Annex G Insulating Fluids Subcommittee

November 1, 2017
Louisville, KY

Chair: David Wallach
Vice-Chair: Jerry Murphy
Secretary: C. Patrick McShane

G.1 Introductions, Roll Call of Members for Quorum, Meeting Agenda Approval, S13 Minutes Approval, and Chair's Comments

G.1.1 Chair's Opening Remarks:

a. Reminded that the AMS must be used for Working Group and Task Force rosters.

b. Reminded that the WG and TF meeting minutes are due for submittal to the SCIF Secretary within 15 days of their meetings. The target date for SCIF Minutes is December 14, 2017.

G.1.2 Roll Call of SC members: (Quorum requirement: 25 minimum)

a. 35 Members signed in. Quorum was achieved. Six new SCIF Members were present: Jason Attard, Don Dorris, Don Platts, Alan Sbravati, Fabian Stacy, and Kevin Sullivan.

b. 61 Guests attended, of which 6 requested or re-requested membership: Stuart Chambers, John Foschia, Brian McBride, Dwight Parkinson, Mickel Saad, Kevin Sullivan

G.1.3 Agenda Approval:

a. The motion from George Forrest and seconded by Dave Sundin was approved unanimously, without objection.

G.1.4 Approval of minutes from the S17 meeting in New Orleans, LA:

a. The motion to approve was made by Susan McNelly and seconded by John John.

The motion was approval unanimously.

G.1.5 WG & TF Reports Presented at the SC Meeting

G.1.5.1 C57.104 – IEEE Guide for the Interpretation of Gases Generated in Oil – Immersed Transformer (PAR Expiration: 12/31/17)

WG Chair - Claude Beauchemin

The report of the WG Meeting was presented at the SCIF meeting by Don Platts.

a. The WG had a notification there is a potential essential patent. Presentation of what happened between meetings was reviewed. The data task force got to the point to develop a procedure to set up collection, storage, evaluation and post evaluation to keep data confidential. Contributions were received from18 different companies with 1.4 million data points.

b. With the database established, queries were made by different types of transformers. The significant difference indicating design groupings was for oxygen level indicative of preservation type, and equipment age were the important variables. The 90% table shows normal from abnormal, and 95th to show exceptional levels. The tables were the major change from last draft.

c. A straw ballot done and received many comments, some technical still unresolved.

d. Claude made a presentation showed wind farm and network units have higher values, and noted in the document as two exclusions. Some other items because we looked 1.4, many units fell in status 2 and status 3. Decided to drop CO2 to correct this.

e. The present draft got 2/3 vote to forward to IEEE SA by the working group. A motion by Luis Cheim with second by Don Platts was made to the Insulating Fluids SC to move to ballot. The motion was unanimously approved.

See ***Appendix I*** for the Minutes (unapproved) of C57.104 WG Meeting as Submitted.

G.1.5.2 IEEE C57.147 Guide for Acceptance and Maintenance of Natural Ester Fluids in Transformers (PAR Expiration: 12/31/18)

WG Chair: Patrick McShane, Vice-Chair: Clair Claiborne, Secretary: Jim Graham

The WG Report at the Sub-Committee Meeting: Presented by Patrick McShane:

a. No WG Meeting was held at F17. The work of the WG is completed as the voting is in the recirculation process.

b. Since the last meeting, a recirculating vote was issued (Draft 4). All but two of the negative voters in the initial ballot switched to affirmative. One of the two has left the industry, and the other appears to be readily resolvable.

c. Five voters submitted 27 comments, which will be reviewed by the Ballot Resolution Group and form the basis of the 2nd Recirculating vote (Draft 5), which will first be submitted to the WG Members for approval prior to submittal to IEEE SA.

G.1.5.3 TF on Consolidation of Insulating Liquid Guides (PAR Deadline: Pending submission. Number assigned (WG C57.166))

Chair: Tom Prevost

The TF Report given at the Sub-Committee Meeting by Tom Prevost:

a. The TF meeting will be the last, as a PAR request will be submitted in time for the January NESCOM meeting.

b. The next meeting, S18 Pittsburgh, will be the first Working Group meeting assuming the PAR application is approved.

c. The TF meeting focused on document format, to help establish Task Forces of the WG, which Tom estimates will be 6 or 7.

d. Patrick McShane asked for a clarification of "as received", assuming it meant "as received *in new equipment*". Tom confirmed that change and welcome additional input from the SC attendees.

See ***Appendix II*** for the S16 Minutes (unapproved) of TF Consolidation of Insulating Liquid Guides as submitted.

Old Business

None was presented.

G.2 New Business

None was presented.

G.3 Next SCIF Meeting:

March 18, 2018 – Pittsburgh, PA

G.4 Adjournment

The motion passed unanimously.

Respectively Submitted, Patrick McShane, Secretary SCIF

Unapproved Minutes from the F17 SCIF WG and TF Meetings

Appendix I – WG C57.104 Minutes

IEEE Guide for the Interpretation of Gases Generated in Oil – Immersed Transformers

C57.104 – IEEE Guide for the Interpretation of Gases Generated in Oil – Immersed Transformers

The meeting was called to order Tuesday, October 31, at 3:20pm by Chair Claude Beauchemin. Vice-Chairs Don Platts and Norm Field, and Secretary Susan McNelly (writer of Minutes) were also present.

There were 129 total in attendance. Of these 48 of 73 members were present. A membership quorum was achieved. There were 85 guests, and 14 of those requested membership. The WG plans to meet at the Spring 2018 Transformers Committee Meeting in Pittsburgh, Pennsylvania.

The following is a list of the working group members. Those in bold text with an asterisk were in attendance at the meeting.

Beauchemin, Claude*

Boettger, William*

Boman, Paul*

Brauer, Stephan

Castellanos, Juan*

Cheatham, Jonathan*

Cheim, Luiz*

Christodoulou, Larry*

Claiborne, C. Clair

Cox, Paul

Crouse, John

Damico, Frank*

Denzer, Stephanie*

Diaby, Mohamed*

Dorris, Don

Dukarm, James*

Duval, Michel*

Ferreira, Marcos*

Field, Norman*

Forrest, George*

Frimpong, George

Frotscher, Rainer*

Galbraith, Shawn*

Gardner, James*

Golarz, Jeffrey*

Golner, Thomas*

Hanson, David

Hayes, Roger*

John, John*

Joshi, Arvin*

Kiparizoski, Zan*

Ladroga, Richard

Lau, Michael

Luo, Shawn

Mani, Kumar*

Mao, Libin

Martin, Terence*

McCullough, Douglas*

McIver, James

McNelly, Susan*

Moleski, Hali

Morales-Cruz, Emilio*

Murphy, Jerry

Mushill, Paul*

Naderian, Ali

Nims, Joe*

Nunes, Jr, Jayme

Nunez, Arturo*

Patel, Poorvi*

Perjanik, Nicholas*

Petosic, Branimir

Pinon, Oscar

Platts, Donald*

Prevost, Thomas*

Pruente, John

Rasco, Jimmy*

Rasor, Robert

Ray, Jeffrey*

Reed, Scott

Roizman, Oleg

Selvaraj, Pugazhenthi*

Simonelli, Richard*

Sparling, Brian*

Stiegemeier, Craig

Sullivan, Kevin*

Sweetser, Charles

Thompson, James

Thompson, Robert

VanderWalt, Alwyn*

Veillette, Michel

Wallach, David*

Wang, Evanne*

Williams, Trenton*

Woods, Deanna*

Yeboah, Kwasi

The following guests requested membership, but due to the status of the document, no new members will be added.

