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Preparing for the new DOE 2016 Transformer Efficiency Law

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POWER FOR THE FUTURE

ISO 14001

ISO 9001

ISO 17025

Established 1996

POWERSMITHS

Transformers

Why is DOE legislating Transformer Efficiency ?

Based on Dept. Of Energy Study

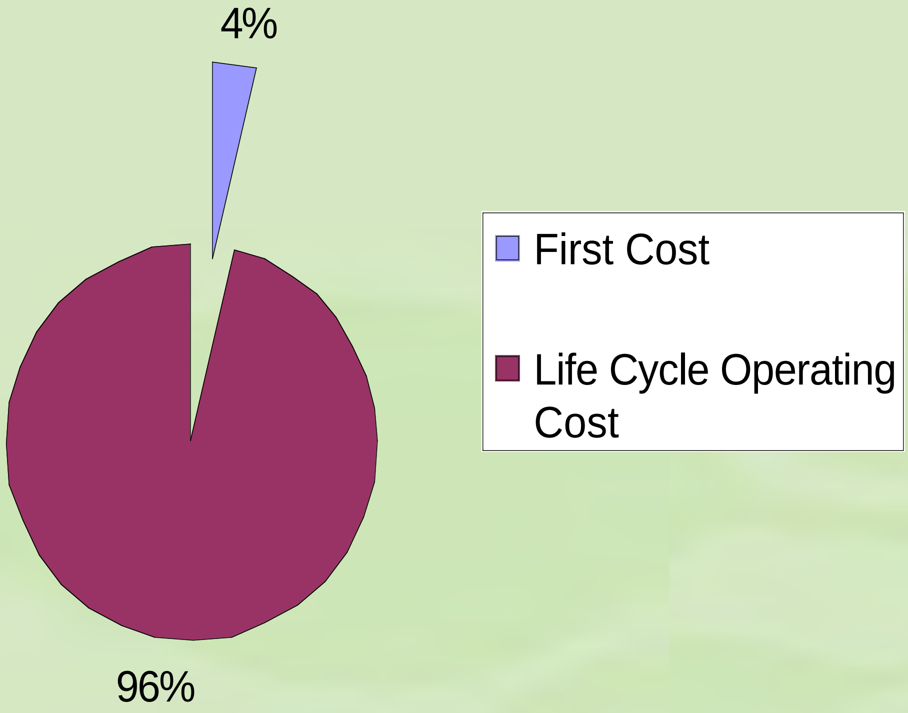
- ~ 11 million dry-type transformers
- Economic & Grid Impact
  - 60-80 Billion kWh losses
  - 9 days generating capacity
  - Annual Cost $3-4 Billion/year
- Environmental Impact
  - Requires burning 145 Million tons of coal
  - Resulting in CO2, Acid Rain, Smog

Losses and Pollution embedded for 30 + years


CTRICAL ROOM
DANGER
You Never Know
What Happens
Behind Closed Doors.
e-SAVER
The E-SAVER™ reduces energy losses up
to 60% or more and is manufactured
with the lowest environmental
impact. (ISO 14001)

Lowest First Cost predominates market embedding energy tax for 30+ years

Energy Operating Cost
Can reach
20-30 times
the purchase price
over installed life



Why does it happen ?:

– Low Bid encourages cheapest first cost -> least efficient
– Small part of package, “invisible”
– Buyer is not one who pays for energy bill, …

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New Federal Register Final Rule Raises Minimum Legal Efficiency

- Outlaws current minimum EPACT 2005/NEMA TP1
- **Takes effect Jan 1, 2016**

23336 **Federal Register** / Vol. 78, No. 75 / Thursday, April 18, 201

DEPARTMENT OF ENERGY

10 CFR Part 431

[Docket No. EERE–2010–BT–STD–0048]

RIN 1904–AC04

Energy Conservation Program: Energy Conservation Standards for Distribution Transformers

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Final rule.

FOR FURTHER INFORMATION CONTACT:
James Raba, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, EE–2J, 1000 Independence Avenue SW., Washington, DC, 20585–0121. Telephone: (202) 586–8654. Email: *Distribution_Transformers@ee.doe.gov*.
Ami Grace-Tardy, U.S. Department of Energy, Office of the General Counsel, GC–71, 1000 Independence Avenue SW., Washington, DC, 20585–0121. Telephone: (202) 586–5709. Email:

FEDERAL REGISTER

Vol. 78 Thursday,
No. 75 April 18, 2013

Part II

Department of Energy

10 CFR Part 431
Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule

Update to 2016 transformer spec now to avoid Change Order

- If building is going up in 2016 or later
- Avoid potential change order if current spec calls for today's TP1 which in 2016 will be illegal….

Powersmiths ESAVER 2016 Guide Specification
HIGH EFFICIENCY K-7 DRY TYPE TRANSFORMERS (US DOE 2016)

SECTION 26-22-13
Sept 03, 2014

SECTION 26-22-13 – HIGH EFFICIENCY K-7 TRANSFORMERS (US DOE 2016)

PART 1 GENERAL

1.1 WORK INCLUDED

A. Copper-wound transformers exceeding US Department of Energy 2016 mandated minimum efficiency. These transformers shall be UL listed to feed a K-7 electronic equipment load profile and be optimized to minimize operating cost under light loading.

B. Compliance with full specification is required

C. Basic compliance with NEMA TP1/EPACT2005, NEMA Premium, CEE Tier 1, or CSL3 is not sufficient to meet this specification due to the following:

a. Efficiencies must exceed the US DOE 2016 minimum requirement

b. No load losses must comply with those defined in this specification

c. Efficiency at low load and under nonlinear K-7 load must meet the minimum requirements of this specification

d. K-7 listing per UL 1561 is required

e. Comprehensive testing under linear and nonlinear loading is required to verify specified performance

f. Performance submittals are required

1.2 REFERENCES

A. US Department of Energy, 10 CFR Part 431, April 18, 2013. Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule

B. DOE Test Method for Measuring the Energy Consumption of Distribution Transformers under Appendix A to Subpart K of 10 CFR part 431.

C. ANSI/NEMA ST 20 - Dry Type Transformers for General Applications.

D. NEMA Premium Efficiency Transformers Program

E. Consortium for Energy Efficiency (CEE): Specification for Low-Voltage, Dry- Type Distribution Transformers

F. EPACT 2005 - United States Energy Policy Act 2005 / NEMA TP1 - Guide for Determining Energy Efficiency for Distribution Transformers

