

Ny utgave 2010

Vg2 elektro

Teori med  
praktiske  
øvinger

Kunnskaps-  
løftet

Svein Johnsen

# Elektriske anlegg

## Vg2 elenergi

*ELFORLAGET*

# Illustrasjoner til Elektriske anlegg Vg2 elenergi

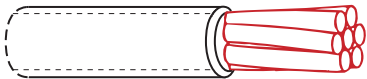
## Kapittel 3

Illustrasjonene kan brukes fritt i undervisningen

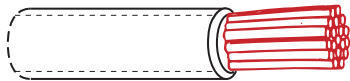
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Helkjernet



Flertrådet

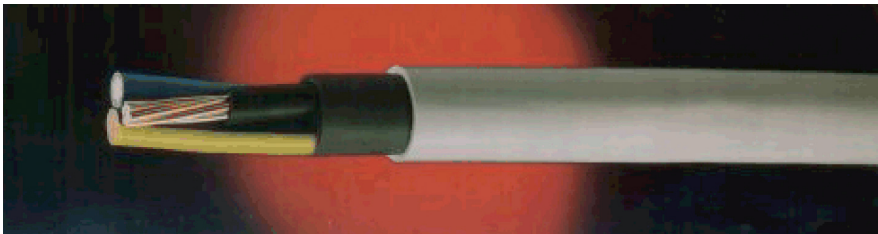


Mangetrådet

*Figur 3.1*

0,5 mm <sup>2</sup>	0,75 mm <sup>2</sup>	1,0 mm <sup>2</sup>	1,5 mm <sup>2</sup>	2,5 mm <sup>2</sup>	4 mm <sup>2</sup>
6 mm <sup>2</sup>	10 mm <sup>2</sup>	16 mm <sup>2</sup>	25 mm <sup>2</sup>	35 mm <sup>2</sup>	50 mm <sup>2</sup>
70 mm <sup>2</sup>	95 mm <sup>2</sup>	120 mm <sup>2</sup>	150 mm <sup>2</sup>	185 mm <sup>2</sup>	240 mm <sup>2</sup>

*Figur 3.2*



*Figur 3.3 PFXP-kabel*

## System for oppbygging av typebetegnelse



### Bestemmelsens status

A: Autorisert nasjonal type  
 H: Harmonisert type  
 NO - N: Nasjonal type som ikke er autorisert (NO = Norge)

### Merkespenning U<sub>0</sub>/U

01: 100/100 V  
 03: 300/300 V  
 05: 300/500 V  
 07: 450/750 V  
 1: 0,6/1 kV  
 3: 1,7/3 kV  
 6: 3,5/6 kV  
 10: 6/10 kV  
 20: 12/20 kV

### Isolasjonsmateriale

B: EPDM-gummi  
 E: PE  
 R: Natur- eller kunstgummi  
 S: Silikongummi  
 V: PVC  
 V2: PVC for temperatur > 70° C  
 X: PEX  
 Z: Halogenfri, kryssbundet  
 Z1: Halogenfri termoplast

### Metallkappe

A5: Aluminiumbånd  
 C: Konsentrisk kobberskjerm

### Kappemateriale (ikke metallisk)

B: EPDM-gummi  
 E: PE  
 G: EVA gummi  
 N: Polykloropren (neopren)  
 R: Natur- eller kunstgummi  
 S: Silikongummi  
 T: Tekstiltetting  
 V: PVC  
 Q: Polyuretan  
 Z1: Halogenfri termoplast

### Ledertverrsnitt

#### Jordleder

G: En av lederne har gul/grønn isolasjon  
 X: Ingen av lederne har gul/grønn isolasjon

#### Antall ledere

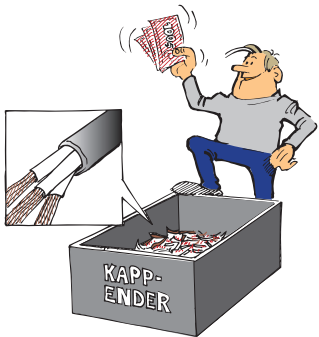
#### Leder

AR: Flertrådet, rund aluminium  
 AS: Flertrådet, sektorformet aluminium  
 AU: Entrådet, rund aluminium  
 F: Mangetrådet bevegelig kabel  
 H: Ekstra mangetrådet bevegelig kabel  
 K: Mangetrådet, fast installasjon  
 R: Flertrådet, rund  
 S: Flertrådet, sektorformet  
 U: Entrådet, rund  
 W: Entrådet, sektorformet

#### Spesiell oppbygging

D4: Selvbærende kabel hvor lederne er bæreelement  
 D8: 8-talls form med stål bæreline  
 H: Flat delbar ledning eller kabel  
 H2: Flat, ikke delbar ledning eller kabel



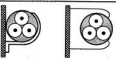



Figur 3.4









*Figur 3.5*

Tabell 52A-2- Oversikt over installasjonsmetoder med instruksjoner for å finne strømføringsevne

MERKNAD - Illustrasjonene er ikke beregnet på å vise aktuelle produkter og installasjonspraksis, men ment for å indikere den beskrevne metoden.

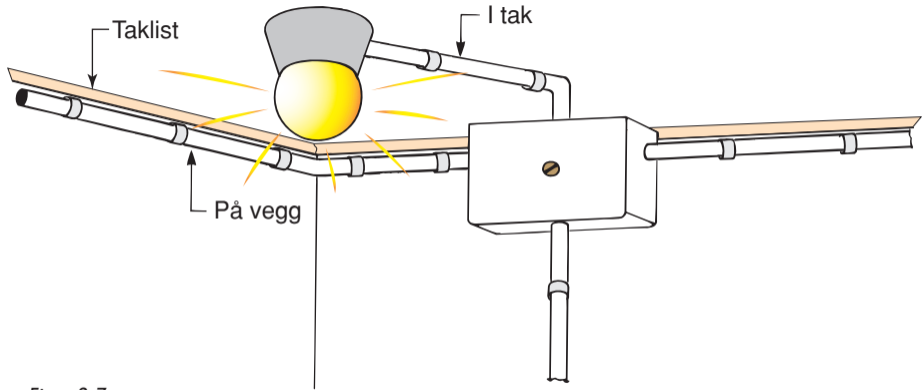
Nr.	Installasjonsmetode	Beskrivelse	Referanseinstallasjonsmetode som benyttes for å finne strømføringsevne (se Tillegg 52A)
1	2	3	4
1	 Rom	Isolerte ledere eller enleder-kabler i rør i en termisk isolert vegg <sup>1)</sup>	A1
2	 Rom	Flerleder-kabler i rør i en termisk isolert vegg <sup>1)</sup>	A2
20		En- eller flerleder-kabler: - forlagt på eller mindre enn 0,3 x kabelens diameter fra en trevegg	C
21		- festet direkte under et tak/himling av tre	C, nr. 3 i Tabell 52A-17
22		- i avstand fra et tak/himling	under overveieelse
73		Enleder- eller flerleder-kabler forlagt direkte i jord: Med tilleggsbeskyttelse mot mekanisk skade <sup>2)</sup>	D

Tabell 52B-1 - Oversikt over referanseinstallasjonsmetoder

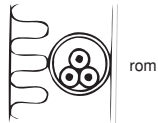
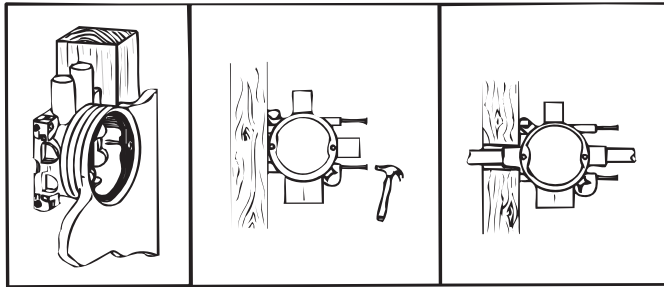
Referanseinstallasjonsmetoder		Tabell og kolonne							Omgivelses-temp.-faktor	Gruppeduk-sjons-faktor
		Strømføringsevne for enkle kurser								
		PVC isolert		PEX / EPR isolert		Mineral isolert				
1	2	2- leder	3- leder	2- leder	3- leder	1, 2 og 3-leder	8	9		
 Rom	Isolerte ledere i rør i en termisk isolert vegg	A1	Tabell 52A-2 kol. 2	Tabell 52A-4 kol. 2	Tabell 52A-3 kol. 2	Tabell 52A-5 kol. 2	-	Tabell 52A-14	Tabell 52A-17	
 Rom	Flerleder-kabel i rør i en termisk isolert vegg	A2	Tabell 52A-2 kol. 3	Tabell 52A-4 kol. 3	Tabell 52A-3 kol. 3	Tabell 52A-5 kol. 3	-	Tabell 52A-14	Tabell 52A-17	
	Isolerte ledere i rør på en trevegg	B1	Tabell 52A-2 kol. 4	Tabell 52A-4 kol. 4	Tabell 52A-3 kol. 4	Tabell 52A-5 kol. 4	-	Tabell 52A-14	Tabell 52A-17	
	Flerleder-kabel i rør på en trevegg	B2	Tabell 52A-2 kol. 5	Tabell 52A-4 kol. 5	Tabell 52A-3 kol. 5	Tabell 52A-5 kol. 5	-	Tabell 52A-14	Tabell 52A-17	
	En- eller flerleder-kabel montert på en trevegg	C	Tabell 52A-2 kol. 6	Tabell 52A-4 kol. 6	Tabell 52A-3 kol. 6	Tabell 52A-5 kol. 6	70 °C skjerm Tabell 52A-6 105 °C skjerm Tabell 52A-7	Tabell 52A-14	Tabell 52A-17	
	Flerleder-kabel i en kabelkanal i jord	D	Tabell 52A-2 kol. 7	Tabell 52A-4 kol. 7	Tabell 52A-3 kol. 7	Tabell 52A-5 kol. 7	-	Tabell 52A-15	Tabell 52A-19	

Figur 3.6

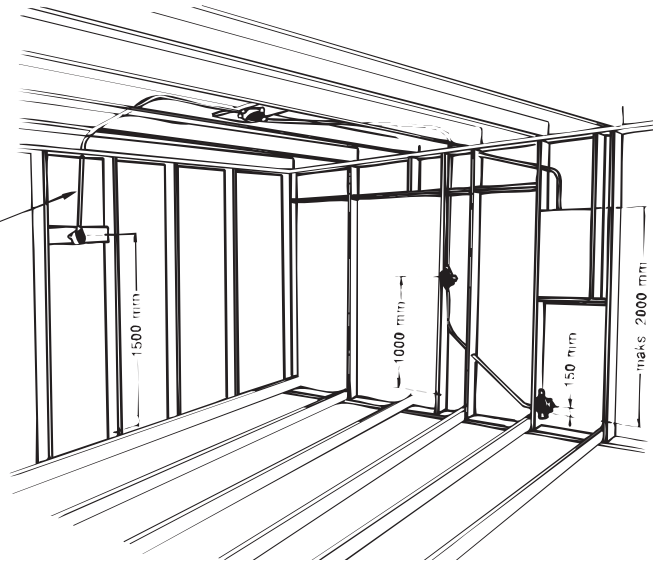




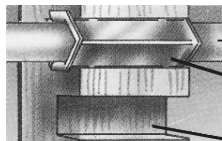
Figur 3.7



Isolerte ledere  
i rør i isolert  
vegg, tak eller  
gulv.



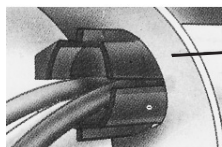
Figur 3.8



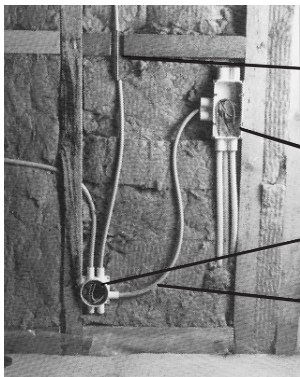
PFXP

Kabelbeskytter

Utfreset spor i stender



Detalj av strekkavlaster i boks



Kabelbeskytter mot gjennomspikring



Strekklaster holder kabelen på plass



PFXP egner seg til installasjonsmåte 51, forlegningsmåte A1 kabel direkte i isolert vegg

Figur 3.9

Tabell 52B-1 – Oversikt over referanseinstallasjonsmetoder som grunnlag for tabeller med strømføringsvevner

Referanseinstallasjonsmetoder		Tabell og kolonne							
		Strømføringsvevner for enkelte kurser					Omgivelses-temp.-faktor	Gruppe-reduksjons-faktor	
		PVC isolert	PEX / EPR isolert	Mineral isolert	2-leder	3-leder			2 og 3-leder
1	2	3	4	5	6	7	8	9	
	Isolerte ledere i rør i en termisk isolert vegg	A1	Tabell 52B-2 Kol. 2	Tabell 52B-4 Kol. 2	Tabell 52B-3 Kol. 2	Tabell 52B-5 Kol. 2	-	Tabell 52B-14	Tabell 52B-17
	Flerleder-kabel i rør i en termisk isolert vegg	A2	Tabell 52B-2 kol. 3	Tabell 52B-4 kol. 3	Tabell 52B-3 kol. 3	Tabell 52B-5 kol. 3	-	Tabell 52B-14	Tabell 52B-17
	Isolerte ledere i rør på en trevegg	B1	Tabell 52B-2 kol. 4	Tabell 52B-4 kol. 4	Tabell 52B-3 kol. 4	Tabell 52B-5 kol. 4	-	Tabell 52B-14	Tabell 52B-17
	Flerleder-kabel i rør på en trevegg	B2	Tabell 52B-2 kol. 5	Tabell 52B-4 kol. 5	Tabell 52B-3 kol. 5	Tabell 52B-5 kol. 5	-	Tabell 52B-14	Tabell 52B-17
	En- eller flerleder-kabel montert på en trevegg	C	Tabell 52B-2 kol. 6	Tabell 52B-4 kol. 6	Tabell 52B-3 kol. 6	Tabell 52B-5 kol. 6	70 °C skjerm Tabell 52B-6 105 °C skjerm Tabell 52B-7	Tabell 52B-14	Tabell 52B-17
	Flerleder-kabel i en kabelkanal i jord	D1	Tabell 52B-2 kol. 7	Tabell 52B-4 kol. 7	Tabell 52B-3 kol. 7	Tabell 52B-5 kol. 7	-	Tabell 52B-14	Tabell 52B-19
	Skjermet enleder eller flerleder-kabel direkte i jorden	D2	Tabell 52B-2 kol. 8	Tabell 52B-4 kol. 8	Tabell 52B-3 kol. 8	Tabell 52B-5 kol. 8	-	Tabell 52B-14	Tabell 52B-19

Tabell 52B-14 – Anvendelse

Omgivelsestemperatur * °C
10
15
20
25
35
40
45
50
55
60
65
70
75
80
85
90
95

Tabell 52A-1 – Oversikt over referanseinstallasjonsmetoder

Referanseinstallasjonsmetoder		Tabell og kolonne							
		Strømføringsvevner for enkelte kurser					Omgivelses-temp.-faktor	Gruppe-reduksjons-faktor	
		PVC isolert	PEX / EPR isolert	Mineral isolert	2-leder	3-leder			1, 2 og 3-leder
1	2	3	4	5	6	7	8	9	
	Isolerte ledere i rør i en termisk isolert vegg	A1	Tabell 52A-2 kol. 2	Tabell 52A-4 kol. 2	Tabell 52A-3 kol. 2	Tabell 52A-5 kol. 2	-	Tabell 52A-14	Tabell 52A-17
	Flerleder-kabel i rør i en termisk isolert vegg	A2	Tabell 52A-2 kol. 3	Tabell 52A-4 kol. 3	Tabell 52A-3 kol. 3	Tabell 52A-5 kol. 3	-	Tabell 52A-14	Tabell 52A-17
	Isolerte ledere i rør på en trevegg	B1	Tabell 52A-2 kol. 4	Tabell 52A-4 kol. 4	Tabell 52A-3 kol. 4	Tabell 52A-5 kol. 4	-	Tabell 52A-14	Tabell 52A-17
	Flerleder-kabel i rør på en trevegg	B2	Tabell 52A-2 kol. 5	Tabell 52A-4 kol. 5	Tabell 52A-3 kol. 5	Tabell 52A-5 kol. 5	-	Tabell 52A-14	Tabell 52A-17
	En- eller flerleder-kabel montert på en trevegg	C	Tabell 52A-2 kol. 6	Tabell 52A-4 kol. 6	Tabell 52A-3 kol. 6	Tabell 52A-5 kol. 6	70 °C skjerm Tabell 52A-6 105 °C skjerm Tabell 52A-7	Tabell 52A-14	Tabell 52A-17

Tabell 52A-14 Korreksjonsfaktorer for omgivelsestemperatur forskjellig fra 30 °C Anvendes for kabler forlagt i luft

Omgivelsestemperatur * °C	Isolasjon		Mineral *
	PVC	PEX eller EPR	
10	1,22	1,15	1,28
15	1,17	1,12	1,20
20	1,12	1,08	1,14
25	1,06	1,04	1,07
35	0,94	0,96	0,93
40	0,87	0,91	0,85
45	0,79	0,87	0,87
50	0,71	0,82	0,84
55	0,61	0,76	0,80
60	0,50	0,71	0,45
65	-	0,65	-
70	-	0,58	-
75	-	0,50	-
80	-	0,41	-
85	-	-	0,47
90	-	-	0,40
95	-	-	0,32

Figur 3.10

Tabell 52B-4 – Strømføringsvevner i ampere for referanseinstallasjonsmetoder i Tabell 52B-1 – PVC isolert / tre belastede ledere / kobber eller aluminium Ledertemperatur: 70 °C / Referanseomgivelsestemperatur: 30 °C i luft, 20 °C i jord

Nominelt leder-tverrsnitt mm <sup>2</sup>	Referanseinstallasjonsmetode iht. Tabell 52B-1							
	A1	A2	B1	B2	C	D1	D2	
1	2	3	4	5	6	7	8	
Kobber	1,5	13,5	13	16,5	16	17,5	18	19
2,5	18	17,5	21	20	24	24	24	24
4	24	23	28	27	32	30	33	33
6	31	29	36	34	41	38	41	41
10	42	39	50	46	57	50	54	54
16	56	52	68	62	76	64	70	70
25	73	68	89	80	96	82	92	92
35	89	83	110	99	119	98	110	110
50	108	99	134	118	144	116	130	130
70	136	125	171	149	184	143	162	162
95	164	150	207	179	223	169	193	193
120	188	172	239	206	259	192	220	220
150	216	196	262	225	299	217	246	246
185	245	223	296	255	341	243	278	278
240	286	261	346	297	403	280	320	320
300	328	298	394	339	464	316	359	359

Tabell 52B-17 – Reduksjonsfaktorer for grupper av mer enn en kurs eller for mer enn en flerleder-kabel

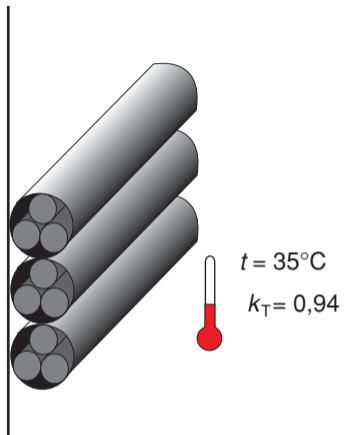
Arrangement (Kabler berører hverandre)	Antall kurser eller flerleder-kabler																Anvendelse i forbindelse med referanseinstallasjons-metode:
	1	2	3	4	5	6	7	8	9	12	16	20					
	1	0,85	0,79	0,75	0,73	0,72	0,72	0,71	0,70	0,68	0,66	0,64	0,63	0,62	0,61	0,59	

Tabell 52A-4 Strømføringsvevner i ampere for referanseinstallasjonsmetoder i Tabell 52A-1 PVC isolert / tre belastede ledere / kobber eller aluminium Ledertemperatur: 70 °C / Omgivelsestemperatur: 30 °C i luft, 20 °C i jord

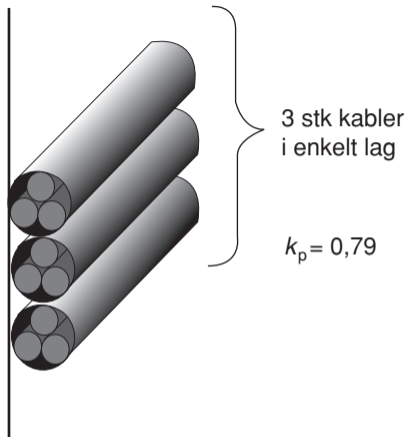
Nominelt leder-tverrsnitt mm <sup>2</sup>	Referanseinstallasjonsmetode i hht Tabell 52A-1						
	A1	A2	B1	B2	C	D	
1	2	3	4	5	6	7	
Kobber	1,5	13,5	13	15,5	15	17,5	18
2,5	18	17,5	21	20	24	24	24
4	24	23	28	27	32	32	32
6	31	29	36	34	41	39	41
10	42	39	50	46	57	52	59
16	56	52	68	62	76	67	77
25	73	68	89	80	96	86	100
35	89	83	110	99	119	103	123
50	108	99	134	118	144	122	144
70	136	125	171	149	184	151	179
95	164	150	207	179	223	179	219
120	188	172	239	206	259	203	249