Ayers, Donald

Crotty, John

Dorris, Don

Franchitti, Anthony

Guner, Ismail

Pellon, Verena

Sandhu, Surinder

Sarkar, Amitabh

Shem-Tov, Mark

Walia, Sukhdev

White, Leon

Woods, Deanna

Cheema, Muhammad

Whitehead, Bill

Agenda

1. Attendance Roster Circulation
2. Member Roll Call & Quorum Check
3. Approval of the Spring 2017, New Orleans minutes
4. Document Status
    a. Straw Ballot Draft 4
    b. Discuss major comments/revisions
    c. Next step
5. New Business
6. Adjournment

A call for essential patent claims was made. Donald Lamontagne from APS indicated he may have an essential patent claim.

A motion to approve the Fall 2017 Louisville Agenda was made by Brian Sparling and seconded by Tom Prevost. There were no objections or additions to the agenda.

A motion to approve the Spring 2017 New Orleans Meeting Minutes was made by Tom Prevost and seconded by Kumar Mani. There were no objections or additions to the minutes.

Introductions of the Chair Claude Beauchemin, Vice-Chair Don Platts, Vice-Chair Norm Field, and Secretary Susan McNelly were made. Attendees were asked to introduce themselves and indicate their affiliations when making comments or asking questions.

Claude gave a brief update on the status of the document and the most recent Straw Ballot (Draft 4).

Straw Ballot 4 – Status/Results

Activities since Spring meeting

- Data analysis performed
- New tables generated
- Draft updated and released for straw ballot
- PAR extension requested

Planned activities

- Review Database analysis results
- Review straw ballot results
- Discuss and implement required modifications
- Request an approval to go to sponsor ballot from the WG
- If positive, request approval to go to sponsor ballot from sub committee

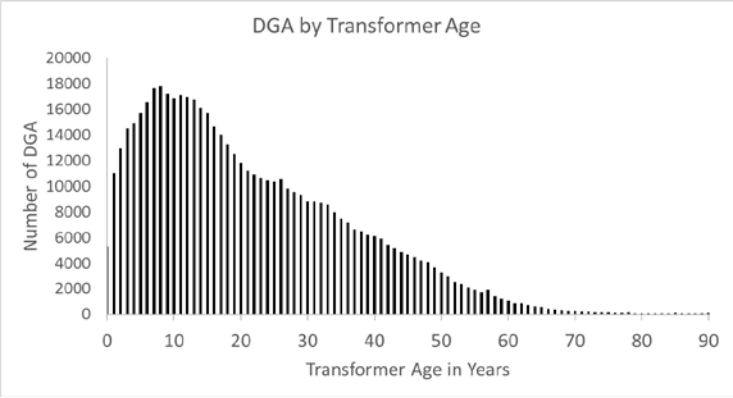
DGA Database

- Data analysis performed on August 30 and 31, 2017 in the presence of the following WG members:
- Don Platts
- Norm Field
- Luiz Chiem
- Bob Rasor
- Hali Moleski
- Claude Beauchemin

Claude expressed a special thank you to Bob Rasor and Hali Moleski from SD Meyer for hosting the data analysis meeting.

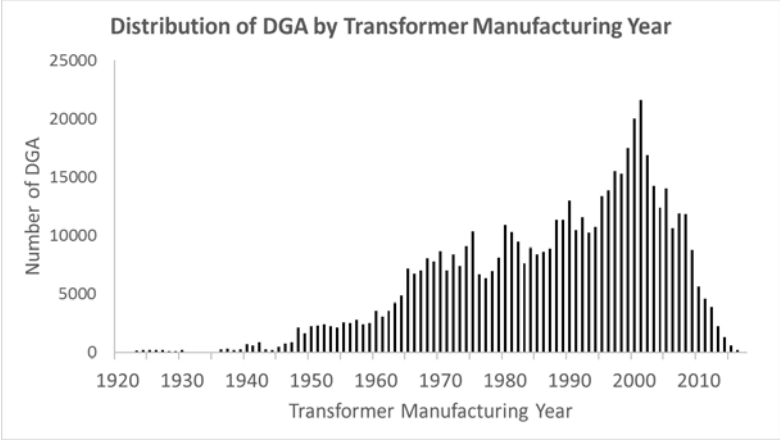
- Number of data suppliers: 18 (some sources have been broken by regions)
- Total number of DGA analysis: 1 391 436
- Total number of Transformers: 313 076
- Total number of DGA with transformer age: 595 650*

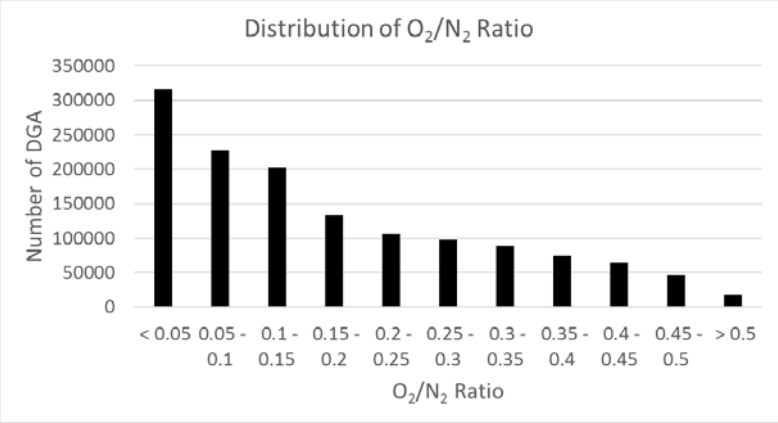
General information

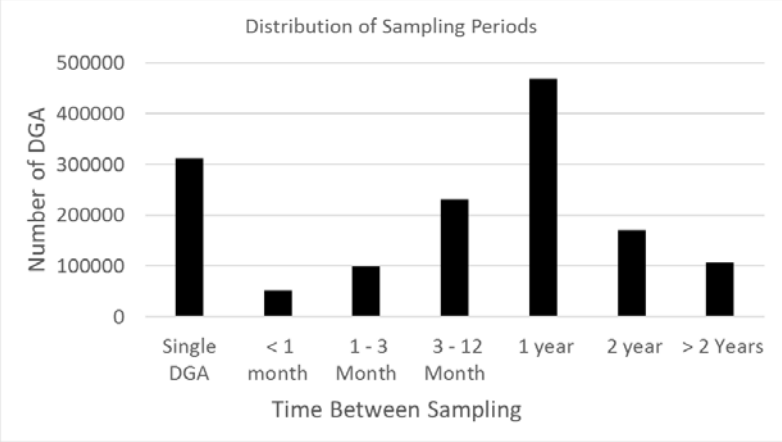


The idea is to preserve as much information as possible since the data set had to be destroyed after the analysis.

