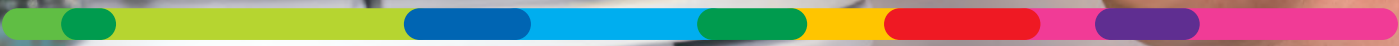

Oil Analyses

Condition assessment of transformers
and rotating machinery

- Detecting and preventing faults
 - Increasing availability
 - Optimizing maintenance
- 

01 Transformers

Prevent failures

A sudden breakdown of a power or industrial transformer usually means unforeseen costs for maintenance, new investments to be made, or unexpected production interruption. As many transformers in companies throughout Europe become older, the probability of such a breakdown increases.

What you should know about transformer failures

- The average transformer age at failure is 18 years.
- The largest financial losses are due to failures of industrial and generator step-up transformers (study by the Hartford Insurance Company).
- Insulation failure is the leading cause (responsible for one fourth of all failures).
- The cost of insulation failures alone accounts for more than half of all failure costs.
- Large power transformers have delivery times between 18 and 24 months.



02

Check your transformer's health

The insulating oil in a transformer can tell you a lot about the actual state of your transformer and its remaining lifetime. Based on this information, you can anticipate potential failures and put in place a precisely targeted maintenance or replacement plan.

What your transformer oil can tell you

An in-depth analysis of your transformer's oil gives you a good insight into the condition of your transformer and its electrical insulation.

- **Internal faults:** you can detect the presence of electrical or thermal faults and determine its exact type (partial discharges, hot spots, arcing, et cetera).
- **Transformer ageing:** the state of the winding insulation paper is the major indicator of the actual ageing of your transformer.
- **Quality of the oil:** since insulating oil in a transformer inevitably degrades with service, you should regularly check whether it still fulfils its insulating and cooling function.

The benefits of oil analyses

- The cost is very small in comparison with the cost of even a single transformer failure.
- No need to interrupt your production process. The necessary oil samples can be taken from your transformer while it is in full operation.

Rotating machinery

- Oil analyses can also provide useful information on your rotation machinery. For more details, see page 8.

Electrabel power plant Herdersbrug, Bruges (B)

'Thanks to the early detection of a hotspot, irreversible damage to the transformer — and in the worst case an explosion — was avoided.'

While remotely monitoring the transformers, Laborelec experts recorded an abnormal amount of dissolved gasses in the insulating oil. Eric Nens, responsible for MCC HV Services: 'An additional oil sample revealed that gasses had increased even further. The experts assumed the presence of a local over-heating of the oil and advised us to stop the plant.' After opening the transformer, it was found that a copper strip had been rubbing against the neighbouring magnetic core. This had led to the melting and dissolving of the copper into the oil. Short-term action was indeed necessary.



03

Transformer services

For easier transformer management

Managing your transformers is often a very complicated task. Which maintenance actions should get priority? When do you have to be concerned? Our services for oil-filled transformers can make your life easier. Whatever the criticality of your transformers, the size of your fleet, or your specific need, we can provide you with the appropriate support.

Condition Monitoring

Our experts regularly assess your transformer's condition using in-depth analysis of the insulating oil samples. These samples can be provided by you or we can take them.

