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Ms. Brenda Edwards-Jones
U.S. Department of Energy
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Mailstop EE-2J
ANOPR for Distribution Transformers
EE-RM/STD-00-550
1000 Independence Ave. SW
Washington, DC 20585-0121

Re: HVolt Inc Statement on DOE ANOPR for Distribution Transformer Energy Conservation Standards from the meeting in Washington on September 27, 2006, including current issues.

Dear Ms. Edwards-Jones

HVolt Inc is a Power and Distribution Transformer Consulting firm, located in Charlotte, NC. HVOLT President, Phil Hopkinson is a long service transformer engineer with lengthy experience at three of the major manufacturers of Distribution Transformers in our country and with consulting experience at most of the US manufacturers. To date, HVOLT has submitted comments through NEMA (National Electrical Manufacturers Association). However, with recent changes in materials availability and other key issues, many small manufacturers as well as several large manufacturers and NEMA have requested that I submit additional comments directly to your office for consideration. I am a strong believer in Energy Efficiency Standards and support efforts to produce comprehensive standards that will strengthen the US economy and move toward energy independence. At NEMA, I chaired the task force to write NEMA TP-1 in both the first edition of 1996 and in the revision of 2002. At IEEE I have chaired the Power Engineering Societies Policy Development Coordinating Committee and have been a co-author of the IEEE PES Policy Statement on Energy and the Environment that was recently approved by the PES Board of Governors. I am an IEEE Fellow, a Registered Professional Engineer in the State of North Carolina and Technical Advisor (TA) to the US National Committee for IEC TC 14 Power Transformers.

At the September 27, 2006 DOE meeting, several issues were raised that may need additional explanation. Issues that were thoroughly discussed at the meeting, and agreed to by the DOE, will not be repeated here. In this write-up, I deal with significant new issues or those that need added explanation. I hope that the following comments may prove useful:

A The NEMA membership has submitted a strong endorsement for the DOE to select NEMA TP-1 as the National standard for Medium Voltage Transformers. Materials availability, impacts on small manufacturers, and the need for greater losses variance tolerance make this a particularly relevant stance. I fully support this position and find that it meets some important DOE principles:

1. **Doable with known materials and methods by small and large manufacturers**
2. **Pays for itself, originally with a 3-5 year payback period and currently with a 4-7 year payback attributable to higher present material costs translating to higher transformer selling prices with steady energy costs.**
3. **Results in Real Energy Savings.**

These were the initial principles used to choose the efficiency tables for all classes of Distribution Transformers. In arriving at the NEMA tables, large and small manufacturers ran designs for each of the key power ratings with loss evaluation formulas that were based on a 3-year payback for the conditions of:

1. $0.065/kwh energy cost, translating to $0.50/wat/yr. value of losses or $1.50/watt. Of present worth over 3 years.

2. 50% rms equivalent loading for all Medium Voltage Transformers and 35% rms equivalent loading for Low Voltage Dry Type Transformers.
3. 15 kV voltage class at 95 kV BIL.
4. 55C reference temperature for Liquid and 75C for Dry Transformers.

Each of the participating manufacturers attempted to meet the same efficiency for 35 kV Class at 150 kV BIL. Each participant complied and sent in data. It turned out that the small manufacturers were just able to reach the chosen efficiencies at all BIL levels with conventional materials and methods. The large manufacturers were able to comfortably meet the levels. Our objective was to make meaningful standards that all could meet and that would preserve the goals of do-ability, affordability and definite energy savings without running anyone out of business. We recognized that not everyone would have the same cost profile but all could continue to participate. As we look at the current materials issues, we find that some manufacturers can just barely reach TP-1 performance at the higher BIL's and even the more popular ratings show paybacks reaching 7 years. Transformer Standard Level 2 (TSL2) and higher is unreachable by some manufacturers. NEMA TP-1 still seems to be the correct efficiency standard.

