inegi
Instituto de Engenharia
Mecânica e Gestão Industrial

LAL

Lubricant Analysis Laboratory

allows premature failure detection in equipment,
optimizing the preventive maintenance and improving reliability

CETRIB
Unidade de Tribologia, Vibrações
e Manutenção Industrial

Laboratory Location

INEGI - Instituto de Engenharia Mecânica e Gestão Industrial
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CETRIB

Unidade de Tribologia, Vibrações
e Manutenção Industrial

CETRIB - "Unidade de Tribologia, Vibrações e Manutenção Industrial" is the unit of INEGI that covers the fields of Tribology and Industrial Maintenance. That includes topics related with the science and technology of friction, lubrication and wear, as well as its implications in the area of industrial maintenance, particularly in the field of condition monitoring by lubricant and vibration analysis.

CETRIB was created in January 1991 by a natural development of a program that begun 20 years ago inside the Mechanical Engineering Department of the "Faculdade de Engenharia da Universidade do Porto".

CETRIB is integrated as Unit nº 130 of FCT (Fundação para a Ciência e Tecnologia do Ministério da Ciência e Tecnologia) since 2002, attaining an overall grading of **EXCELLENT**.

CETRIB is also integrated in the LAETA – Laboratório Associado de Energia, Transportes e Aeronáutica of the Portuguese scientific system.

Since 1991, **CETRIB** produced more than 30 PhD Thesis and MSc in the field of mechanical transmissions through gears and corresponding components.

Since 1991, the researchers within **CETRIB** had published **more than 150 papers** in journals and international conferences concerning several domains, such as, gears, rolling bearings and lubrication.

Since 1991 occurred at **CETRIB** **more than 30 I&D projects in the field of mechanical transmitions and their components:** gears, rolling bearings, surface failures (scuffing, wear, micropitting, contact fatigue) gear oils, gear coatings and grease lubricants.

Such I&D projects were supported by the Portuguese programs (FCT), by European Union (BRITE-EURAM, GROWTH, CRAFT ...) and by several industries, European and Portuguese:

- *Galp Energia*
- *MOBIL Oil Portuguesa*
- *FUCHS Petrolub*
- *RENAULT Technocentre*
- *RENAULT Portuguesa*
- *FICOcables*
- *...*
- *REPSOL*
- *BP*
- *DOW Europe*
- *SKF*
- *EFACEC Energia*
- *CERN*

The **Lubricant Analysis Laboratory** of **CETRIB** were also created in 1991, producing since then, several **thousands of gear oil analysis**, as part of I&D projects and industrial companies:

- *PORTUCEL Soporcel*
- *EFACEC Energia*
- *LUSÁGUA*
- *TRANSMETRO*
- *STCP*
- *DIEHL FOPOBOL*
- *LBC Tanquipor*
- *MIIT, Lisboa*
- *VICAIMA*
- *GALP Energia*
- *F. RAMADA*
- *AUTOMA*
- *MICROplásticos*
- *...*

MAINTENANCE THROUGH MACHINE CONDITION MONITORING

Facing the actual competitiveness, it is essential to implement new strategies in the industrial management to improve productivity and quality of products and/or services. Although, the inherent cost optimization should always be achieved.

This management is shared by two main functions: **production** and **maintenance**.

The consequences of using common maintenance strategies - Corrective and Systematic Preventive Maintenance, can be quantified by the rate of failures, the loss of production due to unavailability of equipment and the amount of discarded products originating in poor working condition of the equipment. Of course, these strategies are not the most effective for costs optimization.

However, the implementation of a maintenance strategy based on knowledge of the equipment condition, can contribute to a substantial reduction in the overall company costs, since:

- provides maximum use of equipment, scheduling their stops for maintenance without interfering with the production;
- improves the quality of the product, which is strongly dependent on the operating condition of the equipment;
- reduces maintenance costs and costs associated with equipment in "standby " and spare parts in stock ;
- increases safety.

The analysis of Operating Lubricants is a technique that allows Condition Maintenance that allows knowing the state of the machine and following the evolution of any change related to the wear of the several lubricated elements, but also detecting the changes of physical and chemical characteristics that occur in the lubricant.

CETRIB Monitoring Service

CETRIB makes analysis of Operating Lubricants, as support for the maintenance actions of various types of industry and application to a wide range of equipment:

- turbines;
- gearboxes ;
- compressors ;
- hydraulic systems ;
- motors ;
- etc. .

