The CETR-MC is a state-of-the-art Tribological Station with interchangeable modules allowing it to perform many tests, either derived from the standards (4 balls, Falex, Timken, SRV) or with more complicated contact situations. It is possible, for example, to perform tests at various Rolling-to-Sliding ratios or to slide creating spiral tracks while keeping a constant linear speed...

In addition, the CETR is equipped with many complementary sensors allowing a perfect understanding of the phenomena taking place during the tests: Acoustic Emission (AE), Electrical Contact resistance (ECR) or even a micro displacement capacitance sensor to monitor the wear as the test proceeds.

This machine is our most versatile piece of equipment for modelling any contact situation in terms of geometry, speed and pressure that our customers may present to finally develop an adequate solution to their problem.

**Characteristics:**
- 6D Force-Torque sensor: Torque & Force on X,Y and Z axis (0.1 to 20N.m, 10 to 1000 N)
- Fully programmable, fully computer controlled (speeds, forces, positions)
- Position or Force servo-control system.
- High Frequency Multichannel Acquisition
- Contact Acoustic Emission
- Electrical Contact Resistance
- Wear quantification by means of a capacitive sensor

**Example of some results:** Friction coefficient; Electrical Contact Resistance and Acoustic Emission
This machine has been specially developed for carrying out tests, in pin-on-disk/ball-on-disk configuration, at temperatures going from room temperature up to 1100°C.

This device is adapted for modelling, on a lab scale, metal deformation processes at high temperatures and tribology phenomena taking place in standard or complex environmental conditions as in aeronautics or the nuclear industry.

All types of metals and alloys can be tested: aluminium, copper, steel, titanium, inconel, maraging, etc.

- Load: 5 - 1000 N ± 50 mN.
- Temperature: Room T - 1100°C ± 0.1 °C.
- Rotation speed: 0 - 3000 rpm.
- Environmentally regulated (N₂) aiming the control of the oxidation speed of the samples.

Coated sample after tribological test at 950°C

Schematics of the disk deformation at high temperature in a friction test.
This device which allows the performance of Falex “Pin&Vee” tests is mounted on CETR-MC platform.

In the so-called Pin&Vee test, the pin-a cylinder spinning at speeds from 0.1 to 3000 rpm- is trapped between the vee blocks. The load, that is radially applied, the rotation speed and the generated torque that overcomes the friction between surfaces, hence letting the spinning of the cylinder, are continuously recorded.

Together with this module, the complementary sensors of the CETR-MC can be used to give a wider view of the processes taking place in the contact, i.e. galling or seizure. The geometry can be adapted to more complex contact situations.

- Direct Load: 50 - 5000 N
- Rotation speeds: 0-3000 rpm.
- Torque max. \( T_2 \): 4000 N.mm

**NOTE:** Being the maximum applied direct load of 5000N, tests can only cope with the low capacity tests detailed on the standards.

**ASTM D2625:** Endurance (Wear) Life and Load-Carrying Capacity of Solid Film Lubricants (Falex Pin and Vee Method)

**ASTM D2670:** Measuring Wear Properties of Fluid Lubricants (Falex Pin and Vee Block Method)

**ASTM D3233:** Measurement of Extreme Pressure Properties of Fluid Lubricants (Falex Pin and Vee Block Methods)

**ASTM D5620:** Evaluating Thin Film Fluid Lubricants in a Drain and Dry Mode Using a Pin and Vee Block Test Machine

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**Seizure endurance for a standard oil**

![Seizure diagram](image_url)
This module allows performing Timken –Block-on-ring tests. It is mounted on the CETR-MC platform.

In the so-called Timken test, a block (or another geometry; i.e. ball, cylinder) is pressed against a rotating ring. The external surface of the latter passes through a fluid which is dragged into the contact thanks to the rotating motion.

