IEEE SF / IAS

Seminar

Green Transformers

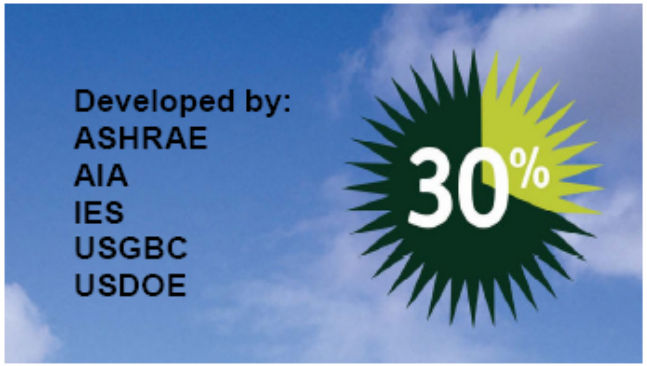
INTEGRATED Building Solutions

Finn Schenck

New Low Loss Transformers are Here

- Lower Losses
  - Manufacturers quote that these transformers are 30 – 50% more energy Efficient.
  - This means that the **losses** are designed to be 30% less @ 35% Loading.
  - What are the losses at 35% Loading?
    - Core Losses
    - Coil Losses
  - What do we get from this new Product?

Understand the Savings Opportunity



Advanced Energy Design Guide
for K-12 School Buildings

Achieving 30%Energy Savings
Toward a Net Zero Energy Building

- These transformers reduce the losses in a XFMR by 30 %
- Transformer losses “typically” range between 1% & 4 %, generally hovering around 2% of the transformer “LOADING”.
- The savings are not multiplied by the rating of the transformer!!!
    - Your new 75 kVA Xfmr will not save you 25 kW
- The Savings are dependant on the transformer load and are based on the losses for that load profile.

Verify Efficiency Claims

For example (following the DOE's lead) a CSL-3 75 kVA 277/480 to 120/208 volt transformer maximum no-load loss is 170 W/h versus the current industry average of more than 850 W/h. This same transformer will meet or exceed 98.4% efficiency at one-sixth loading. The efficiency of the standard transformer at one-sixth loading is 80% to 85%.

Having checked with two manufacturers, the actual losses for a standard TP-1 Transformer at 1/6 load for a one hour period are approximately 330 Wh not 850 Wh. The claim above does not describe The standard transformer as a TP-1, but since 2007, TP-1 is the standard…. What industry / What Average?

And:

The **watt** (**W**) is the unit of power equal to one joule of energy per second. It measures a rate of energy conversion. Energy is measured in watt-hours. What is a W/h????

When considering Low Loss Xfmrs. Consider the cost of the xfmrs.

- Standard TP-1 Transformer, 75 kVA
  - Cost: $2,500.00 + / - Customer Net
- Energy Efficient Xfmr. $7,000.00 - $11,000.00
  - Quotation inquiry, April 2009, DOE CSL-3 type design
- Many of the printed justification documents quote 75 kVA TP-1 transformers at $10,000.00
  - Incorrect market pricing affects the ROI calculations.
- Before doing your financial calcs., understand the actual costs of the xfmrs.

What are we saving?

- 30 – 50% of the losses at 35% loading
- What are the losses at 35% loading?
- 75 kVA TP1, AL Wound, 150 Deg. C. rise

Brand	No Load Losses (Core Losses)	Coil Losses @ 35%	Combined Losses @ 35%	Losses @ Full Load
A	284 W	375 W	660 W	3058 W
B	258 W	302 W	560 W	2467 W

- Potential savings is 30 – 50% of the losses at 35% Loading. (150 – 200 Watts for these two brands)

