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The experimental determination of the combined heat and mass transfer coefficient between the free surface of a water body and an air flow

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ABSTRACT

From temperature decay-time curves of a water-bath the total heat transfer coefficient of a free water surface in contact with an air stream has been determined.
From this total heat transfer coefficient the convective part was deduced and the interdependence between this convective heat transfer coefficient and the air velocity related to a height of 1 m has been established.
The results are in good agreement with the Trabert equation and the equation of the Schweisser Kühlwasser Bericht.
In the report different methods for the determination of the asymptotic water temperature are given as well as formulas for the calculation of the wetbulb temperature of the air from this asymptotic temperature.

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CONTENTS

NOMENCLATURE

α_C	convective heat transfer coefficient
α_R	radiation heat transfer coefficient
α_T	total heat and mass transfer coefficient
β	exponent
β	arc tg $(X_E - X'_F)(\theta_E - \theta'_F)$
δ	arc cotg C_{P_A}/r
δ_e	arc cotg $(0.622/P)C_{P_A}/r$
ϵ	relative humidity
φ	arc tg $(i_{E_S} - i'_{F_S})/(\theta_E - \theta'_F)$
ψ	arc cotg $(1 + \alpha_R/\alpha_C)C_{P_A}/r$
ψ_e	arc cotg $(1 + \alpha_R/\alpha_C)(0.622/P)C_{P_A}/r$
ν	kinematic viscosity of air
ρ_A	density of air
ρ_E	density of water
σ	evaporation coefficient
σ^*	solving equation IV 20
$\overline{\sigma}$	see eq IV 21
	see eq IV 22
σ'	$\sigma + \alpha_R/\text{tg}\varphi = \alpha_T/\text{tg}\varphi$
θ_A	air temperature
θ_{AG}	temperature of air in equilibrium with water
θ_D	dewpoint temperature of air
θ_E	water temperature
$\overline{\theta}_E$	see eq IV 16
$\theta_{E\beta}$	see eq IV 17
θ_F	wetbulb temperature of air
θ'_F	radiation dependent wetbulb temperature of air
θ'_{FG}	(only of planimetrical importance)
θ_N	natural temperature of a river
$\Delta\theta$	$\theta_A - \theta_F$
$\Delta\theta'$	$\theta_A - \theta'_F$
Z	f/f_h
b	constant
c	constant
C_{p_A}	specific heat of air
C_{p_E}	specific heat of water
e_A	partial vapour pressure of the air

e_S	partial vapour pressure of saturated air
f	decay distance
f_h	asymptotic value of f
f_{t^*}	decay distance at the period t*
G_E	liquid flow rate
h	depth of the water bath
i_A	enthalpy of air at θ_A
i_{E_S}	enthalpy of saturated air at water temperature θ_E
i'_{F_S}	enthalpy of saturated air at radiation dependent wetbulb temperature θ'_F
k	cotg δ_e
k'	cotg ψ_e
k_1	constant
k_2	constant
m	time shift parameter
m	exponent
n	number of data points
P	pressure of air
q_e	evaporation heat flux
q_h	sensible heat flux
q_{h_C}	convective part of sensible heat flux
q_{h_R}	radiative part of sensible heat flux
q_{R_a}	adiabatic radiation heat flux
Δq_e	evaporation heat flux difference in respect to state of equilibrium
r	latent heat of vaporization
R_{e_L}	fetch Reynolds number
R_{e_x}	local Reynolds number
t	time for passing between two situations
Δt	idem
t*	period of decay function
t_a	time coordinate of intersection
$\overline{U}_{<n>}$	average air velocity in cross-section of test section determined from n local velocities
U	$\overline{U} = \overline{U}_{<\infty>}$
U_z	velocity on height Z in the atmosphere
$\overline{U}_z$	average velocity on height Z in the test section
U_1	velocity on 1 m height in the atmosphere
U_∞	free flow velocity
V	amount of water evaporated per second at constant temperature conditions per mm Hg pressure difference
X_A	absolute humidity of air

X_{AG}	absolute humidity of air in equilibrium condition
X_E	absolute humidity of saturated air at temperature θ_E
Z	height above water-surface

GENERAL

According to the second law of thermodynamics, the transformation of the thermal power into mechanical power and then into electric power, involves the transfer of a certain quantity of heat to the environment. Due to technological limitations the net performance of a thermal station is approximately 45%, which signifies that 55% of the caloric energy employed to operate the station is discharged into the heatsink. From a nuclear centre roughly 65% must be discharged. Given the fact that the installed power per station now tends to be 1000 - 1200 MWe it will be clear that for such huge quantities of residual heat to be discharged, the fluid used for cooling can only be water, more so, while this same water finally ensures the transfer of heat to the atmosphere. Electric power stations are hence located at or by rivers having a sufficient throughput, or close to a stretch of water, an estuary or to the shore.
In the figures 1 - 4 the main cooling systems used are shown:

Fig. 1 - The circuit is open. The cooling water coming from a river, lake or coastal intake passes "once through" the condensors and returns to the original source.

Fig. 2 - Before returning to the original source, the heated water passes through special devices (spray modules or cooling towers) in order to be cooled partially.

Fig. 3 - The circuit is closed. The water is cooled completely by the air in wet- or dry cooling towers.

Fig. 4 - The circuit is closed or semi closed. The water is cooled during the night and protected against incident solar radiation during the day in storage ponds (so called phased cooling). A combination with pump-storage systems is possible.

Using open circuits, the contamination of the waterbody with heat may cause a deterioration of the ecosystem, in its effects generally called thermal pollution. The most striking effects of thermal pollution are the following:

1. The hot effluents may cause a thermal shock for the aquatic life. In order to limit this effect, the temperature increase in the condensor may not be greater than 10°C, and the discharge of water of having a temperature of more than 30°C has been prohibited.
2. The temperature after complete mixing could diverge too much from the "natural temperature" of the river. This can cause an apparent seasonal shift disastrous for the aquatic life or even create an anomalous ecological situation. In respect of these contingencies the warming up to the total waterbody may not exceed 3°C.
3. With increasing temperature the content of oxigen dissolved in the water diminishes. This can enhance the possibility of a change from an aerobic to an anaerobic decomposition of organic material in the water resource (eutrophication). This phenomenon seems strongly related to a high nutrient content of the water and the type of phytoplankton or algae prevailing at a certain temperature. Due to this fact the upper temperature limit especially for rivers is also established around 30°C.

Regulations and specifications may vary somewhat in the different countries. However, the main trend is the same. To obey these regulations a very good understanding of all mechanisms (as dispersion of heat in rivers, lakes and estuaries, heat and mass transfer) is necessary.
This better insight is also needed for optimisation of the combination wet cooling tower and the free cooling surface of the river stretch between two power stations, a problem for the moment still of present interest.

In order to obtain useful information about the cooling action of the free surface of a waterbody under various meteorological conditions, two methods for research can be followed.
Measurements can be made in situ. In this case also the influence of stratification and diverse types of effluent distribution on the thermal behaviour of a waterfetch under natural condition can be studied. On the other hand, to study the mechanisms of heat and mass transfer under idealized conditions and to develop methods for an adequate measurement of the governing parameters and magnitudes of it, laboratory investigations are imperative.
Other workers studied the transfer mechanisms mainly on the gas-side. It is for this reason that we have tried to obtain the necessary information from the water side, by measuring simply the time temperature decay curves of a well isolated water bath, only at the free surface of it in contact with an airstream having a programmed temperature and humidity. About these measurements we will report in this paper.

I DESCRIPTION OF THE EXPERIMENTAL INSTALLATION

An experimental installation was built by the Technological Division at Ispra. In view of the lack of available resources, we have chosen modest and economical solutions.
Fig.5 shows a drawing of the circuit, and photos 1, 2, 3 and 4 the actual installations.
It is therefore a closed circuit. The gaseous phase, having passed through the test section, is re-conditioned once the thermopsychrometric conditions desired have been reached. This installation is composed of an air conditioning chamber, a closed circuit, a test section and various measurement and control instruments.

a) Air conditioner

This is composed of a ventilation group and two conditioning systems, one for cooling and one for heating, with automatic regulation. The general regulation of the circuit is pneumatic. The thermopsychrometric characteristics are as follows:

- max. supply of treated air	7000 m^3/h
- required heating power with water at a temperature of 120°C and delivery of 500 l/h	15,000 Kcal/h
- required cooling power with cold water, temperature 12°C, pressure 1.5 kg/cm^2, delivery 1000 l/h	15,000 Fg/h
- air temperature, adjustable between	15 - 35°C
- relative humidity, adjustable between	45 - 90%
- precision in the automatic regulation:	
. in the temperature	± 0°C
. in the relative humidity	± 5%
- installed electric power	15 HP

b) Closed circuit

This is made of zinc plated steel, doubly insulated walls, divided in units with connecting flanges. The cross-section is rectangular 200 x 500 mm. A by-pass or bridge has been provided between the inlet and the outlet of the circuit. Two simultaneous adjustable shutters enable the flow of air into the test section to be regulated.
An instrument smoothing the flow is located in front of the test section of the circuit. It is composed of a group of adjacent cylinders, the length of which is equal to 15 times their diameter

c) Test section (Fig.6)

This is composed of 3 concentric containers of wich the internal has a free surface of 200 x 50 cm, i.e. 1 m^2. The other 2 containers act as a double insulation, one the central leaving a space of 2 cm of air and the other external having a gap of 3 cm, filled with thermostatically controlled water.
Four magnetic mixers maintain a homogeneous temperature in the internal tank, using a negligible amount of energy. In order to ensure a constant level in the tank, an automatic regulation was constructed. Fig.7 shows the level of the internal tank, connected to the level of the small tank (a).
A small pump feeds the circuits (b) and (c) and provides the slight quantity of water added to the internal tank previously heated in (d). Fig.8 shows the automatic regulation of the temperature. The temperature of the insulating tank (outer) follows that of the internal tank (a). The difference in temperature between the two tanks is less than ± 0.2°C.
The internal tank is fitted with a Plexiglass cover connected to the closed circuit. The various instruments for measuring the temperature, air-speed and humidity are positioned on the test section or on the input circuit.
In order to avoid an increase in temperature due to radiation, an external screen has been built, so that the test section can be insulated during the tests.

II MEASUREMENTS

a) Temperature measurements

Fig.s 8 and 9 show the positioning of the temperature sensors and Fig.8 also shows the thermal regulator, built between the test vessel and the insulation casing. Four temperature (1 for air, 3 for water) measurement chains were constructed, including:

1) A platinum (Pt 100) resistance detector with a stainless steel coating (100 Ω at 0°C) made by the Rosemount Engineering Company.
2) An amplifier corrected for linearity and calibrated in the temperature range 0°C to 50°C. Accuracy ± 0.1%.
3) Digital control voltmeter. Resolution and precision of ± 0.1°C.

b) Humidity measurements

The psychrometric state of air can always be characterized by the set: air temperature θ_A and respectively one of the following parameters:

. The relative humidity ϵ

  This is the ratio between the actual pressure e_A in the air, and the pressure e_{AS} that the vapour would have if, at the same temperature, the air was saturated. It is expressed in %.

. The absolute humidity X_A

  This is the quantity of watervapour in the air; it is expressed in g/m^3 air or in gr/kg air.

. The dewpoint temperature θ_D

  This is the temperature at which the water vapour, contained in a volume of moist air, becomes saturated when this air is cooled at a constant pressure, consequently it is the temperature corresponding to 100% relative humidity for any given moisture content of the air, at the same partial vapour pressure.

- The wetbulb temperature θ_F
  This is the temperature the air will take on, if the air is adiabatically cooled down, until saturated conditions are reached.

Ad ϵ

An approximate measurement of the relative humidity is given at the exit of the air-conditioning device by an organic type of apparatus. This is based on the lengthening of a tuft of human air which varies according to relative humidity. It is calibrated in %.

Ad X_A

No techniques were applied in the circuit for measuring directly the absolute humidity.

Ad θ_D

The dew-point is recognised by the formation of a mist, or, if the cooling is carried out locally on a test-surface by the formation of dew that can be detected optically.
Fig.10 shows how a small channel draws off a small quantity of air from the circuit, without altering the flow rate in the channel. This air is analyzed in the measurement chamber of the apparatus (EG and G Cambridge-model 880).
The dew-point sensor contains an inert metallic mirror that is chilled by an electronic thermoelectric cooler to the actual dew-point of the air. As the condensate forms dew on the mirror, an optical sensing bridge detects the change in reflectance of the mirror and develops a proportional signal to control the cooler power supply.
The mirror temperature is measured with a premium thermocouple or precision resistance element.

Ad θ_F

In addition, a psychrometer, a fundamental meteorological instrument for measuring humidity, has also been included in the circuit. It consists of two similar glass thermometers. The sensitive bulb of one is surrounded by a humid jacket standing in water. This water evaporates more or less rapidly according to the temperature of this particular bulb called the wet-bulb temperature.

