

# DOE Regulation Changes Energy Conservation Program for Commercial Equipment Distribution Transformers

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With more and more emphasis being placed on energy conservation from for political, economic, and environmental reasons, it is incumbent on the design professional to be informed of the changes in codes, standards, and regulations/laws that will impact the recommendations and application of products they specify on projects.

Initially, energy conservation policies were directed at major household appliances. However, those policies were soon expanded to cover certain industrial equipment, and then once again to add certain commercial equipment into the scope, including distribution transformers.

Most of the electricity that powers the residential, commercial and industrial sectors is stepped-down in voltage by distribution transformers. These transformers are relatively efficient; most convert in excess of 95 percent of input power to output power. However, because most transformers are energized 24 hours per day, 365 days per year, even small improvements in efficiency can yield big energy and cost savings for users. This article will address the proposed changes in the regulations/laws implemented by the federal government, specifically the **D**epartment **o**f **E**nergy (DOE), Office of **E**nergy **E**fficiency and **R**enewable **E**nergy (EERE), as it pertains to energy conservation and the correlation to efficiency associated with distribution transformers.

## **Definitions**

For the purposes of this article, the author utilized the **E**nergy **P**olicy **A**ct of 2005 (EPACT 2005), Public Law 109-58, dated August 8, 2005, as the basis for defining the term low-voltage, dry-type distribution transformer and distribution transformer respectively as noted below.

### Low-Voltage, dry-type transformer;

- (A) has an input voltage of 600 volts or less;
- (B) is air-cooled; and
- (C) does not use oil as a coolant.

### Distribution transformer;

- (i) has an input voltage of 34.5 kilovolts or less;
  - (ii) has an output voltage of 600 volts or less; and
  - (iii) is rated for operation at a frequency of 60 Hertz.
- (B) The term 'distribution transformer' does not include—
- (i) a transformer with multiple voltage taps, the highest of which equals at least 20 percent more than the lowest;
  - (ii) a transformer that is designed to be used in a special purpose application and is unlikely to be used in general purpose applications, such as a drive transformer, rectifier transformer, auto-transformer, Uninterruptible Power Supply transformer\*, impedance transformer, regulating transformer, sealed and non-ventilating transformer, machine tool transformer, welding transformer, grounding transformer, or testing transformer; or

\*Definition amended in Final Rule Section 431-192.

- (iii) any transformer not listed in clause (ii) that is excluded by the Secretary by rule because—
- (I) the transformer is designed for a special application;
  - (II) the transformer is unlikely to be used in general purpose applications; and
  - (III) the application of standards to the transformer would not result in significant energy savings.

The following formula defines the efficiency of a distribution transformer as referenced by the DOE in their ruling:

Efficiency = Power OUT/Power IN

$$\%EFF = \frac{100 \times kVA \times 0.5}{kVA \times 0.5 + ((NL + LL \times 0.91 \times 0.5^2)/1000)}$$

Where:

%EFF = Efficiency means the ratio of the useful power to the total power input; for DOE Rule it is calculated at 50% Load

kVA = Transformer Capacity in kilo-volt Amperes

NL = No Load (Core) Losses corrected to 20°C

LL = Load Losses corrected to 85°C

0.091 = Load Loss Temperature correction from 85°C to 55°C

### **History of Efficiency Rulemaking**

The rulemaking process for distribution transformers can be traced back to the **Energy Policy and Conservation Act (EPCA) of 1975, which was initially enacted to establish an energy conservation program for major household appliances. This initial act was amended in the EPCA of 1978 to add Part C of Title III, which established an energy conservation program for certain industrial equipment. Then the EPCA was amended again in the EPCA of 1992 to add certain commercial equipment, including distribution transformers.**

In addition to the EPCA, amended as noted above, the **National Electrical Manufacturers Association (NEMA), issued an efficiency standard, “Guide for Determining Energy Efficiency for Distribution Transformers”, in 1996 for low voltage distribution transformers known as NEMA TP 1-1996. This standard was amended in 2002 as NEMA TP 1-2002. The TP 1 standard was developed in coordination with the U.S. **Environmental Protection Agency (EPA). It sets minimum efficiency levels for low-voltage distribution transformers, which were also incorporated by the EPA into their ENERGY STAR program. NEMA also published two other standards, TP 2-1998 “Standard Test Method for Measuring the Energy Consumption of Distribution Transformers”, which was revised in 2005 as TP 2-2005 to address concerns by the DOE so as to be acceptable and adopted as the DOE test standard, and TP 3-2000 “Standard for the Labeling of Distribution Transformer Efficiency”, which comprise an integrated package of requirements for all distribution transformers.****

The **Energy Policy Act of 2005 (EPACT 2005), Public Law 109-58, amended the latest EPCA on August 8, 2005 to establish energy conservation standards for low-voltage, dry-type distribution transformers. The DOE amended the Code of Federal Regulations, 10 CFR Part 430 and 431, to include the actions prescribed in EPACT 2005. This required that low-voltage dry-type transformers manufactured on or before January 1, 2007 shall meet the efficiency levels specified in the Final Rule 10 CFR Part 431 (see Table II.1 below), which are identical to**

Table 4-2 (attached below) of the “Guide for Determining Energy Efficiency for Distribution Transformers” published by the National Electrical Manufacturers Association (NEMA TP 1-2002) referenced above.