The techniques used by CETRIB allow:

- quantify machine wear and contamination of the lubricant;
- determine the type of wear that is developing in the machine ;
- identify the component of the machine that possibly is deteriorating;
- determine the lubricant condition.

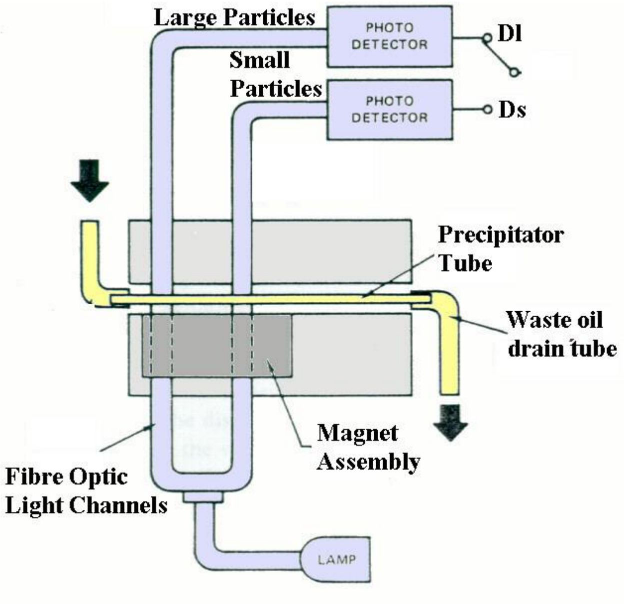
CETRIB draws analysis programs, which include the determination of sampling points on the machine and its frequency, providing all required information and material to obtain a representative sample of the lubricated system and, if required, has specialized technicians for the achievement of those samples.

Once the sample is collected, the next step is to proceed with its identification using a label provided by CETRIB. This should be properly completed with all information concerning the machine and the lubricant. Thus, the sample is ready to be sent to CETRIB to perform the necessary analyses to detect any abnormality, either related to the lubricant condition or to the machine.

ANALYTICAL METHODS

Direct Reading Ferrograph (DRIII)

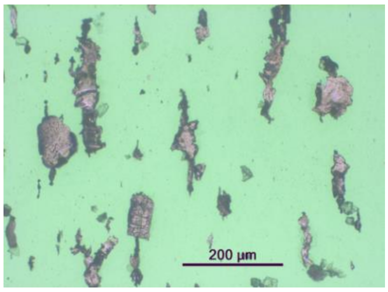
The Direct Reading Ferrograph measure quantitatively the concentration of ferrous particles contained in the lubricant oil.



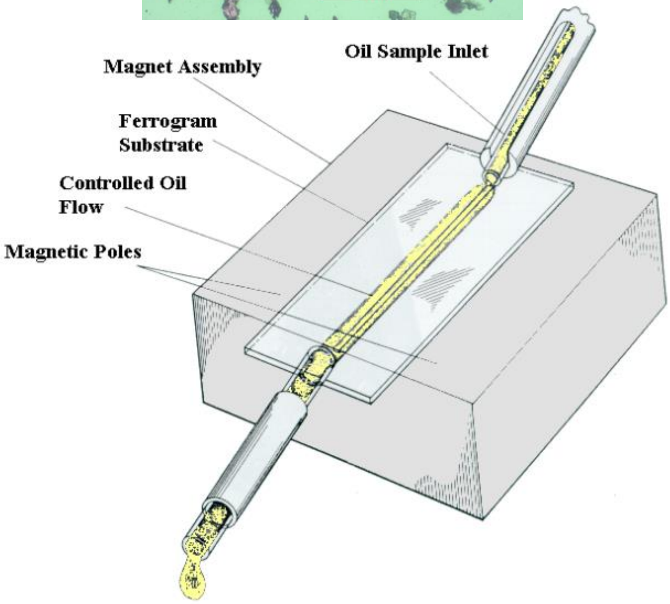
The DR Ferrograph magnetically precipitates the wear particles from a sample and provides digital readings of the quantity of both large - Dl (>5μm) and small - Ds (<5μm) particles present in the fluid. These numerical readings and their relative values provide a reliable basis for assessing the degree of wear occurring in the machine.