Tabell 52A-17 Reduksjonsfaktorer for grupper av mer enn en kurs eller for mer enn en flerleder-kabel Anvendes for strømføringsvevner i tabellene Tabell 52A-2 til Tabell 52A-13

Arrangement (Kabler berører hverandre)	Antall kurser eller flerleder-kabler																Anvendelse i forbindelse med referanseinstallasjons-metode:
	1	2	3	4	5	6	7	8	9	12	16	20					
1 Kabler i luft i hht Tabell 52A-1	1,00	0,80	0,70	0,65	0,60	0,57	0,54	0,52	0,50	0,45	0,41	0,38	Tabell 52A-2 til Tabell 52A-13 Metoden A til F				
2 Enkelt lag på vegg, gulv eller på uferfjort bro	1,00	0,85	0,79	0,75	0,73	0,72	0,72	0,71	0,70	0,68	0,66	0,64	Tabell 52A-2 til Tabell 52A-7 Metode C				
3 Enkelt lag festet direkte under en trehimling/tak	0,95	0,81	0,72	0,68	0,66	0,64	0,63	0,62	0,61	Ingen ytterligere reduksjonsfaktor for mer enn ni kurser eller flerleder-kabler	Tabell 52A-8 til Tabell 52A-13 Metodene E og F						
4 Enkelt lag på en horisontal eller vertikal perforert bro	1,00	0,88	0,82	0,77	0,75	0,73	0,73	0,72	0,72	0,70	0,68	0,67	Tabell 52A-8 til Tabell 52A-13 Metodene E og F				
5 Enkelt lag på kabelflange, knetter eller cleats etc...	1,00	0,87	0,82	0,80	0,80	0,79	0,79	0,78	0,78	0,76	0,75	0,74	Tabell 52A-8 til Tabell 52A-13 Metodene E og F				

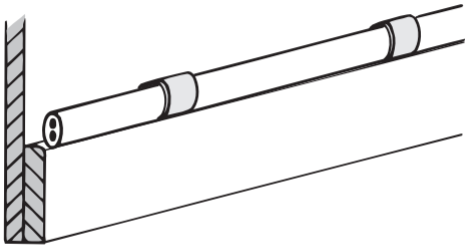


Omgivelsestemperatur  
Tabell 52 A – 14

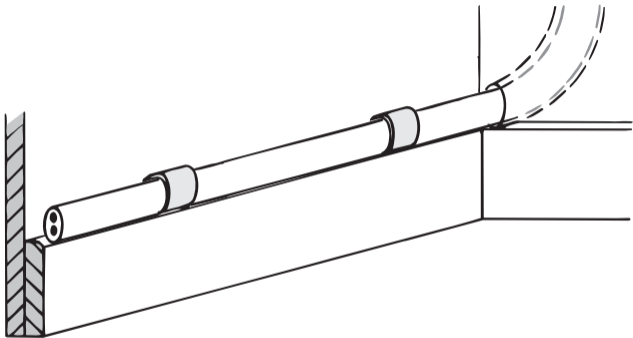


Gruppereduksjonsfaktor  
Tabell 52 A – 17

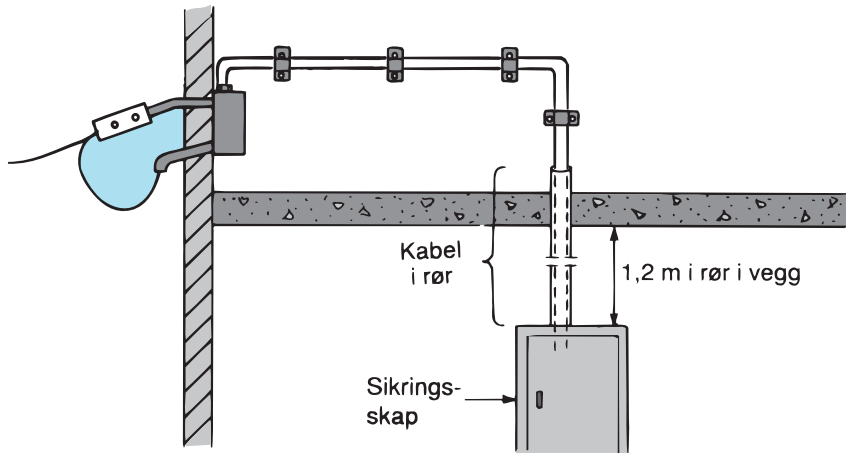
Figur 3.11



*Figur 3.12*

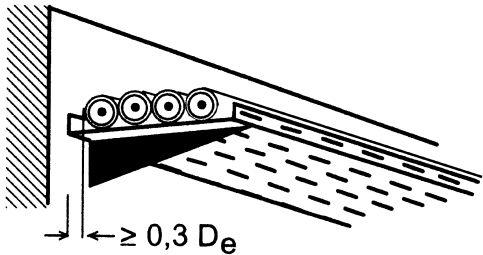


*Figur 3.13*

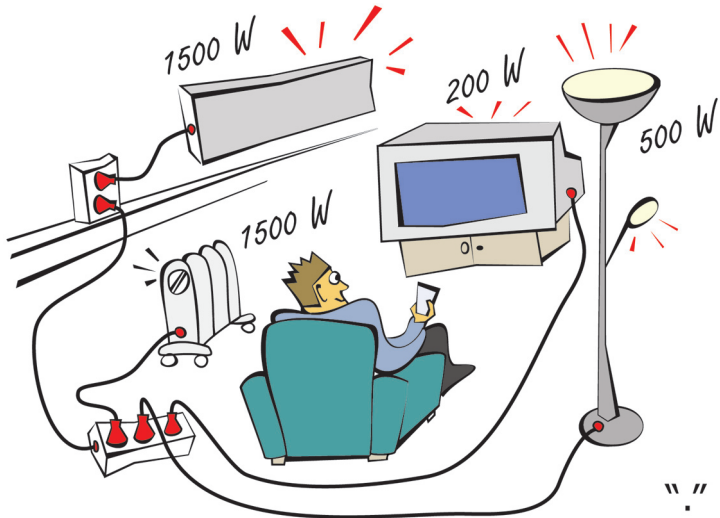


Figur 3.14

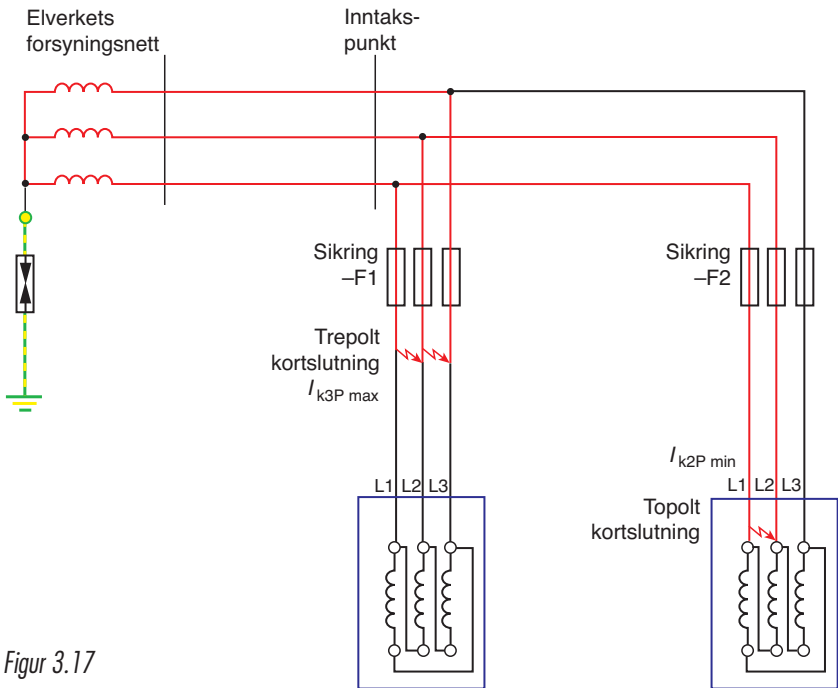




Figur 3.15 Beskyttelse mot overbelastningsstrøm og kortslutningsstrøm



Figur 3.16



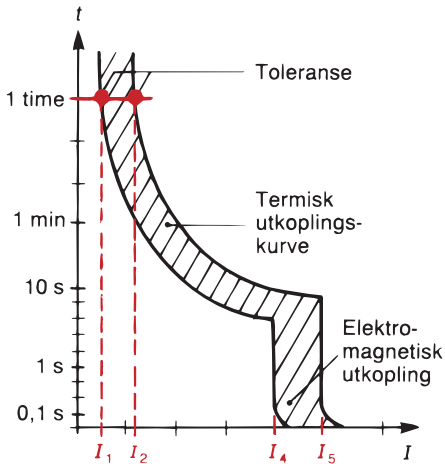
Figur 3.17



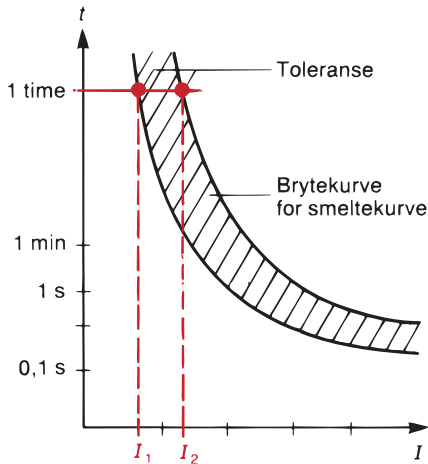
*Figur 3.18 Automatsikring*



*Figur 3.19 Høeffektsikring*

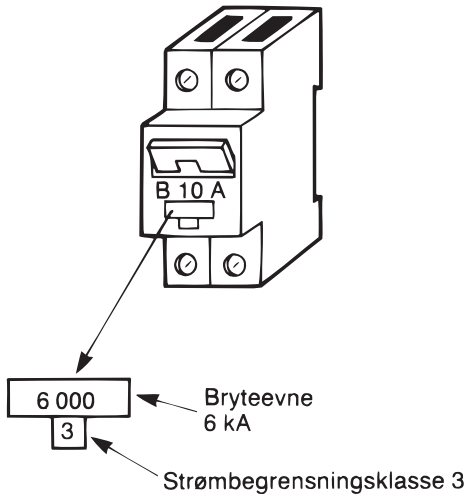
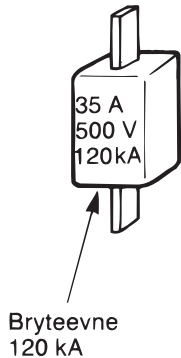
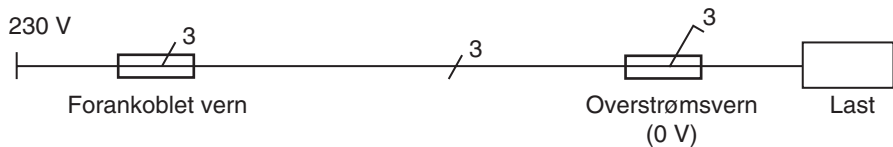


a) automatsikring

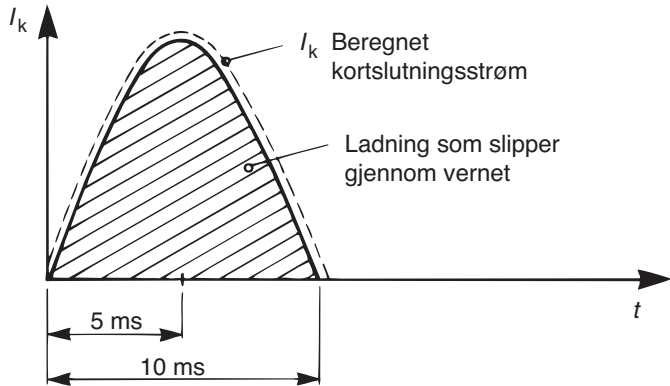


b) smeltesikring

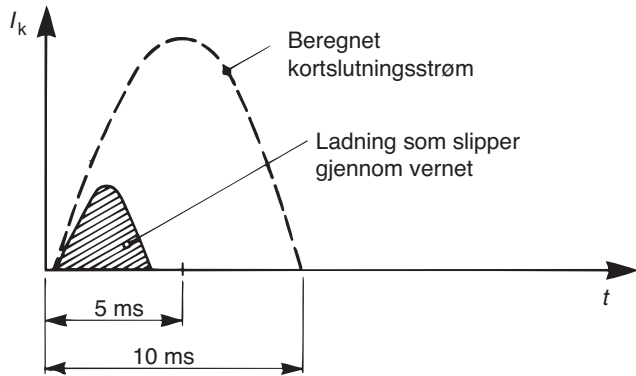
Figur 3.20 Eksempel på strøm-/tidkarakteristikk



Figur 3.21



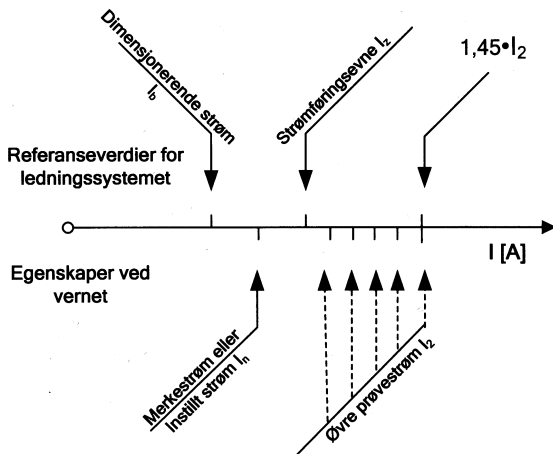
Strømkurve ved ikke-strømbegrensende overstrømsvern



Strømkurve ved strømbegrensende overstrømsvern

Figur 3.22





hvor

$I_b$  er dimensjonerende laststrøm for kretsen

$I_z$  er kabelens strømføringssevne (se avsnitt NEK 400-5-52, avsnitt 523)

$I_n$  er vernets normale strøm

Meknad – For justerbare vern tilsvarer  $I_n$  innstilt utløsestrøm

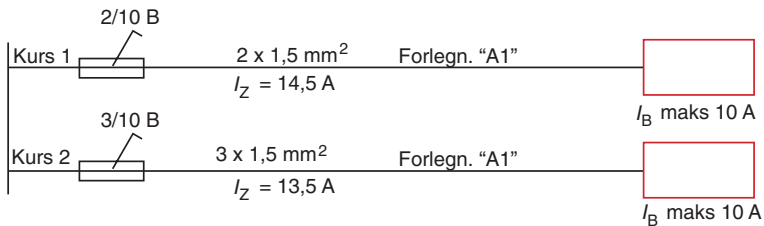
$I_2$  er strøm som sikrer utkobling av vernet innen en fastsatt tid. Strømmen  $I_2$  er produktstandarden eller kan fås fra fabrikanten

Figur 3.23 Koordinering mellom ledere og overstrømsvern



I <sub>B</sub>	Leder	I <sub>Z</sub>	VERN		KRAV	KONKLUSJON
			I <sub>n</sub>	I <sub>2</sub>	I <sub>2</sub> ≤ 145 · I <sub>Z</sub>	
38 A	3 x 6 mm <sup>2</sup>	41 A	40 A	I <sub>n</sub> · 1,45	58 A < 59,5 A	OK

Figur 3.24



Forslag til tverrsnitt og kontroll av kurs nr. 1

$I_B$	Leder	$I_Z$	VERN		KRAV		KONKLUSJON
			$I_n$	$I_2$	$I_2 \leq I_Z$		
10 A	2 x 1,5 mm <sup>2</sup>	14,5 A	10 A	$I_n \cdot 1,45$	14,5 A	14,5 A	OK

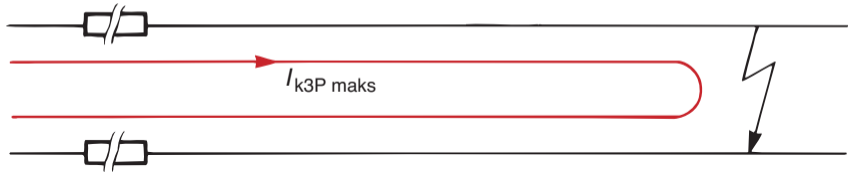
Forslag til tverrsnitt og kontroll av kurs nr. 2

$I_B$	Leder	$I_Z$	VERN		KRAV		KONKLUSJON
			$I_n$	$I_2$	$I_2 \leq I_Z$		
10 A	3 x 1,5 mm <sup>2</sup>	13,5 A	10 A	$I_n \cdot 1,45$	14,5 A	13,5 A	NEI

Nytt forslag og ny kontroll av kurs nr. 2

$I_B$	Leder	$I_Z$	VERN		KRAV		KONKLUSJON
			$I_n$	$I_2$	$I_2 \leq I_Z$		
10 A	3 x 2,5 mm <sup>2</sup>	18 A	10 A	$I_n \cdot 1,45$	14,5 A	18 A	OK