G. NEMA TP1 - Guide for Determining Energy Efficiency for Distribution Transformers

H. ANSI/NEMA TP-2 – Standard Test Method for Measuring Energy Consumption of Distribution Transformers

I. Metering Standards:

a. Computational algorithms per IEEE Std 1459-2000

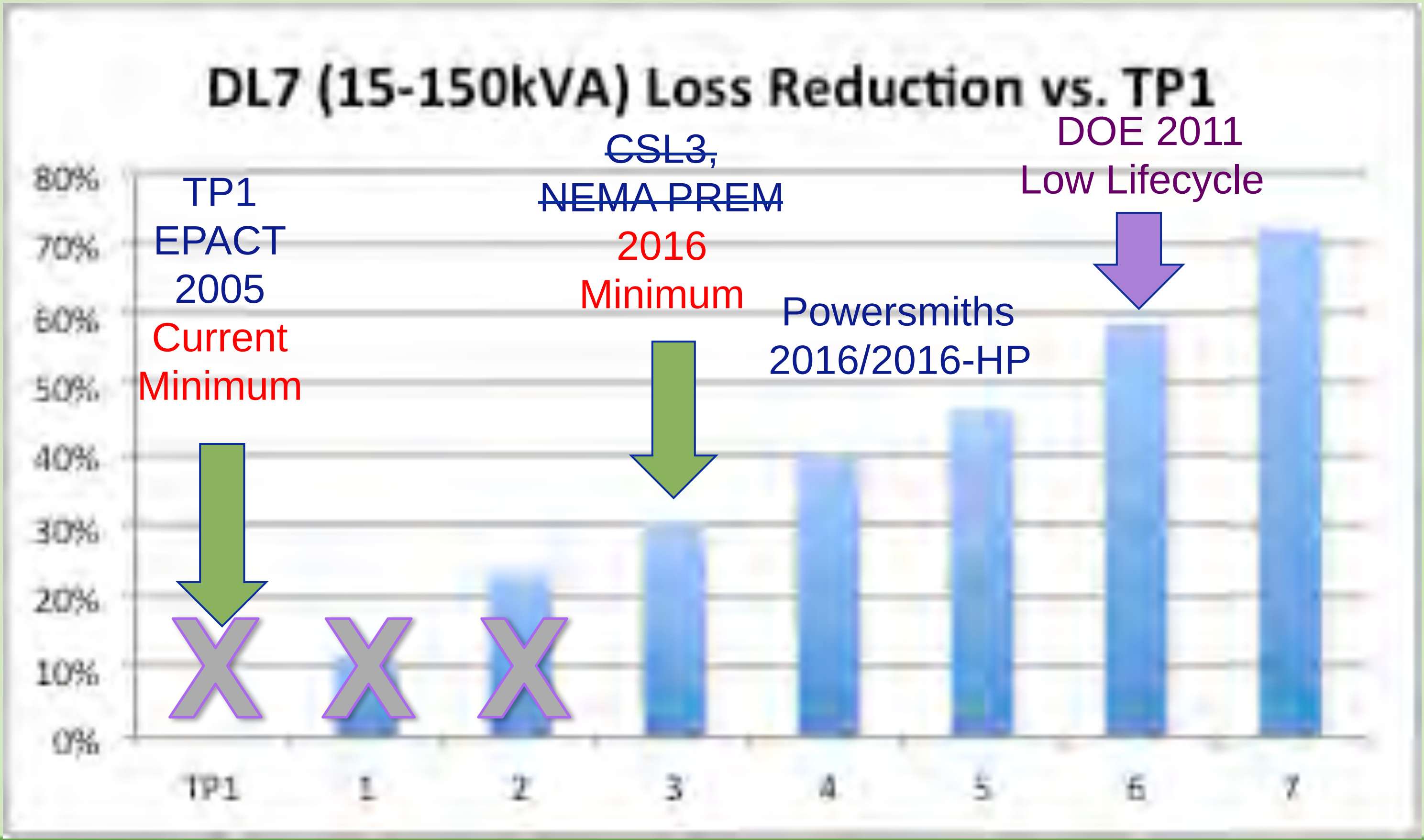
b. UL 916, UL 61010C-1 CAT III

HIGH EFFICIENCY K-7 TRANSFORMERS (US DOE 2016)
Section 26-22-13 807-030439-128-A05

Design Line 7 LCC Results

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

	Efficiency Level						
	1	2	3	4	5	6	7
Efficiency (%)	98.23%	98.47%	98.60%	98.80%	98.93%	99.17%	99.44%



US Dept. of Energy
Significant Lifecycle Savings efficiency beyond 2016 mandate

Efficiency Level	2015-2044 Savings
Level 4	$12B
Level 5	$14.5B
Level 6	$19.4B

DOE 2016 raises efficiency bar but has important weaknesses


FEDERAL REGISTER

Vol. 78 No. 75

Thursday, April 18, 2013

Part II

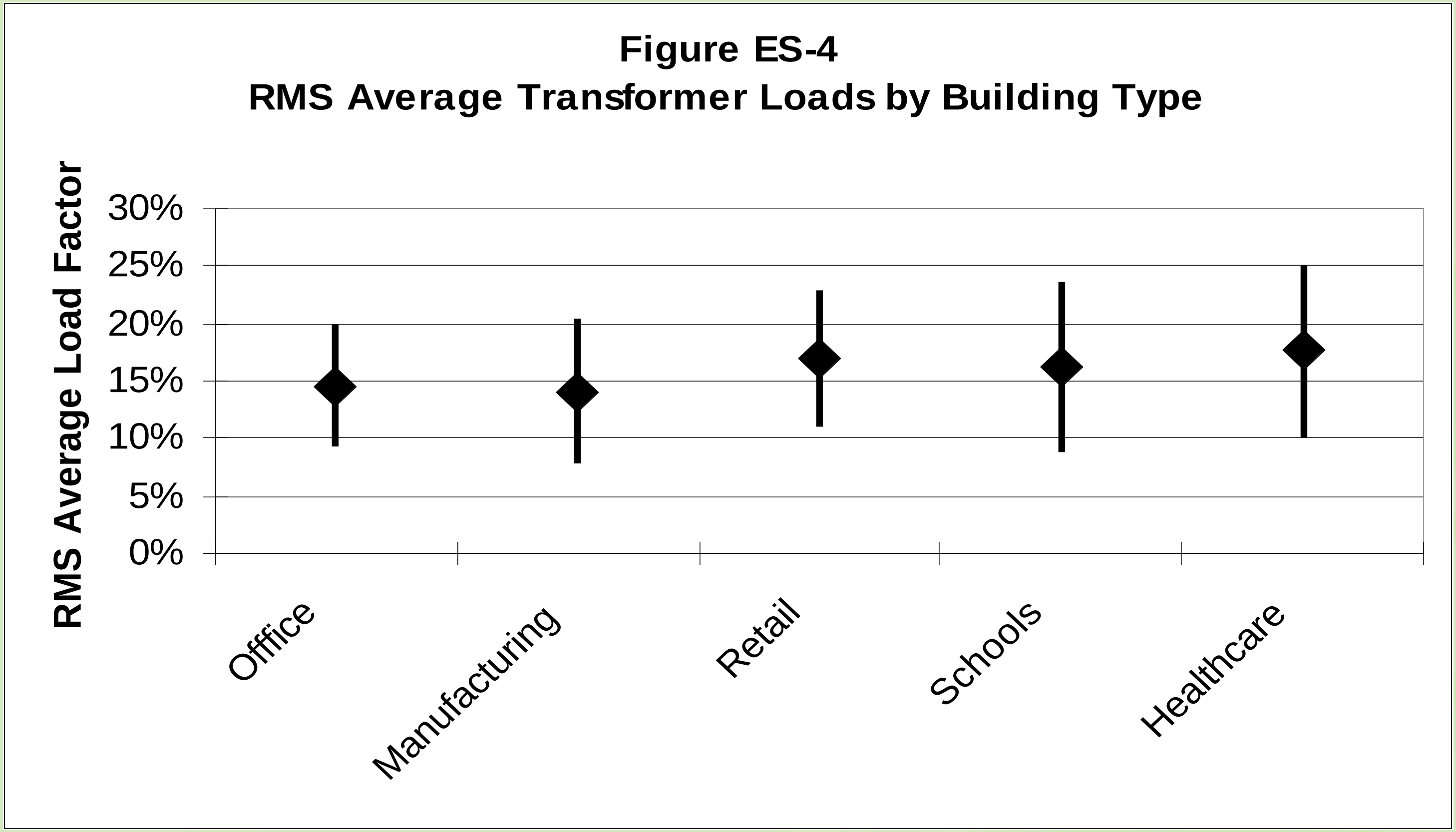
Department of Energy

10 CFR Part 431

Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule

- Same weaknesses as current law – TP1
- Efficiency Requirement only @ 35% of nameplate rating
- Ideal Linear load factory test only
- **Does not reflect real world performance**
- Actual operating efficiency can be MUCH lower than published data - you get less than you think

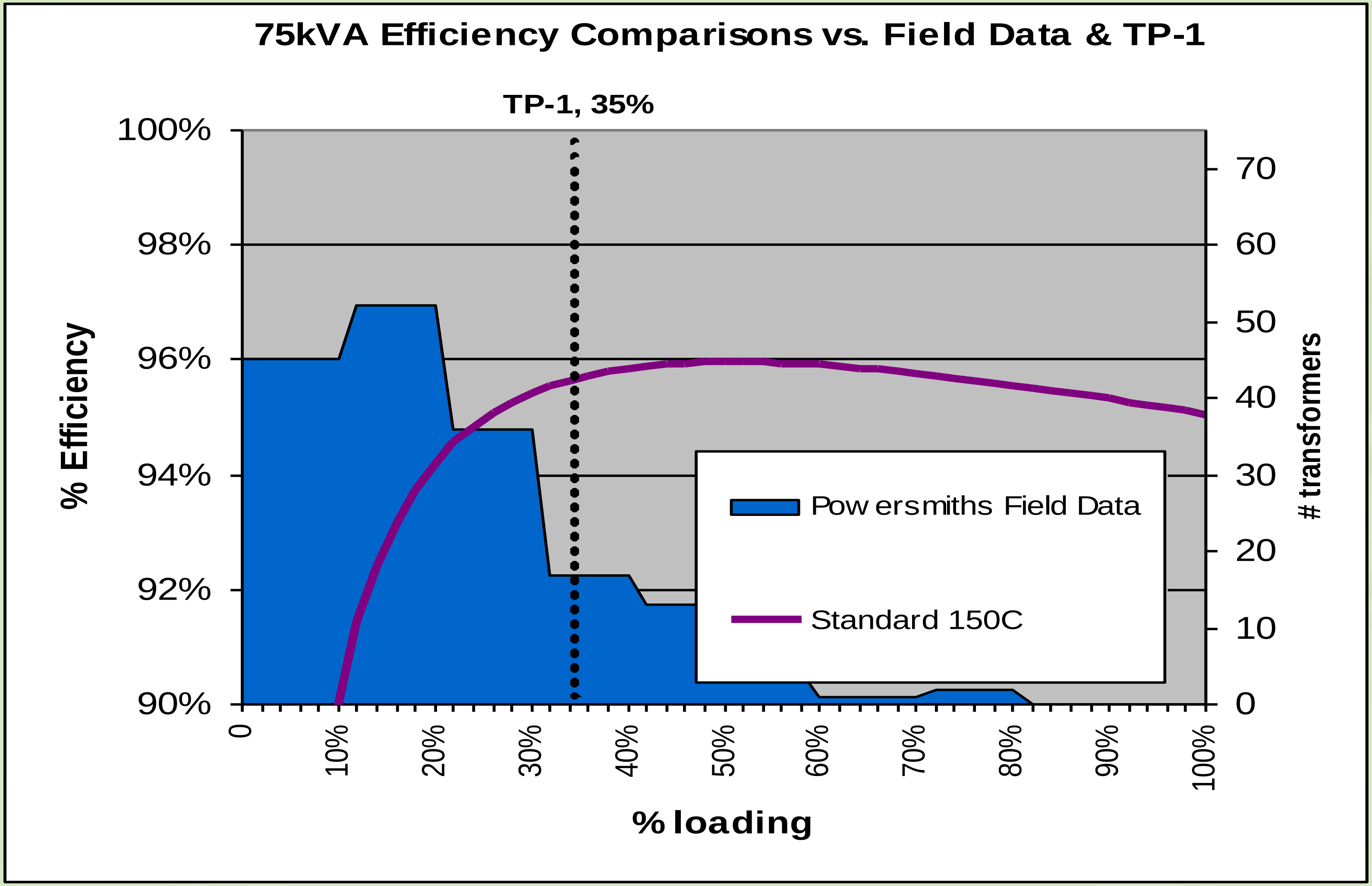
Cadmus Study documents lightly loaded transformers in many applications



