6.2.2 Rogers Ratios Method

The Rogers Ratios Method is summarized in Table 5. It uses three gas ratios indicating five different types (cases) of faults, depending on the values of the ratios in column 2 through column 4 of Table 5.

Table 5— Rogers Ratios Method

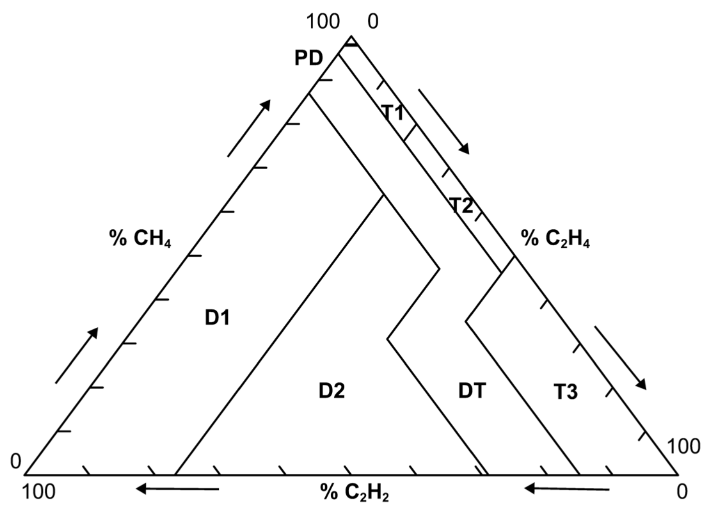
Case	C_2H_2/C_2H_4	CH_4/H_2	C_2H_4/C_2H_6	Suggested fault diagnosis
0	< 0.1	0.1 to 1.0	< 1.0	Unit normal
1	< 0.1	< 0.1	< 1.0	Low-energy density arcing—PD[a]
2	0.1 to 3.0	0.1 to 1.0	> 3.0	Arcing—High-energy discharge
3	< 0.1	0.1 to 1.0	1.0 to 3.0	Low temperature thermal
4	< 0.1	> 1.0	1.0 to 3.0	Thermal < 700 °C
5	< 0.1	> 1.0	> 3.0	Thermal > 700 °C

[a] There is a tendency for the ratios C_2H_2/C_2H_4 and C_2H_4/C_2H_6 to increase to a ratio above 3 as the discharge develops in intensity.

The limitation of the Rogers Ratios Method is that it cannot identify faults in a relatively large number of DGA results (typically 35%), because they do not correspond to any of the cases in column 1 of Table 5, even when µL/L (ppm) values are high and there is obviously a fault.

6.2.3 Duval Triangle 1

The Duval Triangle 1 Method is illustrated in Figure 3:



NOTE—See 3.2 for faults acronym and Annex C for faults type definition

Figure 3—Duval Triangle 1 Method

The Duval Triangle 1 Method uses three gases corresponding to the increasing energy content or temperature of faults: methane (CH_4) for low energy/ temperature faults, ethylene (C_2H_4) for high temperature faults, and acetylene (C_2H_2) for very high temperature/energy/arcing faults. On each side of the triangle are plotted the relative percentages of these three gases.

This method allows identification of the six basic types of faults indicated in Annex C.1, plus mixtures of electrical/ thermal faults in zone DT. Table 6 gives the numerical values for fault zone boundaries of Duval Triangle 1 Method expressed in ($\%CH_4$), ($\%C_2H_4$), and ($\%C_2H_2$).