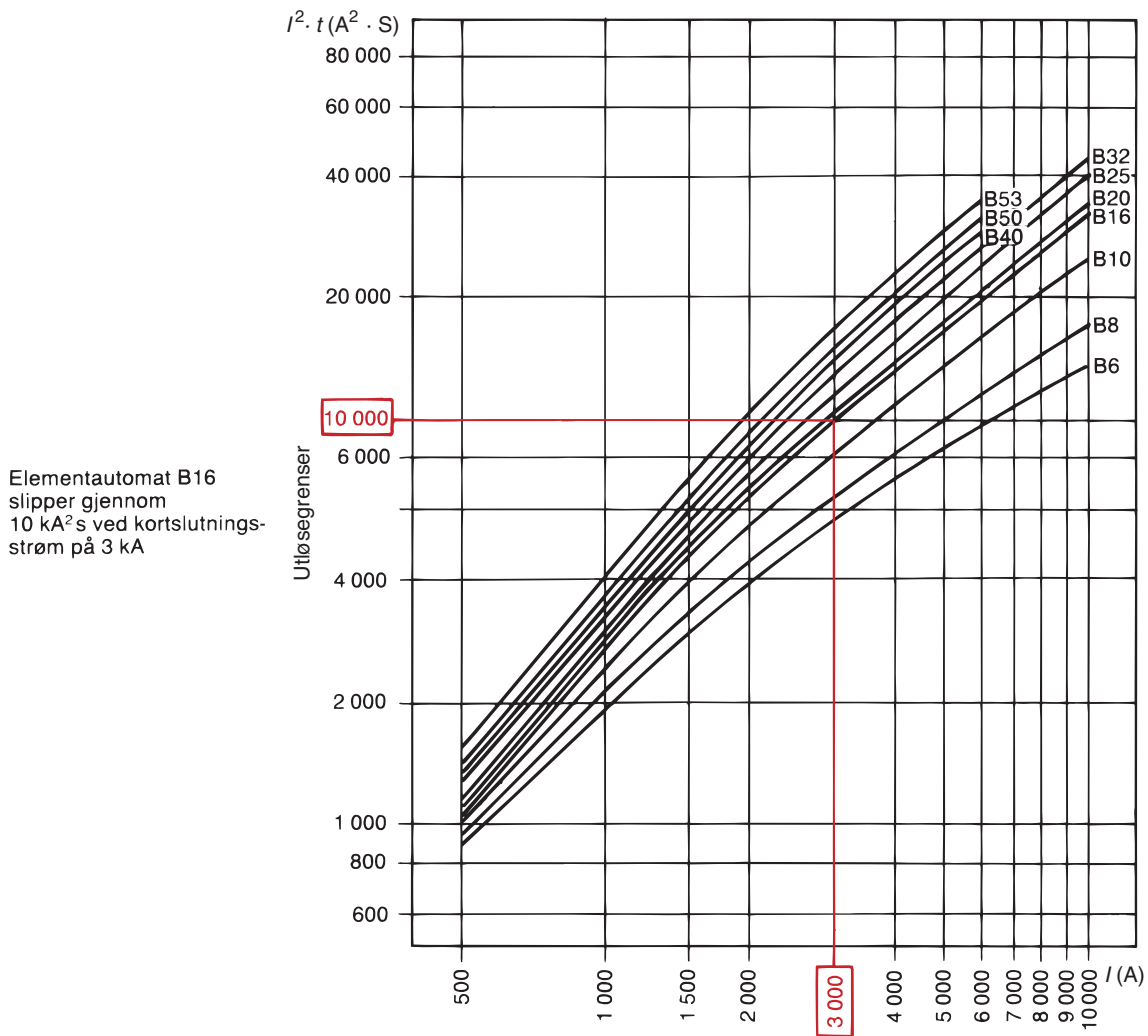
Figur 3.25



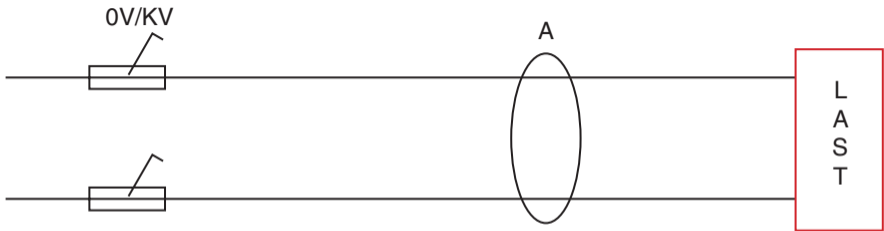
Energigjennomslipp:  $I^2 \cdot t$

$I_{k3P \text{ maks}}$  er kortslutningsstrøm  
 $t$  er vernets utløsetid

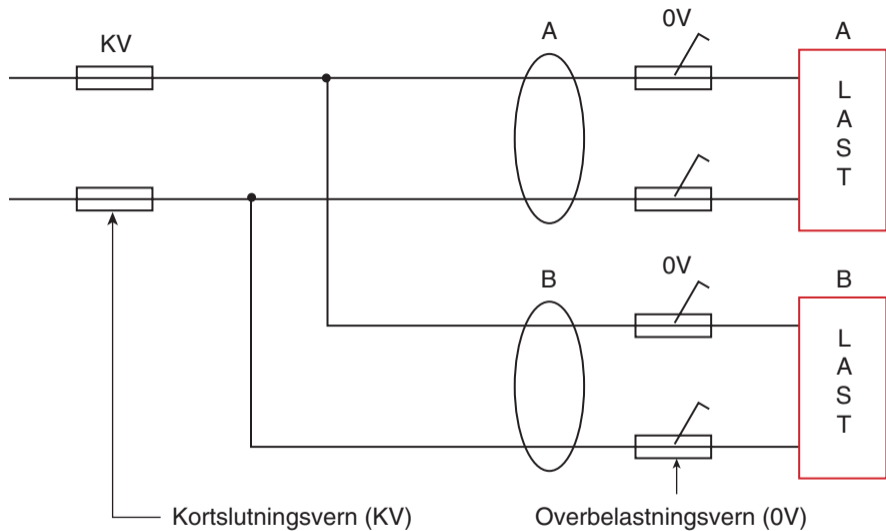
Figur 3.26



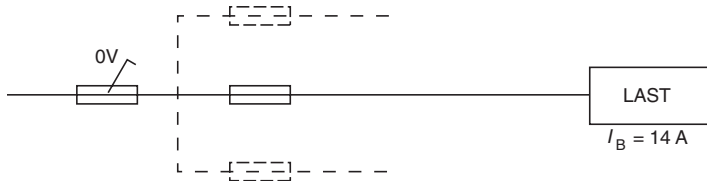
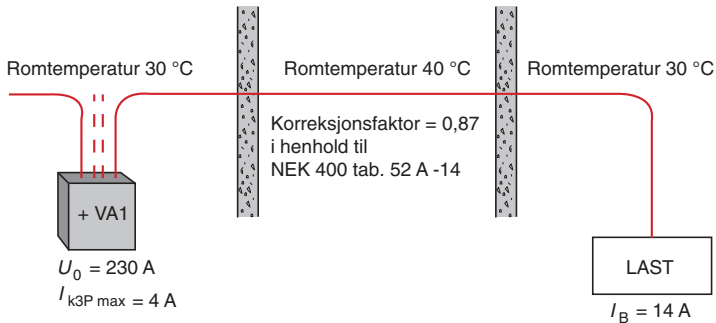
Figur 3.27 Gjennomslippkurve for en elementautomat



*Figur 3.28*

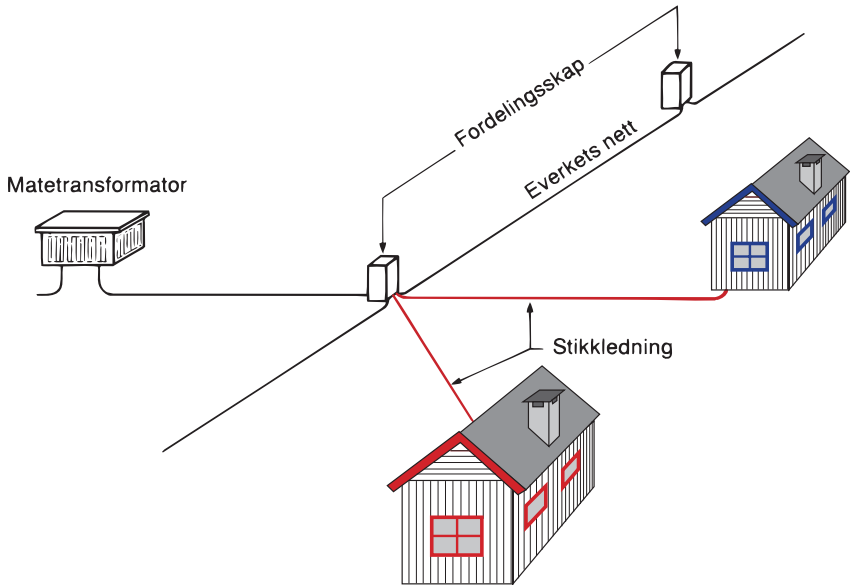


Figur 3.29

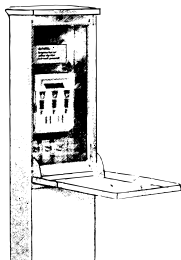


Figur 3.30

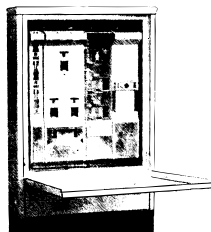




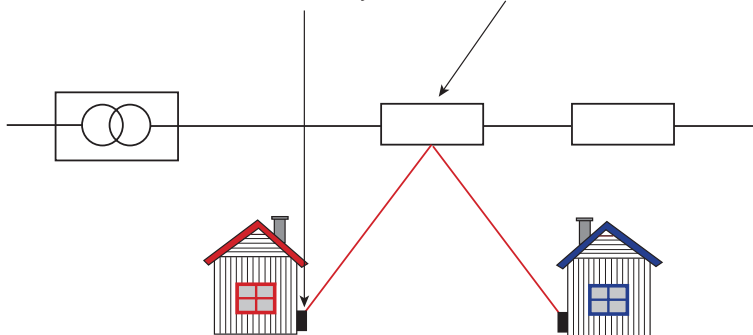
Figur 3.31



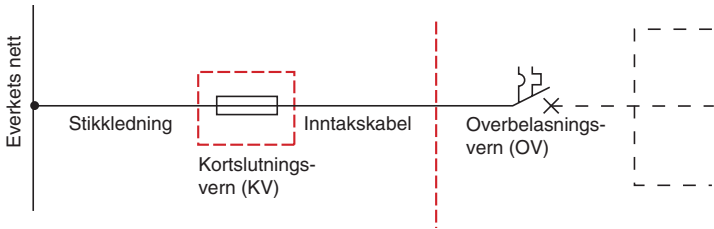
Inntaksskap for kabelmontasje



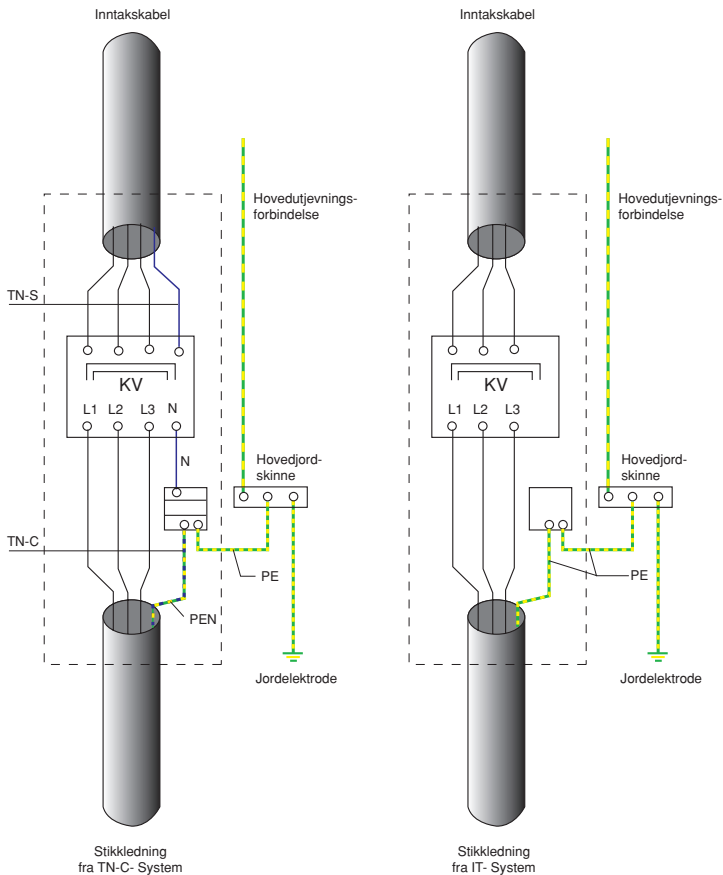
Fordelingsskap med kortslutningssikringer



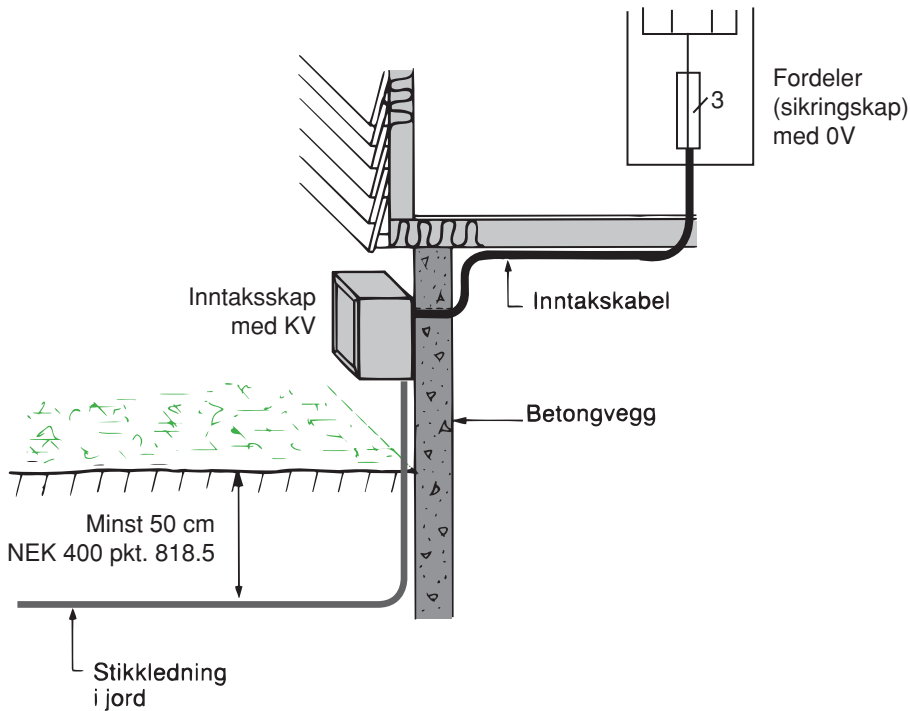
Figur 3.32



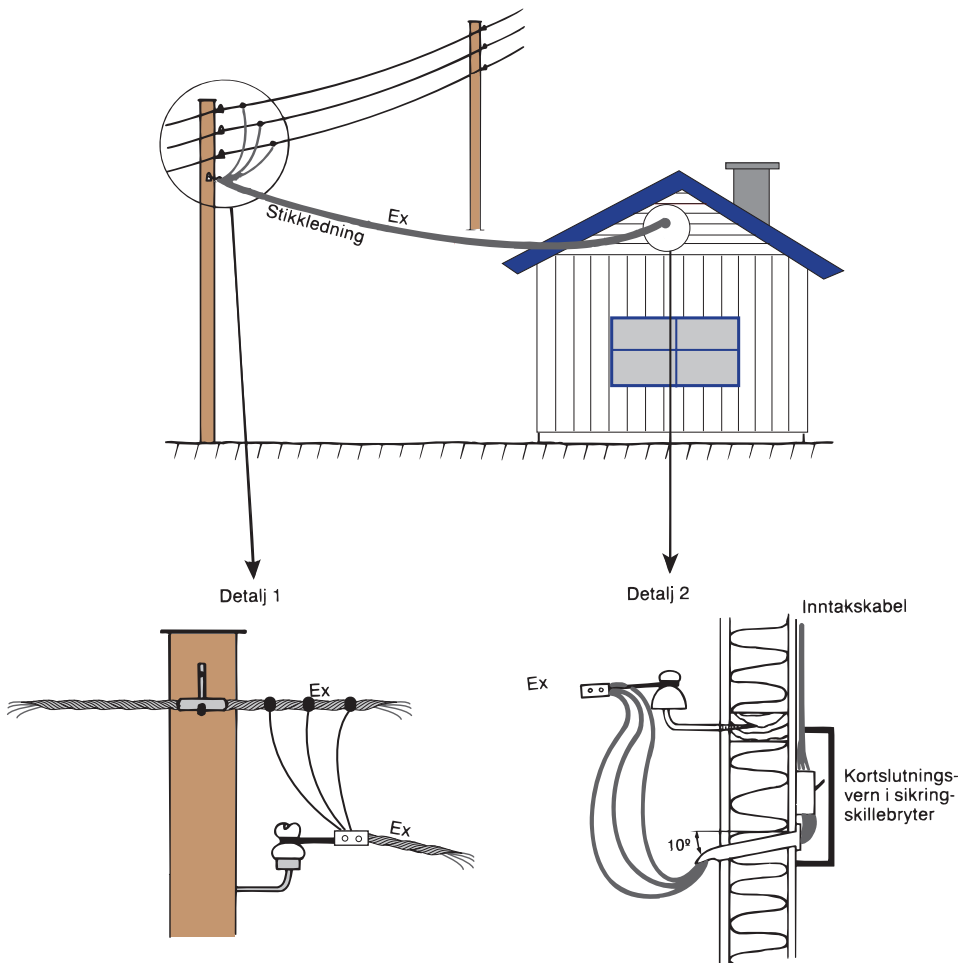
Figur 3.33



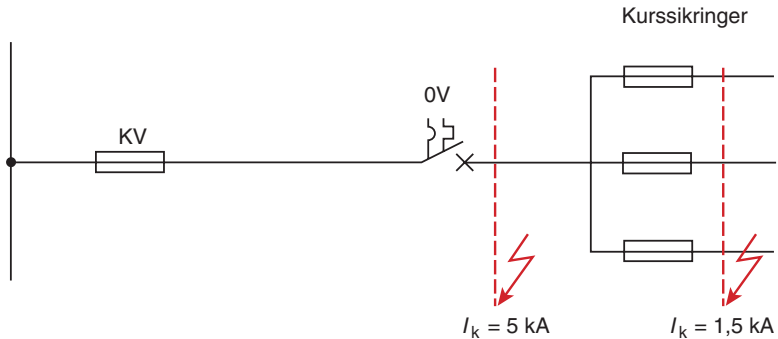
Figur 3.34



Figur 3.35

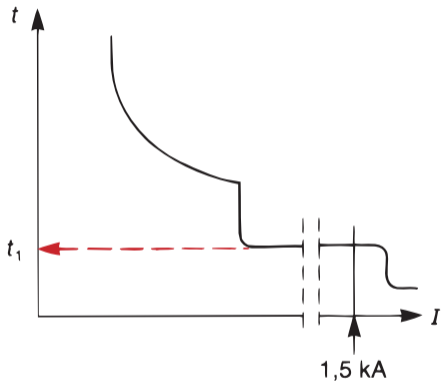


Figur 3.36

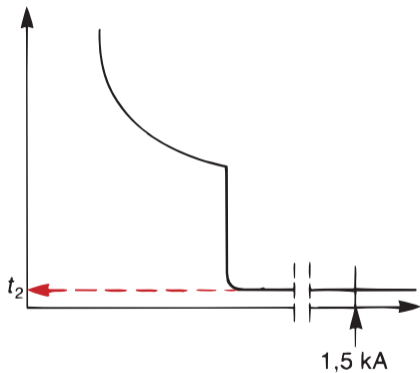


Figur 3.37

Utløserkurve  
overbelastningsvern



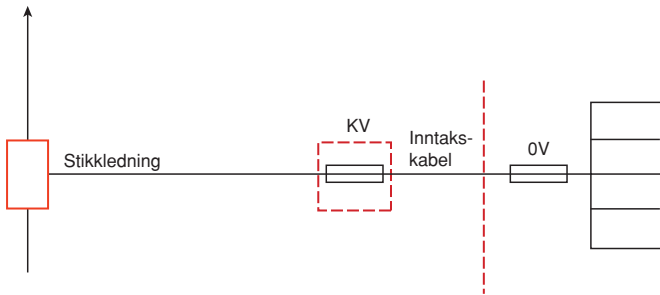
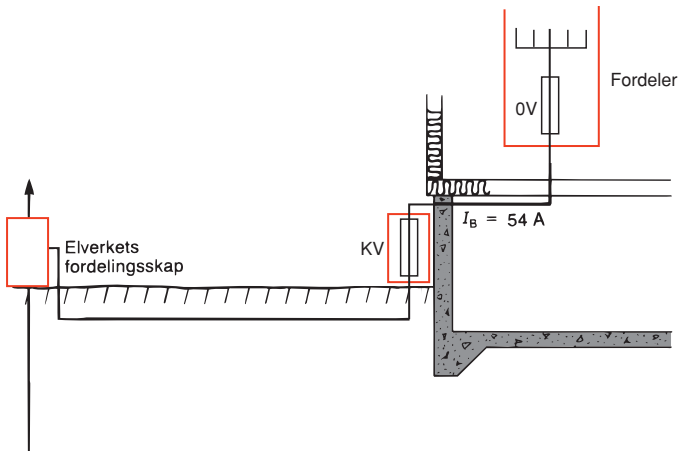
Utløserkurve  
kurssikring



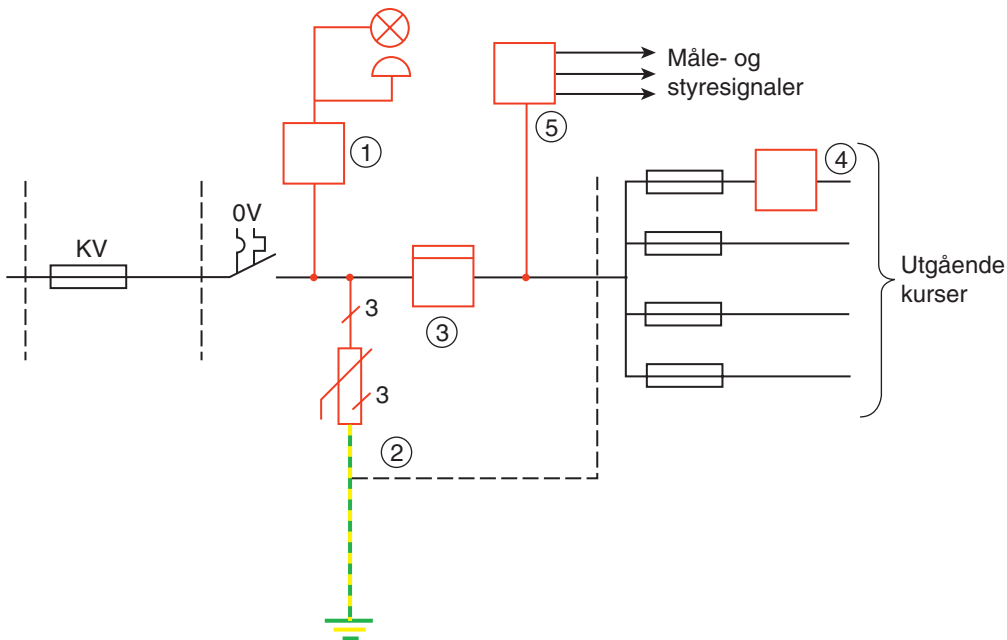
Utløstertid  $t_1 > t_2$

Figur 3.38





Figur 3.39

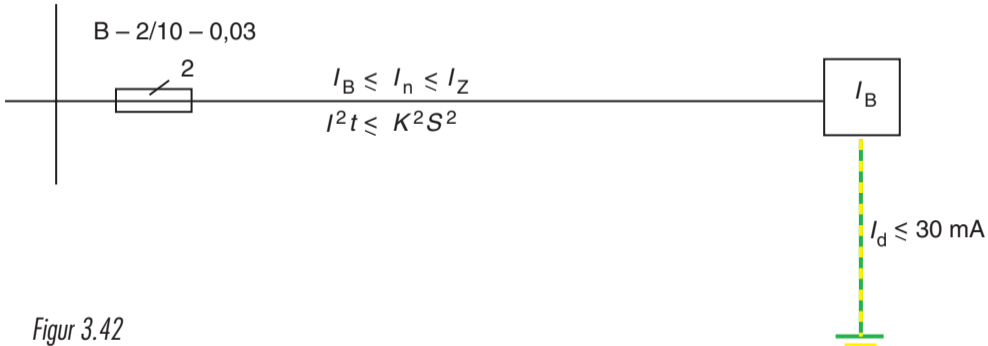


- 1 Jordfeilvarsler med summasjonstrafo
- 2 Overspenningsvern
- 3 Energimåler
- 4 Jordfeilbryter
- 5 Måleverdiomformer med strømtrafo