Most of the DGA is from transformers 30 years or younger.







Factors influencing 90 & 95 Percentiles

- Study the effect of various factors on the 90 and 95 percentile:
  - O_2/N_2 Ratio
  - Age
  - Vintage
  - MVA
  - KV
  - Oil Volume
  - Total Dissolved Gases

	90 Percentiles in ppm and delta in %								
Factor	**DGA**	**H2**	**CH4**	**C2H6**	**C2H4**	**C2H2**	**CO**	**CO2**	**Average all gases**
O2 Ratio < 0.2	876314	83	87	91	54	0	901	9263	**95.4%**
O2 Ratio > 0.2	495561	41	20	14	50	2	481	5011	
Max - Min / Average		67.7%	125.2%	146.7%	7.7%	200.0%	60.8%	59.6%	
Age 1 to 10 Years	147472	65	38	21	20	1	699	4076	**67.2%**
Age 10 to 30 Years	275286	58	67	59	47	1	896	7591	
AgeYear > 30 years	189415	82	73	84	65	2	697	7851	
Max - Min / Average		35.1%	59.0%	115.2%	102.3%	75.0%	26.0%	58.0%	
Manufacturing Year > 1987	331028	54	46	26	31	1	865	6171	**55.4%**
Manufacturing Year < 1987	288202	84	81	90	65	2	705	7634	
Max - Min / Average		43.5%	55.1%	110.3%	70.8%	66.7%	20.4%	21.2%	
Maximum MVA < 10	568682	69	64	56	59	1	884	9449	**31.0%**
Maximum MVA > 10	356038	63	76	74	50	2	652	5689	
Max - Min / Average		9.1%	17.1%	27.7%	16.5%	66.7%	30.2%	49.7%	
HVkV < 60	626153	66	65	56	58	1	864	9126	**30.9%**
HVkV > 60	347877	69	79	83	52	2	643	5687	
Max - Min / Average		4.4%	19.4%	38.8%	10.9%	66.7%	29.3%	46.4%	
Oil Volume Galllons < 2000	554687	72	67	58	58	0	912	9792	**20.6%**
Oil Volume Gallons > 2000	218857	68	62	62	44	0	600	5527	
Max - Min / Average		5.7%	7.8%	6.7%	27.5%	0.0%	41.3%	55.7%	
Total Dissolved Gases < 100000 ppm	1043500	63	65	62	50	1	770	7300	**14.2%**
Total Dissolved Gasse > 100000 ppm	328907	83	67	60	62	1	848	10328	
Max - Min / Average		27.4%	3.0%	3.3%	21.4%	0.0%	9.6%	34.4%	

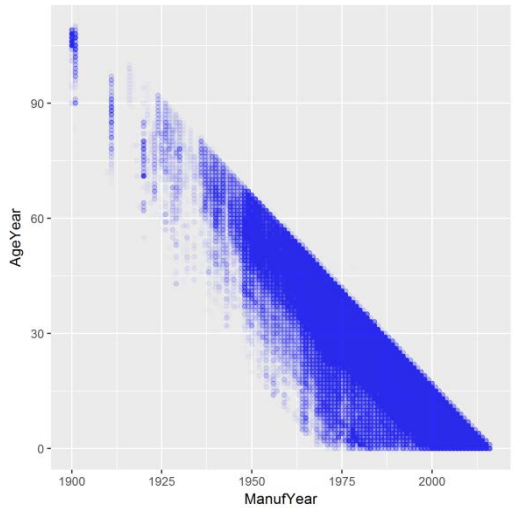
	95 Percentiles in ppm and delta in %								
Factor	**DGA**	**H2**	**CH4**	**C2H6**	**C2H4**	**C2H2**	**CO**	**CO2**	**Average all gases**
O2 Ratio < 0.2	876314	192	163	182	108	2	1110	12524	**76.3%**
O2 Ratio > 0.2	495561	88	50	39	108	7	620	6982	
Max - Min / Average		74.3%	106.1%	129.4%	0.0%	111.1%	56.6%	56.8%	
Age 1 to 10 Years	147472	147	87	56	52	3	898	5716	**54.1%**
Age 10 to 30 Years	275286	140	135	136	101	3	1112	10371	
AgeYear > 30 years	189415	168.3	141	174	133	5	896	10825	
Max - Min / Average		18.6%	44.6%	96.7%	85.0%	54.5%	22.3%	57.0%	
Manufacturing Year > 1987	331028	121	99	74	71	3	1085	8731	**45.3%**
Manufacturing Year < 1987	288202	180	153	180	139	5	897	10471	
Max - Min / Average		39.2%	42.9%	83.5%	64.8%	50.0%	19.0%	18.1%	
Maximum MVA < 10	568682	158	131	131	115	3	1091	12645	**20.2%**
Maximum MVA > 10	356038	139	141	152	107	4	849	7928	
Max - Min / Average		12.8%	7.4%	14.8%	7.2%	28.6%	24.9%	45.9%	
HVkV < 60	626153	150	132	133	114	4	1072	12283	**14.9%**
HVkV > 60	347877	150	147	168	112.2	4	836	7863	
Max - Min / Average		0.0%	10.8%	23.3%	1.6%	0.0%	24.7%	43.9%	
Oil Volume Galllons < 2000	554687	166	134	132	109	2	1115	13081	**27.9%**
Oil Volume Gallons > 2000	218857	147	118	137	94	4	791	7719	
Max - Min / Average		12.1%	12.7%	3.7%	14.8%	66.7%	34.0%	51.6%	
Total Dissolved Gases < 100000 ppm	626153	150	132	133	114	4	1072	12283	**14.9%**
Total Dissolved Gasse > 100000 ppm	347877	150	147	168	112.2	4	836	7863	
Max - Min / Average		0.0%	10.8%	23.3%	1.6%	0.0%	24.7%	43.9%	

Influence of O_2/N_2 ratio

- Of all the possible factors, the O_2/N_2 ratio has the strongest overall effect: 75 - 90%
- Second: Age and/or Vintage: around 45 - 65%
- Third: kV, MVA and Volume, around 15 - 30%

  Note: Age and vintage are strongly correlated, same for MVA, kV and oil volume

Age VS Manufacturing Year



Influence of O_2/N_2 ratio

- Decision: Two levels tables are based on:
  - O_2/N_2 ratio split at 0.2
  - Age split in 4 groups
    - Unknown (based on analysis of all data)
    - 1 – 10 years
    - 10 – 30 years
    - > 30 years

