

Arbejdsblok med beregnings- og kontrolskema

Planlægning af betonstøbning om vinteren under hensyntagen til frostsikkerhed, styrkekrav, tidsterminer og temperaturkrav kan gennemføres systematisk ved hjælp af en arbejdsblok, der er udsendt separat som et tillæg til denne SBI-anvisning 125. Arbejdsblokkens blade er vist på de følgende sider. Forsiden er et beregningsskema og bagsiden er et kontrolskema.

Ved at udfylde de to skemaer opnås en systematisk beskrivelse og dokumentation af det udførte betonarbejde og man sikrer sig en systematisk indsamling af erfaring.

Beregningsskema, planlægning af betonstøbning om vinteren

Øverst anføres sagens navn, initialer og dato. Derefter tegnes i punkt 2: *Systembeskrivelse* en målsat skitse af det tværsnit, der ønskes udstøbt. Skitsen skal vise tværsnittet og de anvendte formtyper. Hver fri eller formsat flade beskrives med et positionsnummer.

For plane tværsnit som vægge og dæk er det hensigtsmæssigt at vise et udsnit på 1 m i snitplanen. Disse tværsnit beskrives ved to positionsnumre idet der kun sker varmetransport vinkelret på vægplanen.

Under skitsen beregnes det skitserede betonvolumen V , og betonens rumvægt R , varmfylde c , og varmeledningstal λ , anføres.

I punkt 1: *Transmissionstal* k aflæses transmissionstallene for hver af skitsens frie eller formsatte flader. k -værdierne skrives på skitsen ud for fladens positionsnummer.

I punkt 3: *Kontrol* undersøges om forudsætningen for brug af hærdediagrammerne er opfyldt. Hvis der er flere formtyper, bør kontrollen udføres for det højeste transmissionstal. For rektangulære tværsnit kan kontrollen eventuelt udføres i to snitretninger. Det undersøges, om den største værdi af $k \cdot \delta / \lambda$ er mindre end 0.5. Hvis denne betingelse ikke er opfyldt, bør der eventuelt ændres på isoleringsniveauet, indtil kravet er overholdt.

Når kontrollen er udført og forudsætningerne dermed er opfyldte, bestemmes tværsnittets afkølingstal i punkt 4: *Afkølingstal* a .

Beregningen af afkølingstallet udføres ved at overføre informationerne fra skitsen i punkt 2. Hver position anføres sammen med den tilhørende k -værdi og formfladens areal F . Det er underforstået, at der regnes med et udsnit på 1 m vinkelret på snitplanen. Dermed bliver arealet F for hver position lig med formfladens snitdimension som anført i skitsen. Herefter kan $(k \cdot F)$ -bidragene fra hver position summeres. Fra punkt 2 overføres volumen, rumvægt samt varmfylde og de ganges sammen, hvorefter afkølingstallet kan beregnes. a -værdien overføres til punkt 5: *Temperaturforløb*.

Under punkt 5 skal de øvrige forventede forudsætninger for betonarbejdet anføres. Det er cementtypen (der sættes en cirkel om A, B eller C), cementindholdet, den forventede gennemsnitlige lufttemperatur i hærdeperioden og betonens udstøbningstemperatur. Cementtypen udpeger et sæt hærdediagrammer, røde, grønne eller blå. Cementindholdet ud-

peger et opslag i et af diagramsættene. Endelig udpeger θ_L , θ_B og a en bestemt beregnet kurve for tværsnittets temperaturforløb, som tegnes i punkt 5. I hærdediagrammet undersøges, hvornår frostsikkerhed opnås, og om der er risiko for frostbeskadigelse ved tidlig frysning. Til slut aflæses tidspunktet for afforskalling ud fra det opstillede krav til modenheden ved afformning.

I punkt 6: *Efterbehandling* undersøges om særlige foranstaltninger er nødvendige for at undgå temperaturrevner i forbindelse med afformningen. Disse foranstaltninger kan enten omfatte tildækning af tværsnittet eller en forlænget formperiode ud over det, der er nødvendigt af hensyn til afformningsstyrken. Beregningerne i punkt 6 kan for normalbeton simpelt gennemføres ved brug af et diagramsystem på indersiden af arbejdsblokkens omslag.

I punkt 7: *Særlige bemærkninger* anføres særlige krav til støbearbejdets udførelse, herunder krav til kontrol af hærdeforløb.

Kontrolskema, udførelse af betonstøbning om vinteren

Ved udførelse af betonstøbning om vinteren bør hærdeforløbet altid kontrolleres ved måling af betonens temperatur under hærdeningen. Formålet med denne kontrol er, om påkrævet, at kunne gribe regulerende ind i hærdeprocessen, fx ved opvarmning, ved ændret tildækning eller gennem ændring af procestider. Herved kan betonen sikres mod beskadigelse ved tidlig frysning og gennem temperaturbelastning. Endelig kan modenhedsudviklingen løbende følges, så det sikres, at betonen har den nødvendige modenhed på afformningstidspunktet.

Kontrollen af betonarbejdet bør ske efter retningslinier, som på forhånd er aftalt mellem bygherren eller dennes tilsyn og den udførende. Hovedpunkterne i kontrolaftalen bør fremgå af kontrolskemaets informationer. Øverst anføres hvem der indgår aftalen. Dernæst tegnes en skitse af beton-tværsnittet. Målepunkternes placering anføres og målsættes, og de gives en tydelig nummerering. Det fastlægges, hvilke temperaturforskelle der specielt skal kontrolleres under hærdeningen samt hvor der er særlig risiko for tidlig frysning.

Under punktet *Hærdeforløb* beskrives selve måleforløbet, herunder hvilket måleudstyr der er anvendt og hvor tit der måles. For at sikre, at der ikke begås grove fejl, er det væsentligt at kontrollere måleudstyret med passende mellemrum. Dette gøres ved at sammenligne med en referencemåling.

Under *Bemærkninger* anføres forhold, som har medført ændringer sammenlignet med det aftalte udførelsesforløb. Der kan fx være tale om vejrændringer, som nødvendiggør ændringer i tildækningen, eller om ændringer i støbearbejdets udførelse.

Arbejdsblokkens brug

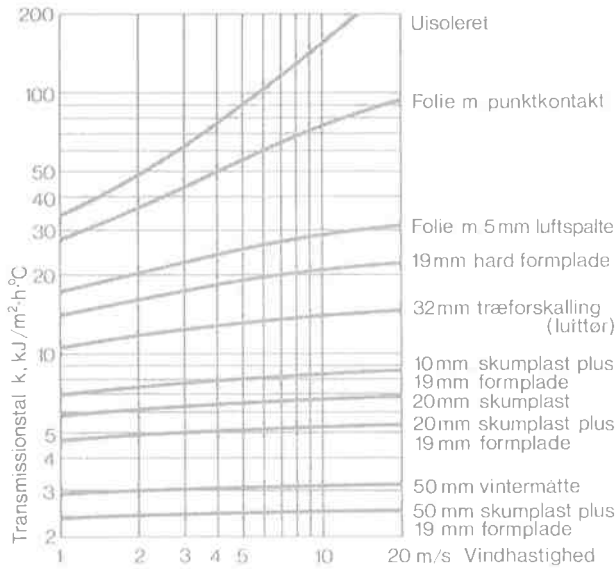
I kapitlet »Nogle typiske vinterstøbningseksempler«, side 42 ff vises den praktiske anvendelse af arbejdsblokkens skemaer.

Sag

Initialer

Dato

1. Transmissionstal k

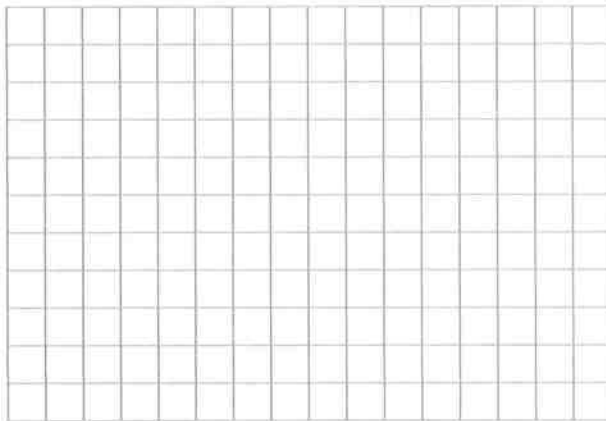


4. Afkølingstal a

Position	k	F	k·F
$\Sigma(k \cdot F)$			
	V	R	c
Fra pkt. 2			
V·R·c			
Afkølingstal, h ⁻¹	$a = \frac{\Sigma(k \cdot F)}{V \cdot R \cdot c}$		

Det beregnede afkølingstal a anvendes i nedenstående punkt 5.

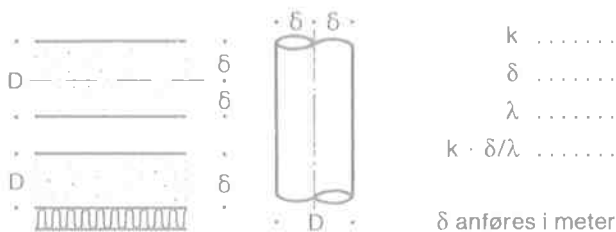
2. Systembeskrivelse



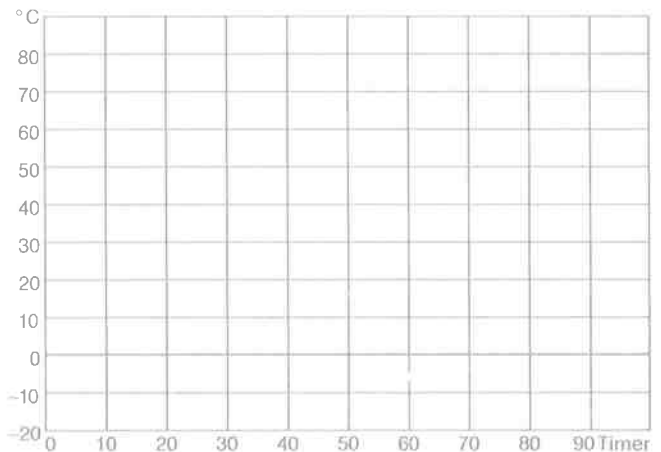
Volumen, m³ V
Rumvægt, kg/m³ R
Varmefylde, kJ/kg·°C c
Varmeledningstal, kJ/m·h·°C λ

3. Kontrol

Forudsætningen om samme betontemperatur overalt i et tværsnit vil tilnærmet være opfyldt, hvis $k \cdot \delta / \lambda < ca. 0.5$



5. Temperaturforløb



Cementtype A B C ? Indhold, kg/m³ C
Lufttemperatur, °C θ_L
Udstøbningstemperatur, °C θ_B
Afkølingstal, h⁻¹ a

6. Efterbehandling

1. Hvis $\theta_m - \theta_L \leq 20^\circ C$ kan form/isolering fjernes.

2. Hvis $\theta_m - \theta_L > 20^\circ C$

a) efterisoleres således at

$$k < \frac{40}{(\theta_m - \theta_L - 20)} \cdot \frac{\lambda}{\delta}, \text{ kJ/m}^2 \cdot \text{h} \cdot \text{°C} \quad k < \dots\dots\dots$$

b) afkøles i form indtil

$$\theta_m \leq \frac{40}{k_a} \cdot \frac{\lambda}{\delta} + \theta_L + 20, \text{ °C} \quad \theta_m \leq \dots\dots\dots$$

θ_m er temperatur °C i midten af simpelt tværsnit
k_a er transmissionstal efter afformning

7. Særlige bemærkninger

Hærdediagrammer

Dette kapitel viser i diagramform beregnede temperatur- og hærdforløb for en række forskellige betonstøbninger. Hver støbning er repræsenteret ved én (sort) kurve, som er fastlagt ved en bestemt cementtype og ved en bestemt værdi for cementindhold, udstøbningstemperatur, lufttemperatur og afkølingstal.

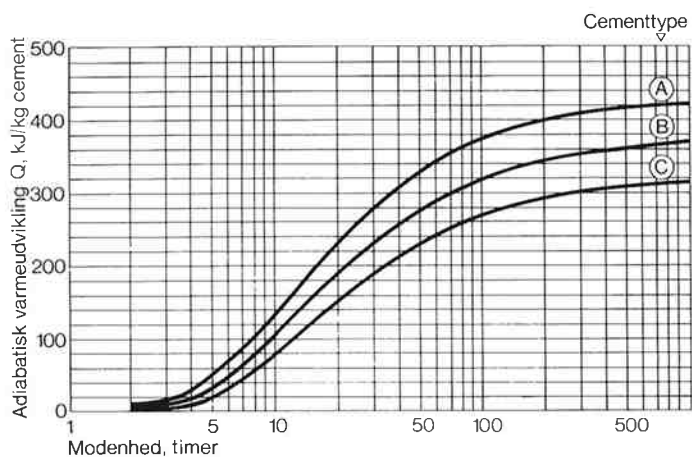
Forudsætningerne for beregningerne er gennemgået i kapitel 5 og 6.

Grundlaget for temperaturberegningen er betonens adiabatiske varmeudvikling. Denne måles i et adiabatisk kalorimeter på en betonprøve af størrelsesordenen 4–8 liter. Resultatet af målingen kan afbildes som »basiskurver«, se figuren øverst til højre. Basiskurverne A, B og C er typiske kurveforløb for henholdsvis hurtighærdnende, normalhærdnende og langsomhærdnende cement. De fleste markedsførte cementtyper kan henføres til én af de angivne cementtyper A, B eller C.

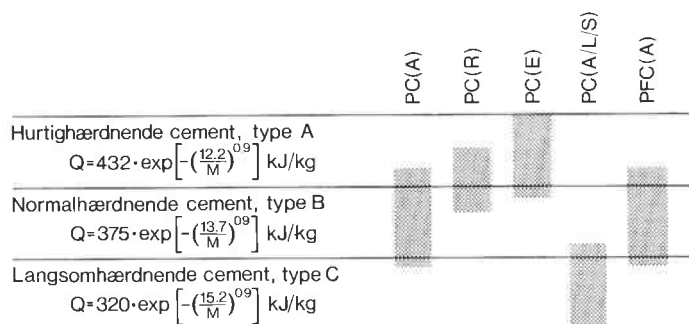
Da varmeudviklingsforløbet bl.a. afhænger af v/c-forhold og eventuelle tilsætningsstoffer, kan et aktuelt målt forløb afvige fra basiskurverne. I sådanne tilfælde må man vælge den kurve, der ligger nærmest ved den aktuelt målte kurve i det tidsinterval, hvori væsentlige arbejdsoperationer skal finde sted.

Hvis der ikke er gennemført målinger, kan man som bedste skøn vælge basiskurver ud fra den nederste figur, der niveaumæssigt placerer de danske cementtyper.

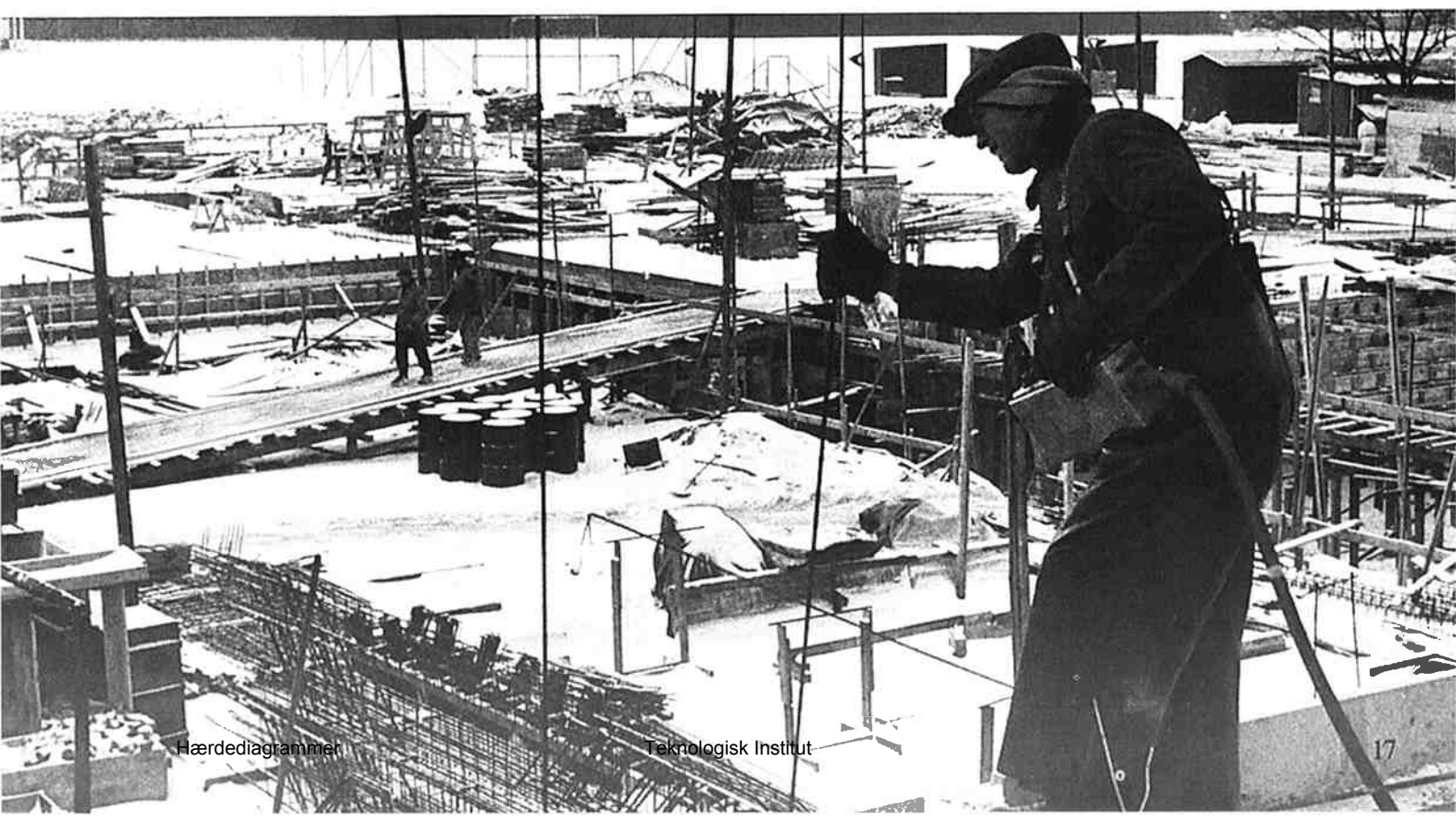
Bagest i anvisningen er basiskurverne afbildet på et transparent bilag. Et aktuelt dokumentationsblad for varmeudvikling (et eksempel er vist på side 47) kan lægges ind under transparenten, hvorefter den nærmest liggende basiskurve kan udpeges.



Basiskurver for hurtighærdnende cement (A), normalhærdnende cement (B) og langsomhærdnende cement (C).



Diagrammet viser denne SBI-anvisnings cementtyper A, B og C i forhold til markedsførte, danske cementprodukter i september 1982. PC(A)=almindelig portlandcement. PC(R)=rapidcement. PC(E)=super-rapidcement. PC(A/L/S)=lavalkali, sulfatbestandig cement. PFC(A)=standardcement med flyveasketilsætning.



Hurtighærdnende cement, type A 250 kg/m³

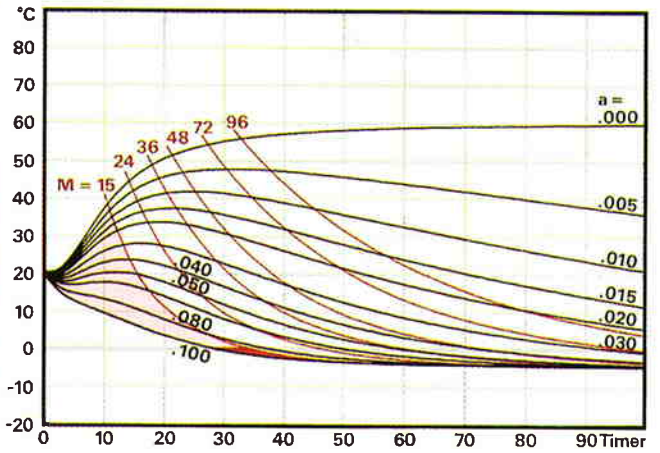
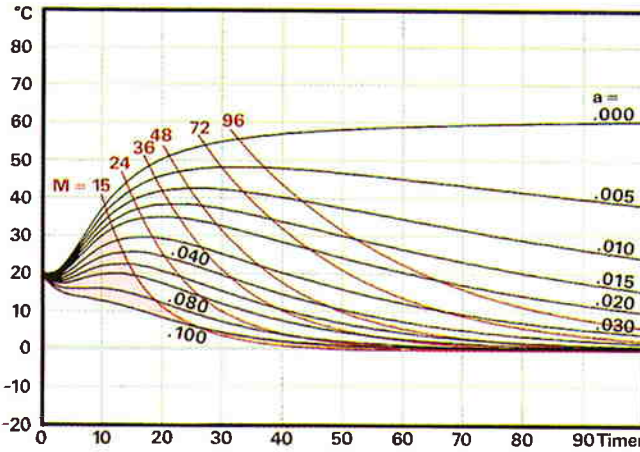
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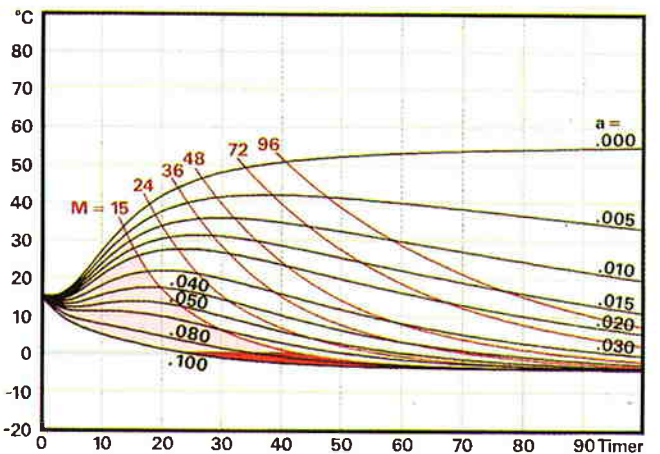
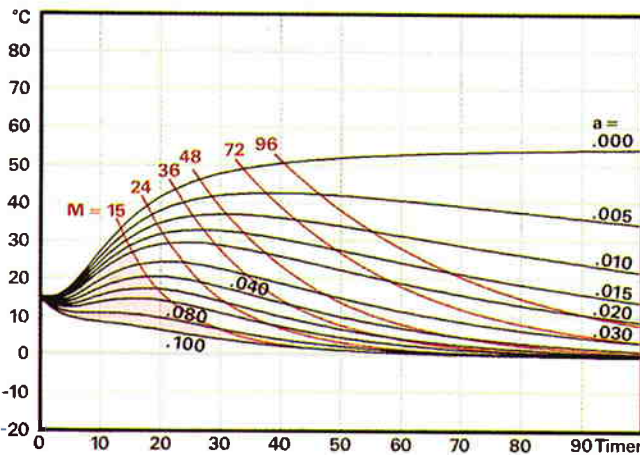
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

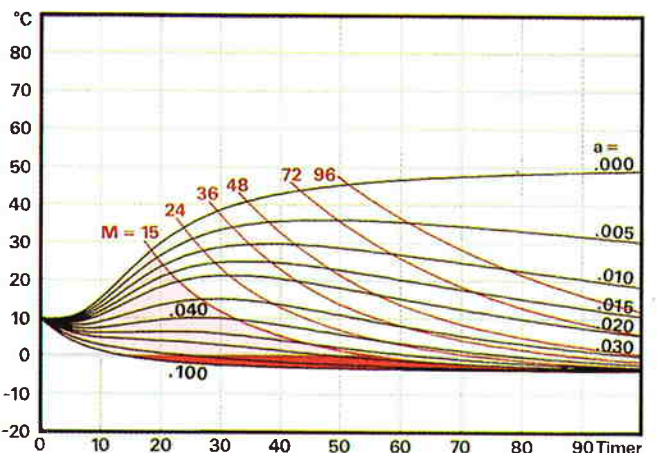
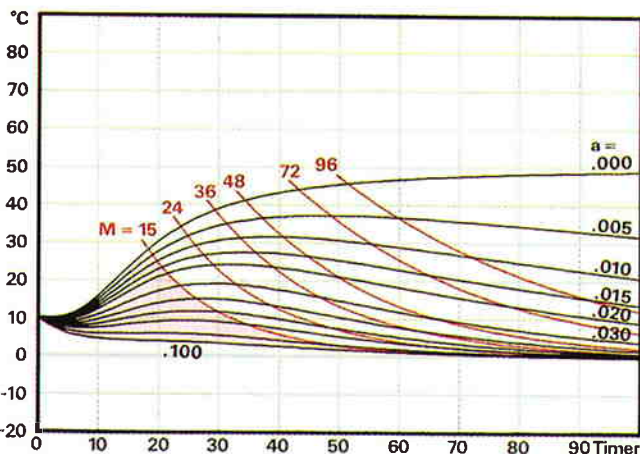
Beton-temp.
 $\theta_B = 20^\circ\text{C}$



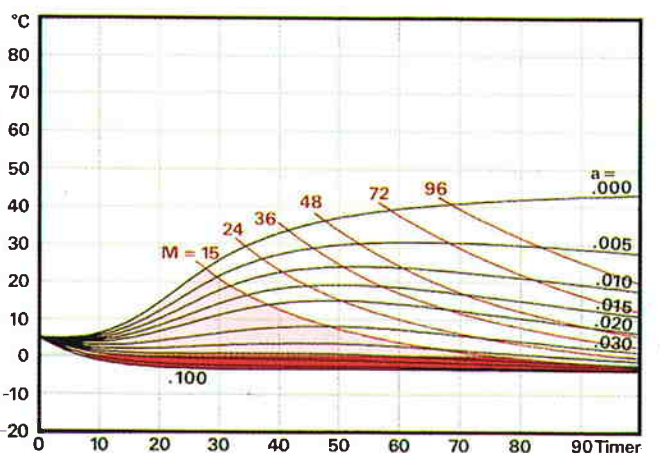
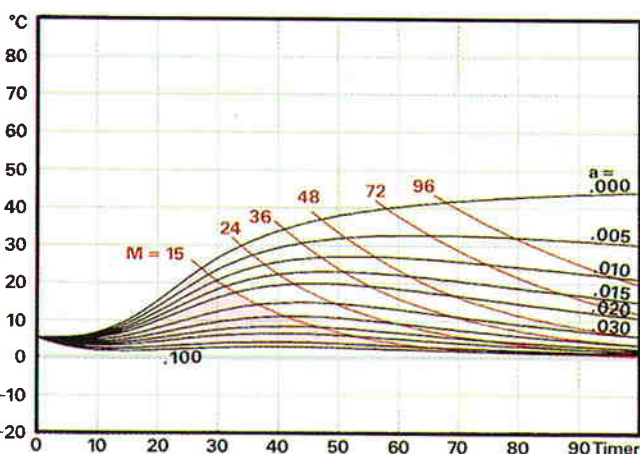
Beton-temp.
 $\theta_B = 15^\circ\text{C}$