When tests with the DR Ferrograph reveal a pronounced increase in the particle density and high severity wear index, an Analytical Ferrogram may be made to determine specifically what type of wear is occurring and to provide the basis from which a decision can be made whether to overhaul or continue operation.

Analytical Ferrograph (FM III)



The Analytical Ferrograph is used to prepare a Ferrogram – a fixed slide of wear particles for optical microscopic examination and photographic documentation.



Wear particles suspended in an oil sample are magnetically precipitated onto a thin glass slide, or Ferrogram. The microscopic analyse of the Ferrogram provides a qualitative basis for evaluating and visually recording the machine wear history. It also provides specific identification of wear mechanisms and individual parts producing patterns of incipient or catastrophic failure.

Particle Counter

ISO 4406:99; NAS 1638 and SAE AS 4059

Contamination is the main cause of the faults occurrence in any lubricated system. Controlling contamination is an effective way to control the wear present in the equipment.

Particle counting is fundamental to monitor the fluid of hydraulic systems or turbines in terms of contamination because these systems require high cleanness grades. Its use can be extended to all lubricated systems, including the condition monitoring of rolling element bearings.

Particle counters determine the amount of particles per sample volume (ml), grouping them according to their size. The results can then be analysed and expressed in terms of codes of cleanliness according to ISO 4406:99, NAS 1638 and SAE AS4059.

Millipore Membrane Filtration

Membrane Filtration is used as an analytical toll for collecting, identifying and measure particles in lubricating oils.

This test method involves passing a representative sample of oil through a Millipore filter disc. All particulate matter that exceeds the membrane pore size will be retained on the surface where the contaminants may be analysed.

There are two simple test procedures for particulate contamination:

- Particle Counting – a quantitative method for determining contamination levels by particle counting using microscopy;
- Gravimetric – a quantitative method for determining contamination level by weight.

Viscosity

Probably the most important property of lubricating oil is its viscosity. This property reflects the degree of internal friction or resistance that a liquid provides to sliding. The measure of the dynamic or kinematic viscosity of an oil is possible using different methods (Engler and vibrational).

Vibro Viscometer (SV- 10)

The dynamic viscosity of a fluid expresses its resistance to shearing flows, where adjacent layers move parallel to each other with different speeds.

The Vibro Viscometer has two metallic plates which are immersed in the fluid, emitting waves at high frequency vibration. The energy absorbed by the fluid will depend on its viscosity and is measured accurately by electronic sensors and microprocessors.

Engler Viscometer (IP 212/92)

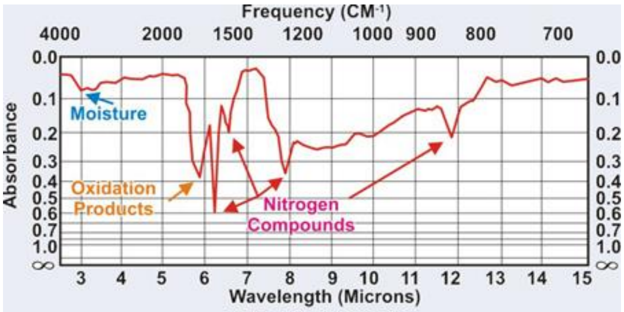
Cinematic viscosity is a measure of a fluid's resistance to flow under gravitational forces. It is determined by measuring the time, in seconds, required for a fixed volume (200 ml) of fluid to flow into a flask at controlled temperature. The oil viscosity is normally measured at 40°C. The value is then compared with the value of the new oil viscosity.

Viscosity affects equipment operation, friction losses and oil film thickness in bearings. Its measurement and trending is therefore, critical to used oil analysis.

Fourier Transform Infrared Spectroscopy (FTIR)

The infrared spectroscopy has recently become a tool commonly used in lubricating oils analysis. This technique is used to quantify molecular organic compounds, monitor the fractionation of additives (antioxidants) and identify molecular compounds resulting from oil degradation (oxidation).

By comparing the spectra obtained for the fresh and used oil it is possible to identify changes in terms of oxidation, nitration and sulphation as well as the presence of water and sludge / varnish (sediment resulting from the degradation of oil). After processing their spectra and obtaining quantitative parameters monitored in time, it is possible to make the right decisions regarding the needs to replace or refreshing the oil.



Total Acid and Base Number

TAN/TBN - ASTM D974, D3339

The determination of the acid number (TAN) by colorimetric titration can be used as a measure of the lubricant degradation (depletion of additives, oxidation and contamination).

