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INSIDER INFO – PARTNER FORUM – TECHNOLOGY FOCUS

CONTENTS

Austro Engine GmbH – Engines for safe and pleasant flying

Austro Engine GmbH engines for sports, private and training aircraft

The ability to fly has always been one of mankind's greatest dreams. But nowadays, air travel is no longer anything out of the ordinary. Flying in the jet of an international airline is today almost the same thing as travelling by bus. Only the smaller sporting and private planes still provide a direct experience of the wonderful feeling of flying and of sheer infinite freedom. The engines of Austro Engine GmbH ensure that this pleasure is also genuinely safe.

Since 2007, the company has produced state of the art piston engines and rotary piston engines for well-known manufacturers of aircraft for general aviation. The new 7,600 m² company building of Austro Engine GmbH in Neustadt, Vienna, Austria is equipped, among other things, with four state-of-the-art engine test beds and a propeller test bed. More than 60 employees work at the head office, of whom around half concentrate on engine development. Austro Engine GmbH is a Diamond Group company and offers innovative products and services in the fields of general aviation, simulators and IT/EDP to its customers around the world.

The core competences of Austro Engine GmbH include the development and production of engines for sports, private and training aircraft. First and foremost, the newly developed AE300 (E4 series). This is a 170 hp turbo diesel piston engine powered by jet A-1 fuel and represents a new generation of aircraft engines. The combination of low fuel consumption and reduced noise generation makes the AE300 (E4 series) the most environmentally friendly aircraft piston engine currently available. It only requires 25 to 30 litres of Jet A1-type kerosene per flight hour. A comparable Otto engine consumes about 55 litres of aviation fuel per hour, which, even in its reduced lead variety still contains over 5,000 mg/l of lead.

Among other engines, piston engines are installed in aircraft of Diamond Aircraft Industries. The sister company of Austro Engine GmbH is an internationally active manufacturer of glass and carbon fibre composite aircraft. The innovative aircraft solutions are produced in Wiener Neustadt and in Canada. In general aviation, Diamond Aircraft Industries is the largest manufacturer of single-engine aircraft in Canada and the third largest in North America. The company employs 1,200 people, who have already built over 3,500 aircraft. Planes with Austro Engine engines are popular not only with private customers but also with flying schools. Even Lufthansa's pilots train on them during their apprenticeships. The cockpit corresponds to that of a commercial aircraft.

Austro Engine GmbH produces rotary piston engines for motor gliders and camcopters used, e.g. for geographical purposes. They are small, light and low vibration. AE50R series engines with their 50 hp have already been installed in over 700 aircraft. An even stronger rotary piston engine named AE75R will be available soon.
The rotary piston engines powered by AvGas 100 LL (low lead) or MoGas (petrol with 95 ROZ) are operated with a fully synthetic two-stroke engine oil. An oil metering pump adds it to the fuel. A new higher performance engine is already under development, which is significantly more environmentally friendly and works with even less 2-stroke oil. A closed oil circuit has been designed to lubricate the main bearing. Only the pistons and the combustion chamber will then be supplied with lubricant through the oil metering pump.

According to the specifications of the manufacturer, partially or fully synthetic automotive engine oils of the 5W30 SAE class will be used to lubricate the piston engine.
As in a car engine, they must lubricate, protect against wear and corrosion, cool engines and keep them clean. A particular challenge awaits the transmission oil of piston engines. At the same time, it also supplies the hydraulic propeller governor and hence must take over the function of a gear and hydraulic oil.
Not every lubricant is suitable for aircraft. Before a given oil is authorised for use in engines or gears, it must undergo elaborate approval procedures. The test runs are carried out on engine test beds at Austro Engine GmbH. The testing plan and protocol are then submitted to the competent aviation authority, Austro Control. Together with EASA, the European Aviation Safety Agency, it issues the official approval. Only then may the oil be used in the respective aircraft.

Austro Engine GmbH recommends regular OELCHECK analyses for every change of oil

But that is not all. Maintenance and thus naturally the oil service of an aircraft must be precisely documented in its logbook. An oil change may also only be carried out by a certified aircraft mechanic or in an authorised service workshop. Every 100 hours, the 7 litres of oil of the piston engine must be changed. After 300 flying hours, the 2 litres of transmission oil must be changed. These intervals are obligatory, pursuant to the guidelines of the engine manufacturer and the aviation authority. Austro Engine GmbH also recommends that users commission OELCHECK to investigate the used oil. As a rule, this piece of advice is followed. Ultimately, any irregularities or potential damage to engines and gears are discovered early through analyses of lubricants and safety is significantly increased. In this way, hundreds of investigation results have accrued over the years. They are all evaluated by the manufacturer of the engines, in accordance with continuous quality controls and optimisation.