Air velocity measurements

In order to know the average velocity of the air flow, as well as the velocity profile in the cross-section of the test area, a number of subsection velocities in the circuit has been measured. Depending upon the value of the velocity, various velocity measurement methods for wind speed were employed. In general, the flow speed is not equal at all points of a cross-section. This is why the cross-section is divided into a number of small areas, and the velocity is measured at the centre of gravity of each of them.
The weighted average value of all these measurements represents the mean velocity.

Methods employed

Pilot tubes

This apparatus combines a static and a dynamic pressure transducer of which each can be connected to the two legs of a differential manometer.
Experience has shown that when the Pilot tube is positioned so that it is parallel to the

velocity, the pressure difference between the two transducers is equal to $\rho_A/2\ U^2$. Of course, the diameter of the tube must be small enough for the velocity to remain constant in both value and direction in the available space and, moreover, the support should be shaped in such a way that the flow is not disturbed.
Under these conditions, the tube can even be inclinated between 10 and 15° to the direction of the velocity without causing an error of more than 2% in the measurements.

Thermal anomometer

Thermal anemometers make it possible to measure air velocities of less than the response threshold of conventional anemometers. They are therefore employed for measuring very low velocities (from 0.1 m/s to 4 m/s).
The cooling effect produced by a flow of air on a heated body has been applied as an established and reproducing relation existing between the cooling and the flow velocity. The heated body is a resistance placed in the head of the detector, which forms a wheatstone bridge with three resistances to be measured. After calibration of the apparatus, the wind velocity can be measured directly.

III THEORETICAL BACKGROUND

The combined effects of heat transfer and mass-exchange across the interface between a water-layer or water-body and the air in contact with it, may be expressed by a set of equations.
For the exchange of "sensible" heat the following equation holds:

$$q_h = (\alpha_R + \alpha_C)(\theta_A - \theta_E) \qquad (1)$$

The heatflux q_h is composed of two different components based first on **radiation heat-transfer** of which the heat-transfer coefficient α_R for practical use can be simplified by the formula:

$$\alpha_R = 0.222\ \left(\frac{\theta_E + 273}{100}\right)^3\ \left[\frac{W}{m^2K}\right] \qquad (2)$$

In this formula the influence of air temperature has been substituted by a constant air temperature of 300°K.
In Fig.11 we have plotted α_R as a function of the water temperature θ_E.

For rivers in which the water is thoroughly mixed the temperature of the water-surface can be taken identical with the bulk temperature of the water.

The second contribution to the exchange of sensible heat is expressed by the convective heat-transfer coefficient α_C being effectively the heat conduction over the diffusion sub-layer.

The value of this coefficient depends also on the transport mechanisms in the outer part of the boundary layer over the interface and is a function of windspeed, size and morphological character of the water-surface.
For the mass-exchange in terms of heat one may write:

$$q_e = \sigma\ (X_A - X_E) \qquad (3)$$

In this formula the water vapour mass concentration on the water surface is given by X_E and the vapour mass concentration in the bulk of air by X_A.

The evaporation coefficient σ is related to the convective heat-transfer coefficient through the LEWIS NUMBER

$$L_e = \frac{\alpha_C}{\sigma \cdot C_{P_A}} \sim 1 \qquad (4)$$

If the net transport of heat across the interface becomes equal to zero, conditions of this type labeled in the following with the subscript G, it results that $q_h = q_e$ and for a constant water-temperature θ_E the air conditions satisfying the assumption may be expressed by:

$$X_{AG} = X_E - (\theta_{AG} - \theta_E) \frac{C_{P_A}}{r} \left(1 + \frac{\alpha_R}{\alpha_C}\right) \qquad (5)$$

This equation can be deduced making use of equations (1) and (3) and the relation (4). Equation (5) gives for $\alpha_C >> \alpha_R$ the "wet bulb line" for which line

$$\cot g\ \delta = \frac{C_{P_A}}{r} = \frac{X_E - X_{AG}}{\theta_{AG} - \theta_E} \qquad (6)$$

For this line is $q_{h_c} = q_e$ (see Fig.12).
A special property of this line is that for any state of the air on this line the enthalpy has the same value, i.e. i = constant.

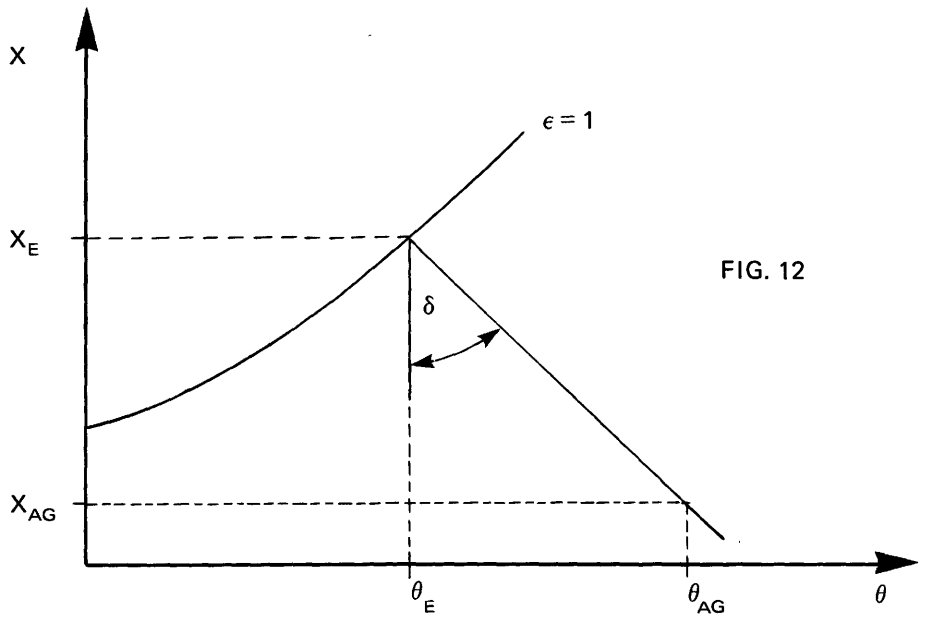


FIG. 12

In the normal situation thus for $\frac{\alpha_C + \alpha_R}{\alpha_C} \neq 1$, we obtain a line under an angle ψ, for which one holds:

$$\cot g\ \psi = \left(1 + \frac{\alpha_R}{\alpha_C}\right) \cot g\ \delta \qquad (7)$$

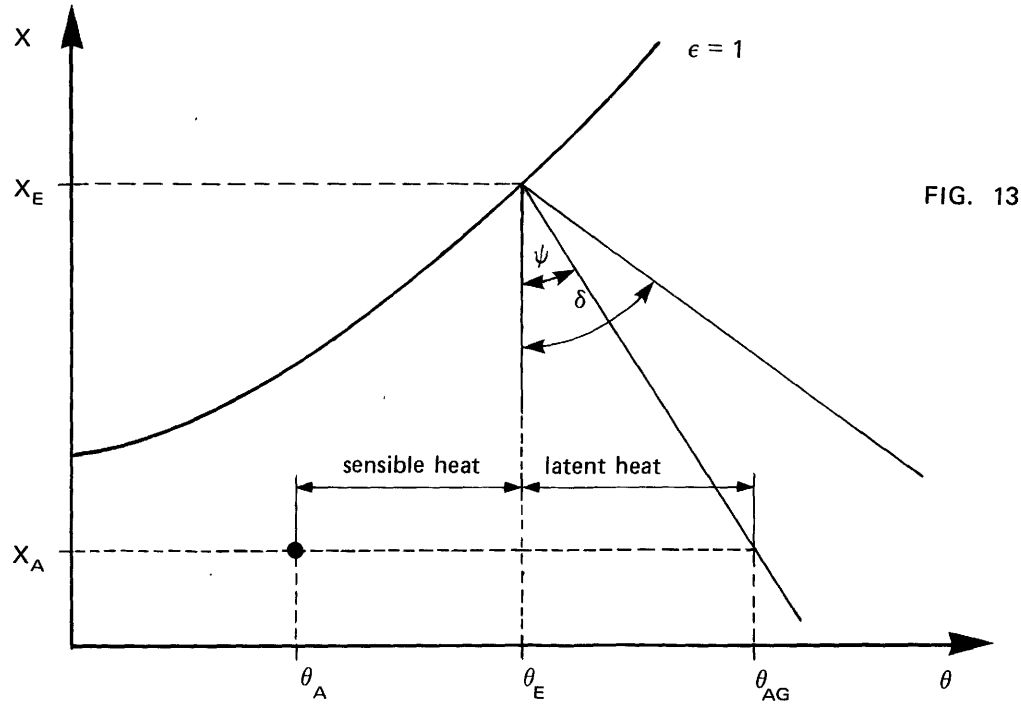


FIG. 13

For a non equilibrium condition for which $\theta_A \neq \theta_{AG}$, we may write:

$$q_h = (\alpha_R + \alpha_C)(\theta_E - \theta_A)$$

$$q_e = \sigma.r(X_E - X_A)$$

$$\sigma.r(\theta_{AG} - \theta_E)\text{cotg}\ \psi$$

$$\sigma.r(\theta_{AG} - \theta_E)\frac{\alpha_R + \alpha_C}{\alpha_C} \cdot \frac{C_{P_A}}{r}$$

$$= (\alpha_R + \alpha_C)(\theta_{AG} - \theta_E)$$

$$q_h + q_e = (\alpha_R + \alpha_C)(\theta_{AG} - \theta_A) \qquad (8)$$

Equation (8) may be expressed in another way as a function of the "radiation dependent-wetbulb temperature" of the air.
The "radiation dependent wetbulb temperature" is that temperature, the wetbulb will take on when the temperature of the air flowing around it remains at the temperature θ_A.
This is formally correct when the wetbulb temperature is measured in huge quantities of air.
Only in the case a small quantity of air is sucked up and flows over the wetbulb, the air cools down adiabatically to the real wetbulb temperature.
So we can give also the definition:
The "wetbulb temperature increment" is caused by the adiabatic radiation heatflux in the case the state of the air remains on the actual one.
For a waterbody with a temperature θ_E, exclusively exposed to an airstream causing a refreshment of the water, the waterbody cools down asymptotically to θ'_F being the radiation dependent wetbulb temperature.
In the case $\theta_E < \theta'_F$, the waterbody will be warmed up asymptotically to θ'_F (see Fig.14).

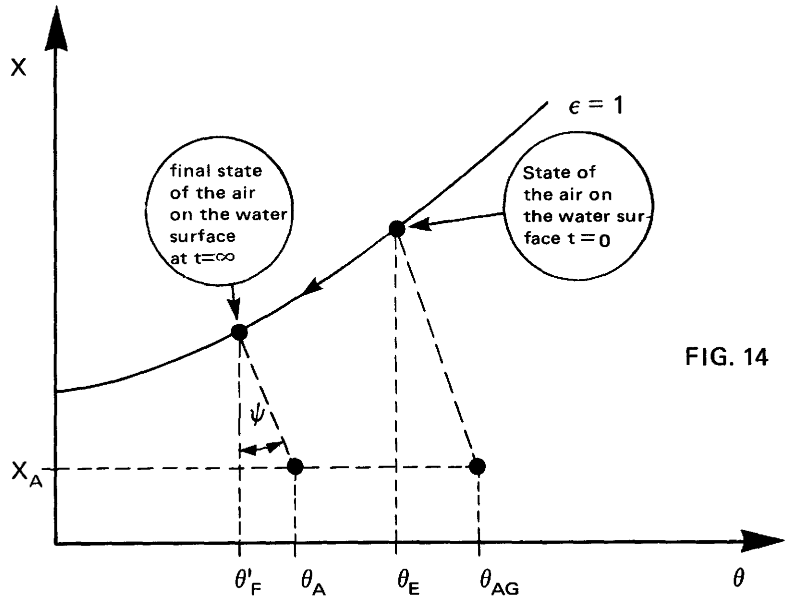


FIG. 14

In the case $\alpha_C = 0$, the radiation dependent wetbulb temperature is equal to the air temperature $\hat{\theta}_A$.