The Total Acid Number (TAN) is a measure of the total acid concentration in the lubricating oil. The TAN values are expressed in milligrams (mg) of potassium hydroxide required to neutralize all the acid components in a gram (g) of sample oil.

As the oil aging occur and is oxidised, small quantities of acids are formed causing an increase in the acidity number (AN).

A high TAN is a clear indication that the life of the lubricant came to the end and it needs to be replaced immediately.

OilView (CSI Model 5100)

OilView Analyser measures the changes in the oil quality, indicating the presence of contamination or a possible chemical change.

The results are expressed as quantitative indexes - Corrosion Index (oil oxidation, soot and water) Contaminant Index, Ferrous Index, Chemical Index (lubricant degradation by contamination with soluble products or in suspension), OilLife Index (lubricant degradation by insoluble material) and qualitative parameters, such as, Large Contaminant, No Large Indications, Large Ferrous Particles, Large Nonferrous Particles, Fluid Droplets (free water).

Oil and Thickener in Lubricating Greases

DIN 51 814

The determination of the oil and thickener fraction in grease can be used to diagnose its condition. As grease nears its end of life, the percentage of oil that can be hold by the thickener is considerably diminished.

It is confirmed that, when the structure of a grease losses approximately half of the initial oil by the combined action of degradation, oxidation and evaporation, the useful life of the grease is at its end.

Using the dialysis method, the percentage of oil in the grease can be easily determined allowing an evaluation of their condition.

Flash and Combustion Point

ASTM D92– 98a

The Flash Point is a measure of the tendency of an oil in certain laboratory conditions to produce a flammable mixture with air. It is just one of the properties that should be considered to meet the flammability hazard of a material.

Flash point is the minimum temperature, to which the application of a test flame causes inflammation of the vapours formed in the surface of the sample.

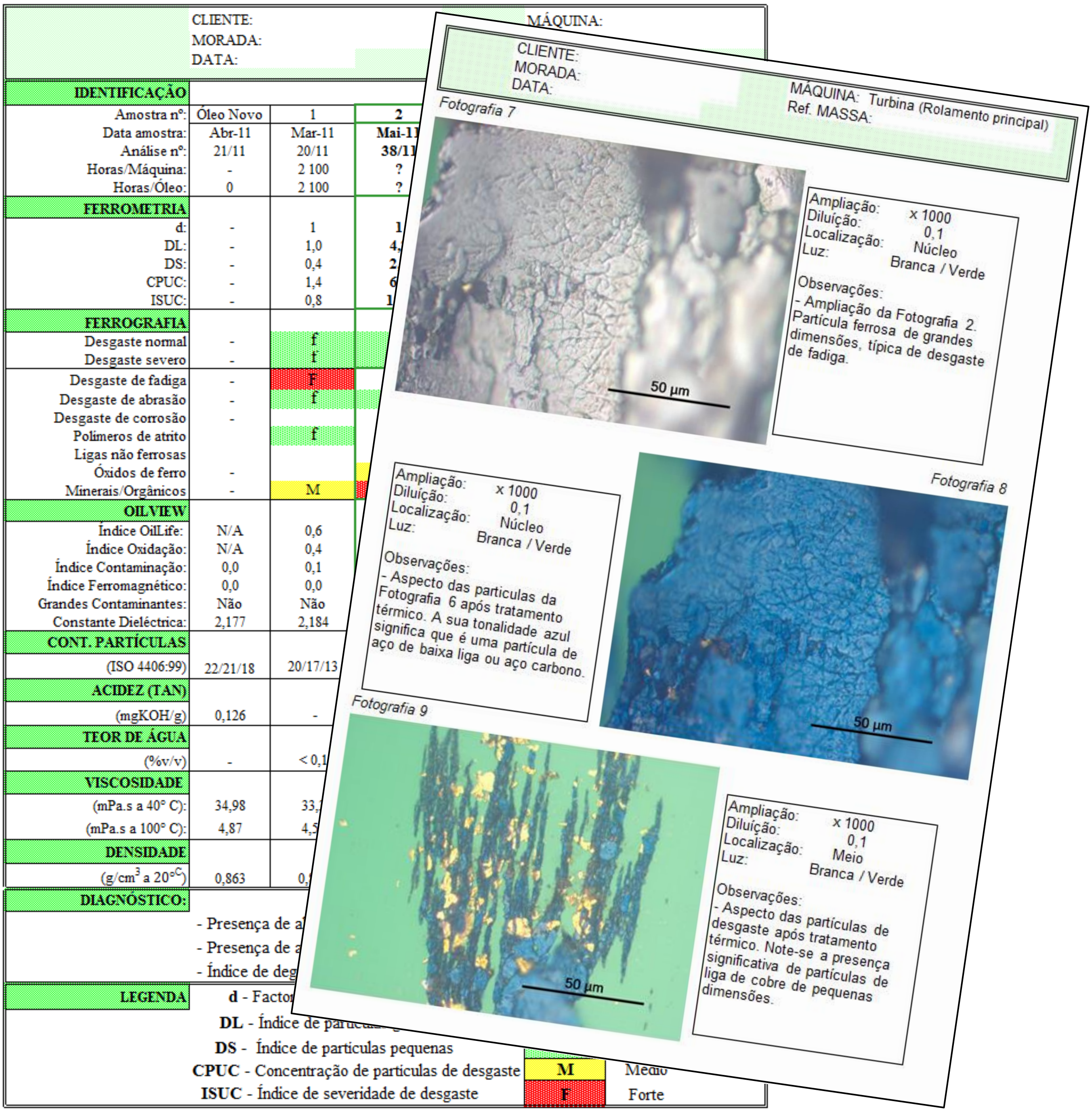
The Flash point can indicate the presence of flammable and highly volatile products. For example, in engine oil, a lowering of the flash point can be the result of contamination of the oil by fuel.