From the results of the OELCHECK laboratory reports, it has nevertheless also been clearly apparent that even after 100 flying hours, the engine oil is almost always as good as new and hence absolutely effective. Empirical values are now collected and the data is then analysed with even greater precision. Austro Engine GmbH aims to draw up documentation and to request a significant extension of the oil change intervals from the aviation authority. This would significantly reduce maintenance expenses and costs for the operators of the aircraft, and this with maximum safety and boundless pleasure in flying!

One of four highly modern engine test beds at the Wiener Neustadt plant

OELCHECK – for 20 years we have been deciphering the message of oil

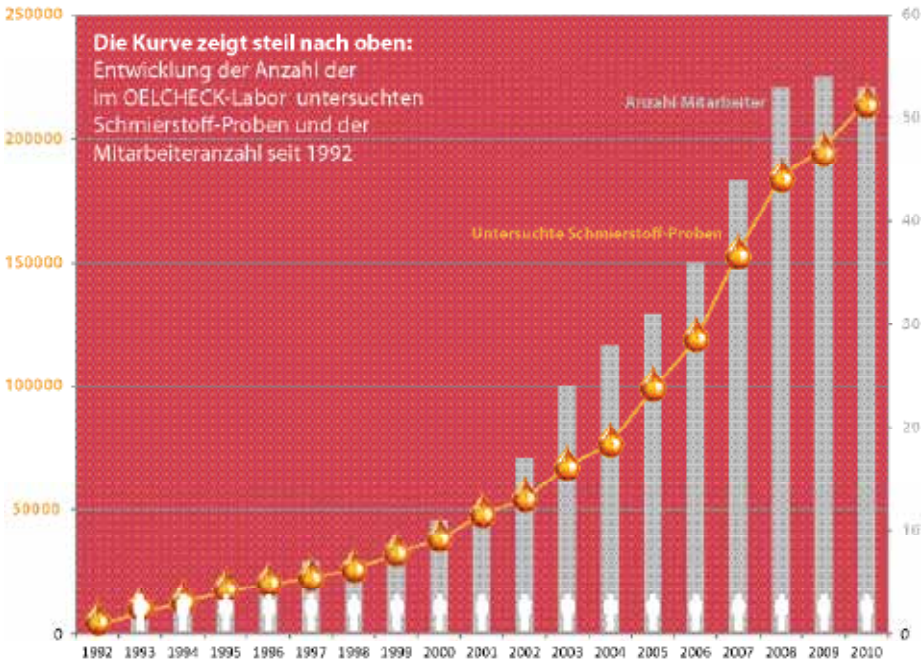
When we founded our company in June 1991, at the time still under the name of WEARCHECK, lubricant analysis was almost unknown in Germany. Many experts from the field of maintenance nevertheless soon became aware of the value of the tool made available to them through our investigations. Suddenly, lubricants were no longer merely a means to an end but an important information medium. For the first time, the message of the oil was deciphered! OELCHECK supplied all of the important information on the lubricant itself and also drew accurate conclusions about the condition of the aircraft and systems. Even at that point, this allowed expensive repairs, downtime and unnecessary oil changes to be avoided.

The Directors and technical management of OELCHECK GmbH:
Dipl.-Ing. Peter Weismann, Bachelor of Science, Paul Weismann and Barbara Weismann

Today, OELCHECK lubricant analyses are an essential part of all preventive maintenance. Our laboratory offers over 50 test processes, and at least in Europe, is the most modern of its kind. The „OELCHECK system", with tailor-made analytical sets for almost every issue, is unique. Today, we investigate over 200,000 samples per year. Our large database is correspondingly comprehensive and contains the results of over 1.5 million analyses. Apart from the investigation of lubricants, we offer many additional services to our customers. OELCHECK experts provide support for the selection of lubricants and act as experts for the clarification of damage. In 2010, the OilDoc Akademie was established within the context of a spin-off from OELCHECK GmbH. This was a consistent step, since demand for our further training and consultancy services is constantly increasing.