- Load = 10-1000 N
- Ø ext. Ring = 36 mm; Ring thickness = 8mm
- Rotation speed: 0-3000 rpm.
- Lubricating Fluid container.
- Additional CETR-MC sensors: Acoustic Emission and Electrical Contact Resistance.

Tests derived from standards:

- **ASTM D2714:** Calibration and Operation of the Falex Block-on-Ring Friction and Wear Testing Machine
- **ASTM D2981:** Wear Life of Solid Film Lubricants in Oscillating Motion
- **ASTM D3704:** Wear Preventive Properties of Lubricating Greases Using the (Falex) Block on Ring Test Machine in Oscillating Motion
- **ASTM G77:** Ranking Resistance of Materials to Sliding Wear Using Block-on-Ring Wear Test
- **ASTM G137:** Ranking Resistance of Plastic Materials to Sliding Wear Using a Block-On-Ring Configuration
- **ASTM G176:** Ranking Resistance of Plastics to Sliding Wear Using Block-on-Ring Wear Test - Cumulative Wear Method

**NOTE:** Because the maximum loading capacity is 1000 N, it is not possible to cover all the specifications in the standards. However the utilisation of the CETR module together with its complementary-high performance sensors allow a better understanding of the phenomena taking place (see fiche CETR-MC)
Variable Rolling to Sliding Fixture (VRS) (CETR-MC)

This test allows evaluating the performance of lubricating fluids when a combined rolling/sliding contact mode takes place in a system (0%; 15%; 35% or 65% rolling to sliding ratio). This fixture has been developed for studying gears, ball screw transmissions, pure rolling phenomena...

Three cylinders/balls (rollers) are symmetrically placed at different positions with respect to the rotation axis. In the meantime, two discs trap the cylinders in between. When the test is running, the discs drag the rollers into a movement that combines both sliding and rolling due to a difference of the rotating radius of all the points along the cylinders.

The additional sensors of the CETR-MC can also be used with this module: Acoustic Emission, Electrical Contact Resistance and micro-capacitance recording.

<table>
<thead>
<tr>
<th>Sliding/Rolling</th>
<th>Normal Load</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0-100)N</td>
</tr>
<tr>
<td>15% et 35%</td>
<td>3000 RPM</td>
</tr>
<tr>
<td>65%</td>
<td>3000 RPM</td>
</tr>
<tr>
<td></td>
<td>3000 RPM*</td>
</tr>
</tbody>
</table>

* Estimated rotation speeds for a hardened steel separator.

Example of results @ 35% R/S ratio:
One can observe a break in ECR signal which denotes an hydrodynamic film breakdown, even if friction remains steady.
This fancy word refers to a branch of Tribology where at least one of the surfaces in relative motion is biological. It gathers together fields apparently as different as surface engineering on one side and medicine, cosmetology, pharmacy and biology on the other.

In most of the cases, the pressure that such biological systems may withstand is really small and in consequence wear is not usually an issue but friction or electrical impedance of the surfaces in contact (i.e. measure of the moisturizing capacity of creams) are important parameters to be characterised.

This module has low range force sensors and a special support that allows to place an arm to test on real-alive samples. It is also possible to perform tests on hairs, nails, hands....

• Load = 5-500 mN ± 50µN, Electrical Impedance Sensor: 0-1 MΩ
• Skin Testing, skin treatment performance measurement
• Evolution of skin softness
• Varnish scratch resistance
• Hair/Shampoo characterization
• ...

4 Balls Test

Four Ball-Test is used to measure the Anti Wear (AW) and Extreme Pressure (EP) properties of grease-and lubricating oil. The point contact interface is obtained by rotating a 12.7mm diameter steel ball under load against three stationary steel balls immersed in the lubricant. The speed of rotation, normal load, and temperature can be adjusted in accordance with published ASTM standards. To evaluate the anti wear characteristics of lubricants, the subsequence wear scar diameters on the balls is measured. To evaluate the Extreme-Pressure (load-carrying) capacity of lubricants, the normal load at which welding occurs at the contact interface is measured.