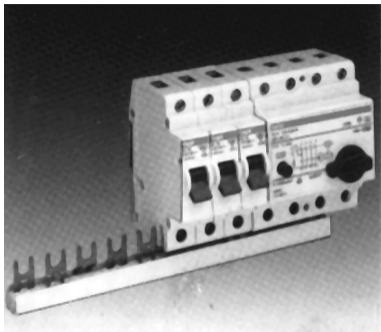
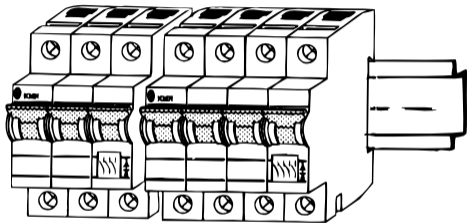
Figur 3.40



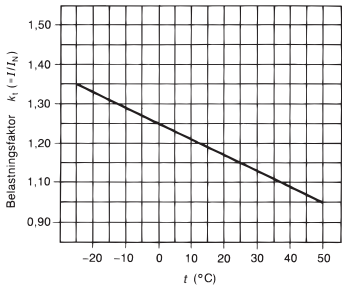
*Figur 3.41 Kombivern*



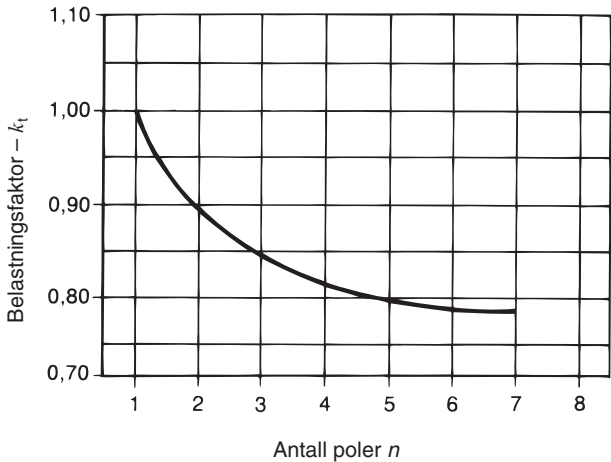
Figur 3.42



*Figur 3.43*



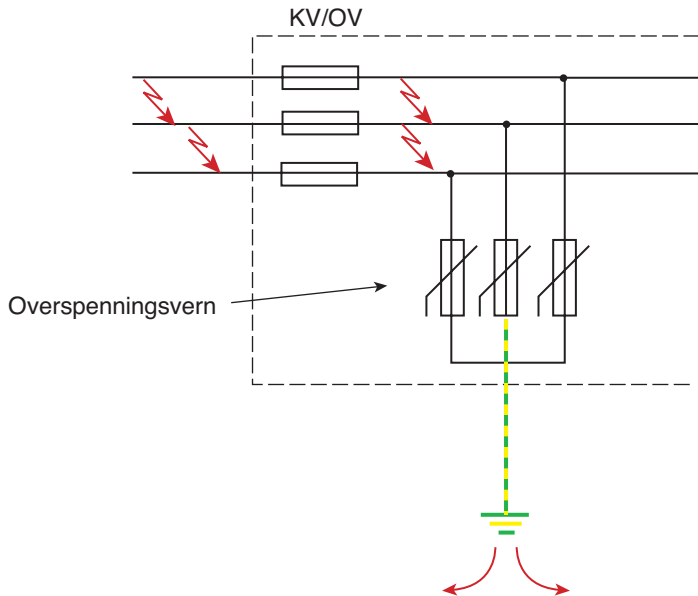
*Figur 3.44*



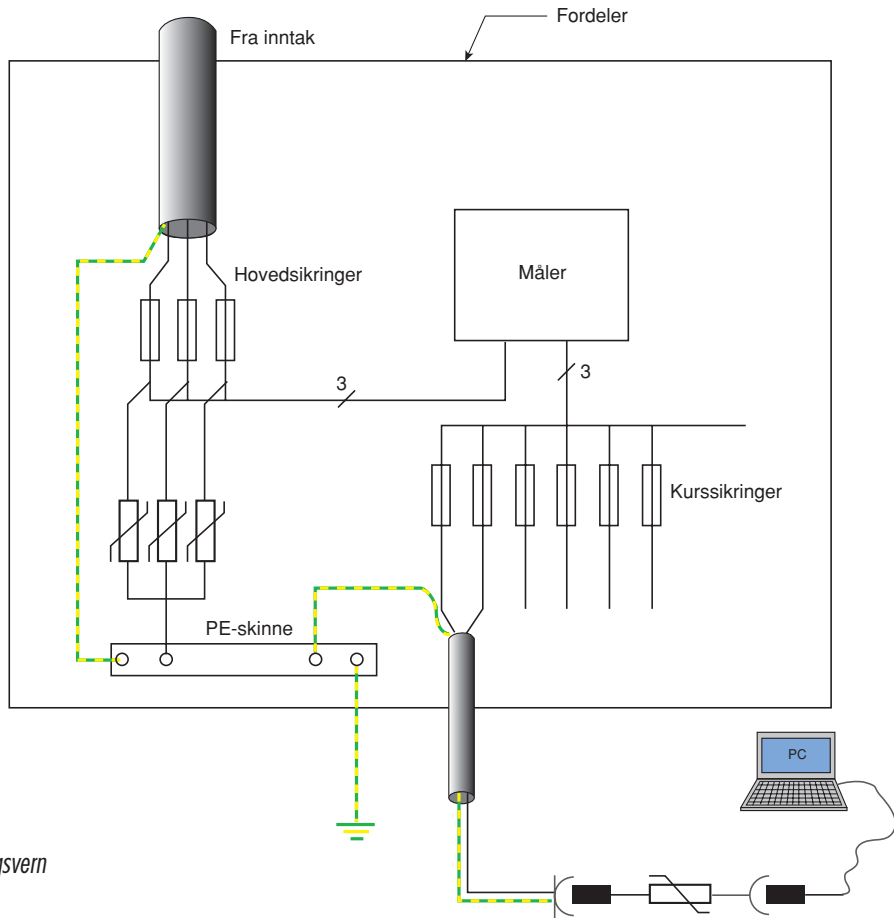
Figur 3.45



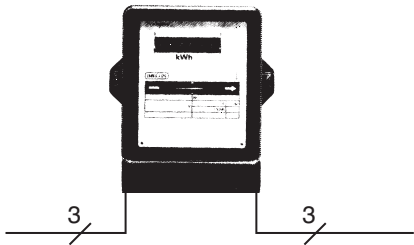
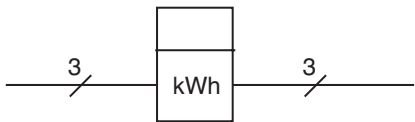
Figur 3.46 Growern







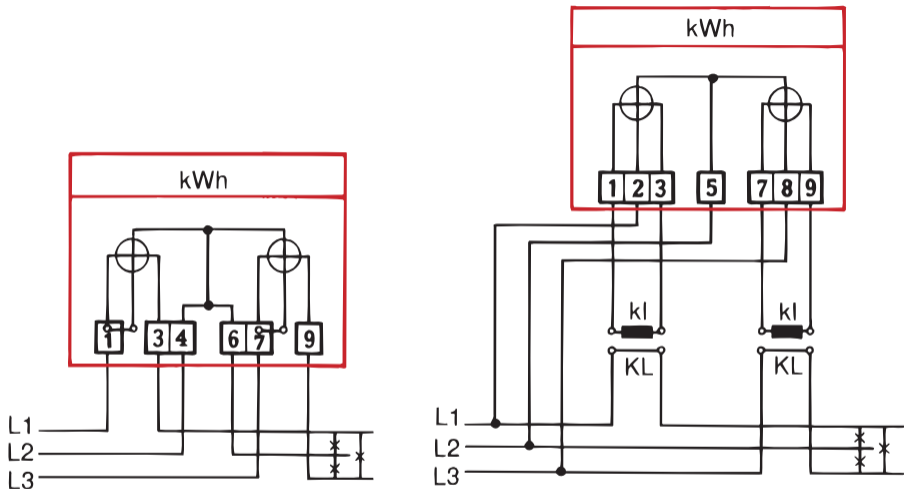
Figur 3.47 Plassering av overspenningsvern



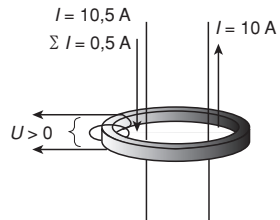
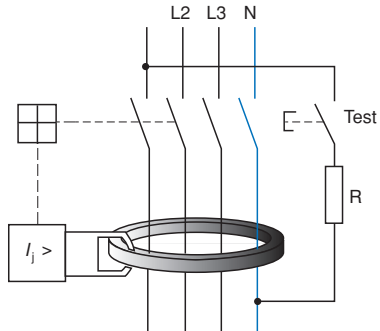
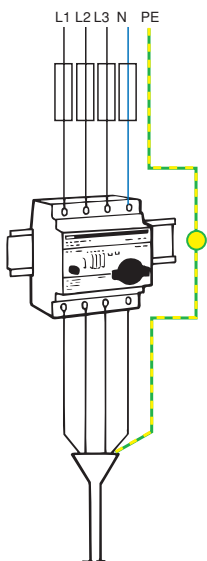
Energi:  $E = P \cdot t$

Enheten for  $E$  er kWh (kilowattimer)

*Figur 3.48a Energimåling*



3.48b Kobling av mätare



Figur 3.49 Jordfeilbryter

AC-klasse



A-klasse



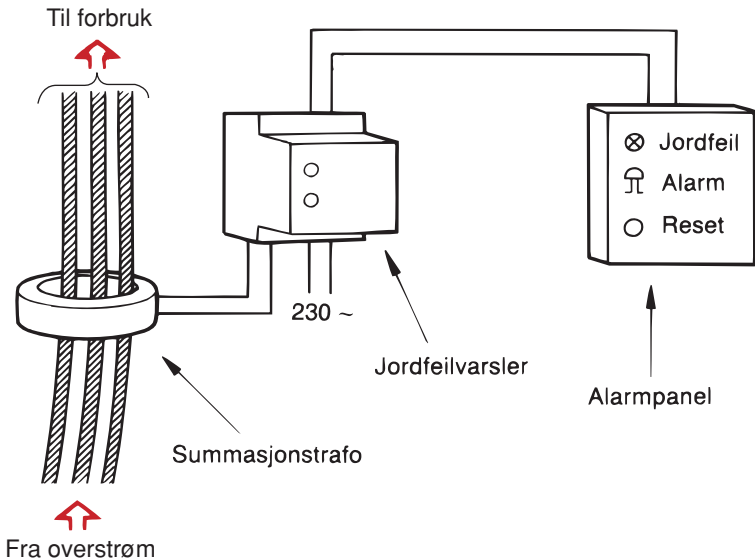
AC S-klasse



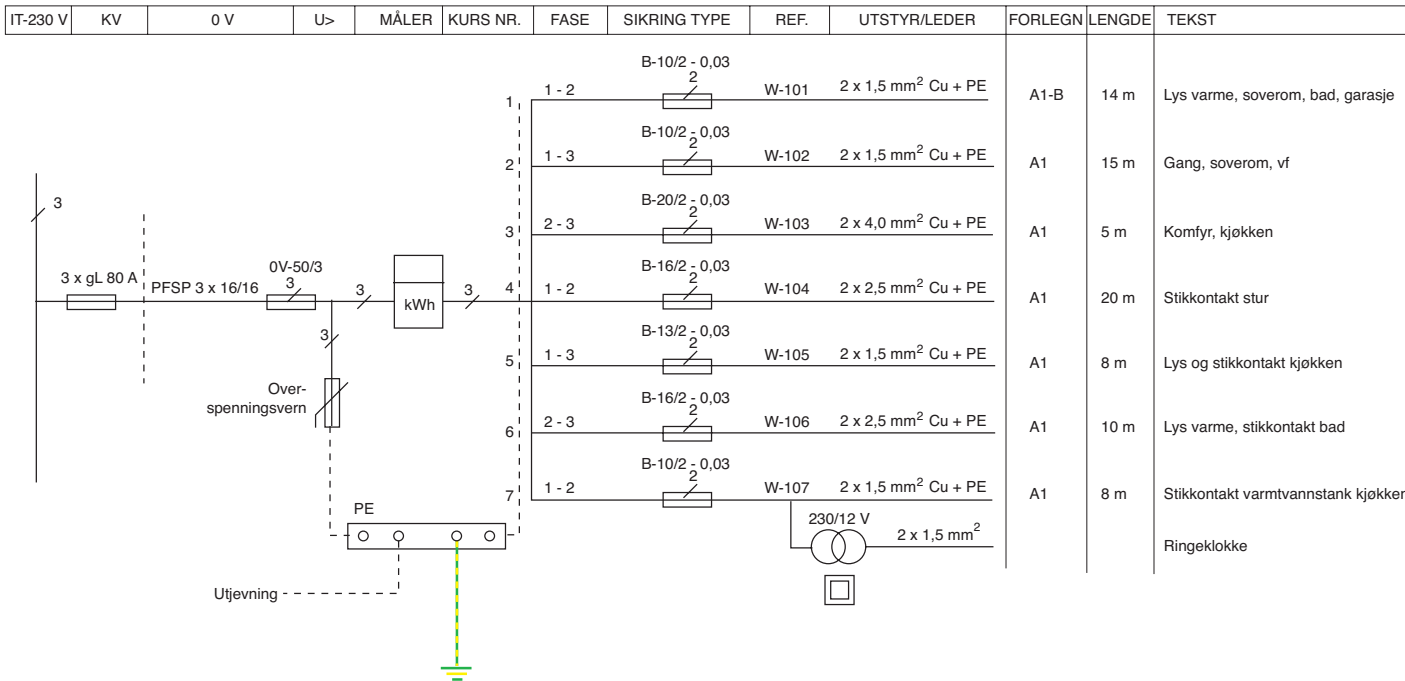
A S-klasse



*Figur 3.50*



Figur 3.51

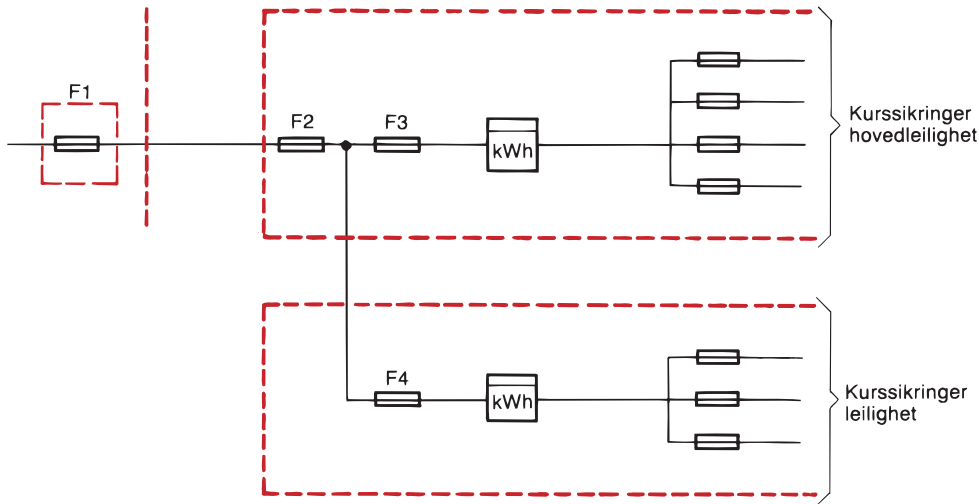


Figur 3.52 Fordelerskjema

Kursfortegnelse		Installatør:			
Eier. Nils Nilsen, Storgt. 230		Nett: IT- 230V	Anlegg: Bolig		
Kurs nr.	Tekst / Lastbeskrivelse	Vern	Ledning		
			Tverrsnitt	Lengde	Forlegn.
OV	OVERBELASTNINGSVERN	50/3/OV	3 x 16 / 16 mm <sup>2</sup>	8m.	A1 - C
1	LYS, VARME, SOVEROM, GARASJE	10/2/B/0,03-A	2 x 2,5 / 2,5 mm <sup>2</sup>	14 m.	A1
2	LYS VARME, STIKKONT. GANG, SOVEROM, VF.	16/2/B/0,03-A	2 x 2,5 / 2,5 mm <sup>2</sup>	10 m.	A1
3	KOMFYR, KJØKKEN	20/2/B/0,03-A	2 x 4 / 4 mm <sup>2</sup>	5 m.	A1
4	STIKKONTAKTER STUE	16/2/B/0,03-A	2 x 2,5 / 2,5 mm <sup>2</sup>	20 m.	A1
5	LYS STIKKONT. KJØKKEN	13/2/B/0,03-A	2 x 1,5 / 1,5 mm <sup>2</sup>	8 m.	A1
6	LYS, VARME, STIKKONT. BAD	10/2/B/0,03-A	2 x 2,5 / 2,5 mm <sup>2</sup>	15 m.	A1
7	VARMTVANNSTANK	10/2/B/0,03-A	2 x 1,5 / 1,5 mm <sup>2</sup>	8 m.	A1

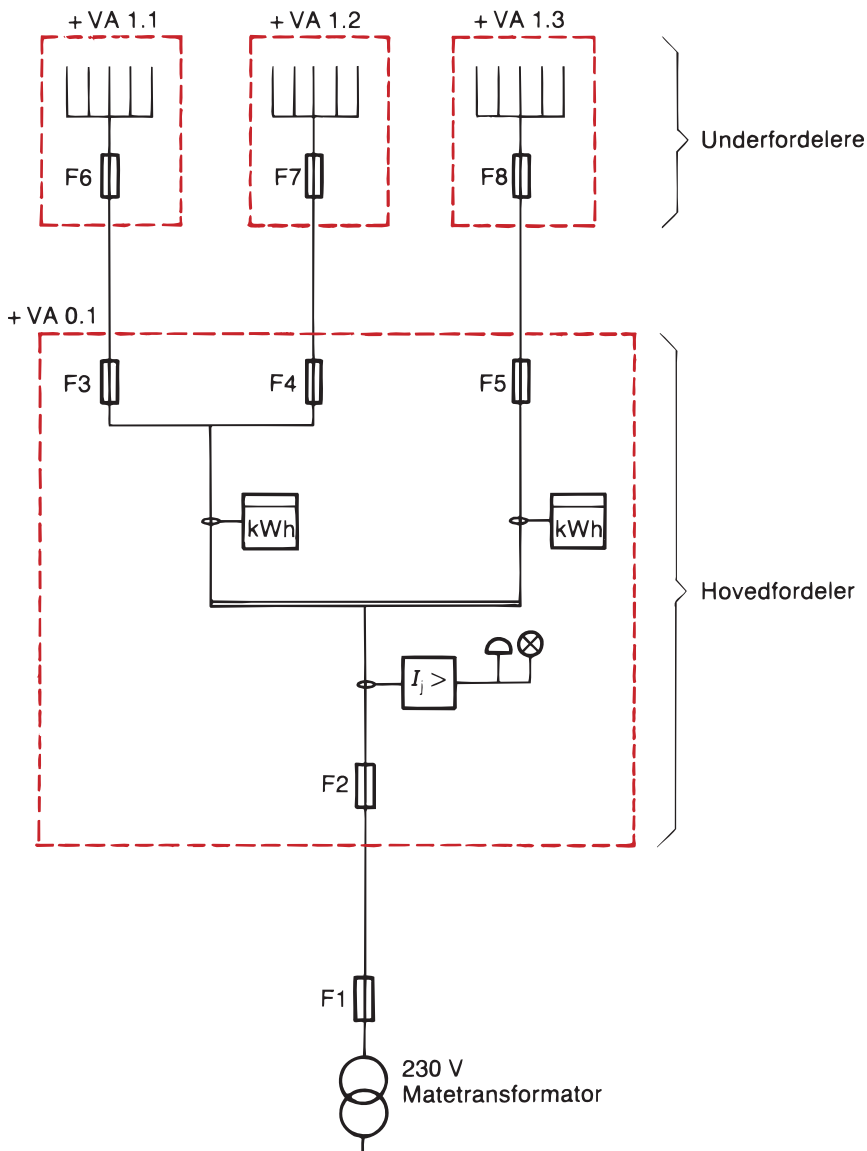
Figur 3.53 Kursfortegnelse





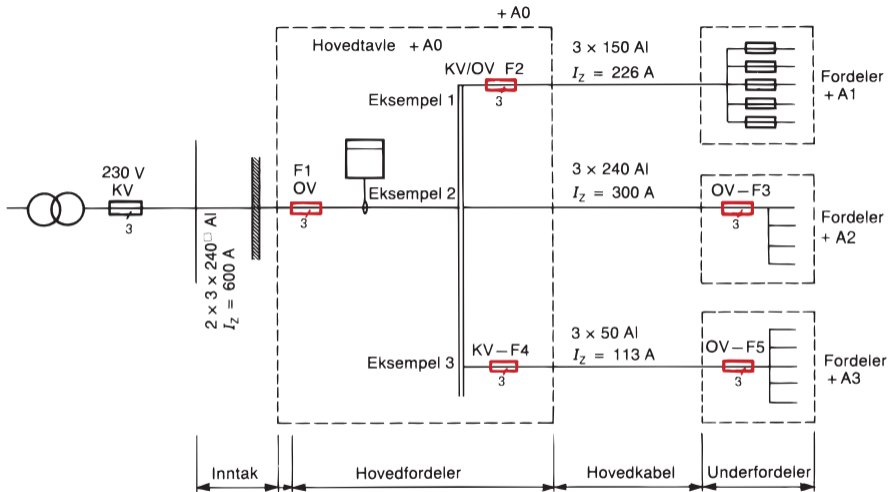
- F1: Kortslutningsvern for inntakskabel
- F2: Overbelastningsvern for inntakskabel
- F3: Overbelastningsvern for fordeler i hovedleilighet
- F4: Overbelastningsvern for hovedkabel til sokkelleilighet