OilDoc Akademie has rapidly become the leading provider of seminars, in-house training courses, expert opinions and individual consultancy on issues of efficient use of lubricants, tribology and lubricant analysis.

We also plan to expand consistently in the future. We are constantly investing in new testing devices and intelligent software and offer our customers an increasingly comprehensive range of services. Only last year, we moved into our supplementary new building. We now employ 53 people at our corporate headquarters in Brannenburg in Upper Bavaria, with its overall area of 3,200 m² and workplaces with the most modern equipment. All of them are experts in their field and seek to recognise the demands and requirements of our customers and to meet their expectations. In every operation, we nevertheless attach the greatest importance to cooperation between colleagues. Ultimately, OELCHECK is a family business, both now and in the future.



from the left: Son-in-law Steffen Bots (Manager of the technical department), Daughter Petra Bots (marketing), Grandmother Rosel Nelz (Assistance in the shipping department), the founders Peter Weismann and Barbara Weismann, Son Paul Weismann (CEO)

Current vacancies at www.oelcheck.de/stellenangebote.html

20 years of OELCHECK - this had to be celebrated with a joint visit to the Rosenheimer autumn festival and a big works outing! From 14-16 October, we were at the Robinson Club on Mallorca. On the first day, cycling, snorkelling, hiking or golfing were on the agenda. On the great jeep safari on the following day, we were able to go all out and demonstrate our skill. On the last day, the fun Olympics awaited us, once again putting us to the test: OELCHECK is a top team!

There were 10 teams at the start of the jeep safari

Together, we conquered the interior of this beautiful island

Active at golfing, snorkelling or cycling

After the warm-up, the fun Olympics started

At the autumn festival in the anniversary year!

New test devices and significantly expanded analytical sets

Transformer oils

Whenever the voltage of alternating current has to be changed, transformers play a role. Regardless of whether they are used for general energy supply of households or industry, for the railways or for other tasks: to ensure that the „right“ current comes out of the socket, transformers must function smoothly. Their operating conditions are nevertheless becoming more and more extreme, ultimately placing higher demands on the transformer oil as well. In this way, energy supply and the safety of many production processes is dependent on oil. Regular checks on transformer oil are more important than ever. Ultimately, oil analyses not only provide information on the condition of the oil, but also allow conclusions to be drawn about the entire transformer. In order to investigate transformer oil in even greater detail, OELCHECK has just installed three new test devices. The extent of the investigation for the prepaid sets was correspondingly adjusted.

The transformer and its oil

A transformer consists in principle of a magnetic circuit, an iron core around which the conductors of at least two adjacent circuits in coils are wound, usually with different numbers of turns. As a rule, copper wire is used for the windings. The winding on the line side is termed the primary side. The winding supplying the electrical load is termed the secondary side. An alternating voltage induces a varying magnetic field in the input winding and an induction voltage in the output winding. The size of this voltage depends on the winding ratio of the primary and secondary side of the transformer. If the number of turns on the primary side is greater than that on the secondary side, then the output voltage is less than the input voltage. This also applies conversely.

In order to insulate the live parts, the copper wires are varnished with synthetic resin or wrapped in films or special papers. Supplementary protection against a sudden discharge is provided by specially designed transformer oils. These insulating oils based on mineral oils, esters or silicon must insulate, cool, be stable at low temperatures and resistant to oxidation and blend with winding and insulation materials.

Insulating properties

Transformer oils insulate the high potential differences, impregnate fibrous insulating materials and contribute to preventing any electric arcs. As a dielectric, they prevent discharges between the live elements at voltages of up to 100 kV. The voltage up to which no discharge of sparks occurs under precisely defined conditions is termed the breakdown voltage. The breakdown voltage of a transformer, but also of the oil, must be significantly higher than its nominal voltage. This is by far the most important parameter for the electrical insulating property of the oil. Traces of water, which is a good electrical conductor, have a negative impact on the useful life of the system. Fresh oils are thus dried during production with vacuum thin film vaporisers. These oils are delivered in containers under a nitrogen blanket in order to prevent penetration of humidity. Transformer oils also expand at high temperatures and contract at low temperatures. For 1,000 litres of oil and a temperature difference of 50°C, this amounts to 35 litres. Transformers thus have an expansion reservoir. Depending on the type of construction, this is provided with dry cartouches, which extract humidity from the air. In determining the further serviceability of transformer oils, the breakdown voltage and the water content are decisive criteria.

