

TEST SPECIFICATION & INTERPRETATION GUIDE

Transformer Insulating Oil Testing to IEC & IEEE Standards

Insulating oil in service is continuously subjected to heat, oxygen, moisture and other catalysts — all of which degrade its dielectric properties. Regular sampling and analysis is the most effective preventive-maintenance programme for oil-filled electrical equipment: it detects incipient faults long before they become failures. This specification describes the four tests performed by Trafohaus Service, the governing standards, and how results are evaluated per **IEC 60422:2013** (mineral insulating oils — supervision and maintenance guidance) and **IEEE C57.104** (interpretation of dissolved gases).

1 Dissolved Gas Analysis (DGA)

IEEE C57.104

What it measures: the concentration (ppm) of seven fault gases dissolved in the oil. Electrical and thermal faults inside a transformer decompose the oil and cellulose insulation, and each fault type generates a characteristic gas signature — gases build up much faster when an active fault is present.

H₂ Hydrogen — partial discharge / corona activity

CH₄ Methane — low-temperature thermal heating of oil

C₂H₆ Ethane — low/medium-temperature thermal faults

C₂H₄ Ethylene — high-temperature thermal faults (hot spots)

C₂H₂ Acetylene — arcing / high-energy discharge (most critical gas)

CO & CO₂ — overheating / ageing of cellulose paper insulation

Gas	H ₂	CO	CO ₂	CH ₄	C ₂ H ₄	C ₂ H ₆	C ₂ H ₂	TDCG
Condition-1 limit (ppm)	100	350	2500	120	50	65	1	720

How to read it: TDCG (Total Dissolved Combustible Gas) below the Condition-1 level indicates the transformer is operating satisfactorily. Any individual combustible gas exceeding its specified level — especially any detectable acetylene — should prompt additional investigation and shorter resampling intervals.

2 Breakdown Voltage (BDV) — Dielectric Strength

IEC 60156

What it measures: the voltage (kV) at which the oil electrically breaks down between two standard electrodes. It is the primary indicator of the oil's ability to withstand electrical stress in service.

How to read it: the measurement serves primarily to reveal **contaminants — water and oxidation particles**. A low breakdown voltage indicates one or more of these are present. If BDV falls below the acceptance range for the equipment's voltage class, the oil should be treated by purification (filtration/degassing) or reclamation.

3 Water Content (Moisture)

IEC 60814

What it measures: dissolved water in the oil (mg/kg), by Karl Fischer coulometric titration. Moisture is one of the most damaging contaminants: it lowers dielectric strength, accelerates cellulose ageing, and migrates between paper and oil with temperature.

How to read it: limits tighten as system voltage rises (see evaluation table below). Rising trend between annual samples matters as much as the absolute value — it can reveal a leaking gasket or breather problem before the oil fails a BDV test.

4 Dielectric Dissipation Factor (Tan Delta) @ 90°C

IEC 60247

What it measures: the dielectric loss of the oil at operating temperature. A perfect insulating oil dissipates almost no energy in an AC field; polar ageing products, dissolved varnish, and colloidal contamination raise the losses.

How to read it: DDF is the most sensitive early-warning parameter for oil deterioration — it typically rises long before BDV falls. Values above the IEC 60422 limit indicate oxidation or contamination and justify further investigation (acidity, interfacial tension) or oil treatment.

Evaluation Limits — IEC 60422:2013 (oil in service, by equipment voltage class)

Parameter	Unit	< 72,5 kV	72,5 - 170 kV	> 170 kV
Water / Moisture Content	mg/kg	≤ 20	< 10	< 10
Breakdown Voltage	kV	> 55	> 60	> 60
DDF (Tan Delta) @ 90°C	—	max 0,015	max 0,015	max 0,010

Worked example — from an actual Trafohaus report: a furnace transformer sample returned moisture 18,1 mg/kg, BDV 44,1 kV, DDF 0,00069 and TDCG 98,6 ppm. Verdict: DGA Condition 1 (satisfactory); DDF excellent; moisture and BDV outside the IEC 60422 acceptance range for its class → recommendation: oil purification and routine resampling. That is the level of interpretation included with every report — a clear verdict and the action to take, not just numbers.

Sampling & Reporting

Samples are drawn per **IEC 60567** (gas and oil sampling for gas analysis) from the main tank and, where applicable, OLTC diverter compartments. Each report states sample date, analysis date, per-parameter results against the correct voltage-class limits, a written conclusion, and a maintenance suggestion — signed by the evaluating engineer. Standard turnaround: as fast as 48 hours from sample receipt.

Schedule Your Oil Analysis Programme

Routine annual testing · fleet packages · on-site sampling nationwide

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References: IEC 60422:2013, IEC 60156, IEC 60814, IEC 60247, IEC 60567, IEEE C57.104. Evaluation limits shown are the in-service screening values applied in Trafohaus Service laboratory reports; project-specific acceptance criteria may differ by client specification. CV. Trafohaus Service — Specialist Maintenance Transformer, OLTC, Oil Tester.