Data Distribution

	O2/N2 <= 0.2				O2/N2 > 0.2			
	Age in Years							
	All	1-10	10-30	>30	All	1-10	10-30	>30
Number of DGA	876 314	84 215	179 829	113 264	495 561	59 320	86 983	72 039
% of DGA	63.0%	6.1%	12.9%	8.1%	35.6%	4.3%	6.3%	5.2%

Factors influencing 90 & 95 Percentiles

Table 1

O_2 Ratio:	O_2/N_2 <= 0.2				O_2/N_2 > 0.2			
Gas / Age	Transformer Age in Years				Transformer Age in Years			
	Unknow	1-10	10 - 30	> 30	Unknow	1-10	10 - 30	> 30
H_2	80	75		110	40	40		
CH_4	90	45	90	110	20	20		
C_2H_6	90	30	90	150	15	15		
C_2H_4	50	20	50	90	50	25	60	
C_2H_2	1	1			2	2		
CO	900	900			500	500		
CO_2	9000	5000	10000		5000	3500	5500	

Table 2

O_2 Ratio:	O_2/N_2 <= 0.2				O_2/N_2 > 0.2			
Gas / Age	Transformer Age in Years				Transformer Age in Years			
	Unknow	1-10	10 - 30	> 30	Unknow	1-10	10 - 30	> 30
H_2	200	200			90	90		
CH_4	150	100	150	200	50	60		30
C_2H_6	175	70	175	250	40	30	40	
C_2H_4	100	40	95	175	100	80	125	
C_2H_2	2	2		4	7	7		
CO	1100	1100			600	600		
CO_2	12500	7000	14000		7000	5000	8000	

Table 3

Maximum µL/L (ppm) variation between consecutive DGA samples below Table 1

Gas \ O_2 Ratio	O_2/N_2 <= 0.2	O_2/N_2 > 0.2
H_2	40	25
CH_4	30	10
C_2H_6	25	7
C_2H_4	20	
C_2H_2	Any Increase	
CO	250	175
CO_2	2500	1750

Straw ballot 2

- Request sent September 28, 2017
- Draft 4.0
- 24 responses
- 178 comments
    - 30% Technical, 70% Editorial
- Processed by the WG leaders in the week of October 22, 2017

Comments

- Most of editorial comments accepted and corrected. Some to be done after meeting
- Some editorial comments could not be corrected due to inadequate references (page and section) or lack of suggestion
- Most Technical comments accepted and corrected
- Some Technical comments need discussion

Discussion: 1.1 Scope

Ballot Comment

- "The scope is not clear if both power and distribution transformers are included. Section 1.3 is clear that Network or Windfarm transformers are not included. Section E.5 has an example of 500 kVA distribution transformer. It is suggested to clarify the scope in section 1.1."

Responses:

- Pro: Adding more categories might clarify
- Con: Will end up in a long list and might miss some categories (GSU, Power, Transmission. Distribution, Industrial…)
- Other guide: Transformer and reactor
- TF Decision: No list.

Discussion:

- Jim Dukarm asked, what is included in the database. For instance, is less than 1MVA included. Claude indicated yes. What is covered should not differ from what is included in the database statistics.
- Vijay K (VTC) comment on splitting information by size. Claude reiterated that the size (rating, voltage, and volume) did not show major differential in results. Claude indicated this is a common opinion, but the data did not prove this true. On the other hand, O_2 ratio and age are factors and are part of the Table 1 and Table 2 division.
- Leon White – Indicated he agrees that size does not matter. He indicated that there should be something in the document indicating the range of the transformer size and types of units as clarification. Claude indicated that this could be added to Annex A. He indicated he could easily add a graph o f rating distribution to the Annex A. Leon indicated that it might be best to have that up front in the document rather than in an Annex.
- Rainer Frotscher – commented that the guide applies to transformers in mineral oil and specifically indicate what types of units are not included. ."This guide applies to mineral oil transformers except those identified in section 1.3." for an example of how the Section 1.1 scope should be revised. Rainer made a motion to modify the scope as identified above.

Discussion: Dave Wallach asked if this revision is worth having to change the scope and as a result request a PAR revision. Claude asked whether this clarification could be moved to section 1.3 instead. There was additional discussion on the effect of this on the plan to proceed to ballot. This process can proceed to ballot. There was a comment to change the title of section 1.3 to "Exclusions". This will be addressed later in discussion of section 1.3. Those in favor 6, 18 opposed.

- Fredi Jakob - ???

Ballot Comments

- "The scope of guide includes "operating procedures". The only place that the document comments on "operating procedure" is the classic TCG (Table G-2). The user is eager to have a guidance as what to do with 90% or 95% limits. Is it possible to come up with a generic guide/table same as Table G-2 like : continue operation, sample more frequent, Exercise caution, Remove. If not, I suggest to remove "Suggested operating procedures" from the scope of work (section 1.1)."
- There is suggestion in section 6.1.2.1 "Normal transformer operation can be continued.", in section 6.1.2.2 "..and warrant additional investigation ...increased sampling frequency should be maintained or started..." and in section 6.1.2.3 "The transformer should be placed under strict surveillance and additional transformer testing is recommended...".
- Will a "Operating Procedure" Table be too much of a short cut, prompting user to just jump to the table without considering all the qualifications presented in the rest of the text ?

Response:

Should such a table be added?. Don Platts indicated that a table like that would be helpful to some people, but disconcerting to others. He indicated it would be disruptive to more people than helpful. Concensus by show of hands was to not add this table.

Discussion: 1.3 Limitations

- Some categories of transformer excluded:
  - Windfarm Step-up
  - Network
- Value much higher than general population
- Should we explain in the guide?
- If yes, where? Main body? Annex? How much explanation?

Discussion:

Brian Sparling indicated he was not part of the Wind Farm WG, but asked if there were any cautions or warnings about gassing in that guide. A response was that it is not.

Don Ayers – Indicated that gassing was discussed in relation to the grounding of the core. This is not in the document, but is a concern.

Rainer Frotscher – Brought up Network TRs. He indicated the addition of as defined in IEEE Std C57.12.80, is now more clear.

Bob Rasor indicated that the data will not be lost, but will be reviewed for inclusion in another document.

Sukhdev Walia – Indicated that the application of wind farm transformers is rising and sooner or later this will need to be address.

- Proposed text:
  This Guide is not applicable to windfarm step-up transformers or network transformers (as defined in IEEE Std C57.12.80) having disconnect/grounding switches in the transformer oil. The user of this Guide must also carefully consider whether the transformer may be purposely designed for special application with normally anticipated excess electrical or thermal stress. Transformers closely connected to power electronics or with frequent and widely fluctuating load (such as transformers at wind turbines) may not be well suited for DGA interpretation using this Guide."

90th Percentile			
	General	**Windfarm**	**Network**
H2	57	2352	2460
CH4	66	593	522
C2H6	56	162	160
C2H4	58	47	36
C2H2	0	5	0
CO	889	977	567
CO2	9138	5173	5670

A question was asked whether the titel of Section 1.3 should be changed to "Limitations and Exclusions? This was approved.

