Sphere of Satisfied Customers Expands

Relay & Control Panels supplied to MEPCO & IESCO

EPESOL has vast and proven record in the field of Protection & Control. One of the mile stones EPESOL has accomplished this quarter is supply of relay panels type *RP3 & RP4* to MEPCO and control panel type *CP30* to IESCO, manufactured and assembled at Panel Manufacturing Shop located at Theater Road, Bedian - Lahore. A team of talented and experienced engineers and technicians have worked day in and day out to generate quality results. "This is a remarkable effort indeed and helped company grow further", CEO praised the team. Mr. Naeem-ul-Haq who set up the shop 5 years back has been leading the manufacturing team since.

EPESOL's Team lead by CEO at 2014 FSE Annual EHS and Cross Training MEA - Dubai

Power Lines get life, EPESOL own supplied solutions

Successful comissioning of AC/DC, Control & Synchronizing Panels at 220kV Rohri Grid station

EPESOL achieved another milestone in this quarter when our commissioning engineers successfully completed commissioning of their own supplied AC/DC, control and synchronizing panels at 220kV Rohri Grid station. Our team of engineers worked on war footing basis in close collaboration with engineers of NTDC (SP), TSG and M/s Chint till energization of all 220kV bays duly acknowledged and appreciated by all quarters of NTDC.

Best thing about memory is making them

A memory of EPESOL Day at Changa Manga Resort

EPESOL DAY has been celebrated with loads of fun, excitement and beautiful memories. The event took place on Nov 8, 2014 at CHANGA MANGA resort. A chill of excitement already swept across the employees and their families when news related to trip floated in the office. All arrangements were completed two days before for the destination PTDC, CHANGA MANGA. The day came and everyone started the journey with fresh morning and blooming smiles on their faces. It was planned to reach the spot at 10:00am and as expected each one was there on time. Everyone was dressed up in casual and there was joy all around. The day kicked off with a cricket match; wonderful display of passion & entertainment. CEO, Team Leads with their Engineers & Technicians all participated actively in it. Chats, gossips and laughters. Everyone was treated in the equal way. No one was boss there. Parallel activities were going on. Ladies along with the children stayed on the next side of ground and they enjoyed this time in their own way. Next session was planned to visit a nearby lake followed by a ride of train. Families moved quickly in their arranged conveyance at the desired spot. That was really something adventurous with lots of photo shoots and selfies. Mnemonics and puns were in air during the ride which made it more enchanting for everyone. This entire activity was almost of one hour and then lunch time started. Lunch was scrumptious and delicious. After lunch, gift session was started. This session was led by the CEO Mr. Akhlaq Ahmad. Gifts were distributed among Singles & Families. Special prizes were given to each child. Lastly, it's the time to conclude this memorable ceremony with a heavy heart. In fact, this is the beginning of a success story that will continue for many more years. With a new year of our journey, we are going to face more challenges, opportunities, greater success - and the memories. – *A memoir by Engr. Waqar Hussain Malik*

Completion of Protection System Studies

49.5 MW Three Gorges First Wind Farm Project, Jhimpir, Sindh

The project included relay configuration, parameter settings and coordination of relays at 33kV and 132kV systems, including Line Protection System, Transformer Protection System, Low Impedance Busbar Protection System, and Over Current & Earth Fault Protection System.

Field Services bags immense successes

From PakGen & Korangi PP, Pakistan to Abqaiq, Juaymah, Shahdum, KSA

Field Services team has done IR, SFRA & TR test of PTs, Testing of all relays from generator to breaker failure protection and testing of PF, Watts, Var, Frequency, Current, Voltage & EMs at PakGen, Pakistan

At ARAMCO sites of Abqaiq, Juaymah & Shehdum our Engineers performed generator, motor, transformer, feeder, breaker failure, synchronizing, busbar and other relays and instrument testing & replacement in record time.