Beton-temp.
 $\theta_B = 10^\circ\text{C}$



Beton-temp.
 $\theta_B = 5^\circ\text{C}$



Hurtighærdnende cement, type A 250 kg/m^3

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VINTERSTØBNING
AF BETON 1982

Lufttemperatur $\theta_L = -10 \text{ }^\circ\text{C}$

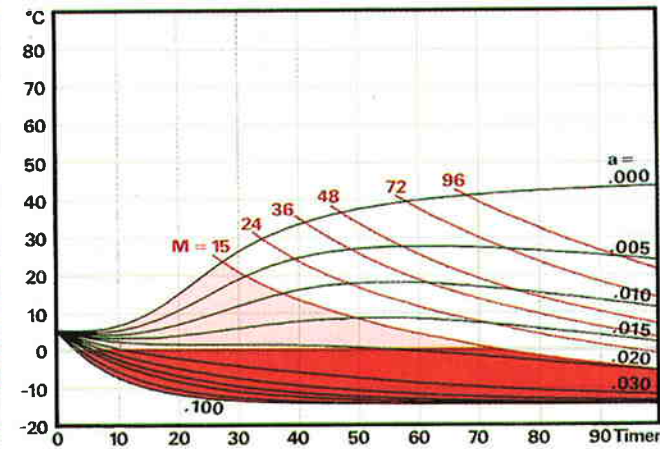
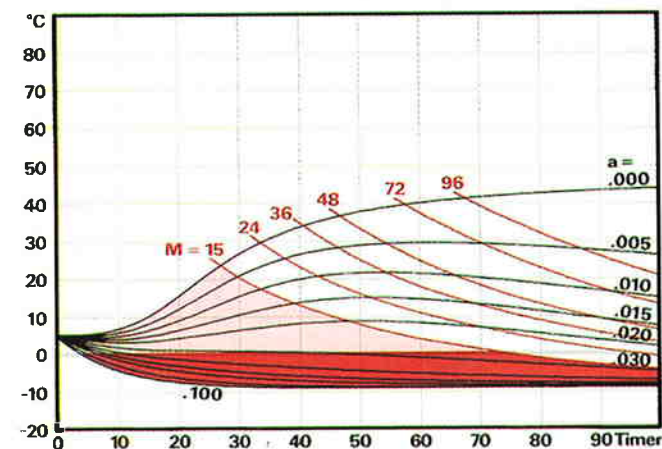
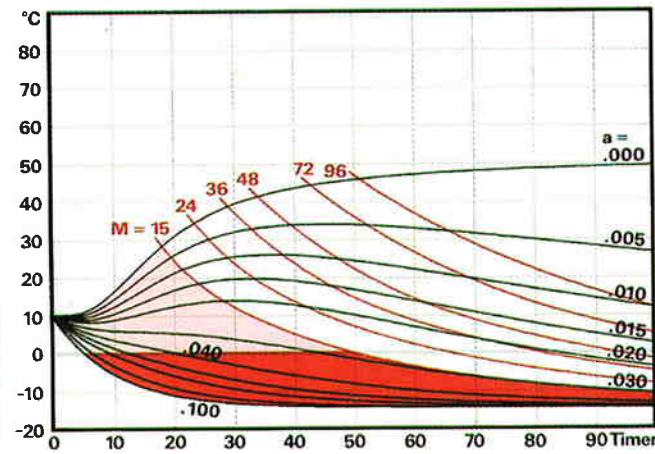
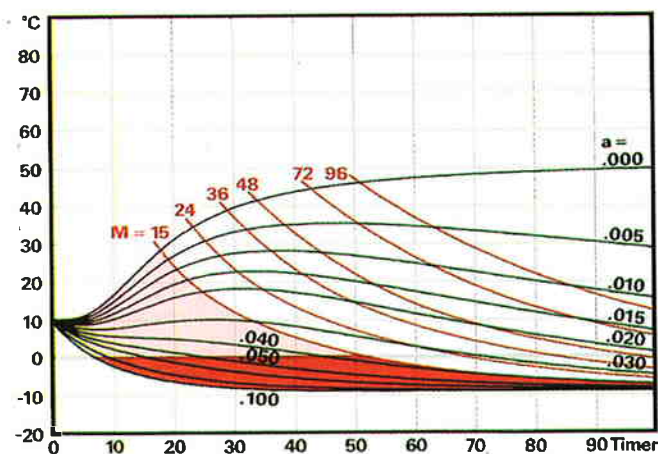
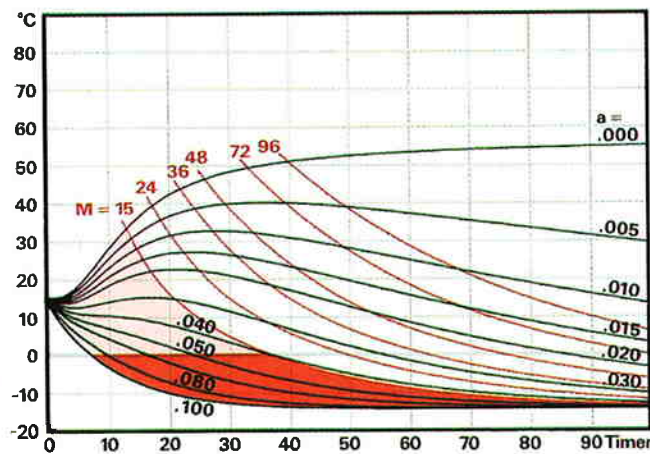
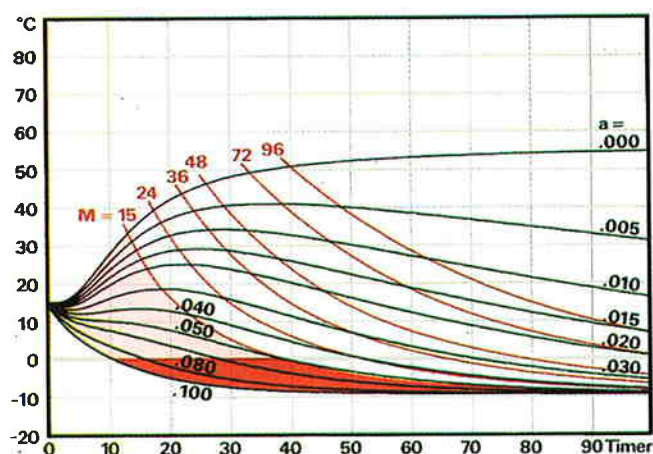
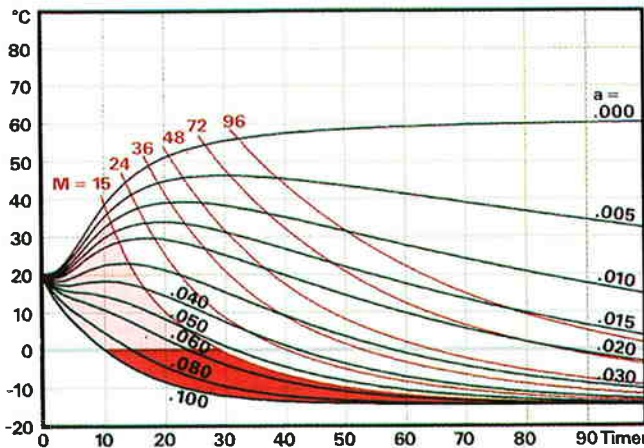
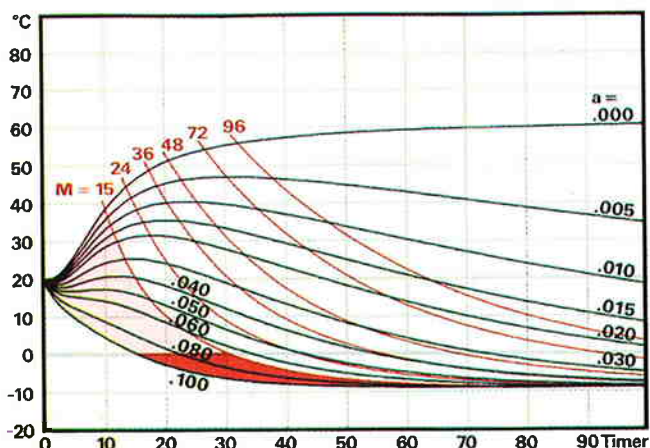
Lufttemperatur $\theta_L = -15 \text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 20 \text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 15 \text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 10 \text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 5 \text{ }^\circ\text{C}$



Hærdediagrammer

Teknologisk Institut

Hurtighærdnende cement, type A 300 kg/m³

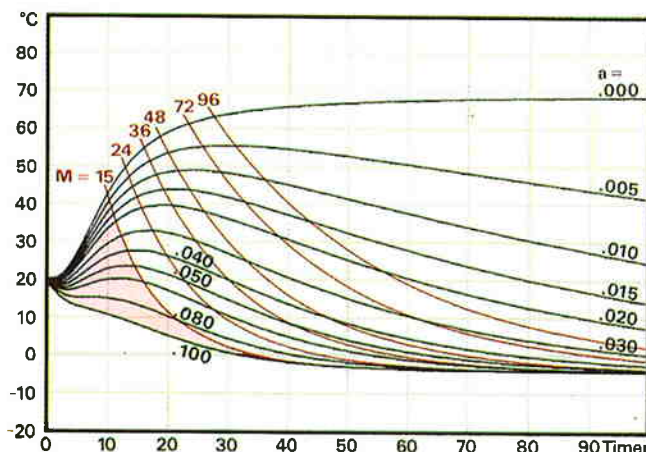
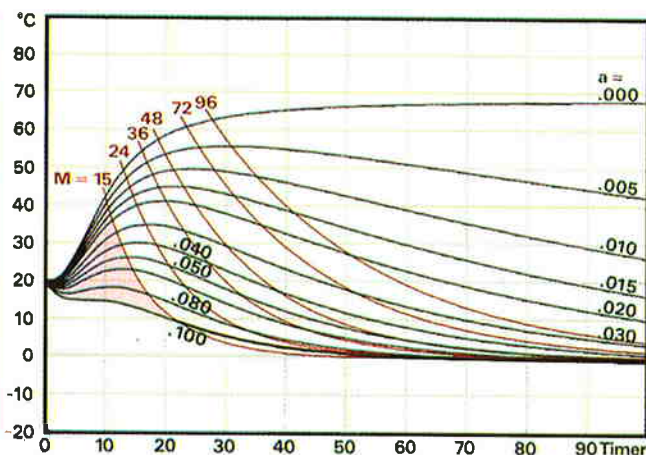
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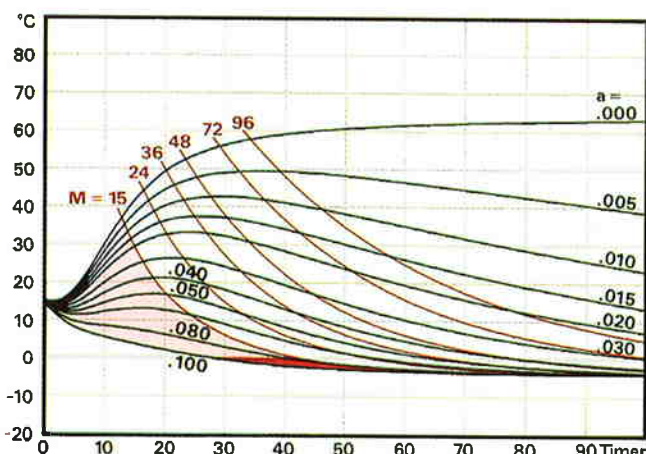
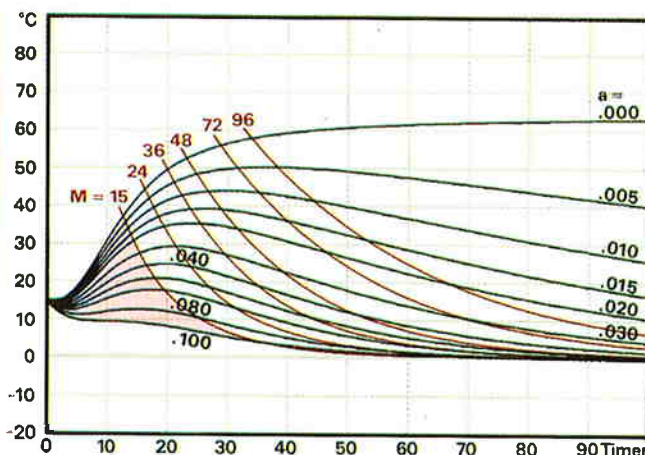
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Lufttemperatur $\theta_L = -5^\circ\text{C}$

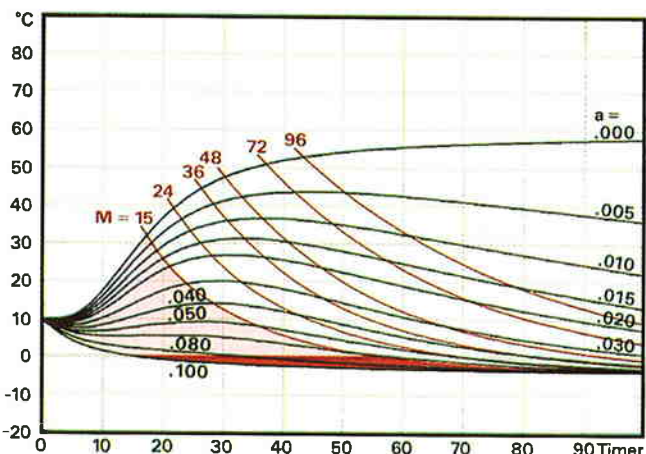
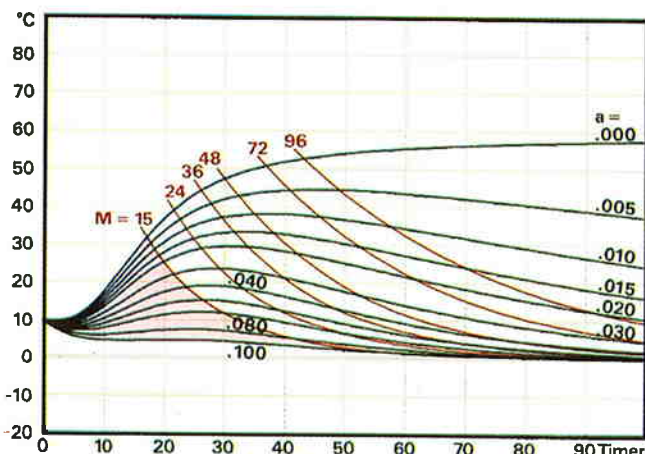
Beton-temp.
 $\theta_B = 20^\circ\text{C}$



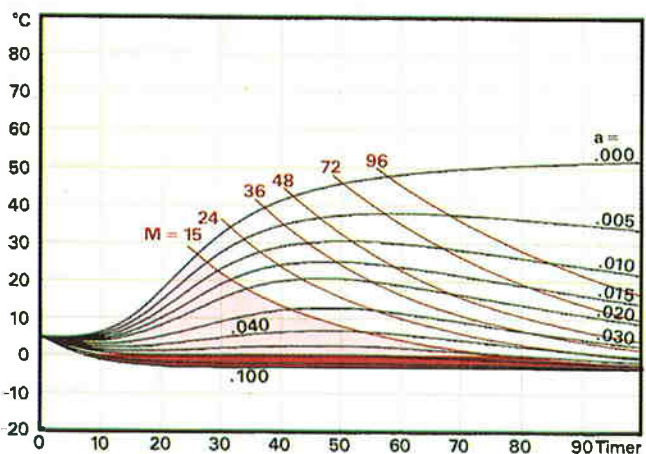
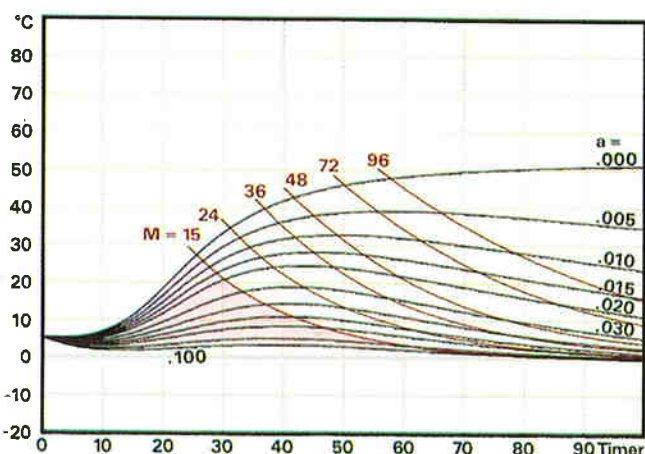
Beton-temp.
 $\theta_B = 15^\circ\text{C}$



Beton-temp.
 $\theta_B = 10^\circ\text{C}$



Beton-temp.
 $\theta_B = 5^\circ\text{C}$



Lufttemperatur $\theta_L = -10\text{ }^\circ\text{C}$

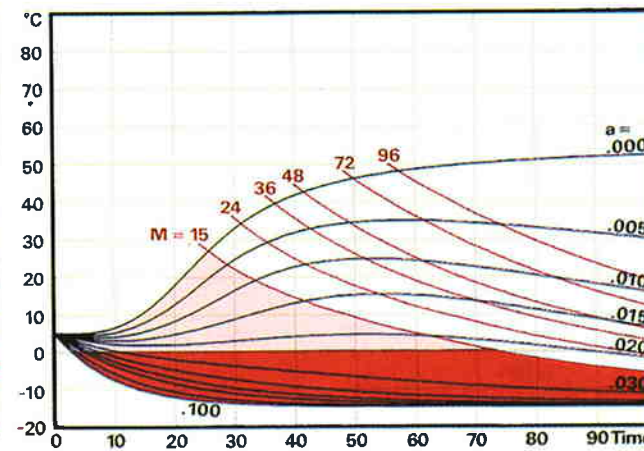
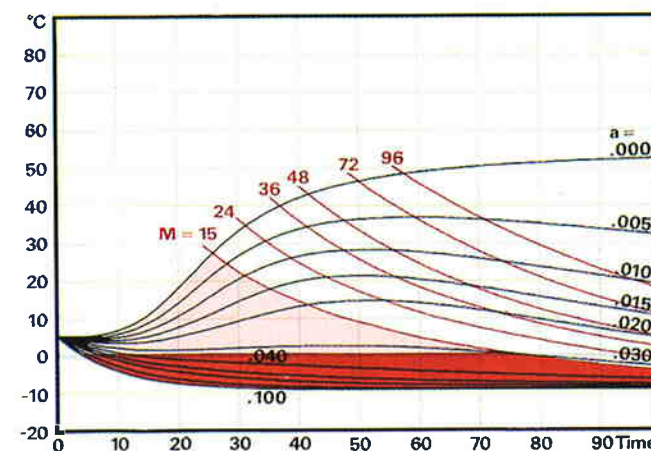
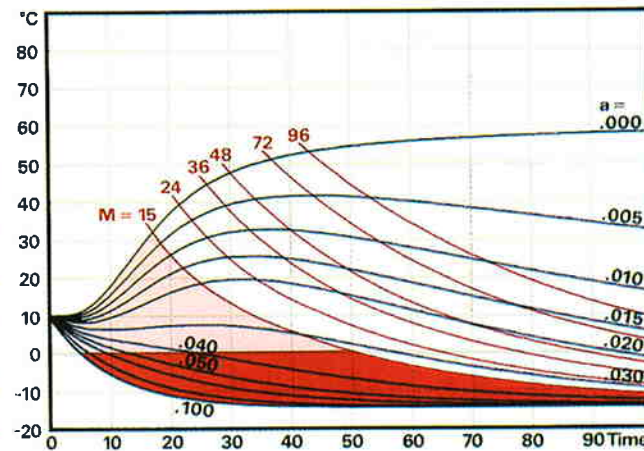
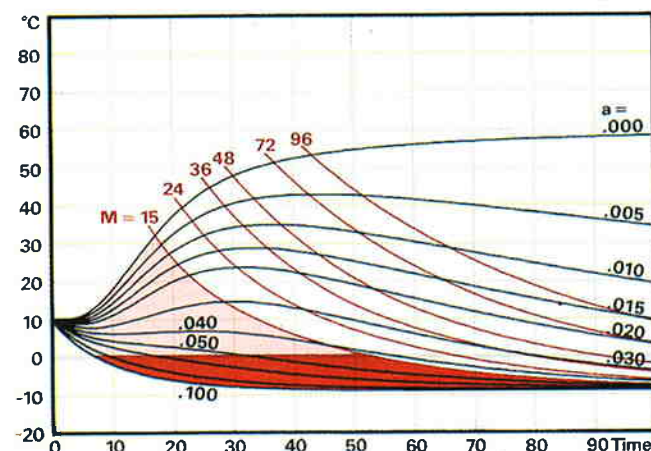
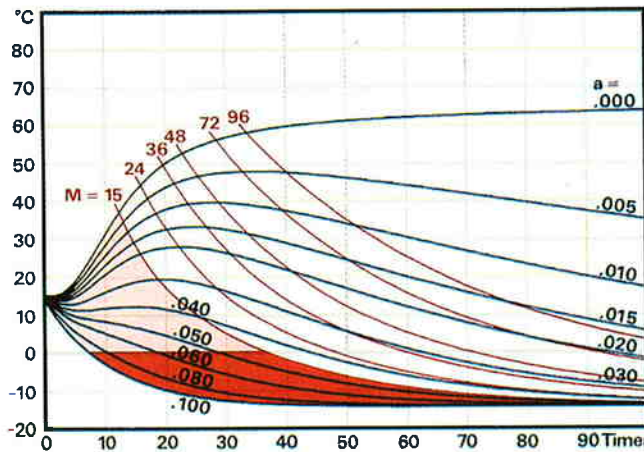
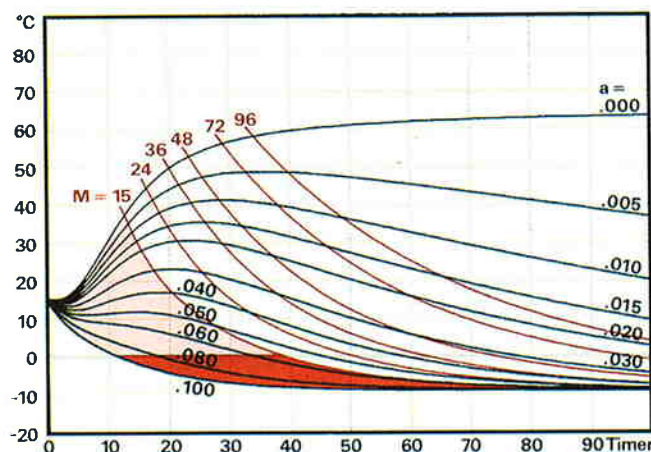
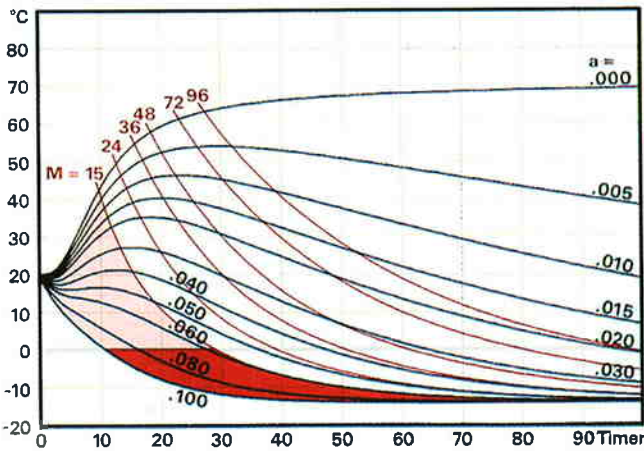
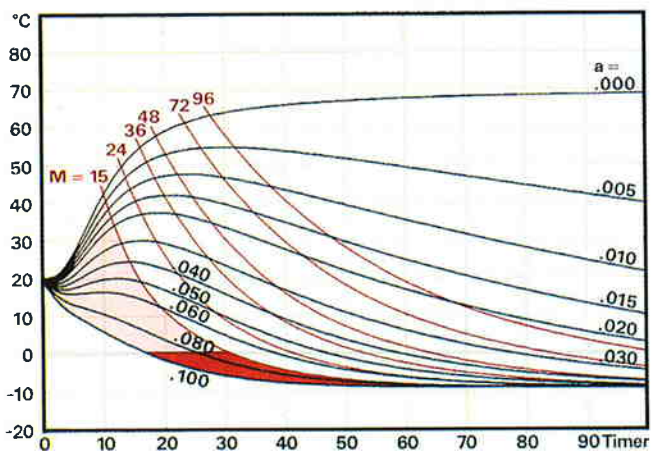
Lufttemperatur $\theta_L = -15\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 20\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 15\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 10\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 5\text{ }^\circ\text{C}$



