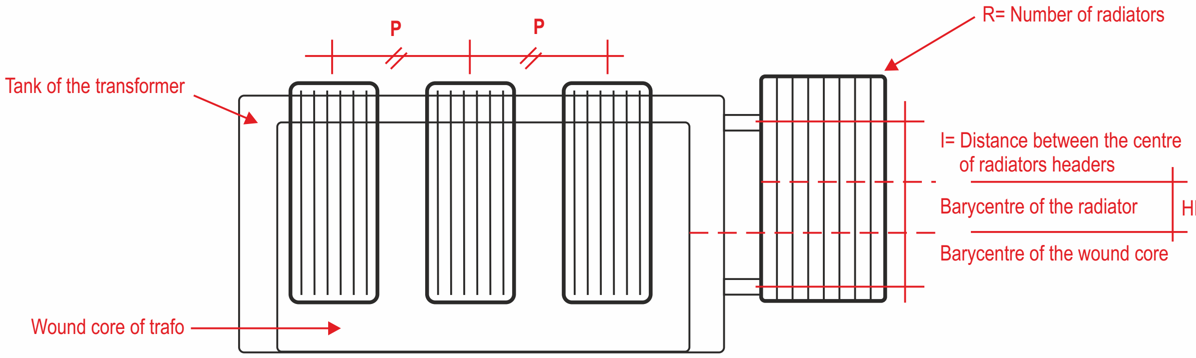
How to decide which CONVETT tubular radiator you need in the transformer

DEFINITIONS



VMAX	=	Losses to be disposed of in Watt;
TMEDIUM	=	Over temperature of medium oil in °C of the oil in the environment;
C	=	Surface in m2 of the total tank with the cover;
KF	=	Coefficient of equivalent tank surface which increases the real tank surface of 1.6 times for ONAN cooling type and of 1.8 times for ONAF cooling type;
KG	=	Coefficient of equivalent radiator surface which depends on cooling type: (1 for ONAN; 1.8 for ONAF with bottom fans, 2.4 for ONAF with side fans);
R	=	Number of radiators;
I	=	Distance between the centers of the headers in meters (radiator centre distance);
N	=	Number of elements per radiator;
KN	=	Coefficient of efficiency reduction, function of the number of elements per radiator;
P	=	Pitch between the radiators on the tank wall in meters (must be> 0.5);
KP	=	Coefficient as function of the distance between one radiator and the next on the tank wall ;
HD	=	Difference in meters between the heights of the thermal barycenter of the radiators and the barycenter of the wound core;
KDH	=	Coefficient as function of the HD difference between the thermal barycenter ;
W	=	Specific losses in W/m².

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RADIATORS CHARATERISTICS

HEIGHT (I) m	SURFACE (S) m^2/el.	WEIGHT (G) Kg/m^2	CAPACITY (C) L/m^2
0.8	0.803	10.41	3.85
0.9	0.894	10.16	3.82
1.0	0.984	9.96	3.80
1.1	1.074	9.80	3.78
1.2	1.165	9.66	3.77
1.3	1.255	9.54	3.75
1.4	1.346	9.45	3.74
1.5	1.436	9.36	3.73
1.6	1.526	9.29	3.72
1.7	1.617	9.22	3.72
1.8	1.707	9.16	3.71
1.9	1.798	9.12	3.71
2.0	1.889	9.06	3.70
2.1	1.978	9.02	3.70
2.2	2.069	8.98	3.69
2.3	2.159	8.94	3.69
2.4	2.250	8.91	3.68
2.5	2.340	8.88	3.68
2.6	2.430	8.85	3.68
2.7	2.521	8.83	3.67
2.8	2.611	8.80	3.67
2.9	2.702	8.78	3.67
3.0	2.792	8.76	3.66
3.1	2.882	8.74	3.66
3.2	2.973	8.72	3.66
3.3	3.063	8.71	3.66
3.4	3.154	8.69	3.66
3.5	3.244	8.67	3.66

$$S = (0.904 \times I) + 0.08 \quad m^2/el.$$
$$G = 9.06 + 0.9 \times (2 - I)/I \quad Kg/m^2$$
$$C = 3.7 + 0.1 \times (2 - I)/I \quad L/m^2$$