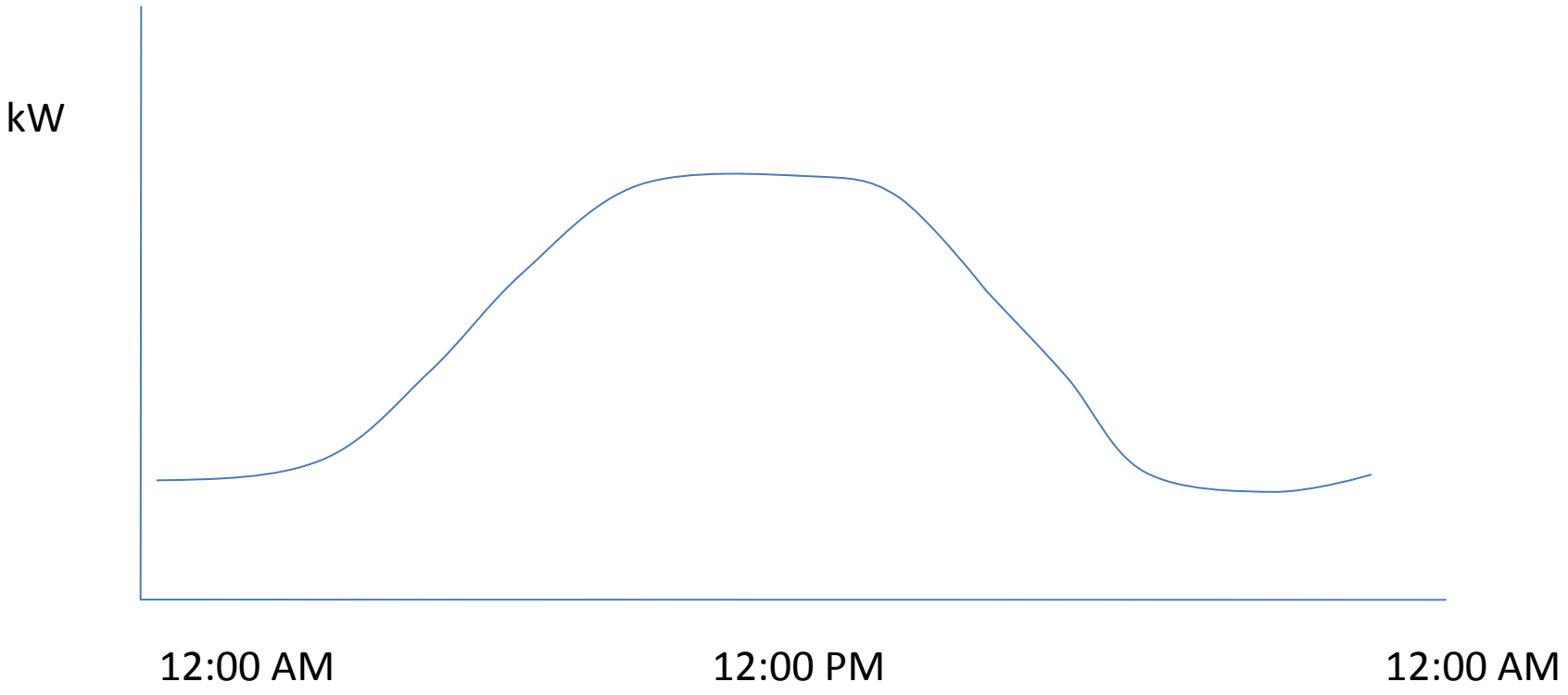
Efficiency for various Types of Xfmrs.

- Need to use formula out of TP1 for total losses

kVA	Part Number	NO LOAD	COIL LOSS	Power Out	Power In	@35% 170C
75	EE75T3H	265	2700	26250	26784.627	98.004%
75	EE75T3HF	257	2301	26250	26752.229	98.12%
75	EE75T3HB	353	1216	26250	26742.888	98.16%
75	EE75T3HCU	218	2409	26250	26709.777	98.28%
75	EE75T3HFCU	225	1737	26250	26660.802	98.46%
75	EE75T3HBCU	332	935	26250	26689.757	98.35%

	Power In Formula
EE75T3H	0.35*75*1000+265+(2700*0.35^2*0.8152)
EE75T3HF	0.35*75*1000+257+(2301*0.35^2*0.87)
EE75T3HB	0.35*75*1000+353+(1216*0.35^2*0.9391)
EE75T3HCU	0.35*75*1000+218+(2409*0.35^2*0.8193)
EE75T3HFCU	0.35*75*1000+225+(1737*0.35^2*0.8732)
EE75T3HBCU	0.35*75*1000+332+(935*0.35^2*0.9408)