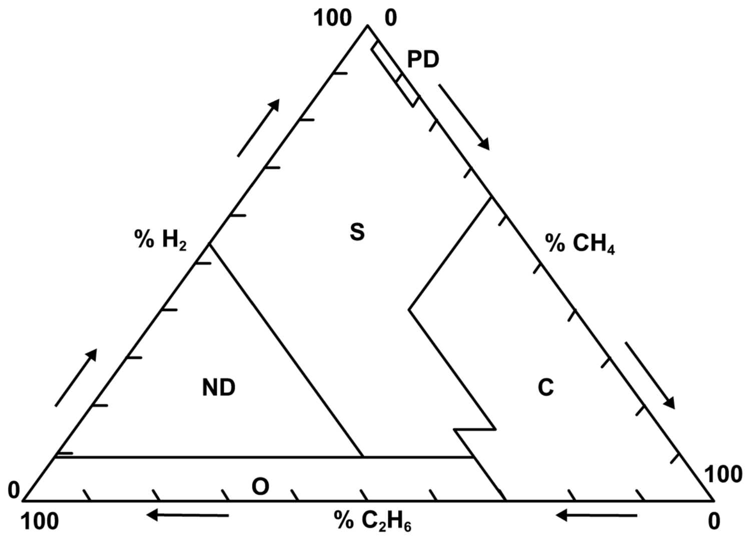


Figure D.3—Duval Triangle 4 method for low temperature faults

Numerical values for fault zone boundaries of Duval Triangle 4 method are the following, expressed in %H2, %CH4 and %C2H6:

Table D.3—Fault zone boundaries for Figure D.3

Gas% / Fault	% H_2	% CH_4	% C_2H_6
PD	—	≥ 2 and < 15	< 1
S	≥ 9	—	≥ 30 and < 46
	≥ 15	—	≥ 24 and < 30
	—	< 36	≥ 1 and < 24
	—	< 36 and ≥ 15	< 1
	—	< 2	< 1
O	< 9	—	≥ 30
C	—	≥ 36	≥ 24
	<15	—	≥ 24 and < 30
ND	≥ 9	—	≥ 46

The Duval Triangle 5 method is illustrated in Figure D.4:

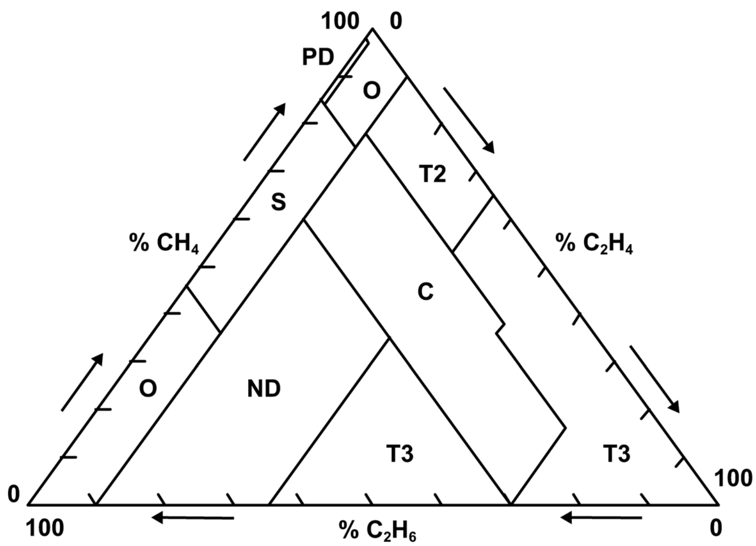


Figure D.4—Duval Triangle 5 method for high temperature fault

The Triangle 5 method allows a user to distinguish between high temperature faults T3/T2 in mineral oil only, of lesser concern in transformers, and potentially more dangerous faults C involving possible carbonization of paper.

Numerical values for fault zone boundaries of Duval Triangle 5 method are the following, expressed in %CH4, %C2H4 and %C2H6:

Table D.4—Fault zone boundaries for Figure D.4

Gas% / Fault	% CH_4	% C_2H_4	% C_2H_6
PD	—	< 1	≥ 2 and < 14
O	—	≥ 1 and < 10	≥ 2 and < 14
	—	< 1	< 2
	—	< 10	≥ 54
S	—	< 10	≥ 14 and < 54
T2	—	≥ 10 and < 35	< 12
T3	—	≥ 35	< 12
	—	≥ 50	≥ 12 and < 14
	—	≥ 70	≥ 14
	—	≥ 35	≥ 30
C	—	≥ 10 and < 50	≥ 12 and < 14
	—	≥ 10 and < 70	≥ 14 and < 30
ND	—	≥ 10 and < 35	≥ 30

Note that:

a) Triangles 4 and 5 should never be used for faults identified first with Triangle 1 as electrical faults D1 or D2.

b) Triangle 4 should be used only in case of faults identified first as faults PD, T1 or T2 in Triangle 1.

c) Triangle 5 should be used only in case of faults identified first as faults T2 or T3 in Triangle 1.