Most recently our team has finished a gigantic task of 2 T60 relays modification, installation and commissioning at Korangi PP, Karachi, Pakistan

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From the desk of CEO

We've geared up ourselves with the new challenges ahead. Our portfolio now includes LV business agreement with the General Electric. Though telecom business is still in the infancy; however, we are hopeful it'll be put on right track through concerted efforts in the coming days. Finally, we're happy to announce the good news of establishing our Karachi office with the hopes to expand our business in the financial capital of the country as well. All praises to the Allah Almighty who has exalted us in a position to contribute in the prosperity of our beloved motherland.

Akhlaq Ahmad
CEO
EPESOL Pvt. Ltd.

From Editor's Scribe

Second EPETribune is in your hands with the hopes that it'll find its right place in your reading material. We've tried to improve the content and outlook from the first issue; however, your feedback will enable us to precisely appraise how far we've succeeded in doing so. The content enhancements comprise of inclusion of a technical article on Dissolved Gas Analysis (DGA) of transformers, and we've planned to make the article essential ingredient in all the future issues. Snaps of corporate get together at EPESOL day held in Changa Manga in November, and various other news snippets are also included. You can drop your feedback and suggestions at: epetribune@epesol.com.

Noor Al Huda
Editor
EPETribune

EPESOLians on March...

Panel Manufacturing turns five!

A journey started just before the dawning of new decade of this millennium leaped a successful completion of 5 years. Since 2009 a huge number of EHV panels have been delivered to satisfied customers across Pakistan. Have a glimpse of plethora:

- 220kV Control Desk Panel at Mangla
- 220kV Synchronizing Panel at Bandala & Rohri
- 220kV AC & DC Panels for Kassowal
- 132kV Event & Fault Recorder Panels for Alstom
- 132kV Relay & Control Panels for ABB
- Generator Protection Panels for Siemens

Transformer DGA Interpretation Techniques & Technologies

Part -I

Engr. Noor Al Huda
Team LEAD - DESIGN
Editor - EPETribune
EPESOL Pvt. Ltd.

Introduction

Transformer DGA or Dissolved Gas Analysis is a condition-monitoring technique with the objective to provide the owner with positive and useful information concerning the health and serviceability of transformer by analyzing the gases generated within the transformer. These gases, also known as key gases, are outcome of chemical degradation of transformer insulation system by normal or abnormal operating conditions and tend to dissolve in the oil. To understand what kind of information DGA can yield is tantamount to understanding how the DGA data is analyzed and interpreted in terms of transformer serviceability. However, interpretation of DGA results is often complex and should always be done with care, involving experienced transformer insulation maintenance personnel. The very purpose of this article is to discuss various interpretation techniques according to two international standards, viz., IEC 60599 & IEEE C57.104 and technology available to perform the analysis. Part-1 covers the techniques, and part-2 the technology.

DGA according to IEEE & IEC:

All transformers in operation produce gases to some extent and the fundamental outcome of DGA is to discriminate between normal and abnormal conditions based on the percentage of dissolved key gases in various samples of the transformer oil. This production of gases within a transformer has resemblance with an oil refinery, where different gases begin forming at specific temperatures either by decomposition of mineral oil or cellulosic paper insulation. Table-1 lists key gases produced in the oil ranked by the energy required to produce each. Table-2 lists the key gases that are produced when a fault occurs near the cellulosic paper insulation.