For the disequilibrium temperature difference $\theta_{AG} - \theta_A$, we obtain (see Fig.15)

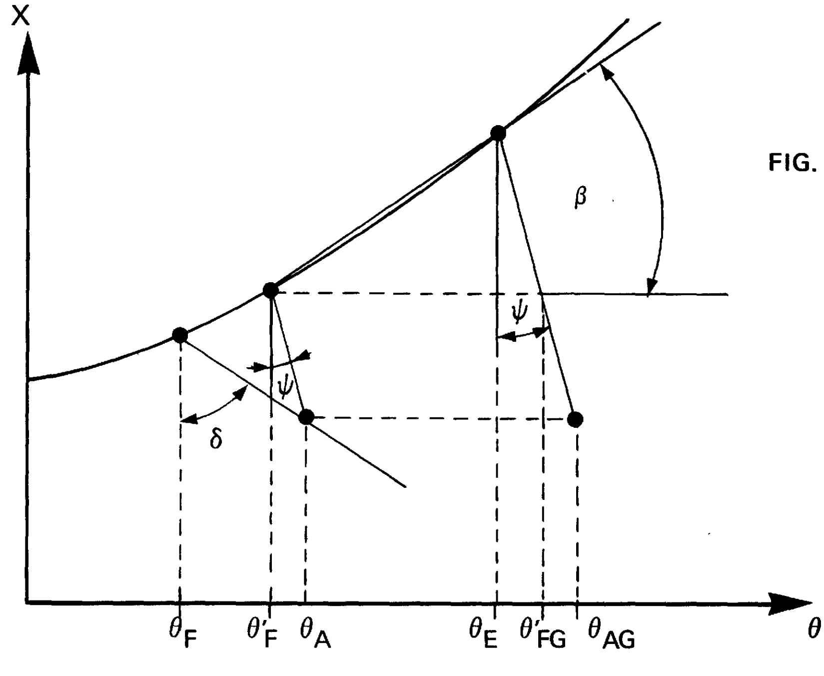


FIG. 15

$$\theta_{AG} - \theta_A = \theta'_{FG} - \theta'_F = (\theta_E - \theta'_F)(1 + \mathrm{tg}\beta \mathrm{tg}\psi)$$

$$= (\theta_E - \theta'_F)\left(1 + \frac{\alpha_C}{\alpha_C + \alpha_R}\,\mathrm{tg}\beta\mathrm{tg}\delta\right)$$

and the equation (8) becomes:

$$q_h + q_e = \alpha_R + \alpha_C\,(1 + \mathrm{tg}\beta\mathrm{tg}\delta)(\theta_E - \theta'_F)$$

Because θ'_F is the equilibrium temperature for which $q_h + q_e = 0$, we observe that:

$$\Delta q_h + \Delta q_e = (q_h + q_e)_{\theta_E} - (q_h + q_e)_{\theta'_F} = (q_h + q_e)_{\theta_E}$$

and the quotient: $\dfrac{\Delta q_h + \Delta q_e}{\theta_E - \theta'_F}$ to be denoted by α_T and thus equal to $\dfrac{(q_h + q_e)_{\theta_E}}{\theta_E - \theta'_F}$.

can only be the total heat transfer coefficient. According to this definition equation (9) becomes:

$$\alpha_T = \alpha_R + \alpha_C (1 + tg\beta tg\delta) \tag{10}$$

Expression (10) is thus the exact presentation of the combined heat and mass transfer coefficient.

From Fig.15 we may equally deduce that

$$\theta'_F = \theta_F + \frac{\alpha_R}{\alpha_T - \alpha_R} (\theta_A - \theta'_F)$$

or:

$$\theta'_F = \theta_F + \frac{\alpha_R (\theta_A - \theta_F)}{\alpha_T} \tag{11}$$

Equation (11) may also be written as

$$\theta'_F = \theta_F + \frac{q_{R_a}}{\alpha_T} \tag{12}$$

because

$$q_{R_a} = \alpha_R (\theta_A - \theta_F) \tag{13}$$

is the adiabatic radiation heatflux.

Equation (12) has the same form as the formulas found for the calculation of the natural temperature of the river (see [1])

$$\theta_N = \theta_F + \frac{\Sigma_q}{\alpha_T} \tag{14}$$

With the foregoing explanations the base of the theory is so far complete. From this theory well known relationships can be deduced.

1) The "Bowen" ratio

The heatflux due to convective heat transfer can be written as:

$$q_{h_c} = \alpha_c (\theta_E - \theta_A)$$

The heatflux due to evaporation or condensation is

$$\begin{aligned} q_e &= (\alpha_R + \alpha_c)(\theta_{AG} - \theta_E) \\ &= (\alpha_R + \alpha_c)(X_E - X_A) tg\psi \\ &= (\alpha_R + \alpha_c)(e_E - e_A) tg\psi_e \\ &= (\alpha_R + \alpha_c)(e_E - e_A) \frac{\alpha_C}{\alpha_C + \alpha_R} tg\delta_e \\ &= \alpha_c (e_E - e_A) tg\delta_e \end{aligned}$$

The quotient of these two heatfluxes is known as the BOWEN RATIO and is consequently:

$$\frac{q_{h_c}}{q_e} = \frac{\theta_E - \theta_A}{e_E - e_A} \text{ cotg } \delta_e \qquad (15)$$

Because $X = 0.622\ ^e/_P,$ (16)

the transition of a X-θ in a e-θ diagram results consequently in the application of the relationship

$$\text{cotg } \delta = \frac{0.622}{P} \text{ cotg } \delta_e \qquad (17)$$

According to this "translation" and introducing numerical values for cotg $\delta = \frac{C_{P_A}}{r}$, equation (15) becomes:

$$\frac{q_{hc}}{q_e} \doteq \frac{\theta_E - \theta_A}{e_E - e_A} \frac{P}{0.622} \text{ cotg } \delta \approx 0.46 \frac{P}{760} \frac{\theta_E - \theta_A}{e_E - e_A} \qquad (18)$$

Equation (18) is the conventional expression for the BOWEN RATIO.

The value of $\text{cotg } \delta_e = 0.46 \frac{P}{760}$ is called psychrometric constant. (19)

2. *The wetbulb temperature correction*

In Fig.16 we have illustrated again the determination of the wetbulb temperature. In plain air we measure instead of $\Delta\theta$ the temperature difference $\Delta\theta'$ as temperature decrease for the wetbulb thermometer.

We want to know:

$$\Delta\theta = \frac{e_S - e_A}{k}, \text{ with } k = \text{cotg } \delta_e.$$

Introducing k' = cotg ψ_e, we obtain:

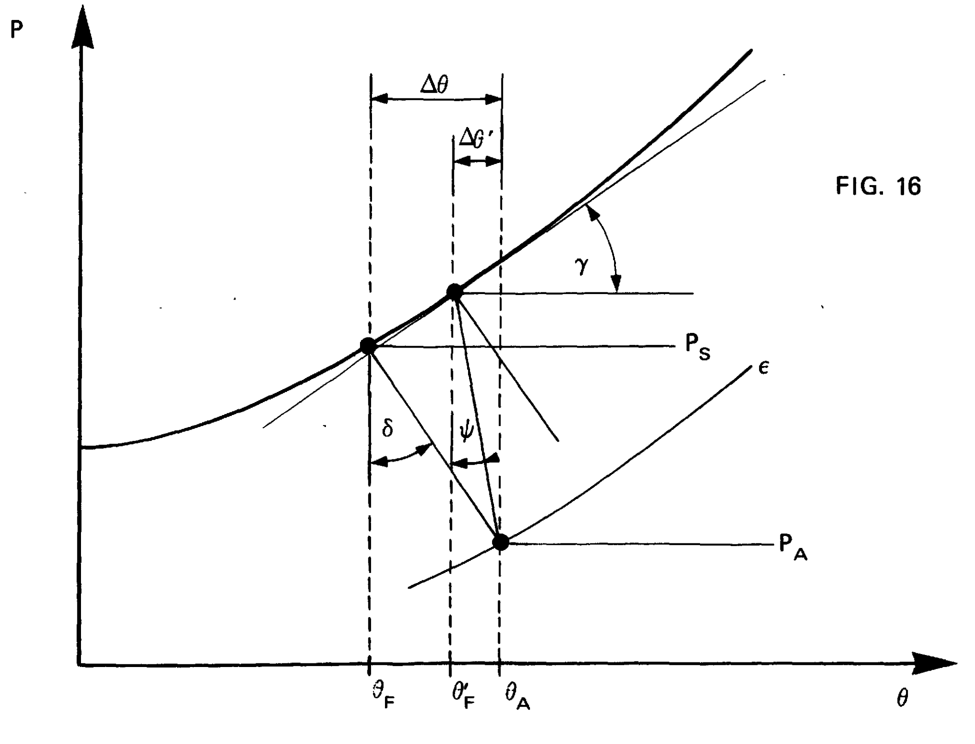


FIG. 16

$$\Delta\theta = \frac{e_S - e_A}{k} = \frac{k'\Delta\theta'}{k} - (\Delta\theta - \Delta\theta')\frac{tg\gamma}{k}$$

or $$\Delta\theta = \Delta\theta' \left(\frac{k' + tg\gamma}{k + tg\gamma}\right)$$

From the foregoing therory we found relation (7)

$$k' = \text{cotg } \psi_e = k(1 + \frac{\alpha_R}{\alpha_C}) \quad (20)$$

and thus: $$\Delta\theta = \Delta\theta' \frac{\alpha_T}{\alpha_T - \alpha_R} \quad (21)$$

Remark:
Relation (2) plotted as a function of the wind velocity (see later on) goes asymptotically to the value $k' = k$.

3. The evaporation formula

According to $\alpha_T = \alpha_R + \alpha_C\ (1 + \ tg\beta\ tg\delta)$, we may write also:

$$\alpha_T = (\alpha_R + \alpha_C) + \sigma\ r\ tg\ \beta \quad (22)$$

because $\frac{\alpha_C}{\sigma.C_{P_A}} = 1$, and $tg\ \delta = \frac{r}{C_{P_A}}$

In this manner the total heat transfer coefficient is again expressed in a group representing sensible heat and a group representing latent heat.
In the latent heat, we have to remember that:

$$\Delta q_e = \sigma.r\ tg\ \beta\ (\theta_E - \theta'_F)$$

and: $$q_e = \alpha_C(e_E - e_A)\ tg\ \delta_e = \sigma.r(X_E - X_A)$$

This is equal to: $$q_e = \sigma.r\ tg\ \beta\ (\theta_E - \theta'_F)(\frac{X_E - X_A}{X_E - X'_F})$$

or $$q_e = \Delta q_e\ (\frac{X_E - X_A}{X_E - X'_F}) \quad (23)$$

The amount of water evaporated at constant θ_E and θ_A for each mm Hg pressure difference between air and the saturated air on the water surface expressed in mm H_2O/sec may be found by:

$$V = \frac{q_e}{r(e_E - e_A)} = \frac{\alpha_c\ tg\delta_e}{r} = \frac{0.622\ \sigma}{P}\ [\frac{mm\ H_2O}{mmHg.s}] \quad (24)$$

For graph's given as $V = f(U)$, it is easy to transfer this graph's in $\alpha_C = f(U)$ diagrams by the simple translation:

$$\alpha_C = \frac{C_{P_A}.P}{0.622} . V \quad (25)$$

N.B. : The same remarks can be made for e.g. the radiation heatflux.

$$q_R = \alpha_R(\theta_E - \theta_A)$$

$$\Delta q_R = \alpha_R(\theta_E - \theta'_F)$$

So we may write:

$$q_R = \Delta q_R \frac{(\theta_E - \theta_A)}{\theta_E - \theta'_F}$$

$$q_R = \Delta q_R \left[1 - \frac{\alpha_R(\theta_A - \theta'_F)}{\alpha_R(\theta_E - \theta'_F)}\right]$$

$$q_R = \Delta q_R - q_{R_a} \left(\frac{\alpha_T - \alpha_R}{\alpha_T}\right) \qquad (26)$$

4. The "Merkel" equation

From our formula: $q_t = \alpha_R + \alpha_C\,(1 + \text{tg}\,\delta\,\text{tg}\,\beta)\;(\theta_E - \theta'_F)$

we deduce

$$q_t = \alpha_R(\theta_E - \theta'_F) + \sigma\, C_{P_A}(\theta_E - \theta'_F) + r\,\text{tg}\beta(\theta_E - \theta'_F)$$

$$= \alpha_R(\theta_E - \theta'_F) + \sigma\, C_{P_A}(\theta_E - \theta'_F) + r(X_E - X'_F)$$

$$= \alpha_R(\theta_E - \theta'_F) + \sigma(i_E - i'_F)_s$$

and consequently:

$$\alpha_T = \alpha_R + \frac{\sigma(i_E - i'_F)_s}{\theta_E - \theta'_F} \qquad (27)$$

N.B. : The subscript s will indicate the situation of the air in saturated condition thus for $\epsilon = 1$. For a combination of an "infinite air mass flowrate" and a liquid flowrate G_E, we obtain for the increase of temperature due to the heat transport over a surface element dF:

$$d\theta_E = \frac{\alpha_T(\theta_E - \theta'_F)\,dF}{G_E \cdot C_{P_E}} \qquad (28)$$

Combination of (27) and (28) gives:

$$\frac{d\theta_E}{(i_E - i'_F)_s} = \frac{(\sigma + \frac{\alpha_R}{\text{tg}\,\varphi})\,dF}{G_E \cdot C_{P_E}} \qquad (29)$$

with (see Fig.17):

$$\text{tg}\varphi = \frac{i_{E_s} - i'_{F_s}}{\theta_E - \theta'_F} \qquad (30)$$

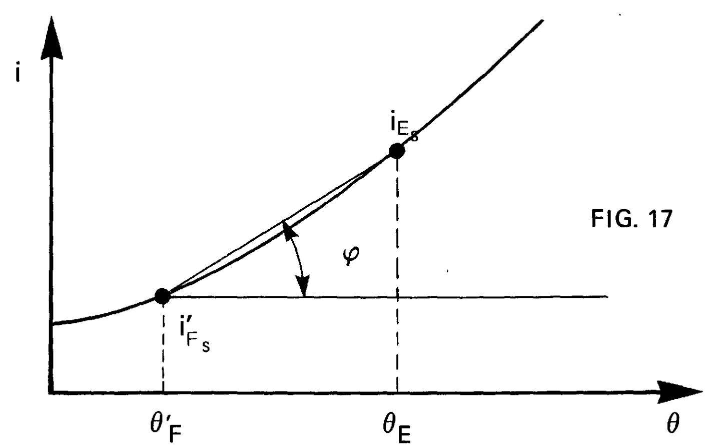


FIG. 17

Writing equation (29) as:

$$\frac{d\theta_E}{i_{E_s} - i_A} = \frac{\sigma' dF}{G_E \cdot C_{P_E}} \tag{31}$$

we have the conventional Merkel equation, with only one difference, i.e.

$$\sigma' = \sigma + \frac{\alpha_R}{tg\varphi} \tag{32}$$

N.B. : $i_A = i_{F_s} \approx i'_{F_s}$

Combination of equations (32), (30) and (29) gives

$$\sigma' = \frac{\alpha_T}{tg\varphi} \tag{33}$$

Comparing equations (10) and (29) we obtain finally:

$$1 + tg\,\beta\, tg\,\delta = \frac{tg\,\varphi}{C_{P_A}} \tag{34}$$

This function is determined by us in a different way using graphical techniques in the $X - \theta$ diagram.
The values found in this way are consequently not very exact. See Fig.18.

