



POWER BALANCE CONDUCTORS DIMENSIONING

TERMS

- power balance
 - summary of el. energy demands in a building
- installed (rated) power P_i
 - maximal consumed el. energy
- contemporary power (calculational loading)
 P_v
 - real loading
 - respects relative loading of consumers connected simultaneously

CALCULATIONAL LOADING

- determines:
 - supplying source size
 - conductors design for distribution
 - switching devices powers
 - measuring and protective apparatuses powers
(protection setting)
 - compensation devices size
- necessary to distinguish solution range:
 - one consumer?
 - industrial site, city part, flats housing estate?

DEMAND COEFFICIENT

- source design must result from a reality:
 - a low probability that all consumers in a group work at the same time
 - a very low probability that these consumers are operated with the full rated power at the same time
- simultaneousness coefficient
 - ratio of simultaneously connected consumers power and the total rated power

$$k_s = \frac{\sum P_{is}}{\sum P_i}$$

DEMAND COEFFICIENT

- loading capacity coefficient
 - relative loading of simultaneously connected consumers in the group

$$k_z = \frac{\sum P_s}{\sum P_{ns}}$$

- demand coefficient
 - determines real loading

$$\beta = \frac{k_s \cdot k_z}{\eta_m \cdot \eta_s}$$

consumers efficiency for
given utilization

supplying system
efficiency

CALCULATIONAL LOADING

- homogenous consumers group
 - consumers of comparable powers:
$$P_s = \beta \cdot P_i = \beta \cdot \sum P_n$$
 - P_V : calculational loading (real maximum of the whole n-consumer group)
- non-homogenous consumers group
 - mainly consumers which differ significantly (of the order) from the others
 - check-up for three biggest consumers

$$P_s = a \cdot P_x + b \cdot P_i$$

CALCULATIONAL LOADING (FLATS)

- demand coefficient for flats group

$$\beta_n = \beta_\infty + \frac{(1 - \beta_\infty)}{\sqrt{n}}$$

flats in the group n	β	flats in the group n	β	flats in the group n	β
2	0,77	13	0,42	24	0,36
3	0,66	14	0,41	25	0,36
4	0,60	15	0,41	26	0,36
5	0,56	16	0,40	27	0,35
6	0,53	17	0,39	28	0,35
7	0,50	18	0,39	29	0,35
8	0,48	19	0,38	30	0,35
9	0,47	20	0,38	40	0,33
10	0,45	21	0,37	50	0,31
11	0,44	22	0,37	80	0,29
12	0,43	23	0,37	100	0,28

CALCULATIONAL LOADING (DTS)

- cable outlet loading from DTS:

SP5 number in an outlet	demand coef. β_n	SP5 number in an outlet	demand coef. β_n
2	0,75	11	0,41
3	0,64	12	0,40
4	0,58	13	0,39
5	0,53	14	0,38
6	0,50	15	0,37
7	0,47	16-17	0,36
8	0,45	18-19	0,35
9	0,43	20	0,34
10	0,42		

- for flats (houses) with el. heating (convector, accumulation) must be $\beta_n = 0,7 \div 0,9$

CALC. LOADING (non-flats)

- standard non-flat consumptions:
 - medical institutions:

P_i (kW)	P_{maxn}=f(sur)	surgeries	5	10	20	30	40
3,5/sur	2,5.sur	P _{maxn} (kW)	12,5	25	50	75	100

- restaurants:

P_i (kW)	P_{maxn}=f(pl)	places	50	100	150	200	250
0,5/places	0,4.pl	P _{maxn} (kW)	20	40	60	80	100

- hotels:

P_i (kW)	P_{maxn}=f(b)	beds	100	250	500	750	1000
0,7/bed	0,5.b	P _{maxn} (kW)	50	125	250	375	500

CALCULATIONAL CURRENT

- 3ph consumption:

$$I_s = \frac{1000 \cdot P_s}{\sqrt{3} \cdot U_{3S} \cdot \cos \varphi} \quad (\text{A})$$