Figur 3.54 Bolig med to leiligheter



- F1: Kortslutningsvern for inntakskabel
- F2: Overbelastningsvern for inntakskabel
- F3–F4–F5: Kortslutningsvern for hovedkabler
- F6–F7–F8: Overbelastningsvern for hovedkabler

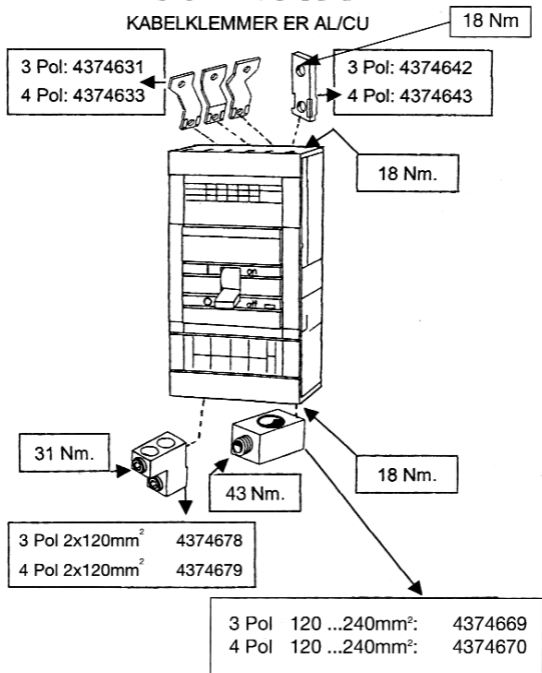
Figur 3.55 Hovedfordeler og underfordelere



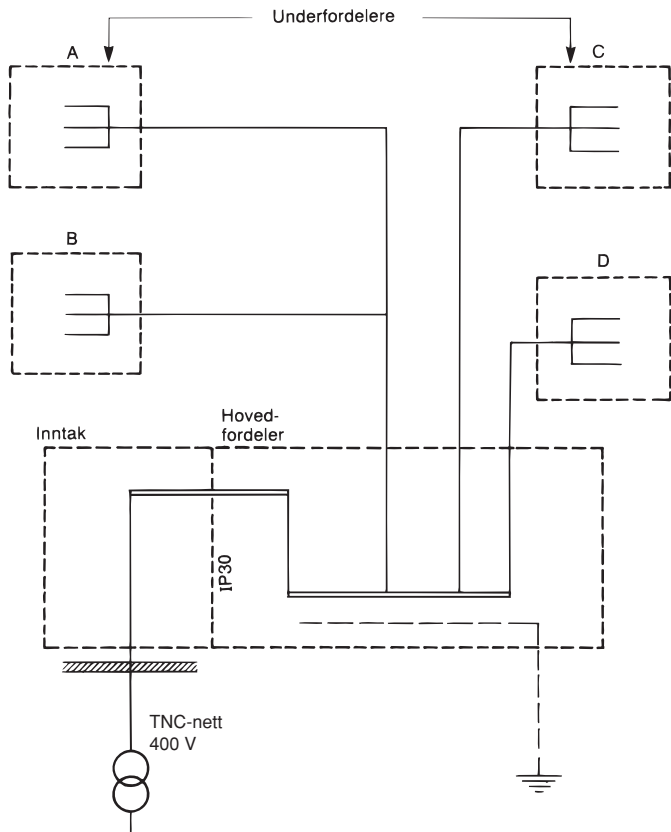
Figur 3.56

# S5 - 400A

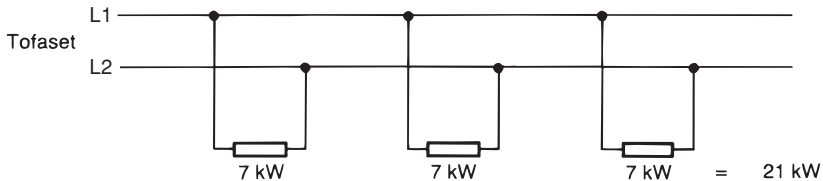
KABELKLEMMER ER AL/CU



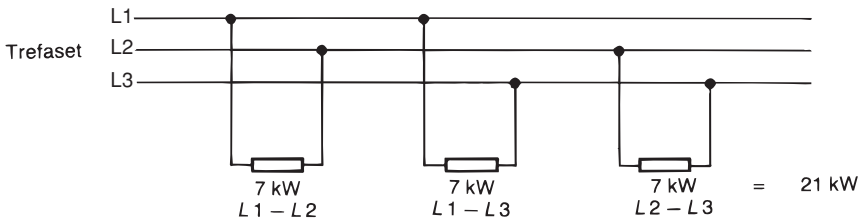
Figur 3.57 Effektbryter



Figur 3.58

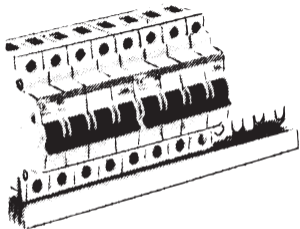


Dimensjonerende strøm:  $I_B = \frac{21\,000\text{ W}}{230\text{ V}} = 91,3\text{ A}$



Dimensjonerende strøm:  $I_B = \frac{21\,000\text{ W}}{230\text{ V} \cdot \sqrt{3}} = 52,7\text{ A}$

Figur 3.59



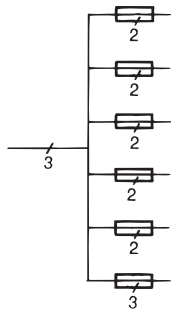
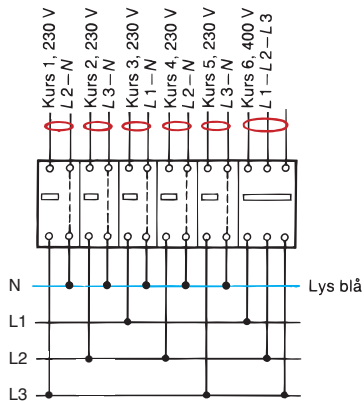
Trepolet

10 mm<sup>2</sup>, 264 mm lengde, 5 × 3 tilkopl.

10 mm<sup>2</sup>, 1000 mm lengde, 19 × 3 tilkopl.

16 mm<sup>2</sup>, 1000 mm lengde, 19 × 3 tilkopl.

*Figur 3.60*



Nettsystem: TN-S-      Spenning: 400/230 V						
Tilkobling	Effektfordeling (P)				Spenning	Kursens strøm $I_B$
	L1 - N	L2 - N	L3 - N	L1-L2-L3		
Kurs 1		1000 W			230 V	4,3 A
Kurs 2			1500 W		230 V	5,8 A
Kurs 3	3000 W				230 V	13 A
Kurs 4		1000 W			230 V	4,3 A
Kurs 5			2000 W		230 V	8,7 A
Kurs 6				6000 W	400 V	8,7 A
$\Sigma P$	3000 W	2000 W	3500 W	6000 W		

Figur 3.61 Fordeling av belastninger i et TN-S-system



$$\text{Strøm L1 - N} \quad \frac{3000 \text{ W}}{230 \text{ V}} =$$

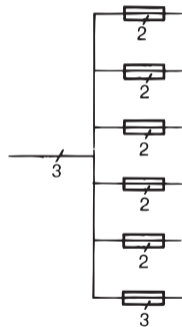
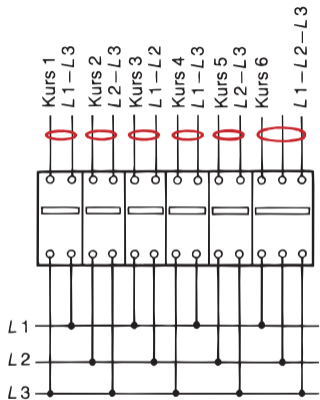
$$\text{Strøm L2 - N} \quad \frac{2000 \text{ W}}{230 \text{ V}} =$$

$$\text{Strøm L3 - N} \quad \frac{4500 \text{ W}}{230 \text{ V}} =$$

$$\text{Strøm L1 - L2 - L3} \quad \frac{6000 \text{ W}}{\sqrt{3} \cdot 400} =$$

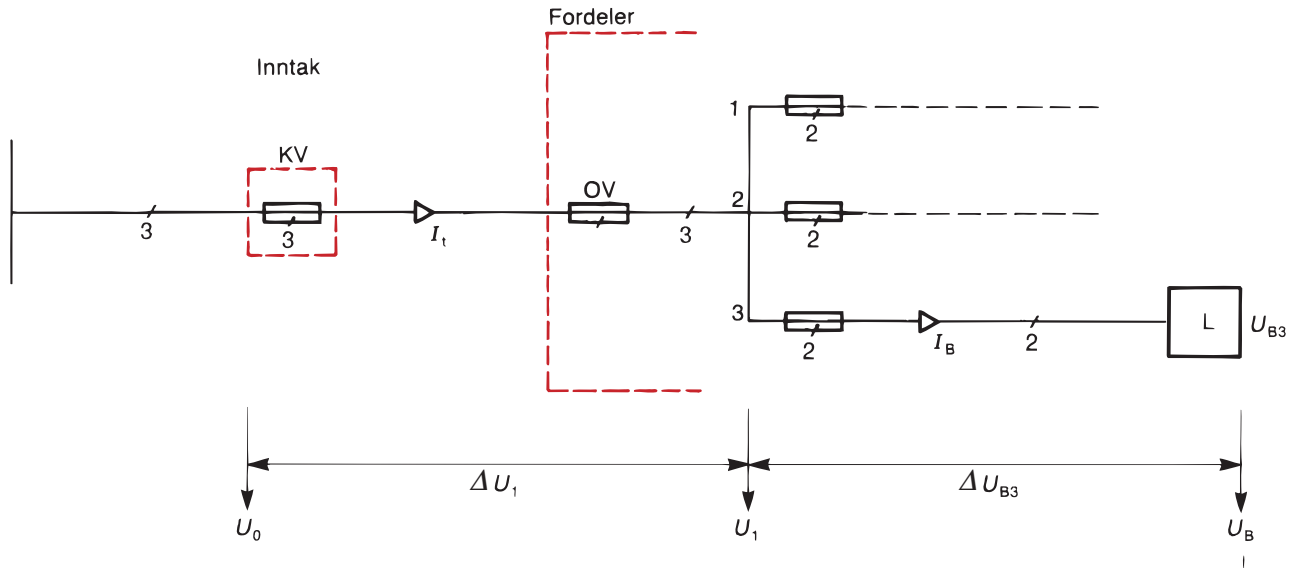
$I_1$	$I_2$	$I_3$
13 A		
	8,7 A	
		19,6 A
8,7 A	8,7 A	8,7 A
21,7 A	17,4 A	28,3 A

Figur 3.62

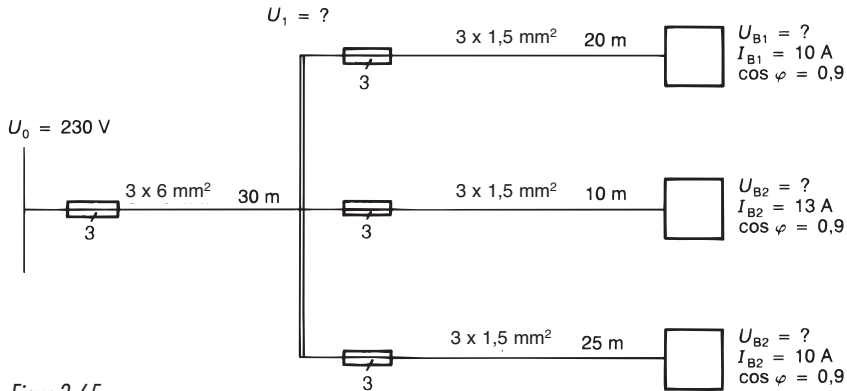


Nettsystem: IT- Spenning: 230 V					
Tilkopling	Effekt (P)	Effektfordeling			Kursens strøm $I_B$
		L1 - L2	L1 - L3	L2 - L3	
Kurs 1	1000 W		1000 W		4,3 A
Kurs 2	1500 W			1500 W	5,8 A
Kurs 3	3000 W	3000 W			13 A
Kurs 4	1000 W		1000 W		4,3 A
Kurs 5	2000 W			2000 W	8,7 A
Kurs 6	6000 W	2000 W	2000 W	2000 W	15,1 A
	$\Sigma P$	5000 W	4000 W	5500 W	

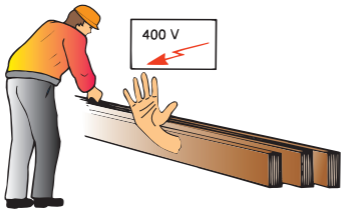
Figur 3.63



Figur 3.64 Spenningsfall

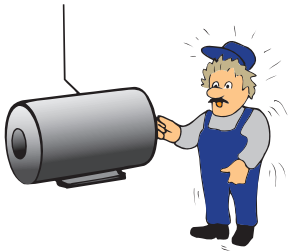


Figur 3.65

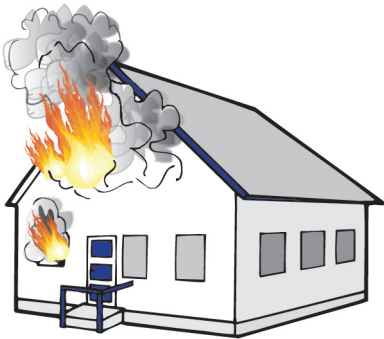


*Figur 3.66 Direkte berøring NEK 400-131.2.1*

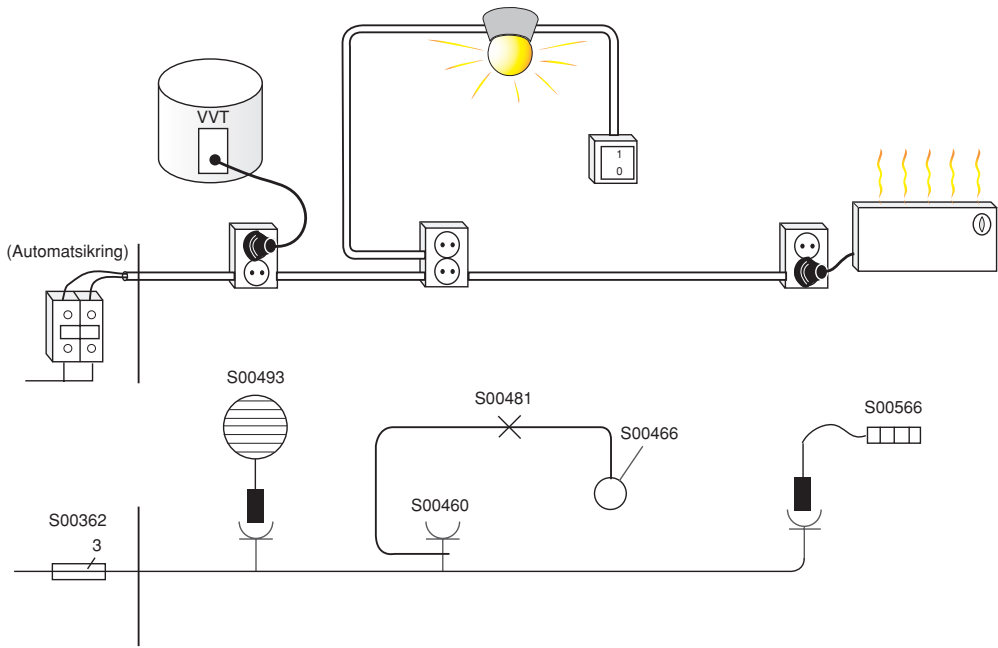
3 · 230 V



*Figur 3.67 Indirekte berøring NEK 400-131.2.2*

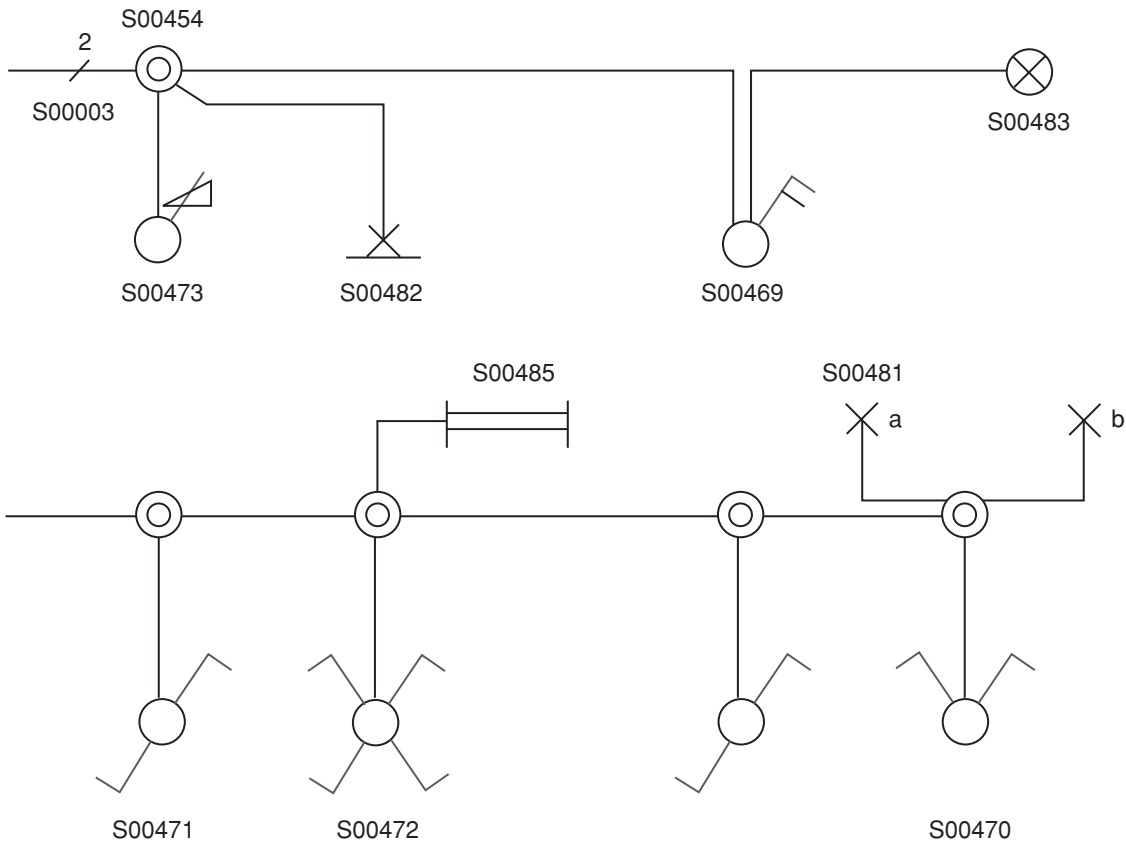


*Figur 3.68 Termiske virkninger NEK 400-131.3 og 4*

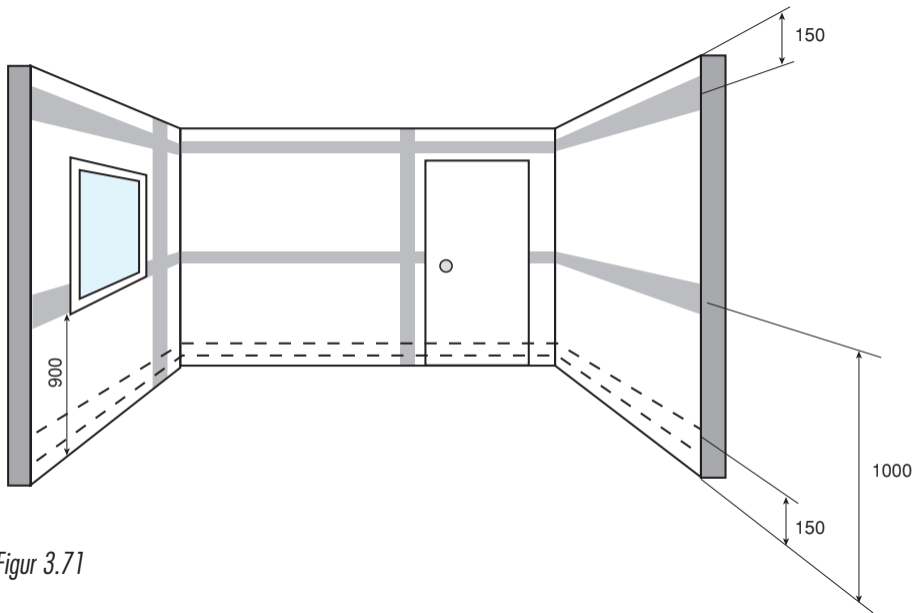


Figur 3.69

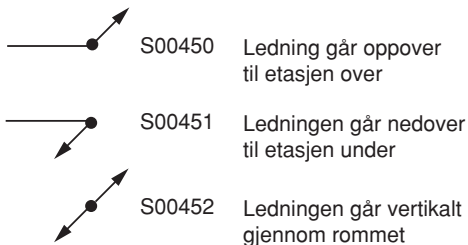
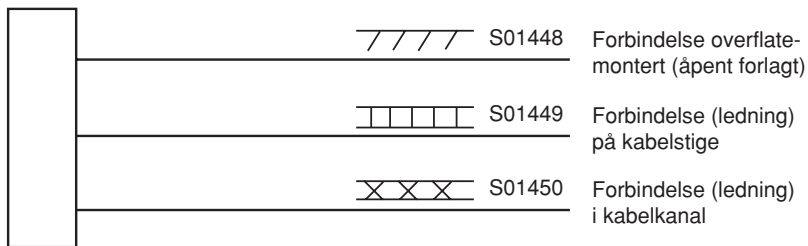