5. *The exponential equation*

The Merkel equation (31) may also be written keeping θ'_F = constant as

$$\frac{\sigma' dF}{G_E . C_{P_E}} = \frac{d(\theta_E - \theta'_F)}{tg\,\varphi\,(\theta_E - \theta'_F)}$$

or

$$\frac{\alpha_T . dF}{G_E . C_{P_E}} = \frac{d(\theta_E - \theta'_F)}{(\theta_E - \theta'_F)}$$

The solution of this differential equation is:

$$\theta_{E_2} - \theta'_F = (\theta_{E_1} - \theta'_F) e^{-\frac{\alpha_T . F}{G_E . C_{P_E}}} \tag{35}$$

as F is the surface between the situations 1 and 2.

As $F = \dfrac{G_E . t}{\rho_E . h}$

in which formula t is the time to pass from situation 1 to situation 2, and h is the depth of the waterlayer, we may also use the alternative equation:

$$\theta_{E_2} - \theta'_F = (\theta_{E_1} - \theta'_F)\, e^{-\frac{\alpha_T . t}{h . \rho_E\, C_{P_E}}} \tag{36}$$

This equation will be in the same time the base of our computations. In this equation the exponent is also called the number of transfer units (N.T.U.)

$$\text{N.T.U.} = \frac{\alpha_T . F}{G_E . C_{P_E}}$$

This was also equal to

$$\text{N.T.U.} = \frac{\sigma' \text{tg}\, \varphi . F}{G_E . C_{P_E}}$$

The proposal of SPANGEMACHER [2] is to define $\frac{\sigma F}{G_E}$ as the MERKEL NUMBER.

This may be converted in:

$$\text{MERKEL NUMBER} = \frac{\alpha_C . F}{G_E . C_{P_A}}$$

However, according to our modification of the Merkel equation it should be:

$$\text{MERKEL NUMBER} = \frac{\alpha_T . F}{G_E . C_{P_A} (1 + \text{tg}\,\beta\, \text{tg}\,\delta)}$$

using equations (31), (33) and (34).
Compared with the Number of Transfer Units we become:

$$\text{Merkel Number} = \text{N.T.U.} \frac{C_{P_E}}{C_{P_A} (1 + \text{tg}\,\beta\, \text{tg}\,\delta)}$$

with

$$C_{P_E} = 1 \text{ kcal/kg}$$

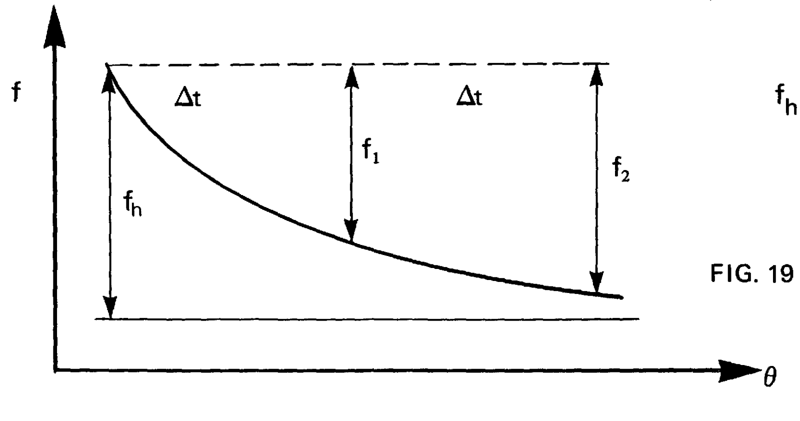
$$C_{P_A} = 0.24 \text{ kcal/kg}$$

The Merkel Number = N.T.U. for $1 + \text{tg}\,\beta\, \text{tg}\,\delta = 4.17$. This is at about $\theta'_F = 27°C$. Especially for a cooling tower $\theta'_F = 27°C$ is high and consequently, except a few summerdays, the Merkel Number > N.T.U.

IV ELABORATION OF MEASUREMENTS

1. Numerical methods for the determination of θ'_F

As we have already discussed the temperature of a waterbath assumes for a time $t \to \infty$ the asymptotic temperature θ'_F. For a "temperature decay (run up) - time curve" with a constant exponent the asymtotic can be found by the formula (see Fig.19)



$$f_h = \frac{f_1^2}{2f_1 - f_2} \qquad (1)$$

FIG. 19

The time interval between f_o and f_1, is equal to the interval between f_1 and f_2. We can easily prove this formula:

$$f_1 = f_h(1 - e^{-\beta\Delta t}),\ f_1^2 = f_h^2(1 - 2e^{-\beta\Delta t} + e^{-2\beta\Delta t})$$

$$f_2 = f_h(1 - e^{-2\beta\Delta t}),\ 2f_1 - f_2 = f_h(1 - 2e^{-\beta\Delta t} + e^{-2\beta\Delta t})$$

Now the first row divided by the second one, gives consequently formula (1).

In the results we have also given the values of f_h found in this manner. From this method we may deduce the constant β in the following way:

$$\frac{f_2}{f_1} = \frac{1 - e^{-2\beta\Delta t}}{1 - e^{-\beta\Delta t}} = 1 + e^{-\beta\Delta t}$$

$$\frac{f_2 - f_1}{f_1} = e^{-\beta\Delta t}$$

$$\beta = \frac{1}{\Delta t} \ln \frac{f_1}{f_2 - f_1} \qquad (2)$$

Still more sophisticated methods to determine the value of β are possible. (See Fig.19a).

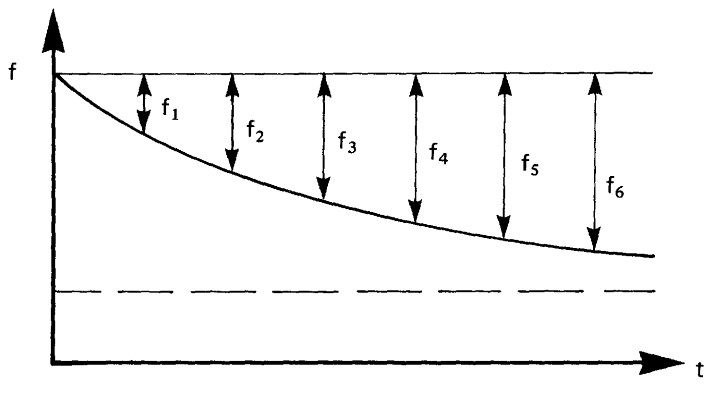


FIG. 19A

For a curve with ordinates f_1, f_2, f_3, f_4, f_5 and f_6 at intervals of 3600 seconds, we obtain:

$$\beta_1 = \frac{1}{3600} \ln \frac{f_1}{f_2 - f_1} \qquad \beta_1 = \frac{1}{3600} \ln \frac{f_4 - f_3}{f_5 - f_4}$$

$$\beta_1 = \frac{1}{3600} \ln \frac{f_2 - f_1}{f_3 - f_2} \qquad \beta_1 = \frac{1}{3600} \ln \frac{f_5 - f_4}{f_6 - f_5}$$

$$\beta_1 = \frac{1}{3600} \ln \frac{f_3 - f_2}{f_4 - f_3} \qquad \overline{\beta_1} = \frac{\Sigma\beta_1}{5} \ln \frac{f_1}{f_6 - f_5} \qquad (3)$$

For the intervals of 7200 seconds we find:

$$\beta_2 = \frac{1}{7200} \ln \frac{f_2}{f_4 - f_2}$$

$$\beta_2 = \frac{1}{7200} \ln \frac{f_3 - f_1}{f_5 - f_3}$$

$$\beta_2 = \frac{1}{7200} \ln \frac{f_4 - f_2}{f_6 - f_4}$$

and thus $$\overline{\beta}_2 = \frac{\Sigma\beta_2}{3} = \frac{1}{21600} \ln \frac{f_2 (f_3 - f_1)}{(f_5 - f_3)(f_6 - f_4)} \qquad (4)$$

For the interval of 10800 seconds we have:

$$\beta_3 = \frac{1}{10800} \ln \frac{f_3}{f_6 - f_3} \qquad (5)$$

Now is $$\beta = \frac{\overline{\beta}_1 + \overline{\beta}_2 + \beta_3}{3} \qquad (6)$$

This method we have not practicised.

2. *Graphical methods for the determination of θ'_F and α_T*

Plotting f lineary and t logarithmically, the curve obtained in this manner may be considered over a certain part as a "linear" one.
Shifting the curve over a time interval m gives another line intersecting the original at a time t_a and at $f = f_h$. So over the linear part we may write for the bundle of curves, the following two equations:

$$f_t = f_h[1 - e^{-\beta(t - m)}] \text{ with } \beta = \alpha_T.c \qquad (7)$$

$$f_t = f_h - k_1 (\lg t_a - \lg t)$$

$$= f_h - k_2 (\ln t_a - \ln t) \qquad k_2 = \text{constant} \qquad (8)$$

These equations could be identical in the case β = variable. At a certain time t* when equation (7) "follows" equation (8) the exponent β passes the minimum value.

This follows from:

$$k_2 = \frac{f_h\, e^{-\beta(t - m)}}{\ln t_a - \ln t} = f(\beta,t,m) \tag{9}$$

Determination of $\frac{d\beta}{dt} = 0$, gives:

$$\ln t_a - \ln t^* = \frac{1}{\beta_m t^*} \tag{10}$$

Also this function has a minimum for β_m.

Determination of $\frac{d\beta_m}{dt^*} = 0$, gives

$$\ln t_a - \ln t^* = 1,\ \beta_{min} = \frac{1}{t^*} \tag{11}$$

Now equation (9) becomes:

$$k_2 = f_h\, e^{-\frac{t^* - m}{t^*}} \tag{12}$$

and

$$f_{t^*} = f_h(1 - e^{-\frac{t^* - m}{t^*}}) \tag{13}$$

In Fig.20 an example has been given.

$\beta = 0.226532$ gives $t^* = 4.41$ hours
and $t_a = 12.20$ hours

The plot was made with $f_h = 10$

Equation (13) gives for $m = 0$, $f_{t^*} = 6.32$

This is another control for t^* and thus for β or α_T.

A very excellent control on the exactness of β or f_h is using the method of Rosin-Rammler described by Fontaine and Cannoy [3].

Writing

$$Z = \frac{f_t}{f_h} = 1 - e^{-c\alpha_T . t}$$

$$Z = 1 - e^{-\beta t}$$

or

$$1 - Z = e^{-\beta t}$$

$$- \ln(1 - Z) = \beta t$$

we obtain finally:

$$\ln[- \ln(1 - Z)] = \ln\beta + \ln t \tag{14}$$

In a log - log diagram the points plotted according to the method of equation (14) have to be situated on a line under 45°. If this is not the case, either f_h is not correct or equation (14) has to be expressed as:

$$\ln[-\ln(1-Z)] = \ln\beta + b\ln t \qquad (15)$$

For big temperature differences in respect to θ'_F this could be the case.