Cooling effect

The coils of a transformer consist of closely wound wires. Heat is generated in the interior of these windings, which is conducted away by the oil. In order to dissipate heat into the surrounding area, large surfaces are required. For this reason, transformers mostly look like enormous radiators, which are sometimes equipped with additional ventilators or heat exchangers. In order for the oil to circulate properly, these must be correspondingly thin. The measurement of viscosities, which can increase from the usual 8-9 mm²/s at 40°C to over 10 mm²/s due to operating influences, is an integral part of every trend analysis.

Oxidation stability

Transformer oils should remain in use for decades. High oxidation stability is thus particularly important. Depending on the working temperature, the oil oxidation increases, which in turn shortens the useful life of the oil filling and makes the oil „sour“ and darker. The viscosity also increases and conductivity decreases. In addition, water from humidity or decomposition products from the insulation paper change the dielectric strength. For this reason, the performance of these oils must be constantly rechecked. Within the context of a trend analysis, the colour index and acid value are measured and the oxygen incorporated by the oil due to ageing determined with the FT-IR device.

Compatibility

Transformer oils must be compatible with all of the materials with which they come into direct contact. This includes copper, since it is used in the windings, resin, special winding papers and other insulating materials and seals.

Oil types and specifications

Depending on the particular system, different types of transformer oils are used:

Mineral oil-based transformer oils

- Classic transformer oils without additives
- Inhibited oils, e.g. with good oxidation stability

Synthetic transformer oils

- Silicon oils
- Synthetic esters

For selection, it is imperative to observe the manufacturer‘s specifications. Products must often meet the specifications of institutions, such as:

- Verband der Elektrotechnik Elektronik Informationstechnik e.V. (VDE)
- International Electrotechnical Commission (IEC)
- American Society for Testing and Materials (ASTM)

The new OELCHECK analytical sets for transformer oils

The demands on transformers are increasing. In alternative energy generation, they operate today in areas with extreme climates and under increasingly adverse environmental conditions. At the same time, maximum operating safety, ever greater flexibility and a long service life is simultaneously required of them. Demands on transformer oils are growing accordingly.

But oils not only have to perform their diverse tasks. They also serve as a source of information which allows the condition of the transformer to be monitored reliably. In order to be able to deliver more significant analytical results and at the same time, to provide significantly better protection of the energy supply, we have made crucial improvements in our investigations of transformer oils.

Analytical set for transformer oils: Shipping carton with 20 ml glass syringe, sampling tube, protective gloves, paper towels, test data sheet and optional 1 litre aluminium bottle

Analytical sets for the monitoring of transformer and insulating oils:

Set	Sample container	Scope of the analysis
ISO 1	20 ml syringe	Dissolved gas in oil (DGA)
ISO 2	20 ml syringe + 1 l aluminium bottle	Dissolved gas in oil (DGA) Breakdown voltage, water (KF), colour index, viscosity at 40°C
ISO 3	20 ml syringe + 1 l aluminium bottle	Dissolved gas in oil (DGA) Breakdown voltage, water (KF), colour index, viscosity at 40°C Neutralisation number, oxidation (FT-IR), dielectric dissipation factor (tan δ)
ISO 4	20 ml syringe + 1 l aluminium bottle	Dissolved gas in oil (DGA) Breakdown voltage, water (K.F.), colour index, viscosity at 40°C, neutralisation number, oxidation (FT-IR), dielectric dissipation factor (tan δ) Density, additives, impurities, wear, interface tension (IFT)
ISO 5	20 ml syringe + 1 l aluminium bottle	Dissolved gas in oil (DGA) Breakdown voltage, water (K.F.), colour index, viscosity at 40°C, neutralisation number, oxidation (FT-IR), dielectric dissipation factor (tan δ) Density, additives, impurities, wear, interface tension (IFT) Microscopic particle count (MPC)
ISO 6	20 ml syringe + 1 l aluminium bottle	Dissolved gas in oil (DGA) Breakdown voltage, water (K.F.), colour index, viscosity 40°C, neutralisation number, oxidation (FT-IR), dielectric dissipation factor (tan δ) Density, additives, impurities, wear, interface tension (IFT) PCB, Furfurol