Discussion 1.4 – Future Work

- A sub-section named "Future work" has been added to section 1
- Should we keep it?
- Does any items need to be added?
- Does any items need to be removed?
- Does any items need to be modified?

Future Work

The procedure to interpret DGA results presented in this guide is, by its very nature, a work in progress.

Evolution of our understanding of DGA contributes to the evolution of DGA interpretation techniques and must continue to evolve due to a wide variety of industry changes:

- New material and new material processing,
- New transformer designs,
- New applications of transformers,
- Changes in data availability and quality,
- Changes in the operation and use of transformer;
- Change in the expectation of what DGA interpretation should supply to the transformer owners.

This guide represents the best interpretation of the data available based on the experience of the experts contributing to this document. Therefore, the industry should strive to continue to upgrade and improve it.

Several opportunities for improvement have been identified during the revision work that resulted in the present guide. While some effort was put into pursuing these topics, resolution of them remains too elusive to be included in this current guide

- Reduce the number of DGA marked as “Investigate” without losing the capability to detect abnormal situations.
- Obtain a better correlation between DGA results and actual fault detection and identification.
- Adapt DGA interpretation to specific applications, such as Windfarm, Network, GSU, distribution.
- Build an industry wide database of DGA, including all pertinent transformer information’s, to support the future evolution of this guide.
- Application of DGA interpretation with the use of on-line DGA monitors, specifically in regard to their rate of change calculations.

Comments (3):

- Section 1.4 "Future Work" is not within the scope of the document and should be omitted.
- I like the approach of adding the Future Work section. Suggested clarification. "…current guide. These topics include:
- Much earlier in the development of this guide, we discussed creating a section or appendix for the express purpose of documenting how key features of the guide were achieved. The intent was to give contributors to future revisions documentation that might be instructive for their work. I recommend that suggestions for future work be included with this in the context of challenges this working group faced or would have faced to address that work. This section will also be instructive to those who question the origins of that key information.

So, what should we do? Keep in its present location, move to annex, or remove completely?

Discussion

Jim Dukarm - Indicated he was the one that commented that the future work is not within the scope of the document and should be discarded.

Dave Wallach proposed to move the future work to Annex A. This was seconded by Jim Dukarm.

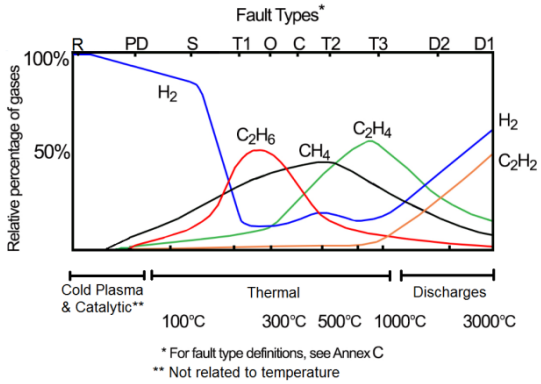
A recheck on quorum after the break verified that a quorum was still present.

All but one abstaining were in favor of the proposal. Proposal passed.

Discussion Figure 1

- Figure 1 shows Fault Type D2 occurs at a temperature that is lower than that of D1. I would have thought it should be the other way?

  Answer: D2 are discharges with high energy that are usually affecting a larger volume of oil than D1 which lower the overall temperature of the affected oil



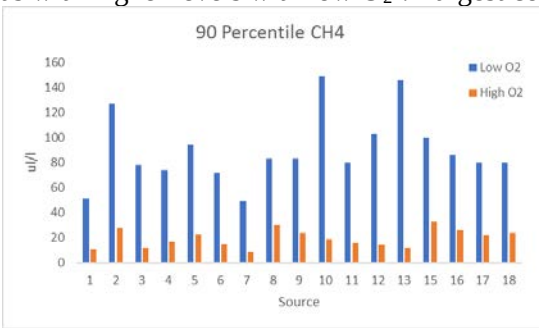
Discussion Table 1 & 2

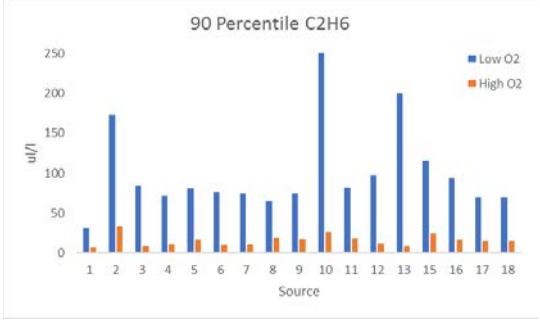
- One could easily see the C_2H_2 has a different pattern than other gases, i.e. it has a lesser limit for sealed transformers. Is there a logical explanation for this? If so, can we include it? If no, should we modified the table so as not to confuse the users?
- Some values should be changed or at least get an explanation to justify them.
  - For O_2/N_2>0.2 and Age > 30 , CH_4 limit is 30 ppm, lower than younger transformer. It is in opposition with all other values in table 1 and table 2. This value will change the DGA status from 2 to 3 just based on the age.
  - For O_2/N_2 > 0.2, it specifies a higher C_2H_2 level (7 ppm), but for all other gases, the gas limits are lower or equal to those in O_2/N_2<0.2. Why?

Influence of O2/N2 ratio

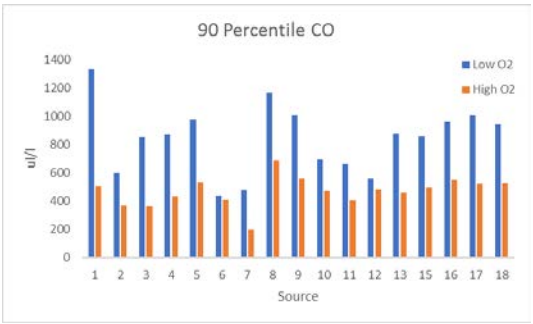
- High O_2/N_2 ratio: Generally lower values, except for C_2H_2
- Low O_2/N_2 ratio: More differences in function of age
- C_2H_2 question: Why it is different? Could it be the result of a single data source skewing the analysis?