Metered Load Factors for Low-Voltage, Dry-Type Transformers in Commercial, Industrial and Public Buildings

The Cadmus Group Inc. 12/7/99, Prepared for Northeast Energy Efficiency Partnership

Overview of Transformer Efficiency vs. Real World Load Distribution



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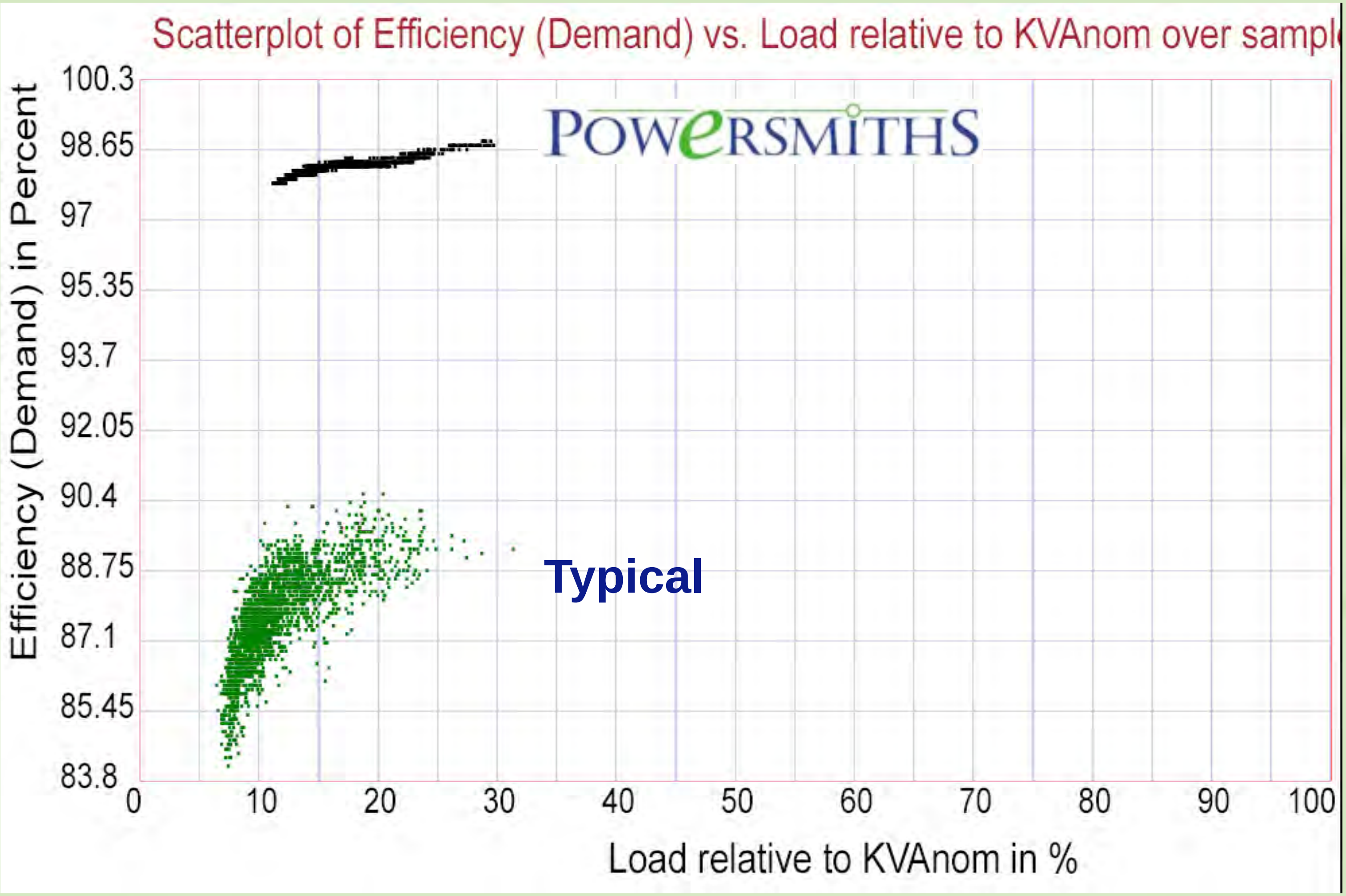
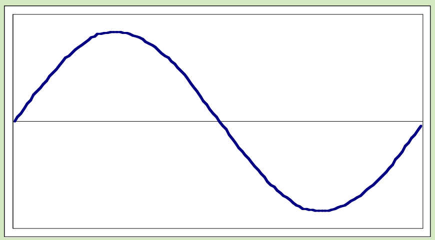
Dramatic Real World Performance Difference

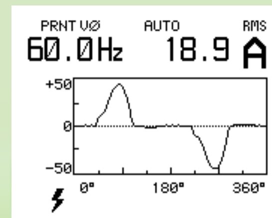


Connected load today is NOT ideal/linear
Electronics are everywhere

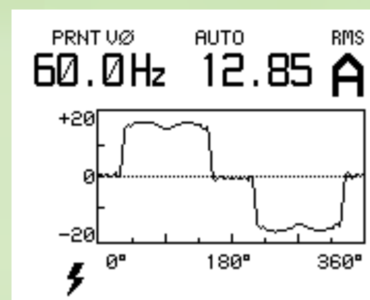


Electrical systems deliver optimum performance when feeding continuous “linear” loads:

- motors
- incandescent lighting
- resistive heating



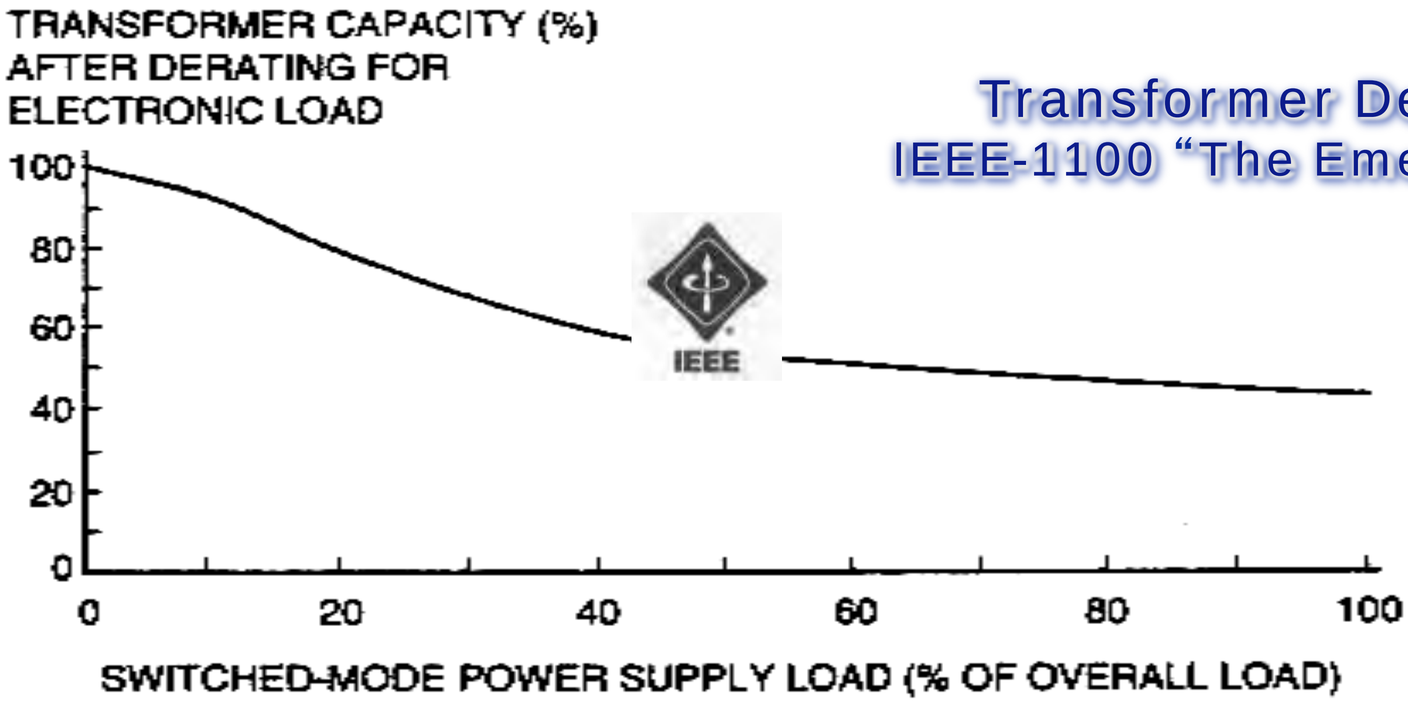
Electronics are everywhere
- computers, lab, diagnostic & operating equipment, & patient care