B. The small manufacturer

1. Small manufacturers are generally considered to be those with annual sales volumes of less than $20 million. There are many of these manufacturers throughout the country and they tend to serve the niche markets, build to order specials, and some OEM equipment. Most of their stand-alone transformers of 10-2500 kVA are considered Distribution Transformers and must comply with the energy efficiencies that will be established by the DOE.
2. Most small manufacturers, both liquid filled and dry, use stacked core transformers or toroidal wound core transformers and can not make distributed gap wound cores. For the occasions that they need distributed gap wound cores, they buy them from places like Magmetals in California or the equivalent at a cost premium.
3. Many small manufacturers can't make miter cores either. They can only do straight cutoffs. If miter cores are needed, they buy them today from specialty houses like that of Chuck Erhard in Monroe, North Carolina. However, such out-sourcing is quite expensive and is not doable for all of their production. In addition to cost, the special dimensions needed for high efficiency make lead times too long to be practical. We made TP-1 a design that could be reached with but-lap cutoff cores. Clearly the higher performing miter cores and distributed gap wound cores could do the design with either higher efficiency or lower material costs but all could participate. Also clear is that the large manufacturers had much greater investment in equipment in order to reach the sophistication of distributed gap wound cores or of step-lap mitered cores.
4. Wire size and strip size standardization is a major concern for small manufacturers. There are minimum quantity order sizes (usually 500 lbs), and discounts that come from higher weights of a material. There is also the stocking consideration. When one has hundreds of wire sizes and strip sizes in inventory, the carrying cost is immense and some sizes rarely get reused. The result is that the small manufacturer must standardize and compromise designs on efficiency.
5. Certain materials are becoming very difficult to source. At the September 27 meeting in Washington, DC, we talked about core steel, which is a continuing issue for availability. Interestingly, however, is that aluminum is now being diverted for the high voltage transmission line market and is being rationed to transformer makers. The small guys don't have much clout and are being squeezed. Even the larger manufacturers are now having to convert many of their designs in the 10-50 kVA rating range to 100% copper wire for both the high voltage and low voltages. Small manufacturers are at a clear disadvantage.

C. Concern about High Material Costs and Material Availability:

Material prices for conductors and core iron today are approximately twice the cost per unit weight as they were when TP-1 was updated in 2002. These critical materials show no signs of abating as world demand for electrical components continues to stress the commodity markets. This is a very important factor in the determination of the correct efficiency. Two medium size NEMA-represented transformer manufacturers have rerun several of the critical designs to re-establish the projected pay-back periods that result from just meeting NEMA TP-1. Interestingly, instead of finding a 3-yr. payback at present market prices, their calculated payback periods now project to 7 years! This number is determined by the change in selling price to meet TP-1 (above that for the non-evaluated transformer) divided by the energy savings per year. The deterioration in value of TP-1 compliant transformers has occurred because high material costs must be passed on to the end customer for transformer manufacturers to remain in business. This is a critical concern which I believe needs to be recognized in the US Energy Standard.

Perhaps more distressing is that the magnetic core steel companies are allocating both total pounds of steel as well as M3 and higher performing core steels on a percentage basis to the previous year's consumption. Much of the transformer production has to be sourced on the spot market at higher prices and built with M6. This is especially true for smaller manufacturers. The result is that designs must be modified with increased size and weight, and in some cases run to the limit to just meet the efficiency of TP-1. TSL2 and higher standards may not be reachable for some of the transformers that will need to be built in the future! Material costs will apparently continue to see upward pressure for the foreseeable future under this scenario.

D. Major Concern with Candidate Level 2 and Higher Standards

The small manufacturers can just reach NEMA TP-1 efficiency tables for the highest BIL's. TSL2 and higher standards are problems that will limit their participation and may ultimately drive them out of business.

E. Concern for Losses Tolerance Band: 12% Needed

Presently, the Testing standard recognizes an 8% loss tolerance for a single unit on test. This tolerance is consistent with IEEE C57.12.00, which allows 10% on no-load loss and 6% on total losses at full load, and which computes to 8% at 50% load. However, the standard deviation for total losses is 4% for most manufacturers. A manufacturer needs 3 standard deviations of tolerance in order to ship 99% of production without rework. In existing market conditions, some manufacturers design losses to be 4% lower than guarantees so that they may meet the tolerance cutoff window. Other manufacturers in the present market design right up to the guarantee and then reimburse their customers for transformers that miss the normal cutoff in accordance with the customer's owning cost formula. Under the DOE limits, an efficiency table will be published, and the manufacturers will have only an 8% loss tolerance beyond the table. The only way for manufacturers to consistently meet such a table will be for them to design losses to be 4% (one standard deviation) lower than that allowed by the efficiency table. The impact of this is that transformers with a published TP-1 efficiency table will actually be designed to be slightly more efficient than the table of TSL2.