3. *Computer programs*

With the formula $\theta_E = (\theta_{E_0} - \theta'_F)\, e^{-c\alpha_T . t} + \theta'_F$

and the least squares method the computer program APPEX was made. We have used this program to calculate our results. Other formulas used are:

$$\overline{\theta}_E = \frac{\theta_{E_0} + \theta_{E_6}}{2} \qquad (16)$$

$$\theta_{E\beta} = \frac{\overline{\theta}_E + \theta'_F}{2} \qquad (17)$$

$$\lg(1 + tg\beta tg\delta) = 0.192 + 0.0159\ \theta_{E\beta} \qquad (18)$$

$$\alpha_R \approx 1.1 + 0.0125\ \overline{\theta}_E\ \left[\frac{cal}{m^2.s.k}\right] \qquad (19)$$

$$c = 18000$$

Furtheron the formulas

$$\theta_F = \alpha_T\theta'_F - \frac{\alpha_R}{\alpha_T - \alpha_R}\ \theta_A$$

$$\alpha_c = \frac{\alpha_T - \alpha_R}{1 + tg\beta tg\delta}$$

Starting from the formula:

$$\alpha_T = \alpha_R + \alpha_c + \sigma\, r\, tg\,\beta$$

We substitute this formula by the expression:

$$\alpha_T = \alpha_R + \overline{\alpha}_c + \sigma^*\, tg\,\beta \qquad (20)$$

Solving σ^* from this equation for that whole collection of n data from which $\overline{\alpha}_c$ was calculated, we can determine also

$$\overline{\sigma} = \frac{\Sigma\sigma^*}{n} \qquad (21)$$

This value of $\bar{\sigma}$ corresponds with the expression:

$$\bar{\sigma} = \frac{\bar{\alpha}_c}{C_{p_A}} \tag{22}$$

Therefore again the two formulas:

$$\alpha_{T_{calc}} = \alpha_R + \bar{\alpha}_c + \bar{\sigma} r \, tg\beta \tag{23}$$

and

$$\alpha_{T_{calc}} = \alpha_R + \bar{\alpha}_c (1 + tg\beta tg\delta) \tag{24}$$

are synonymous and both may be used to obtain α_T calculated.
We were calculating α_c, σ^* (written as σ), $\bar{\alpha}_c$ and $\bar{\sigma}$.
With the calculated θ_F and the measured θ_A we were determining ϵ in the psychrometric diagram.

4. Some justifications about the application of the e-function with a constant α_T

Starting from the differential equation:

$$h F \rho_E C_{p_E} d\theta_E = F\alpha_T (\theta_E - \theta'_F) dt \tag{25}$$

assuming α_T to be constant, we found the solution

$$(\theta_E - \theta'_F) = (\theta_{E_0} - \theta'_F) e^{-\frac{\alpha_T . t}{h\rho_E C_{p_E}}} \tag{26}$$

Is, however, α_T a function of θ_E and thus implicit a function of time, the solution of the differential equation gives the result:

$$(\theta_E - \theta'_F) = (\theta_{E_0} - \theta'_F) e^{-\left[\frac{\int_0^t \alpha_T dt}{h\rho_E C_{p_E}}\right]} \tag{27}$$

As a general formula for α_T could be applied the hyperbolic equation:

$$\frac{\alpha_T}{\alpha_{T_0}} = \frac{a(1 - b)}{a + t} + b \tag{28}$$

In Fig.21 we have demonstrated the position of the asymptotes and the type of functions in relation to the kind of "process of heat transfer".

For the case of cooling down, we can calculate the position of the two asymptotes from three given values (Fig.21a).

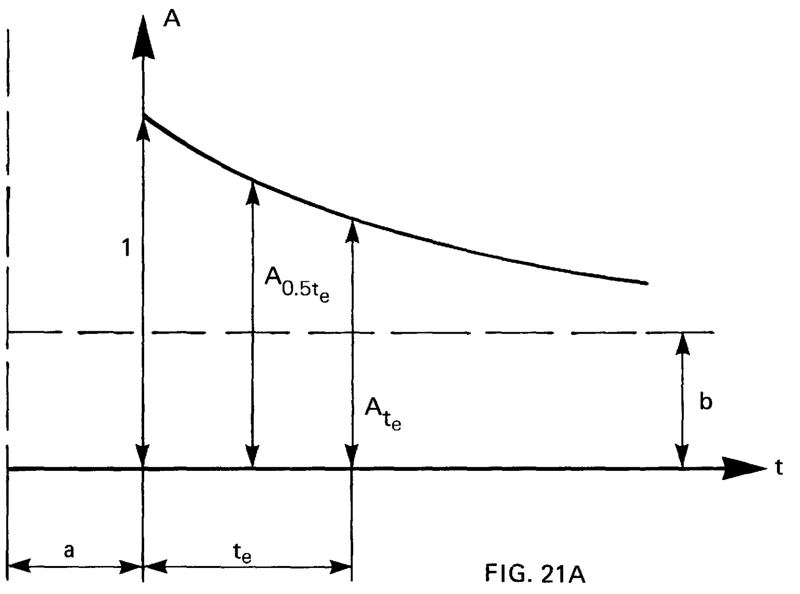


FIG. 21A

Writing for $\alpha_T/\alpha_{T_0} = A$, we obtain for a cooling time t_e, with $A_o = 1$ and $A_{0.5t_e}$, A_{t_e} as known values, the following relationship:

$$(1 - b)a = (A_{0.5t_e} - b)(a + 0.5t_e) = (A_{t_e} - b)(a + t_e)$$

From this relationship we deduce

$$b = \frac{2A_{t_e} - A_{0.5t_e}(1 + A_{t_e})}{A_{t_e} + 1 - 2A_{0.5t_e}} \tag{29}$$

and

$$a = \frac{(A_{0.5t_e} - b)\, 0.5t_e}{1 - A_{0.5t_e}} \tag{30}$$

For simplicity we have given in equation (30) the interrelationship between a and b.

In the case $b = 0$, we obtain:

$$A_{0.5t_e} = \frac{2A_{t_e}}{1 + A_{t_e}} \tag{31}$$

Normally, this is for cooling down experiments a good approximation. Let us give an example.

$\theta_o = 30°C$, $\theta'_F = 26°C$, $\overline{\alpha}_T = 15 \times 10^{-6}$ Mcal/m^2.s.K

$\alpha_R = 1.5 \times 10^{-6}$ Mcal/m^2.s.K

$h = 0.2$ m, $\rho C_P = 1$ Mcal/m^3, $t_e = 6$ hours

For $\theta_E = 30°C$ $1 + tg\beta tg\delta = 4.3$

After 3 hours $\theta_E = 27.78°C$ and $1 + tg\beta tg\delta = 4.1$

After 6 hours $\theta_E = 26.15°C$ and $1 + tg\beta tg\delta = 4.0$

If we take the situation at 3 hours as "the average" situation, we obtain:

$$(15 - 1.5) \times 10^{-6} = \alpha_c.4.1,$$

giving: $\alpha_c = 3{,}3.10^{-6}$ Mcal/m^2.s.K.

Now $\alpha_{T_0} = (1.5 + 3.3 \times 4.3)\ 10^{-6} = 15.56 \times 10^{-6}$

and $\alpha_{T_{t_e}} = (1.5 + 3.3 \times 4.0)\ 10^{-6} = 14.67 \times 10^{-6}$

According to equation (31) we find

$$\alpha_{T_{0.5t_e}} = \frac{2.\frac{14.67}{15.56}}{1 + \frac{14.67}{15.56}} \quad 15.56 \times 10^{-6} = 15.10 \times 10^{-6}$$

We find applying this formula an error of about 0.66%.

From the foregoing we assume, consequently, as a general formula for cooling down experiments that:

$$\alpha_T = \frac{a}{a + t}\ \alpha_{T_o} \tag{32}$$

Doing this, equation (25) could be written as:

$$(\theta_E - \theta'_F) = (\theta_{E_0} - \theta_F)(\frac{a}{a+t})\frac{a\alpha_{T_0}}{\rho_E C_{p_E}.h} \tag{33}$$

But also, to some extent, writing $\int_0^{t_e} \alpha_T dt = \overline{\alpha}_T t_e$ holds for the equation:

$$(\theta_E - \theta_F) = (\theta_{E_0} - \theta_F)\ e^{-\frac{\overline{\alpha}_T t}{\rho_E C_{p_E} h}} \tag{34}$$

with

$$\overline{\alpha}_T = \alpha_o\ [\frac{a}{t_e}.\ \ln(1 + \frac{t_e}{a})] \tag{35}$$

The question is now, for what values of a/t_e is the above relation still applicable?

For $a/t_e = 1$, we find already $\bar{\alpha}_T = 0.69\ \alpha_o$

For $a/t_e = 10$, we get $\bar{\alpha}_T = 0.953\ \alpha_o$

and for $a/t_e = 25$, we have $\bar{\alpha}_T = 0.981\ \alpha_o$

Normally, we may expect a value for a/t_e between 10 and 25. Also in this case it would be valuable to compare the equations (33) and (34), with respect also to the values for

$$\frac{\theta_E - \theta'_F}{\theta_{E_o} - \theta'_F} \text{ at } t = t_e/2 \text{ and } t = t_e$$

In the case $a/t_e = 10$, we found $\bar{\alpha}_T = 0.953\ \alpha_o$ and we have consequently to compare with each other

$$\frac{\theta_E - \theta'_F}{\theta_{E_o} - \theta'_F} = e^{-\frac{0.953\,\alpha_o.t}{0.2}}$$

for $t = t_e/2$ and $t = t_e$

and

$$\frac{\theta_E - \theta'_F}{\theta_{E_o} - \theta'_F} = \left(\frac{10t_e}{10t_e + t}\right)^{\frac{10t_e\alpha_o}{0.2}}$$

It will be clear that the exponential factor $\frac{\alpha_o.t_e}{h\rho_E C_{pE}}$ is a very important one.

For instance, at $t_e/2$ we obtain for $\frac{\alpha_o t_e}{0.2} = 1$ for the e-function:

$$\frac{\theta_E - \theta'_F}{\theta_{E_o} - \theta'_F} = 0.62095, \text{ and for the polynome:}$$

$$\frac{\theta_E - \theta'_F}{\theta_{E_o} - \theta'_F} = 0.61391$$

The e-function gives a "deviation" of +1.15%, compared to the polynome.

In the table we have listed these deviations for a number of combinations for a/t_e-values of respectively 5, 10 and 20 with $\alpha_o t_e/0.2$-values of 0.5, 1 and 3.

Our assumption is that the real situation can be described in an optimal way by a polynome of the type according to equation (33), although the basis of this polynome is already an approximation. But the measured points would also have to be considered to belong to an exponential decay function, i.e. to another type of approximation. The asymptote of this decay function can be determined by following the procedure described in equation (1), using either the real coordinates or equation (33).

Following this last presumption, we may calculate the distance to the asymptote f_h, but it will be clear that the distance $f_h \leqslant 1$. Again, at different values of $\alpha_o t_e/0.2$ for $a/t_e = 10$, and for $a/t_e = 20$, we have calculated f_h (see the table). The error is normally smaller than 7%.

Temperature reduction table at different values of the exponent $\frac{\alpha_0 t_e}{0.2}$ as a function of a/t_e

		$\frac{\alpha_0 t_e}{0.2} = 0.5$		$\frac{\alpha_0 t_e}{0.2} = 1.0$		$\frac{\alpha_0 t_e}{0.2} = 3.0$
	$t = 0.5\ t_e$		$t = 0.5\ t_e$		$t = 0.5\ t_e$	
	e-funct.	0.7961	e-funct.	0.6338	e-funct.	0.2546
	polyn.	0.7871	polyn.	0.6209	polyn.	0.2394
$a/t_e = 5$	error	+1.05%	error	+2.1%	error	+6.3%
	$t = t_e$		$t = t_e$		$t = t_e$	
	polyn.	0.6340	polyn.	0.4019	polyn	0.0649
	f_h	0.779	f_h	0.9	f_h	0.987
	$t = 0.5\ t_e$		$t = 0.5\ t_e$		$t = 0.5\ t_e$	
	e-funct.		e-funct.	0.621	e-funct.	0.2394
	polyn.	0.78353	polyn.	0.614	polyn.	0.2314
$a/t_e = 10$	error	< 1%	error	+1.14%	error	+3.46%
	$t = t_e$		$t = t_e$		$t = t_e$	
	polyn.	0.62092	polyn.	0.3855	polyn	0.0573
	f_h	0.87	f_h	0.945	f_h	0.994
	$t = 0.5\ t_e$		$t = 0.5\ t_e$		$t = 0.5\ t_e$	
	e-funct.		e-funct.	0.6139	e-funct.	0.2314
	polyn.	0.7812	polyn.	0.6103	polyn.	0.2273
$a/t_e = 20$	error	< 1%	error	+0.6%	error	+1.8%
	$t = t_e$		$t = t_e$		$t = t_e$	
	polyn	0.6139	polyn.	0.3769	polyn.	0.0535
	f_h	0.93	f_h	0.972	f_h	0.997

From the foregoing observations we have concluded that the use of an averaged value for α_T, based also on an averaged value of $1 + \mathrm{tg}\beta\mathrm{tg}\delta$ is an acceptable and practical method to elaborate our measurements.