Hurtighærdnende cement, type A 350 kg/m³

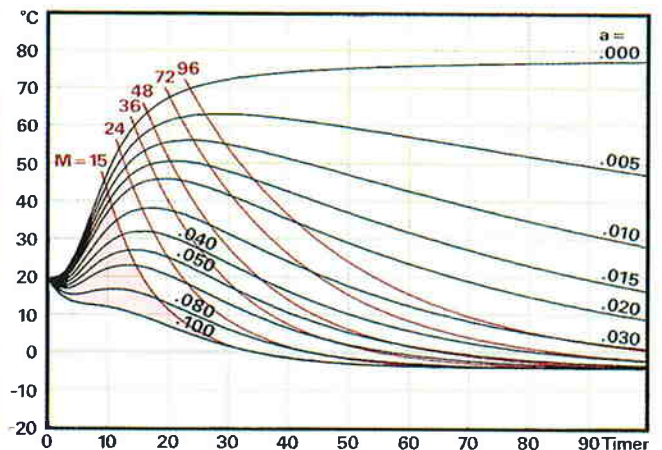
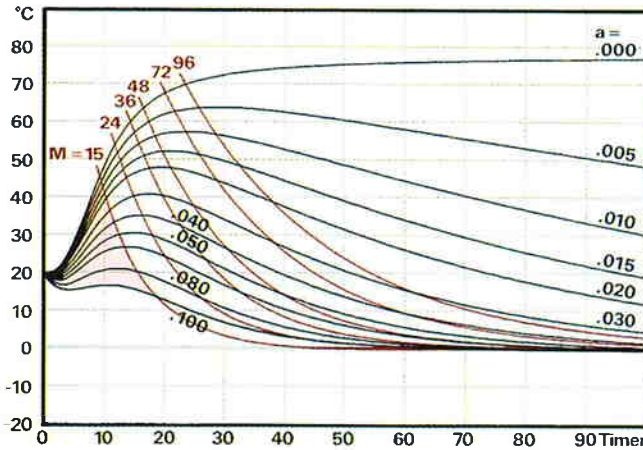
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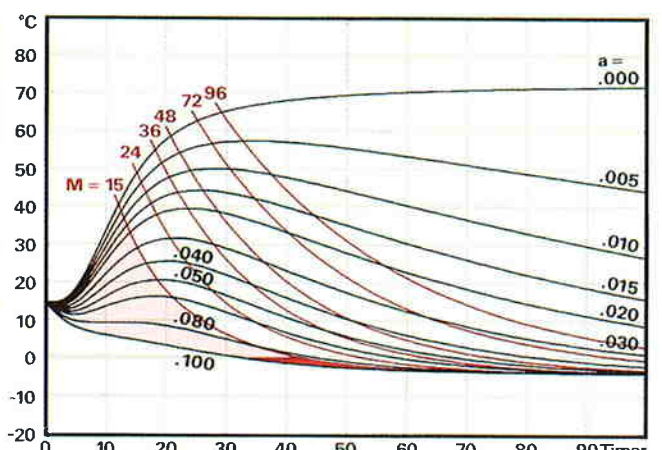
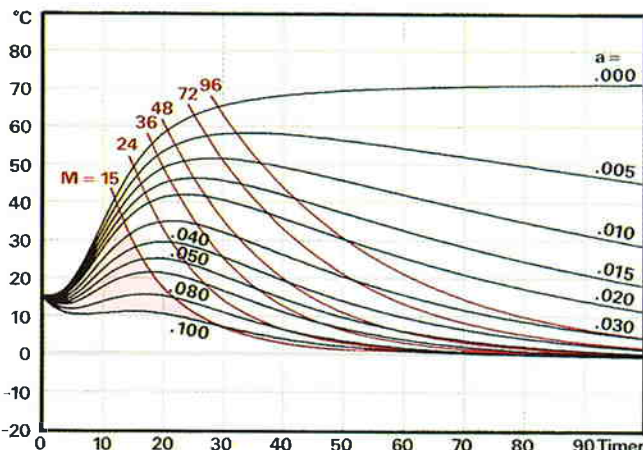
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

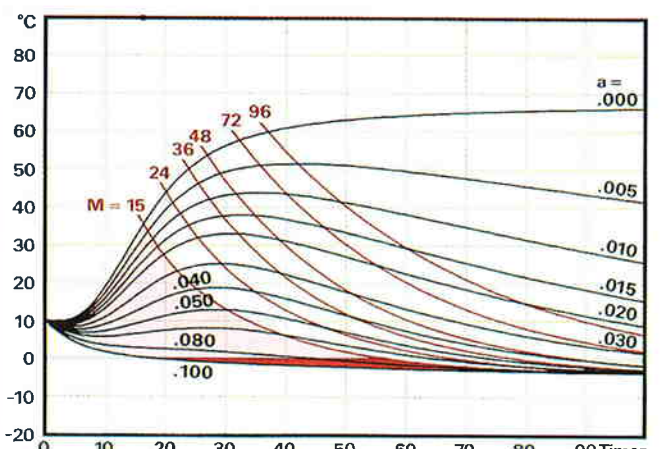
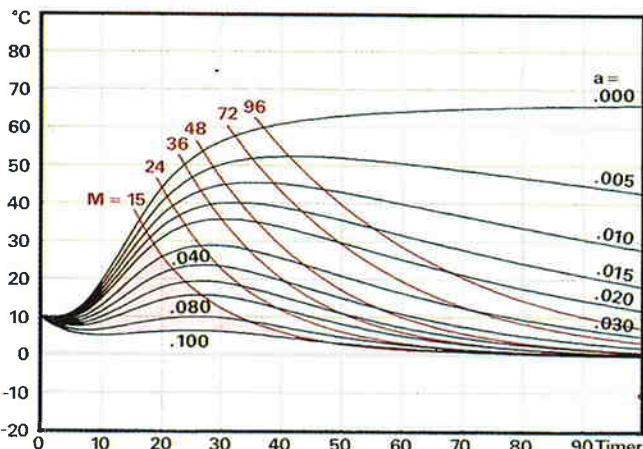
Beton-temp. $\theta_B = 20^\circ\text{C}$



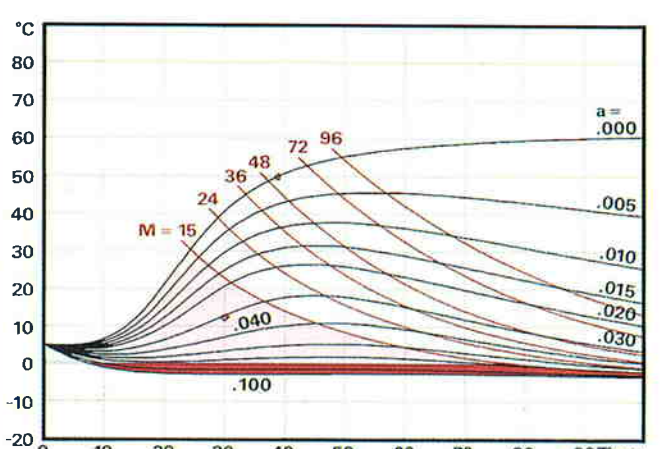
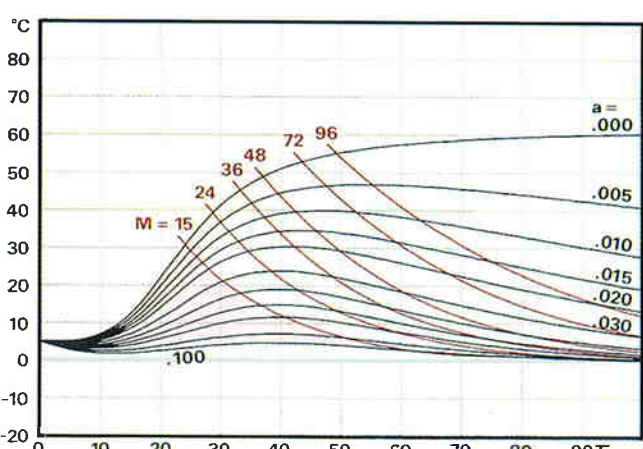
Beton-temp. $\theta_B = 15^\circ\text{C}$



Beton-temp. $\theta_B = 10^\circ\text{C}$



Beton-temp. $\theta_B = 5^\circ\text{C}$



Hurtighærdnende cement, type A 350 kg/m^3

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Lufttemperatur $\theta_L = -10 \text{ }^\circ\text{C}$

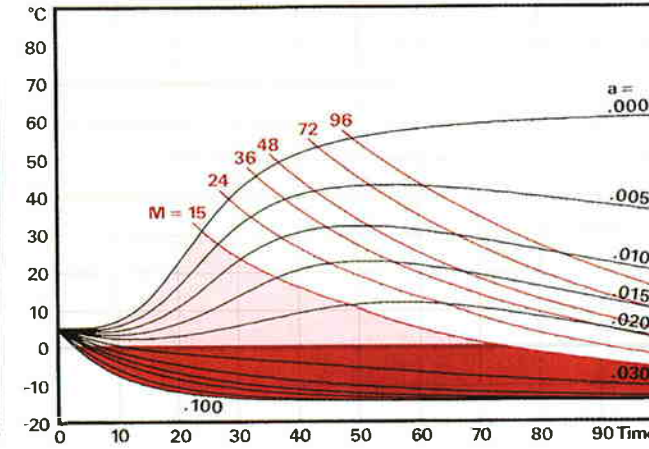
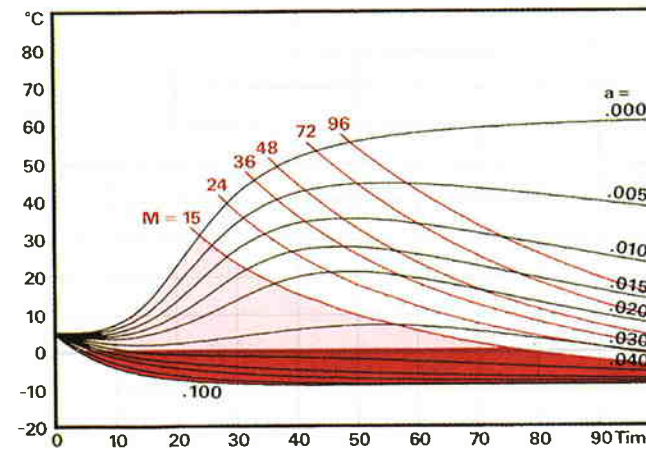
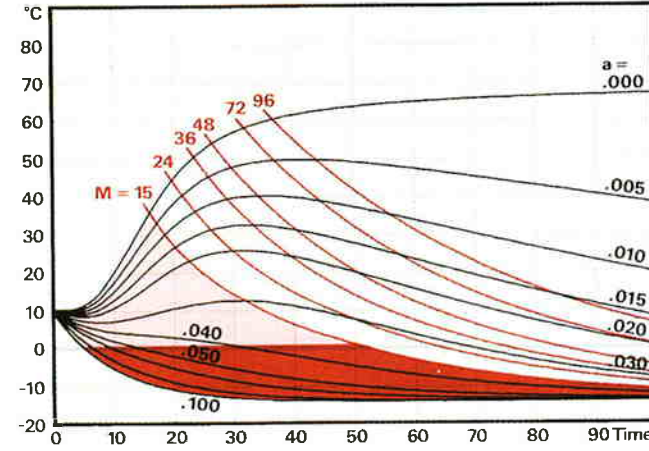
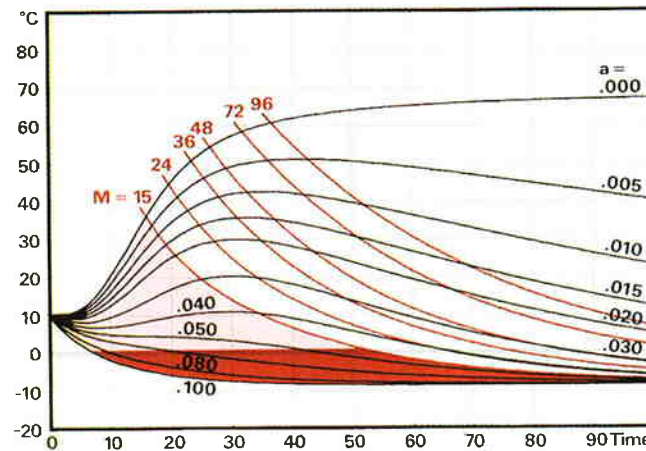
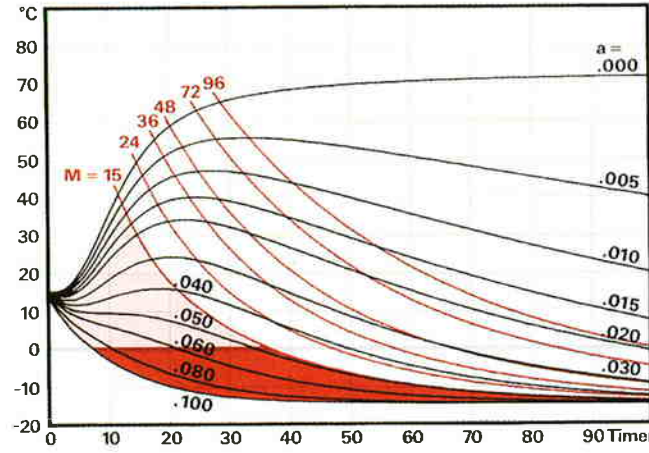
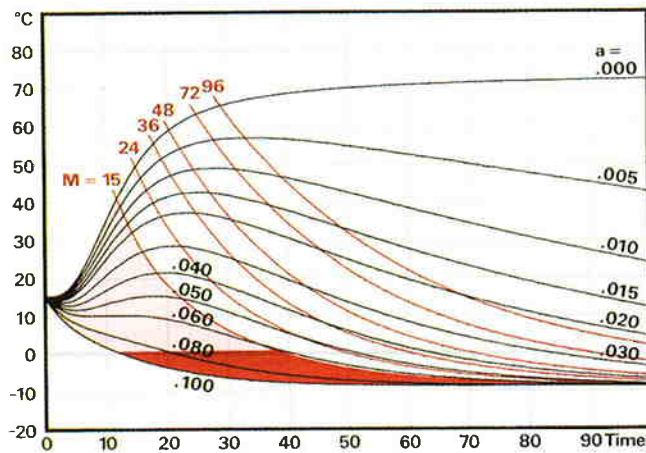
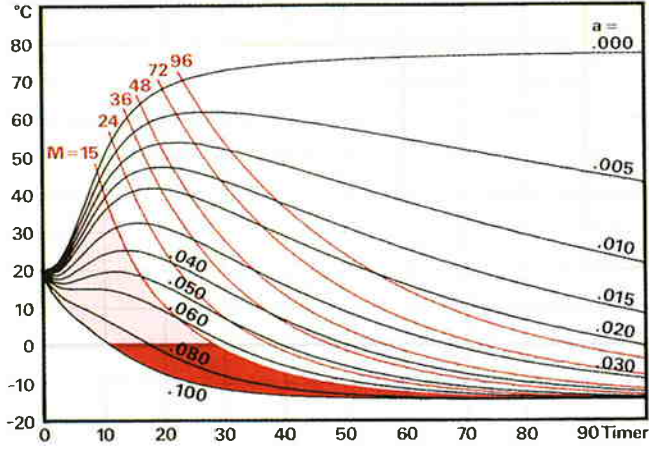
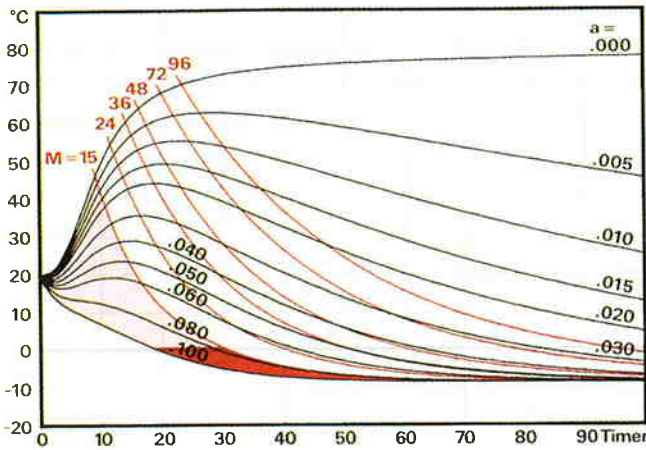
Lufttemperatur $\theta_L = -15 \text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B =$
 $20 \text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B =$
 $15 \text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B =$
 $10 \text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B =$
 $5 \text{ }^\circ\text{C}$



Hærdediagrammer

Teknologisk Institut

Hurtighærdnende cement, type A 400 kg/m³

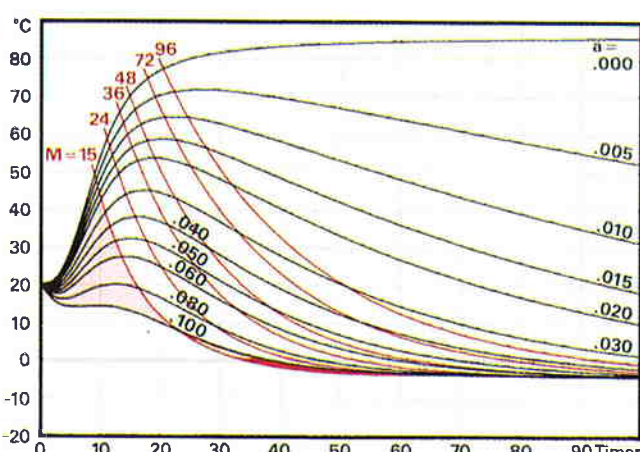
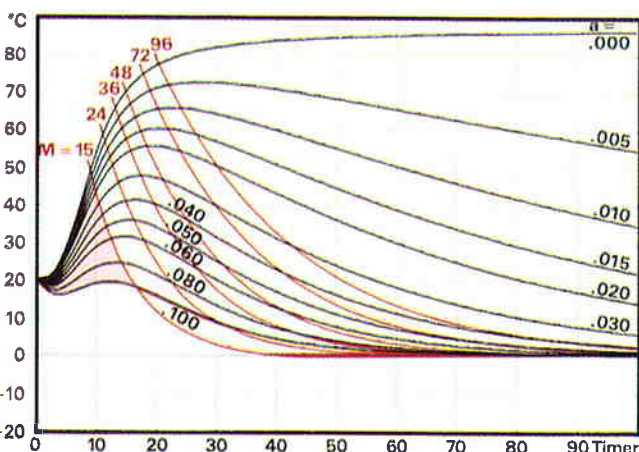
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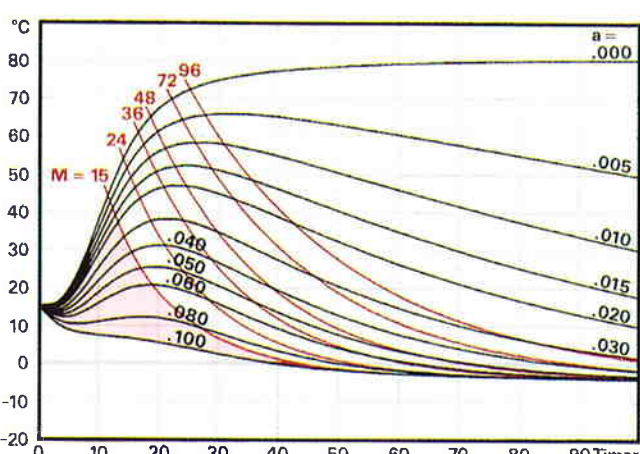
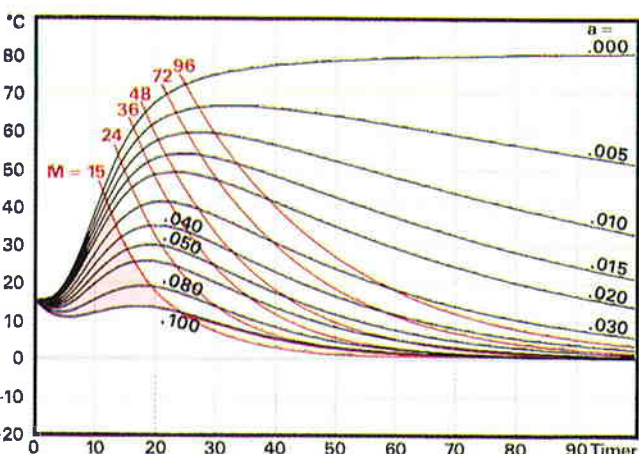
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

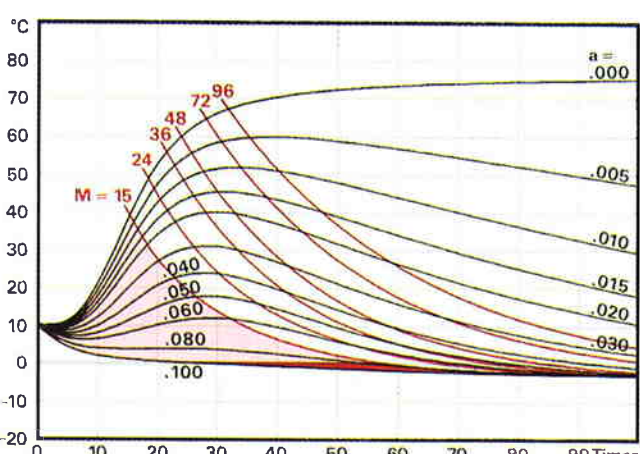
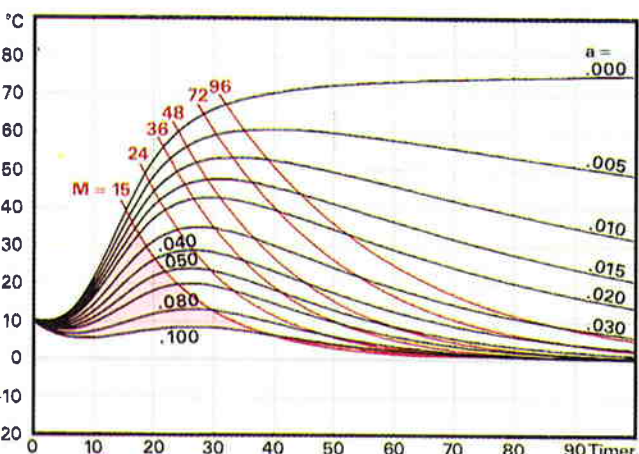
Beton-temp.
 $\theta_B = 20^\circ\text{C}$



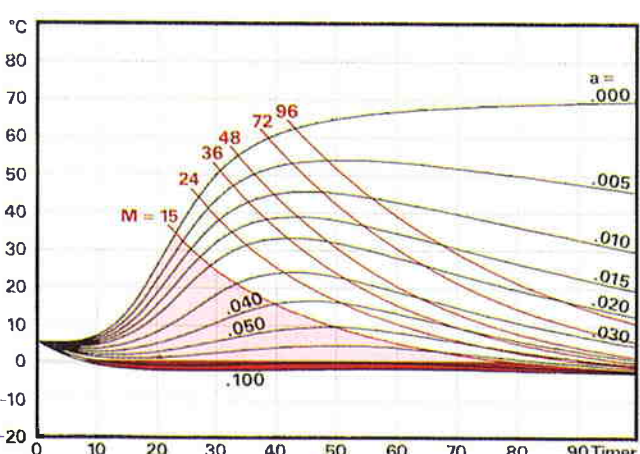
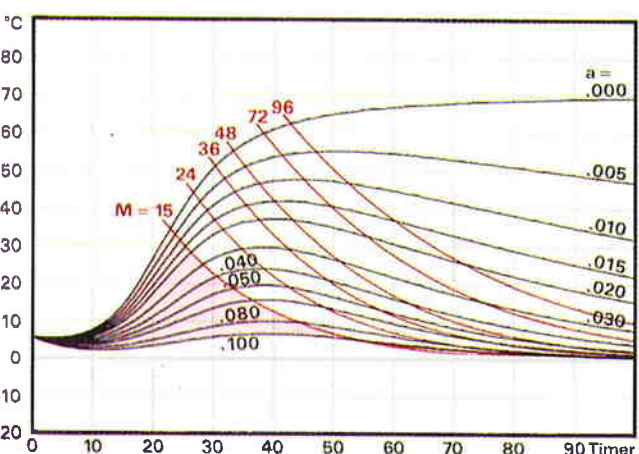
Beton-temp.
 $\theta_B = 15^\circ\text{C}$



Beton-temp.
 $\theta_B = 10^\circ\text{C}$



Beton-temp.
 $\theta_B = 5^\circ\text{C}$



Lufttemperatur $\theta_L = -10\text{ }^\circ\text{C}$

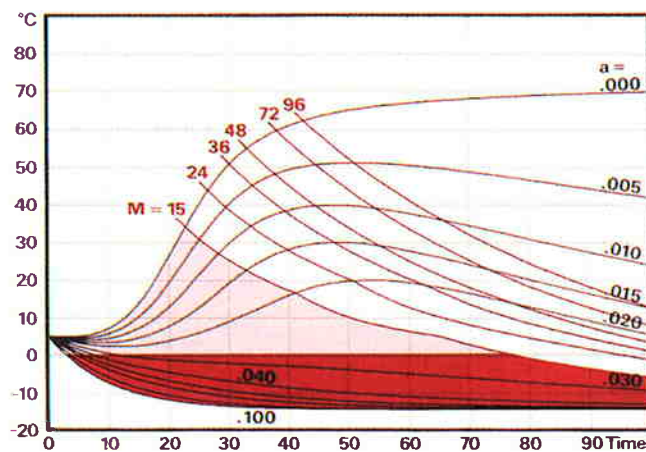
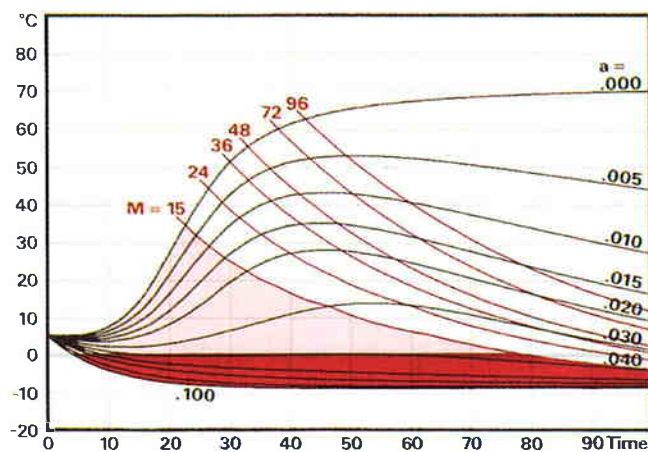
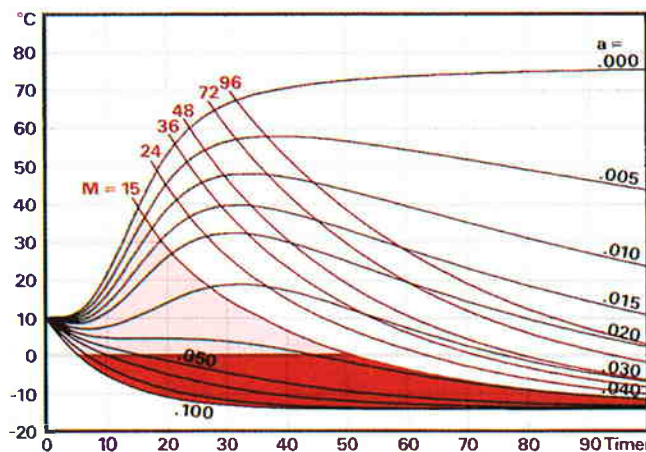
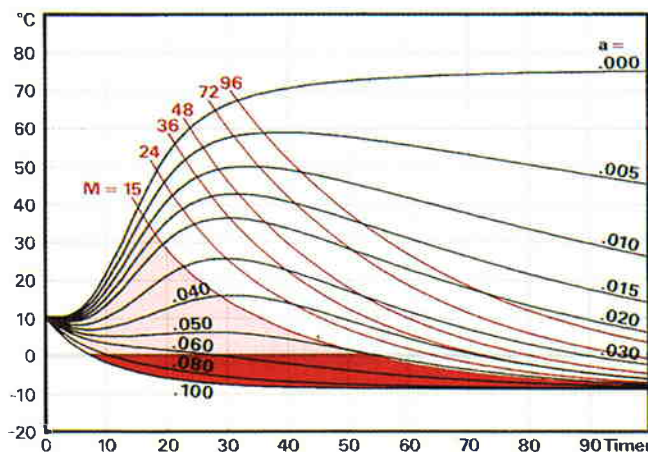
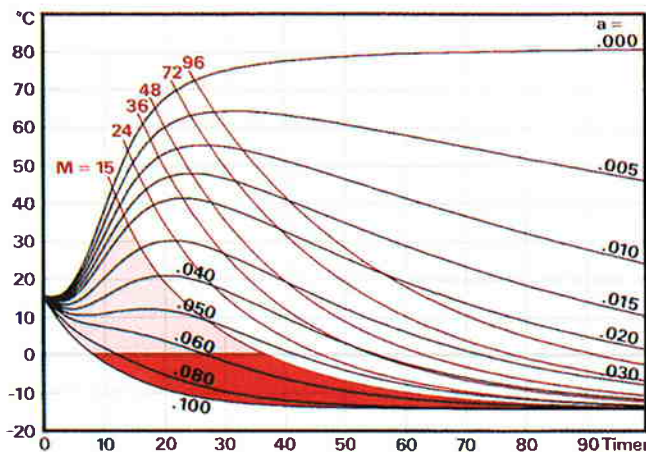
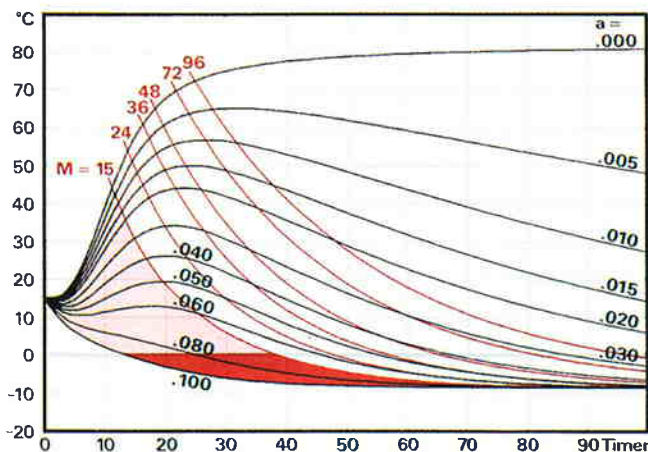
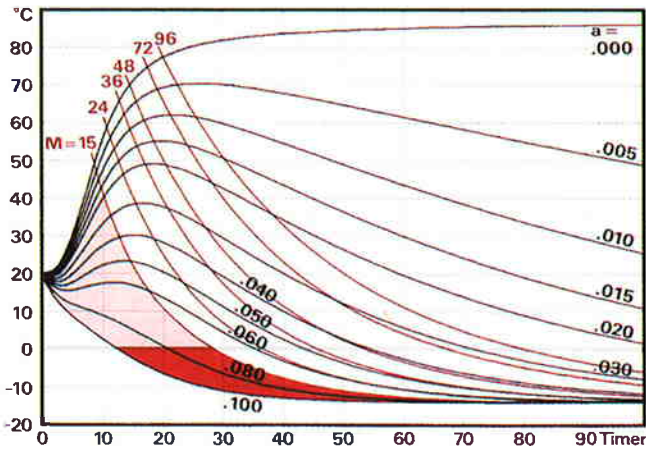
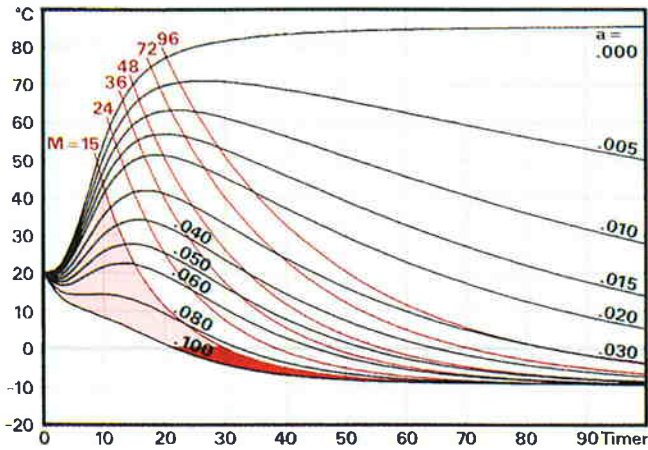
Lufttemperatur $\theta_L = -15\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 20\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 15\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 10\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 5\text{ }^\circ\text{C}$