A. Anti Wear (AW): ASTM D 4172 (lubricating fluids) & D 2266 (lubricating greases)

Three ½ in. (12.7-mm) diameter steel balls are clamped together and covered with the lubricant to be evaluated. A fourth ½ in. diameter steel ball, referred to as the top ball, is pressed with a force of 40 kaf (392 N) into the cavity formed by the three clamped balls for three-point contact. Then the top ball is rotated at 1200 rpm for 60 min. Lubricants are compared by using the average size of the scar diameters worn on the three lower clamped balls. The four-ball wear-test method can be used to determine the relative wear-preventing properties of greases under the test conditions.

B. Extreme Pressure (EP): ASTM D 2783 (lubricating fluids); ASTM D 2596 (lubricating greases); ISO 20623

The test is run with one steel ball under load rotating against three steel balls held stationary in the form of a cradle. The rotating speed is 1770 ± 60 rpm. Lubricating fluids are brought to 27°C ± 8°C and then subjected to a series of tests of 10-s duration at increasing loads until welding occurs. This test method, used for specification purposes differentiates between lubricating greases or fluids having low, medium, and high level of extreme-pressure properties.

InS 4 balls tester can be set up in order to perform any custom tests in terms of speed, duration, applied load in accordance with device limitations.

![Graph: Load vs. Wear curves for 4 different samples exhibiting different AW and EP behaviour]

Example of wear scar on a ball

4 welded balls after test

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SRV is an acronym for «Schwingung Reibung Verschleiß», German for *reciprocating friction and wear*. This tribometer allows any lubricant (oils, greases, coatings...) qualification versus different contact configurations representative of various problematic such as piston-cylinder, cam-valve, chain, fretting...

SRV tribometer is covered by numerous standards. Any kind of materials can be tested, specific samples can be designed in order to simulate exotic contact.

**Standardized Tribometer:**
- ASTM D5706: Method for determining extreme pressure properties of lubricating greases
- ASTM D5707: Method for measuring friction and wear properties of lubricating greases
- ASTM D6425: Method for measuring friction and wear properties of extreme pressure lubricating oils
- ASTM G133-02: Standard test method for linearly reciprocating ball-on flat sliding wear
- DIN 51834: Determination of friction & wear data of lubricating oils

**Adjustable Tribometer:**
- Normal load: 25 to 1000 N
- Frequency: 10 to 250 Hz
- Amplitude: 10 µm to 3 mm
- Temperature: Up to 250°C
- Controlled atmosphere

**Examples of wear scars**

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**Additive influence on anti seizure performances of a grease**
**Timken Test**

Timken test is ideally suited for evaluation of Extreme Pressure and Anti Wear properties of lubricants and greases. Both lubricating fluids and greases can be evaluated to determine the load required for the onset of severe abrasive wear and scuffing.

The Timken test consists in a bearing race mounted on a tapered arbour rotating at high speed. The race is brought into contact with a square steel test block under normal load. The contact area is flooded with the lubricant being tested. The width of wear scar is measured at several applied normal load and the « OK load » is defined by the load at which scoring, scuffing or seizure appears.

The test method is widely used for specification purposes and to differentiate among lubricants having low, medium, or high levels of extreme pressure characteristics. The device also allows the measurement of anti wear properties of specific material under dry lubricating conditions.