Variable Speed Drives run Ventilation System

Overheating Risk

Rated heat output reached at ½ load even if only partial load is nonlinear

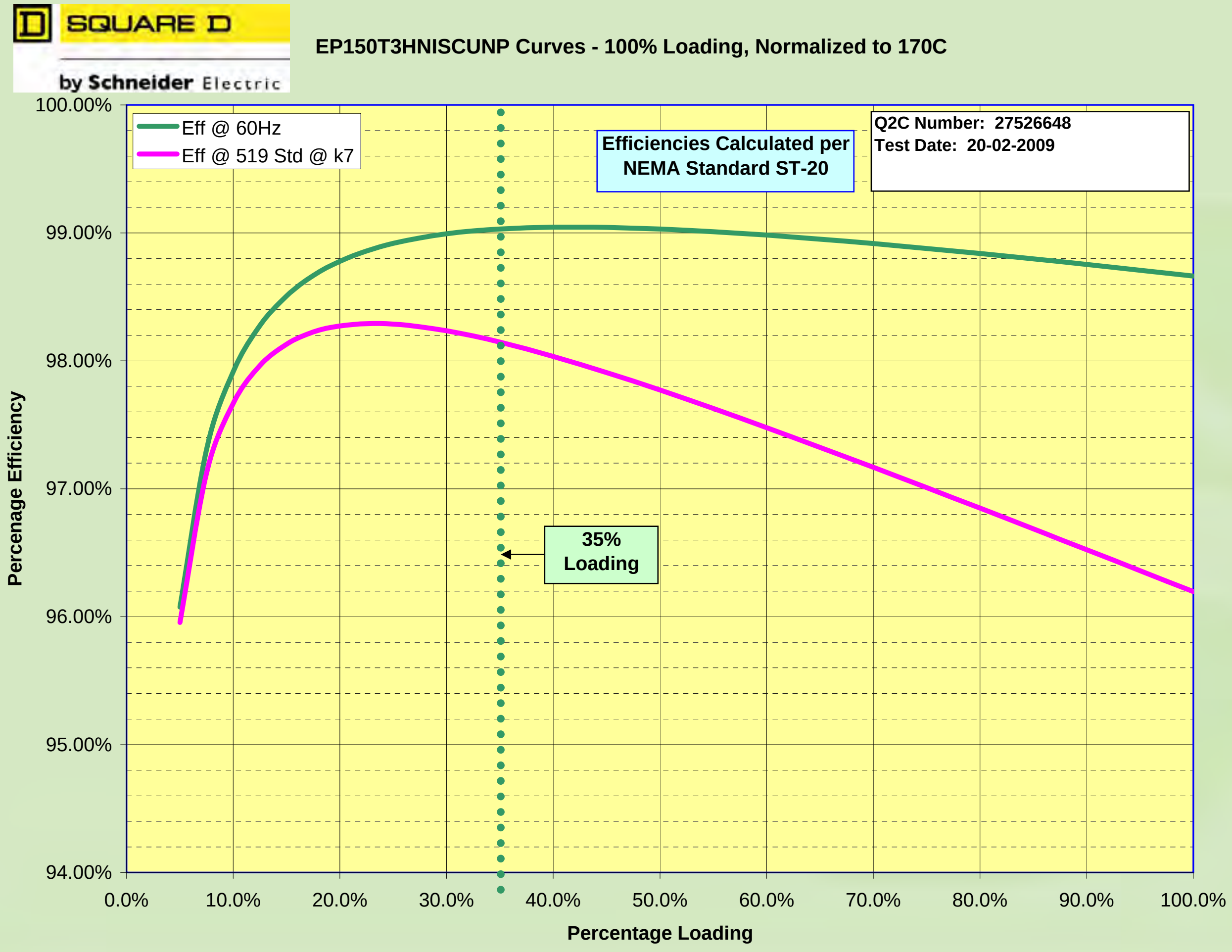


Transformer Derating
IEEE-1100 "The Emerald Book"

Source: Based on [B4].

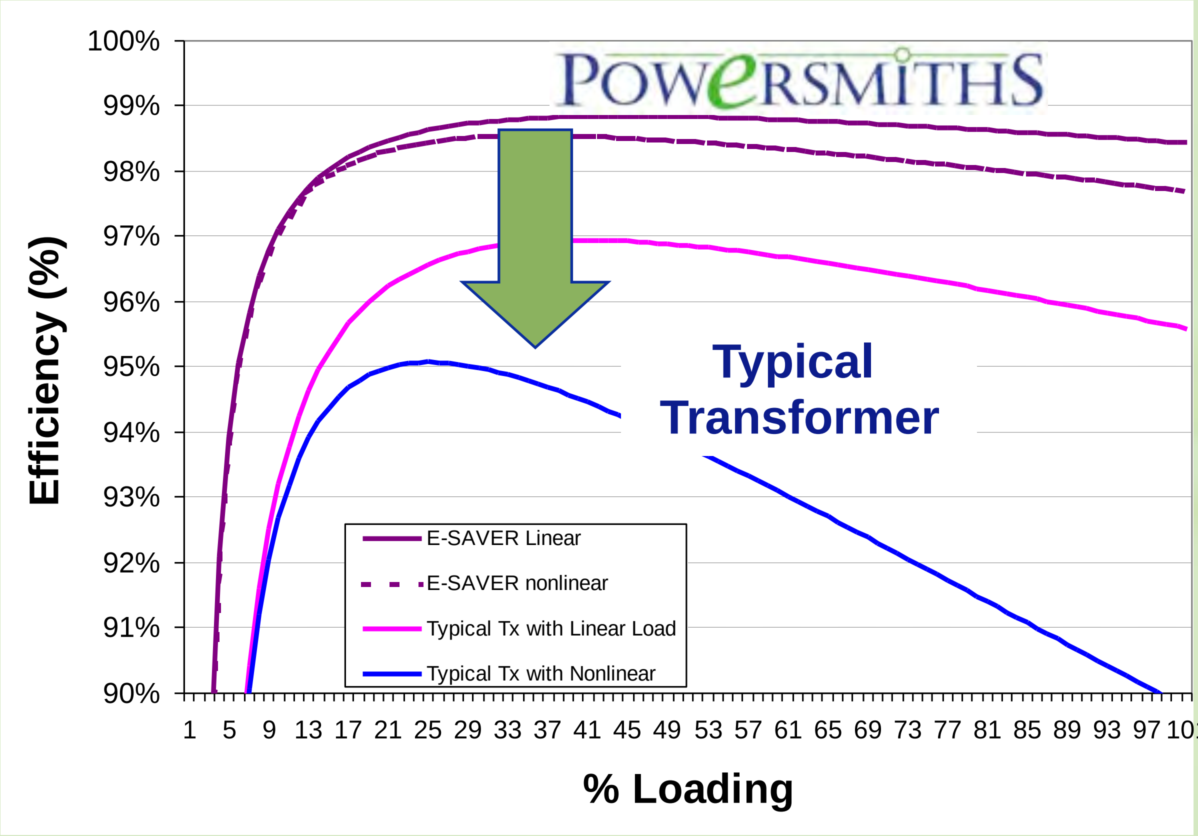
Fig 9-11
Transformer Capability for Supplying Electronic Loads

Other manufacturers concede significant decrease in efficiency under nonlinear load