Key Gas Name	Chemical Formula	Combustible / Non-Combustible	Energy Required to Produce Key Gas
Hydrogen	H_2	Combustible	↓
Methane	CH_4	Combustible	
Ethane	C_2H_6	Combustible	
Ethylene	C_2H_4	Combustible	
Acetylene	C_2H_2	Combustible	Increasing

Table-1

Key Gas Name	Chemical Formula	Combustible / Non Combustible
Oxygen	O_2	Non-Combustible
Carbon Dioxide	CO_2	Non-Combustible
Carbon Monoxide	CO	Combustible

Table-2

• TDCG Method (IEEE):

Total dissolved combustible gas (TDCG), by definition, is the sum of the individual combustible gas concentrations. Symbolically speaking, $TDCG = H_2 + CH_4 + C_2H_6 + C_2H_4 + C_2H_2 + CO$. In IEEE C57.104, a four-level criterion exists to classify risks to transformers when there is no previous dissolved gas history. If a previous analysis exists, it should be reviewed to determine if the situation is stable or unstable. Table-3 lists the dissolved gas concentrations in ppm for the individual gases and TDCG for various Conditions and conclusion based on indicated condition.

Condition	H_2	CH_4	C_2H_2	C_2H_4	C_2H_6	CO	CO_2	TDCG	Conclusion
Condition 1	< 100	< 120	< 35	< 50	< 65	< 350	< 2500	< 720	Satisfactory Operation
Condition 2	101-700	121-400	36-50	51-100	66-100	351-570	2500-4000	721-1920	Trend Study
Condition 3	701-1800	401-1000	51-80	101-200	101-150	571-1400	4001-10000	1921-4630	Immediate Action
Condition 4	> 1800	> 1000	> 80	> 200	> 150	> 1400	> 10000	> 4630	Chances of Failure

Table -3

Table-4 indicates the recommended initial sampling intervals for various levels and rate of generation of TDCG. An increasing gas formation indicates a problem of increasing severity; and therefore, a shorter sampling interval is recommended by the standard. The standard also outlines a procedure to calculate the TDCG rates and may be referred to for further consultation. Standard also dictates standard operating procedures based on engineering judgment of these conditions that vary from continuation of normal operation, to consultation with manufacturer, and finally to removal of transformer from service in worst case scenarios. For example, if a transformer has a TDCG level of 1300 ppm and generates gas at a constant rate below 10 ppm per day, it should be sampled quarterly, and the operator should follow the recommended procedure. If the rate increases to 30 ppm per day but remains constant, the operator should now sample monthly. In case of condition 3 and condition 4, the sampling intervals reduce from monthly to daily depending upon TDCG rate and levels.

Condition	TDCG Levels (PPM)	TDCG Rates (PPM/Day)	Sampling Interval
Condition 4	> 4630	>30	Daily
		10–30	Daily
		<10	Weekly
Condition 3	1921–4630	>30	Weekly
		10–30	Weekly
		<10	Monthly
Condition 2	721–1920	>30	Monthly
		10–30	Monthly
		<10	Quarterly
Condition 1	≤ 720	>30	Monthly
		10–30	Quarterly
		<10	Annual

Table -4

• Key Gas Method (IEEE):

The Key Gas Method, represented in IEEE C57.104, is a method for determination of fault types from the gases that are typical, or predominant, at various temperatures. The method relates the key gases to different fault types by using the percentage for the combustible gases. The Key Gas Method considers the following four general fault types:

1. Thermal fault due to overheated oil
2. Thermal fault due to overheated cellulose
3. Electrical fault due to corona
4. Electrical fault due to arcing