Normalhærdnende cement, type B 250 kg/m³

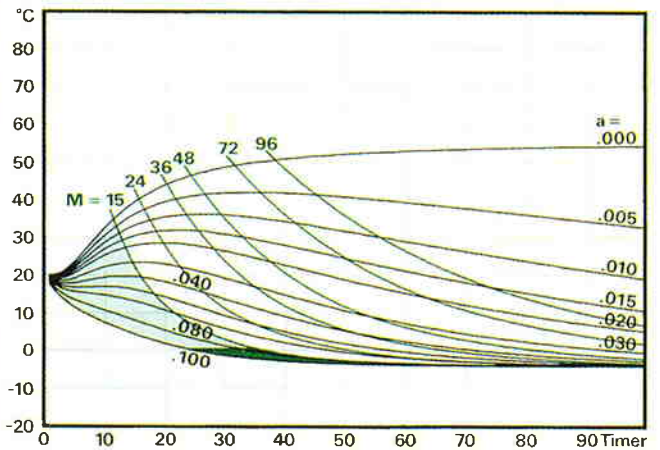
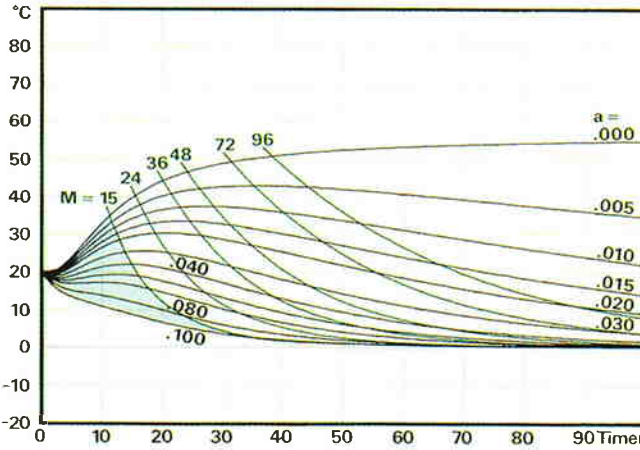
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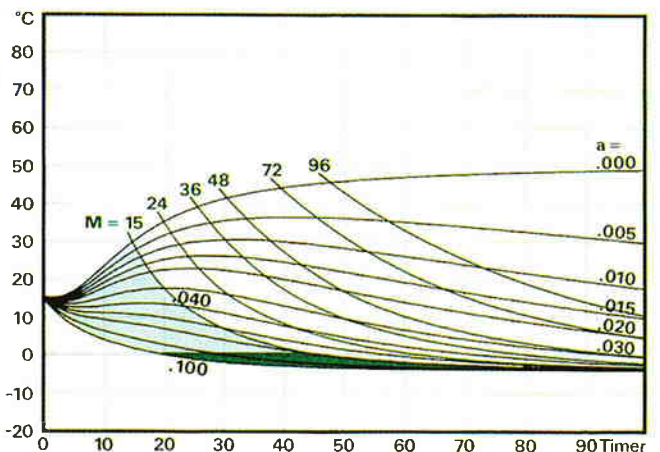
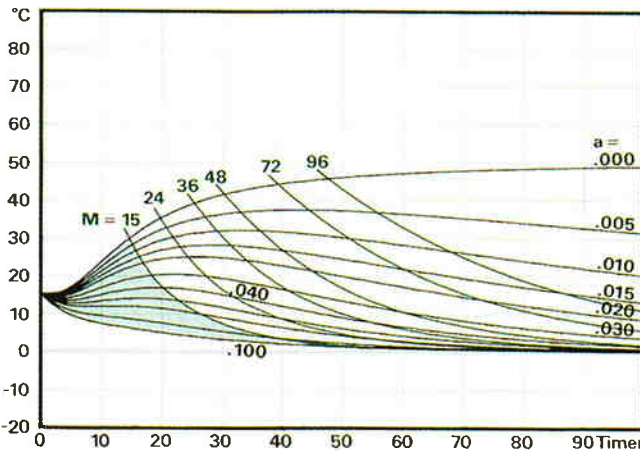
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

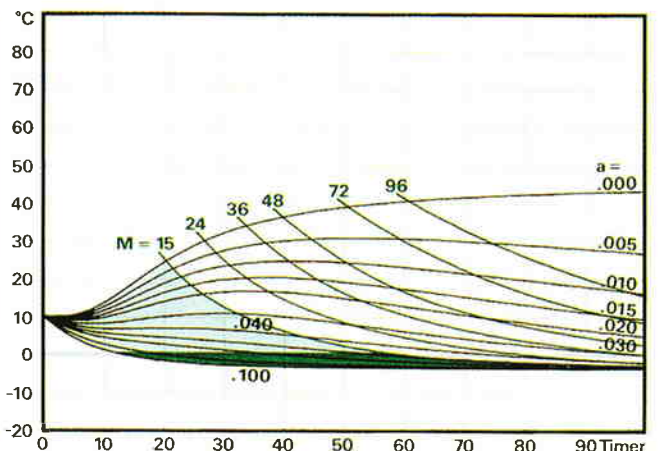
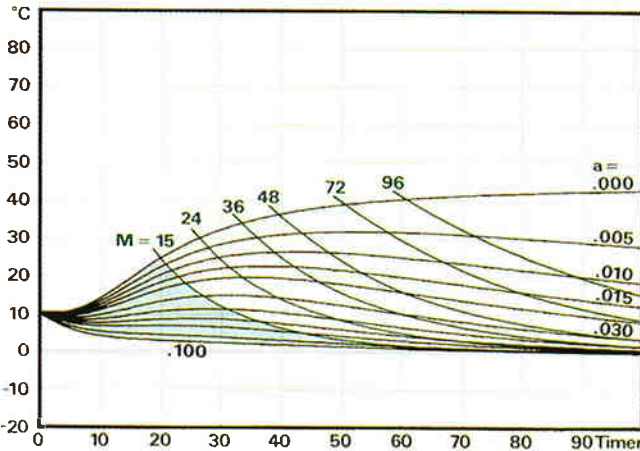
Beton-
temp.
 $\theta_B = 20^\circ\text{C}$



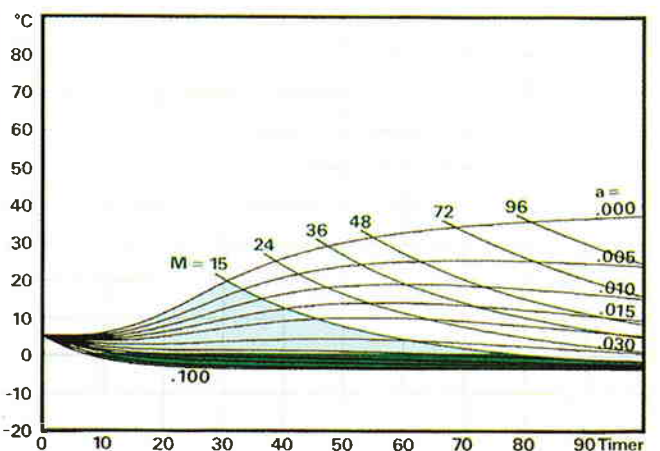
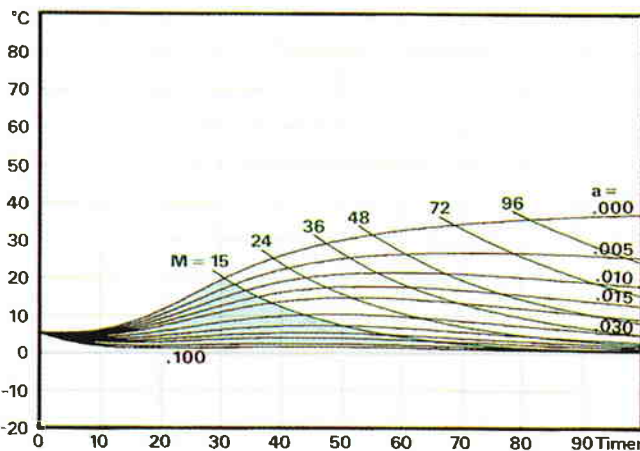
Beton-
temp.
 $\theta_B = 15^\circ\text{C}$



Beton-
temp.
 $\theta_B = 10^\circ\text{C}$



Beton-
temp.
 $\theta_B = 5^\circ\text{C}$



Normalhærdnende cement, type B 250 kg/m³

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Lufttemperatur $\theta_L = -10\text{ }^\circ\text{C}$

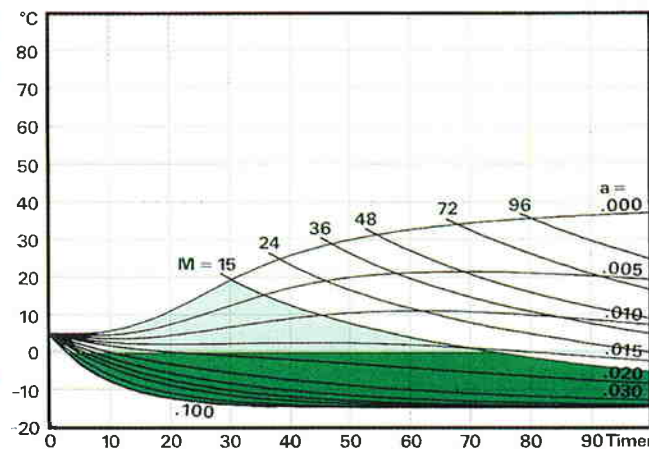
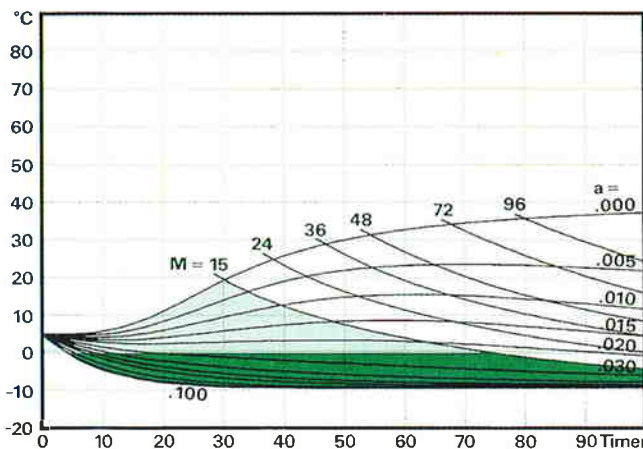
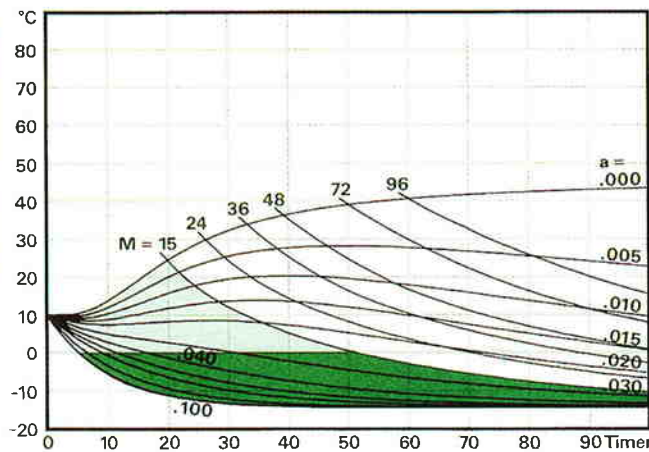
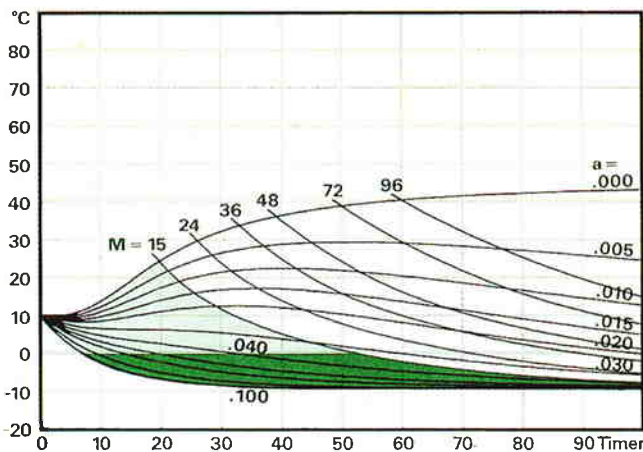
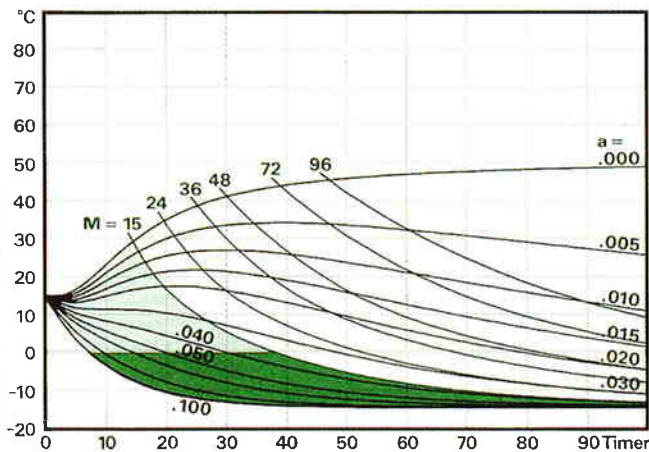
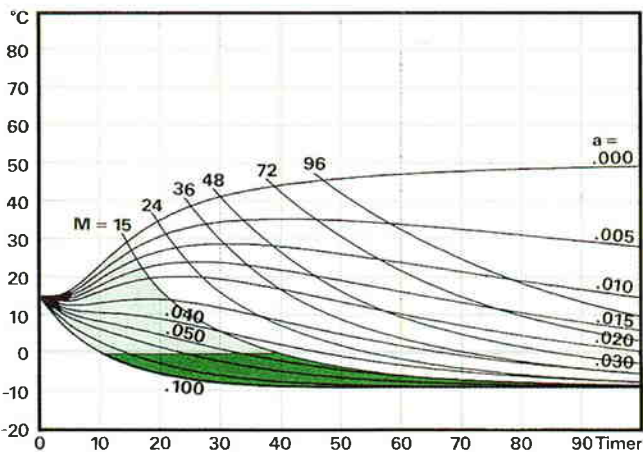
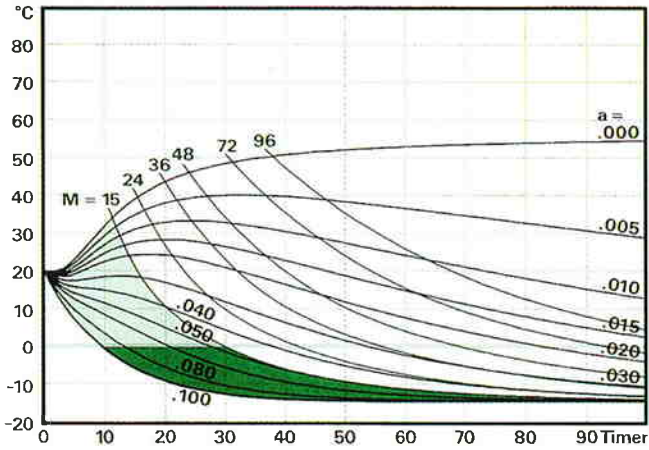
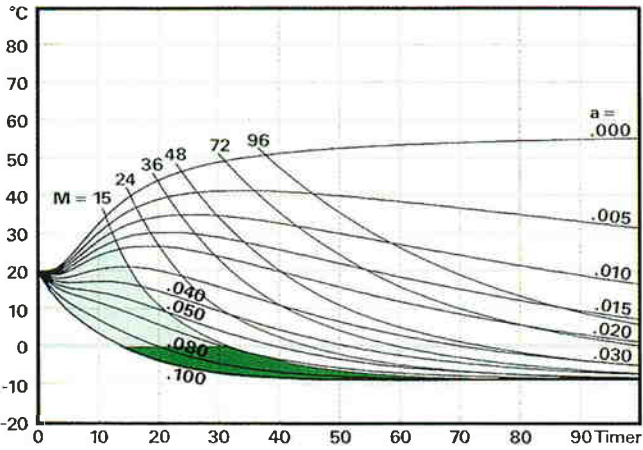
Lufttemperatur $\theta_L = -15\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 20\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 15\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 10\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 5\text{ }^\circ\text{C}$



Hærdediagrammer

Teknologisk Institut

Normalhærdnende cement, type B 300 kg/m³

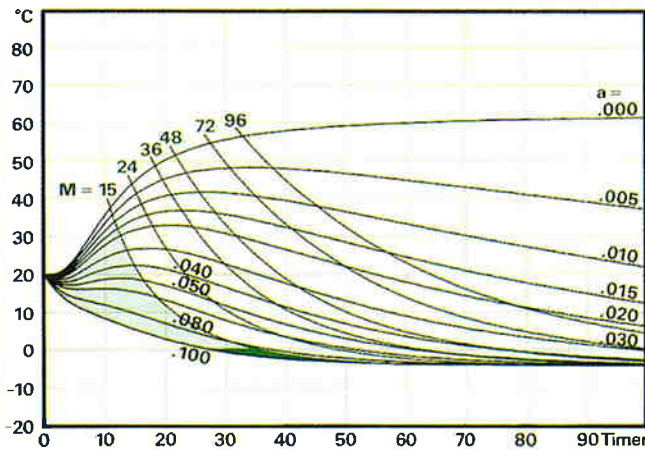
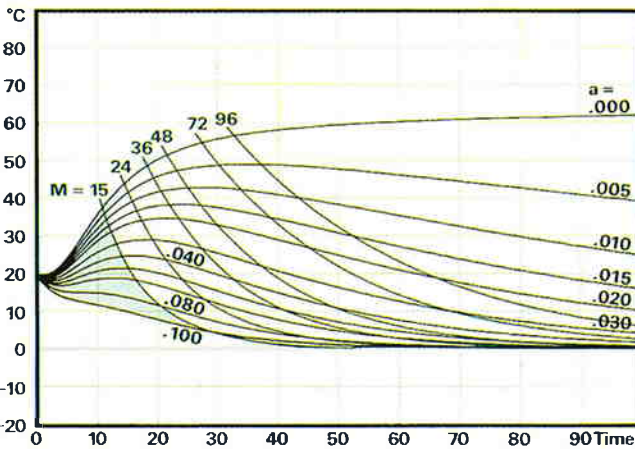
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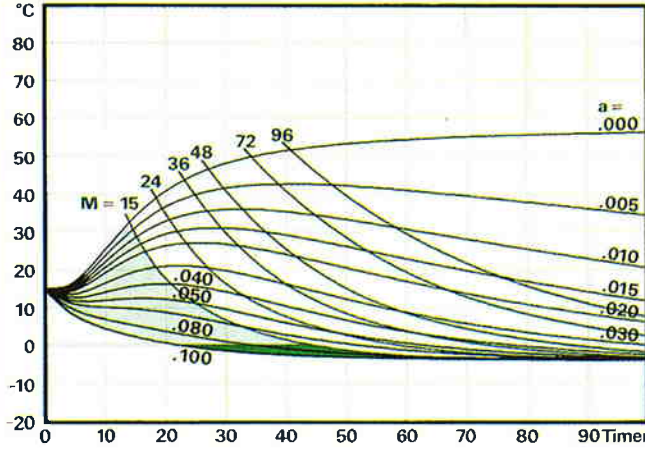
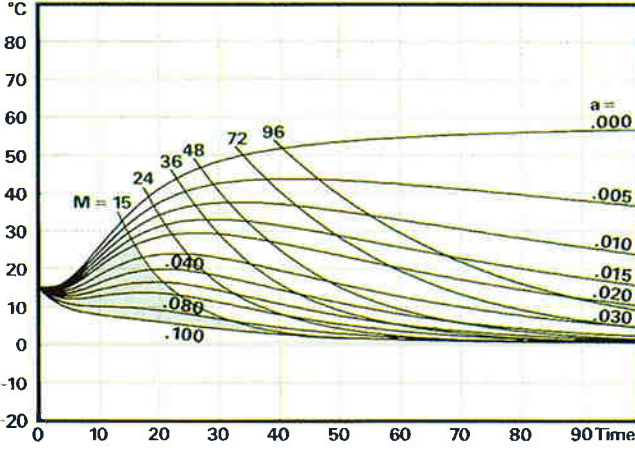
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

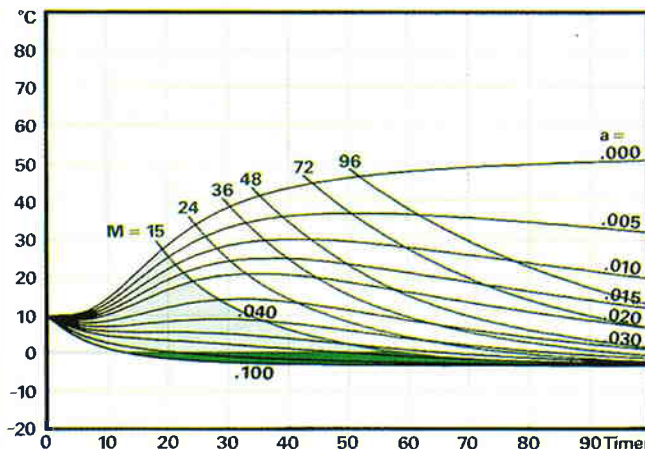
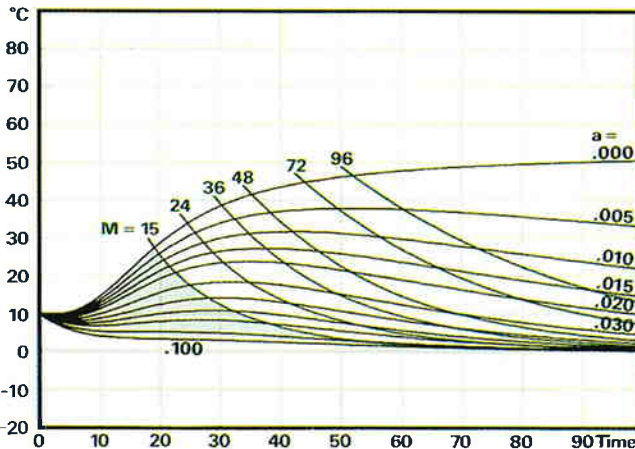
Beton-
temp.
 $\theta_B = 20^\circ\text{C}$