Glass syringe prepared for sampling, including a 3-way stopcock and sampling tubes

Correct sampling

For the correct execution of analyses of transformer oils, in part for the determination of gas in oil, oil sampling is enormously important. Sampling can only be carried out with a special sampling set, in accordance with standards. In order to obtain a representative sample, the insulating oil cannot come into contact with air or other impurities from the environment during sampling. During transport as well, the absolute impermeability of the specimen containers must be guaranteed. OELCHECK analyses the gases dissolved in the oil directly from the 3-way stopcock, with a gas-proof 20 ml glass syringe, with which the sample was extracted. For the other investigations, the oil sample is filled into a gas-proof 1,000 ml aluminium bottle.

Each of the prepaid OELCHECK ISO 1 to ISO 6 analytical sets contains, in addition to a test data sheet, a self-adhesive laboratory address for the return of the syringe, a shipping carton lined with plastic foam, in which there is a 20 ml glass syringe with a firmly attached 3-way stopcock in a recess designed for this purpose. An optional sampling tube, which provides the connection between the transformer and the injection connection, is available. In addition to the syringe, which is required in filled form for each ISO set for the DGA analysis, the analytical sets ISO 2 to ISO 6 contain an aluminium bottle with a filling volume of 1,000 ml. With this large container, sufficient volume of sample is available for the analyses contained in the extended set volume. All sample containers should be filled to the brim so that no air can influence the measurement results. A requirement is that all equipment coming into contact with the oil must be clean.

The complete instructions are available at www.oelcheck.de.

Sampling in a glass syringe, on the left in the figure: Bucket as a flushing container

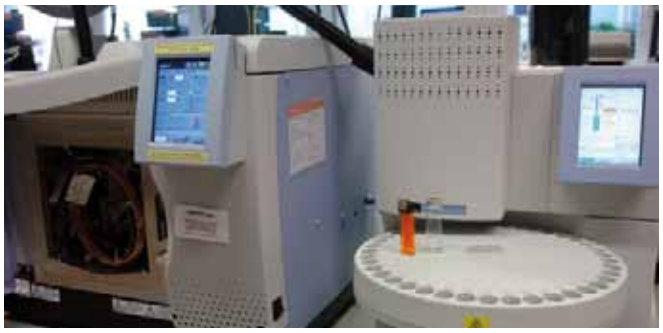
Transformer oil investigations in the OELCHECK laboratory

Some of the most common testing procedures for the analysis of used transformer oils, such as breakdown voltage, viscosity, acid value, density, colour index, oxidation, elements, purity class, MPC test, water, have already been described exhaustively in previous editions of OelChecker. The corresponding information can be obtained from the website www.oelcheck.de/pruefverfahren.html or under the heading „Knowledge A-Z".

Three techniques are essentially new, with OELCHECK using this to analyse mainly insulating and transformer oils:

- **DGA --> Dissolved Gas Analysis**
- **IFT --> InterfaceTension**
- **Dielectric dissipation factor tan δ(DF --> Dissipation factor)**

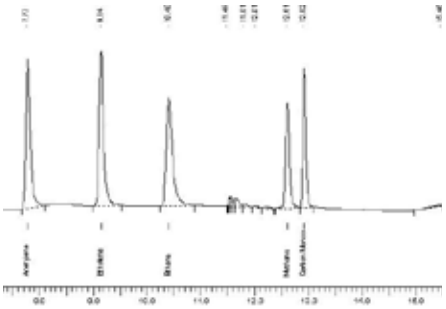
Dissolved Gas Analysis



PerkinElmer Clarus 680 with a TurboMatrix 40 Headspace Sampler

Test standard:
ASTM D3612-02,
VDE0370-9:1994-06,
VDE0370-7:1999-12
Measuring range: 0-10,000
Unit: µl/l (ppm)
Sample volume: 5 ml

Determined:
Dissolved gases in transformer oils
H_2, O_2, N_2, CO_2, CO, CH_4, C_2H_6, C_2H_4, C_2H_2



DGA chromatogram of a used transformer oil

The analysis of gases present in the transformer oil in dissolved form is carried out with a PerkinElmer Clarus 680 with a TurboMatrix 40 Headspace Sampler, specially developed for this purpose.