ANALISYS REPORT

Joining all the analysis results, a report is prepared which sets out the results obtained with their interpretations and recommendations. However, if a serious problem is detected, the client will be contacted immediately to allow a fast and ready action.

Previous analysis results are also included in the report so, it is possible to create a historical of the equipment condition over time and perform tendency analysis.

CETRIB Service Monitoring permits maintenance saving costs, giving timely information about the operating condition of the equipment, allowing a better planning of the needed interventions without interference with production. Thus it is ensured maximum availability of equipment which consequently will capitalize on both the productive and human sector.


CLIENTE:
MORADA:
DATA:
MÁQUINA:

IDENTIFICAÇÃO			
Amostra nº:	Óleo Novo	1	2
Data amostra:	Abr-11	Mar-11	Mai-11
Análise nº:	21/11	20/11	38/11
Horas/Máquina:	-	2 100	?
Horas/Óleo:	0	2 100	?
FERROMETRIA			
d:	-	1	1
DL:	-	1,0	4,
DS:	-	0,4	2
CPUC:	-	1,4	6
ISUC:	-	0,8	1
FERROGRAFIA			
Desgaste normal	-	f	
Desgaste severo	-	f	
Desgaste de fadiga	-	F	
Desgaste de abrasão	-	f	
Desgaste de corrosão	-		
Polímeros de atrito		f	
Ligas não ferrosas			
Óxidos de ferro	-		
Minerais/Orgânicos	-	M	
OILVIEW			
Índice OilLife:	N/A	0,6	
Índice Oxidação:	N/A	0,4	
Índice Contaminação:	0,0	0,1	
Índice Ferromagnético:	0,0	0,0	
Grandes Contaminantes:	Não	Não	
Constante Dieléctrica:	2,177	2,184	
CONT. PARTÍCULAS			
(ISO 4406:99)	22/21/18	20/17/13	
ACIDEZ (TAN)			
(mgKOH/g)	0,126	-	
TEOR DE ÁGUA			
(%v/v)	-	< 0,1	
VISCOSIDADE			
(mPa.s a 40° C):	34,98	33,	
(mPa.s a 100° C):	4,87	4,5	
DENSIDADE			
(g/cm^3 a 20°C)	0,863	0,	

DIAGNÓSTICO:
- Presença de a
- Presença de a
- Índice de deg

LEGENDA
d - Factor
DL - Índice de partículas
DS - Índice de partículas pequenas
CPUC - Concentração de partículas de desgaste
ISUC - Índice de severidade de desgaste
M Médio
F Forte

CLIENTE:
MORADA:
DATA:
MÁQUINA: Turbina (Rolamento principal)
Ref. MASSA:

Fotografia 7
50 µm
Ampliação: x 1000
Diluição: 0,1
Localização: Núcleo
Luz: Branca / Verde
Observações:
- Ampliação da Fotografia 2. Partícula ferrosa de grandes dimensões, típica de desgaste de fadiga.

