A Revised Framework for the Transformer DGA Guide

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for WG C57.104
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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
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 \times 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)
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.
### Gas Analysis

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

**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