This analytical procedure is used to evaluate defects in electrical equipment with the aim of initiating countermeasures in good time. Dissolved gas analysis is the most frequently performed method for monitoring transformers. It offers many advantages and not only for the detection of defects:

- Reliable information on the condition of a transformer
- Timely recognition of defects
- Condition monitoring of new and repaired systems
- Scope for planning of measures.

The basic principle of the dissolved gas analysis is based on the capacity of the insulating oil to dissolve not only air from the atmosphere, but also cracked gases. These evolve not only from the natural ageing of oil and insulation materials, but above all when thermal or electrical defects occur in transformers. The extent of a defect and its increase over time (trend analysis) can be concluded from the quantity of dissolved gases in the respective oil.

The cracked gases, also termed pollutant gases, evolve as a result of high-energy electrical discharges as well as partial discharges. However, local overheating can also cause the evolution of pollutant gases. If pollutant gases are discovered in the analysis of the transformer oil, this indicates sources of defects in the transformer.

These dissolved gases can only be measured with a gas chromatograph (GC). In order to ensure correct measurement results, the oil sample must not come into contact with atmospheric oxygen. For this reason, as soon as the oil is sampled, it is poured into a 20 ml gas-tight glass syringe. A crimped head space bottle is flushed with argon to remove air. From the syringe, 5 ml of sample are injected directly through a canula via the 3-way stopcock. In the sampler, the gases are expelled from the sample at 80°C and are then gradually heated in a GC oven up to 200°C. The escaping gases are flushed with the aid of argon (carrier gas) through a „column" (about 10 m long, wrapped small glass tubes). Depending on the structure of the respective gases, these remain on the surface of the column for different lengths of time. In order to ensure clean separation, two different columns are used. Detectors recognise the individual components and record corresponding chromatograms. The larger the area under a peak, the greater the proportion of the corresponding component.

The following pollutant gases are determined using the chromatograph: H_2 (hydrogen), O_2 (oxygen), N_2 (nitrogen), CH_4 (methane), CO (carbon monoxide), CO_2 (carbon dioxide), C_2H_6 (ethane), C_2H_4 (ethene/ethylene), C_2H_2 (ethyne/acetylene).

In the laboratory report, the respective individual values and their sum are indicated in µl/litre and/or ppm. An analysis is recommended at regular intervals, since by observing a trend, it is possible to react to changes in good time.

Depending on the intensity of the individual gases, differentiation is made between different defects. Different conclusions can be drawn from the respective defects with regard to the consequences for the oil or paper insulation. These values and their diagnoses are noted in the laboratory report in compliance with evaluation procedures defined in the VDE standard.

Type of defect	Cause of defect	Effects, appearance
PD	Partial discharges	Paraffin wax formation on the paper insulation
D1	Low energy discharges	undissolved small carbon particles in the oil, larger holes in the paper insulation
D2	High energy discharges	Carbonisation of the oil, destruction of the paper insulation, molten metal
T1	Thermal defects, temperatures of up to about 300°C	Oil oxidation, brownish discolouration of paper
T2	Thermal defects, temperatures of 300 to 700°C	increased oil oxidation, carbonisation of paper
T3	Thermal defect, temperatures of over 700°C	Oil carbonised, metal discolouration/molten metal

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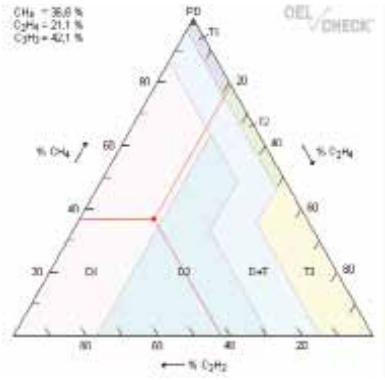

In addition to the values for pollutant gases, the Duval triangle is illustrated in the laboratory report. This allows the visualisation of the type of defect present. At increased concentrations, a summary statement can be generated using this tool.

Example: in a DGA analysis, the following percentages were calculated based on the ppm values: Ethylene (C_2H_4) = 36.8%, acetylene (C_2H_2) = 21.1%, methane (CH_4) = 42.1%.

These values are entered into an isosceles Duval triangle parallel to the sides. The point at which the three lines intersect lies in a field with the types of defect listed in the table. In this way, a conclusion about the type of defect present in the case of example = D1 can be made.