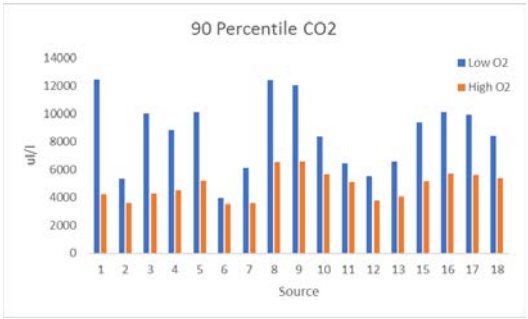
- Gas with higher levels with low O_2 : Largest correlation: CH_4 and C_2H_6



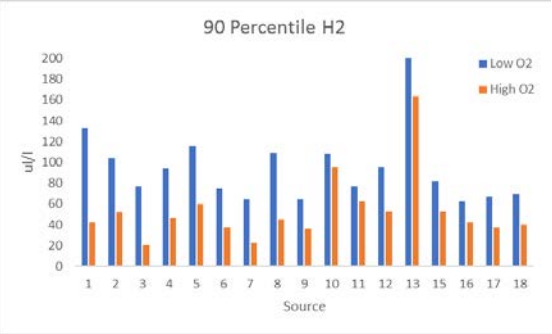


- Gas with higher levels with low O_2 : Strong correlation: CO and CO_2

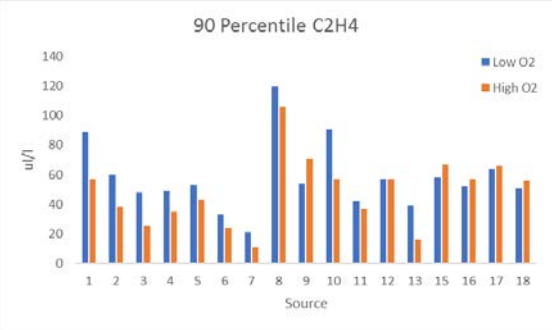


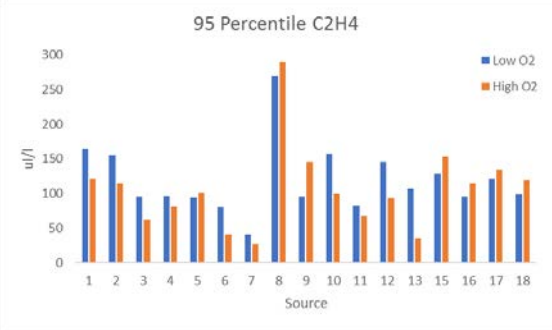


- Gas with higher levels with low O_2 : Strong correlation: H_2

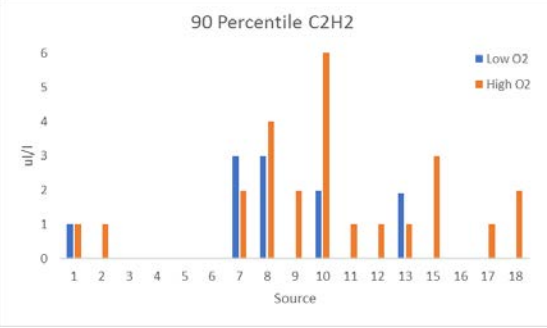


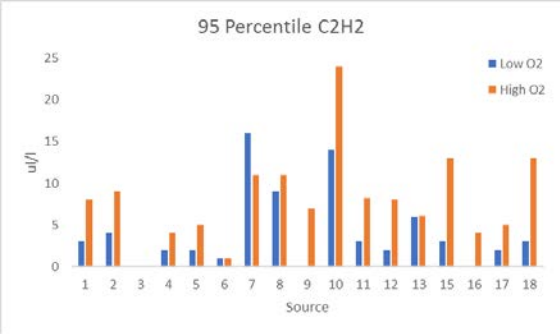
- Gas with higher levels with low O_2 : Correlation ??: C_2H_4





- Gas with higher levels with high O_2 : Inverse correlation: C_2H_2





Discussion

Claude concluded that the higher C_2H_2 level in high O_2/N_2 ratio in comparison to low O_2/N_2 ration is real.

Fredi Jakob – Normally the higher O_2 indicates some leakage in the system which affects the loss of gas from the oil. The other factor is that if you have higher O_2, there is a likelihood of oxidation which could be the reason for the acetylene. He indicated he doesn't think any further explanation is needed. Claude added than another possible explanation could be that transformers with conservators (mostly with high O_2/N_2 ratio) are more exposed to possible gas leak from the LTC compartment through an adjacent conservator compartment.

Table 1

Table 1								
O_2 Ratio:	O_2/N_2 <= 0.2				O_2/N_2 > 0.2			
Gas / Age	Transformer Age in Years				Transformer Age in Years			
	Unknow	1-10	10 - 30	> 30	Unknow	1-10	10 - 30	> 30
H_2	80	75		110	40	40		
CH_4	90	45	90	110	20	20		
C_2H_6	90	30	90	150	15	15		
C_2H_4	50	20	50	90	50	25	60	
C_2H_2	1	1			2	2		
CO	900	900			500	500		
CO_2	9000	5000	10000		5000	3500	5500	

Table 2: Should we modify CH4 for O2/N2 >0.2?

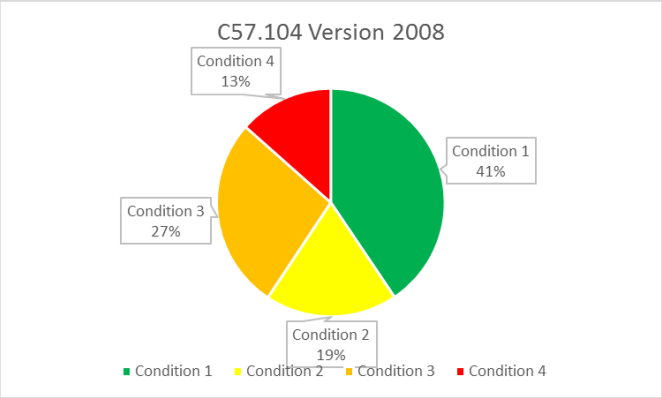
Table 2								
O_2 Ratio:	O_2/N_2 <= 0.2				O_2/N_2 > 0.2			
Gas / Age	Transformer Age in Years				Transformer Age in Years			
	Unknow	1-10	10 - 30	> 30	Unknow	1-10	10 - 30	> 30
H_2	200	200			90	90		
CH_4	150	100	150	200	50	60		30
C_2H_6	175	70	175	250	40	30	40	
C_2H_4	100	40	95	175	100	80	125	
C_2H_2	2	2		4	7	7		
CO	1100	1100			600	600		
CO_2	12500	7000	14000		7000	5000	8000	

Claude asked whether these values should be merged or left as is. Concensus was to keep as is and not merge.

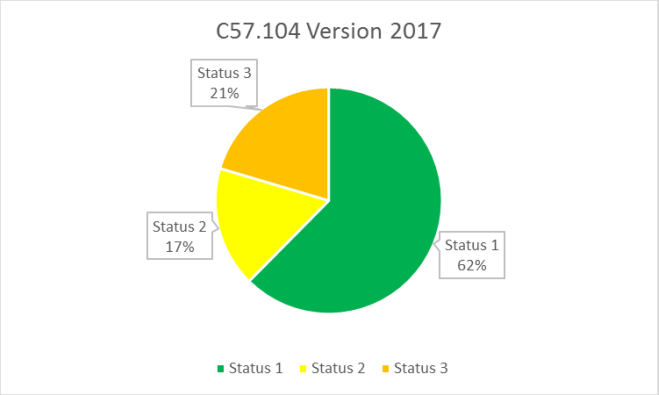
Discussion: High level of status 2 and 3

- "Discussion of high false alarm rates expected from the interpretive method: Reduce or eliminate the reliance on gas concentrations for deriving the status code."
- "This Guide suffers from the same consequences of gas levels as previous guides, Once a gas level associated with Status 3 is reached, that status will potentially be permanent. I am concerned that units with Status 3 reached because of Carbon Oxides alone will remain permanently in that status. I do not see the benefit of this particular circumstance."