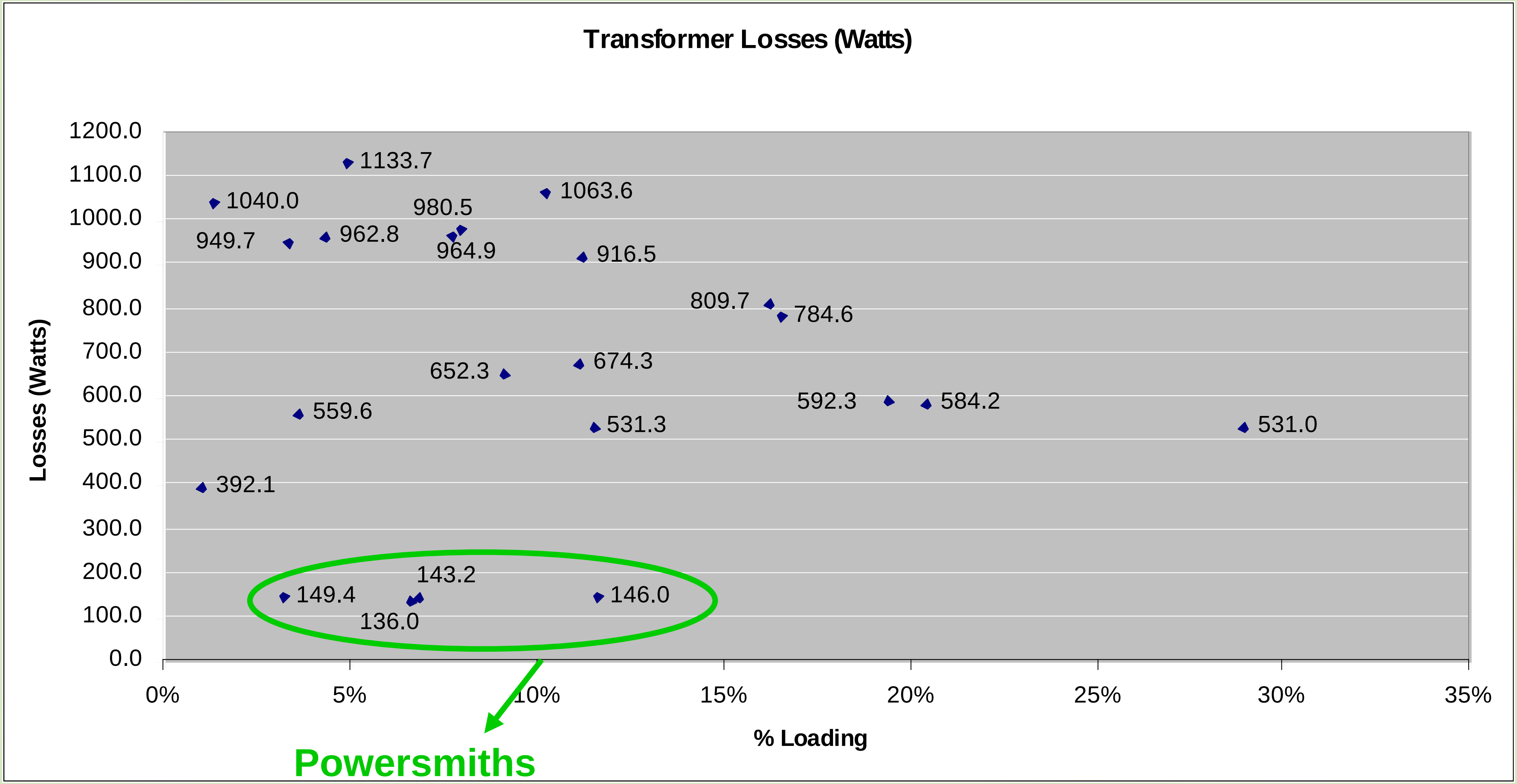


Powersmiths delivers performance under real world nonlinear load conditions

- Lowest no load losses
  - Ensure excellent low load performance
- Design optimized for nonlinear loads
  - Maximize Efficiency & Power Quality



Proven, significant, real world reduction in losses

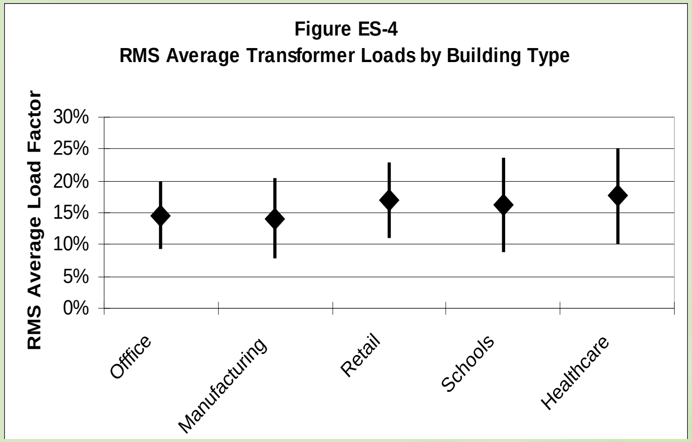


(Losses for 75 kVA Transformer)

Value: Upfront savings vs long term savings

Cutting this upfront
cost just doesn't
make sense

E-Saver 2016



- **Optimized for modern reality: light loading, electronic profile**
- **Copper, K7, 115C rise, 3dB quieter than NEMA ST20, 6 taps**
- **Higher 35% efficiency**
  - 41% less than NEMA TP1
  - 14% less than DOE 2016, NEMA Premium…
- **Qualifies for CEE Tier 1 utility incentive**

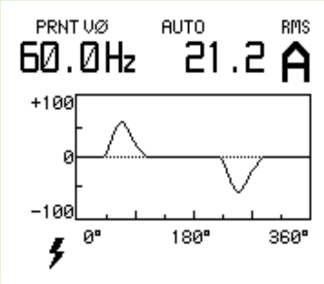
E-Saver 2016-HP

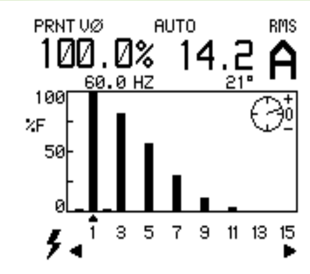
- **Focus: Maximize lifecycle savings**
- Optimized for
  - Wide ranging loads (0-100%)
  - Capacity **right-sized** to the load
  - Data Centers (7x24 operation)
- **Copper, K13, 105C rise**
- **3dB quieter than NEMA ST20**
- **Higher 35% efficiency**
  - 48% less than NEMA TP1
  - 24% less than DOE 2016, NEMA Premium…

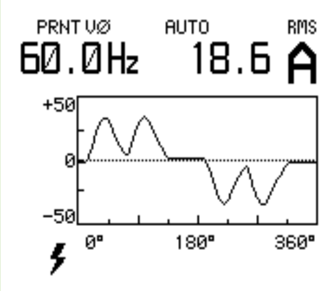
Qualifies for CEE Tier 2 efficiency

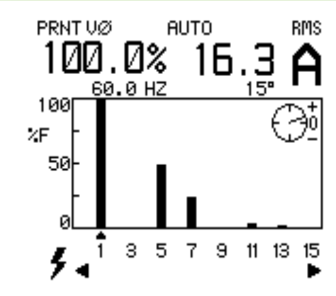
What about Harmonics
Nonlinear loads are everywhere

- Yes
  - amount of electronic equipment continues to rise
  - loads are nonlinear









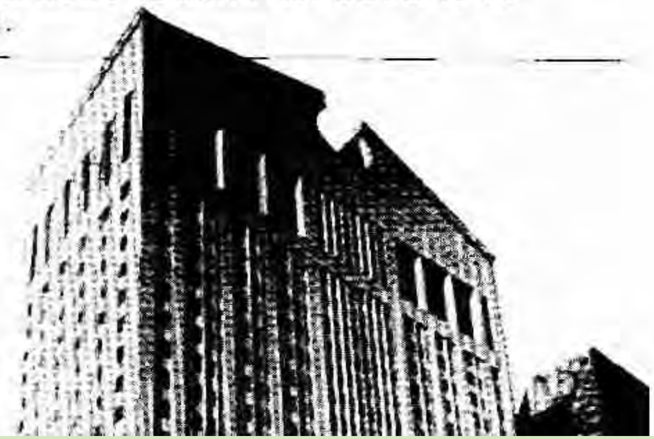
1990's Media focus on harmonics

(EC&M Magazine)

DOUBLE THE NEUTRAL AND DERATE THE TRANSFORMER—OR ELSE!

Arthur Freund, Senior Editor

CBEMA has issued an information letter explaining critical power problems from computer and electronic loads, with drastic recommendations to prevent damage to the distribution system.