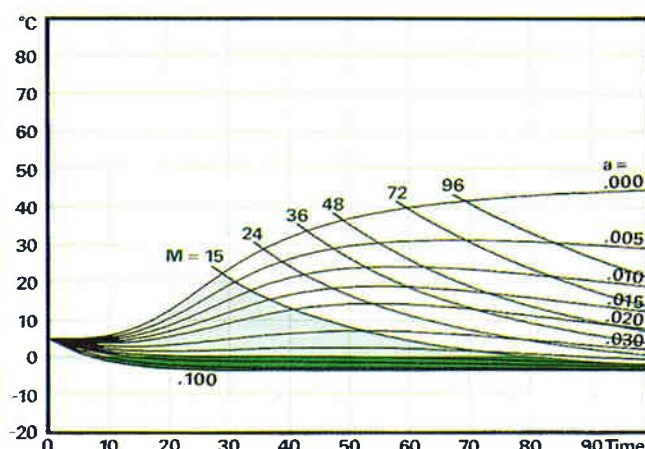
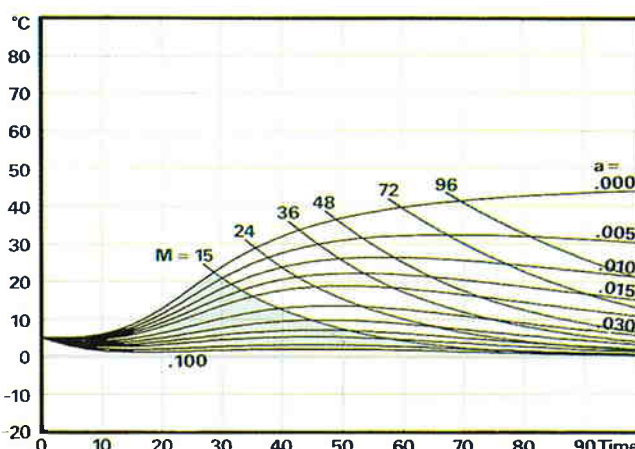
Beton-
temp.
 $\theta_B = 15^\circ\text{C}$



Beton-
temp.
 $\theta_B = 10^\circ\text{C}$



Beton-
temp.
 $\theta_B = 5^\circ\text{C}$



Normalhærdnende cement, type B 300 kg/m³

Lufttemperatur $\theta_L = -10\text{ }^\circ\text{C}$

Lufttemperatur $\theta_L = -15\text{ }^\circ\text{C}$

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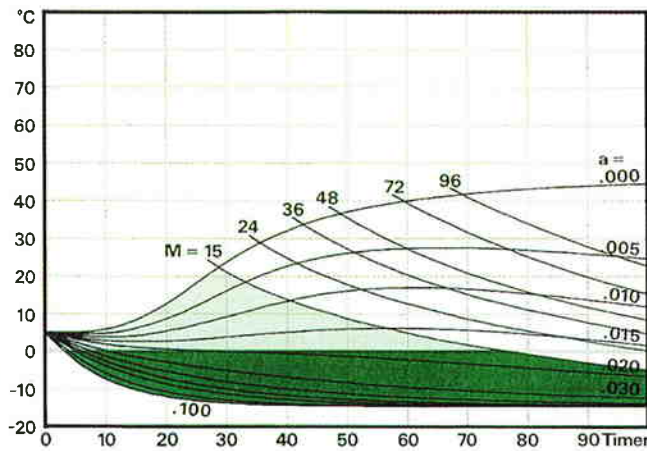
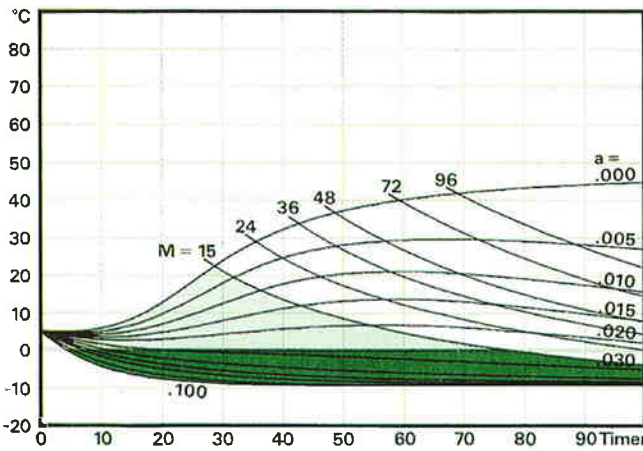
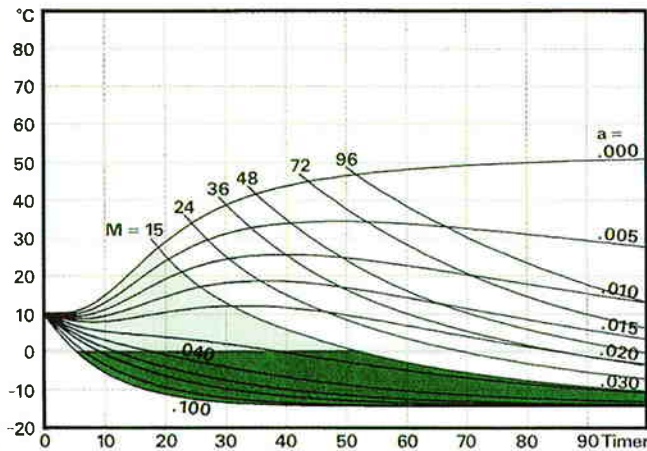
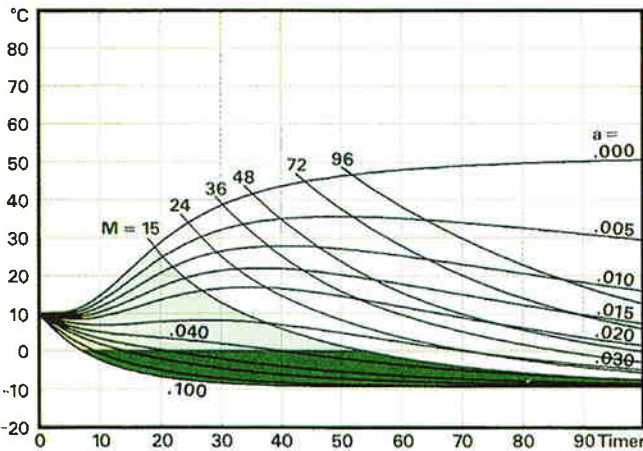
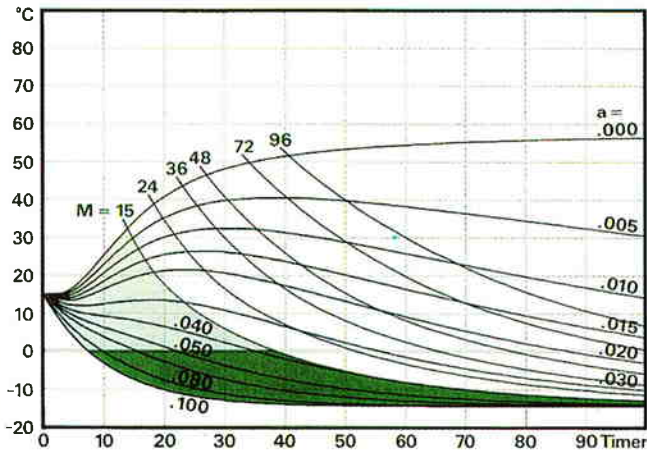
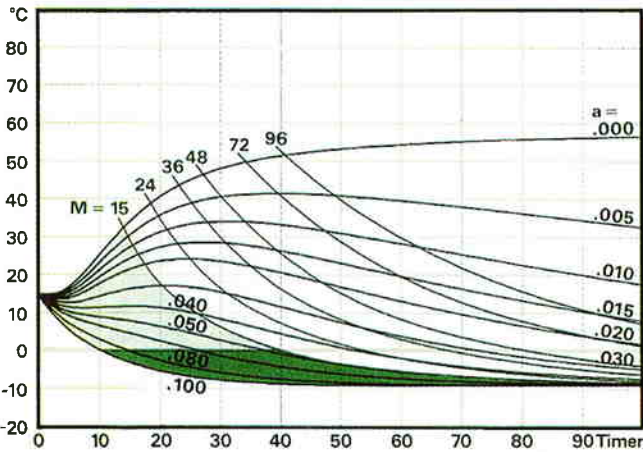
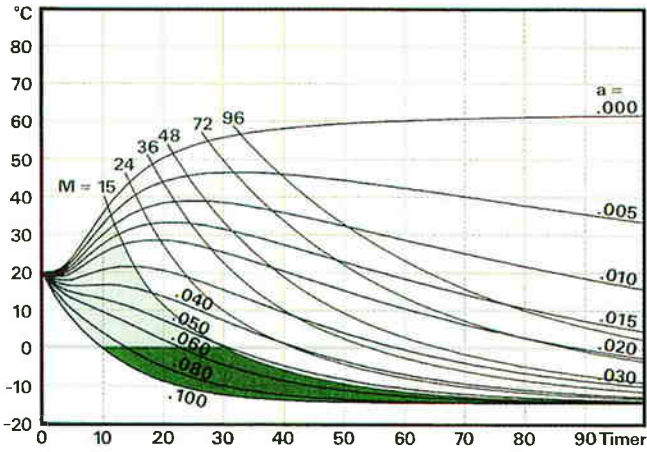
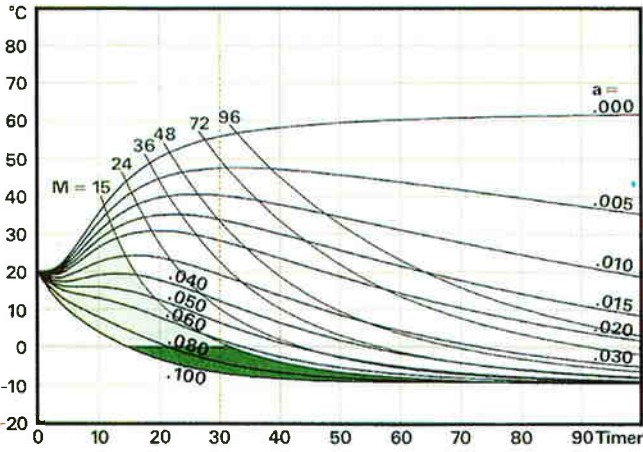
VINTERSTØBNING
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Beton-
temp.
 $\theta_B = 20\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 15\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 10\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 5\text{ }^\circ\text{C}$



Hærdediagrammer

Teknologisk Institut

Normalhærdnende cement, type B 350 kg/m³

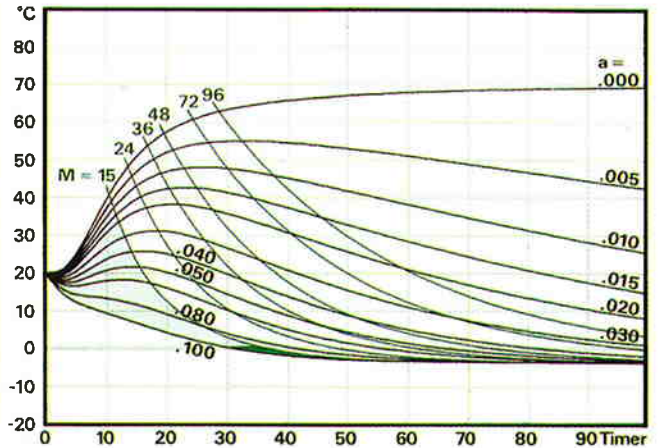
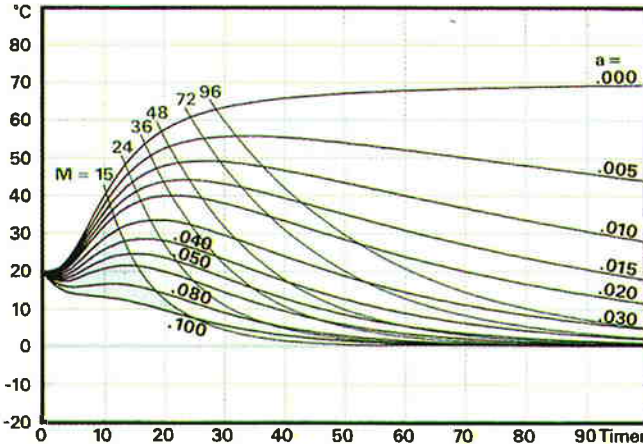
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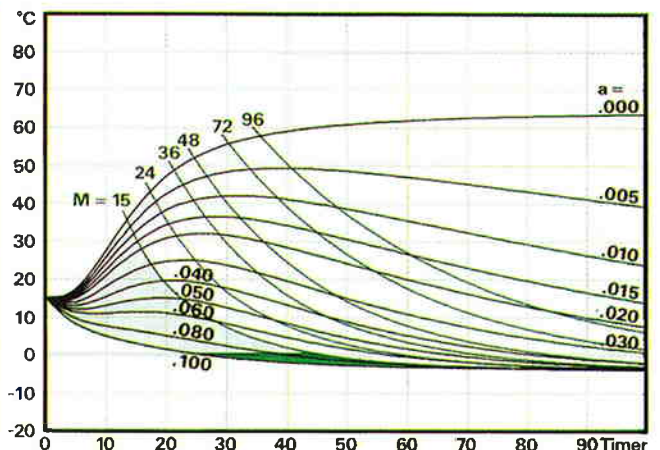
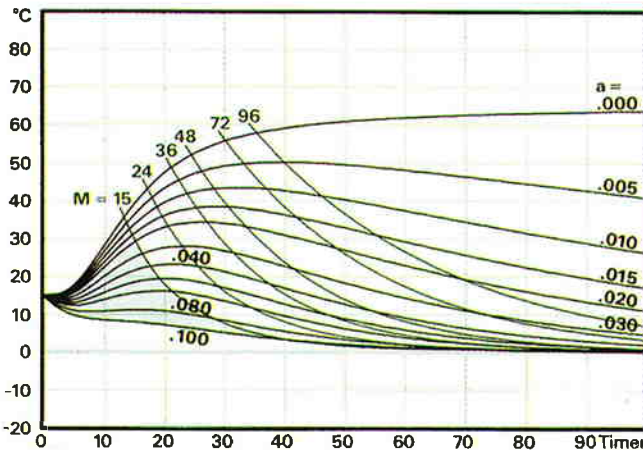
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

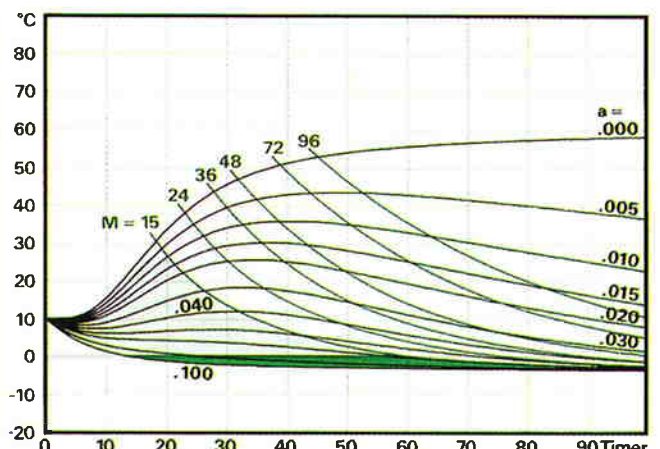
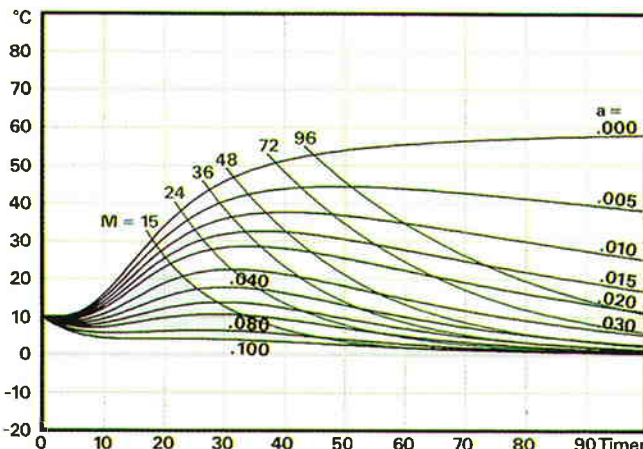
Beton-
temp.
 $\theta_B = 20^\circ\text{C}$



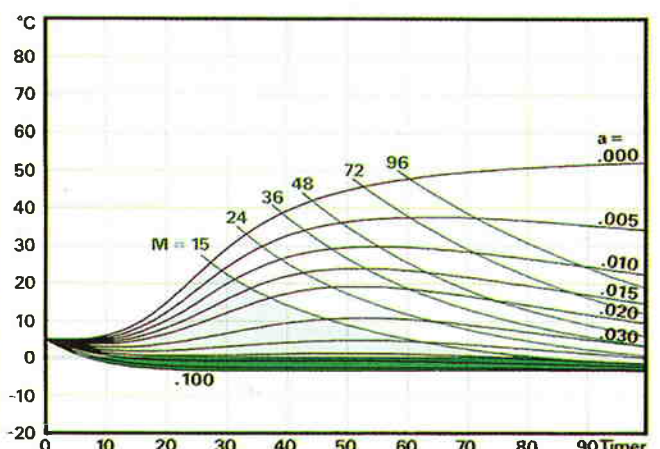
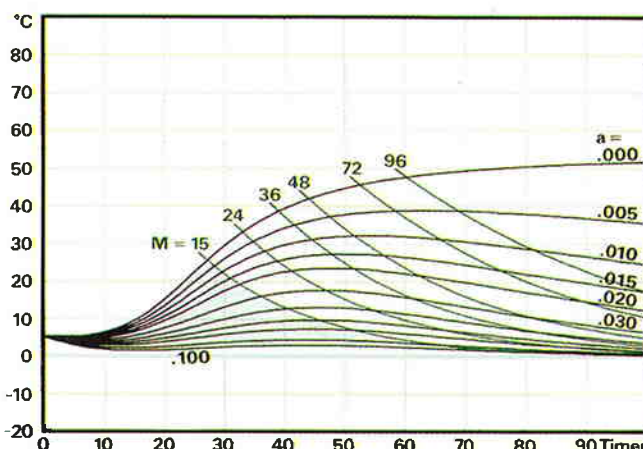
Beton-
temp.
 $\theta_B = 15^\circ\text{C}$



Beton-
temp.
 $\theta_B = 10^\circ\text{C}$



Beton-
temp.
 $\theta_B = 5^\circ\text{C}$



Normalhærdnende cement, type B 350 kg/m³

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Lufttemperatur $\theta_L = -10\text{ }^\circ\text{C}$

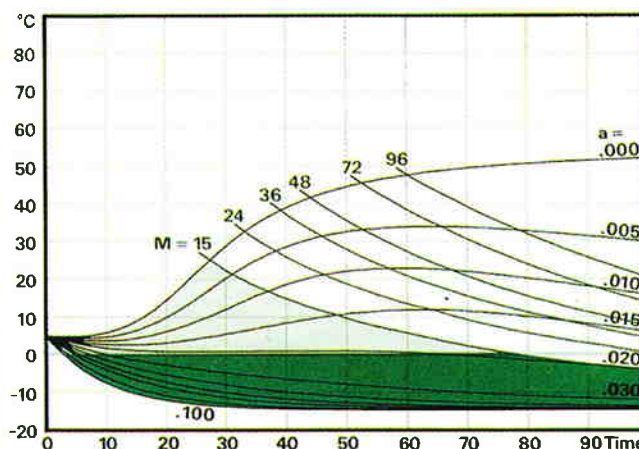
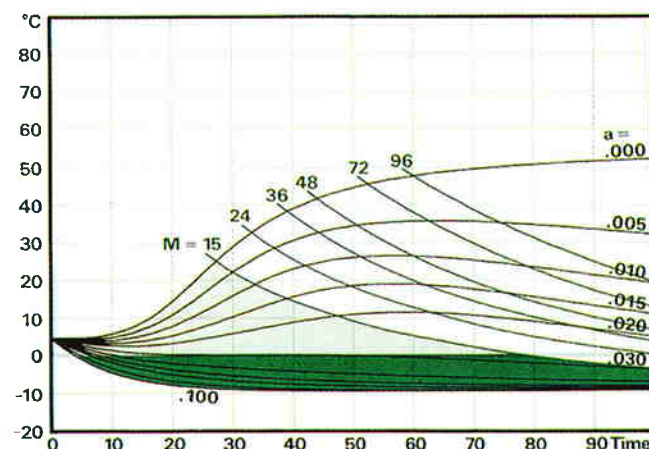
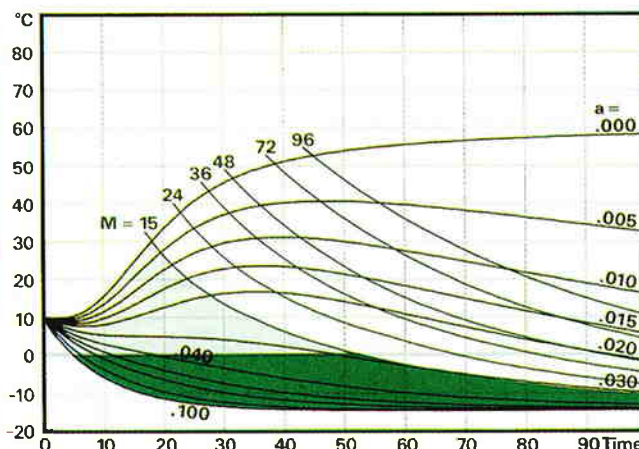
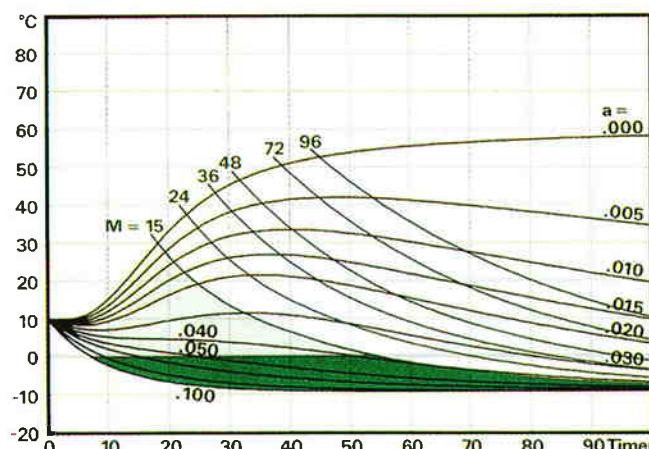
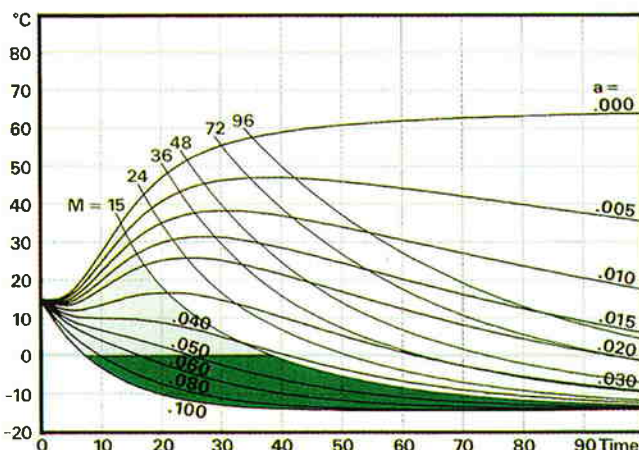
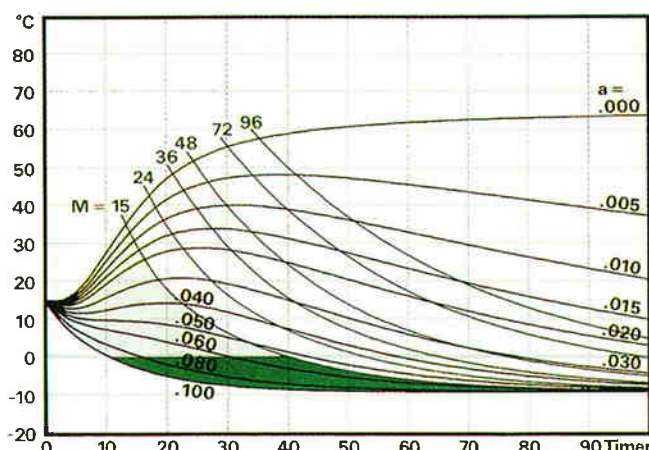
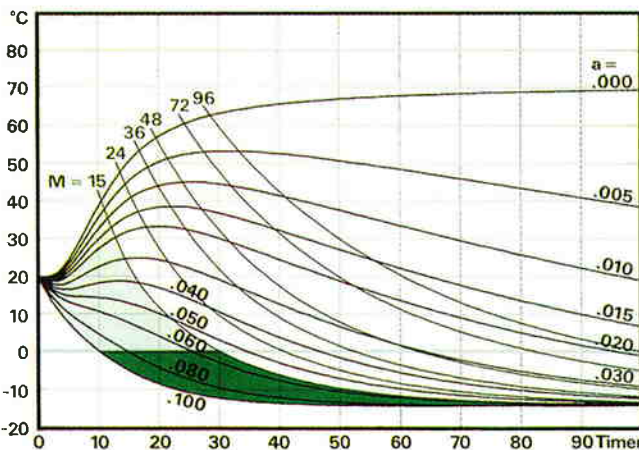
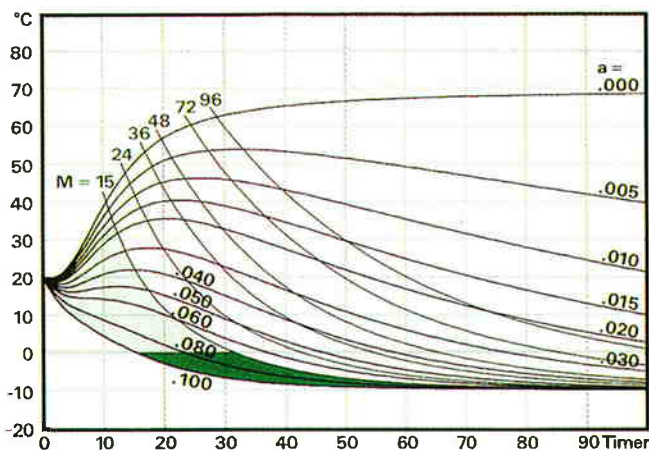
Lufttemperatur $\theta_L = -15\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 20\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 15\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 10\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 5\text{ }^\circ\text{C}$