Number of DGA marked as "Investigate"

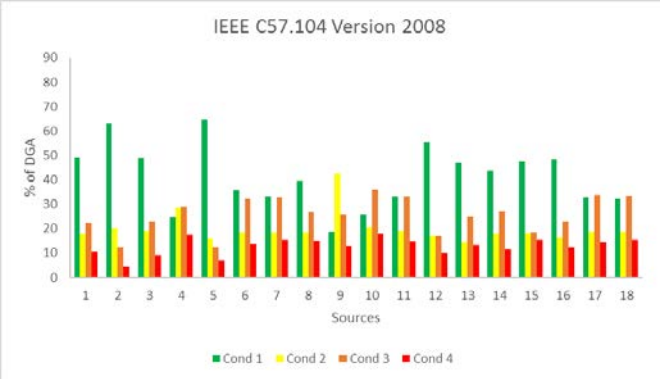


Jim Dukarm – indicated that there was a disclaimer on Table 1 in the 2008 version of C57.104 indicating that the limits applied only to the first sample. Claude indicated that this is correct, but Table 1 of the 2008 version is routinely misapplied and when it is used as it is practically used today by the vast majority of users, it generates the above graph with the studied database..

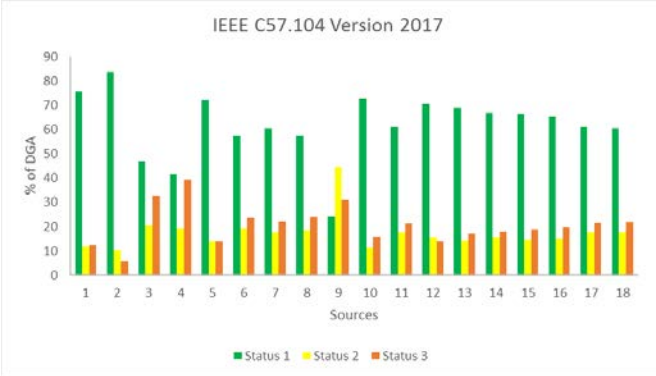


Applying the same data using the new proposed guide will provide the above distribution.

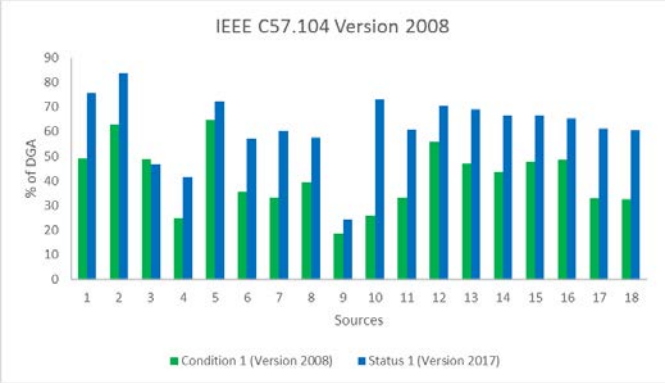
IEEE Version 2008 by Sources



IEEE Version 2017 by Sources



Condition 1 VS Status 1



Number of DGA marked as "Investigate"

- Already improved in regards of the 2008 version:
- Classified as 1 ("Normal"):
    - 41% in 2008 version
    - 62% in 2017 version

- Part of "Future work" suggestion
- Three possible avenues:
    - Reduce the number of gases used in Table 1 & 2
    - Use higher percentiles
    - Develop a combination of indices in the same philosophy as the old TDCG
- Reduce the number of gas used in Table 1 & 2
- Advantage: each gas removed will reduce the number in Status 2 or 3
- Drawback: could reduce the sensibility to some fault types
- Only possible candidate at this stage: CO and CO_2 (To be discussed in a few slides)
- Use higher percentiles
- Advantage: using higher percentile is simple
- Drawback:
    - Higher percentile are more susceptible to variations
    - Decision to use 90-95 taken by vote
    - 90-95 are used by other industries and are generally recognized at valid for this type of work
- Develop combination indices in the same philosophy as the old TDCG
- Advantage: Use of a single indices (agglomeration of several gases in a single value) will produce status 2 and 3 populations of 5% each
- Drawback: Developing such indices will require time and involve additional discussions: No time left!!

The CO & CO2 question

- One practical possibility for future work: Remove CO and CO2 from Table 1 & 2 and keep only in Table 3 (Deltas)

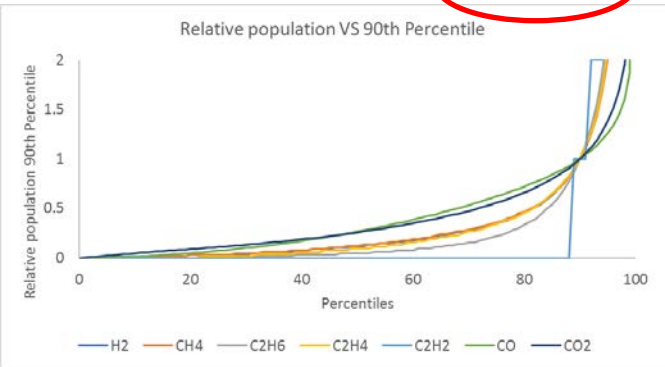
Discussion: High level of status 2 and 3 (as mentioned earlier)

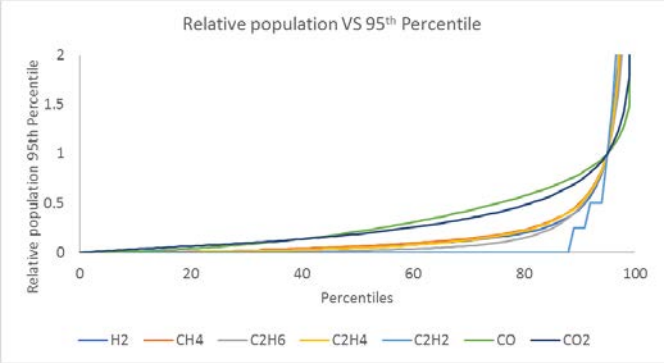
- "This Guide suffers from the same consequences of gas levels as previous guides, Once a gas level associated with Status 3 is reached, that status will potentially be permanent. I am concerned that units with Status 3 reached because of Carbon Oxides alone will remain permanently in that status. I do not see the benefit of this particular circumstance."