What equipment

Available for all oil-filled transformer types

How

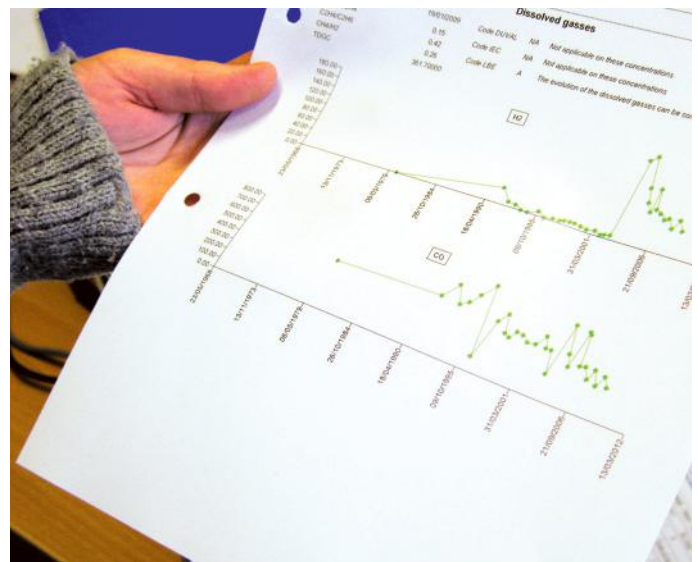
- We initially perform a standard series of oil analyses in our laboratory. We give you a **first indication** of the oil quality, the ageing of the transformer, and its general condition.
- We then **advise** you on how often your transformer should be analyzed and on the most appropriate combination of analyses for your specific transformer and situation.
- We gather all data into a **database** to enable the trending of your transformer's behaviour. Deviations in its behaviour often indicate upcoming failures.
- You receive a **report** with specific recommendations after each intervention.

Benefits

- The **risk** of an unexpected transformer breakdown is **minimized**.
- You can **optimize planning and budgeting** of necessary replacements or maintenance actions.
- **Timely** ordering of spare parts.

Incineration plant – Siomap, Brussels (B)

A regular Oil Analyses revealed an unexpected increase of the amount of dissolved gasses in the oil. 'Laborelec raised the analysis frequency to obtain more data', notes Natale Lattuca, maintenance supervisor at Siomap. 'The analysis data enabled the experts to relate the presence of gasses in the oil to a degradation of the contacts in the transformer tap changer. This problem occurs often and if not detected in time can lead to a severe electrical fault in the tap changer.'



Online Monitoring

We closely follow the behaviour of your critical transformers at Laborelec by continuously monitoring the data automatically received from onsite measurement equipment.

What equipment

Transformers that are so critical that any fault might have catastrophic consequences.

‘Sick’ transformers that are (temporarily) at an increased failure risk, for instance aged or repaired transformers.

How

- Every fifteen minutes, **crucial parameters** are **automatically measured** onsite and sent to our servers.
- In the event of deviations from normal behaviour, we immediately contact you with **guidance on appropriate countermeasures**.

Benefits

- Very **quick intervention** and prevention of major risks.
- The **assurance** that experts are continuously following up your transformer.
- You receive **(discount) credits** from your transformer insurance company.

When you need a fast answer

You can rely on us when you have an acute transformer problem. We can perform analyses 24/7 and can carry out critical oil analyses very quickly. You receive the analysis results within hours of the sample taking.

Fleet Screening

A tool to manage your transformer fleet more easily.

We make a priority ranking of the various attention points based upon our interpretation of existing data.

What equipment

Suitable for all transformer fleets, from small to very large fleets.

How

- We **gather all relevant operational and historical transformer data** and the results of existing oil analyses.
- On the basis of this data, we assess the condition of each transformer. We make a **ranking by various parameters**.
- We use a specific colour code system to help you to **quickly note attention points and establish priorities**.

Benefits

- You get a **clear overview** of the strengths and weaknesses of every transformer in your fleet.
- You know which replacements, repairs, or maintenance actions have to be executed first.
- The tool helps you to **optimize your budget planning**.

Internal name	LEE nr	manufacturer and serial number	year of start-up	SVVA	KVmax	DGA	corrosive sulfur	insulating paper ageing	general oil characteristics	overall condition and ageing
TR-2	3407 EX	ELTA/193100	1974	240	250	102110 (300-750 °C) neutral	conductive to Fe S&S<0.05	DFAL = 0.15	OK	
TR-3	3408 EX	ELTA/198356	1979	240	250	OK	conductive to Fe S&S<0.05	DFAL = 0.20	OK	
TR-4	3409 EX	ENERGOSYSTEM / ?	2004	240	250	102110 (300-750 °C) neutral	conductive to Fe S&S<0.05	DFAL = 0.21	OK	
TR-6	3410 EX	ELTA/198507	1983	240	420	102110 (300-750 °C) neutral	OK	DFAL = 0.38	power = 3.6, TAU = 0.02	
TR-5	3411 EX	ELTA/172309	1980	240	420	OK	OK	DFAL = 0.26	OK	
TR-7	3385 EX	ELTA/178103	1982	240	420	OK	OK	DFAL = 0.27	OK	
TR-8	3387 EX	ELTA/192590	1983	240	420	OK	OK	DFAL = 0.03	OK	
MAREGES 1	3451 EX	CEM/142978	1977	35	242	102110 (300-750 °C) neutral	conductive to Fe S&S<0.05	DFAL = 0.21 TAU = 0.02	OK	power = 0, TAU = 0.14