Hærdediagrammer

Teknologisk Institut

Normalhærdnende cement, type B 400 kg/m³

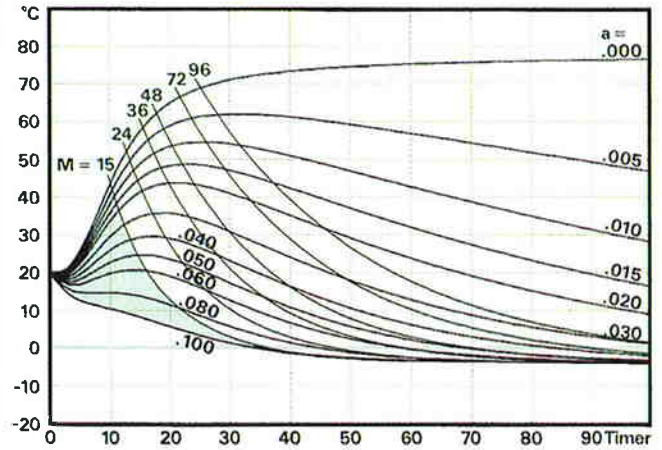
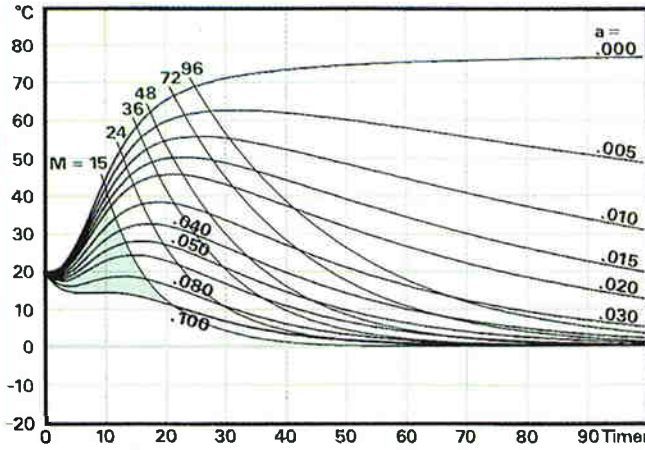
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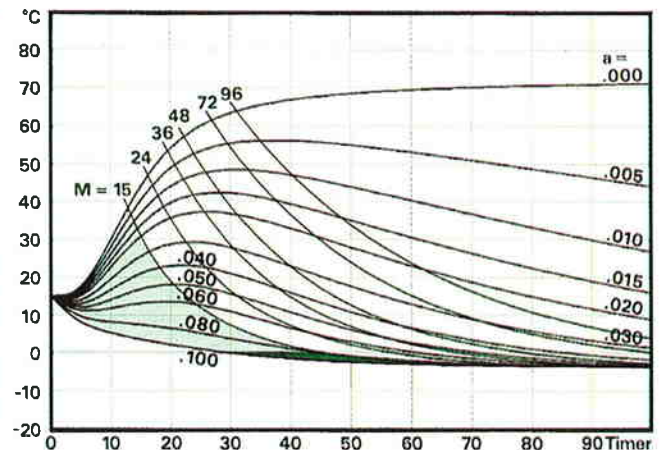
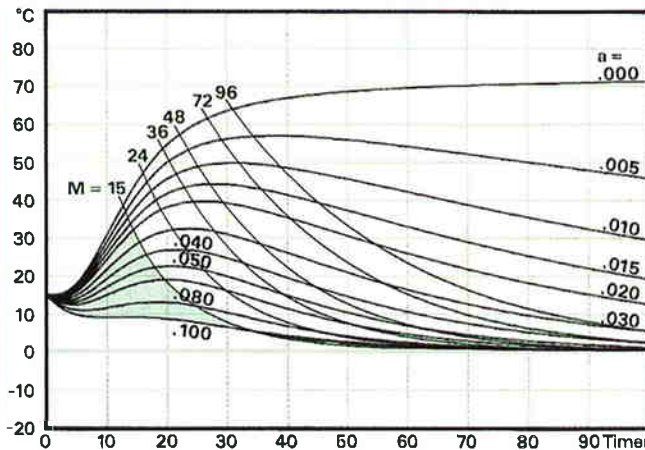
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

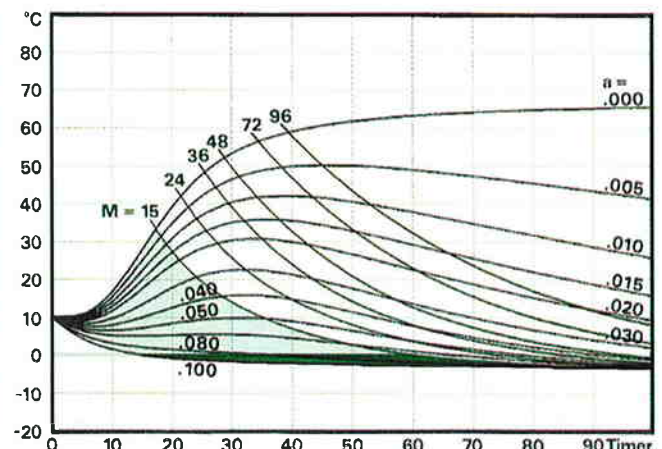
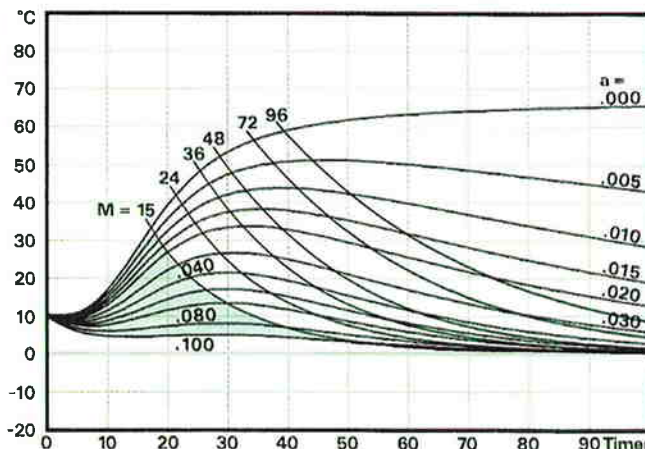
Beton-
temp.
 $\theta_B = 20^\circ\text{C}$



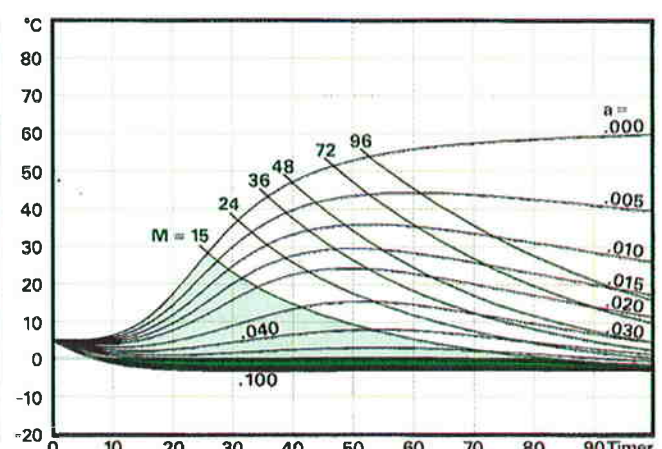
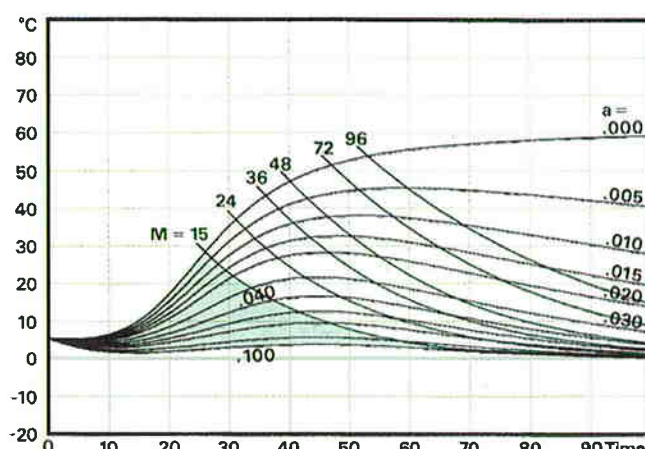
Beton-
temp.
 $\theta_B = 15^\circ\text{C}$



Beton-
temp.
 $\theta_B = 10^\circ\text{C}$



Beton-
temp.
 $\theta_B = 5^\circ\text{C}$



Normalhærdnende cement, type B 400 kg/m³

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Lufttemperatur $\theta_L = -10\text{ }^\circ\text{C}$

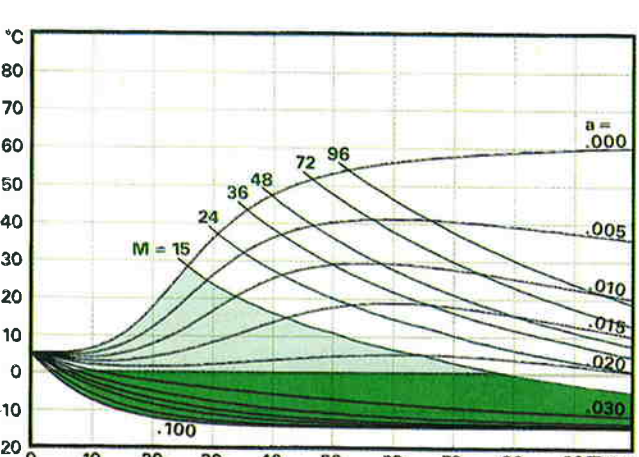
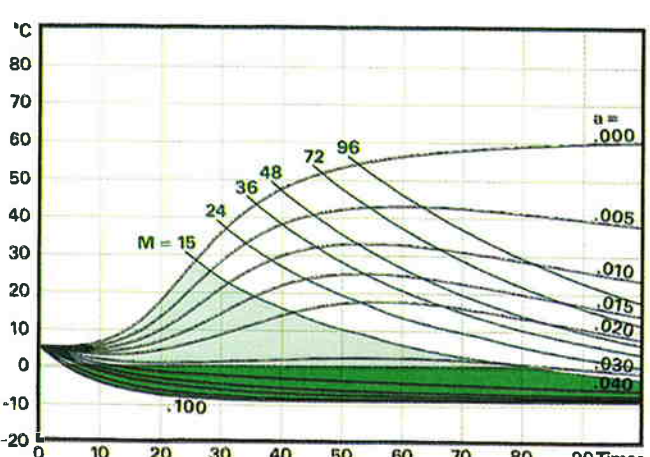
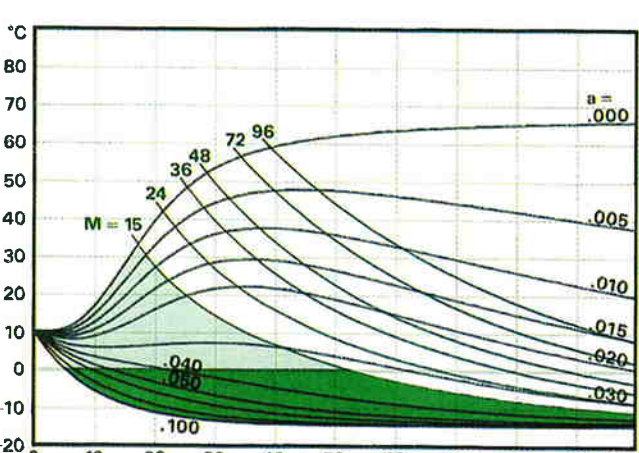
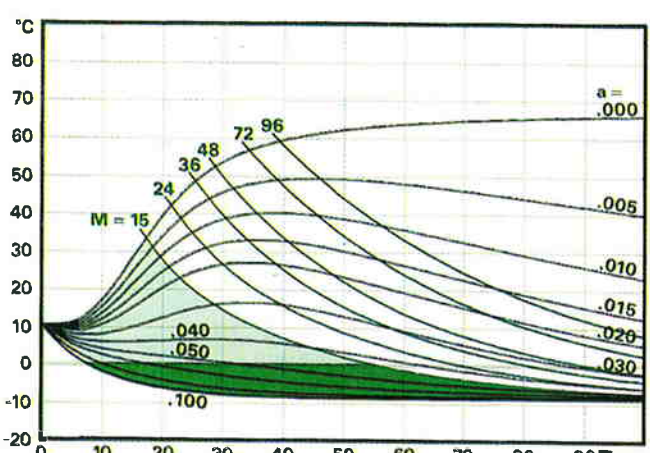
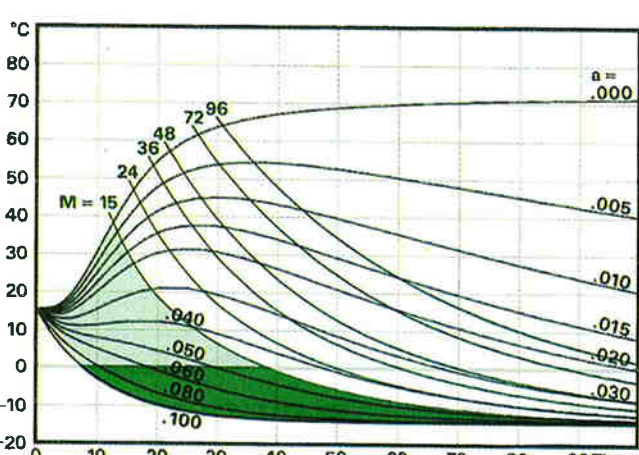
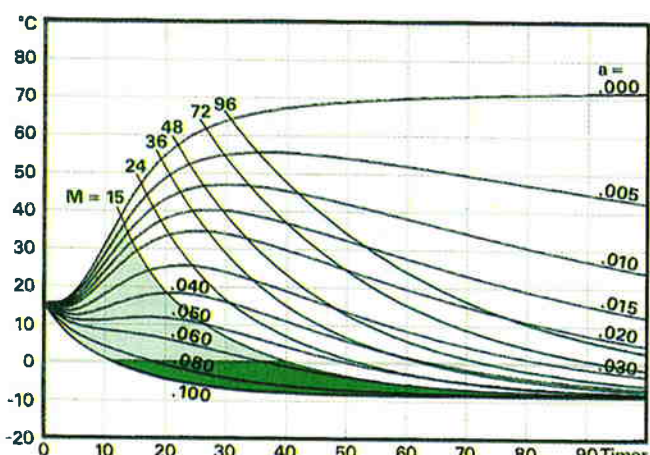
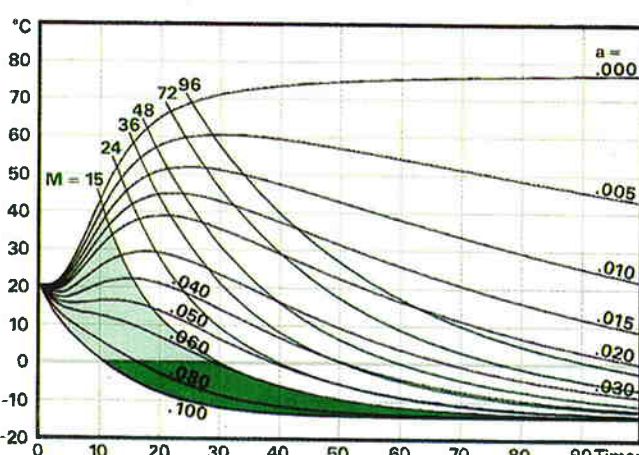
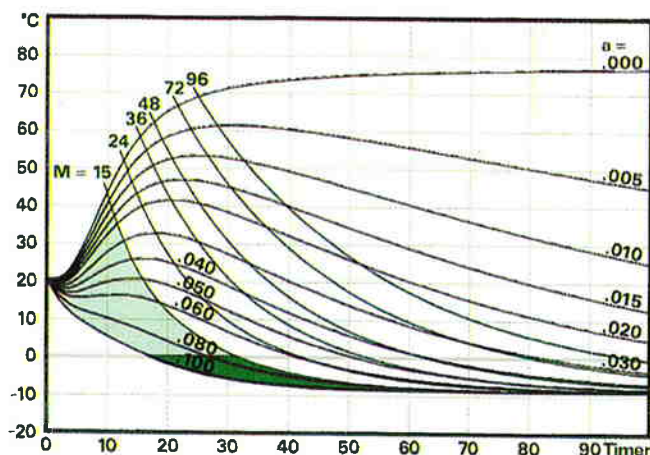
Lufttemperatur $\theta_L = -15\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 20\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 15\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 10\text{ }^\circ\text{C}$

Beton-
temp.
 $\theta_B = 5\text{ }^\circ\text{C}$



Langsomhærdnende cement, type C 250 kg/m³

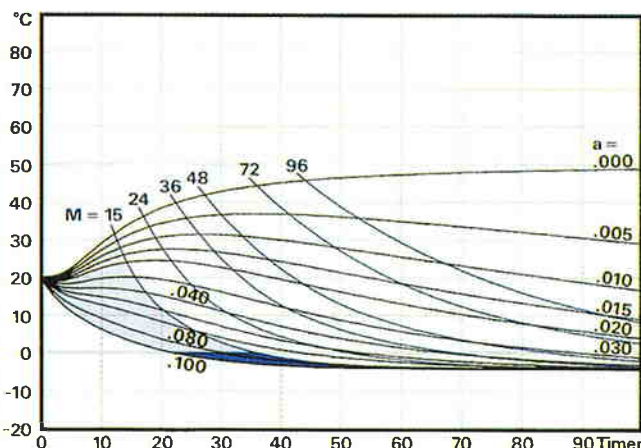
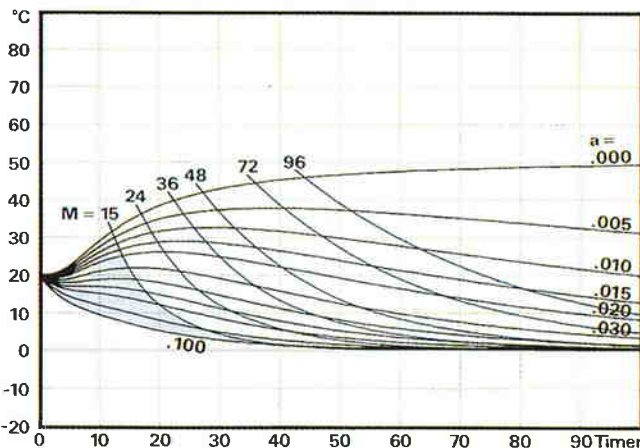
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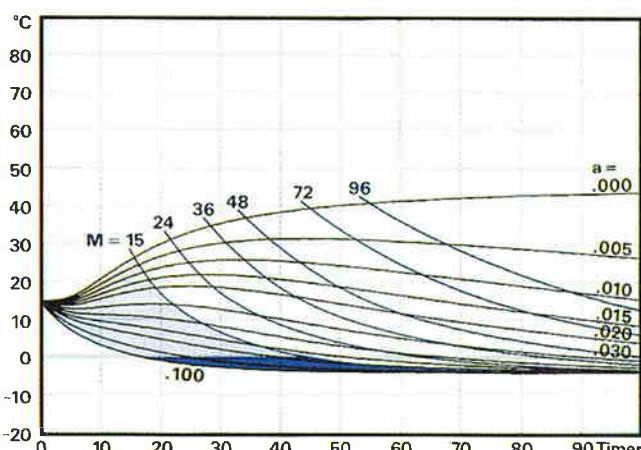
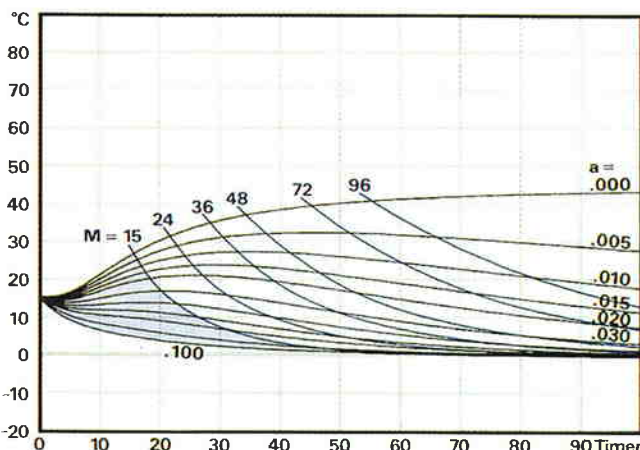
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

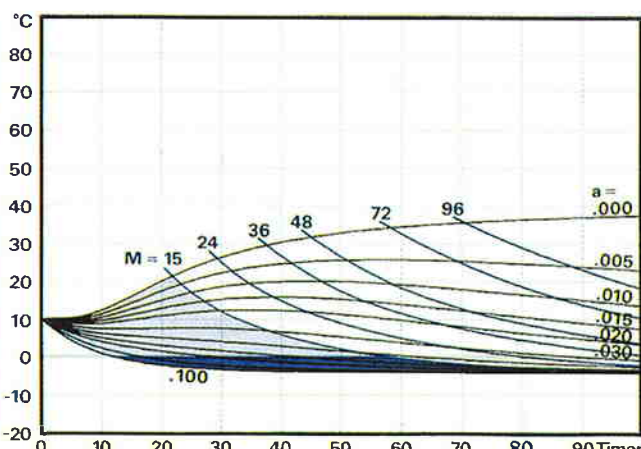
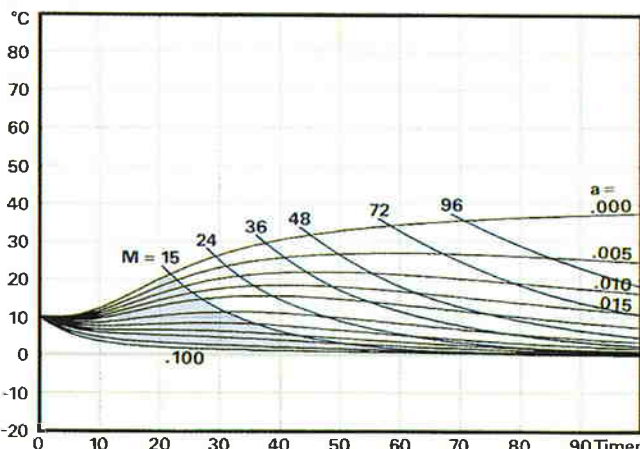
Beton-
temp.
 $\theta_B =$
 20°C



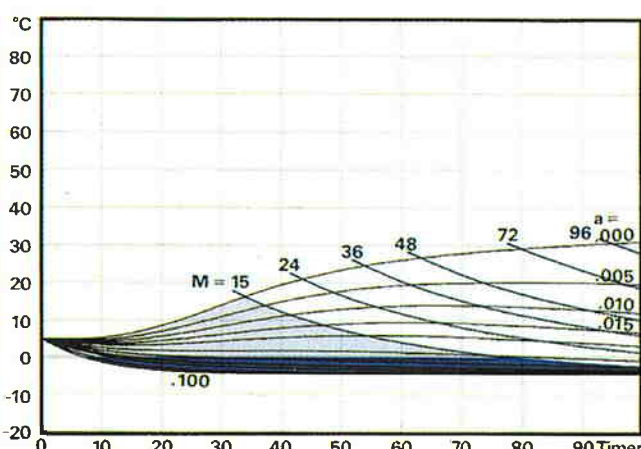
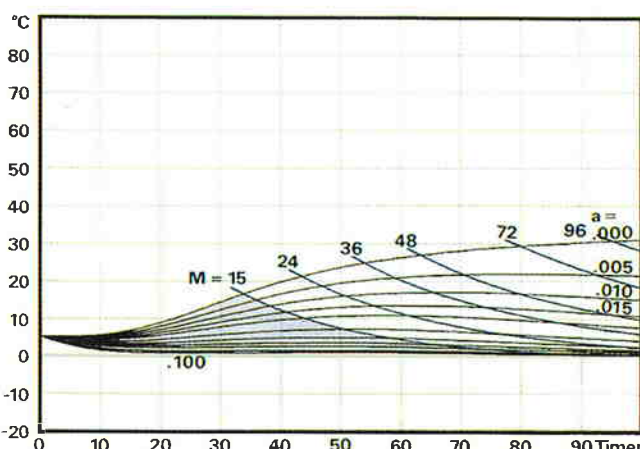
Beton-
temp.
 $\theta_B =$
 15°C