Fotografia 8
50 µm
Ampliação: x 1000
Diluição: 0,1
Localização: Núcleo
Luz: Branca / Verde
Observações:
- Aspecto das partículas da Fotografia 6 após tratamento térmico. A sua tonalidade azul significa que é uma partícula de aço de baixa liga ou aço carbono.

Fotografia 9
50 µm
Ampliação: x 1000
Diluição: 0,1
Localização: Meio
Luz: Branca / Verde
Observações:
- Aspecto das partículas de desgaste após tratamento térmico. Note-se a presença significativa de partículas de liga de cobre de pequenas dimensões.

CETRIB laboratories and equipment

Lubricant Analysis Laboratory:

- ◊ Precision Weighing Scales
- ◊ Thermostatic Bath
- ◊ Particle Counters
- ◊ Densimeter
- ◊ Thermostatic Oven
- ◊ Direct Reading Ferrography
- ◊ Analytical Ferrography
- ◊ Flash/Combustion Point
- ◊ Millipore Filtering
- ◊ Optical Microscope and Digital Camera
- ◊ Oil View
- ◊ Rotational Rheometer
- ◊ TAN/TBN
- ◊ Engler Viscometer
- ◊ Vibro Viscometer

Mechanical Transmissions Laboratory:

- ◊ FZG Machine
- ◊ Gearbox Test Rig
- ◊ Rolling Bearing Test Machine

Metrology Laboratory:

- ◊ Roughness and Profile Measuring Device
- ◊ Double-flank Rolling Gear Tester

Lubrication and Wear Laboratory:

- ◊ Twin Disc Machine
- ◊ Pin-on-Disc Machine
- ◊ Ball-on-Disc Machine
- ◊ Four-Ball Machine
- ◊ Reciprocating Tribometer
- ◊ Piston Ring Cylinder Liner Tribometer
- ◊ Bloc and Cylinder Tribometer
- ◊ Ball Cratering

Noise and Vibration Laboratory:

- ◊ Noise and Vibration Analyser
- ◊ Vibration Shaker
- ◊ Vibration Transducers (Laser Doppler, force and accelerometers)
- ◊ Instrumented Hammer

CETRIB Technicians

The technical staffs of **CETRIB** integrates **15 Doctorates** in the main fields of Tribology, trained in several European laboratories of worldwide reputation, of which 6 are experts in the field of lubrication, failure analysis and condition monitoring on mechanical transmissions.

In the Lubricant Analysis domain, **CETRIB** integrates several technicians to coordinate, implement and manage the analysis, namely:

Jorge Seabra (PhD, MsC, Eng)

- ◊ President of INEGI since July 2013.
- ◊ Full Professor at DEMec-FEUP .
- ◊ Doctorate in Tribology by INSA de Lyon, França.
- ◊ CETRIB director since 1991.
- ◊ Responsible by Lubricant Analysis Laboratory creation and implementation.
- ◊ Author of more than 100 reports of lubricant analysis and failure diagnostics in gears.
- ◊ International expert in lubrication, failure analysis and condition monitoring in mechanical transmitions.
- ◊ Author of more than 100 papers published in journal and international conferences and coordinator of more than 20 R&D projects in the field of mechanical transmitions.
- ◊ Member of the Society of Tribologists and Lubrication Engineers (USA) and Member of the "Ordem dos Engenheiros" (Portugal).

Beatriz Graça (MsC, Eng)

- ◊ Manager of the Lubricant Analysis Laboratory since 1995.
- ◊ Master in Condition Monitoring by University College of Swansea (Wales, UK).
- ◊ Performed in her career several thousand lubricant analyses from the most diverse industries and equipment types.
- ◊ Expert in wear particle analysis from gear oils, particulary in particle counting, ferrometry and analytical ferrography.
- ◊ Author of several hundred reports concerning in service Lubricant Analysis (oils and greases).