5. *Determination of α_T by eliminating the procedure to obtain θ'_F*

In case the temperature decay curve is known, and also the wetbulb temperature θ_F has been measured, we may determine α_T in the following way:

From equation (34) we obtain:

$$\frac{\theta_E - \theta'_F}{\theta_{E_o} - \theta'_F} = e^{-\frac{\bar{\alpha}_T t}{\rho C_p h}}$$

and

$$\frac{d(\theta_E - \theta'_F)}{dt} = -\frac{\bar{\alpha}_T}{\rho C_p h} \cdot \frac{\theta_E - \theta'_F}{\theta_{E_o} - \theta'_F}$$

For $\theta_E = \theta_{E_o}$ we obtain

$$\frac{d(\theta_E - \theta'_F)}{dt} = -\frac{\bar{\alpha}_T}{\rho C_p h} \quad \text{and } t'_F = t^* \text{ is } \frac{\rho C_p h}{\bar{\alpha}_T}$$

Then we obtain for t_F (the intersection between the tangent and the θ_F-line):

$$t_F = \frac{\theta_{E_o} - \theta_F}{\theta_{E_o} - \theta'_F} \cdot \frac{\rho C_p h}{\bar{\alpha}_T}$$

From $\theta'_F - \theta_F = \dfrac{\alpha_R(\theta_A - \theta_F)}{\bar{\alpha}_T}$ now follows:

$$\alpha_T = \frac{\rho C_p h}{t_F} + \alpha_R \frac{(\theta_A - \theta_F)}{\theta_{E_o} - \theta_F}$$

V PRESENTATION OF RESULTS

1. *Velocity measurements*

In Fig.22 a distribution scheme has been given for the 35 regions in which and the coordinates at which the velocity of the air in the test section was measured. The multiplication factors for the area under consideration are given as a percentage of the whole cross-section.

For velocities of nominal 2, 3, 4, 5, 6 and 7 m/sec, measured on a height of 0.1 m over the watersurface (this is exactly in the center of the channel), the velocity distribution using the scheme of fig.22 is presented in figs. 23-28.

From this scheme the average velocity $\bar{U}_{<35>}$ is calculated, and compared with the center-velocity U_c (see Fig.29).

For this group of six different velocities, we found for the average deviation:

$$\frac{\bar{U}_{<35>} - U_c}{\bar{U}_{<35>}} = -5.7\% \qquad (1)$$

Making use of a somewhat reduced distribution scheme for the velocity measurement locations, with nine fields instead of thirtyfive, thus by eliminating twentysix locations as has been shown in Fig.30, the difference with the 35 fields method is relatively small. This follows also from the list given in Fig.29.

$$\frac{\bar{U}_{<35>} - \bar{U}_{<9>}}{\bar{U}_{<35>}} = -\,2.9\% \qquad (2)$$

From equation (1) we obtain:

$$U_c = 1.057\ \bar{U}_{<35>}$$

From equation (2) in the same way:

$$\bar{U}_{<9>} = 1.029\ \bar{U}_{<35>}$$

Elimination of $\bar{U}_{<35>}$ gives the relationship:

$$\bar{U}_{<9>} = 0.974\ U_c \qquad (3)$$

This corresponds with the average deviation for

$$\frac{\bar{U}_{<9>} - U_c}{\bar{U}_{<9>}} = -\ 3\%$$

determined from six velocity schemes.
For another 17 "nine field" velocity data sets, we have calculated $\frac{\bar{U}_{<9>} - U_c}{\bar{U}_{<9>}}$ giving –4.5% as an average deviation, or written in another way:

$$\bar{U}_{<9>} = 0.957\ U_c$$

Weighting these results with the other six results gives:

$$\bar{U}_{<9>} = \frac{17 \times 0.957 + 6 \times 0.974}{23}\ U_c = 0.962\ U_c \qquad (4)$$

Assuming that the relation $\bar{U}_{<9>} = 1.029\ \bar{U}_{<35>}$ is also valid for these 17 "nine field" data combinations, we obtain for the $U_c - \bar{U}_{<35>}$ relationship:

$$U_c = 1.075\ \bar{U}_{<35>}$$

Weighting of these results with the first six data gives finally:

$$\bar{U}_{<35>} = 0.934\ U_c$$

Writing now

$$\bar{U}_{<1>} = U_c \rightarrow f_o = 0$$

$$\bar{U}_{<9>} = 0.962\ U_c \rightarrow f_8 = 0.038\ U_c$$

$$\bar{U}_{<35>} = 0.934\ U_c \rightarrow f_{34} \approx f_{32} = 0.066\ U_c$$

and assuming an exponential function for $\bar{U}_{<n>} = f(n)$, we obtain for

$$\bar{U} = \bar{U}_{<\infty>} \approx 0.925\ U_c$$

(This method is certainly not universally applicable.)
Substituting thus U_c for $\bar{U}$, we introduce an error of about 7.5%.

2. *Plot of wind profile*

Averaging the field volocities on the same height of scheme fig.22, the wind velocity profile as a function of the height z above the free water-surface may be determined. These wind profile curves are given as log U_z - log z plots in fig.31.
Writing the equation for the wind velocity as:

$$\lg U_z = \lg U_1 + m \lg z \qquad (z \text{ in m}) \qquad (5)$$

we obtain for m the value: $m = 0.149$

Remark: $m = {}^1/_7$ is a normal value for channel flow. In the free nature we meet a variety of m-values. Among them also $m = 0.149$ is a very common value.

3. *The α_c-U plot*

This plot has been made taking in consideration the fact that the wind profile follows a logarithmic distribution according to the formula:

$$U_z = U_r \left(\frac{z}{z_r}\right)^m \qquad (6)$$

for $z_r = 1$, we obtain $U_z = U_1 z^m$. Consequently, plotting α_c versus U_1 would be the same as plotting α_c versus U_z/z^m. We followed this procedure in our Fig.32. U_1 can be taken from Fig.33, where $\bar{U} = 0.925\ U_c$.
From $U_1 = (100)^{0.149} \approx 2\ U_{0.01}$ some conclusions may be taken forth.
For flat plate experiments in laboratory dimensions the boundary layer thickness is not far from 0.01 m. Consequently $U_{0.01} \approx U_\infty$ (free flow velocity) and $U_1 \approx 2\ U_\infty$.
If we also remember that

$$U_1 = (10)^{0.149}\ U_{0.1} \approx 1.4\ U_{0.1}$$

we arrive for channel flow under the conditions of our experiments at

$$U_1 \approx 1.37\ U_c \approx 1.48\ \bar{U} \qquad (7)$$

With these relations we are able to compare our results with flat plate laboratory experiments and with the results from atmospherical boundary layer interactions with a free water surface.
In the latter case we have to reflect that the turbulence pattern and structure in an atmospherical boundary layer is completely different from that originated in a wind tunnel. Hence there could be a big difference too in transport properties between otherwise equal types of wind flow (velocity and m-values).
Another important point is the influence of the length of fetch and the depth of a waterbody especially according to wind-wave formation. Our results are therefore only com-

parable with nearly smooth water surfaces in nature. In Fig.34 we have given a scheme of the different hypotheses to be used for the comparison of results from different origin.
From the plot $\alpha_c \div U_z.z^{-m}$, precise conclusions can be hardly taken. Determining, however, from discrete conglomerations of data points the average value $\bar{\alpha}_c$, we obtain plotting $\lg \bar{\alpha}_c$ versus $\lg(U_z.z^{-m})$, the results given in Fig.35.
The equation for $0.5 \leqslant U_z.z^{-m} \leqslant 8$ [m/s] can be expressed as:

$$\bar{\alpha}_c = 1.11 \left(\frac{U_z}{U^m}\right)^{0.58} \frac{\text{cal}}{\text{m}^2\,\text{s.c}} \tag{8}$$

Converting $\bar{\alpha}_c$ according to equation III 25 in the evaporation function $\bar{V}$, we obtain

$$\bar{V} = 0.294\,\bar{\alpha}_c \frac{\text{mm}\,H_2O}{\text{mm Hg.day}} \tag{9}$$

$$\bar{V} = 0.326 \left(\frac{U_z}{z^m}\right)^{0.58} \tag{10}$$

In this way we are able to compare our results with the most close by situated equations.
Referring to [4], the Trabert equation is very useful for not too low wind velocities.
According to the opinion of Guenneberg [5] the formula of the "Schweizer Kuehlwasser Bericht" is the most convenient formula for river surfaces.
As follows from Fig.35 our formula is just between these two mentioned formulas, assuming however that the wind speed used in these formulas is not far from U_1.

Observations

The hypothesis that by application of the extrapolated wind speed to a height of 1 meter as a reference velocity a better base should be obtained for the comparison of the mass and heat transfer parameters over as well thin as more extended or even atmospherical boundary layers, has to be proved.
It regards all that flow situations by which the velocity distribution may be described or fairly approximated by power law functions even very close to the free water surface. This is for open waters the case as the wave height does not superate 0.1 m.
Assuming for wind over water, and also for air flow in channels a standard power law with an exponent equal to 0.1505, we obtain for the ratio $U_1/U_{0.01} = 2$.
Estimating that for flat plate experiments the free stream velocity $U_\infty \approx U_{0.01}$, we arrive at the relationship $U_1 \approx 2U_\infty$.
Substituting this relationship in those formulas of which the origin with a great probability comes from flat plate research or from similar work, we obtain formulas indeed close to those based on in situ measurements, i.e. from meteorological origin.
E.g. the equation of Thiesenhusen (see again ref.4) becomes modified:

$$V = 0.5\sqrt{U_1} \tag{11}$$

and is in between two formulas coming forth from measurements in nature, i.e. the formula of Trabert:

$$V = 0.41\sqrt{U_{10}} = 0.49\sqrt{U_1} \tag{12}$$

and the formula of Wuest:

$$V = 0.6\sqrt{U_{10}} = 0.72\sqrt{U_1} \tag{13}$$

Other formulas based on flat plate experiments covering a wide range of velocities are linearised equations with extrapolation to $U = 0$.
Application of the foregoing substitution relation on the formula of Lurie and Michailoff or to the not very different formula of Sprenger gives as modified equation:

$$V \approx 0.526 + 0.1\ U_1 \tag{14}$$

This formula now is comparable with the Lake Hefner formula of Kohler et al:

$$V = 0.419 + 0.214\ U_1 \tag{15}$$

Remark

We assume that in this latter formula the reference velocity is not far from U_1.
Also the in this manner correllated formula of Carrier is very close to the Lake Hefner formula, i.e.

$$V = 0.427 + 0.182\ U_1 \tag{16}$$

A shallow conclusion to be drawn could be that the relative transport properties of the extended boundary layer are of secondary importance, but the transport mechanisms in the immediate air layer over the water surface having a thickness of about 1 cm are determinant.

4. Nusselt number - Reynolds number relation

The relation between Nusselt number and Reynolds number is based on the fetch length and average wind velocity. In our plots we were using the whole length of the tank, i.e. 2 m as fetch length.
The viscosity of the air is based on a standard temperature of 20°C at which $\upsilon = 0.152\ cm^2/s$.
The fetch Reynolds number is accordingly to these data:

$$Re_L = 1.3158\ 10^5\ \overline{U} \tag{17}$$

For flat plates the critical fetch Reynolds number is - with reference to the literature - at the value of which transition from laminar to turbulent flow in the boundary layer starts, given as about: Re_L critical $\approx 0.5 \,.\, 10^5$.
Complete turbulence begins at $Re_L \approx 6.10^5$. This corresponds with $\overline{U} = 4.56$ m/s.
Laminar flow for this fetch length ends at $\overline{U} = 0.3$ m/s.
The local values of Reynolds number for the transition points are of course somewhat different.

Laminar flow ends at a length for which $Re_x = 0.25.10^5$.
Complete turbulence begins at a length for which $Re_x = 10^5$.
The consequences of these different criteria are that, if for a flat plate over 62.5% of length, laminar flow exists and over the rest of the length a transition type of turbulence prevails, the plate as a whole may be considered as still having a flow type with a laminar aspect.
On the other hand, considering the case $Re_L = 6.10^5$, the whole plate should be covered by a full turbulent boundary layer. However, the length for which $Re_x = 10^5$ is situated at 0.16 L part over which the flow starts laminar, then transforms into a transition type of flow and finally over the remaining 84% of the plate the flow becomes really fully turbulent.