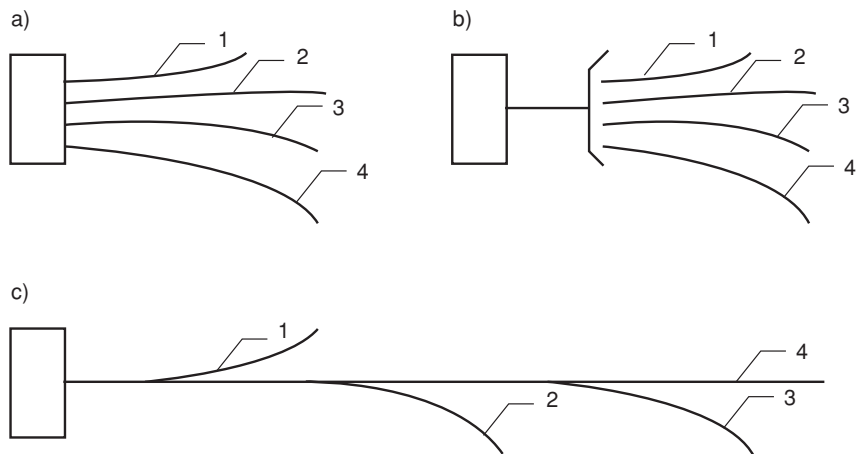
Figur 3.70



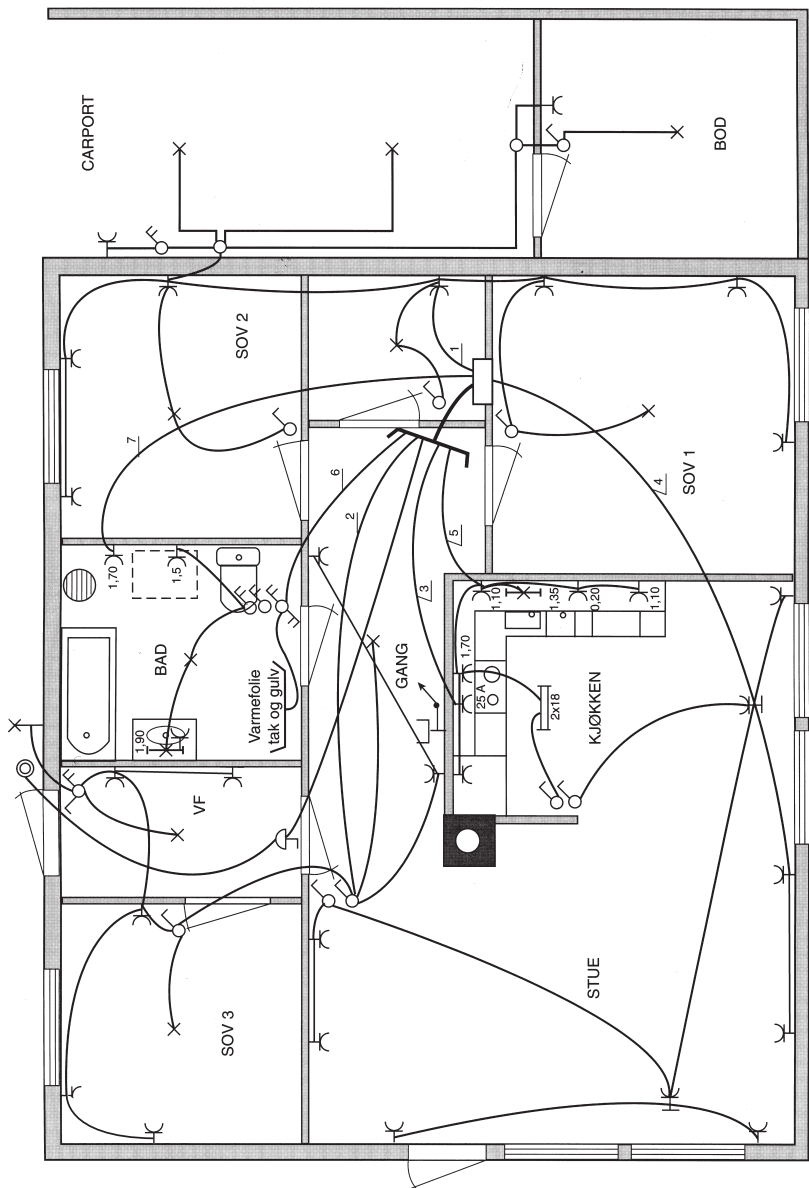
Figur 3.71



Eksempel på fremstilling av skjulte ledningsføringer ut av fordeler



Figur 3.72

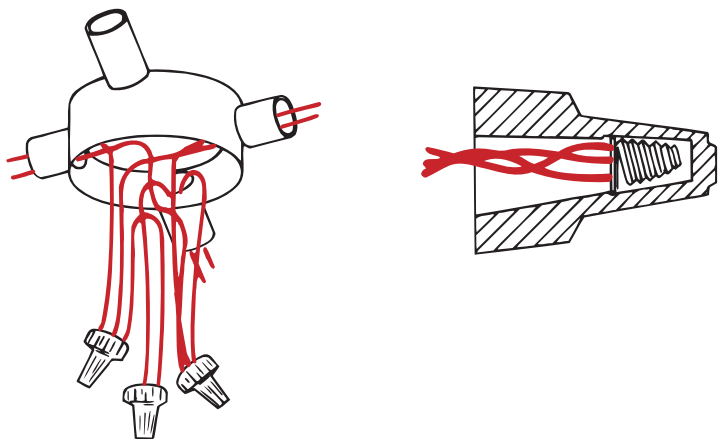


Figur 3.73

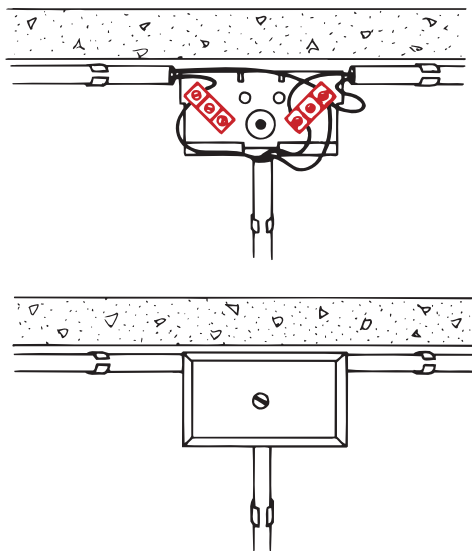


*Figur 3.74 Presstang*

### Kobling i skjult forlegning



### Kobling i åpen forlegning



Figur 3.75 Kobling i takboks og koblingsboks

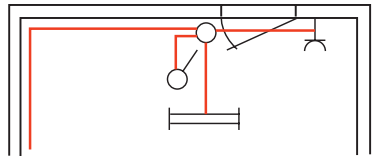
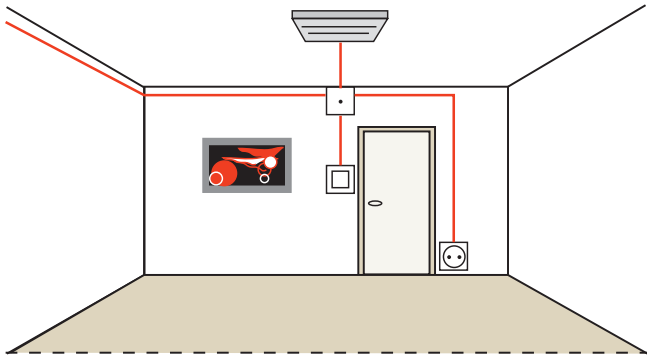
## Kabler med gul-grønn leder:

Antall ledere	Fargemerking					
3	Gul	Grønn	Blå	Brun		
4*	Gul	Grønn	Blå	Brun	Svart	
4	Gul	Grønn		Brun	Svart	Grå
5	Gul	Grønn	Blå	Brun	Svart	Grå

## Kabler uten gul-grønn leder:

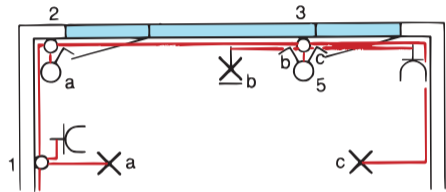
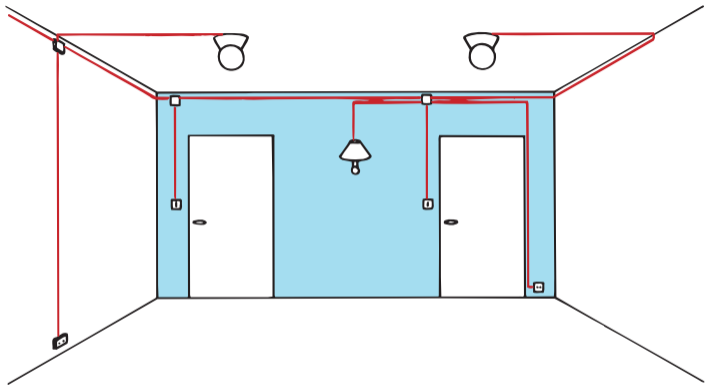
Antall ledere	Fargemerking					
2	Blå	Brun				
3*	Blå	Brun	Svart			
3		Brun	Svart	Grå		
4	Blå	Brun	Svart	Grå		
5	Blå	Brun	Svart	Grå	Svart	

Figur 3.76

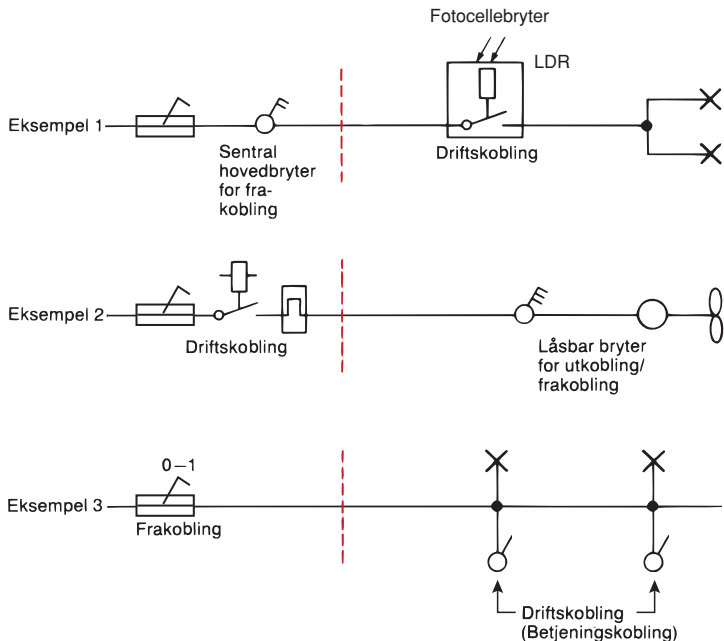


*Figur 3.77*

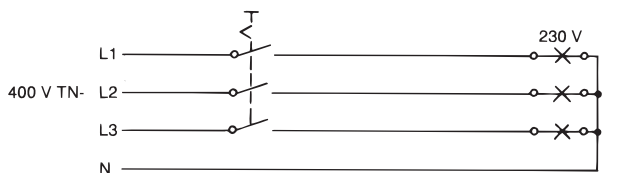
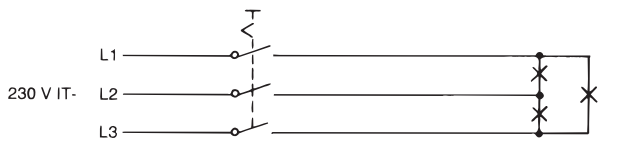
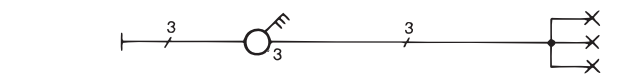
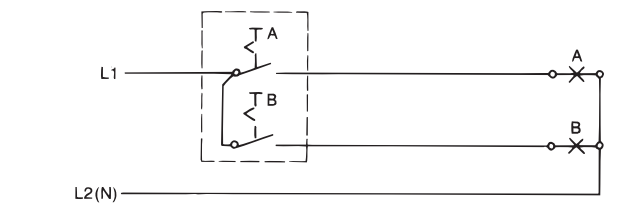
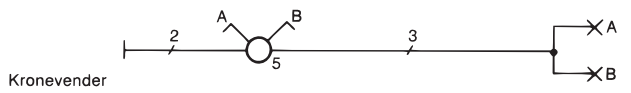
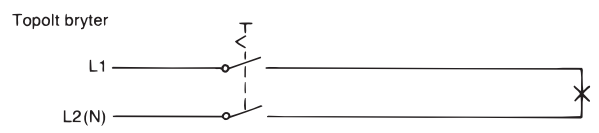
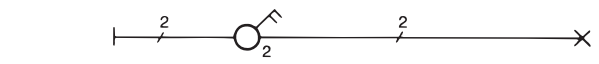
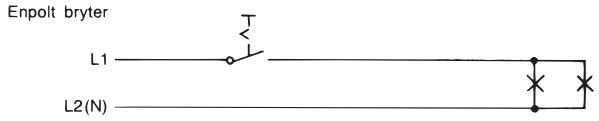
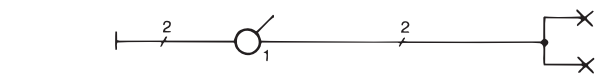




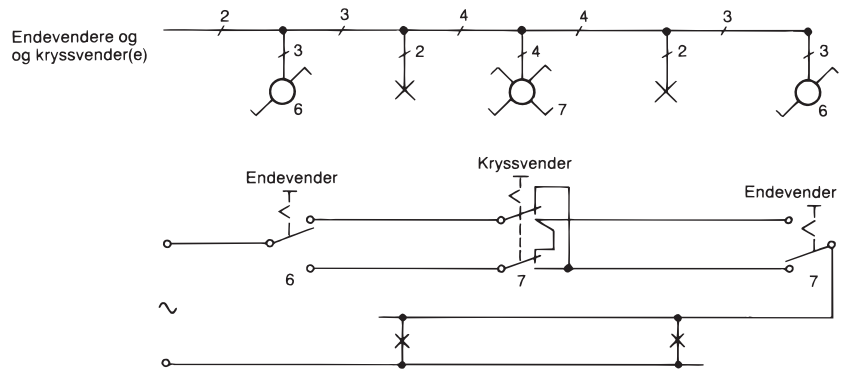
Figur 3.78



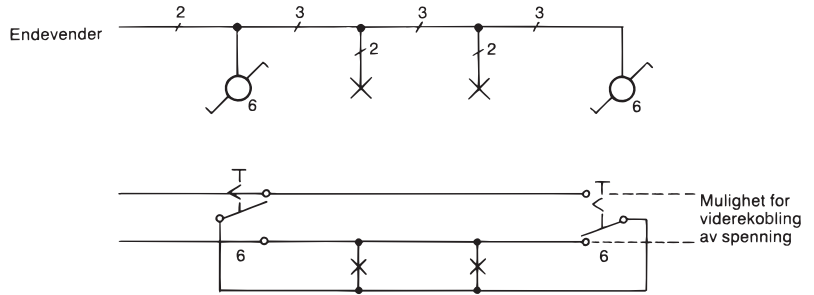
Figur 3.79 Forskjellige måter å arrangere koblingsutstyr med ulike funksjoner på



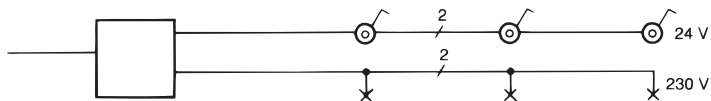
Figur 3.80 Brytere for betjening fra en posisjon



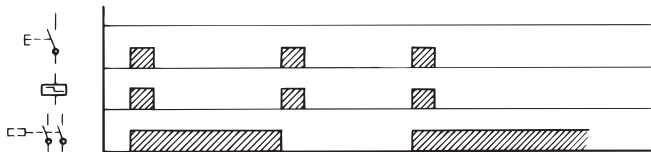
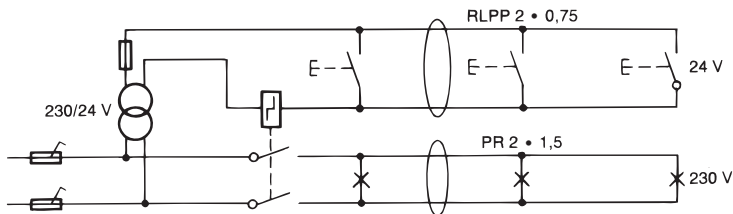
Bruk av endevender (6) og mulighet for ubegrenset antall kryssvender



Figur 3.81 Brytere for betjening fra flere posisjoner

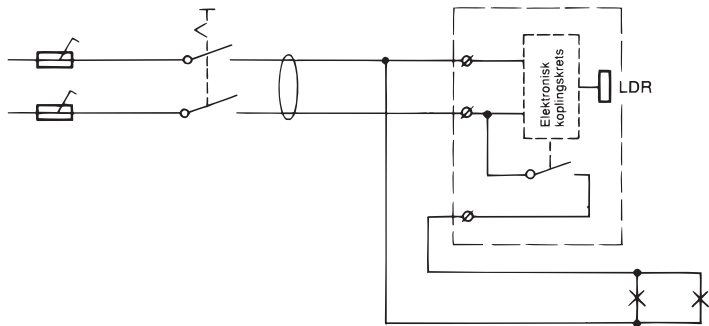
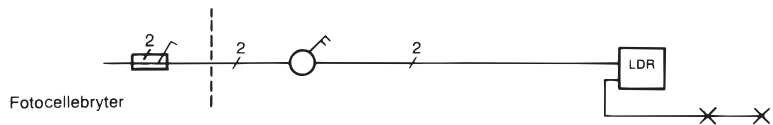


Impulsrelé

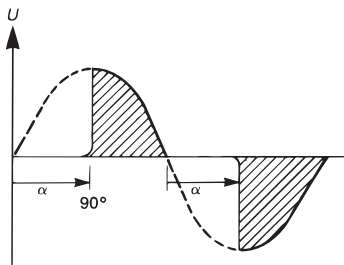
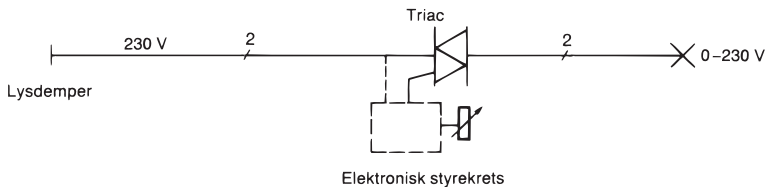