TABLE II.1.—ENERGY CONSERVATION STANDARDS FOR LOW-VOLTAGE, DRY-TYPE DISTRIBUTION TRANSFORMERS

Single-phase		Three-phase	
kVA	Efficiency (%)	kVA	Efficiency (%)
15	97.7	15	97.0
25	98.0	30	97.5
37.5	98.2	45	97.7
50	98.3	75	98.0
75	98.5	112.5	98.2
100	98.6	150	98.3
167	98.7	225	98.5
250	98.8	300	98.6
333	98.9	500	98.7
		750	98.8
		1000	98.9

Note: All efficiency values are at 35 percent of nameplate-rated load, determined according to the DOE test procedure. 10 CFR Part 431, Subpart K, Appendix A.

**Table 4-2**  
**NEMA CLASS I EFFICIENCY LEVELS FOR DRY-TYPE DISTRIBUTION TRANSFORMERS**

Reference Condition		Temperature		% of Nameplate Load					
Low Voltage		75°C		35%					
Medium Voltage		75°C		50%					
Single Phase Efficiency				Three Phase Efficiency					
kVA	Low Voltage		Medium Voltage		kVA	Low Voltage		Medium Voltage	
			≤60 kV BIL	>60 kV BIL				≤60 kV BIL	>60 kV BIL
15	97.7	97.6	97.6	15	97.0	96.8	96.8		
25	98.0	97.9	97.9	30	97.5	97.3	97.3		
37.5	98.2	98.1	98.1	45	97.7	97.6	97.6		
50	98.3	98.2	98.2	75	98.0	97.9	97.9		
75	98.5	98.4	98.4	112.5	98.2	98.1	98.1		
100	98.6	98.5	98.5	150	98.3	98.2	98.2		
167	98.7	98.8	98.7	225	98.5	98.4	98.4		
250	98.8	98.9	98.8	300	98.6	98.6	98.5		
333	98.9	99.0	98.9	500	98.7	98.8	98.7		
500	—	99.1	99.0	750	98.8	98.9	98.8		
667	—	99.2	99.0	1000	98.9	99.0	98.9		
833	—	99.2	99.1	1500	—	99.1	99.0		
				2000	—	99.2	99.0		
				2500	—	99.2	99.1		

**Final Rule/Code of Federal Regulation**

In the Final Rule for Distribution Transformer Efficiency (FR 10 CFR Part 431), the EPCA was amended again to include liquid-immersed and medium voltage dry-type distribution transformers. This required that all liquid-immersed and medium-voltage dry type transformers manufactured on or after January 1, 2010 for use in the domestic USA, it’s territories, and/or possessions shall meet the efficiency levels specified in the Final Rule 10 CFR Part 431 (see Tables I.1 and I.2 below). The exclusions to this Final Rule are as follows:

- Special application Underground Mining distribution transformers

- UPS Transformers
- Very large KVA DT's (e.g., 3000 kVA - above 2500 kVA)
- Used and repaired transformers
- DT's manufactured in US but shipped to non-US customers (export markets)
- DT's manufactured before 1/1/2010 in distributor inventories

TABLE I.1.—STANDARD LEVELS FOR LIQUID-IMMERSED DISTRIBUTION TRANSFORMERS, TABULAR FORM

Single-phase		Three-phase	
kVA	Efficiency (%)	kVA	Efficiency (%)
10	98.62	15	98.36
15	98.76	30	98.62
25	98.91	45	98.76
37.5	99.01	75	98.91
50	99.08	112.5	99.01
75	99.17	150	99.08
100	99.23	225	99.17
167	99.25	300	99.23
250	99.32	500	99.25
333	99.36	750	99.32
500	99.42	1000	99.36
667	99.46	1500	99.42
833	99.49	2000	99.46
		2500	99.49

Note: All efficiency values are at 50 percent of nameplate-rated load, determined according to the DOE test procedure. 10 CFR Part 431, Subpart K, Appendix A.