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DIAGRAM RADIATOR DISSIPATION

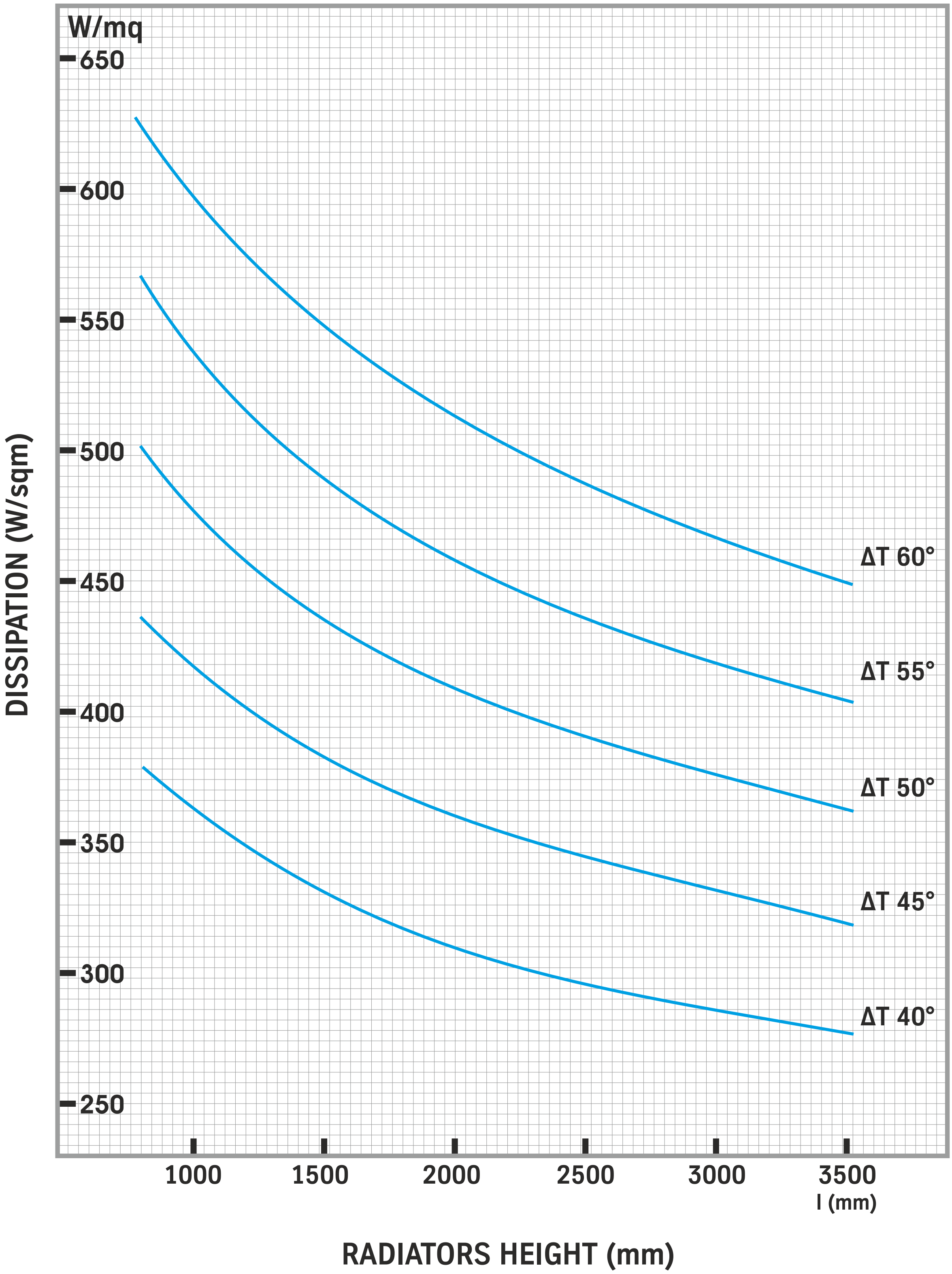

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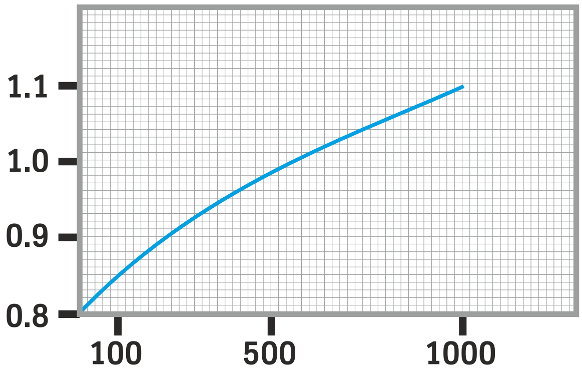
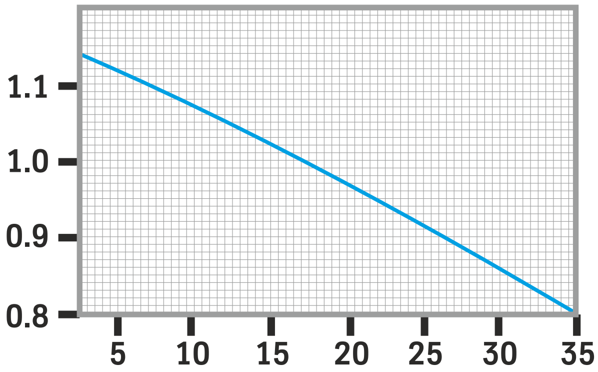
Diagram KDH, KN, KP

COEFFICIENT **KDH**



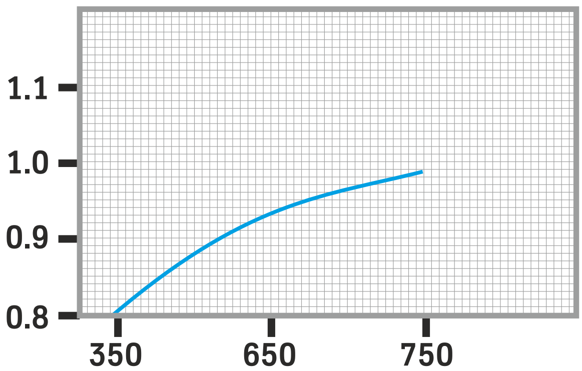
KDH coefficient where **HD** is the difference in height between the nucleus center line and radiator

COEFFICIENT **KN**



KN coefficient where **N** is the number of elements for each radiator

COEFFICIENT **KP**



KP coefficient where **P** is the difference between center of adjoining radiators (pitch)

The global coefficient will be **KT= KDH x KP x KN**

For ONAF cooling the efficiency increases by approximately 80%, with 4 m/s air speed and pressure of electric fan at 10 mm. water

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INSTRUCTION

1.Calculate the surface **S** for each element (in m²) as a function of I by looking at the table "radiators characteristics"
2.Extrapolate the value of the three coefficients KN, KP, and KDH from the charts above represented "**Diagram KDH, KN, KP**"
3.Calculate the total coefficient **KT** as the sum of : **KT = KN x KP x KDH**
4.Then calculate **W = WMAX / (KG x R x S x N x KT + KF x C) [W/m²]**