Sekvensdiagram for impulsrelé

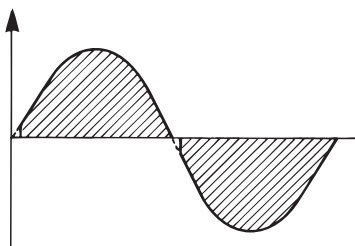
Figur 3.82



Figur 3.83

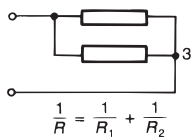
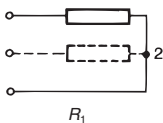
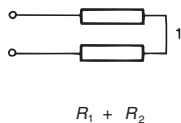
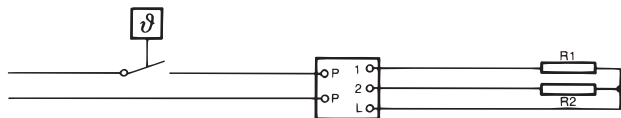
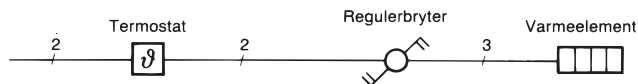


50% effekt  
Tennvinkel  $\alpha = 90^\circ$



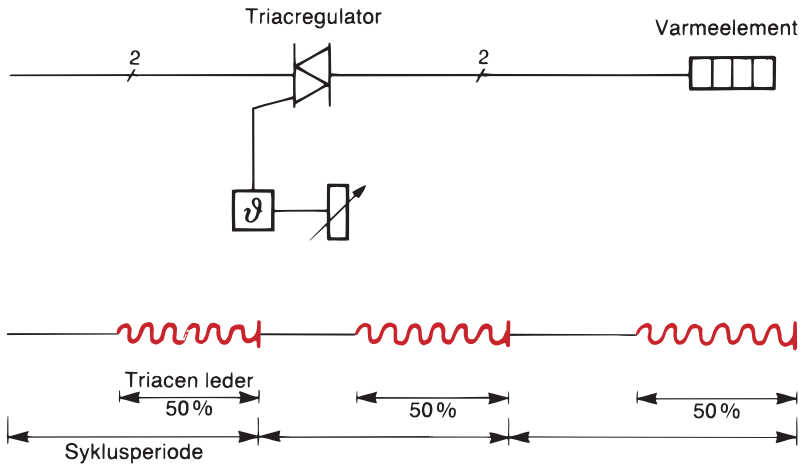
$\approx 100\%$  effekt  
Tennvinkel  $\alpha \approx 0^\circ$

Figur 3.84 Kabling av enkel effektregulator for glødelampe

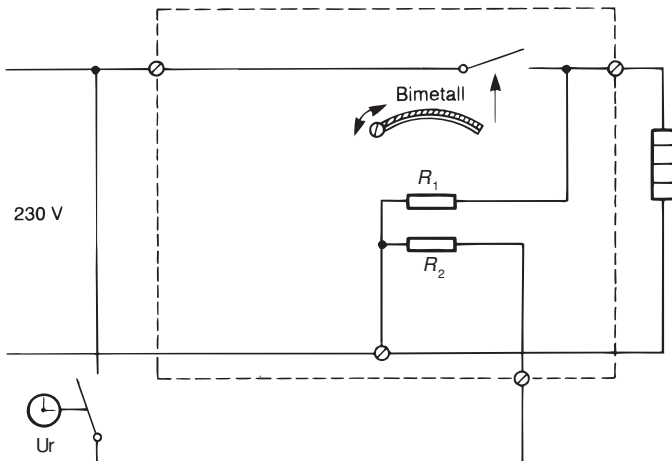
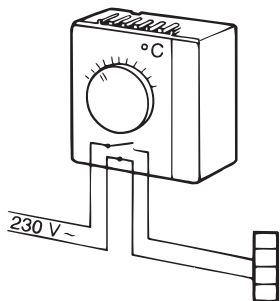


Figur 3.85 Reguleringsbryter

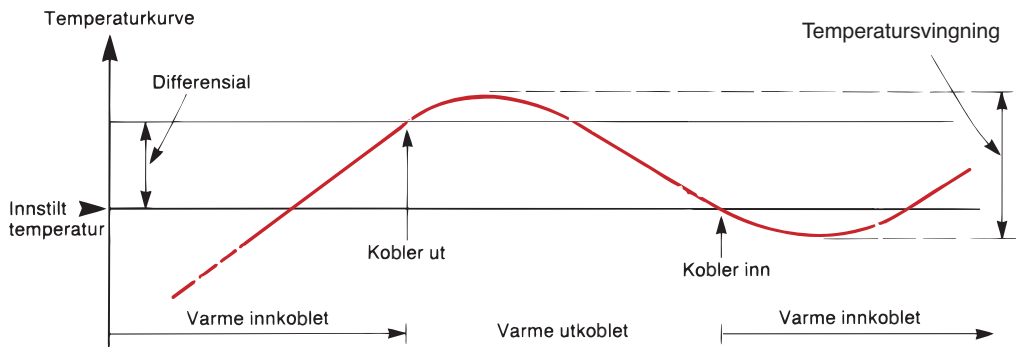




Figur 3.86 Pulstogstyring

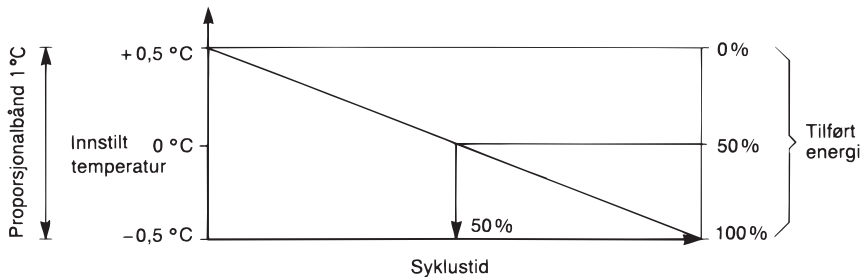
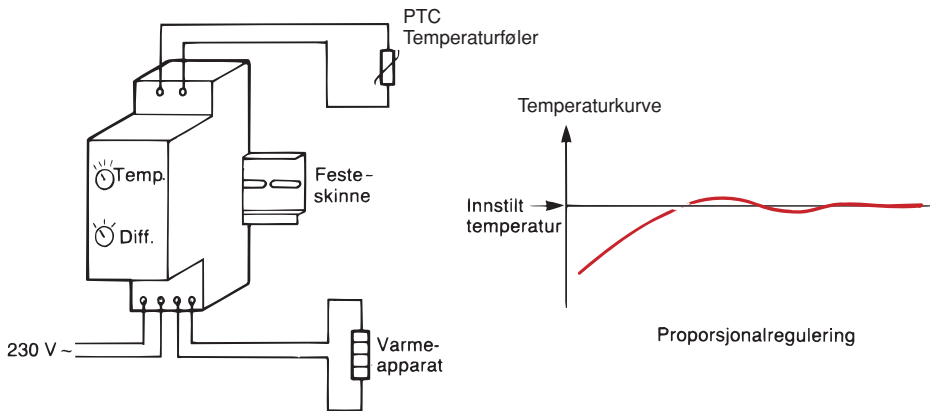


$R_1$  (kompensasjonselement)  
 $R_2$  (temperatursenkning 5 °C)



Figur 3.87 Bimetalltermostat

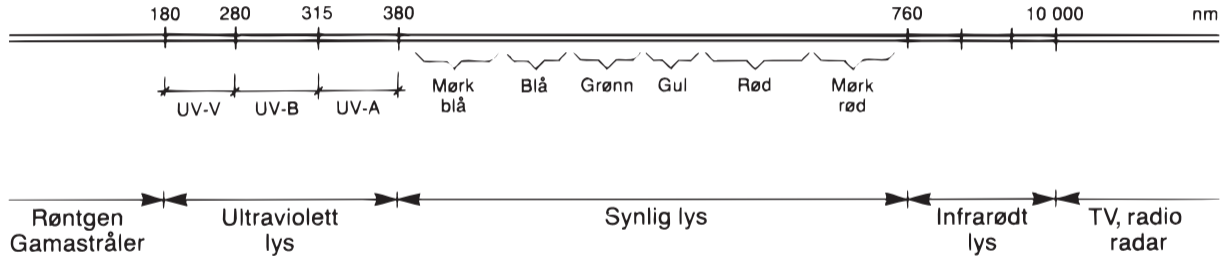
Av/på-regulering



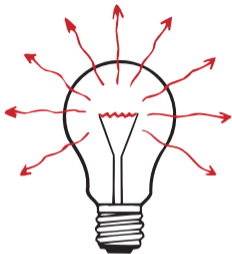
Ved innstilt temperatur vil varmen være innkoblet i 50% av syklustiden og vi får tilført 50% varmeenergi.

Figur 3.88 Prinsipp for elektroniske regulering

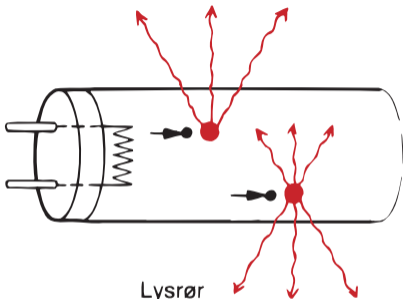
## Elektromagnetisk strålingspekter



Figur 3.89 Elektromagnetisk strålingspekter

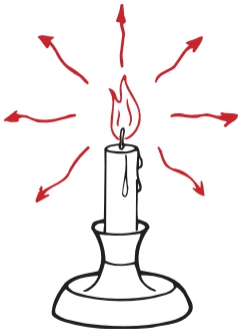


Glødelampe

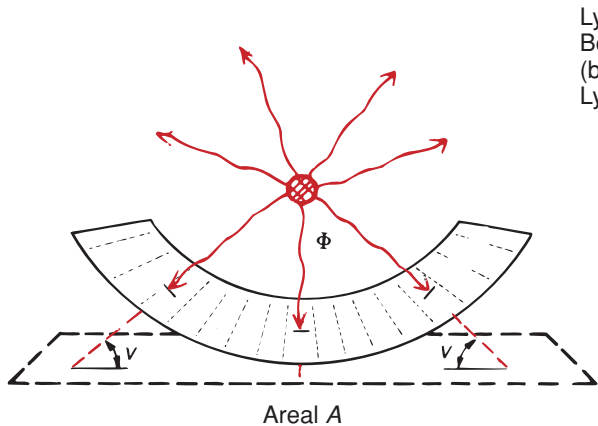


Lysrør

Figur 3.90 Lyskilder



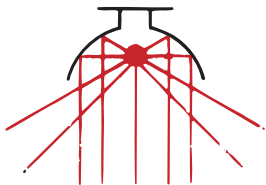
*Figur 3.91*



Lysstrøm  $\Phi$   
 Belysningstetthet  
 (belysningsstyrke)  $E$   
 Lysstyrke  $I$

$$E = \frac{d\Phi}{dA}$$

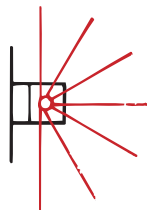
Figur 3.92



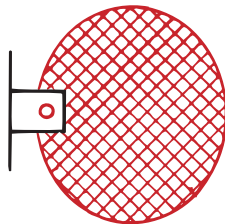
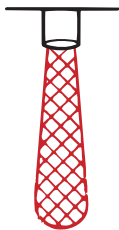
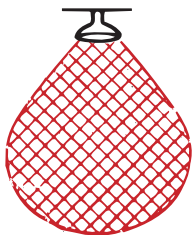
Taklampe med reflektor



Spotlight

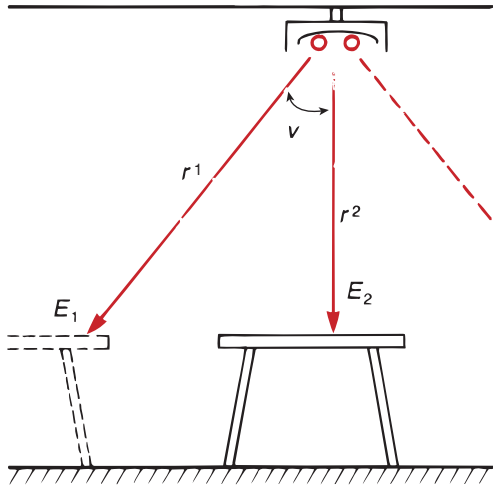


Veggarmatur  
uten reflektor



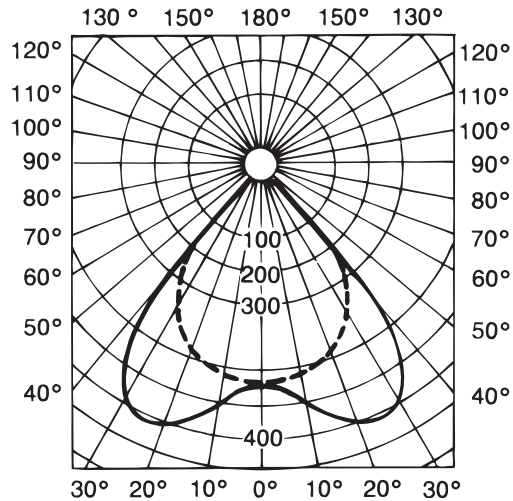
Figur 3.93





$$E = \frac{I}{I^2} \cdot \cos v$$

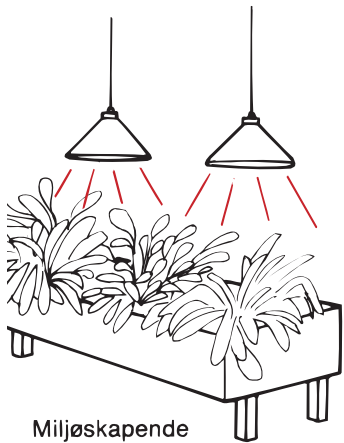
Figur 3.94



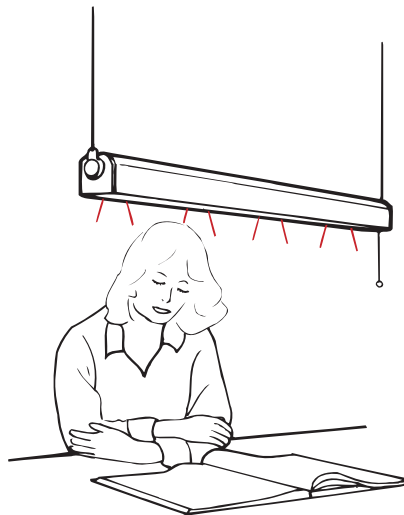
Eksempel på typisk lysfordelingskurve



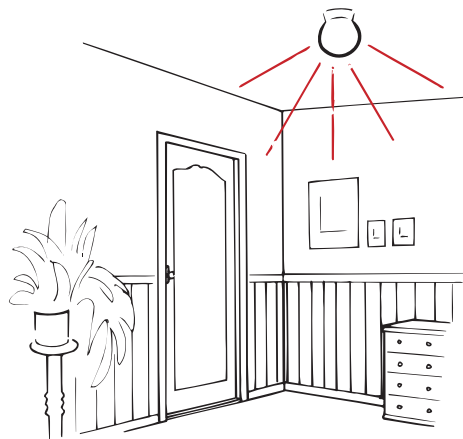
*Figur 3.95 Luxmeter*



Miljøskapende  
belysning

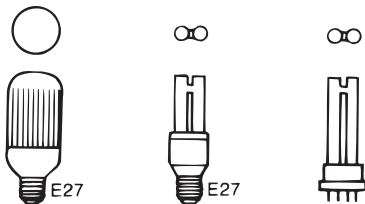


Plassbelysning



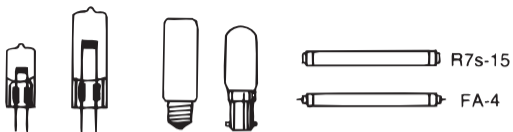
Almenbelysning

Figur 3.96



	SL	PLC	PL
Sokkel	E27	E27	2G11
Levetid	6000 t	6000 t	9000 t
Effekt	9–25 W	7–20 W	18–36 W
Lysutbytte	50 lm/W	ca. 60 lm/W	66–80 lm/W
Farge-temperatur	$T = 2700 \text{ K}$	$T = 2700 \text{ K}$	$T = 2700 - 4000 \text{ K}$
Farge-gjengivelse	$Ra = 82$	$Ra = 82$	$Ra = 82$

Figur 3.97 Kompaktlamper



G4

GY6.35

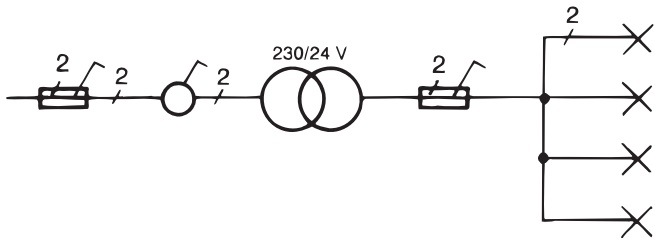
E27

B15d

For horizontal montering

	G4 GY6.35	E27 B15d	For horizontal montering
Sokkel	G4/GY6.35	E27/B15d	R7s-15/FA-4
Levetid	2000 t	2000 t	1000–2000 t
Spenning	12–24 V	220–230 V	220–230 V
Effekt	20–100 W	75–150 W	100–2000 W
Lysutbytte	17–25 lm/W	14–17 lm/W	14–22 lm/W

Figur 3.98 Halogenlamper

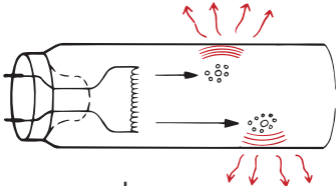


Figur 3.99 Kobling av lavvolthalogenlysanleg



*Figur 3.100*

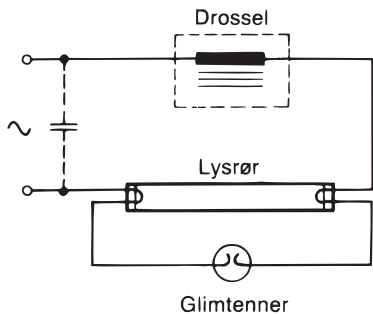
*LED-lampe: Effekt 4,5 W, lysfarge:  
varm hvit, levetid: 25 000 timer*