When Calculating Financial Justification – Consider Load Profile



Simple Loss Calculation

For this example, we are not considering the load profile - I only have 15 minutes

Coil Loss @ load Level + Core Loss = Total Losses

Coil Loss@ Load Level = Full Load Loss x $(\text{load level})^2$

- Perform these calculations for the predicted daily load profile.
- Obtain Full Load Loss from the manufacturer.
- Obtain Core Loss from the manufacturer.

Very Simple Loss Comparison

- Assuming constant 35% loading

Type	Energy Losses / Day	Energy Losses / Yr	Annual Operating Cost at $.12 /kWh
TP-1 (Brand B)	13.4 kWh	4,907 kWh	$ 588.00
30% More Energy Eff.	9.8 kWh	3,611 kWh	$ 433.00

$155.00 per year operating cost difference @ $.12 / kWh, and assuming constant 35% load

Type	Xfmr. Cost
TP-1 (Brand B)	$2,500
30% More Energy Eff. Type CSL-3	$7,000 - $10,000

Don’t Forget To Consider HVAC Costs

- Difficult to give rule of thumb – Ask your M.E. to calculate the cost of dissipating the xfmr. heat loss based on existing HVAC systems.
- But, Your savings increase 2X, or more, if you consider the cost of HVAC (The less efficient your HVAC System, the more your savings increase – yes, counter intuitive)
- Load Profile is important here. Run costs based on load profiles.
- Consider outdoor air exchange in lieu of HVAC.
  - By focusing on Design Considerations, you save on the xfmr. Initial cost, save on the HVAC System, and save on not having to extract the energy dissipated by the xfmr.. Once again – system design offers the biggest benefits.

Comparison

Standard TP-1 Xfmr

- Low initial price
- Typical Losses range 1-4% of transformer loading, typically around 2%
- Note that most xfmrs. run far below the 35% TP-1 design rating, significantly impacting actual losses.
- Shelf Item at many distribution channels Through 150 kVA Often 225 kVA.

New Energy Efficient transformers Type CSL-3

- Current initial cost is several times the cost of a standard TP-1 Xfmr.
- Savings are 30% - > 50% of the xfmr. Losses.
  - Savings thus equal .6% – 1% of transformer Loading , compared at 98% efficiency (Consider Load Profile)
- Still a special order item for most distribution channels

Conclusion

- It is critical to understand the savings opportunity provided by CSL-3 type product when compared to NEMA TP-1 Product.
- The current difference in cost between CSL-3 type transformers and standard TP-1 units make justifying CSL-3 units difficult.
- CSL-3 ROI should improve as the market levels out the price differential.
- A significant opportunity exists with the HVAC system design (i.e. outside air exchange in lieu of air conditioned electrical rooms)
- Contact your transformer manufacturer when transformer loading exceeds 35% for long periods of time, or where there exist significant power quality issues.
- One can make a case for investing today's cost difference, between the TP-1 and CSL-3 type transformers, in more effective energy efficient solutions. (HVAC / Design / Measurement and Verification Systems)

Thank You

OK, you have to install the xfmr. In an air conditioned space, what are the benefits of the new xfmrs.?

- Full Load Losses (Should we design based on Full Load?)
  - Full Load Losses, AL wound, 150 deg. C rise, Std. TP-1, 75kVA – 2725 Watts
  - Convert to BTUs/HR
    - 3.412 x 2725 = 9298 BTUs/HR
  - Used to size HVAC (Note that few xfmrs. Run at full load, this will typically oversize the HVAC and lead to addl. Energy waste.)

- Using Loading Profile (maximum BTUs created in One Hour)
  - TP1 units: 3633 BTU
  - CSL 3 Type Xfmr. Manufacturer B: 2544 BTU
  - Difference: 1089 BTU – can be used in optimizing energy performance