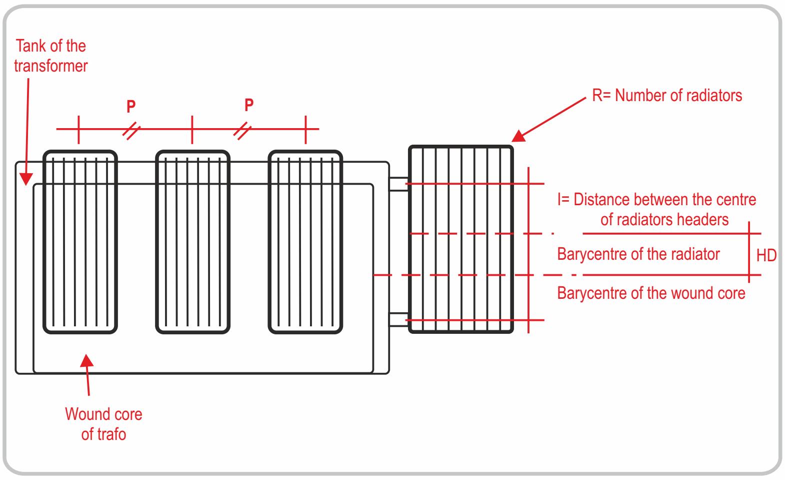
1.From the "diagram radiator dissipation" it is possible to calculate the value of **DT** as a function of **W** and of **I**. In this way you can check whether you have made the correct choice of the number of radiators, of elements per radiator and of the radiator height. In fact it will be necessary to have: **DT < TMEDIUM** with the respective safety margin.
2.If the radiators **R** do not have the same I and/or if part of the N elements is lowered and if their pitch **P** is not the same for all the radiators, the product (**R x N x S**) will be replaced by the summation (**Ri x N i x S i**) and the **KN, KP** and **KDH** values will be weighted averages.
3.Note also that the oil circulation is influenced not only by the position and type of radiator (see coefficients **KDH, KN, KP**) but also by the constructive type of winding. We therefore advise each constructor to check the results obtained during testing so as to foresee any further correction factor linked exclusively with his own system of transformer operation
4.The "specific dissipation" diagram Click shows the values in **W/m²** referred to the overtemperature of the medium oil, in particular the value of 40°C, 45°C, 50°C, 55°C, 60°C. To obtain the different **DT** oil values, use the following formula:

$$K = \frac{t}{T} \times \left(\frac{t}{T}\right)^{0,25}$$

Where: **t** = desired temperature **T** = temperature of the reference curve
You must then correct the dissipation with the new coefficient of correction: **WATT / m2 x K = WATT / m²** (at "**t**" temp.)

EXAMPLE OF ONAN TRAFO
with lowered radiators as in the respective drawing

Wmax = 190 kW
TMED = 41.5°C
C = 41.62 m²
KF = 1.6
KG = 1
R = 14
I = 1.8 m
EI =0.3 m
P = 0.8 m from which KP = 1
HD = 0.57 m from which KDH = 0.992



From the "radiator diagram dissipation": for T = 40 OC / I+EI = 2.1m -------------> W/m² 310

Where: **I + EI** is the height of normal elements.
As **DT** is different from **TMED**, we must correct the read value with the formula on the previous page: **K** = (41.5/40)1.25 = 1.05
Therefore: **W/m2 = 310 x 1.05 = 326**
The total surface of dispersion **St** is given by: **St = 190.000 / 326 = 582.8 m²**
subtracting the tank contribution: **KF x C = 1.6 x 41.62 =66.8 m²**

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So the equivalent surface of the radiators will be: **Sr = 582.8 - 66.8 = 516 m²**

Therefore with the known symbols: **Sr = KDH x KP x R x S x N x K**

replacing: **516= 0.992 x 1 x 14 x 1.978 x N x KN**

hence: **N x KN = 516 / (0.992 x 1 x 14 x 1.978) =18.78**

We can round this off to 20 elements in order to have a certain margin:

for **N = 20** ---------> **KN = 0.96**

As the first two elements are lowered, it is correct to calculate the mean pondered surface of the element, that is:

S' = (2 x 1.707 + 18 x 1.978)/20 = 1.95

Replacing **S'** for **S** in **W** = **WMAX / (KG x R x S x N x KT + KF x C)**

we obtain: **W** = **WMAX / (KG x R x S' x N x KT + KF x C)**

where: **KT = KN x KP x KDH = 0.96 x 1 x 0.992 = 0.952**

Replacing: **W = 190000/ (1x14x1.95x20x0.952x20x0.952+66.8) = 323.8**

which is about the same as the value read on the curves and later corrected with the medium oil real overtemperature.

The real surface of the radiators is: **14 x 20 x 1.95 = 546 m²**

As a calculation made for the same conditions with stamped plate radiators gives a real surface of radiators of 773 m², the percent difference between both solutions is therefore:

(773 - 546) / 773 x 100 = 29.4%

We can conclude that, in this case, the surface saving is about 30%.

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