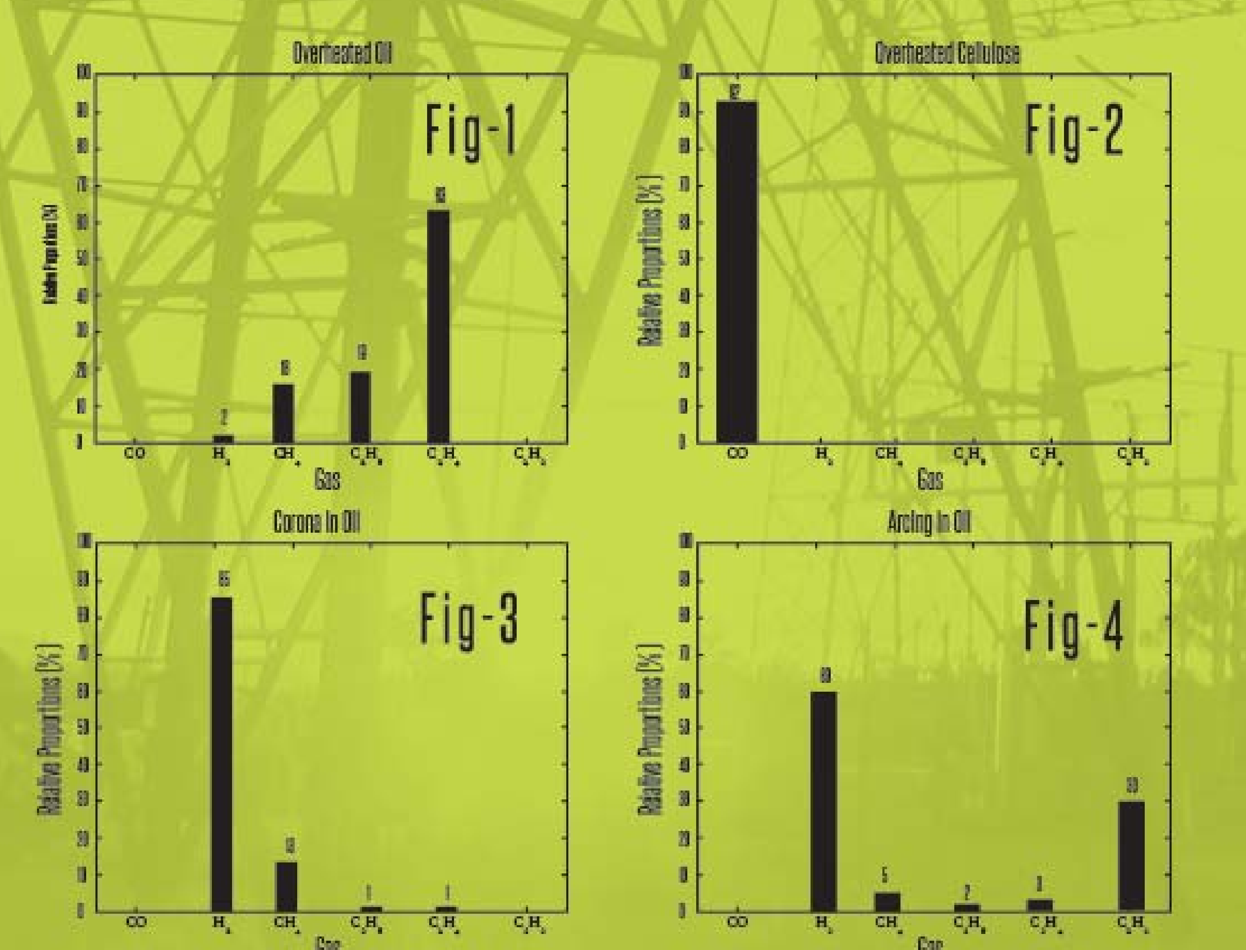

Figure-1, 2, 3 and 4 show histograms over the main decomposition products for each of the four fault types.

• Doernenburg Ratio Method (IEEE):

The Doernenburg ratio method suggests the existence of three general types of faults; thermal decomposition, corona and arcing. Figure-5 illustrates a flowchart representation of the method.

