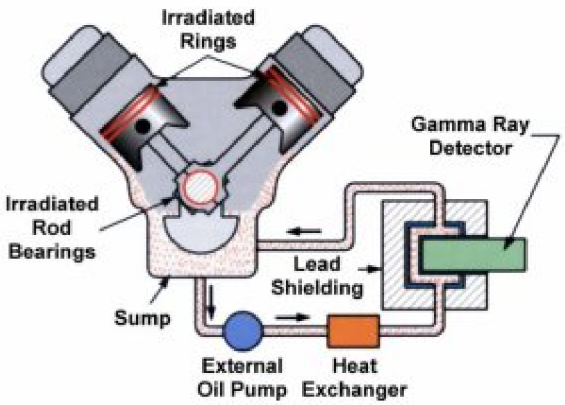


Figure 2 : Irradiation of a DLC-coated crankshaft

- ✓ **Step 2**: On-line wear measurement

When wear occurs debris are released due to friction from labelled areas to a fluid (i.e. a lubricant). As a consequence, there is an increase of radioactivity (gamma-rays) in the lubricant and a radiation probe is installed in a measuring chamber where the fluid is circulated. It allows detecting very little wear rates in the range of one nanometer per hour.





Principle of a TLA-RNT measurement → On-line wear measurement (i.e. piston rings)

HIGH RESOLUTION SPECTROSCOPY SYSTEM

TLA-RNT equipment uses a Multi-Channel Analyser spectroscopy system (MCA) to allow separation of the gamma-rays coming from different isotopes. The equipment allows monitoring simultaneously wear of 2 different parts installed in an engine.

FLOW-THROUGH CHAMBER AND FILTER CHAMBER

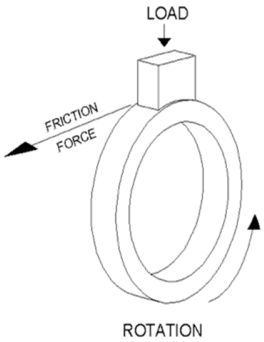
With the Flow-Through method, the engine oil is circulated from the engine sump through a chamber where the volumetric activity of the oil is measured. The same oil can also be circulated in an additional chamber equipped with an oil filter to measure the accumulation of wear.

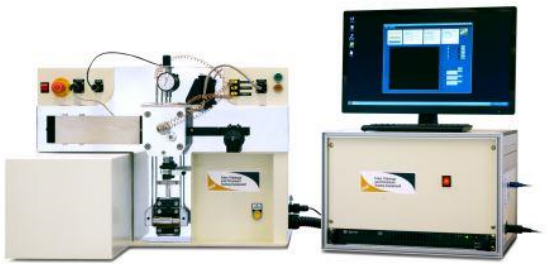
Figure 3 : TLA-RNT Chamber for Flow-through measurement

SOFTWARE

TLA-RNT equipment includes a user-friendly software (**B-Wear**) that performs a multitude of control and analysis functions to effect TLA/RNT experiments. It operates under Windows and performs automatic saving of raw data on hard disk during the measurements and re-analysis of raw data with new parameters. I/O are available to communicate with the control system of most tribology test rigs. B-Wear is also equipped with its own data acquisition system and, as an option, additional analog/digital inputs are available for acquiring external signals issuing from the test rig itself.
Another feature of B-Wear is the determination of wear rates at any time. A function allows performing linear fits in the acquired wear date to calculate the rate and standard deviation.

EXAMPLE: UPGRADE OF A FALEX BLOCK-ON-RING MACHINE

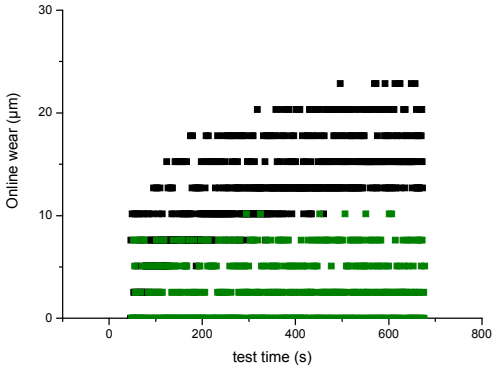


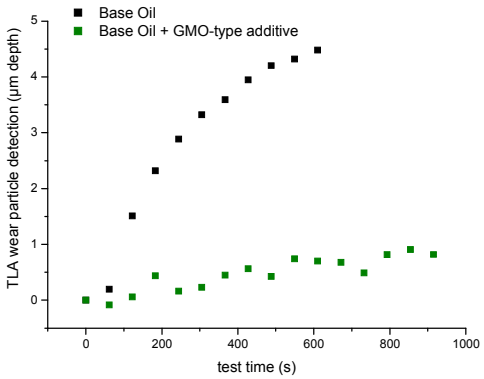


TEST SPECIFICATION:

Simulation of sliding journal bearing (e.g. Crankshaft)
TAN code 1519
Realistic contact pressures (1-10 MPa)
Block material: brass
Ring material: SAE steel ring S-25
Isotopes for TLA measurement: Zn-65 (block) and Co-57 (ring)
Lubricant: using B-Wear flow through measuring chamber + pump
Engine base oil with and w/o GMO-type friction modifier
Test performed at constant speed/load

COMPARATIVE RESULTS:





Test results with standard wear probe	Test results with B-Wear upgrade
✓ Resolution of wear depth: 2.5 µm ✓ Precision on wear depth: 10µm ✓ Estimated total wear: 20 µm ✓ Realistic results?	✓ Precision on wear depth: 0.1 µm ✓ Total wear: 4.5 µm and 0.8 µm (GMO) ✓ Wear rate calculation: possible ✓ Differentiation between block & ring: yes

TABLE OF TLA-RNT FEATURES

- **Dimensions**:
  - Flow-through equipment: 800 (Length) x 650 (Width) x 1000 (Height) mm
  - Filter equipment: 950 (Length) x 500 (Width) x 500 (Height) mm
- **Weight:**
  - Flow-through equipment: 350 kg
  - Filter equipment: 250 kg
- **Power supply:** 110 / 220V
- **Power consumption:**
  - Flow-through equipment: 1 kW
  - Filter equipment: < 0.5 kW
- **Cooling:** Internal fans + Compressed air input for detector cooling
- **Configuration:** Cart on 4 wheels
- **Pump specs:** Flow: 0-5 L/min, controlled and regulated
- **Capacity:**
  - Flow-through chamber: 0.7L
  - Filter chamber: 0.2L
  - Total volume with hoses: < 1.2L
- **Hydraulic connectors and hoses:** ½ inch, BSP as standard, other type on request
- **Lead shield:** 70mm thick to 80mm
- **Inputs / Outputs:** 4 digital I/O and 4 analog I/O
- **Typical sensitivity:** 0.5 to 1 nanometer wear depending on oil volume and part activity

TABLE OF TLA-RNT FEATURES (ELECTRONICS AND SOFTWARE)

- **Processor:** Last generation PC
- **Detector Type / Size:**
  - Flow-through equipment: NaI 4" x 4"
  - Filter equipment: NaI 3" x 3"
- **High Resolution Ge Detectors :** Optional
- **Spectrometer (MCA):** Each detector is connected to a 4096 channel digital MCA
- **Maximum throughput rates :** Maximum Count Rate (gamma rays) 25,000 Cps
- **Operating environment:** Windows latest release
- **TLA Software:** "B-Wear" V1.3, controls the MCA and I/O data acquisition board, collects data, analyses on-line, displays data and graphs
- **Counting in defined energy windows (ROI):** Independent windows (ROIs) defined by upper and lower energy, and related to MCA channels by an energy calibration. Counts from each ROI (with or without background subtraction) analyzed according to its own parameter set
- **Max. number of ROIs:** 5
- **Real-time analysis:** Data extracted from spectrum (ROIs) & I/O card, and analyzed to produce wear or other physical measurements.
- **Depth profiles:** Yes, as input data
- **Data storage:** Data file containing all extracted and analyzed data
- **Regeneration of data set from spectra:** Entire data file may be regenerated from spectra. User may change ROIs and all analysis parameters to reanalyze any campaign
- **Max. number of counting periods:** Unlimited
- **Min. acquisition interval:** 2 seconds
- **NaI Gain Stabilization:** Software routine follows peak to correct for fluctuations in gain when measurement is performed over long periods of time
- **Additional I/O system:** Optional acquisition board allows user to include data from the test (RPM, torque, oil temperature, etc.) to be recorded, analyzed and displayed. A/D outputs to test bench management system also available as an option.

CONTACT

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