The transition fetch Reynolds numbers are consequently indications for the fact that a certain type of flow starts percentually to prevail over another type. However, due to different causes also a local transition has a certain band-width and consequently the overall α_c-value varies also over a certain range.
In Fig.36, the Nussel-Reynolds relation has been plotted as $\overline{N}_u = f(Re_L)$ giving the formula:

$$\overline{N}_u = 0.491 \, Re_L^{\;0.58} \tag{18}$$

5. The Stanton number

From the Stanton number

$$St = \frac{N_u}{Re.Pr} = \frac{\alpha_c}{P_A \cdot C_{P_A} . \overline{U}} \tag{19}$$

we may deduce the relationship

$$\bar{\alpha}_c = P_A \cdot C_{P_A} . \bar{St} . \overline{U}$$

$$= P_A C_{P_A} . \bar{St} . 0.68 \, U_1 \tag{20}$$

The Stanton number between laminar and turbulent regime is for flat plates to express by:

$\bar{St} \approx 2.7.10^{-3}$ (see RENZ and VOLLMERT [6])

With: $P_A = 1.293$ Kg/m^3 and $C_{P_A} = 240$ cal/Kg°C

we obtain consequently:

$$\bar{\alpha}_c \approx 0.57 \, U_1 \tag{21}$$

This relation plotted in Fig.32 gives a good average result over the velocity interval $10 > U_1 > 4.5$ m/s.
We may write equation (21) in terms of $\overline{V}$ using equation II125 resulting in:

$$\overline{V} = 0.167 \, U_1 \tag{22}$$

This result is in a very good agreement with the Lake Colorado City studies according to Edinger and Geyer [4], i.e.

$$\overline{V} = 0.1715 \, U_1 \tag{23}$$

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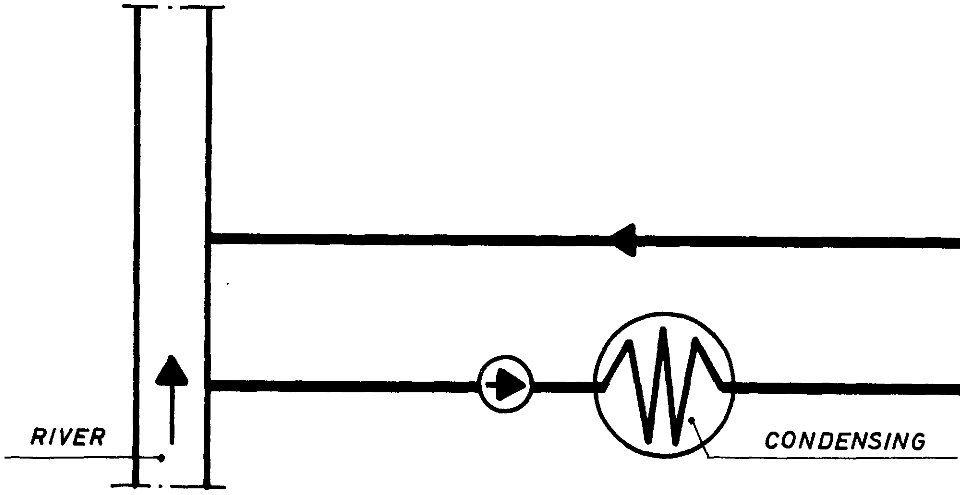


Fig.1

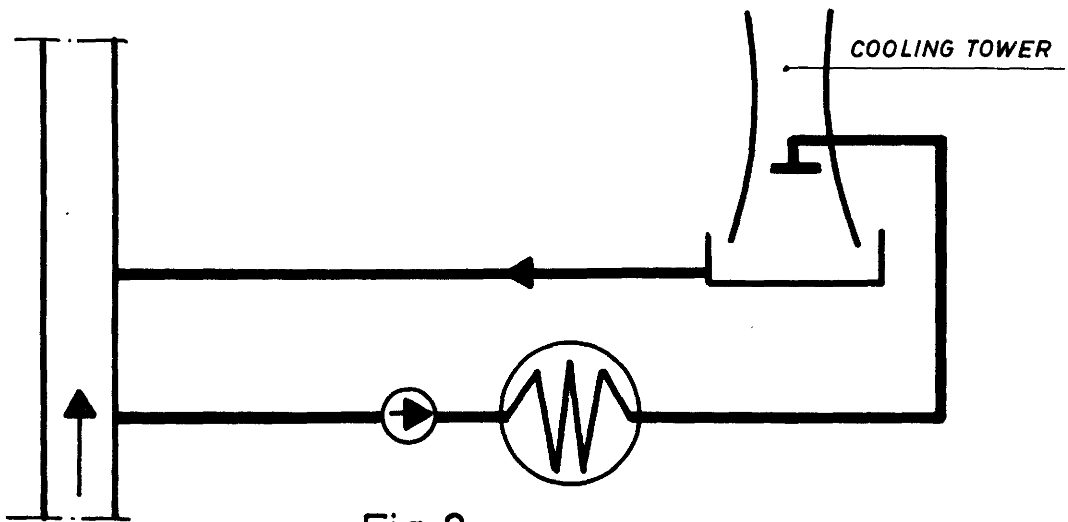


Fig.2

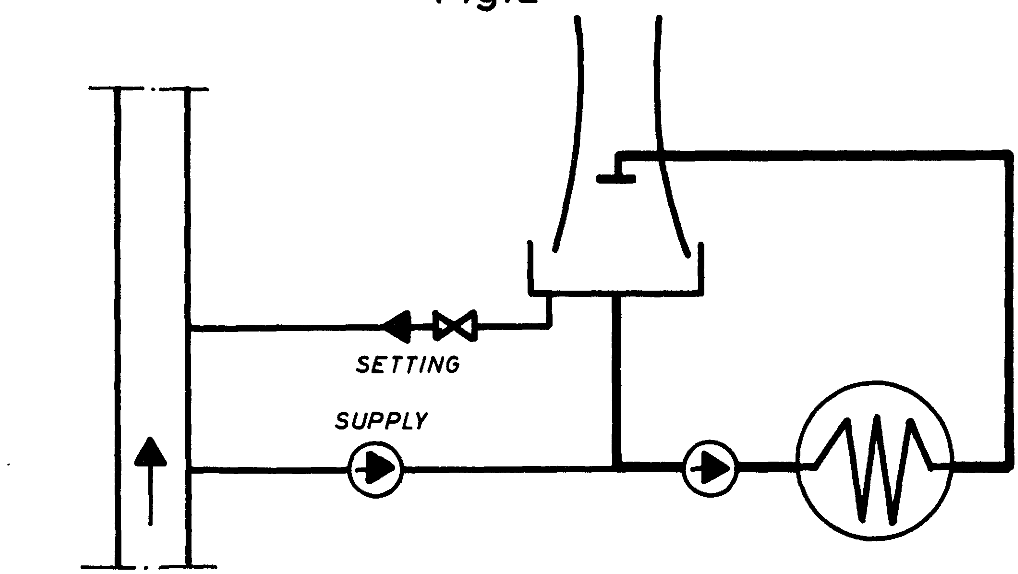


Fig. 3

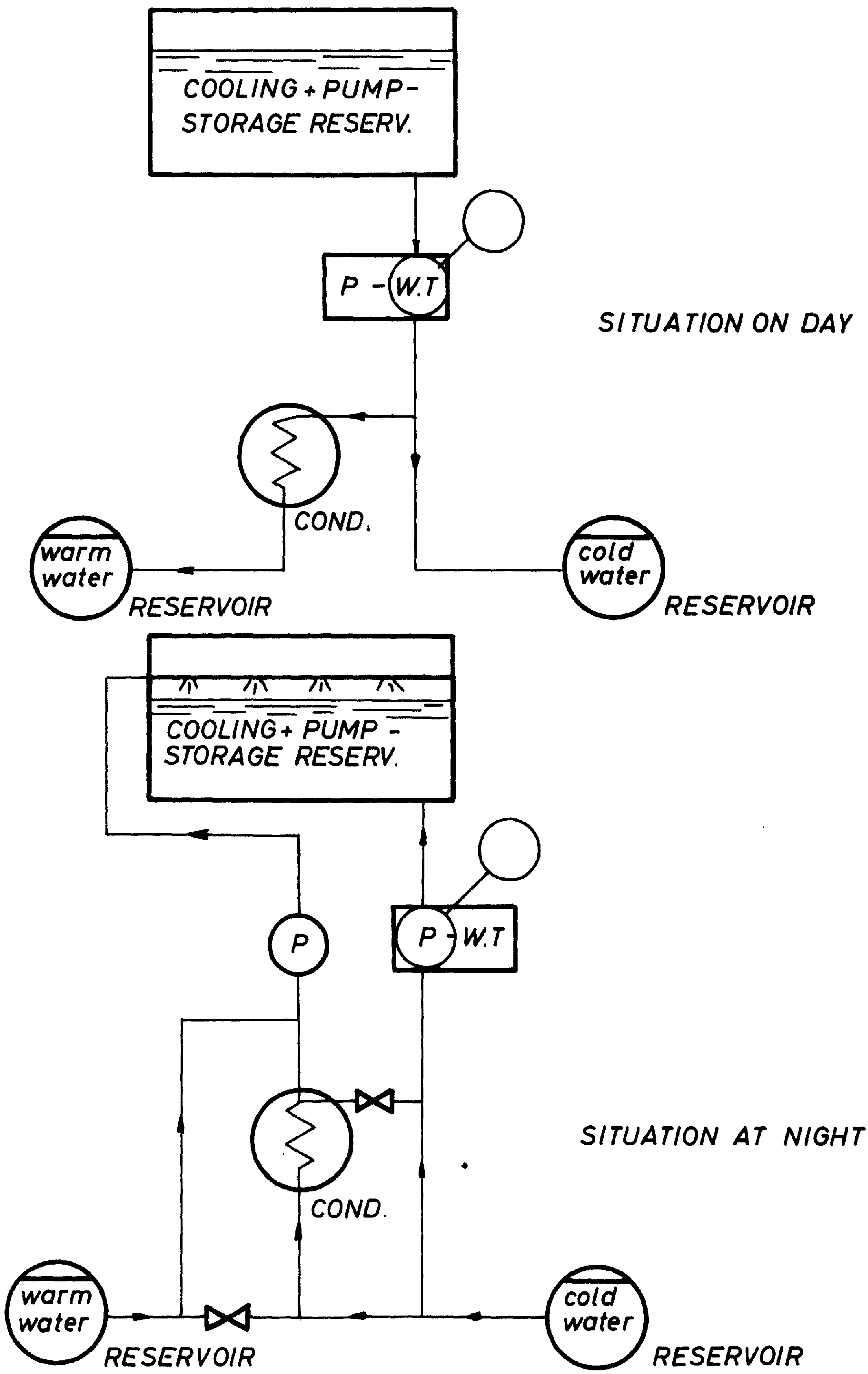

COOLING + PUMP-
STORAGE RESERV.
P - W.T
SITUATION ON DAY
COND.
warm water
RESERVOIR
cold water
RESERVOIR
COOLING + PUMP -
STORAGE RESERV.
P
P - W.T
SITUATION AT NIGHT
COND.
warm water
RESERVOIR
cold water
RESERVOIR