- **Normal Loads**: 5 N – 5000 N
- **Rotating speeds**: 0-2500 rpm.
- **Temperatures**: Ambient to 300°C

**Extreme Pressure properties:**

ASTM D2509; DIN 51434 P3; IP 326: EP Properties of Lubricating Greases  
ASTM D2782; DIN 51434 P2; IP 240 : EP Properties of lubricating Fluids

**Anti Wear properties:**

ASTM G77: Ranking Resistance of Materials to Sliding Wear using Block on ring Wear Test  
ASTM G 176-03: Ranking Resistance of Plastics to Sliding Wear using Block-on-Ring Wear Test—Cumulative Wear Method.  
ASTM G 137-97: Ranking Resistance of Plastic Materials to Sliding Wear Using a Block-On-Ring Configuration
**Scanning Electron Microscope / Energy Dispersive X-Ray Spectroscopy**

**Scanning Electron Microscope (SEM)** is a type of electron microscope that images the sample surface by scanning it with a high-energy beam of electrons in a raster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample’s surface topography, composition and other properties such as electrical conductivity. Scanning electron microscopes are equipped with a cathode and magnetic lenses to create and focus a beam of electrons, and since the 1960s they have been equipped with elemental analysis capabilities.

**Energy dispersive X-ray spectroscopy** (EDS, EDX or EDXRF) is an analytical technique used for the elemental analysis or chemical characterization of a sample. SEM/EDX coupling allows high resolution elementary mapping of a sample and its chemical composition.

**SEM Optical Column**

**Electrons/Matter interactions: X-Rays Emission**

**High Resolution imaging of a surface**

**EDX Spectrum**: Elements detection, chemical composition and quantitative analysis

**Elementary mapping of imaged area (Zinc and Iron)**

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**Atomic Force Microscopy**

**Atomic force microscope** (AFM) or Scanning Force Microscope (SFM) is a very high-resolution scanning probe microscope, with demonstrable resolution of fractions of a nanometer, more than 1000 times better than the optical diffraction limit. AFM is one of the foremost tools for imaging, measuring and topography characterizing up to nanoscale. The information is gathered by “feeling” the surface with a mechanical probe. Piezoelectric elements, that facilitate tiny but accurate and precise movements on (electronic) command, enable the very precise scanning. AFM also allows measurement of interaction forces between tip and surface sample.

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**Block Diagram of AFM**

**SEM view of an AFM Tip (x 3000)**

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**Topographical analysis of a tribofomed film:**
One can observe small «hills» of about 200nm in height

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**3D Imaging of a surface**

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**AFM Q-Scope Ambios:**
- PZT scanner X-Y : 90 x 90 μm
- Z Range : 12 μm
- Open loop
- X & Y Resolution : 12 Å
- Z Resolution : 2,5 Å
- Contact and Tapping Mode
Among the classics of the analytical chemistry, regular tests are frequently required by the industry in order to characterize its lubricants in use or before use. These tests do not correspond to standard tests, but can be adapted on demand to measure, check or validate other conditions than standard conditions. These various analyses are the most common. A lot of other tests are available on demand: please feel free to contact us.

### Available Techniques

**pH meter, acid / base titration, determination of the neutral points**

**Potentiometric titration, specific electrodes: TAN-TBN, iodine index, saponification index, general chemical titration by potentiometric analysis**

In the case of low water content, Karl Fisher allows the determination of this content in some medias. Dry extract can also be conducted for the quantification of water and volatile compounds content of your lubricants or for the follow up of the water dilution rate of your lubricant in use.

The dynamic viscosity can be evaluated using this Brookfield viscometer, from room temperature up to 150°C. These measurements allows the follow up of your lubricants in use or the determination of the viscosity of non-Newtonian fluids.

This cone penetrometer allows the determination of the consistency of greases in agreement with the standard method ASTM D217 – "Standard test methods for cone penetration of lubricating grease". It allows also the classification on the basis of the NLGI standard.
Like molecular vibrational spectroscopy, the Fourier Transformed Infrared Spectroscopy allows the identification of unknown compounds and the determination of structures and microstructures by detecting the presence or the absence of atoms groups. Mainly used for the qualitative analysis of the chemical functions of your lubricants, the Fourier Transformed Infrared Spectroscopy also allows to quantify their components after calibration. Equipped by an ATR Germanium, the FTIR allows the analysis of powders, liquids or solids lubricants.