Reference values for which a more frequent analysis is advisable, if exceeded:

Gas component		90% concentration values in µ/l
Hydrogen	H_2	60 - 150
Carbon monoxide	CO	540 - 900
Carbon dioxide	CO_2	5,100 - 13,000
Methane	CH_4	40 - 110
Ethane	C_2H_6	50 - 90
Ethene	C_2H_4	60 - 280
Ethyne	C_2H_2	3 - 50 (up to 270 for the diverter switch)

The dielectric dissipation factor

Test standard: IEC 60247, ASTM D924
Measuring range: tan δ up to 1x10^{-6}
Sample volume: 40 ml
Determined: Dissipation factor tan δ relative dielectric constant ε_r.

The dielectric dissipation factor tan δ measured with a Baur DTL-C provides information on the extent of dielectric losses in the transformer oil occurring during operation. It is defined as the ratio between the active and reactive currents flowing in a measurement circuit.

In determining the dielectric dissipation factor, it is assumed that current and voltage in an alternating current circuit are subject to a phase shift. This phase change is due to the fact that molecules in the insulation oil can no longer align with the alternating electric field. In order to define the tan δ, the measuring cell of the device is filled with 40 ml of oil and heated to a standard 90°C. A test voltage of 2,000 V at a frequency of 50 Hz is applied across the two electrodes of the measuring cell, which are arranged at a distance of 2 mm. The dielectric dissipation factor is dimensionless. It is noted in the laboratory report as tan δ, with a corresponding numerical value.

When the oil ages, polar components occur in the oil, leading to a phase displacement and in turn to dielectric losses in the insulating oil. Impurities such as water, dissolved insulating resin and paper can also have polar effects and thereby influence the dielectric dissipation factor. The tan δ is also significantly influenced by the temperature-dependent viscosity, and with it, the size of the molecules, in addition to the ageing of the oil and the impurities. The sum of these changes is expressed as tan δ . At the same time, the dielectric constant ε_r required for the design of most on-line oil sensors is also defined during measurement.

A sharply negative trend of the dissipation factor indicates unwanted heat generation within the insulating liquid and the fixed insulation, which can ultimately lead to thermal breakdown. For this reason, this test is highly significant for assessment of the condition of the complex arrangement of a transformer.

Value ranges for tan δ

Type	Resin impregnated Insulation paper	Oil-impregnated insulation paper	Resin-bonded insulation paper
Dielectric dissipation factor tan δ	< 0.007	< 0.007	<0.015
Typical fresh oil values	0.003 – 0.004	0.002 – 0.004	0.005 – 0.006

Interface tension

Test standard: ASTM D971–99, DIN 53914
Measuring range: 0 - 300 mN/m
Unit: mN/m (milliNewton/Meter)
Sample volume: 20 ml
Determined: The interface tension between water and oil.

During the oxidation and ageing of oils subject to heavy demands or which are in use for several years, insoluble polar constituents are formed. Interface tension can detect these in the oil. In this way, it provides information on the ageing and remaining useful life of the oil.

In order to determine this with the Lauda TD 3 tensiometer, a testing cylinder is filled with 20 ml each of distilled water and the transformer oil to be tested. Due to the differences in density, two phases are rapidly formed, with the heavier water forming the lower phase and the insulating oil floating above. Fresh transformer oil is non-polar. Polar components have formed in the used oil, which accumulate in the region of the barrier layer of water (polar) and oil (non-polar). The interface tension of the water/oil phases is influenced by the interaction of the ageing products with the water. The Lecomte Du Noüy ring, secured by a thread to a scale, is lowered into the water-oil mixture. By lowering the cylinder, the ring is first drawn through the water and then through the interface into the oil. The force occurring during phase change at the interface is measured.

The interface tension is specified in mN/m in the laboratory report. If its value has fallen sharply by comparison with fresh oil or the previous sample, then ageing of the oil has occurred. The engineer will then recommend appropriate diagnostic countermeasures, such as regeneration or an oil change.

Limiting values for interface tension

Type of oil	Interface tension (IFT)
Oil in delivery condition	Minimum 40 mN/m
Oil from a new system	Minimum 35 mN/m
Usable used oil	
< = 69 kV	Minimum 24 mN/m
69 - 288 kV	Minimum 26 mN/m
> 345 kV	Minimum 30 mN/m