04 Transformer Oil Analyses

How it works

The cornerstone of all our condition monitoring services is the Oil Analyses. We put together the most appropriate package of analyses for each specific case. Each intervention includes the following four steps:

Sampling 1



Oil-testing 2



Interpretation 3



Recommandation 4

Step 1: Sampling

Accurate and traceable

A reliable analysis starts with a proper oil sample. We ensure that sampling takes place in optimal conditions:

- You receive the correct type of sampling devices free of charge.
- We provide you with sampling guidelines. If necessary, our experts can support you.
- For large transformer fleets, we can train a dedicated individual from your company locally.
- We register your samples into our Laboratory Information Management System (LIMS). This guarantees the full traceability of your sample data at any time.



Step 2: Oil testing

An extensive range of tests

Laborelec can perform all relevant oil analyses in its own laboratory. An overview of the most important tests:

- **To detect internal faults**

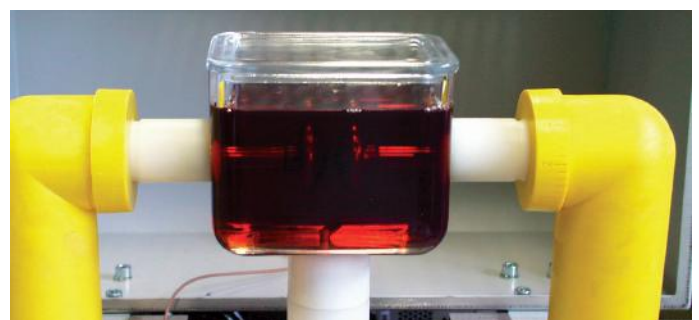
Dissolved Gasses Analysis (DGA): each type of fault generates a unique mix of gasses in a specific quantity. By removing the gasses from the sample and analyzing them, we can determine the type and seriousness of the internal transformer fault.

- **To indicate transformer ageing**

Furan and methanol content: we measure the content of furans and methanol — degradation products of the insulating paper — in the oil. This is a measure of the insulating paper quality (mechanical strength) and hence an indicator of the consumed lifetime of a transformer.

- **To assess the oil quality**

Water content and dielectric strength: we check whether the insulating capacity of the oil is still sufficient. Both an excessive level of water-in-oil concentration and/or the presence of particles in the oil can decrease this capacity. We can also evaluate acidity, dissipation factor, inhibitor content, corrosive sulphur, viscosity, oxidation stability, interfacial tension, et cetera.



Step 3: Interpretation

Incorporating experience and transformer specific data
Having reliable analysis results is one thing, the interpretation of it quite another. Interpretation is probably the most difficult phase of the entire analysis process. Based on experience with a vast number of oil analyses and specific data from your transformer, our experts assess the failure risk associated with the analysis results.

Step 4: Recommendation

Providing independent advice

Working in close cooperation with you, we provide recommendations and guidelines involving:

- Specific maintenance or replacement actions: dehydrating or degassing the oil, the use of additives, oil replacement, internal investigation, installing online monitoring, electrical measurements, et cetera up to transformer replacement.
- Future analyses: adaptation of the frequency or the set of analyses, additional analyses to be carried out, et cetera..

PCB-analysis

European legislation requires the inventory of PCBs in transformers. We provide all necessary equipment to measure the level of PCB contamination in your transformer.