Industrial Services

Lubricant analysis of wind turbine gearboxes oils from various Portuguese wind farms for the company - **O&M Serviços – Operação Manutenção Industrial S.A.:**

1. ……..(actualizar)

2. Wear Analysis III of a lubricating oil TEXACO MEROPA 320 from a Wind Turbine gearbox VESTAS V80 2MW (Gerador 1 - Lamego).
February 2009, 9 pp

3. Wear Analysis III of a lubricating oil TEXACO MEROPA 320 from a Wind Turbine gearbox VESTAS V80 2MW (Gerador 2 - Lamego).
February 2009, 9 pp

4. Wear Analysis III of a lubricating oil TEXACO MEROPA 320 from a Wind Turbine gearbox VESTAS V80 2MW (Gerador 3 - Lamego)
February 2009, 9 pp

5. Wear Analysis III of a lubricating oil TEXACO MEROPA 320 from a Wind Turbine gearbox VESTAS V80 2MW (Gerador 4 - Lamego)
February 2009, 8 pp

6. Wear Analysis III of a lubricating oil TEXACO MEROPA 320 from a Wind Turbine gearbox VESTAS V80 2MW (Gerador 5 - Lamego)
February 2009, 9 pp

7. Wear Analysis III of a lubricating oil TEXACO MEROPA 320 from a Wind Turbine gearbox VESTAS V80 2MW (Gerador 6 - Lamego)
February de 2009, 9 pp

8. Wear Analysis III of a lubricating oil TEXACO MEROPA 320 from a Wind Turbine gearbox VESTAS V80 2MW (Gerador 7 - Lamego)
February 2009, 9 pp

9. Wear Analysis III of a lubricating oil TEXACO MEROPA 320 from a Wind Turbine gearbox VESTAS V80 2MW (Gerador 8 - Lamego)
February 2009, 9 pp

10. Wear Analysis III of a lubricating oil TEXACO MEROPA 320 from a Wind Turbine gearbox VESTAS V80 2MW (Gerador 9 - Lamego)
February 2009, 9 pp

11. Wear Analysis III of a lubricating oil CASTROL OPTIGEAR SYNTHETIC A320 from a Wind Turbine gearbox (Gerador 5 - Pradela)
February 2009, 7 pp

12. Wear Analysis III of a lubricating oil CASTROL OPTIGEAR SYNTHETIC A320 from a Wind Turbine gearbox (Gerador 4 – Alto do Talefe)
February 2009, 6 pp

13. Wear Analysis III of a lubricating oil CASTROL OPTIGEAR SYNTHETIC A320 from a Wind Turbine gearbox (Gerador 7 – Alto do Talefe)
February 2009, 6 pp

14. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 1 – Bolores)
February de 2009, 6 pp

15. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 2 – Bolores)
OFebruary de 2009, 6 pp

16. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 3 – Bolores)
February 2009, 6 pp

17. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 4 – Bolores)
February 2009, 6 pp

18. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 1 – Mosteiro)
February de 2009, 6 pp

19. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 2 – Mosteiro)
February 2009, 6 pp

20. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 3 – Mosteiro)
February 2009, 6 pp

21. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 4 – Mosteiro)
February 2009, 6 pp

22. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 5 – Mosteiro)
February 2009, 6 pp

23. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 6 – Mosteiro)
February 2009, 6 pp

24. Wear Analysis III of a lubricating oil CASTROL TRIBOL 1710-320 from a Wind Turbine gearbox (Gerador 7 – Mosteiro)
February 2009, 6 pp

The Lubricant Analysis programs are carried out to monitor the condition of both, lubricant and equipment. The reports include, in addition to the interpretation of the results, the appropriate recommendations to improve the equipment health and availability.

Equipament Monitored and some Clients:

Wear Analysis III of a lubricating oil REPSOL TURBO ARIES 46 from a Steam Turbine – TG5.
Quartly analysis to PORTUCEL Cacia, since 2011

Wear Analysis I of a lubricating oil GALP TRANSGEAR 220 from a reducing gearbox.
Anual analysis to MIIT, Lisboa, since 2008

Wear Analysis III of two lubricating oils from diesel motors of two generators groups.
Anual analysis to MIIT, Lisboa, desde 2008

FTIR Analysis of a lubricating oil FUCHS RENOLIN B15 from an hydraulic system.
Annual analysis to Gustavo CUDELL, Porto, desde 2008

Ferrography Analysis of a lubricating oil MOBILGARD M440 de um motor MAK 9M32.
Annual analysis to ENERCOR, Montijo, desde 2008