Products aspect: Powders, liquids, solids

Wavelength: 400cm⁻¹ to 4400cm⁻¹

Quantification: After Calibration
The Inductively Coupled Plasma Atomic Emission Spectrometer (ICP spectroscopy) allows the titration of almost all the elements of your samples in minutes thanks to the power of argon plasma (> 8000°C). The analysis of solids necessary needs a prior step of mineralization, either acid in temperature and under pressure, or by alkaline fusion.

**Directly analyzable samples**
Inorganic Powder dispersion (<100µm) et aqueous solutions

**Analyzable samples after mineralization step**
Non-organic powders and solids

**Absolute Quantification**
1/10 ppm precision

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High Performance Liquid Chromatography (HPLC) allows qualitative and quantitative analysis of your samples. Diluted in a solvent, the organic constituents of your samples are then separated by chemical nature depending on their interactions with the chosen column. It determines their retention time. The various constituents are then detected using a refractometer. For your samples doped with solid particles, these particles are extracted before performing the analysis.

**Fluents:** water, halogenated solvents, acetonitrile,...

**Detection method:** Refractometry

**Temperature:** from 5°C to 90°C (Peltier effect oven)

**Quantification:** Internal or external calibration

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**Results**

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Thermal analysis gathers two main analytical methods developed to evaluate the properties of your materials when the temperature changes. **Thermogravimetric analysis (TGA)** allows to precisely determine **changes in weight** of a sample as a **function of the temperature**. Its coupling with **Differential Thermal Analysis (SDTA)** allows the **simultaneous characterization** of all the weight-independent phenomena (fusion, change in structure,...).

This technique will allow you to know better your lubricants in terms of **high temperature life** and **oxidation resistance**. You will also be able to determine the **endothermic or exothermic reaction characteristics** of your systems.

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**Analyzable Materials**: Organic or inorganic solids, powders, liquids

**Temperature range**: 15 to 1600°C

**Heating rate**: 0.01 to 100 °C/min

**Weighing device precision**: ± 1 µg

**Atmosphere**: Air or Inert (nitrogen)

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![Thermographs](image1.png)

- Thermographs
- Quantification
- Identification

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Based on the analysis of diffracted light, the Particle Size Distribution (PSD) with Laser Diffraction Method allows the determination of the relative amount of particles, sorted according to size, in your samples ranging from 40nm to 500µm. Equipped with a water cell and an organic cell, PSD Laser will give you the distribution of the particles dispersed in your water-based, oil-based or organic solvent-based lubricants.

**Analyzable solutions:**
Water, mineral oil, synthetic oil, vegetal oil, solvents (alcohols...), ...

**Analysis methods:**
Mie and/or Fraunhöfer

**Particle size range:**
40nm to 500µm

☑ Graphic Representation
☑ Numeric Datum
☑ D-values (ex: D_{10}, D_{50}, D_{90})
The combined salt spray and humidity cabinet allows evaluation of the corrosion resistance of your raw or chemically treated materials as well as your coatings in various corrosive environments. Your systems can be tested under salt spray conditions only, under humid conditions only or under alternative conditions of salt spray, drying and humidity. All these conditions are programmable and are defined by time duration, temperature and number of cycles.

**Tests panels**
Standard panels or support of your choice (within the limits of size/weight of the cabinet) in the dimension/weight limits of the enclosure made of the material of your choice

**Testing conditions**
- Salt spray
- Humidity cabinet
- Cycle: salt spray/drying/humidity cabinet

**Temperature:** from room temperature to 55°C

**Standards:** as a function of your conditions and your systems to be tested (NF EN ISO 9227 and 14993, ASTM B117, NF EN ISO 17872, DIN 50017, ...)

Follow up by pictures of the evolution of your systems versus exposure time.

Rating of the degree of rusting (Re) on the basis of the European scale and on the basis of the standard NF EN ISO 4628/1-8