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Mail Stop EE-2J
Public Meeting for Distribution Transformers
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RFC: Discussion of DOE Distribution Transformer Energy Efficiency EERE-2010-BT-STD-0048

Dear Brenda and all:

For the last several years, I have led an IEEE Transformers Committee Taskforce to review and comment on DOE Energy Efficiency considerations for Distribution Transformers. This taskforce has more than 100 members, composed of manufacturers, users, and other interested parties. My comments reflect both my own findings and those of the IEEE Taskforce participants to the extent that they have been shared with me.

1. The DOE team has done well to gather so many materials in so short a time period. The chapters are nicely laid out and identified.
2. The Market size is reasonable and I believe accurate for the 2009 period that is in the numbers. It should be able to reflect real impacts of any changes in per unit savings. We may need to think more about probable changes in market size that will occur over the next 30 years of forecast if the economy returns more to traditional robustness.
3. I believe that you have chosen wisely to apply 2010 material costs to the new models. However, it is my belief and that of most manufacturers that you have grossly understated both the finished copper and the aluminum wire and sheet material prices. Other material prices may also be underestimated. As an example, with copper on the Comex at $4.40/lb. most manufacturers are reporting finished copper wire and sheet at more than $6.50/lb. and not at $4,30/lb. as in the DOE assumptions. Aluminum is even more distorted. **I have requested that each manufacturer send their material price lists to the DOE for consolidation and have offered to compile them myself if the manufacturers choose to send them to me for examination**.
4. Finished transformer prices seem to have serious errors. Several transformer makers have attempted to optimize transformer designs using their current material prices and using their minimum markups to transformer selling prices. Both manufacturers report that their CSL 6 selling prices are between 2.5 and 4 times higher than DOE has published. This is a serious deviation and must be better understood. **I believe that the DOE designs should be sent to me for analysis to see if I can find the problems.**
5. With electric vehicles and plug-in hybrids entering the market I must believe that rms equivalent loading will increase but the effective timing may be decades long. At this point in time the 35% rms load for low voltage dry and 50% rms load for medium voltage liquid and dry transformers seems reasonable.

6. Electricity costs are rising largely due to the push toward renewable energy sources and the growing disdain for coal. It is not yet clear whether the EIA estimate is reasonable but I do not have a better estimate. It is desirable to use an accurate estimate because the present worth of the energy cost projection is the basis for the value of a watt saved. If the present worth is very expensive then more energy efficient transformers are justified. In contrast, low cost energy results in a determination for less energy efficient transformers.
7. The total owning cost methodology would seem the best way to derive the new optimums. If TOC is used then a present worth $/no load watt and $/load watt set of values must first be determined.
8. The relationships between single phase and three phases are still quite confusing for many people. The first DOE efficiency publications in the mid 2000's identified higher efficiencies for 3-phase wound core transformers than were real. This was attributed to an error in the 3-phase calculations, in which a 1.3 times the single phase core loss was missing. The first published table and each succeeding table has given the impression that 3-phase transformers could be much more efficient than is now required and that they are getting a free ride. The fact is that single phase low kVA transformers are required to meet half way between TSL 4 and TSL 5. The published table would have the readers believe that 3-phase transformers only have to meet TSL 2. It is not true and three phase transformers are already in effect at the same TSL 4 to TSL 5 the same as single phase. I believe that this was one of the confusions that resulted in the law suit against the DOE by the several Green Groups. It likely would not have occurred if this point was clarified. **I believe that the DOE should explain the 3-phase error that exists in the 2007 publication and show that the 2010 rule is between TSL 4 and TSL 5 for both single and three phase liquid filled transformers.**
9. I applaud your relooking the relationships between liquid filled transformers and dry type transformers and believe that TOC methods are easily able to sort out the natural relationships between the two. Through TOC, watts loss has a distinct value and material is added until cost exceeds value of reduced losses.
10. I commend your work in recognizing that high temperature liquid filled transformer insulation systems are quite similar in space factor to mineral oil systems and should have quite similar losses.
11. I believe that it is good to bring low voltage dry transformers into consideration at this time to get a fresh look at all distribution transformers simultaneously.
12. You have done very well to allow low voltages for single phase pole type transformers to be tested only on the series connection. About 99% of them are used that way and the work to reconnect is extensive and punishing to the rest of the fleet.
13. Pole type and pad mounted transformers with series multiple high voltages should be treated like the low voltages. Series multiple transformers are designed to operate at two unique primary voltages, like 2400 volts and 7620 volts. Unless the series connection is an integer ratio of the parallel connection, there will be unused turns in the parallel connection which fundamentally renders the parallel connection to be less efficient than the series connection. Utilities that purchase such transformers always do so because they plan to upgrade a distribution circuit to higher voltages. The changeover is within a couple of years and more than 90% of the transformer's life on the system will be in the series connection. Load is likely to grow some with time and the series connection will see the load increases. The IEEE Taskforce does not see any significant value in forcing the parallel connection to also meet the efficiency.
14. Transformers with de-energized or de-activated cores is a very thought-provoking understudy that I have wrestled with many times in my career. The curiosity got to me enough that I made up an EXCEL spreadsheet to analyze. In my analysis, I used the DOE assumptions of the following:
    a. 75 kVA as a total load and (3) 25 kVA's singly, doubly or all 3 connected in parallel to supply the load.
    b. Loadings of 0%, 15%, 35%, 50%, and 75 %.

c. Low Voltage Dry Type transformers, each designed to be tested at 35% load as sold.

Using these assumptions the following table was my resulting losses:

75 KVA load analys comparison for losses of (1) 75 kVA vs. combinations of 25 kVA's					
% Load	% Time	(1) 75 kVA total	1-25 kVA total	2-25 kVA total	3-25 kVA total
0	31	133	58	115	173
15	22	162	174	174	212
35	20	295	693	433	385
50	18	464	1354	764	605
76	9	878	2975	1574	1145

For this analysis, only the unloaded single 25 kVA transformer had lower losses than the single 75 kVA transformer. With considerations of impedance, regulation, economics for switching devices, and total reliability, the deactivated core approach looks like a stretch.

15. Symmetrical 3-phase core transformers are not practical for much of the market.
    a. Utility transformers are nearly all grounded Y-grounded Y.
    b. Industrial medium voltage transformers start at around 300 kVA and go to very large units.
    c. Wound cores in the skew as shown in the analysis are difficult to produce and difficult to fabricate in large units.
    d. If done for low voltage dry applications, the wound cores must be potted to keep them from buzzing.
16. Overall comments-Design. I have been a designer of distribution transformers for the United States since 1966 and have worked as a writer of NEMA, IEEE, ANSI and other industry standards since 1972. It has always been a practice to make US standards that describe form, fit, and function. The voluntary consensus standards have avoided design-specific standards. This is particularly important for the health of the industry and applies to materials, configurations, and manufacturing methods. When standards are design specific, many manufacturers are disadvantaged for capricious reasons and the country suffers.
17. Overall comments-Energy Efficiency. Energy efficiency is important only to the extent that it can be reached affordably, with do-able technology, and with multiple sources of supply. US energy efficiency should never be driven to the point that only one set of materials and one design configuration can ever reach it. It is my opinion that the 2010 rule largely hit the limits for all product lines. The April 5 public meeting of DOE had presenters who believed that significantly higher energy efficiency appeared justified. However, once the errors in the DOE material prices and transformer selling prices are corrected, the IEEE Taskforce believes that this illusion will vanish.

Please let me know how I can be of further assistance,

Philip J Hopkinson

Philip J Hopkinson, PE
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