A Revised Framework for the Transformer DGA Guide

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Presentation Topics

- Purpose and scope of the Guide
- Main departures from earlier versions
- Definition of transformer DGA
- Components of DGA
- DGA risk classification
- Triage and review
- DGA contexts
- Review example

Purpose & Scope

- Scope
  - In-service transformers filled with mineral oil
- Purpose
  - Provide a practical and up-to-date approach to transformer DGA for persons who need it

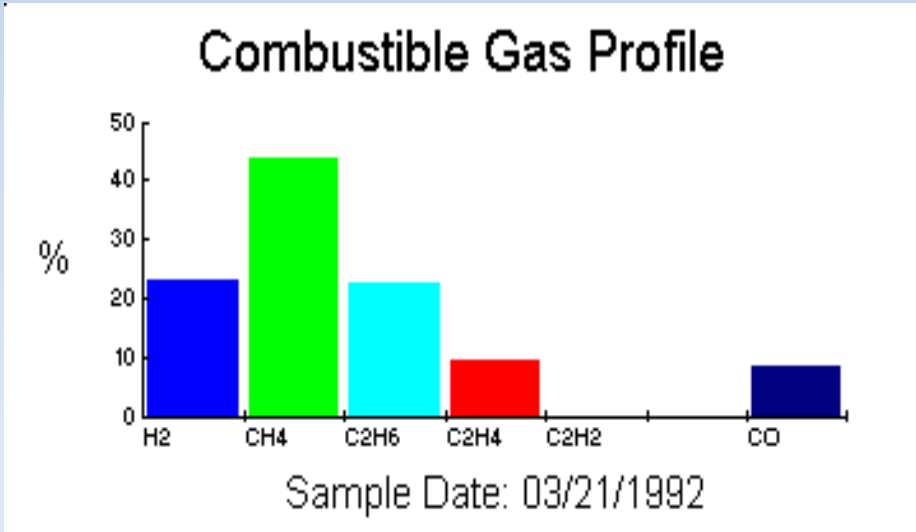
Keep the main content simple and straightforward; put technicalities in appendices.

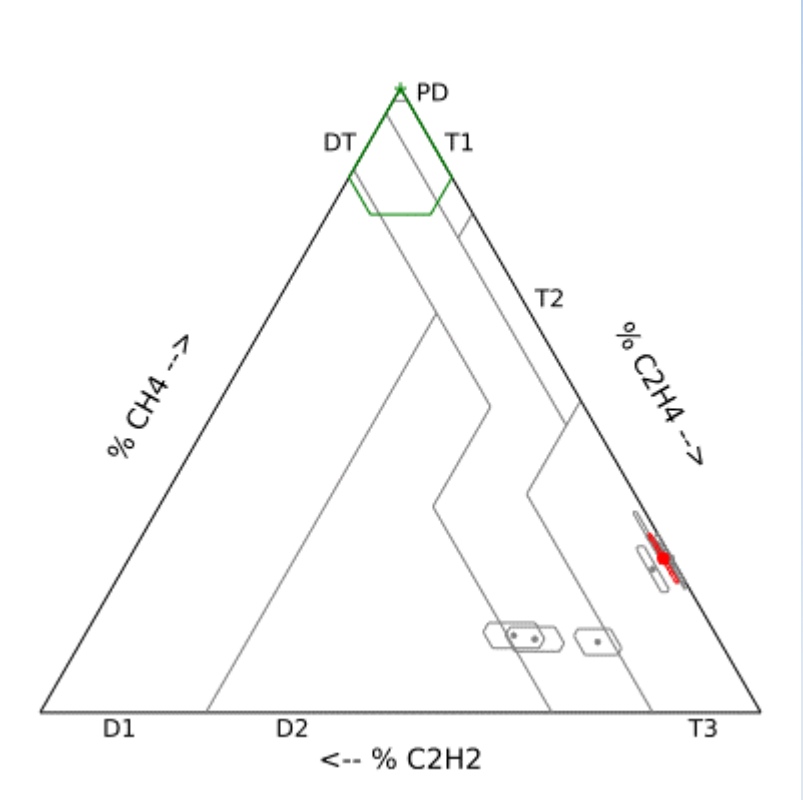
Main departures . . .

- More of a tutorial style
- More examples
- Basic principles
- Emphasis on detecting & interpreting suspicious change
- Avoidance of “sacred numbers” where possible
- Visual approach to diagnosis

Definition of Transformer DGA

Transformer dissolved-gas analysis (DGA) is the **measurement** and **interpretation** of gases dissolved in the insulating fluid of a transformer.