- 1ph consumption :

$$I_s = \frac{1000 \cdot P_s}{U_f \cdot \cos \varphi} \quad (\text{A})$$

- DC consumption :

$$I_s = \frac{1000 \cdot P_s}{U} \quad (\text{A})$$

EX.: BLOCK OF FLATS

Block of flats power balance:

- flat units
- non-flat units
- common object consumption

Objekt X	Instalovaný příkon P_i (kW)	Soudobost β (-)	Soudobý příkon P_s (kW)
25× bytová jednotka (kat. B, á 11,0 kW)	275	0,36	99
2× nebytový prostor (á 7 kW)	14	0,77	11
1× společná spotřeba objektu	10	0,6	6
1× provozovna restaurace (vč. gastroprovozu)	63	0,6	38
Celkem (kW)	362		154

Meziskupinová soudobost:

$\beta = 0,85$

Maximální soudobý příkon:

130 kW

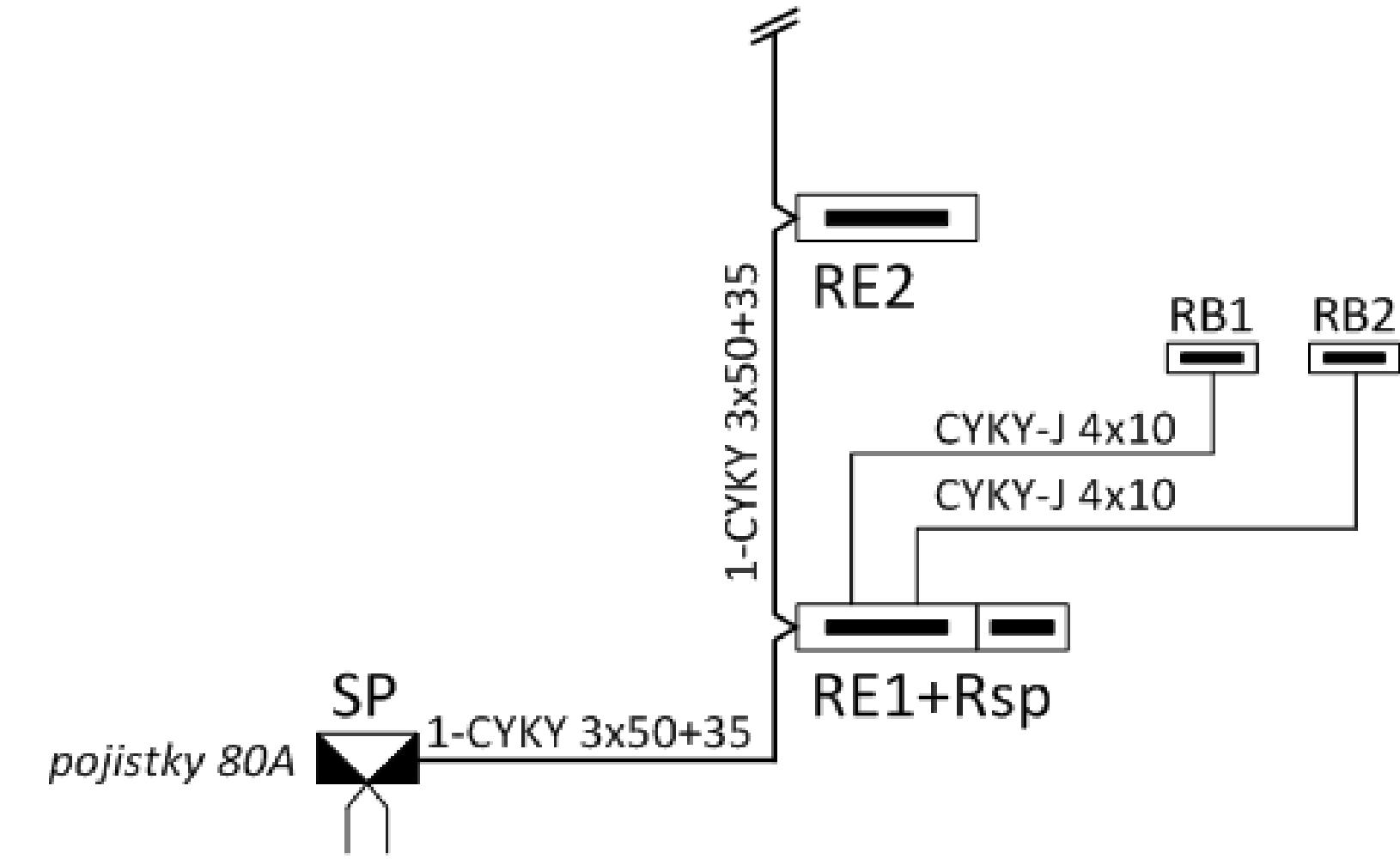
Pojistky osazené v připojkové skříni:

315 A

POWER DISTRIBUTION

- base for el. distribution dimensioning:
 - calculational loading P_v
 - calculational current I_v
 - voltage drop $\Delta U\%$

HOUSE MAIN LINE



HOUSE MAIN LINE (HML)

- full core insulated (single phase) conductors, alt. cables, are used for HML
- HML cross-section is chosen with respect to the expected load (calculational loading)
- HML cross-section must ensure that conductors allowed current is lower than calc. loading
- HML is protected in a connection cabinet, alt. in the main switchgear
- HML must be place and realized so that:
 - unauthorized consumption is more difficult
 - its change is possible without construction activities

CABLES FOR HML

- full-plastic cables 1-YY

Core number and cross-section (mm ²)	Diameter (mm)	Bending radius (mm)	Loading capacity (A)	
			Air	Ground
1x25	12	180	144	208
1x35	13	200	176	250
1x50	14	215	214	296
1x70	16	240	270	365
1x95	18	270	334	438
1x120	19	300	389	501
1x150	21	315	446	563
1x185	24	360	516	639

CABLES FOR HML

- full-plastic cables 1-CYKY

Core number and cross-section (mm ²)	Diameter (mm)	Bending radius (mm)	Loading capacity (A)	
			Air	Ground
3x25+16	27	325	105	188
3x35+16	27	330	129	159
3x50+25	29	350	157	188
3x70+35	32	390	199	232
3x95+50	36	440	246	280
3x120+70	38	470	285	318
3x150+70	42	505	326	359
3x185+95	49	590	374	406

HML DIMENSIONING

- minimal cross-sections acc. to ČSN 33 2130/Z2:

HML conductors number and cross-section (mm ²)		Flat electrification level	
Al	Cu	A	B
Flats number for HML			
4x16	4x10	≤7	≤3
4x25	4x16	8÷10	4÷5
3x35+25	3x25+16	11÷14	6÷7
3x50+35	3x35+25	15÷19	8÷10
3x70+50	3x50+35	20÷26	11÷14
3x95+70	3x70+50	27÷32	15÷19
	3x95+50	33÷46	20÷27

CONDUCTORS DIMENSIONING

- Design:
 - conductor type choice
 - for given environment
 - for given conditions
 - conductor placement type
 - conductor cross-section determination
 - for given power
 - for given placement

CONDUCTORS DESIGN PRINCIPLES

- operational conductor temperature in allowed limits
- economical cross-section
- sufficient mechanical strength
 - rated loading
 - assembly
- voltage drop on conductors in allowed limits
- endurance against short-circuit currents impacts

1) Allowed operational temperature

- the highest conductor temperature for permanent operation
- influences on conductor temperature:
 - current loading
 - ambient temperature
 - direct solar radiation
- rated current-carrying capacity I_{NV} :
 - permanent current loading value for basic placement type