Chemical industry - Solvay, Antwerp (B)

After an alarm from the Buchholz relay in an industrial water-cooled transformer, Laborelec promptly performed several oil analyses. 'Within just a few hours, a high water content combined with a low breakdown voltage was identified as the root cause of the excessive gas formation in our transformer. Indeed, further investigation revealed a water leak in the heat exchanger caused by material incompatibility,' says Pascal Dufour, in charge of maintenance at Solvay Antwerpen. 'This knowledge has now enabled us to adapt two other heat exchangers to prevent a reoccurrence.'



05

Rotating Machinery

Reducing equipment wear and optimizing maintenance

A regular analysis of your machinery oil baths can determine if lubrication is still efficient and if any equipment wear is developing. This enables you to plan optimal maintenance actions and oil replacements to reduce equipment wear.

Condition Monitoring Service

Our experts analyze the oil bath of your equipment and inform you on the condition of the oil and the equipment.

Equipment type

For all rotating machinery: steam and gas turbines, pumps, and other critical system components such as gear boxes, hydraulic circuits, and fans.

How

- We measure the **contamination level** of the lubrication oil, often caused by external contamination (inadequate maintenance or oil refilling)
- We **assess the quality of the lubrication oil** (oil properties, oxidation/degradation state, varnishing potential, etcetera)
- We **assess mechanical wear of equipment components** through the Oil Analyses as a measure for the equipment condition

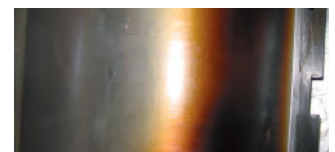
Benefits

- Improve availability of your equipment by keeping the oil bath in optimal condition.
- Optimize your maintenance planning.
- Provides timely detection of wear and prevents further damage.
- The cost is very small in comparison with an early oil replacement or unplanned shutdown.

E.ON power plant - Vilvoorde, Brussels (B)

‘Thanks to Laborelec’s experience with interpreting oil analyses results, an additional outage for oil bath replacement was avoided.’

Plant operators feared that they had topped up the lubrication oil of a steam turbine with the wrong type of oil. They wanted to know whether the oil bath still met the quality requirements. Gunter Pauwels is responsible for mechanical maintenance at the Vilvoorde Power Plant: ‘A specific Oil Analyses package revealed that only the desemmulsibility (capacity of the oil to separate water) had deteriorated. It was decided that the replacement of the oil bath could be postponed with limited risk until the next scheduled revision.’



06

Lubrication Oil Analyses

How it works

Similar to insulating oils, lubrication oil analyses encompass four steps.

Step 1: Sampling

Accurate samples taken at the appropriate location

We support you in collecting your oil samples:

- You get free sample vials
- We advise you on the optimal sampling location
- If necessary, we can assist with the sample taking

Step 2: Oil testing

Testing crucial quality parameters

Laborelec performs all relevant lubrication oil analyses.

Some examples:

- **Viscosity:** if this value is too low/high — for instance by adding a wrong type of oil to the oil bath — lubrication can be insufficient.
- **Additives:** mainly antioxidants in steam and gas turbine oils. Because of ageing, this value can become too low and cause premature sludge and oxidation.
- **Acidity:** a too high value can indicate the presence of oxidation products in the oil bath. This can cause corrosion and sludge in your system.
- **MPC Test (Membrane Patch Colorimetry):** we assess the probability of deposition of oxidation and degradation products (varnish). Varnish often causes start-up problems or unforeseen stops due to clogged components or filters.
- **Water content:** a too high value reduces the lifespan of the oil and has an influence on the lubrication properties.
- **Oil contamination by particle counting, metal analysis, and oil filtration:** we measure the purity level and perform trending. Excess particles can be the result of oil degradation or contamination and this can cause undue equipment wear.

Step 3: Interpretation

Evaluating the evolution of oil parameters

We check the measured oil parameters against the initial values of a new oil bath or against standards set by the equipment manufacturer and international maintenance guides. Our experience enables us to properly assess the criticality of each deviation.

Step 4: Recommendation

Supporting your maintenance plan

Working in close cooperation with you, we provide

recommendations and maintenance guidelines involving:

- Oil filtration, addition or replacement of oil
- Replacement of worn components, filters, or drying granules
- Optimization of the sample location
- More frequent or additional analyses



07

Additional Services

Covering all of your needs

To complement our standard offer, we have also developed a number of additional services for transformers and rotating machinery.