The CO & CO2 question

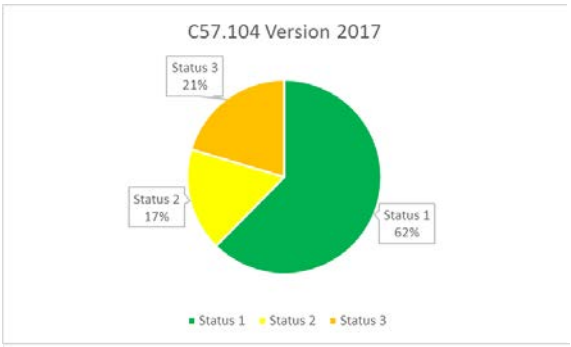
- One practical possibility to reduce the number of DGA in Status 2 and 3: Remove CO and CO2 from Table 1 & 2 and keep only in table 3 (Deltas)
- Rationale:
    - CO and CO_2 also produced by oil aging, not just paper as traditionally believed.
    - CO and CO_2 are produced by natural aging of paper, so level produced by abnormal conditions are easily masked by "natural" background level, reducing effectiveness of these gases to detect anomalies
- Result: population curves is flatter, less discrimination between 90^{th}-95^{th} and the lower percentiles compared to the other gases.

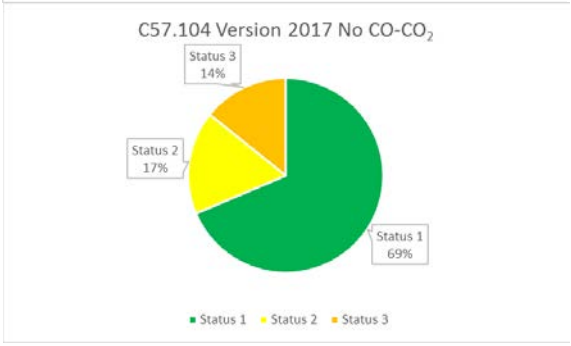
Ratio 95th/90th						
H2	CH4	C2H6	C2H4	C2H2	CO	CO2
2.3	2.0	2.2	2.1	4.0	1.3	1.4





- Rationale: CO2 was not part of initial guide. Added on 1991 without explanation.
- There is no interpretation of CO and CO2 in the main body of the guide, only in the annex.
- Keeping CO and CO2 in table 3 (Delta) still preserve the sensibility to detect sudden changes if a fault producing those two gases occur.
- This approach could increase the number of DGA in status 1 from 62% to 69%
- This approach could decrease the number of DGA in status 3 from 21% to 14%
- This imply that 7% of DGA are classified in Status 3 due to CO and CO_2 only





Discussion

Jim Dukarm made a motion that Table 1 and Table 2 should include a disclaimer that the tables only be used with initial samples and Table 3 should only be used with additional samples.

Discussions on motion by Luis Chiem, Fredi Jakob, Claude Beauchemin and Jim Dukarm. Jim indicated the motion just is that the table is a first cut as to the urgency of what the next step should be.

Claude indicated that this is what was attempted to be done. Rainer Frotscher indicated that he disagreed with the motion and indicated that there is already discussion in the document that covers this. Jim indicated that the raised status is the concern.

The vote of the motion was called. Those in favor: 9, those opposed 21, abstentions 6. Motion failed.

Norm Field made a motion that CO2 be removed from Table 1 and Table 2. Jim Dukarm seconded the motion. The vote was called. Those in favor: 8, Those opposed 18. Motion failed.

Claude indicated that he feels the document is sufficiently complete to go to ballot. Additional work can be done as part of ballot comments. A 2 year PAR extension has been requested, but not yet approved. Brian Sparling made a motion to proceed to ballot and was seconded by Tom Prevost. There were 32 in support of the motion, which met the 2/3 of members present requirement.

Claude indicated that there are still some additional corrections needed from the straw ballot comments, and the meeting, that will be done prior to submittal to ballot.

The meeting was adjourned at 6:01PM

Claude Beauchemin

WG Chair

Don Platts
WG Vice-Chair

Norm Fields
WG Vice-Chair (not present)

Susan McNelly
WG Secretary

Appendix II – TF Insulating Liquid Guides Consolidation Minutes

Chairman Tom Prevost
Secretary Scott Reed

Task Force on Consolidation of Insulating Liquid Guides
Monday, October 30, 2017
9:30 – 10:45 AM
Marriott 5
Louisville, Kentucky

Chairman Tom Prevost
Secretary Scott Reed

The meeting was called to order at 9:41 am by Chair Tom Prevost.

There were 33 of 74 members present. There were 24 guests and 29 visitors. A membership quorum was not achieved.

Agenda

1) Introductions
2) Quorum
3) Approval of agenda
4) Approval of Spring 2017 minutes
5) Call for patents
6) Review of current document status
    a. C57.147 "Guide for Acceptance and Maintenance of Natural Ester Insulating Fluids in Transformers and Other Electrical Equipment"
        i. In Revision process, PC57.147
        ii. Ballot Status
7) New Document:
    a. Title
    b. Scope
    c. Purpose
    d. Status of PAR
8) Presentation and discussion of document format
9) Establishment of Task Forces
    a. Editorial
    b. Test methods
    c. Mineral Oil
    d. High Molecular Weight Hydrocarbons
    e. Silicon
    f. Natural ester
    g. Synthetic Ester
10) New Business

11) Adjourn

Due to the time constraints, attendees did not introduce themselves.

There was unanimous approval of the Agenda.

Chairman Prevost posted the Patent Claim. David Sundin announced a potential claim.

There was a unanimous approval to the Spring 2017 New Orleans meeting minutes.

Chair's Remarks:
Chairman Prevost announced we are applying for a PAR. It has not been approved yet but it will be ready for the Spring 2018 meeting in Pittsburgh. The membership roster will start anew once the Par is approved. Each member will have to apply at the time.

Next, the scope and purpose of the guide were reviewed.

Scope:
This guide provides acceptance and maintenance criteria for insulating liquids used in transformers, tap changers, regulators and reactors.

Purpose:
To assist the user of the equipment in evaluating insulating liquids:

- As received from insulating liquid supplier prior to processing and/or filling into equipment.
- Received in new equipment filled prior to energization.
- In service-aged equipment.

This guide also discusses the following related in insulating liquids:

- Test methods and their significance
- Methods of handling and storage
- Mixtures of insulating liquids
- Re-processing, re-claiming and replacement

This guide does not cover dissolved gas analysis of insulating liquids, which is covered by other IEEE Standard Guides.

Chairman Prevost reviewed the Document Format template and members contributed suggestions.

1. Overview
2. Normative References
3. Definitions
4. Types of Insulating Liquids
5. Oil Tests and their Significance
6. Evaluation of Insulating Liquids
    1. New-As supplied
    2. New- As received.

3. Service-Aged
7. Mixture of Fluids
   1. Retrofilling
8. Sampling
9. Maintenance of Insulating Liquids
   1.Reprocessing
   2. Reclaiming
10. Insulating Liquids for Load Tao Changers
11. Health and Environmental Care
12. Bibliography

There was discussion about test methodology and establishment of Task Forces

No New Business was discussed and the meeting was adjourned at 10:48 am.