For example, the 25 kVA rating is the most popular single phase Pole Type Transformer built today. The NEMA TP-1 table shows a minimum efficiency of 98.7% and the DOE level 2 efficiency is listed at 98.73%. If we translate 98.7% efficiency into efficiency loss watts, the calculation is as follows:

Efficiency loss watts = kVA/2*1000*(100/(efficiency)-1) (1)

Here for kVA, we substitute 25, and for efficiency we substitute 98.7 for meeting TP-1 (2)

Hence, NEMA TP-1 for 25 kVA single phase transformers, the efficiency loss watts is 164.6 (3)

If the nominal design is set 4% lower in losses, then it would have
New losses = 0.96 * 164.6 watts or 158.0 watts (4)

Now with a nominal design setting of 158.0 watts, the effective efficiency would be as follows:

Effective efficiency =100* kVA/2*1000/(kVA/2*1000 + design watts at half load) (5)

Now for the 25 kVA with 158.0 watts the Effective efficiency is as follows:

Effective efficiency = 100*25/2*1000/(25/2*1000 + 158.0) = 98.75% (6)

This is higher efficiency than would be required to meet the proposed DOE TSL2 efficiency of 98.73%. Hence, the DOE is encouraged to recognize the 4% design burden that manufacturers must bear to meet published efficiency tables while complying with the 8% test tolerance. This recognition could be accomplished by setting the efficiency tables lower. My recommendation would be to publish a NEMA TP-1 table and recognize savings from 4% lower watts, i.e. from design level 2. However, a second alternative would be to publish TSL2 and change the loss tolerance from 8% to 12%. Either approach would effectively accommodate level TSL2 efficiency performance but recognize the watts improvement that will occur from meeting published tables.

F. Concern for Rebuilt transformers that do not need to meet the efficiency

At the September 27th meeting, we discussed Refurbished transformers and noted that they make up about 20% of the population of Distribution Transformer installations each year on the US Utility System. Refurbishment occurs when existing transformers are cleaned up, repaired, repainted, electrically retested, and subsequently reinstalled. Refurbishers consist of Electric utilities repair shops and independent operations. Common reasons for transformers being candidates for refurbishment are voltage upgrades, damage, electrical faults, load-growth in an area, high voltage regulation or excessive rust. Often times a refurbishment requires replacement of the electrical winding but reuses the magnetic core. A surprising statistic about the US fleet is that some transformers are more than 50 years old. By imposing a requirement that refurbished transformers meet the new tables, higher efficiency electrical systems will occur more quickly. A more vibrant new transformer industry is also likely to occur as well as long as the standards are reachable. I recommend that the DOE look closely at refurbished transformers with the possibility of requiring them to meet the new efficiency tables. A fall-back position might be to impose the new efficiencies only on transformers with new electrical windings.

G. Concern for policing program:

It is my understanding that the enforcement for meeting Distribution Transformer Energy Efficiency will be based on whistleblowers in the industry. Under that arrangement, manufacturers will be expected to monitor their competitors and notify the DOE when noncompliance is detected. One issue with this approach is that it takes a significant departure from the requirement to be definitely noticed. Small departures may be attributed to inaccurate testing. Many whistleblowers are hesitant to get involved for fear of repercussions.

One big concern is inexpensive imports that may be difficult to police. People who purchase such transformers may not be overly anxious to report violations or to cooperate with those who would.

The most favorable way to solve each of the policing concerns is for the DOE to periodically collect recertification from the producers of distribution transformers.

