Transformer K-Factor and Derating from a Harmonic Spectrum

K-factor of a non-linear load from the per-unit harmonic currents of up to six orders, and the approximate transformer derating for a standard (K-1) transformer.

Method: K-factor definition (UL 1561) and eddy-loss derating I_max = √((1 + P_EC)/(1 + K·P_EC)) (IEEE C57.110 approach)

Input parameters

Unit system: SI

Parameter	Value	Unit
Fundamental current (per unit)	1.0000	
3rd harmonic (pu)	0.050000	
5th (pu)	0.35000	
7th (pu)	0.20000	
11th (pu)	0.080000	
13th (pu)	0.060000	
Eddy-current loss share at rated load (pu of I²R)	0.10000	

Calculated results

Parameter	Value	Unit
Total rms current (pu)	1.0840	
K-factor	6.3215	
Current THD	41.833	%
Permissible load as share of rating	82.095	%

Notes for this case

• K = ΣI_h²h²/ΣI_h². Derating I_max = √((1 + P_EC)/(1 + K·P_EC)) per unit of rated rms current (IEEE C57.110 approach with P_EC from the transformer maker; 0.05–0.15 for dry types).

Formula and method

$$K = \frac{\sum I_h^2 h^2}{\sum I_h^2}, \quad I_{max} = \sqrt{\frac{1 + P_{EC}}{1 + K\,P_{EC}}}$$

Variables

I_1	Fundamental current (per unit)	-
I_3	3rd harmonic (pu)	-
I_5	5th (pu)	-
I_7	7th (pu)	-
I_{11}	11th (pu)	-
I_{13}	13th (pu)	-
P_{EC}	Eddy-current loss share at rated load (pu of I²R)	-
I_{rms}	Total rms current (pu)	-
K	K-factor	-
THD_I	Current THD	-
I_{max}	Permissible load as share of rating	-

Method and standards

K-factor and derating.

Assumptions and limits

- Only the winding eddy-current loss is scaled by K. IEEE C57.110 also scales the other stray losses (in structural parts and tank) with harmonic order to the power 0.8; for liquid-filled transformers these can be significant, so the derating here is optimistic for them.
- Only the orders listed (up to the 13th) are counted; spectra with large higher-order content give a higher K than shown.
- Listed orders only.

References

- K-factor definition (UL 1561) and eddy-loss derating I_max = √((1 + P_EC)/(1 + K·P_EC)) (IEEE C57.110 approach)

Report details

Report reference	FCC-NTSV-XKP9 (the same inputs always give the same reference)
Generated	17 November 2026, 19:44 UTC
Calculator	Transformer K-Factor and Derating from a Harmonic Spectrum
Method last reviewed	13 November 2026
Software release	FireCAD Calc, release of 17 November 2026
Release checks	2 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/power-quality/transformer-k-factor

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.