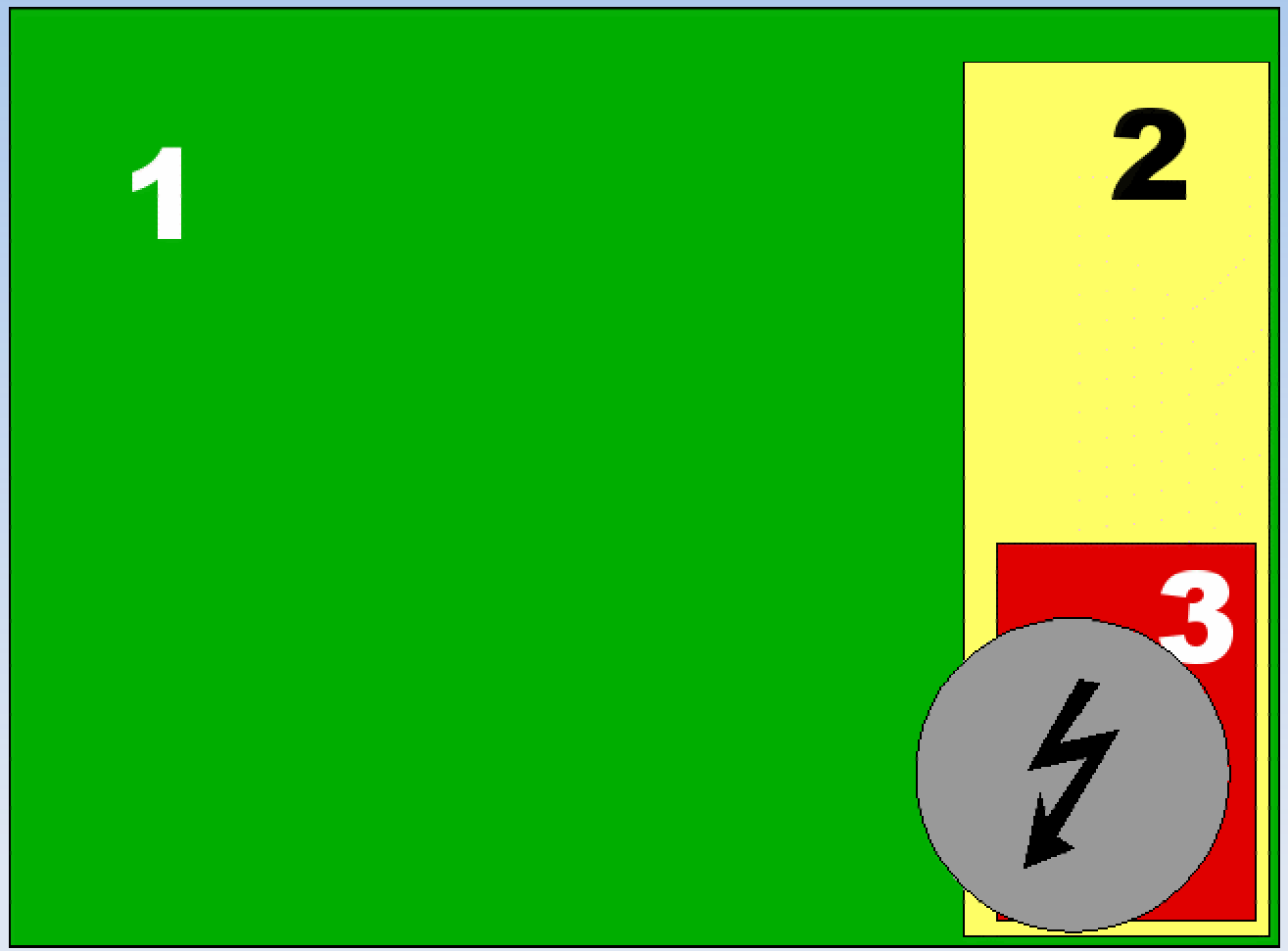


Components of DGA

- Measurement-related
  - Sampling, sample handling, gas analysis (referred to other documents)
  - Data quality checking
  - Handling measurement uncertainty
- Interpretation
  - Triage & risk classification
  - Fault detection
  - Diagnosis

DGA risk classification

Risk = Failure cost x Probability of failure within next screening interval



- Low to normal risk
- Higher than normal risk
- Very high risk
- Immediate failure expected

(Gray circle represents units which will actually fail)

Triage & Review

- Triage
  - Initial separation of “sheep” from “goats”
  - Based on presence or absence of **suspicious change** (increments or trends) or **possible data quality problems**
  - “Sheep” considered OK (risk classification 1)
  - “Goats” subjected to review
- Review
  - Based largely on **examination of graphical evidence**
  - Risk class, resampling, diagnosis, action

DGA contexts

DGA context is based on sampling interval, and each has its particular concerns.