Beton-
temp.
 $\theta_B =$
 10°C



Beton-
temp.
 $\theta_B =$
 5°C



Lufttemperatur $\theta_L = -10\text{ }^\circ\text{C}$

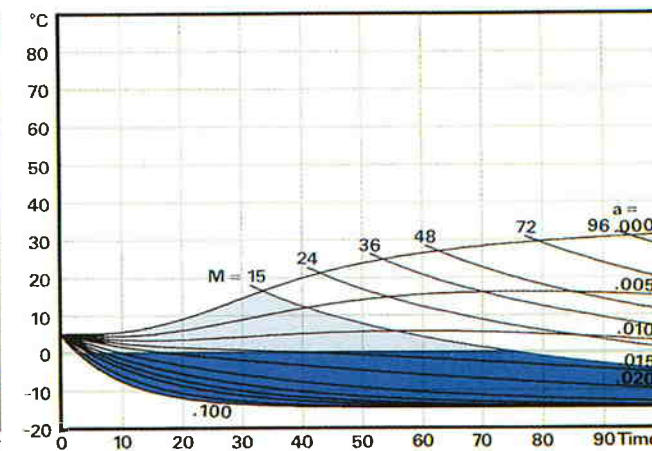
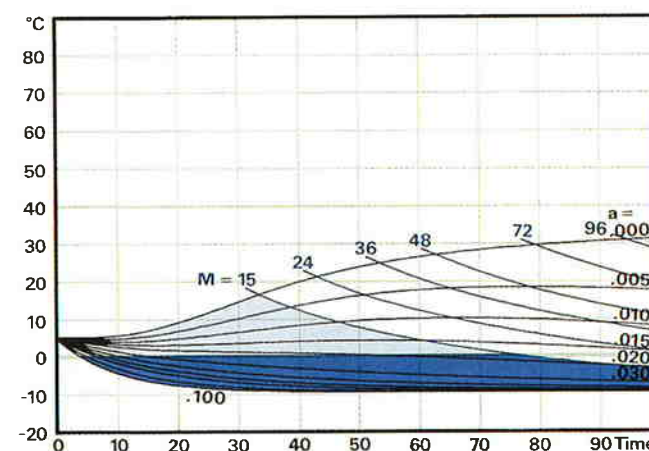
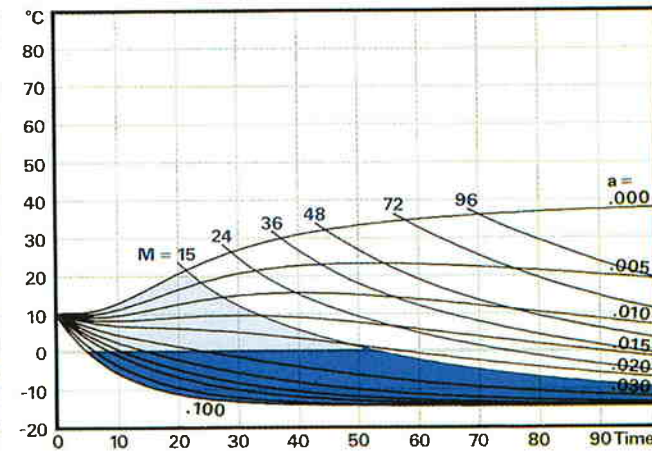
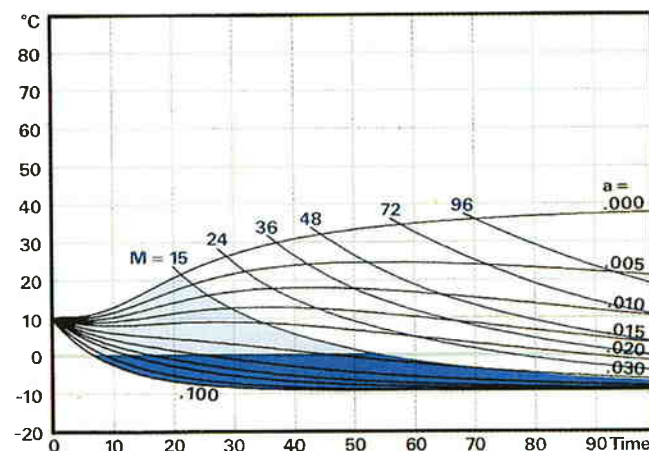
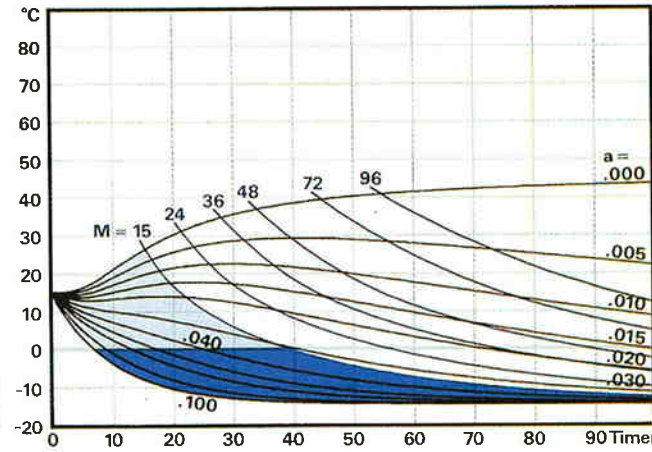
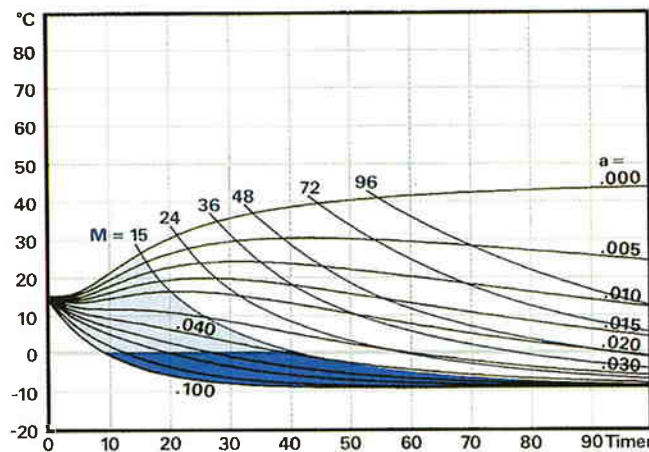
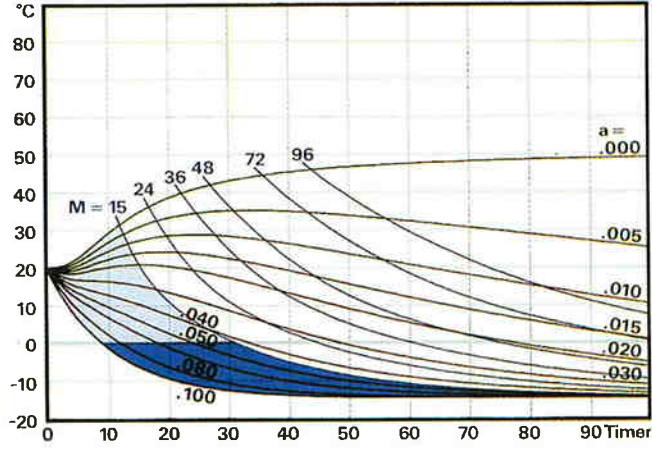
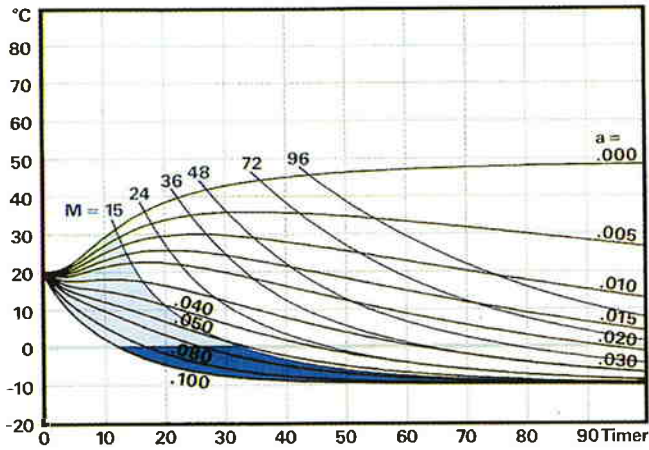
Lufttemperatur $\theta_L = -15\text{ }^\circ\text{C}$

Beton-temp.
 $\theta_B = 20\text{ }^\circ\text{C}$

Beton-temp.
 $\theta_B = 15\text{ }^\circ\text{C}$

Beton-temp.
 $\theta_B = 10\text{ }^\circ\text{C}$

Beton-temp.
 $\theta_B = 5\text{ }^\circ\text{C}$



Langsomthærdnende cement, type C 300 kg/m³

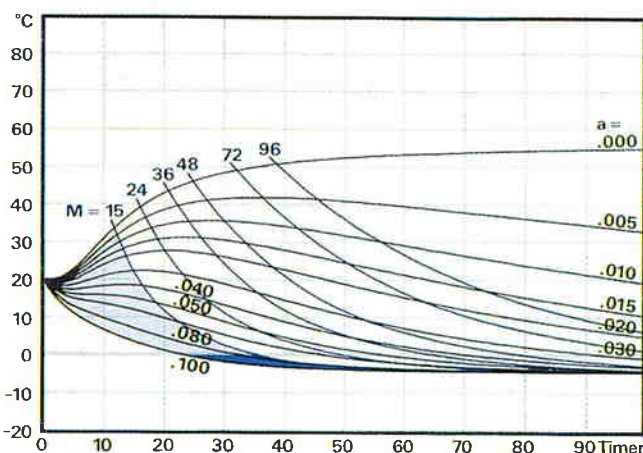
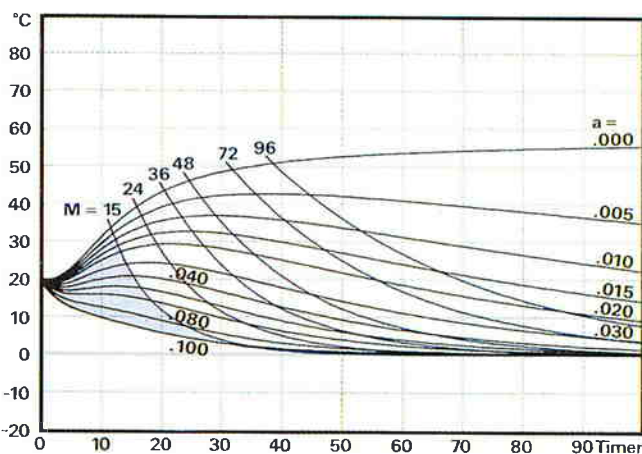
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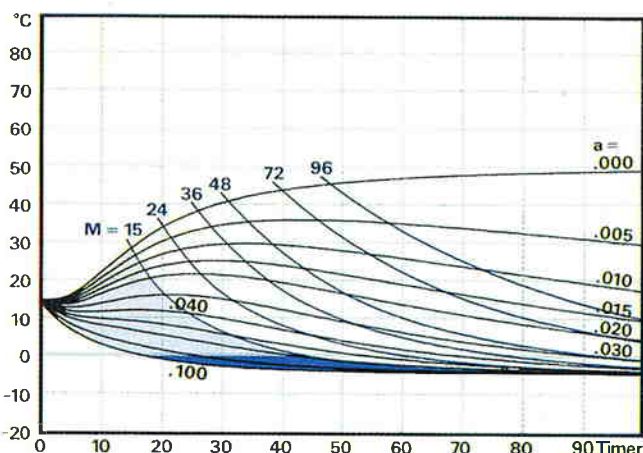
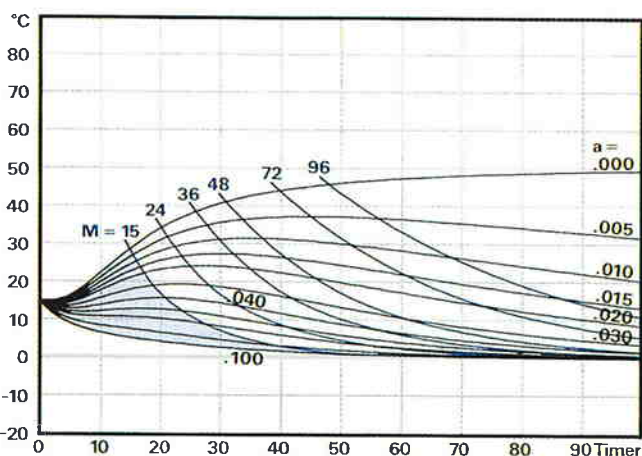
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

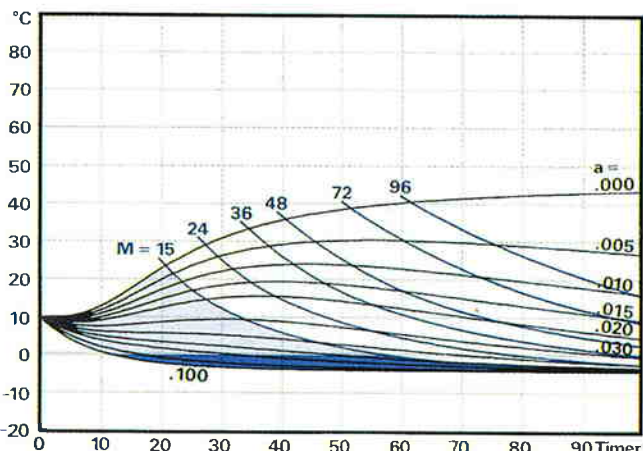
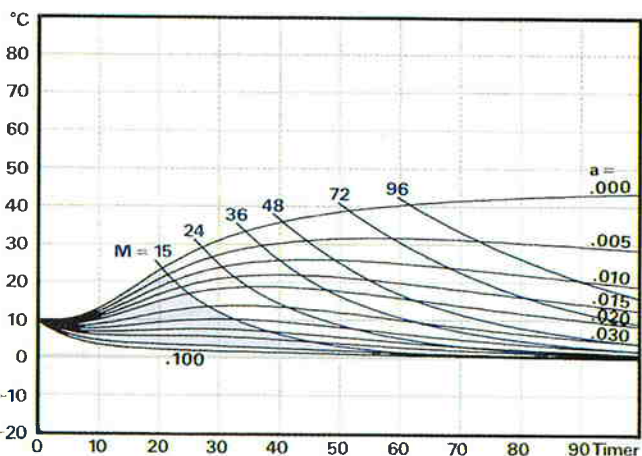
Beton-
temp.
 $\theta_B =$
 20°C



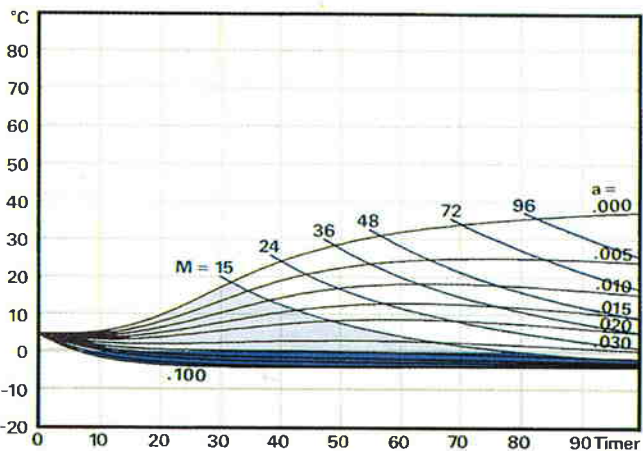
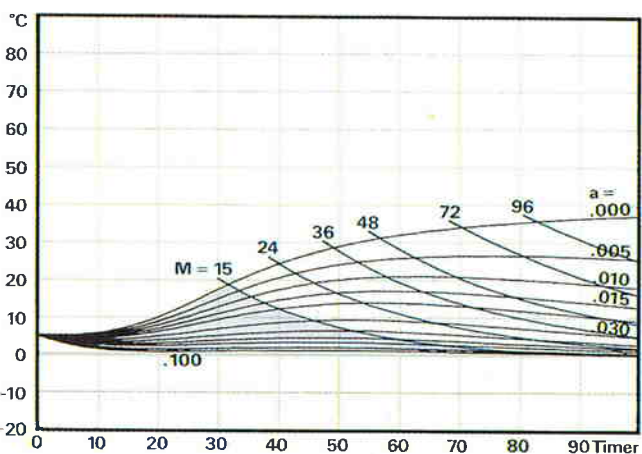
Beton-
temp.
 $\theta_B =$
 15°C



Beton-
temp.
 $\theta_B =$
 10°C



Beton-
temp.
 $\theta_B =$
 5°C



Lufttemperatur $\theta_L = -10\text{ }^\circ\text{C}$

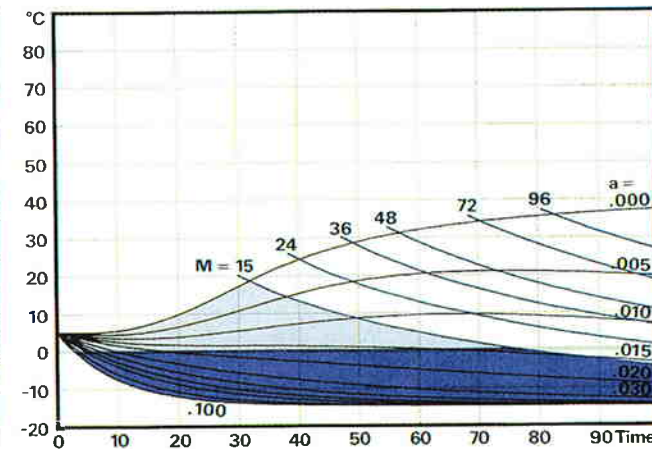
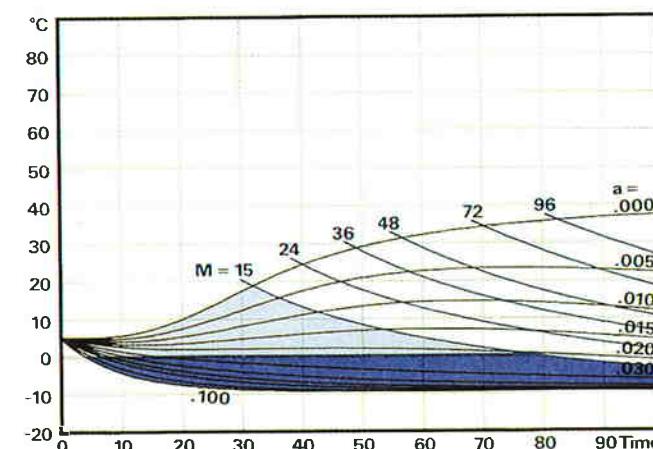
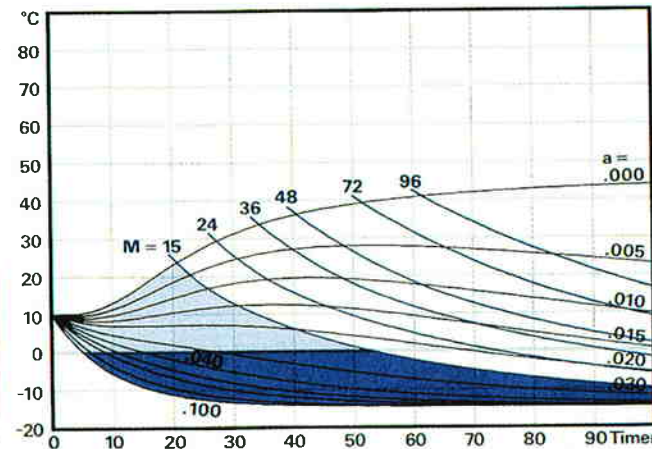
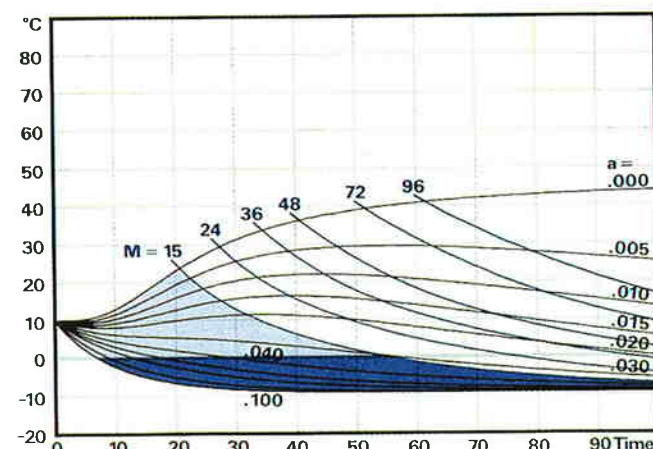
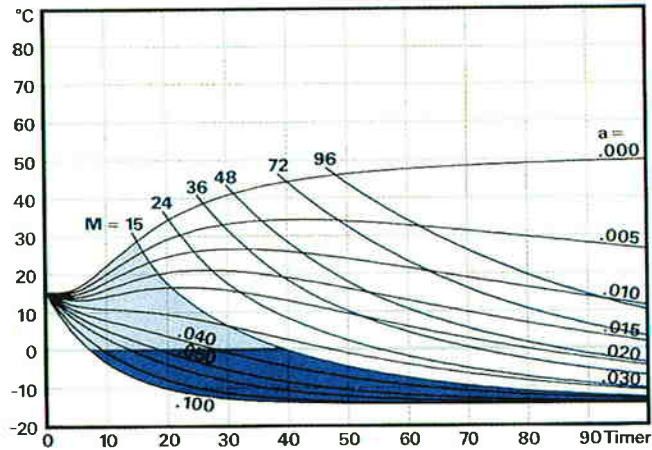
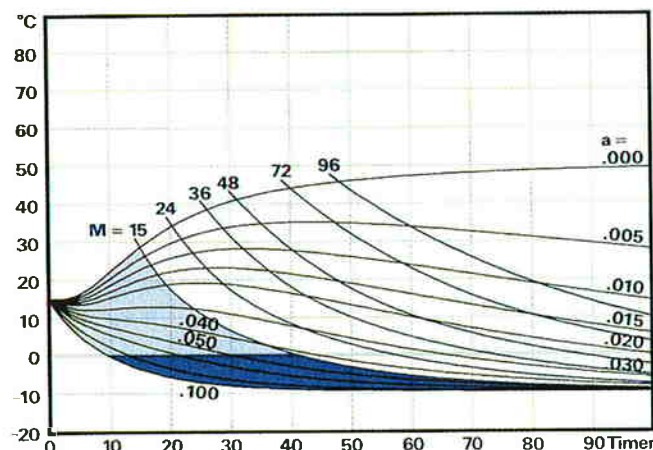
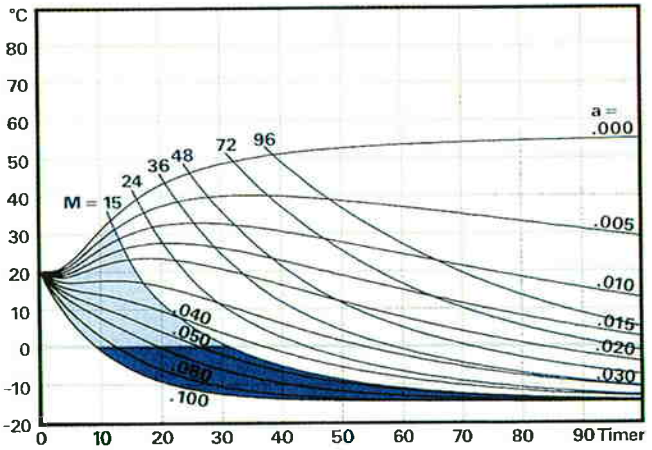
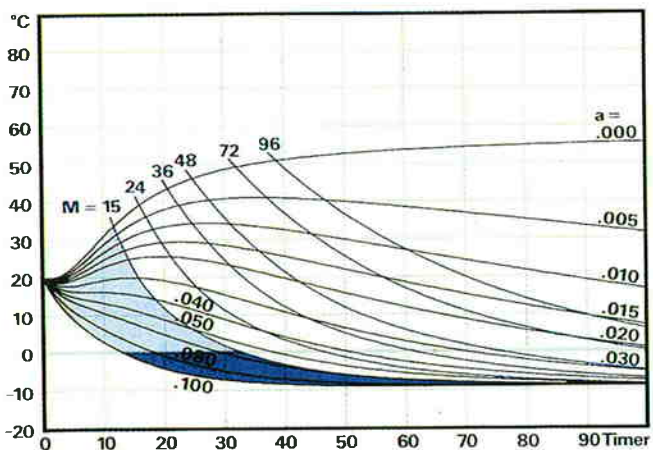
Lufttemperatur $\theta_L = -15\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 20\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 15\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 10\text{ }^\circ\text{C}$

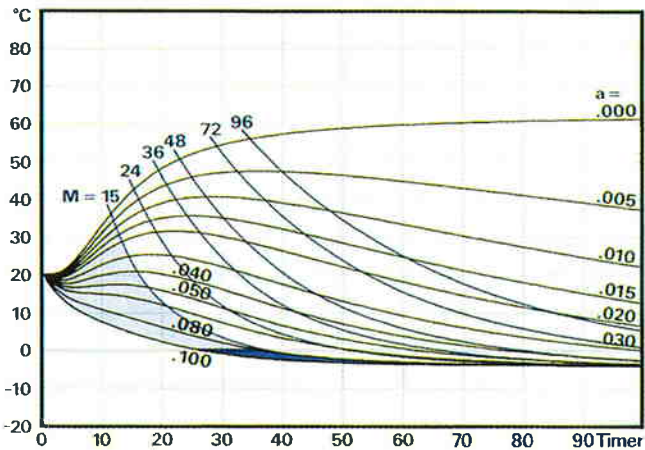
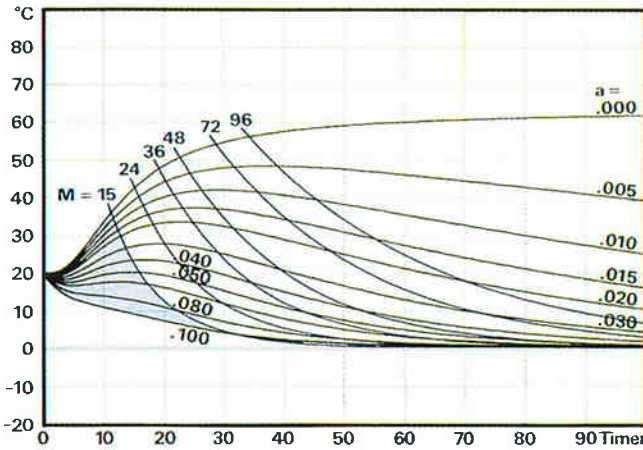
Beton-temp. $\theta_B = 5\text{ }^\circ\text{C}$



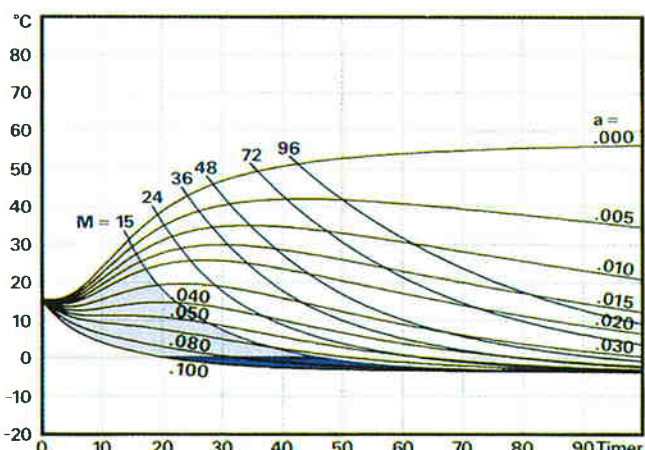
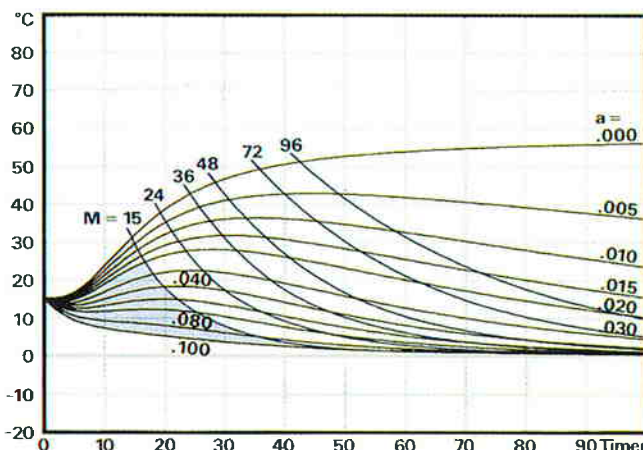
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

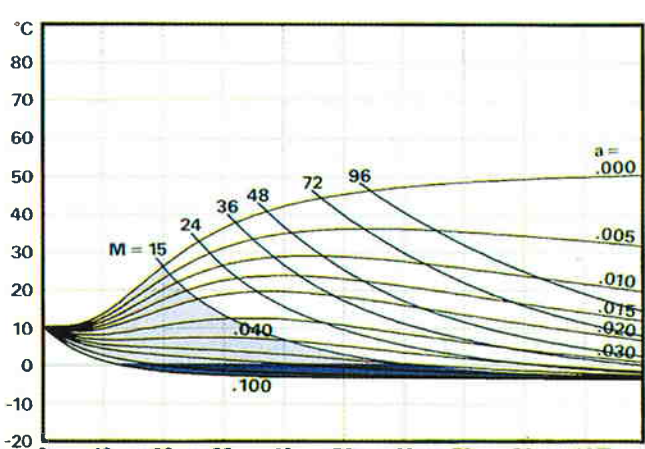
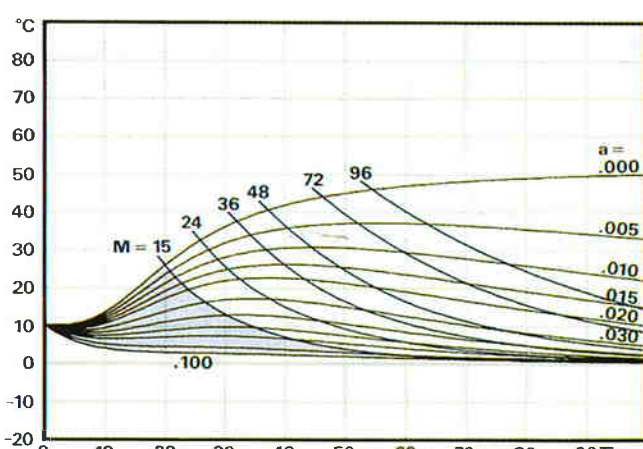
Beton-temp. $\theta_B = 20^\circ\text{C}$