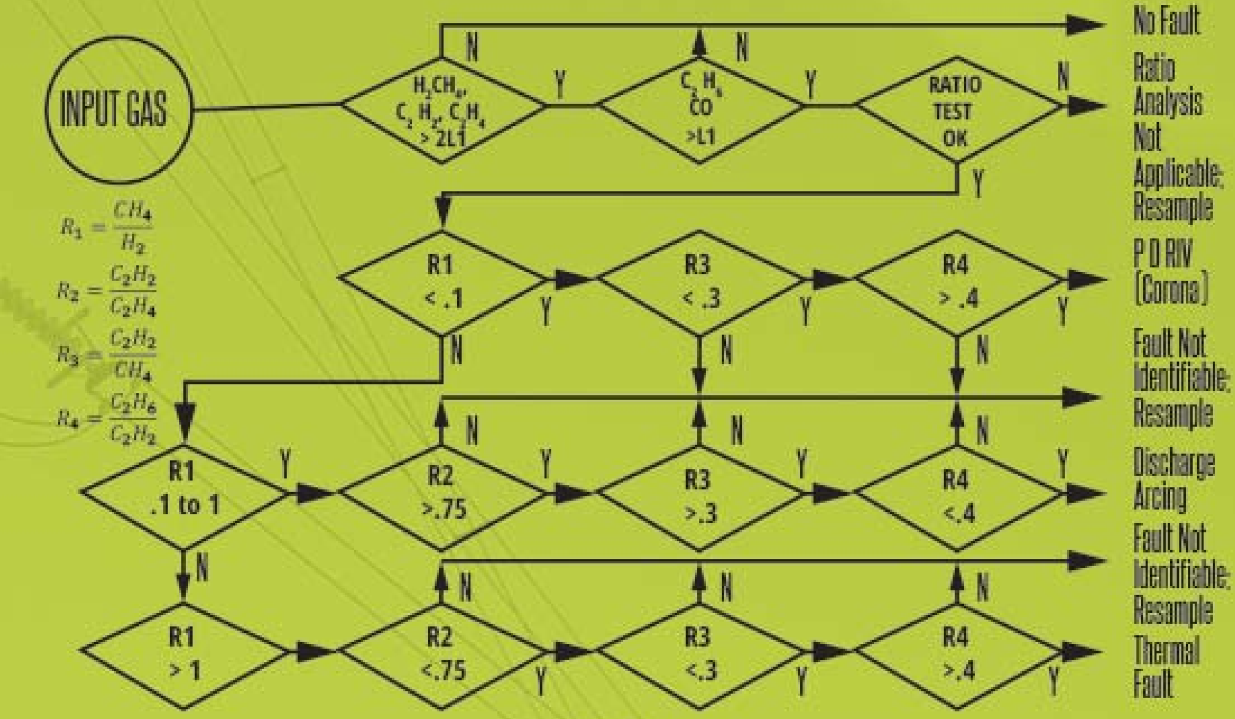

Figure-5

• Rogers Ratio Method (IEEE):

The Rogers ratio method follows the same general procedure as the Doernenburg method, except only three ratios, CH_4/H_2, C_2H_2/C_2H_4 & C_2H_4/C_2H_6 are used. The validity of this method is based on correlation of the results of a much larger number of failure investigations with the gas analysis for each case. But, as with the Doernenburg method, the Rogers ratios can give ratios that do not fit into the diagnostic codes, and one must decide that the transformer may has a problem from the total amount of gas. The upper section of Table-5 is used to assign each ratio a code, 0, 1 or 2, depending on which range the ratio belongs. Then one can identify the suggested fault type by comparing the obtained code combination with those in the lower section of the table.

Range of ratios	C_2H_2 / C_2H_4	CH_4 / H_2	C_2H_4 / C_2H_6
< 0.1	0	1	0
0.1-1	1	0	0
1-3	1	2	1
> 3	2	2	2
Characteristic fault			
No fault	0	0	0
PD of low energy	0	1	0
PD of high energy	1	1	0
Discharge of low energy, arcing	1 -> 2	0	1 -> 2
Discharge of high energy, arcing	1	0	2
Hot spots *t* < 150°C	0	0	1
Hot spots 150 < *t* < 300°C	0	2	0
Hot spots 300°C < *t* < 700°C	0	2	1
Hot spots *t* > 700°C	0	2	2

Table -5

• Ratio Method (IEC):

The IEC Ratio method utilizes five gases H_2, CH_4, C_2H_2, C_2H_4 and C_2H_6. These gases are used to produce a three gas ratios: C_2H_2/C_2H_4, CH_4/H_2 and C_2H_4/C_2H_6. The method is very similar to the Rogers Ratio method. Table-6 shows the IEC standard for interpreting fault types and gives the values for three key-gases ratios. Figure-6 shows graphical representation of the ratio method.