- Initial sample
- Periodic screening (long interval)
- Surveillance (short interval)
- Monitoring (several samples per day)

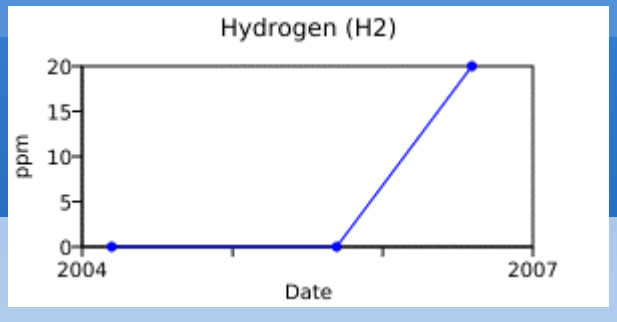
Review example

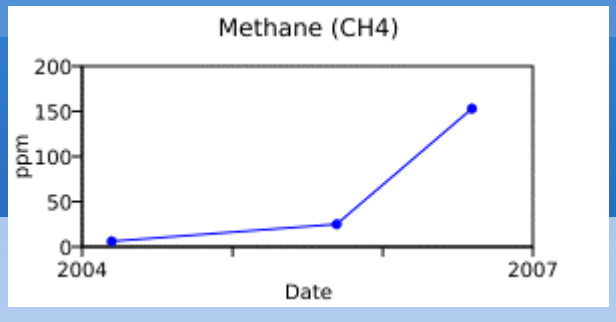
Gas Analysis

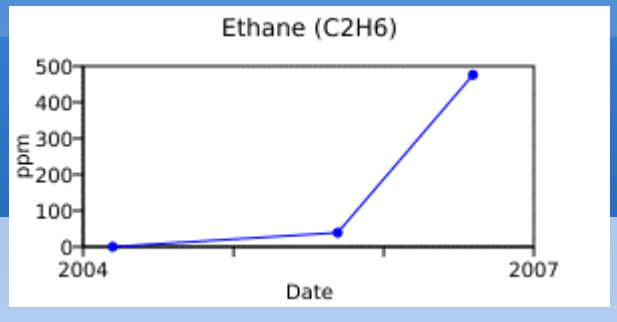
Sample date	2006-08-06	2005-09-11	2004-03-13
Fluid temp C	30	30	30
Hydrogen (H2)	20	0	0
Methane (CH4)	153	25	6
Ethane (C2H6)	476	39	0
Ethylene (C2H4)	146	5	0
Acetylene (C2H2)	0	0	0
Carbon Monoxide (CO)	253	273	95
Carbon Dioxide (CO2)	5482	4555	4783
Oxygen (O2)	3558	4189	12989
Nitrogen (N2)	21180	78569	90001
Total heat gas	775	69	6
TDCG 1048	342	101	
O2/N2 0.17	0.05	0.14	
Reference days	329	547	0
Risk class ?	2	1	
Diagnosis ?	T1	-	
Retest days	?	365	365
Retest date	?	1998-09-11	1997-03-13

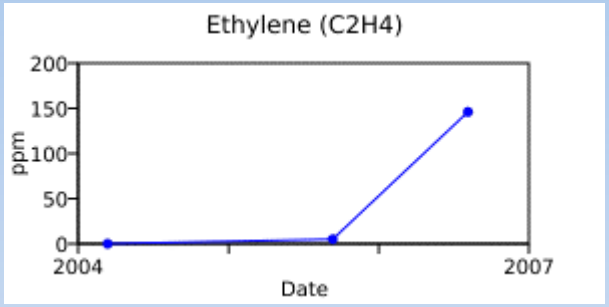
The 2004 sample had very little combustible gas. In 2005 there were discernible increases in all 3 heat gases, suggesting T1 and risk class 2. Decision was made to continue with screening. By 2006 heat gases had increased significantly.