H. Concern for Ability to upsell for higher profitability

One subtle area of concern, but still a valuable one is for the larger manufacturers to be able to upsell transformers at higher prices for higher efficiencies. One benefit in doing so is that higher efficiency products get into the market. A second one is that the industry is less of a commodity and less of a target for low cost foreign manufacturers to penetrate the US and destroy the local manufacturing market. It should be noted that this is not an entity that small manufacturers can participate in because they generally

do not have the ability to produce higher efficiency transformers than TP-1. It is difficult to score-keep the market to accurately count the participants. However, my review of 2006 for several large manufacturers suggests that perhaps 20% of the market has now returned to loss evaluations of $3.00/watt as was generally popular during the early 1990's before the experiments with Electric Utility Deregulation. For such market segments, Efficiency Candidate Level 4 is able to be produced and sold profitably. This is an important concept, which should be encouraged but not mandated.

I. Mining Transformers should be exempted

Mining transformers were extensively discussed at the September 27 meeting in Washington. When NEMA TP-1 was being written, we missed mining transformers as an exclusion category.

J. Zero Load Growth:
Most Distribution Transformers are installed with a load that is as high as it will get. Residential transformers are installed with a cluster of houses that they serve. The big loads are heating, cooling, water heating, cooking, laundry, dish-washing, and to a lesser degree lighting. Within a short period of a transformer installation, loading reaches steady-state. Without electric automobiles, there does not appear to be any load that will produce growth. Commercial and Industrial transformers see similar load patterns. Such transformers are installed for a specific need. New facility additions result in new transformers. A zero-load growth assumption is the most likely one based on the current environment.

One can speculate that plug-in rechargeable automobiles will be common over the next 20 years. If this were to happen, then rms equivalent load would rise and likely make the optimal reference loading points for efficiency compliance move higher. However, should that occur, then I recommend that the DOE revisit efficiency regulations and use real information for a revised Distribution Transformer Energy Efficiency Ruling.

K. Energy Costs foreseen as mostly stable: NEMA TP-1 was assembled with an assumption of present worth energy costs at $0.065/ kWH. For Industrial and Commercial applications, this assumption has been correct and continues to be so today. Electric Utilities have lower costs today when generating with coal and nuclear. New Utility investment plans include more than 100 new coal generators and several new nuclear plants. Each new plant has stated objective costs of $0.04-$0.06/ kWH. The NEMA TP-1 assumption of $0.065/ kWH appears to still be appropriate.

Environmental considerations for new clean coal generating plants may place upward pressure on the cost assumption sometime in the future. However, this would be better addressed in a revision to the DOE Distribution Transformer Energy Efficiency Rules. IEEE applies a 5-yr. review philosophy for transformer standards. This may be an appropriate consideration for the DOE Distribution Transformer Efficiency Tables as well.

L. Conclusions and Recommendations

1. The US Distribution Transformer Industry is fragile and has many small manufacturers of liquid filled and dry type transformers that should be encouraged to continue serving our Nation.
2. Energy Efficiency is extremely important to the National interests and needs to be encouraged.
3. NEMA TP-1 efficiencies were well thought through when they were first introduced to the country in 1996 and have been well accepted by manufacturers and customers. It is my belief as well as that of the National Electrical Manufacturers Association that NEMA TP-1 is still the correct level of efficiency because of material availabilities and other issues discussed above for a National Standard and serves all stakeholders well.
4. Mandated efficiency levels greater than NEMA TP-1 may be unreachable by many manufacturers and may reduce the number of manufacturers in the industry.
5. Refurbished Distribution Transformers should be reexamined for possible inclusion in the standard to maximize energy savings.
6. The DOE should consider periodic auditing of manufacturer's efficiency levels to be certain that the industry continues to comply with published requirements.

7. Mining transformers should be exempted from meeting the efficiency requirements.
8. A zero-load growth assumption still appears to be most representative of the existing market place.
9. Energy costs have been stable for many years and appear to be so in the foreseeable future.

M. Discussion

All names of individual manufacturers have been excluded from this report to protect their competitive interests. However, I believe that the statements in this report are timely and accurate. This report is being circulated to NEMA and many of the stakeholders for their edification. Some of the manufacturers may wish to expand on areas raised here-in. They are free to use or reuse any or all parts of this report as they find useful.

Hopefully, the issues are clearly defined to help you with your considerations. Please let me know where additional information may be needed.

Very truly yours,

Philip J Hopkinson, PE
President & CEO HVolt Inc