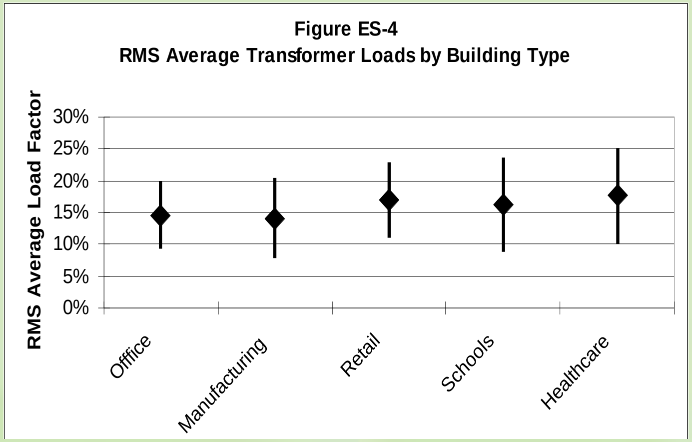


COMPUTER AND BUSINESS Equipment Manufacturers Association (CBEMA, pronounced "seebeemah") is the electronic business equipment industry equivalent of the electrical industry National Electrical Manufacturers Association (NEMA). CBEMA became aware that the proliferation of switching-mode power supplies for computers and business equipment was resulting in large harmonic currents, and that these harmonics were causing severe and increasing problems in electrical distribution systems and equipment. (See "Nonlinear loads mean trouble" in *EC&M*, March, 1988). John Roberts, Manager of Corporate Power Standards for IBM, is chairman of the Power Subcommittee of the Environment and Safety Subcommittee of CBEMA. This subcommittee studied the problem and possible solutions, and CBEMA has issued an

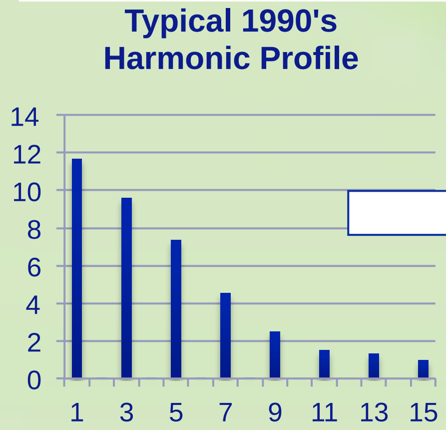
System Reality has changed since 90's

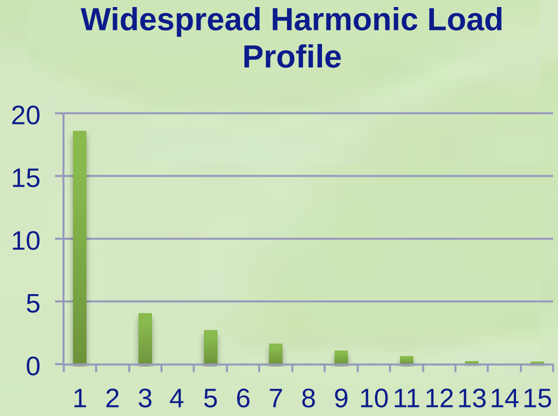
Newer equipment uses less power

Electrical Systems are lightly loaded



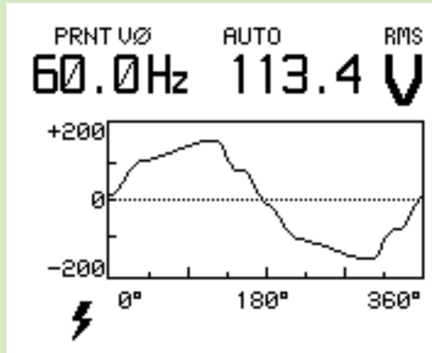
Harmonic content has declined over past decade due to cleaner power supply designs

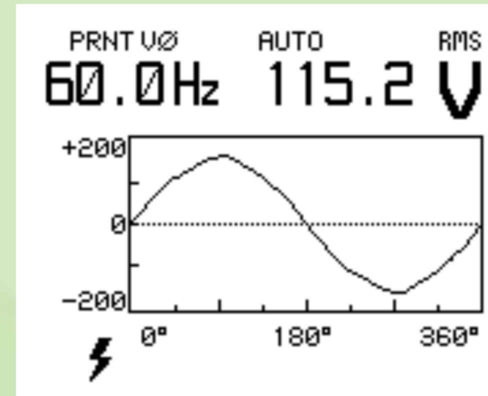




T1000-2016

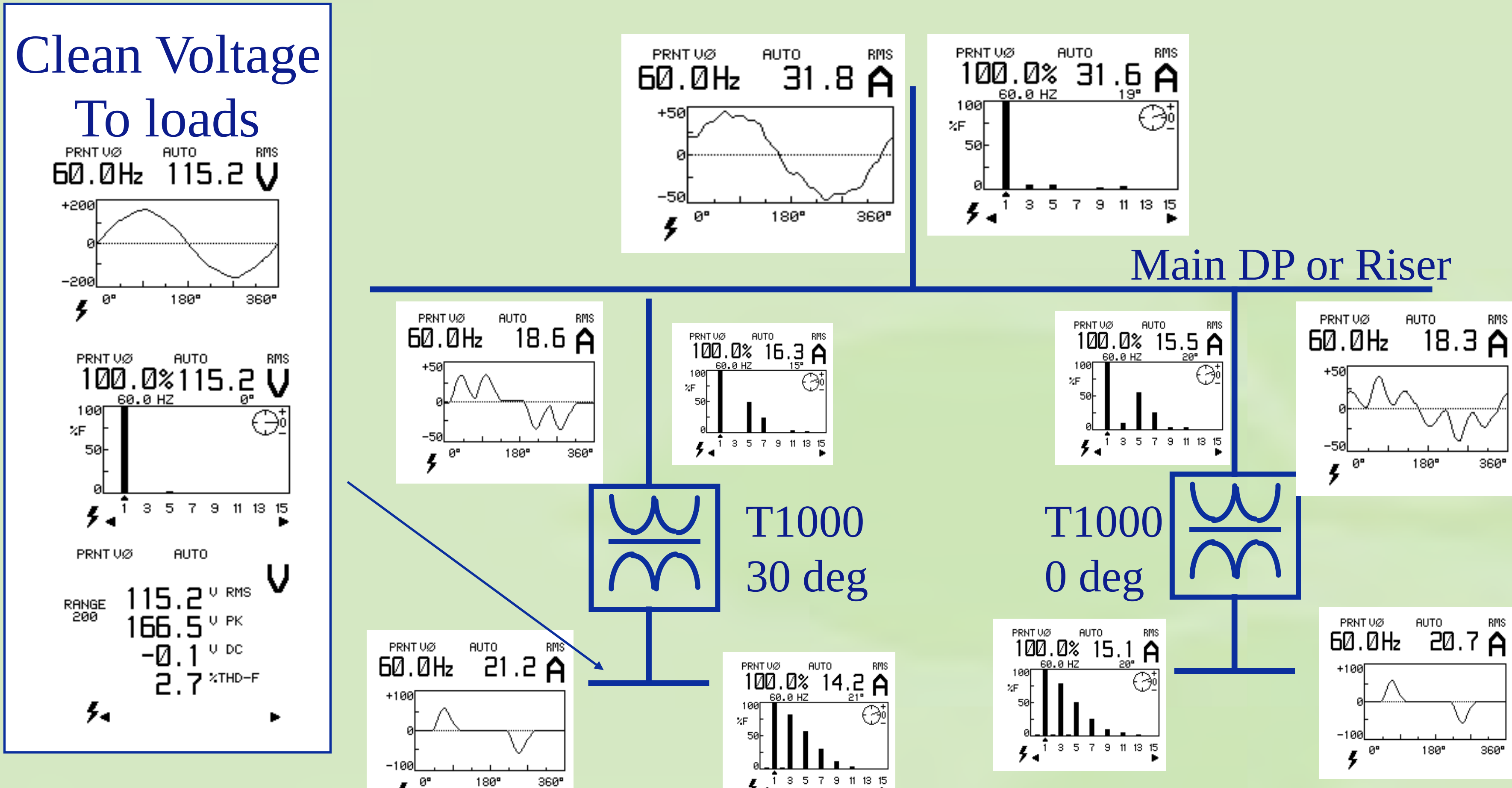
Harmonic Mitigating Transformer





- **Improves Power Quality & saves Energy under harmonic rich load**
- **Harmonic mitigation premium quickly paid for out of energy savings**
- **Small adder for long term protection for load changes in future**
- **Copper, K13, 115C rise**
- **Higher 35% efficiency**
  - 41% less than NEMA TP1
  - 14% less than DOE 2016, NEMA Premium…
- **Qualifies for CEE Tier 1 utility incentive**

Powersmiths T1000-2016 Application –
Ultra-Efficient System-Based Harmonic Treatment



- 3^{rd} harmonic cancelled in secondary windings
- 5^{th} & 7^{th} are inverted through 30 deg. Shift and subtract a the main DP
- Voltage is kept clean for loads, current is cleaned up for upstream system benefit
- Loads continue to draw current per their design spec. for maximum immunity and ride-through