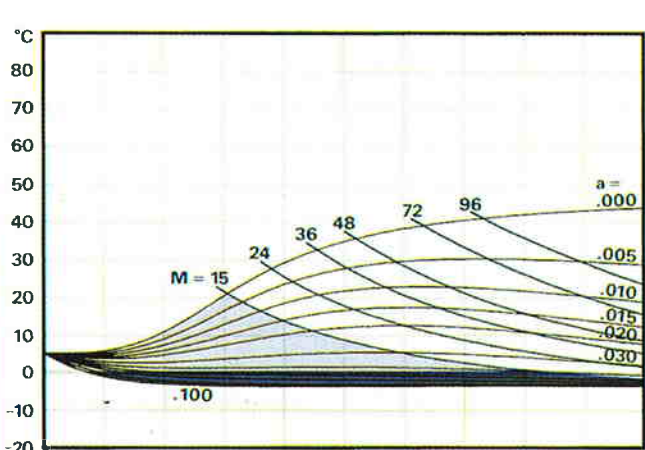
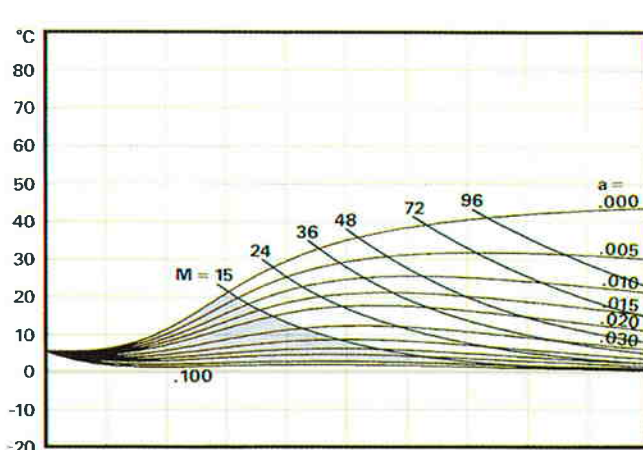
Beton-temp. $\theta_B = 15^\circ\text{C}$



Beton-temp. $\theta_B = 10^\circ\text{C}$



Beton-temp. $\theta_B = 5^\circ\text{C}$



Lufttemperatur $\theta_L = -10\text{ }^\circ\text{C}$

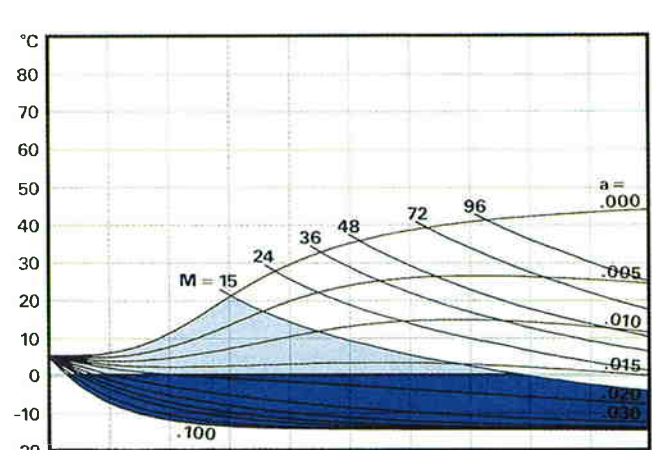
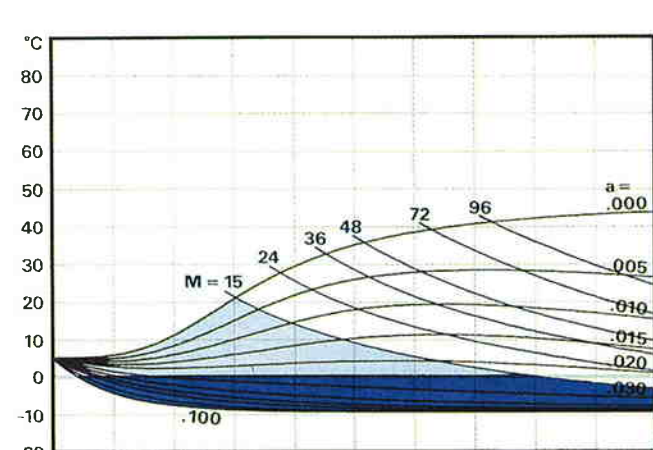
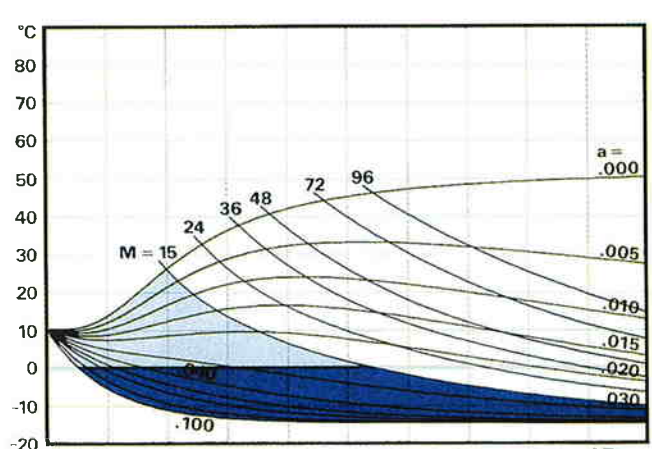
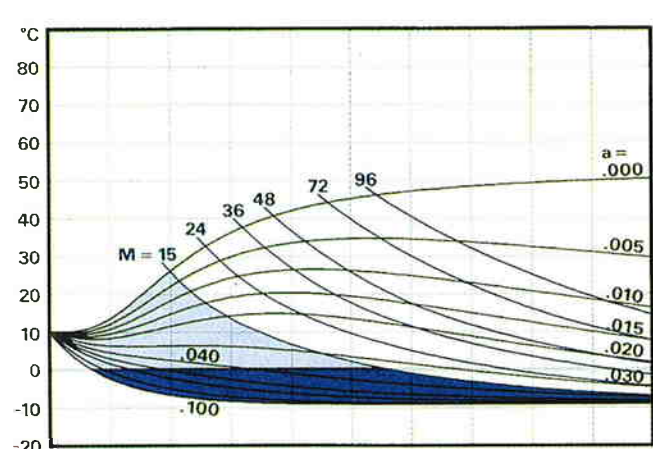
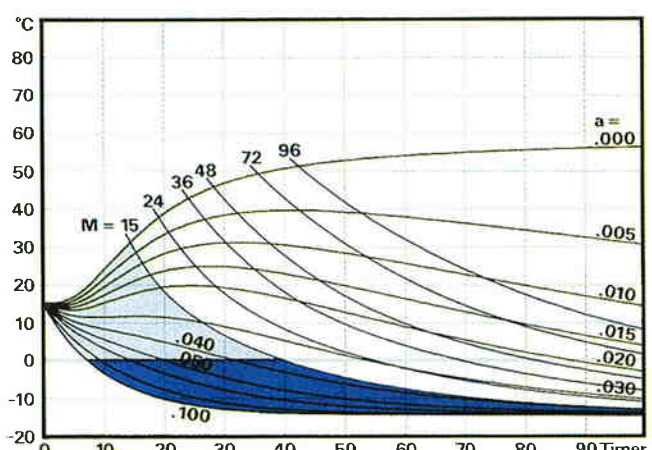
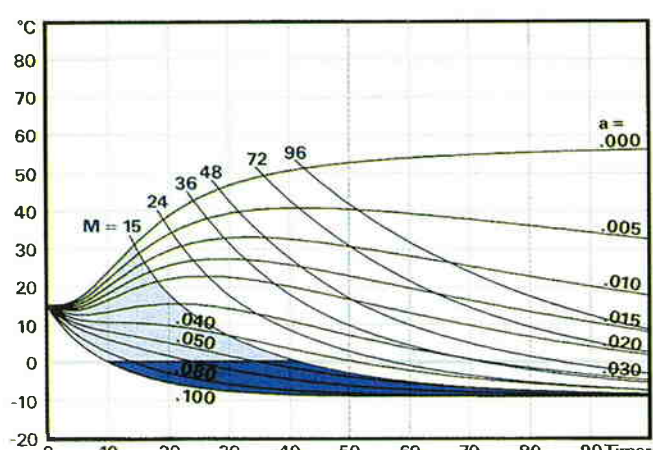
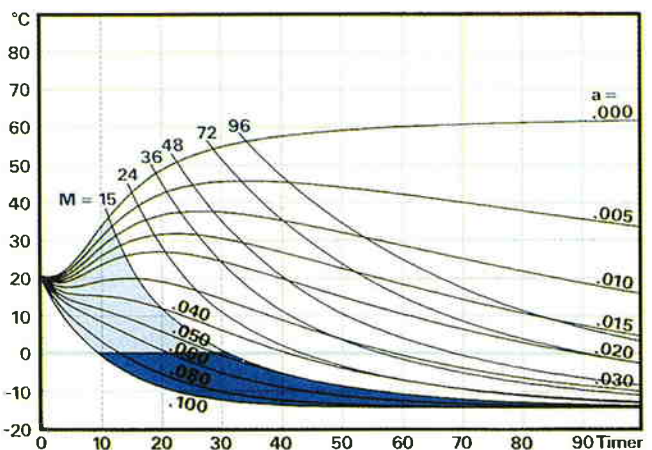
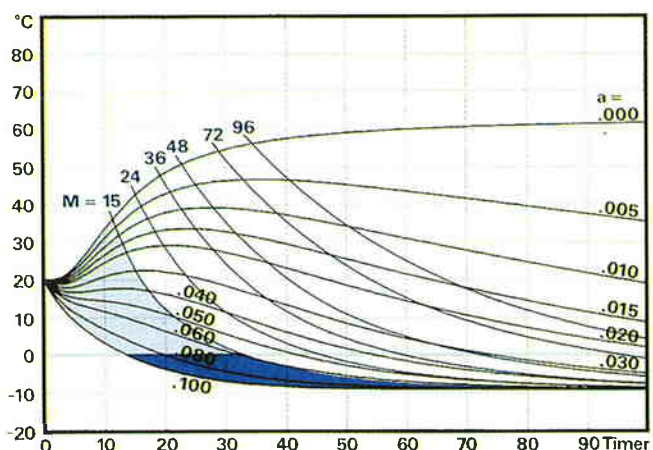
Lufttemperatur $\theta_L = -15\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 20\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 15\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 10\text{ }^\circ\text{C}$

Beton-temp. $\theta_B = 5\text{ }^\circ\text{C}$



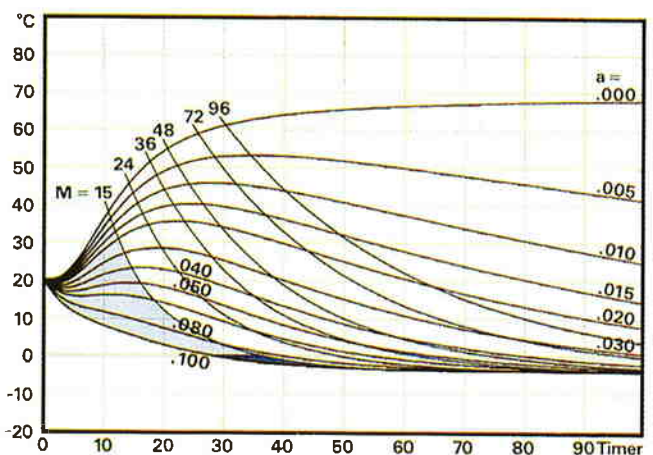
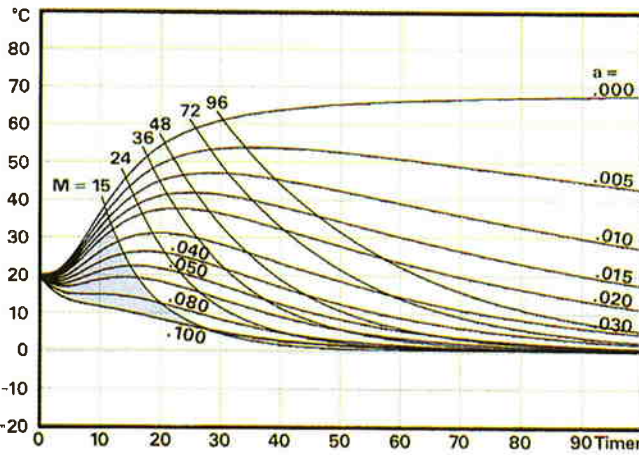
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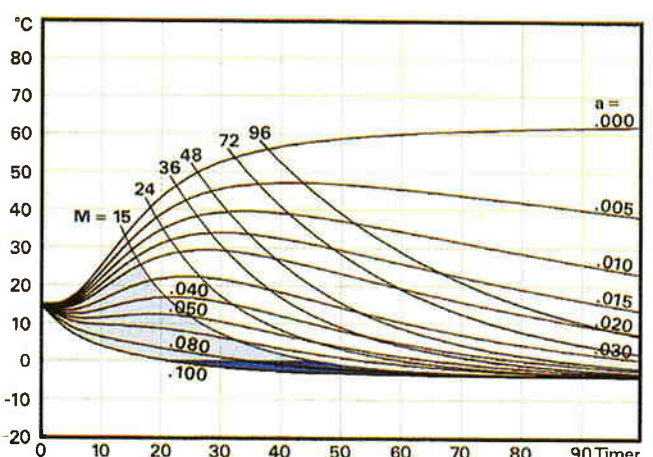
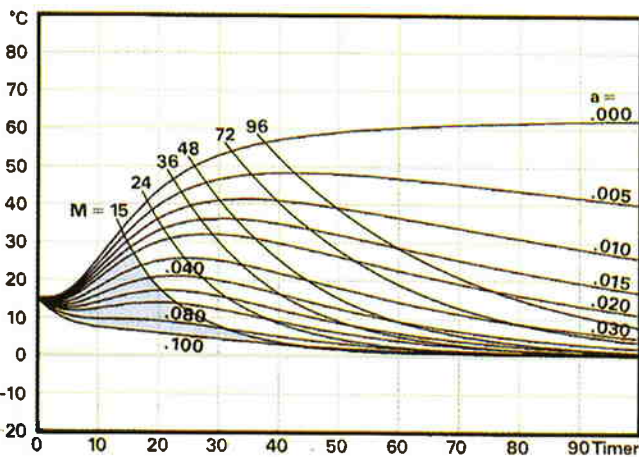
Lufttemperatur $\theta_L = -1^\circ\text{C}$

Lufttemperatur $\theta_L = -5^\circ\text{C}$

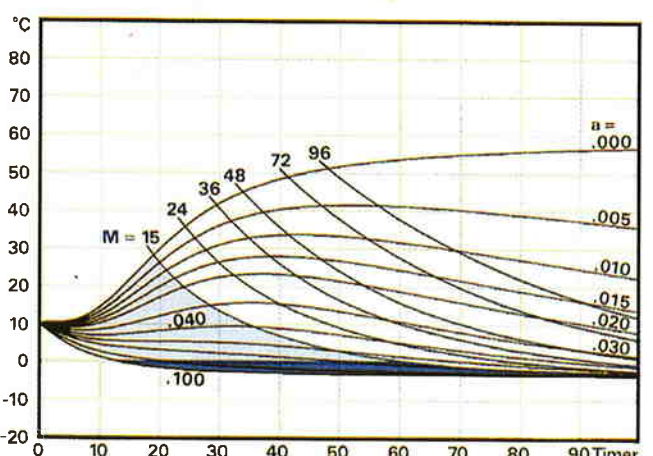
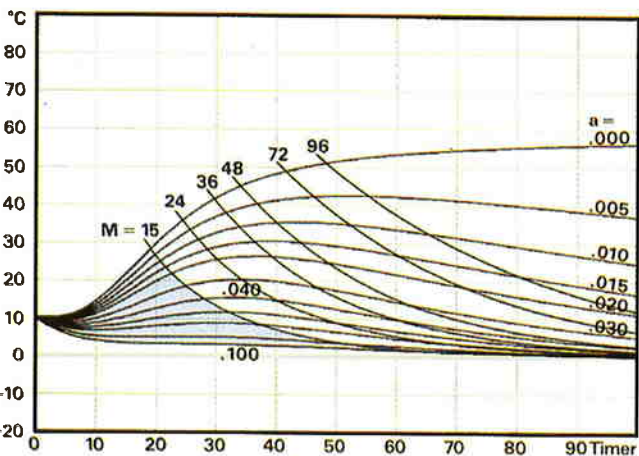
**Beton-
temp.
 $\theta_B = 20^\circ\text{C}$**



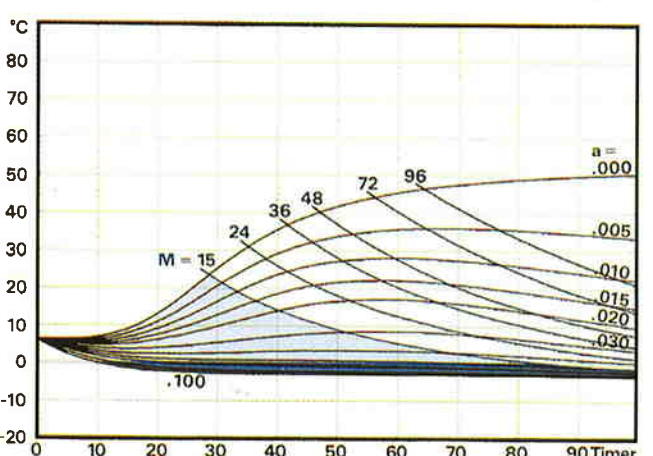
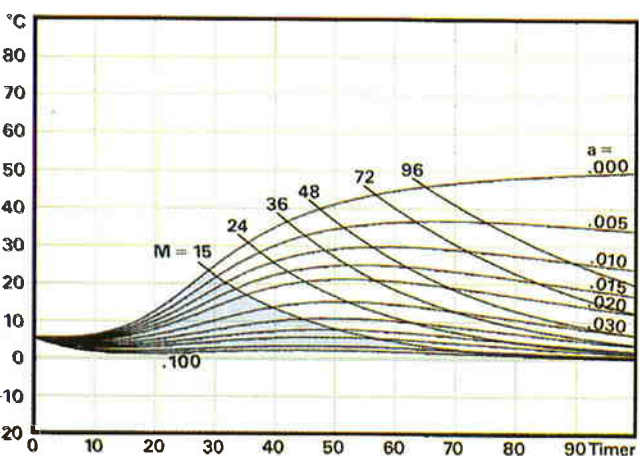
**Beton-
temp.
 $\theta_B = 15^\circ\text{C}$**



**Beton-
temp.
 $\theta_B = 10^\circ\text{C}$**



**Beton-
temp.
 $\theta_B = 5^\circ\text{C}$**



Lufttemperatur $\theta_L = -10\text{ }^\circ\text{C}$

Lufttemperatur $\theta_L = -15\text{ }^\circ\text{C}$

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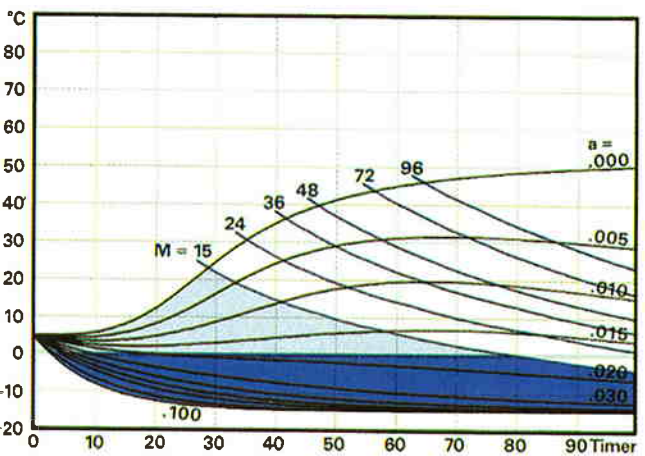
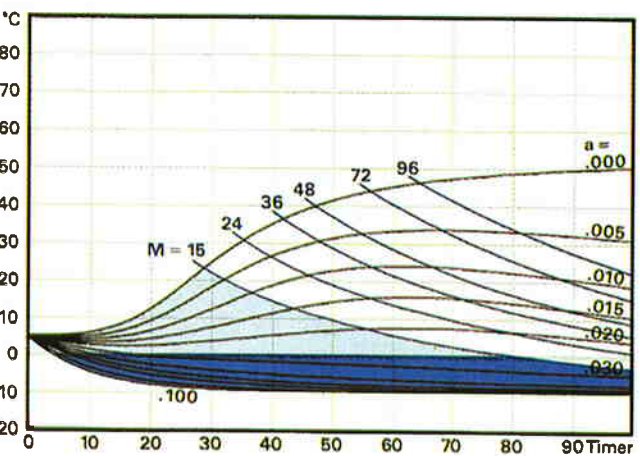
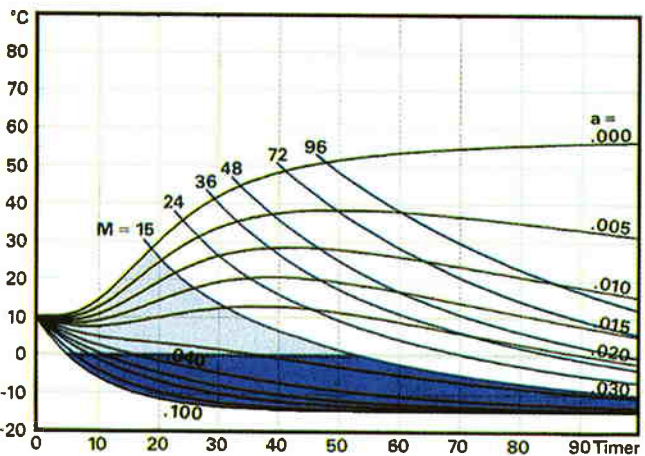
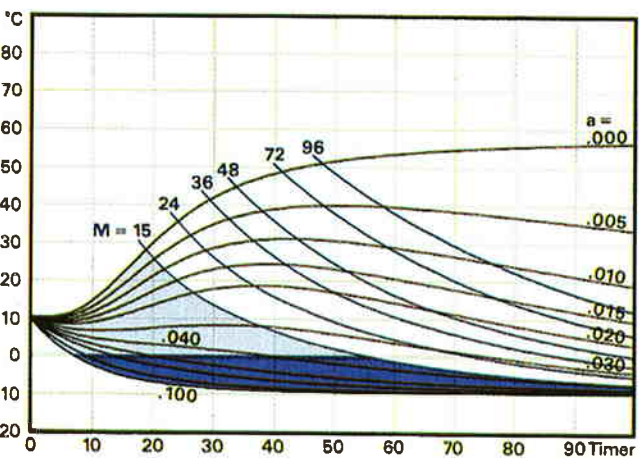
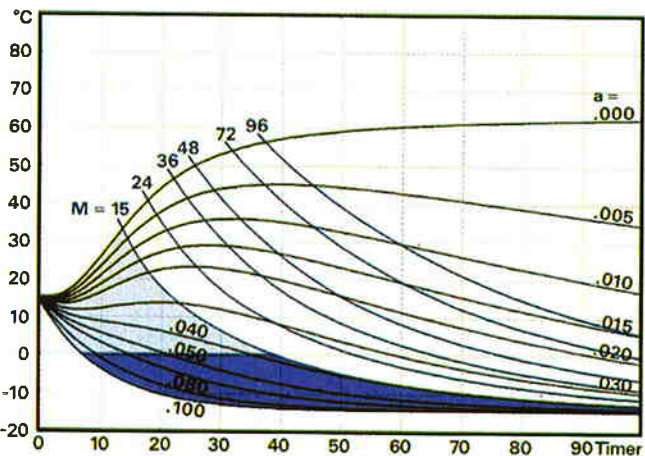
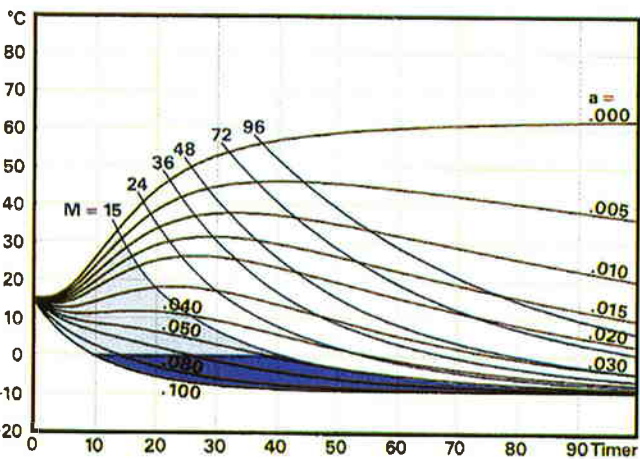
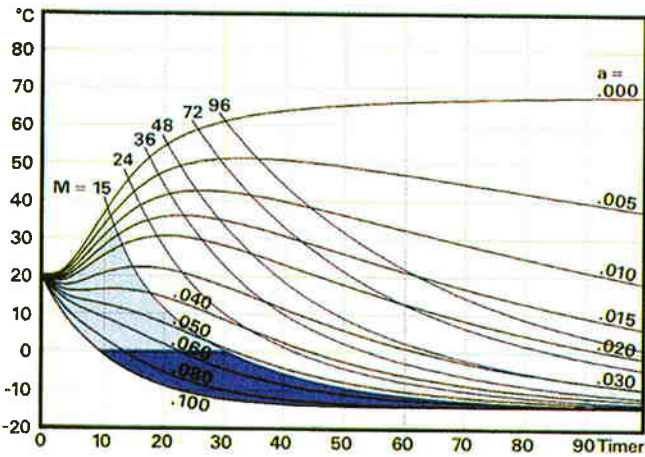
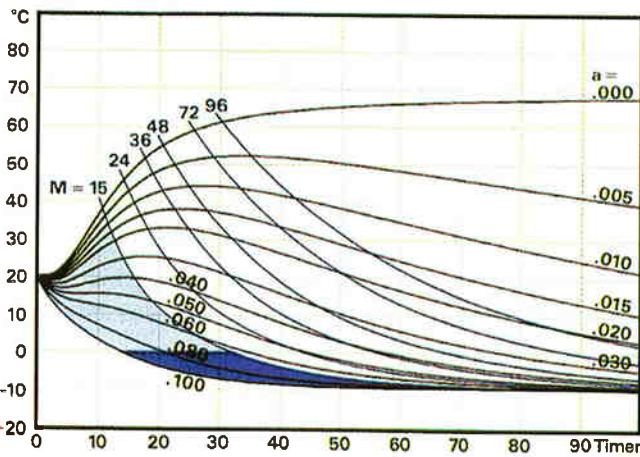
VINTERSTØBNING
AF BETON
1982

Beton-
temp.
 $\theta_B =$
20 °C

Beton-
temp.
 $\theta_B =$
15 °C

Beton-
temp.
 $\theta_B =$
10 °C

Beton-
temp.
 $\theta_B =$
5 °C



Hærdediagrammer

Teknologisk Institut