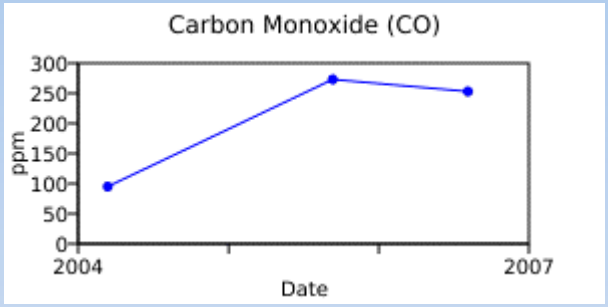
Review example - continued

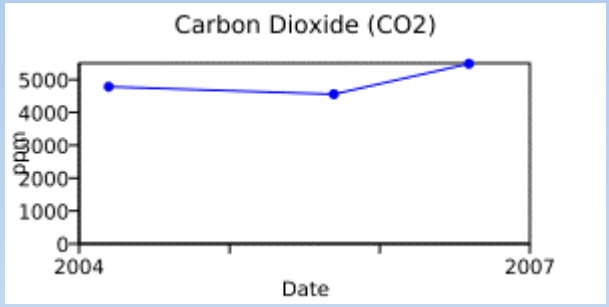


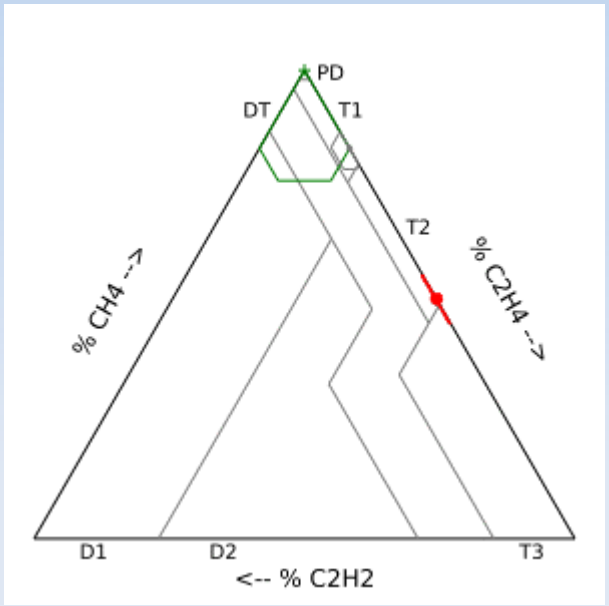


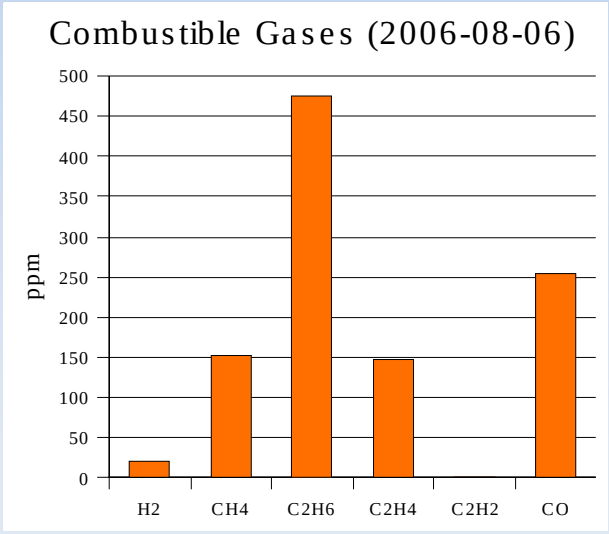












Review example - continued

- In the latest sample we see parallel significant increases in H2 and the heat gases since the previous screening sample. No apparent involvement of COx.
- Both the triangle and the combustible gases bar chart indicate a mid-range thermal fault (T2).
- Classify as a “3” and recommend weekly surveillance sampling and other testing (e.g. I.R.) until decision can be made.

Review example - continued

Gas Analysis

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Fluid temp C	30	30	30
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Total heat gas	775	69	6
TDCG 1048	342	101	
O2/N2 0.17	0.05	0.14	
Reference days	329	547	0
Risk class **3**	2	1	
Diagnosis **T2**	T1	-	
Retest days	**7**	365	365
Retest date	**2006-08-13**	1998-09-11	1997-03-13

DGA surveillance and other testing are ordered to support an investigation as to what may be happening and whether repairs may be required.

Technical appendices (partial list)

- DGA calculations
  - Ratios and increments, taking into account measurement uncertainty
  - Linear regression for data with uncertainty (average rate of change, trend line)
- DGA charts
  - History line charts for gas concentrations & load
  - Stacked area chart (combustible gases)
  - Bar charts for combustible gas concentrations
  - Log-log scatter plots for gas ratios
  - Duval triangle for diagnosis & fault evolution
- Lots of case histories
  - Fault examples
  - Normal operation, stray gassing, bad data