Case	Characteristic Fault	C_2H_2/C_2H_4	CH_4/H_2	C_2H_4/C_2H_6
PD	Partial discharges	Non-significant	< 0.1	< 0.2
D1	Discharges of low energy	> 1	0.1 – 0.5	> 1
D2	Discharges of high energy	0.6 – 2.5	0.1 – 1	> 2
T1	Thermal fault *t* < 300 °C	Non-significant	> 1 but Non-significant	< 1
T2	Thermal fault 300 °C < *t* < 700 °C	< 0.1	> 1	1 – 4
T3	Thermal fault *t* > 700 °C	< 0.2	> 1	> 4

Table - 6

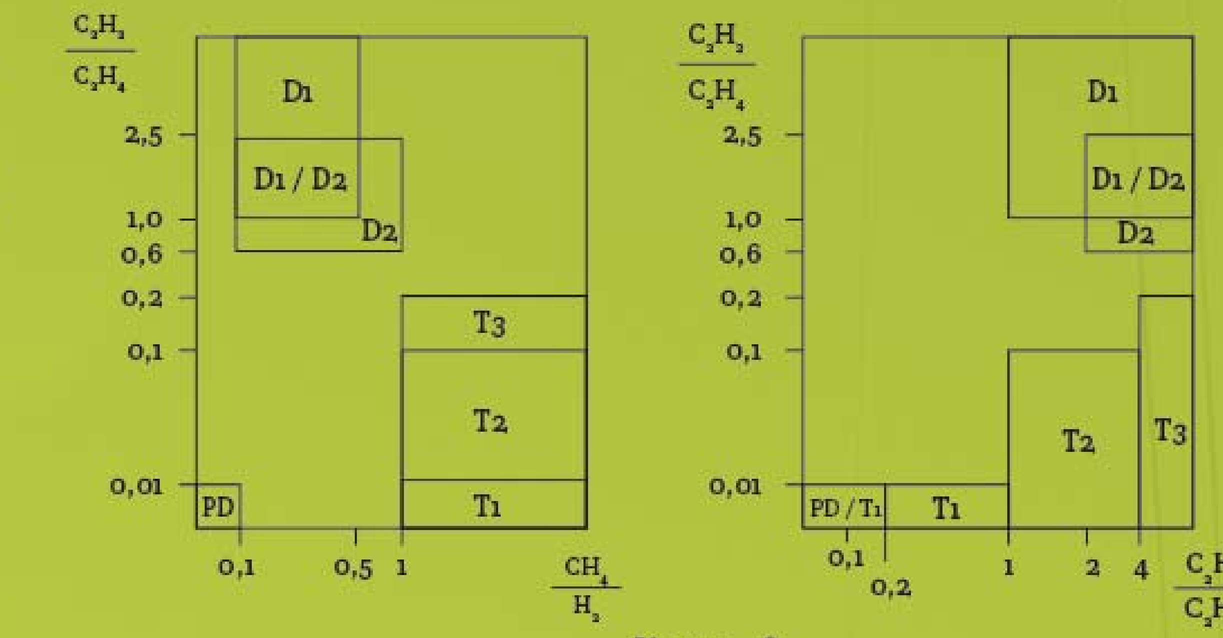

Figure - 6

• Duval Triangle (IEC):