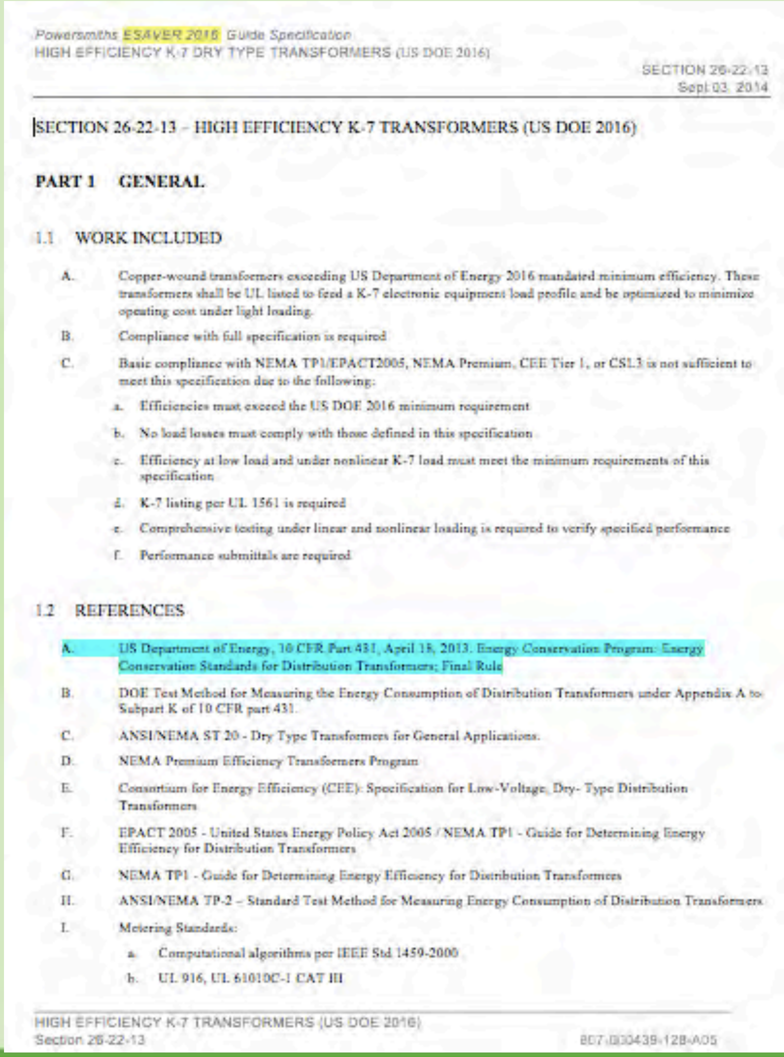
E-Saver-SOL

- Ultra efficient low voltage, dry type, up to 600V, 10-1000kVA
- Optimized for solar load profile @ 0% to100% loading
- All Winding configurations (typically Y-D, Y-Y)
- Great payback, lowest lifecycle cost - high value of solar kWh

Low E-Saver-SOL losses mean more solar kWh reach the meter

Powersmiths has DOE 2016 guide specs

- ESAVER-2016
  - K7, Real World Efficiency
- ESAVER-2016-HP
  - K13, Real World Efficiency, lowest lifecycle cost
- T1000-2016
  - Harmonic Mitigation
  - Real World Efficiency
  - Lowest Voltage Distortion
- ESAVER-SOL
  - Minimize Solar Losses
- Energy Station PDUs
  - Reduce Datacenter PUE & footprint



Powersmiths ESAVER 2016 Guide Specification
HIGH EFFICIENCY K-7 DRY TYPE TRANSFORMERS (US DOE 2016)

SECTION 26-22-13
Sept 03, 2014

SECTION 26-22-13 – HIGH EFFICIENCY K-7 TRANSFORMERS (US DOE 2016)

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A. Copper-wound transformers exceeding US Department of Energy 2016 mandated minimum efficiency. These transformers shall be UL listed to feed a K-7 electronic equipment load profile and be optimized to minimize operating cost under light loading.

B. Compliance with full specification is required

C. Basic compliance with NEMA TP1/EPACT2005, NEMA Premium, CEE Tier 1, or CSL3 is not sufficient to meet this specification due to the following:

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d. K-7 listing per UL 1561 is required

e. Comprehensive testing under linear and nonlinear loading is required to verify specified performance

f. Performance submittals are required

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C. ANSI/NEMA ST 20 - Dry Type Transformers for General Applications.

D. NEMA Premium Efficiency Transformers Program

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G. NEMA TP1 - Guide for Determining Energy Efficiency for Distribution Transformers

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I. Metering Standards:

a. Computational algorithms per IEEE Std 1459-2000

b. UL 916, UL 61010C-1 CAT III

HIGH EFFICIENCY K-7 TRANSFORMERS (US DOE 2016)
Section 26-22-13 807-000439-128-A05

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Right-Sizing

Right-Size as much as possible

- **Select transformer as close to NEC Calc as possible**
- **Intermediate kVA sizes are available – use them**
- **Big Upfront construction budget savings:**
  - Smaller distribution COSTS LESS
  - transformer, panelboard, breakers, conductors, conduit
  - Smaller footprint of infrastructure
- The smaller system is win-win
  - Helps construction budget - reduces first cost
  - Helps operating budget – energy savings

Standard kVA	Additional kVA
15	
	20
	25
30	
45	
	50
	63
75	
	100
112.5	
	125
150	
	175
	200
225	
	250
300	
	400
	450
500	
	600
750	
	850
1000	

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Retrofits and Major Renovations

Major Renovations-
DON'T LEAVE THE OLD TRANSFORMERS

- Near end of life
  - DOE = 32 yrs
- Inefficient
- Not compatible with modern electronics
- Failure mode is expensive, downtime
- Pays for itself out of energy savings
- Add more savings since "low hanging fruit" savings already taken

Energy Saving
-ROI
- Life Cycle Cost
- Environmental Impact

General
LEED
Mission Critical

POWERSMITHS
Toll Free : 1-800-747-9627 or (905) 791-1493

The ESP Calculator ™

Energy Savings Payback Calculator

Black box indicates data entry field

Project Description	**New Project**
Date	**13-Sep-02**

Data Entry

% Load during normal operating hours	35%	
% Load outside operating hours	20%	
equipment operating hrs/ day	10	
equipment operating days/yr	260	
kWh rate	$ 0.080	
demand rate ($/kW/mo) ex. $10.00	$10.00	
Load Power Factor	0.90	
% additional cooling losses	0%	
		Nonlin Loss Mult
Other Transformer Linear Efficiency & Loss Multiplier*	95.0%	2.0
Powersmiths Nonlinear Efficiency	98.0%	

Transformers on Project

QTY	kVA
	15
15	30
15	45
4	75
	112.5
	150
	225
	300
	500
	Other kVA

Energy Cost Analysis (calc)

	Annual Operating Cost	kW Losses in Normal operation	kW Losses outside operating hours
Traditional Transformers *	$30,404	49.9	28.5
Powersmiths Transformers	$5,584	9.2	5.2
ANNUAL Energy Savings with Powersmiths	**$24,819**	40.7	23.3

Estimated Annual Power Quality Savings $0

Life Cycle Savings and Payback

	First Cost	Life Cycle Cost: Operating	Total Ownership
Traditional Transformers	$52,000	$760,095	$812,095
Powersmiths Transformers	$80,000	$139,609	$219,609
Total Life Cycle Savings	-$28,000	**$620,486**	**$592,486**
Payback on Incremental Cost	1.13	years	

Leasing Option

	60 Month Term	48 Month Term	36 Month Term
Total Annual Leasing Payments	**$21,216**	**$25,680**	**$32,784**
Net Annual Cost with savings	($3,603)	$861	$7,965

Summary of Environmental Benefits

Annual Reduction in Greenhouse Gases	184 tons of CO_2	1,442 kgs of SO_2
(Per EPA)	596 tons of Coal	621 kgs of NO_x
Equivalence	34 Acres trees planted	25 homes heated
	25 Car Emissions	

IMPORTANT: By using the ESP Calculator™, you are agreeing the TERMS OF USE section on page 2