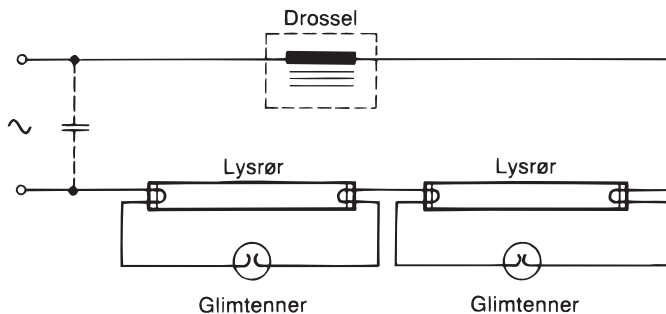
Lysrør

*Figur 3.101*

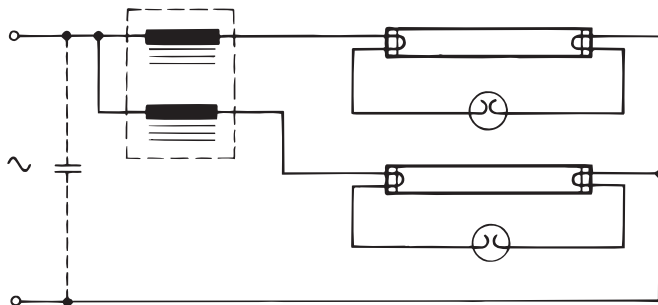




Lysrørarmatur  
med 1 rør

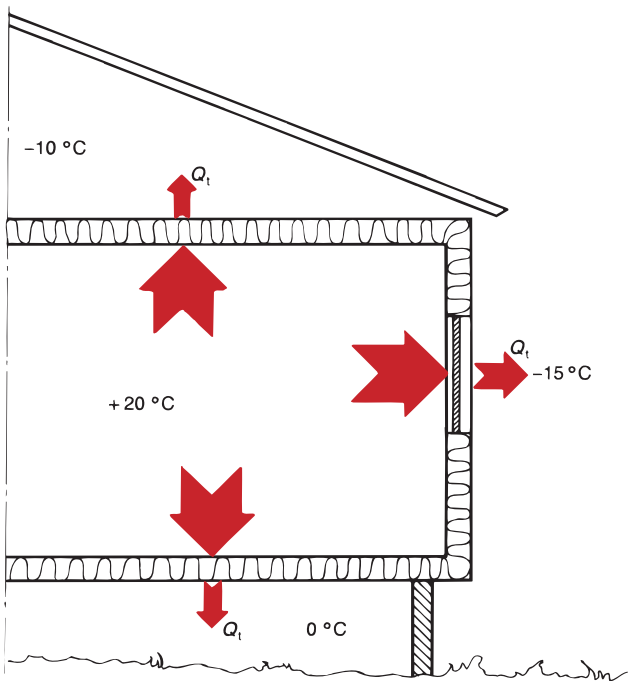


Lysrørarmatur med 2 rør –  
enkel drossel

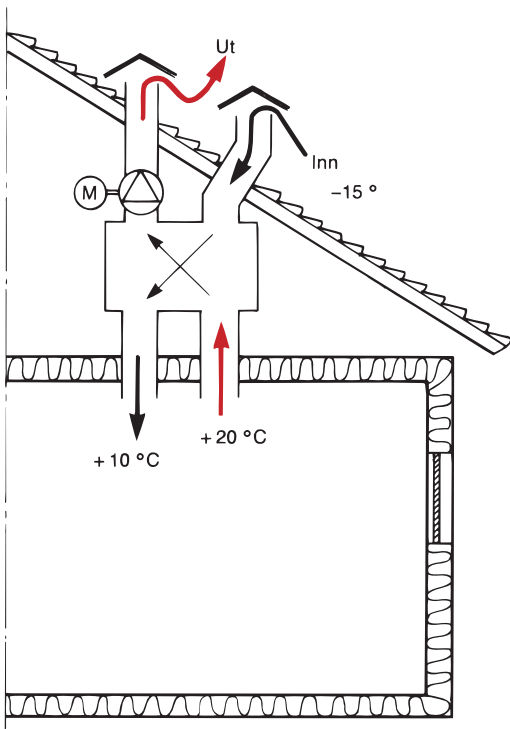


Lysrørarmatur med 2 rør –  
dobbel drossel

Figur 3.102 Kobling av lysrørarmatur

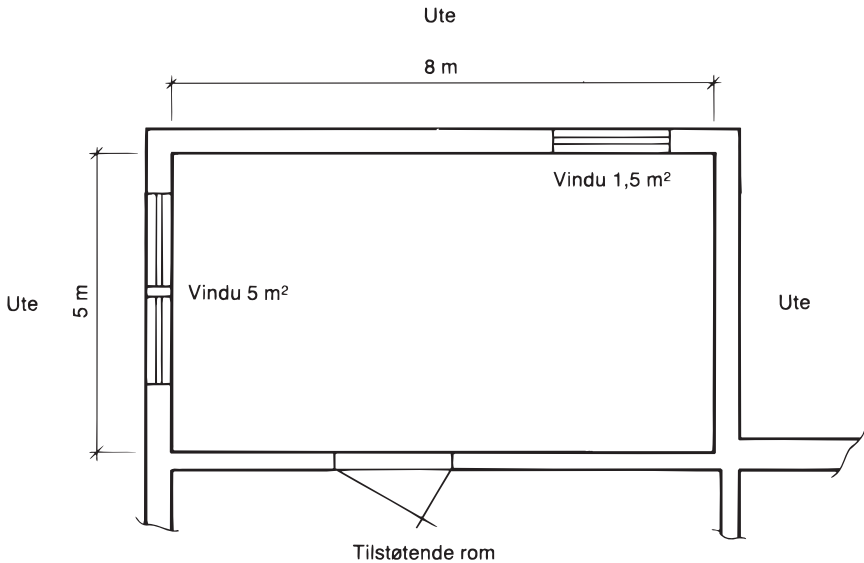


Figur 3.103 Transmisjonstap

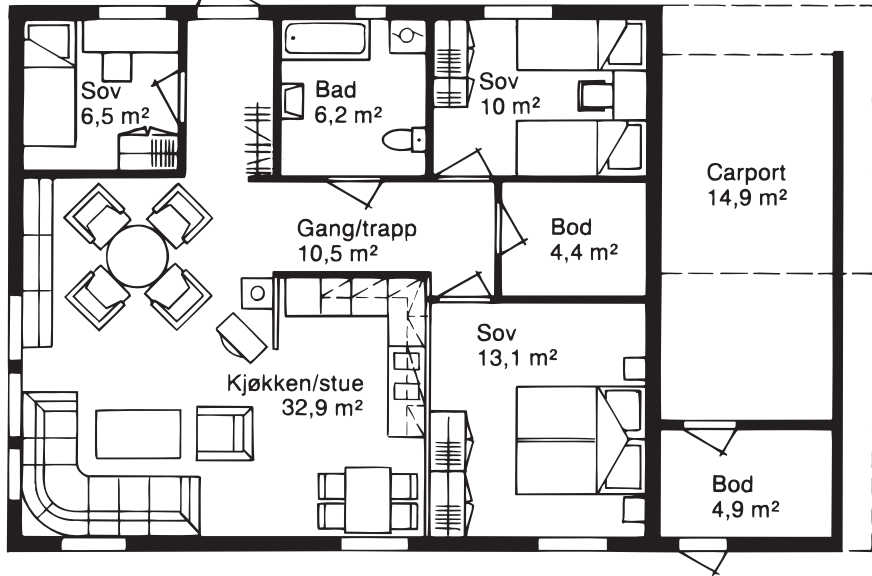


Temperaturforskjell med varmegjenvinner:  $20\text{ }^{\circ}\text{C} - 10\text{ }^{\circ}\text{C} = 10\text{ }^{\circ}\text{C}$   
 Temperaturforskjell uten varmegjenvinner:  $20\text{ }^{\circ}\text{C} - (-15\text{ }^{\circ}\text{C}) = 35\text{ }^{\circ}\text{C}$

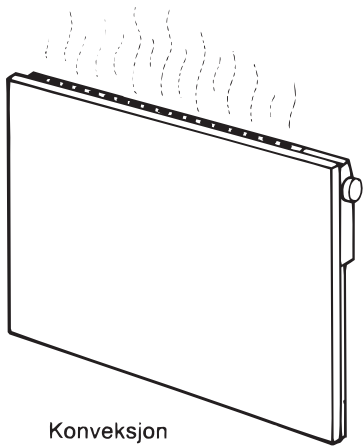
Figur 3.104 Ventilasjonstap



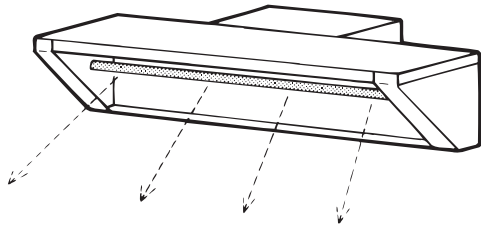
Figur 3.105



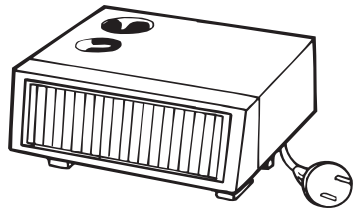
Figur. 3.106



Konveksjon

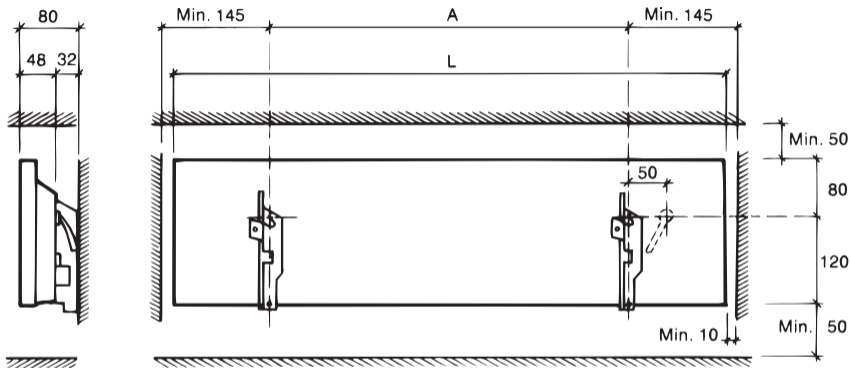


Stråle



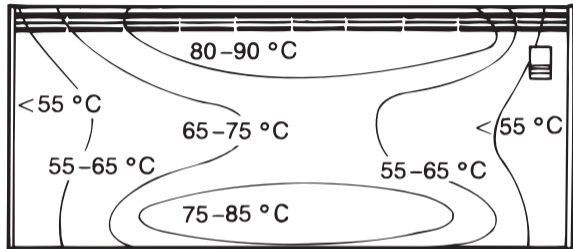
Varmluft

Figur 3.107



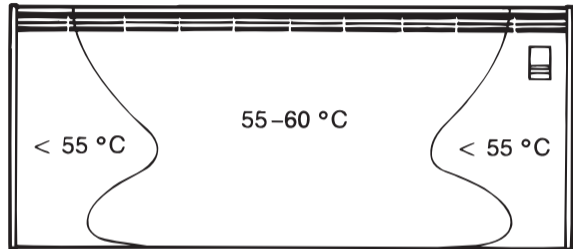
- Minste tillatte avstand fra overkant til vindusbrett o.l.: 50 mm
- Minste tillatte avstand fra gulv til underkant: 50 mm
- Minste tillatte avstand til sidevegg: 10 mm

Figur 3.108 Monteringsmål



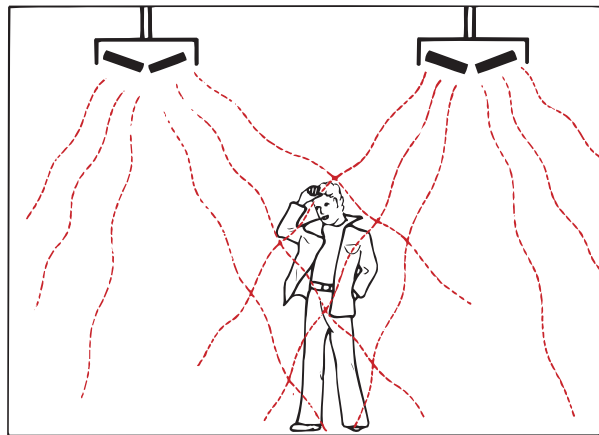
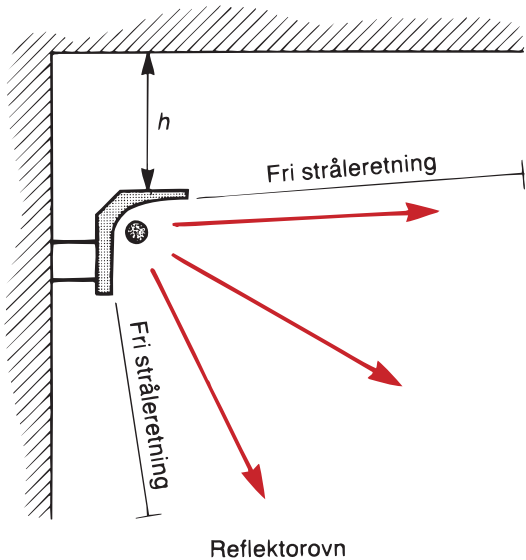
Normaltemperaturovn.  
Maks. overflatetemperatur 90 °C

*Figur 3.109 Overflatetemperaturer*

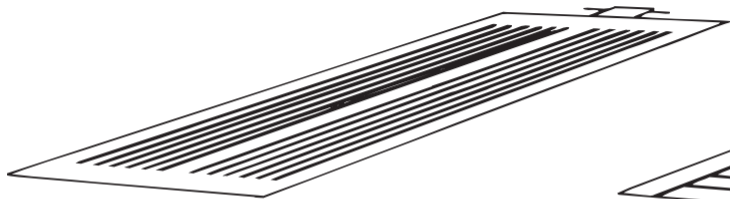


Lavtemperaturovn. Maks. overflatetemperatur 60 °C

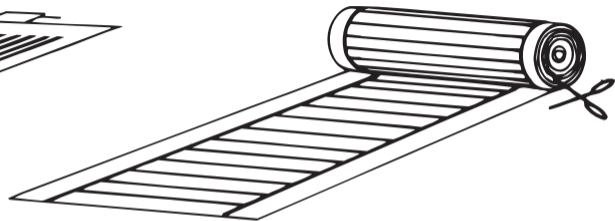




Figur 3.110 Stråleovner

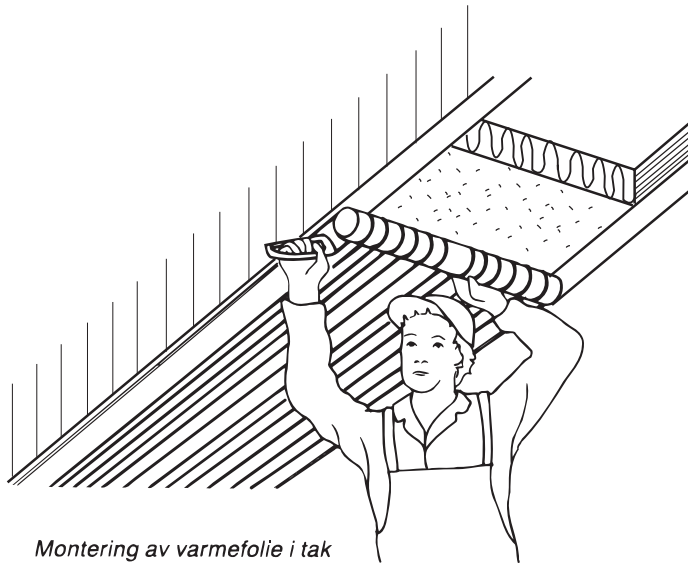


Varmefolie i fast lengde

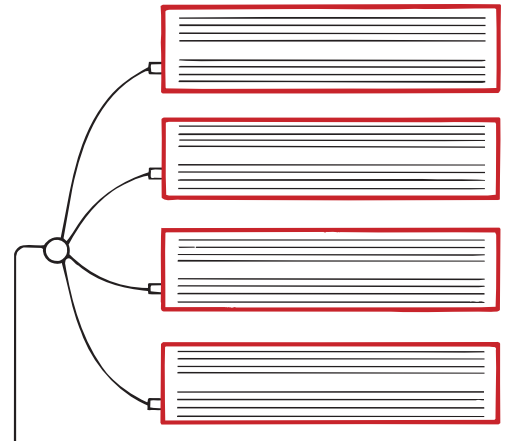
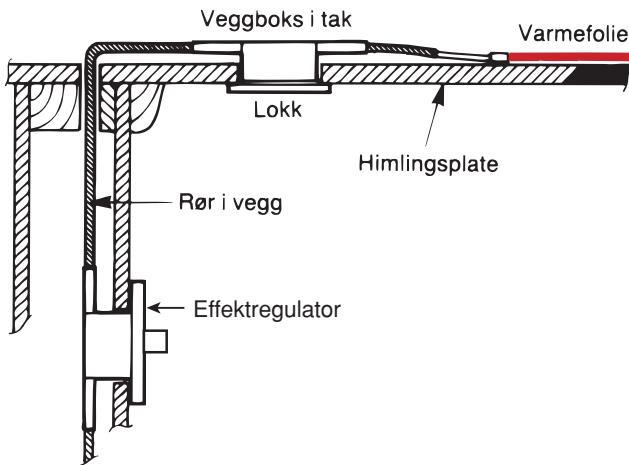


Varmefolie levert som metervare

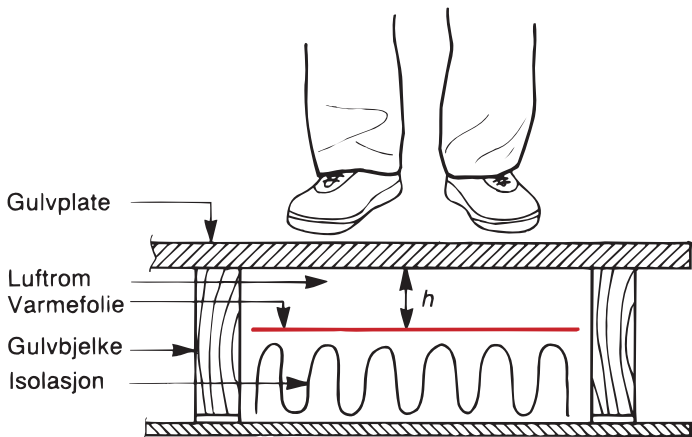
*Figur 3.111*



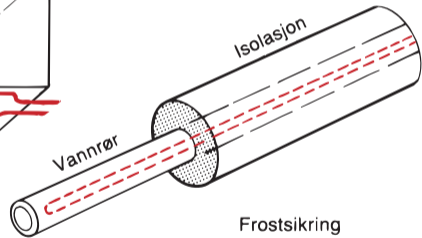
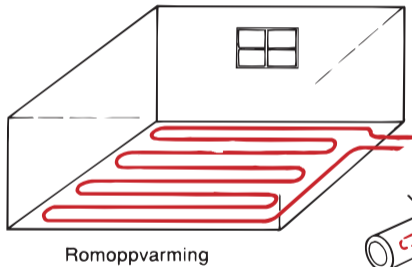
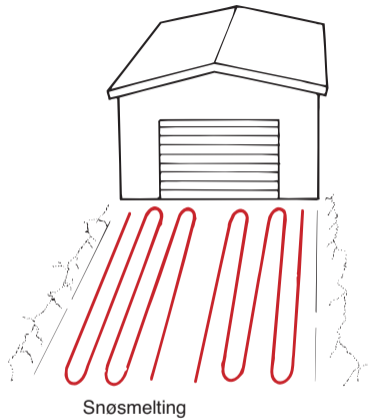
Montering av varmemefolie i tak



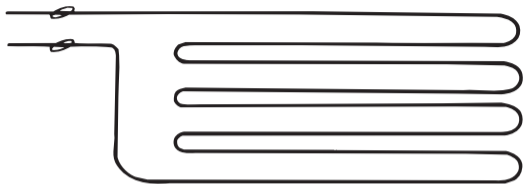
Figur 3.112 Installasjon av takelement



*Figur 3.113 Luftrom ved montering i gulv*



Figur 3.114 Bruksområder for varmekabler



Lengde 100 m

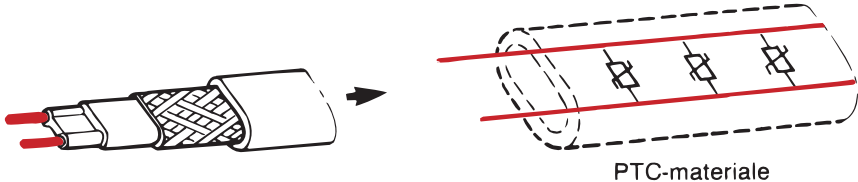
Resistans 0,49  $\Omega$ /m

Varmekabel

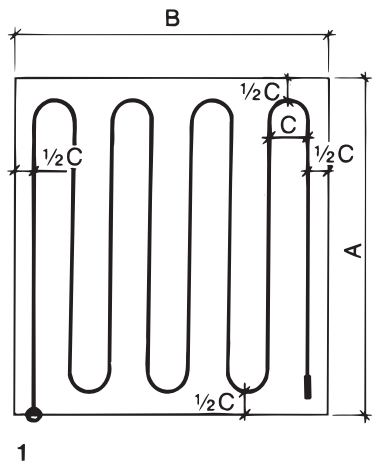
$$\text{Effekt } P = \frac{U^2}{R} = \frac{(230 \text{ V})^2}{0,49 \text{ } \Omega/\text{m} \cdot 100 \text{ m}} = \underline{1\ 080 \text{ W}}$$

$$\text{Effekt per meter kabel: } \frac{1\ 079,6 \text{ W}}{100 \text{ m}} = \underline{10,8 \text{ W/m}}$$

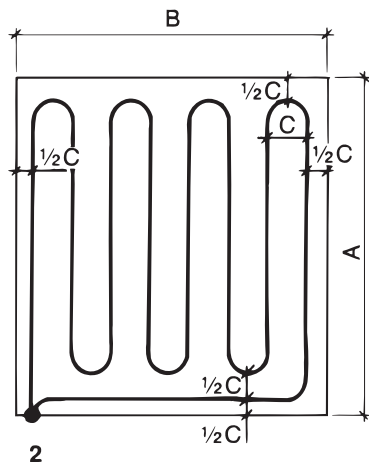
Figur 3.115



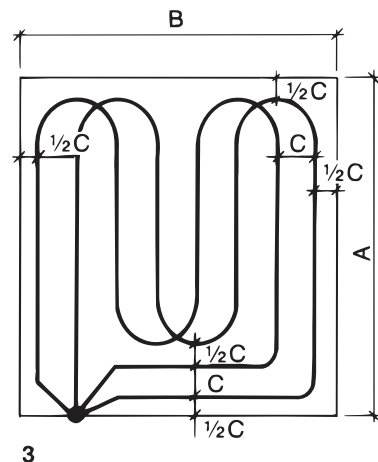
*Figur 3.116 Parallellresistanskabel*



En toleder varmekabel i gulv.  
Kabeltampen føres ikke tilbake  
til koplingsboksen med tilledning



En enleder varmekabel i gulv.  
Begge kabellengder avsluttes  
i felles koplingsboks med til-  
ledning



To enleder varmekabler forlagt  
parallelt i gulv. Alle kabellengder  
avsluttes i felles koplingsboks  
med tilledninger

Figur 3.117 Plassering av varmekabler