Ferrography Analysis, TAN e FTIR of a lubricating oil GALP TERMOIL 32 from a thermal system.
Annual analysis to VICAIMA, Vale Cambra, desde 2003

Ferrography Analysis of a lubricating oil BP ENERGOL IC-DC 40 from a motor Jenbacher da CTE.
Annual analysis to RIG Inc. – International Loss Adjusters, Maia, desde 2008

FTIR analysis of a lubricating oil FUCHS RENOLIN B15 from a hydraulic system .
Annual analysis to Sogevinus, Maia, desde 2008

Wear Analysis II of a lubricating oil SHELL TELLUS 68 from the journal bearing Nº2 Grupo III (hydraulic turbine – EDP). Analysis to A. Brito, Porto, 2008

Wear Analysis II of the lubricating oils TOTAL RUBIA TIR 6400 from two motors Mercedes Benz.
Analysis to Câmara Municipal Vale de Cambra, 2008

Ferrography and FTIR analysis of the lubricating greases from several rolling bearings of the "Formador de Tiragem 3".
Annual analysis to PORTUCEL Cacia, since 2007

Ferrography Analysis of a lubricating oil Castrol Alphasyn PG320 from the gearbox of an electric generator in a wind turbine.
Analysis to FIIS, Esposende, 2006

Wear Analysis of a lubricating oil SHELL Turbo Oil T32 from the journal bearings of a alternator.
Annual analysis to EFACEC Energia, desde 2006

FTIR and SEM analysis of two lubricating greases from electric switchs.
Analysis to HUF Portuguesa, Lda, Tondela 2006

Ferrography Analysis of a lubricating grease Molykote BR2 Plus. Analysis to HUF Portuguesa, Lda, Tondela, 2006

Ferrography Analysis of a lubricating oil RENOCAL FN 745/94 from a gearbox.
Analysis to TOTAL, França, 2006

Wear Analysis of the lubricating oils TOTAL Azolla ZS 46 from tree compressors (Nº 1, 2 and 3).
Analysis to COPEFI TEC, Braga, 2006

Wear Analysis of a lubricating oil Falcon MG 46 from a hydraulic unit.
Analysis to Paulo C. Barbosa, Porto, 2006

Analysis through Dialyse of the lubricating greases Kluber Microlube GB0 from the motors ABB of a robot.
Analysis to Paulo C. Barbosa, Porto, 2006

Flash and Combustion Point of a lubricating oil Transcal N. Analysis to TIMALHA, Caldas de Vizela, 2005

Particle Counting following SAE ARP 598B. Analysis to EFACEC Energia, 2005

Water Content in a oil from water Pumps F e G.
Analysis to EFACEC Ambiente, Maia, 2005

Particle Counting following SAE ARP 598B in a voltage transformer oil (Nynas 11EN).
Analysis to EFACEC Energia, 2005

Ferrography Analysis, Oil View an Filtering by Membrane of a lubricating oil from a coal mill (Kluberoil GEM 1 – 680 N). Analysis to CIMPOR, 2005

Ferrography Analysis and Engler Viscometry of a lubricating oil from an alternator (Fuchs Renolin B 15).
Annual analysis to EFACEC Energia, desde 2005

Wear Analysis II e FTIR of a lubricating oil from a turbo compressor (GALP Turbinoil 46)
Quartly analysis to QUIMIGAL, Estarreja, 2004

Wear Analysis III of a lubricating oil BP TURBINOL X46 from a steam turbine – TG4.
Quartly analysis to PORTUCEL Cacia, desde 2004

Ferrography Analysis of a lubricating oil BP ENERGOL RC 100 from a compressor H_2
Semiannual analysis to MIIT, Lisboa, desde 2004

Ferrography Analysis of a lubricating oil SHELL TURBO OIL 46 from a compressor of HNO_3
Semiannual analysis to MIIT, Lisboa, desde 2004

Wear Analysis IIA of a lubricating oil GALP Fórmula 1 (5W40) of a Compressor Nº1 and Nº2
Annual analysis to LUSÁGUA, Porto, since 2004

Ferrography Analysis of a lubricating oil BP ENERGOL LPT100 from a compressor of HNO_3.
Annual analysis to LBC Tanquipor, Lisboa, desde 2003

Ferrography Analysis of a lubricating oil BP ENERGOL LPT100 from a compressor of H_2.
Annual analysis to LBC Tanquipor, Lisboa, desde 2003