1) Allowed operational temperature

- basic conductor placement type:
 - horizontal, in a calm air with temperature 30°C
 - horizontal, in the ground with thermal resistivity 0,7 K.m.W⁻¹, in the depth 70 cm with soil temperature 20°C
- allowed current loading I_{DOV} (for the worst heat conditions along the power line):

$$I_{DOV} = (k_1 \cdot k_2 \cdot \dots \cdot k_n) \cdot I_{NV}$$

- conductor cross-section determination acc. to operational temperature: $A \geq \frac{I_{DOV}}{J}$

1) Allowed operational temperature

- cable dimensioning acc. to loading and placement:

Průřez kabelu	Způsob uložení kabelu**)			
	A	B	C	D
	Ip (A)			
1,5	10	10	10	25
2,5	16	16	16	32
4	20	25	25	40
6	32	32	32	50
10	40	40	40	63
16	50	63	50	80
25	63	80	63	125
35	80	100	80	125
50	100	125	100	160
70	125	160	125	200
95	160	200	160	250
120	160	225	200	315

**) placement:

A – in the insulating wall

B – in a tube on the wall

C – on the wall

D – in the ground

2) Economical cross-section

- conductor cross-section should ensure that the conductor is not loaded during operation with a higher current than corresponding the economical current density
- **full losses time** τ_z – time for generating year power losses if loading with the maximal current
- for economical cross-section (for $\tau_z > 1000$ hour/year and lifetime min 10 year):

$$A = k \cdot I_v \cdot \sqrt{\tau_z}$$

3) Voltage drop

- calculated for given cross-section and length
- conductor loading results in voltage drops, dependent on conductor parameters and loading current size (important mainly for radial power lines)
- voltage drop:

- 1ph system: $\Delta U = \frac{2 \cdot \rho \cdot l}{A} \cdot I \cdot \cos \varphi = \frac{2 \cdot \rho \cdot l}{A} \cdot \frac{P}{U_f}$

- 3ph system: $\Delta U = \frac{\sqrt{3} \cdot \rho \cdot l}{A} \cdot I \cdot \cos \varphi = \frac{\rho \cdot l}{A} \cdot \frac{P}{U_s}$

3) Voltage drop

- allowed voltage drops:
 - between connection cabinet and home switchgear (behind electrometer):
 - light and mixed consumption: 2 %
 - other consumptions: 3 %
 - from home switchgear to consumers:
 - light circuits: 2 %
 - heaters and cookers circuits: 3 %
 - other circuits: 5 %

4) Conductors mechanical strength

- mechanical strain endurance during assembly and different operation conditions
- conductors in buildings are (besides assembly) only under mutual forces → we choose minimal cross-section for conductors up to 1 kV
- for overhead lines MV and HV: ACSR conductors (different ratio of Al coat and steel core) – acc. to climatic conditions (wind speed, frost, conductor weight)

5) Short-circuit endurance

- short-circuit currents can be multiple higher than rated currents
- short-circuit currents impacts:
 - mechanical (dynamic) – mainly at tightly placed stiff conductors
 - heat – mainly at freely placed or hanged-up conductors

5) Short-circuit endurance

- s.-c. currents mechanical impacts:

- force between 2 conductors: $F = B \cdot I \cdot l \cdot \sin\alpha$

- el. field intensity in the distance x from the conductor:

$$H = \frac{I}{2 \cdot \pi \cdot x}$$

- max. force perpendicularly to the conductor axis:

$$F = \mu_0 \cdot \frac{I}{2 \cdot \pi \cdot x} \cdot I \cdot l = 2 \cdot 10^{-7} \cdot \frac{I^2}{x} \cdot l$$

- max. force per 1 meter length:

$$f_K = 2 \cdot k_1 \cdot k_2 \cdot 10^{-7} \cdot \frac{I_{KM}^2}{x}$$

5) Short-circuit endurance

- s.-c. currents heat impacts :
 - they are given by s.-c. currents changing in time during the s.-c. duration time
 - heat produced in the conductors: $Q = f(R(T), i_k^2(t))$
 - s.-c. current can be replaced by thermal equivalent current I_{Ke} :
- conductor cross-section satisfying heat strain

$$A = \frac{I_{Ke} \cdot \sqrt{t_K}}{K}$$