Transformers sizing

Which transformer for which circuit ?

Each circuit needs a specific transformer output: transformer sizing But, to size an equipment transformer it is not enough to add up the powers of the operating circuits, the permissible instantaneous power must be considered (inrush power)

How to calculate a transformer's power and size?

For equipment including automatic devices, transformer's power depends on:
- The max. power needed at a given moment (inrush power)
- Constant power absorbed by the circuit
- Voltage drop
- Power factor

1) Determining the inrush power

To determine the inrush power, we make the following assumptions:
- Two inrushes cannot occur at the same time
- Power factor cos φ 0.5 at closing
- Max. 80 % of devices power supplied at the same time

Empirically and to simplify, this power can be calculated using the following formula:

P inrush = 0.8 (Σ Pm + Σ Pv + Pa)

Σ Pm: sum of all contactors holding powers
Σ Pv: sum of all indicators light powers
Pa: inrush power of the largest contactor

Example :

A machine tool control cabinet contains :
- 10 contactors for 4-kW motors, holding power 8 VA
- 4 contactors for 18.5-kW motor, holding power 20 VA
- 1 contactor for 45-kW motor, holding power 20 VA, inrush power 250 VA cos φ 0.5
- 25 remote control relays, holding power 4 VA
- 45 signalling lights, consumption 1 VA

Σ Pm = 10 x 8 VA = 80 VA
4 x 20 VA = 80 VA
1 x 20 VA = 20 VA
25 x 4 VA = 100 VA
280 VA

Σ Pv = 45 x 1 VA = 45 VA
Pa = 250 VA

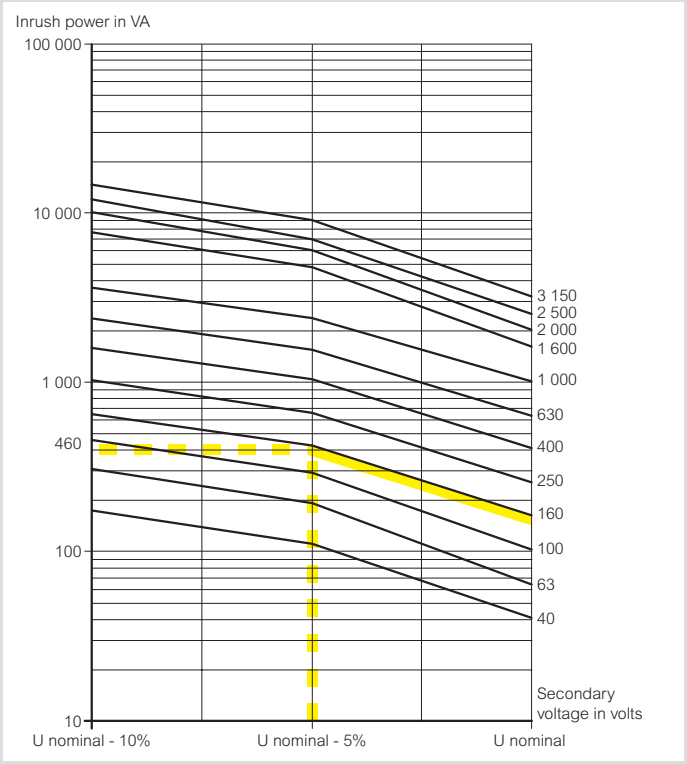
P inrush = 0.8 (280 + 45 + 250) = 460 VA at cos φ 0.5

2) Determining the transformer's size

Especially for control transformers, just read the size below from the inrush power at cos φ 0.5:

Nominal power VA IEC and CSA	Permissible instantaneous power VA IEC/EN 61558-2-2 with cos φ of :								
	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
40	90	80	72	66	61	57	53	51	53
63	160	140	130	120	110	100	90	90	90
100	210	190	170	160	150	140	130	130	140
160	480	400	350	300	270	240	220	200	190
250	830	690	590	510	450	400	360	330	310
400	1600	1400	1200	1000	900	800	800	700	700
630	2000	1800	1500	1400	1200	1100	1100	1000	1000
1000	5400	4600	4000	3600	3200	3000	2700	2600	2500
1600	9000	8000	7200	6600	6100	5700	5400	5300	5600
2500	7300	6600	6000	5700	5200	4900	4700	4600	5100
4000	34500	28800	24400	17000	16600	16400	14800	13400	12400
5000	29000	23000	20000	17000	16000	14000	13000	12000	12000
6300	20000	18000	17000	16000	15000	15000	15000	15000	18000
8000	45000	39000	35000	32000	30000	28000	27000	26000	29000

Inrush power of 460 VA at cos φ 0.5 entails minimum size of 250 VA



For power of 460 VA cos φ 0.5, the curve at U nominal - 5 %* indicates a value of 160 VA
* Value deliberately selected as a precaution

3) Checking the choice

Make a check according to each piece of equipment:
- calculate the total sum of the holding powers of the windings and of the live indicator lights
- then apply a factor: either that of 80 % of devices held live at the same time, or that from the actual calculations for your equipment

The sizing power must be equal to or more than the result of this calculation

Rule for determining the secondary protection rating :

To check that the device chosen is suitable, an approximate minimum short-circuit value at the furthest point of the installation can be obtained using the following formula:

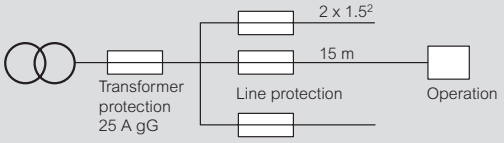
$$I\ c/c\ mini = \frac{Us}{\left(\frac{U^2s}{P} \times \frac{U\ c/c\ \%}{100}\right) + \frac{2\rho l}{S}}$$

Us = transformer secondary voltage
P = transformer power
U c/c % = transformer short-circuit voltage
l = line length in m
S = line cross-section in mm²
ρ copper = 0.027 Ω mm²/m

Choose the protection rating so as to obtain a cut-off time of 5" max. for the current I c/c defined above :

gG fuse : $In \leq \frac{I\ c/c\ min.}{4}$ type C MCB: $In \leq \frac{I\ c/c\ min.}{8}$

Example : control transformer 630 VA - 230/24 V Cat.No 0 442 17



$$I\ c/c\ min. = \frac{24}{\left(\frac{24^2}{630} \times \frac{3.7}{100}\right) + \frac{2 \times 0.027 \times 15}{1.5}} = 41.82\ A$$

$\frac{41.82}{4} = 10.45$ --> gG 10 A max. $\frac{41.82}{8} = 5.22$--> DX 5 A max. C.curve