Fast isothermal analysis of transformer oil (TOGA)

Application Note

Energy & Fuels

Introduction

Certain faults in electrical transformers can result in the production of gases which remain dissolved in the transformer fluid. The transformer fluid and insulating materials will break down into a few easily identifiable by-products when subjected to possible fault conditions.

Typically a “key gas” will be generated that identifies the type of fault. Identification and quantitation of these gases can provide an early indication of developing problems in the equipment.

ASTM methods 03613, 02945, and 03612 describe sampling, gas extraction, and analysis procedures, respectively.

Extraction equipment specially designed for this purpose is commercially available.

The components of interest in the extracted gas are typically hydrogen, oxygen, nitrogen, carbon monoxide, carbon dioxide, methane, ethane, ethylene and acetylene.

The elemental gases are detected by a thermal conductivity detector using argon as carrier. This provides the best detectivity of hydrogen, while still providing adequate detectivity of oxygen and nitrogen. Flame ionization detection is used for quantitation of hydrocarbons and catalyzed carbon oxides (those that have been converted to methane by means of a nickel catalyst or “methanizer”).

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Figure 1.
Experimental

Two columns are needed for the separation: (1) a molecular sieve for the lighter gases and (2) a porous polymer for the heavier gases, CO₂ and C₂ hydrocarbons. As illustrated in Figure 1, the columns are connected to an 8-port valve (V2) such that the position of the valve selects which column is directed to the detector and, in turn, which column is backflushed to vent.

Sample is injected simultaneously into each of the two columns using the 10-port valve (V1). The delay column upstream of the porous polymer column delays the entry and subsequent elution of components from that column until H₂, O₂, N₂, CH₄ and CO have eluted from the molecular sieve.

After CO elutes, V2 is switched to direct the porous polymer effluent to the detector for measurement of close up C0₂ and C₂ hydrocarbons. The valve switch also positions the molecular sieve to be backflushed to vent to remove the heavy components.

The first three components (H₂, O₂, N₂) are detected by TCD followed by a programmed detector signal switch which then selects the FID for the remainder of the analysis.

With 0.25 mL sample loops, detection limits of all carbon gases are <1 ppm in the injected sample.

This column/valve configuration is designed to provide backflushing of each column while the other is in use.

Performing the analysis isothermally at 70 °C, this system offers accurate low level detection of transformer gases with short analysis and cycle times.

Peak identification

<table>
<thead>
<tr>
<th>Molecular Sieve</th>
<th>Porous Polymer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. hydrogen</td>
<td>6 composite</td>
</tr>
<tr>
<td>2. oxygen</td>
<td>7. carbon dioxide</td>
</tr>
<tr>
<td>3. nitrogen</td>
<td>8. ethylene</td>
</tr>
<tr>
<td>4. methane</td>
<td>9. ethane</td>
</tr>
<tr>
<td>5. carbon monoxide</td>
<td>10. acetylene</td>
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</tbody>
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