It is a graphical method which utilizes the relative percentages of the three fault gases CH_4, C_2H_2 and C_2H_4. The ratios are plotted as a point in a triangular coordinate system on a triangular chart which is divided in different fault zones as shown in Figure-7. This figure can be translated in a table that gives the limits of each fault which are summarized in Table-7. The method should be applied only when there is some suspicion of a fault based on an increase in combustible gas or some other suspicious symptom. If reasonably stable concentrations of the gases are present before the onset of the suspected fault, it is advisable to subtract out the background concentrations. A drawback of this method is that it will always suggest a fault even when none is present. The coordinates in the Duval Triangle are computed as following:

$\%CH_4 = 100x/(x+y+z)$; $\%C_2H_2 = 100y/(x+y+z)$; $\%C_2H_4 = 100z/(x+y+z)$

Where $x = C_2H_2$; $y = C_2H_4$; $z = CH_4$ in microlitres per litre.

Limits of Zones				
PD	98 % CH_4			
D1	23 % C_2H_4	13 % C_2H_2		
D2	23 % C_2H_4	13 % C_2H_2	38 % C_2H_4	29 % C_2H_2
T1	4 % C_2H_2	10 % C_2H_4		
T2	4 % C_2H_2	10 % C_2H_4	50 % C_2H_4	
T3	15 % C_2H_2	50 % C_2H_4		

Table - 7

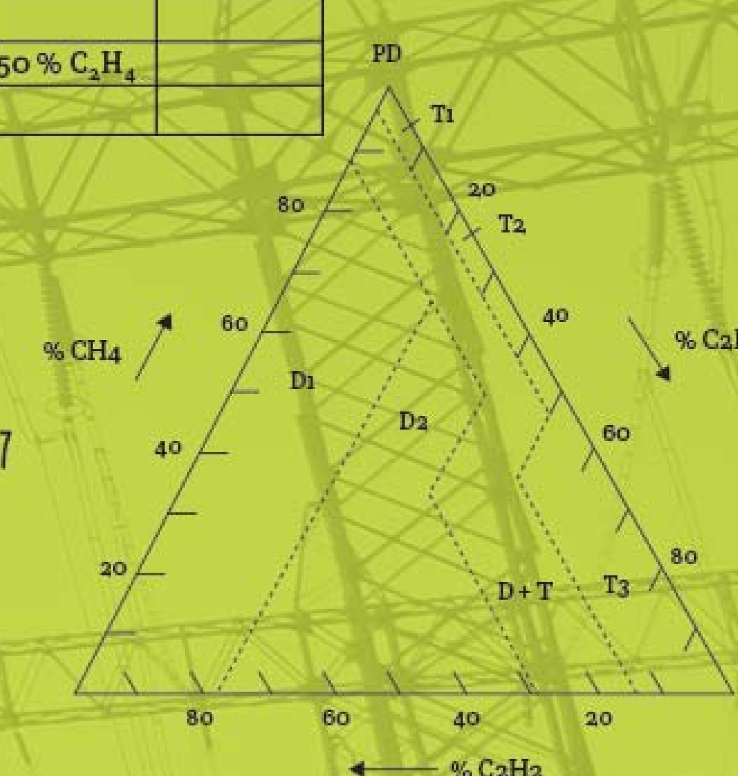

Figure - 7

Conclusion

It is underscored in the standards that the analysis of the key gases and interpretation of their significance is not a science, for their presence and quantity are also depending on numerous equipment variables such as type, location, and temperature of the fault; solubility and degree of saturation of various gases in oil; the type of oil preservation system; the type and rate of oil circulation; the kinds of material in contact with the fault; and finally, variables associated with the sampling and measuring procedures themselves. IEC & IEEE standards are, in general, advisory in nature and aid in interpretation of DGA results, which together with further field inspections and experienced personnel judgment can give an answer to what is going on inside a suspected unhealthy transformer.

[The second part of the article will continue in the next EPETribune due the length of the article.]

References: *1. IEC 60599, Mineral oil-impregnated electrical equipment in service – Guide to the interpretation of dissolved and free gases analysis.* *2. IEEE Std C57.104, IEEE Guide for the Interpretation of gases generated in Oil-Immersed Transformers*