

IEEE Loss Evaluation Guide for Power Transformers and Reactors

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Abstract: A method for establishing the dollar value of the electric power needed to supply the losses of a transformer or reactor is provided. Users can use this loss evaluation to determine the relative economic benefit of a high-first-cost, low-loss unit versus one with a lower first cost and higher losses, and to compare the offerings of two or more manufacturers to aid in making the best purchase choice. Manufacturers can use the evaluation to optimize the design and provide the most economical unit to bid and manufacture. The various types of losses are reviewed.

Keywords: economic, loss evaluation, reactors, transformers

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Foreword

(This foreword is not a part of IEEE Std C57.120-1991, IEEE Loss Evaluation Guide for Power Transformers and Reactors.)

The users of power transformers and reactors have become more concerned about the value of losses as the cost of energy and of installing generating capacity has increased. The evaluation of losses has become a very significant part of the purchase decision for some users.

This guide has been written to provide a method of establishing loss evaluation factors for transformers or reactors. With loss evaluation factors, the economic benefit of a high-first-cost, low-loss unit can be compared with a unit with a lower first cost and higher losses. This enables a user to compare the offerings of two or more manufacturers to aid in making the best purchase choice among competing transformers or reactors. Loss evaluation also provides information to establish the optimum time to retire or replace existing units with modern low-loss transformers or reactors.

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IEEE Loss Evaluation Guide for Power Transformers and Reactors

1. Purpose and Scope

The purpose of this guide is to provide a method of establishing the dollar value of the electric power needed to supply the losses of a transformer or reactor. Users can use this loss evaluation to determine the relative economic benefit of a high-first-cost, low-loss unit versus one with a lower first cost and higher losses. Manufacturers can use the evaluation to optimize the design and provide the most economical unit to bid and manufacture. The evaluated cost of losses also enables a user to compare the offerings of two or more manufacturers to aid in making the best purchase choice among competing transformers or reactors. Loss evaluation also provides information to a user for establishing the optimum time to retire or replace existing units with modern low-loss transformers or reactors.

The user should determine, on a dollars-per-kilowatt basis, the sum of the present worth of each kilowatt of losses of a transformer throughout its life, or some other selected period of time. This figure represents the maximum amount that can be spent to save a kilowatt of loss. A portion of this evaluated cost can be paid to the manufacturer to reduce losses. However, this evaluated cost includes other costs associated with owning a more expensive piece of equipment, such as financing costs, taxes, etc.

This guide provides formulas by which the costs of energy, power, and money, and the loading pattern of a transformer can be converted to dollars-per-kilowatt values of the transformer losses.

These dollars-per-kilowatt figures should be furnished to the manufacturer when bids are requested. If the final tested values of losses vary from the manufacturer's guaranteed values, economic adjustments may be made.

Nothing in this guide is mandatory. It should not be inferred from this paper that the methodology described in the following pages is the only valid methodology for computing the cost of transformer losses. Many users have developed their own transformer loss evaluation techniques that are suitable for the intended purpose. The list of terms in Section 2 uses symbols selected for mnemonic effectiveness and might be different from symbols used in other references.

2. List of Terms Applicable to Transformer Loss Evaluation Equations

Term	Unit	Symbol	Text Reference
Auxiliary loss cost rate of stage one cooling equipment	\$/kW	ALCR1	6.2.3.1
Auxiliary loss cost rate of stage two cooling equipment	\$/kW	ALCR2	6.2.3.2
Auxiliary power lost in stage one cooling equipment	kW	APL1	5.5
Auxiliary power lost in stage two cooling equipment	kW	APL2	5.5
Auxiliary power loss	kW	APL	5.5
Availability factor	—	AF	6.1.2
Average hours per year for stage one cooling alone	hours (h)	AHPY1	5.5
Average hours per year for stage two cooling equipment	hours (h)	AHPY2	5.5
Booklife	years	BL	Section 4
Capital recovery factor	—	CRF	6.1.7
Carrying charge (see fixed charge rate)			
Current year energy cost	\$/kWh	CYEC	App. B
Efficiency of transmission	—	ET	6.1.1
Energy cost inflation rate	per year	EIR	A1.
Fixed charge rate (generator)	\$/\$/yr	FCRG	6.1.6
Fixed charge rate (transformer)	\$/\$/yr	FCRT	6.1.6
Fixed charge rate (transmission systems)	\$/\$/yr	FCRS	6.1.6
Generation installation cost	\$/kW	GIC	6.1.9
Increase factor	—	IF	6.1.8
Levelized auxiliary energy cost for stage one	\$/kW-yr	LAEC1	6.1.11

Term	Unit	Symbol	Reference
Levelized auxiliary energy cost for stage two	\$/kW-yr	LAEC2	6.1.12
Levelized energy and operating cost	\$/kW-yr	LECN LECL	6.1.10 6.1.10
Levelized generation investment cost	\$/kW-yr	LGIC	6.1.9
Levelized total system investment cost	\$/kW-yr	LIC	6.1.9
Levelized transmission system investment cost	\$/kW-yr	LSIC	6.1.9
Load Loss (copper or conductor loss)	kW	LL	5.4
Load loss cost rate	\$/kW	LLCR	6.2.2
No-load loss (iron or core loss)	kW	NLL	5.3
No-load loss cost rate	\$/kW	NLLCR	6.2.1
Number of years	years	N	6.1.7
Peak-per-unit load	—	PUL	6.1.4
Peak responsibility factor	—	PRF	6.1.3
Present worth energy and operating cost	\$/kWh	PWEC	6.1.10
Rate of return	per year	ROR	6.1.7
Sum of present worth — energy and operating cost	\$/kWh booklife or \$/kW-yr booklife	SPWECH SPWECY	6.1.10 6.1.10
Transformer loading factor	—	TLF	6.1.5
Transmission system installation cost	\$/kW	SIC	6.1.9

3. Definitions

For further explanation of the following terms, see Sections 5 and 6. For definitions not found in this guide, consult IEEE Std 100-1988 [B3].¹

auxiliary power losses (APL). The power required for cooling fans, oil pumps, and other ancillary equipment.

¹ The numbers in brackets correspond to those of the Bibliography in Section 7.