TABLE I.2.—STANDARD LEVELS FOR MEDIUM-VOLTAGE, DRY-TYPE DISTRIBUTION TRANSFORMERS, TABULAR FORM

Single-phase				Three-phase			
BIL kVA	20–45 kV efficiency (%)	46–95 kV efficiency (%)	≥96 kV efficiency (%)	BIL kVA	20–45 kV efficiency (%)	46–95 kV efficiency (%)	≥96 kV efficiency (%)
15	98.10	97.86		15	97.50	97.18	
25	98.33	98.12		30	97.90	97.63	
37.5	98.49	98.30		45	98.10	97.86	
50	98.60	98.42		75	98.33	98.12	
75	98.73	98.57	98.53	112.5	98.49	98.30	
100	98.82	98.67	98.63	150	98.60	98.42	
167	98.96	98.83	98.80	225	98.73	98.57	98.53
250	99.07	98.95	98.91	300	98.82	98.67	98.63
333	99.14	99.03	98.99	500	98.96	98.83	98.80
500	99.22	99.12	99.09	750	99.07	98.95	98.91
667	99.27	99.18	99.15	1000	99.14	99.03	98.99
833	99.31	99.23	99.20	1500	99.22	99.12	99.09
				2000	99.27	99.18	99.15
				2500	99.31	99.23	99.20

<sup>1</sup>kVA is an abbreviation for kilovolt-ampere, which is a capacity metric used by industry to

classify transformers. A transformer's kVA rating

represents its output power when it is fully loaded (i.e., 100%).

Note: BIL means basic impulse insulation level.

Note: All efficiency values are at 50 percent of nameplate-rated load, determined according to the DOE test procedure. 10 CFR Part 431, Subpart K, Appendix A.

### Potential Upcoming Changes in Energy Conservation/Transformer Efficiencies

In recent years there has been a drive by organizations to propose higher efficiencies for distribution transformers for commercial building projects, especially K-12 school buildings. There seems to be some mixed messages and concerns about higher energy efficient transformers and their viability for commercial building projects with respect to initial cost and payback period (Return on Investment/ROI).

The American Society of Heating, Refrigeration, and Air-conditioning Engineers' (ASHRAE) current design guide for K-12 school buildings recommends specifying transformers that are 30% more efficient than the TP 1 units adopted by the U.S DOE for the Energy Policy Act of 2005. The DOE classifies a transformer having this higher efficiency rating as Candidate Standard Level 3 (CSL3). According to DOE officials, CSL3 is not a recognized efficiency standard but an intermediate efficiency level used during the rulemaking process. Moreover, the energy conservation requirements for distribution transformers are set forth in the Code of Federal Regulations as noted above.

However, these devices would reduce even further a transformer's core loss (or no-load related energy loss from its core's magnetic field) and coil loss (or resistive energy loss due to current flow). But even with the 30% increase in efficiency, the resulting total gain in transformer efficiency is approximately 0.6-0.8% over the TP 1 minimum standards. The cost to produce this product is a multiple of 2-3 times a standard TP 1 unit. Throw in K-Factor ratings and the payback period for these transformers installed in a building having a life expectancy of 33-50 years is in the order of magnitude of 12-16 years (approximately one half to one third the life of the building).

However, with the focus on Green Building, obtaining LEED certification/points, and the effort of the industry and administration to reach a Zero-Energy building, the potential for this to come before the DOE for consideration is likely.

Ultimately the design professional should weigh all factors and present the alternates to the owner for consideration.

### **Summary**

The anticipated result of these standards/regulations/policies that have been enacted is that it will provide significant energy conservation benefits to the Nation. The DOE estimates that the standards/regulations referenced in this article will save approximately 2.74 quads (quadrillion (10<sup>15</sup>) British thermal units (BTU)) of energy over 29 years (2010–2038). This is equivalent to all of the energy consumed by 27 million American households in a single year. By 2038, the DOE expects the energy savings from the standards to eliminate the need for approximately six new 400-megawatt combined-cycle gas turbine power plants. The total energy savings from the standard will result in cumulative greenhouse gas emission reductions of approximately 238 million tons (Mt) of carbon dioxide (CO<sub>2</sub>) from a variety of generation sources. This is an amount equal to what would be saved by removing 80 percent of all light vehicles from U.S. roads for one year.

The impact of the results noted above is one of the most important factors for the design professional to keep abreast of new technologies that are mandated by the adoption of new codes, standards, and passage of legislation. The above article is just one example of a product group that is evolving due to policy directives. As legislation drives improvements from a technology standpoint with respect to energy and environmental concerns, the GE Specification Team is keeping abreast of these industry changes and stands ready to assist the design professional with technical support, industry updates, and/or suggested language for your specifications.

### **References**

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