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  V02.10.30

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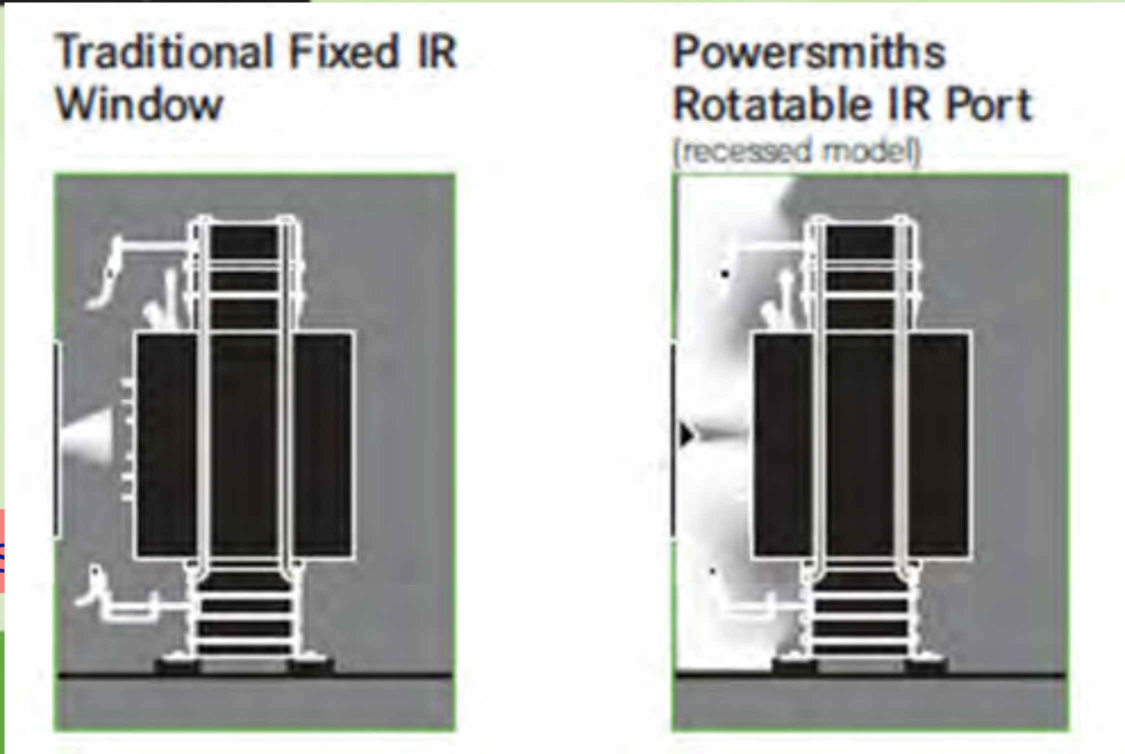
Transformer Options

Rotatable IR Port

- Thermal Scan connections through rotatable port
- Safe and Saves time



Safety First – Eliminates

Lockable Hinged Doors

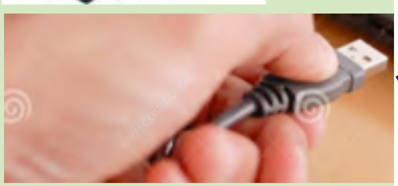
- Quick, cost-effective access
- thermal scans
- metering
- maintenance

Safety First – Eliminates Arc Flash Risk of opening enclosure

Transformer Integrated Metering & Logging
Arc Flash Safe & quick access to data

- Track energy intensive systems or equipment
- History of infrastructure loading

Embedded long term Cyberhawk Express Logger
Accessible locally without opening enclosure



Capable of real-time push to WOW
Connect to BAS
Access port for efficiency spot checks

Safety First – Eliminates Arc Flash Risk of opening enclosure

Factory Nonlinear Load Test

- Proof of performance
- In ISO 17025 Efficiency Test Lab

Powersmiths Transformer Nonlinear Load Test

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Model: eSaver-C3L-45-480-208
Serial: 31517

Tester: Jason Yang
Reported by: Nancy Xie

Test Da 10/30/2009 12:57:19
Report Date: 12/10/09

Step	Time	TextPO	TextSerialNo	TextVprimary	TextVSecondry	TextkVARating	ModbusOutput. kVAtot	Loading %	ModbusInput.kWtot	ModbusOutput.kWtot	ExpTrafoEfficiency	ModbusInput.VaTHD	ModbusInput.VbTHD	ModbusInput.VcTHD	ModbusInput.IaTHD	ModbusInput.IbTHD	ModbusInput.IcTHD	ModbusOutput.VaTHD	ModbusOutput.VbTHD	ModbusOutput.VcTHD	ModbusOutput.IaTHD	ModbusOutput.IbTHD	ModbusOutput.IcTHD	ModbusOutput.I1kfactor	ModbusOutput.I2kfactor	ModbusOutput.I3kfactor
1	10/30/2009 12:57:19	TT3697	31517	480	208	45	0.070	**0.16**	0.152	0	**0.00**	1.04	1.03	1.22	25.49	32.55	26.8	0	0	0	0	0	0	0	0	0
2	10/30/2009 12:57:45	TT3697	31517	480	208	45	4.400	**9.78**	2.844	2.695	**94.76**	1.36	1.44	1.3	80.71	67.32	69.3	0.99	1.86	1.67	111.37	115.11	106.9	13.48	12.3	10.7
3	10/30/2009 12:58:19	TT3697	31517	480	208	45	8.455	**18.79**	5.644	5.481	**97.11**	1.76	1.9	1.67	67.42	63.58	63.4	1.98	2.96	2.76	103.28	107.68	105.3	9.66	10.3	9.84
4	10/30/2009 12:58:52	TT3697	31517	480	208	45	14.320	**31.82**	10.26	10.06	**98.11**	2.12	2.19	2.05	49.75	50.58	49.6	3.15	3.94	3.74	92.35	92.32	94.95	7.71	7.43	7.88
5	10/30/2009 12:59:20	TT3697	31517	480	208	45	18.315	**40.70**	13.38	13.13	**98.09**	2.52	2.48	2.32	46.58	47.7	46	3.92	4.74	4.48	90.32	89.39	91.77	7.49	7.08	7.41
6	10/30/2009 12:59:58	TT3697	31517	480	208	45	22.082	**49.07**	16.49	16.19	**98.16**	2.61	2.64	2.56	40.48	43.8	41	4.36	5.34	4.97	85.07	84.99	88.94	6.61	6.44	7.09
7	10/30/2009 13:00:28	TT3697	31517	480	208	45	25.675	**57.06**	19.67	19.3	**98.09**	2.56	2.76	2.54	36.03	37.57	37.5	4.61	5.65	5.48	82.35	79.93	84.04	6.28	5.78	6.39
8	10/30/2009 13:01:23	TT3697	31517	480	208	45	29.043	**64.54**	24.16	23.71	**98.14**	2.58	2.7	2.52	27.16	28.84	28.4	4.6	5.69	5.5	64.49	65.83	67.81	5.01	4.8	5.31
9	10/30/2009 13:02:30	TT3697	31517	480	208	45	32.855	**73.01**	28.73	28.18	**98.08**	2.7	2.71	2.61	21.81	23.24	23.1	4.89	5.95	5.68	53.15	55.68	56.83	4.17	4.05	4.4
10	10/30/2009 13:03:19	TT3697	31517	480	208	45	37.199	**82.66**	33.74	33.06	**98.00**	2.61	2.76	2.58	18.38	19.61	19.1	4.62	5.74	5.39	44.48	47.76	47.95	3.34	3.38	3.54
11	10/30/2009 13:04:20	TT3697	31517	480	208	45	41.565	**92.37**	38.53	37.71	**97.88**	2.56	2.68	2.48	15.77	16.81	16.3	4.65	5.57	5.48	38.2	41.85	41.53	2.73	2.85	2.93
12	10/30/2009 13:05:06	TT3697	31517	480	208	45	45.973	**102.16**	43.5	42.53	**97.77**	2.57	2.66	2.5	13.8	14.72	14.1	4.62	5.5	5.42	33.41	37.14	36.61	2.34	2.47	2.52
13	10/30/2009 13:06:03	TT3697	31517	480	208	45	50.378	**111.95**	48.35	47.15	**97.53**	2.43	2.56	2.36	12.24	13.1	12.5	4.39	5.38	5.14	29.72	33.37	32.76	2.06	2.2	2.22
14	10/30/2009 13:06:35	TT3697	31517	480	208	45	54.791	**121.76**	53.2	51.77	**97.30**	2.42	2.5	2.31	10.96	11.77	11.1	4.32	5.36	5.11	26.7	30.31	29.62	1.85	1.98	2
15	10/30/2009 13:07:31	TT3697	31517	480	208	45	25.933	**57.63**	26.02	25.63	**98.50**	1.07	1	1.27	0	0.31	0.32	0	0	0	0	0	0	1	1	1

Step 1 – 7 Single phase non-linear load
Step 8 –9 Add three phase non-linear load
Step 10– 14 Add resistive load
Step 15 Only resistive load

Note: Efficiency Measurement Based On Power Out/ Power In at Room Temperature. (No Temperature Correction Applied)

POWERSMITHS

Data Center Products

Data Center Applications

Focus:

Transformer Attributes

- Efficiency
- Power Quality
- Low Inrush
- Impedance Optimization

Data Center Application: Comprehensive Integrated Distribution

Focus
- Efficiency
- Minimize Effective footprint (ex. front-only access)

Load Migration: Multi-Voltage 208/415/480

Transformer with Integrated Breakers

Feed Overhead Busways

- 2 x Output or Input/Output
- Either side
- Small Footprint
- Less Expensive than Switchgear or PDU
- Advanced Efficiency/PQ Meter – show impact on PUE
- Rotatable IR Port

Metering & Logging Products

Cyberhawk
POWER MANAGEMENT PLATFORM

Power Quality (C300)

Revenue Certified 200M

Express

Integrated options

WOW is a comprehensive cloud-based platform that provides enterprise-level sustainability management applications to help organizations reduce energy and validate building system performance

POWERSMITHS

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