Dismantling of transformers

A post-mortem analysis of a dismantled transformer can provide more insight into the ageing behaviour of your other transformers.

What type of equipment

For a fleet with similar transformers that are operated in a comparable way.

How

- We carry out a general internal inspection of the dismantled transformer and cut away samples of the insulating paper for detailed study.
- We compare the actual condition of the paper with its condition estimated during the transformer's lifetime.
- We optimize the ageing simulation model of your remaining transformers.

Benefits

You can more accurately manage the maintenance of the remaining transformers.

Training

We offer one-day training sessions to increase your knowledge on various aspects of oil analyses.

For whom

For everyone who has to deal with insulating or lubrication oil.

How

Sample taking:

- We explain the characteristics of a good sample and learn how to take proper samples.
- You test the theory by practical experience.

Interpretation of oil analyses:

- We help you to understand what oil can tell you about the condition of your equipment.
- We combine theory with hands-on exercises.

Benefits

- Increased insight into oil analyses.
- You no longer rely solely on the knowledge of external experts.

Acceptance tests for insulating oil

Insulating oil must meet certain requirements before it can be used inside a transformer as insulating liquid. Laborelec can perform all necessary acceptance tests for oil producers or end-users.



Nuclear power plant, Tihange (B)

An electrical fault, detected by the online monitoring system, caused one of six similar step-up transformers at Tihange 1 to be replaced and dismantled. 'Investigation of the dismantled transformer revealed that its insulation paper was more degraded than estimated during its lifetime on the basis of furan measurements', says Christian Delhaye, responsible Ageing Programme Electrical Equipment in Tihange. 'Laborelec used the insight from the post-mortem analysis to fine-tune the ageing simulation model for the other transformers. This finally led to the replacement of an additional step-up transformer.'



Why ENGIE Laborelec?

Nearly half a century of experience

Our experts have built up vast experience with both insulation and lubrication oils and transformer behaviour. We combine the strength of a long history of oil analyzing with the challenge of anticipating future requirements.

In-house knowledge

- Expertise from numerous oil analyses (more than 2,500 transformers yearly and 300 to 400 rotating machines)
- Frequent contacts with oil producers and transformer manufacturers
- An extensive data bank

Anticipating future requirements

- Participation in international working groups and standardization commissions for insulating oil analyses
- Member of the Belgian Electrotechnical Committee (BEC)
- Participation in the International Electrotechnical Committee (IEC)
- Active member of Cigré
- Member of ASTM



Certified services

- Our oil analyses meet the IEC, ASTM, and ISO procedures.
- Our sample taking strictly follows QA and VCA safety requirements.
- Several analyses are accredited according to ISO 17025.

Investing in research

Striving for optimal accuracy

Since ensuring equipment availability is becoming increasingly important, our constant aim is to further optimize our existing analysis methods and develop new interpretation systems. Some of our recent research projects include:

- **Stray Gassing:** research on the interference between gasses produced by new oil at startup and gasses due to internal faults in the transformer.
- **Alternative paper ageing markers** that are more stable than furans in assessing transformer ageing.
- **Corrosive sulphur:** research on the most appropriate corrective actions and risk assessment methods.
- **Dissolved Gasses** (in cooperation with consultant Dr. Michel Duval): continuous improvement of the interpretation scheme for DGA (also for on-load tap changers).
- The applicability of **non-mineral biodegradable oils** as insulating oil in transformers.
- Research on new **analysis methods for lubricants**. Laborelec was one of the first research centres in Europe to introduce the MPC test.
- **Laborelec Cyclic Turbine Oxidation Test:** a new test able to detect differences between the oxidation stability of new oils that cannot be detected by the standard test (TOST).



Five reasons for you to choose Laborelec

- Wide range of technical competencies in Electricity Generation, Grids, and End-Use
- Increased profitability and sustainability of your energy processes and assets
- Unique combination of contract research and operational assistance
- Independent advice based on certified laboratory and field analyses all over the world
- More than 50 years of experience

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Training needs?

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