Fig. 4

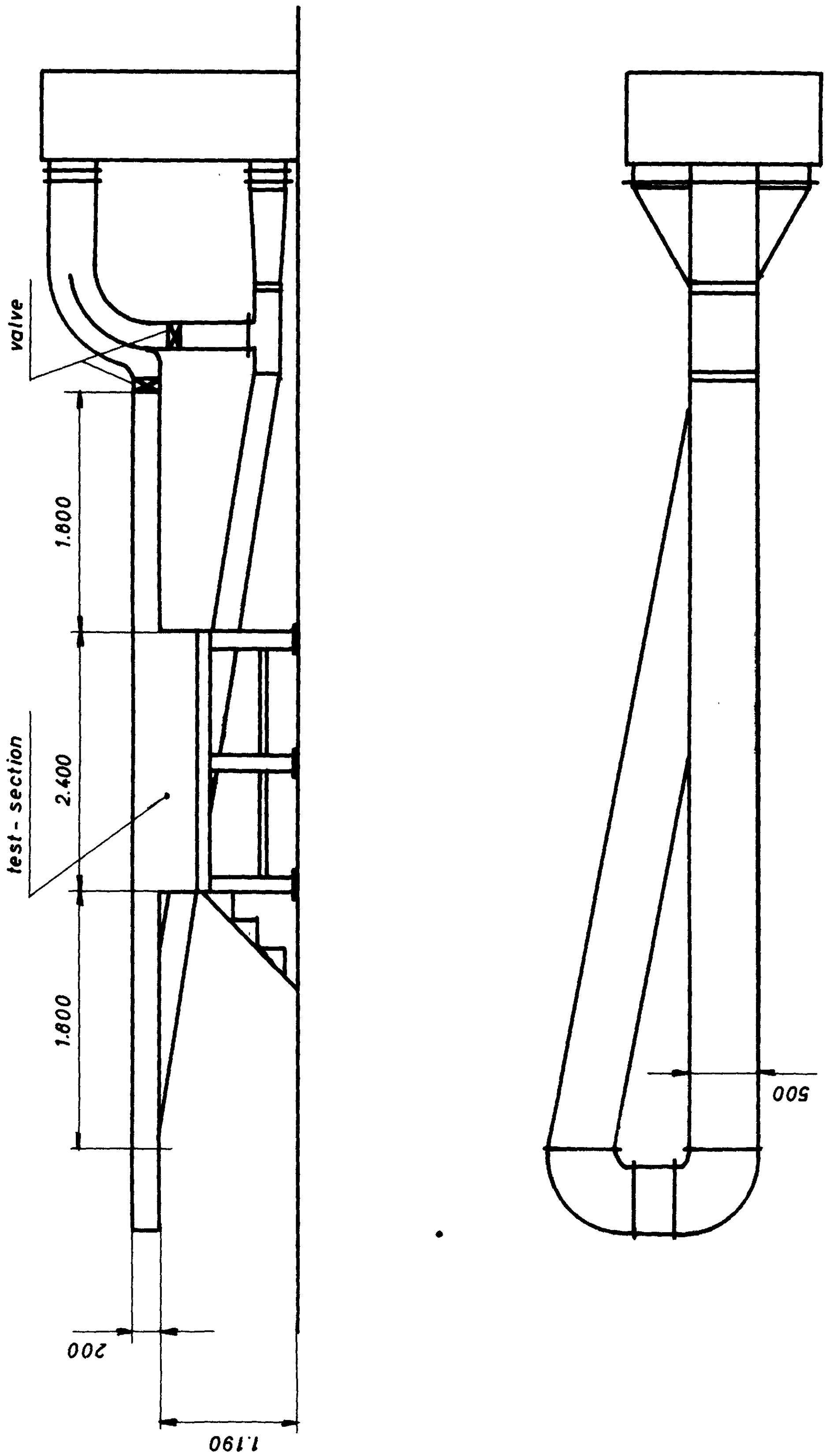
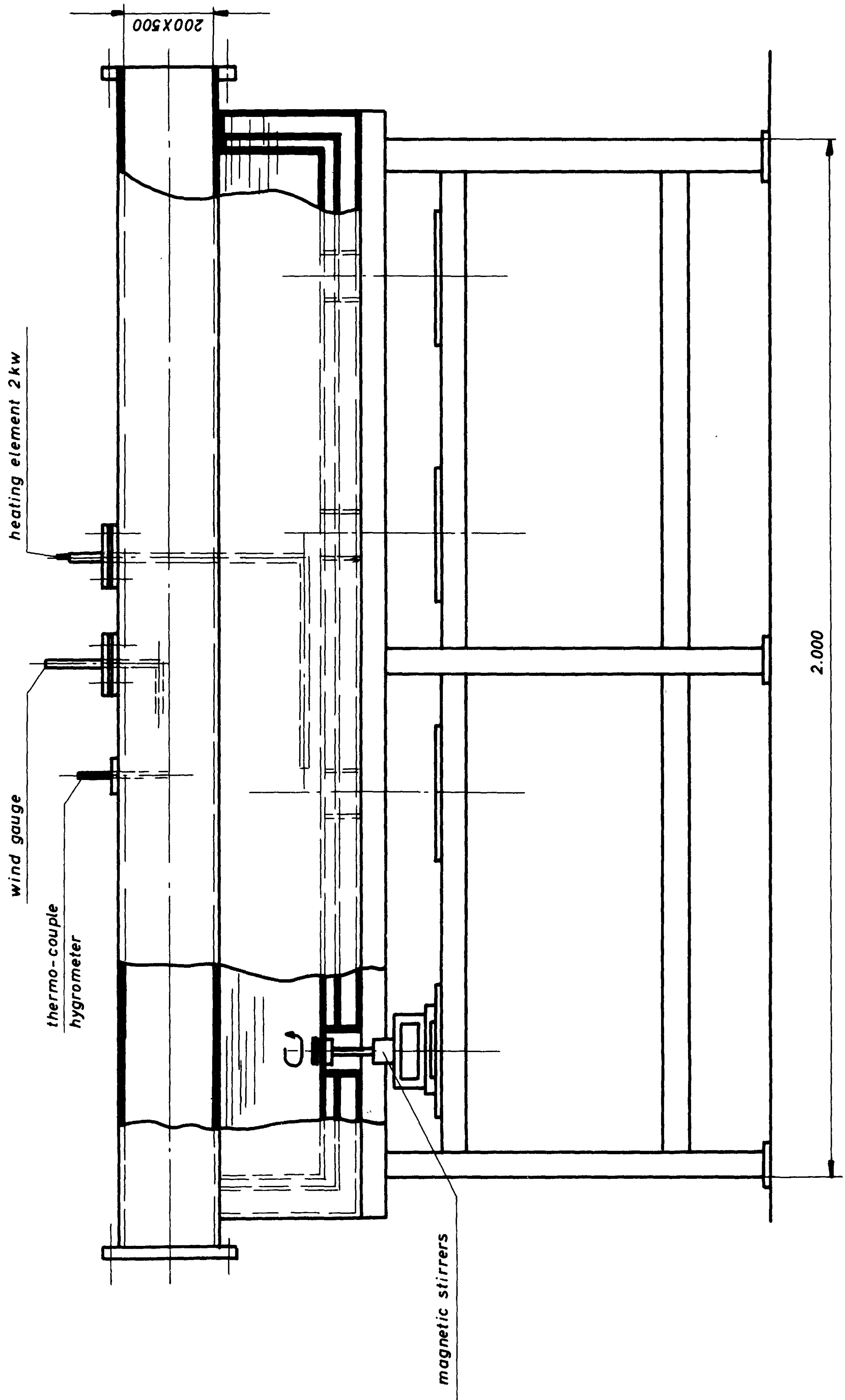


Fig. 5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heating element 2kw
wind gauge
thermo-couple
hygrometer
magnetic stirrers
2.000

1:10

Fig. 6

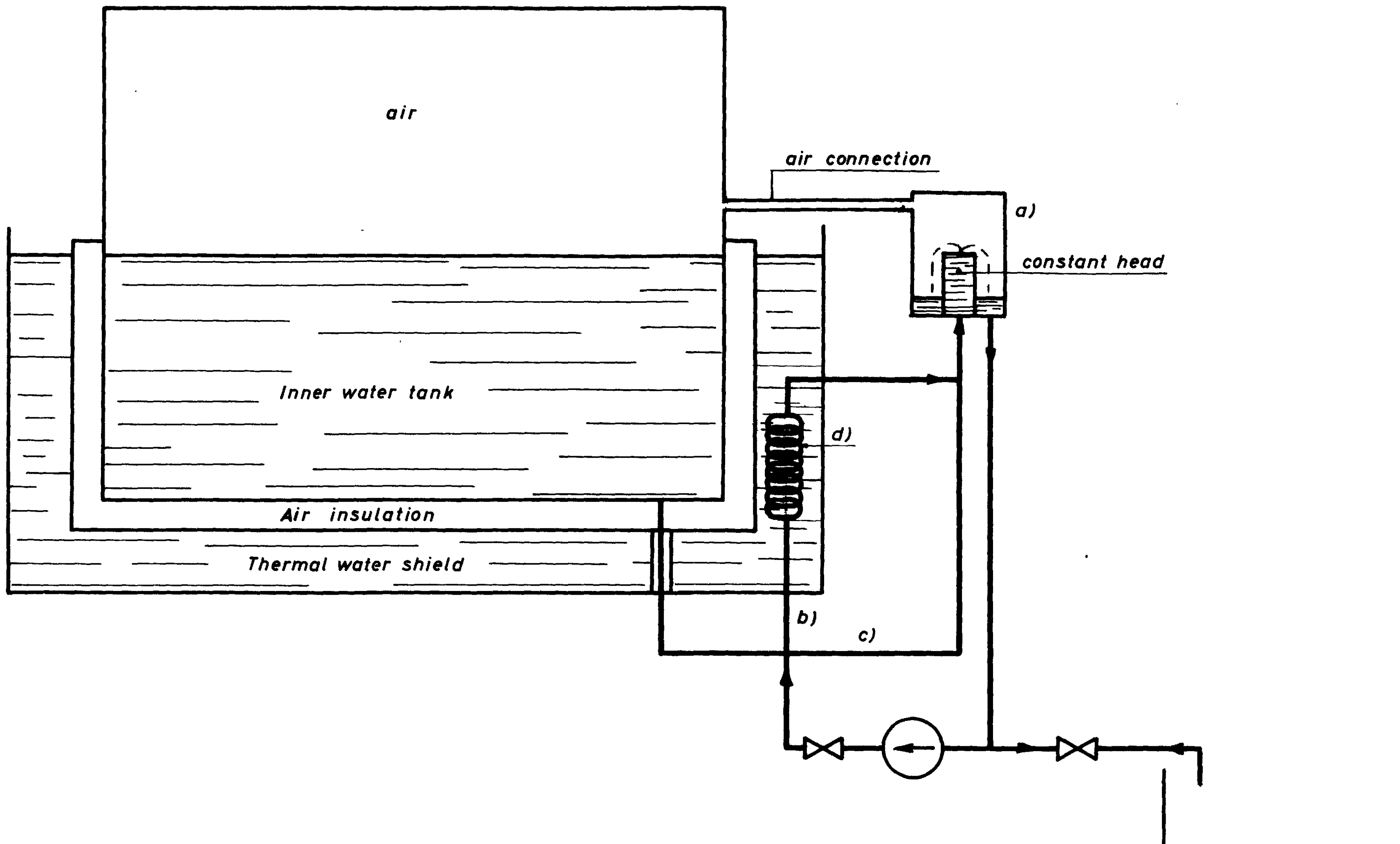


Fig.7 Automatic water level assembly of inner water tank

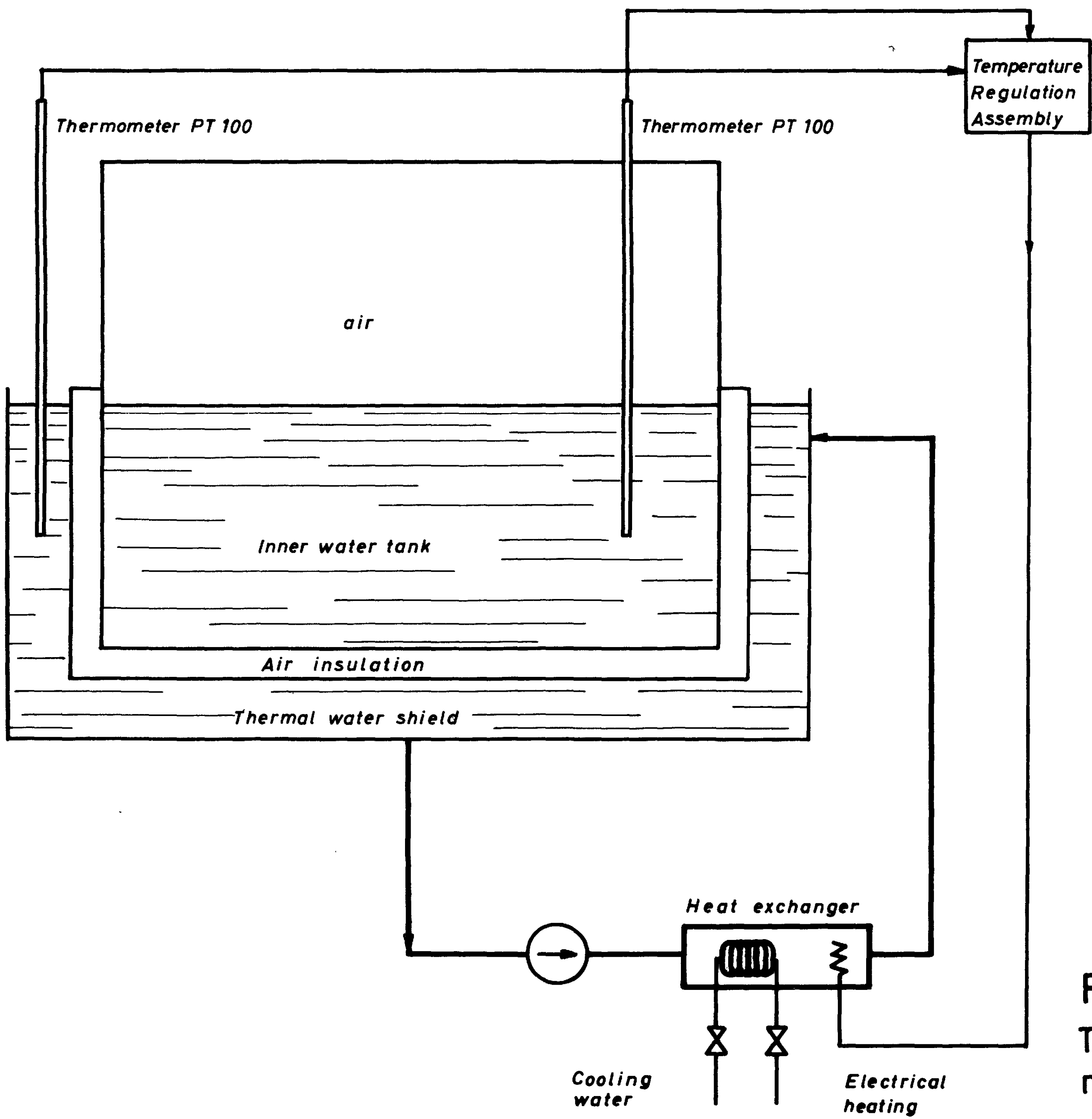


Fig. 8
Thermal shield temperature regulation

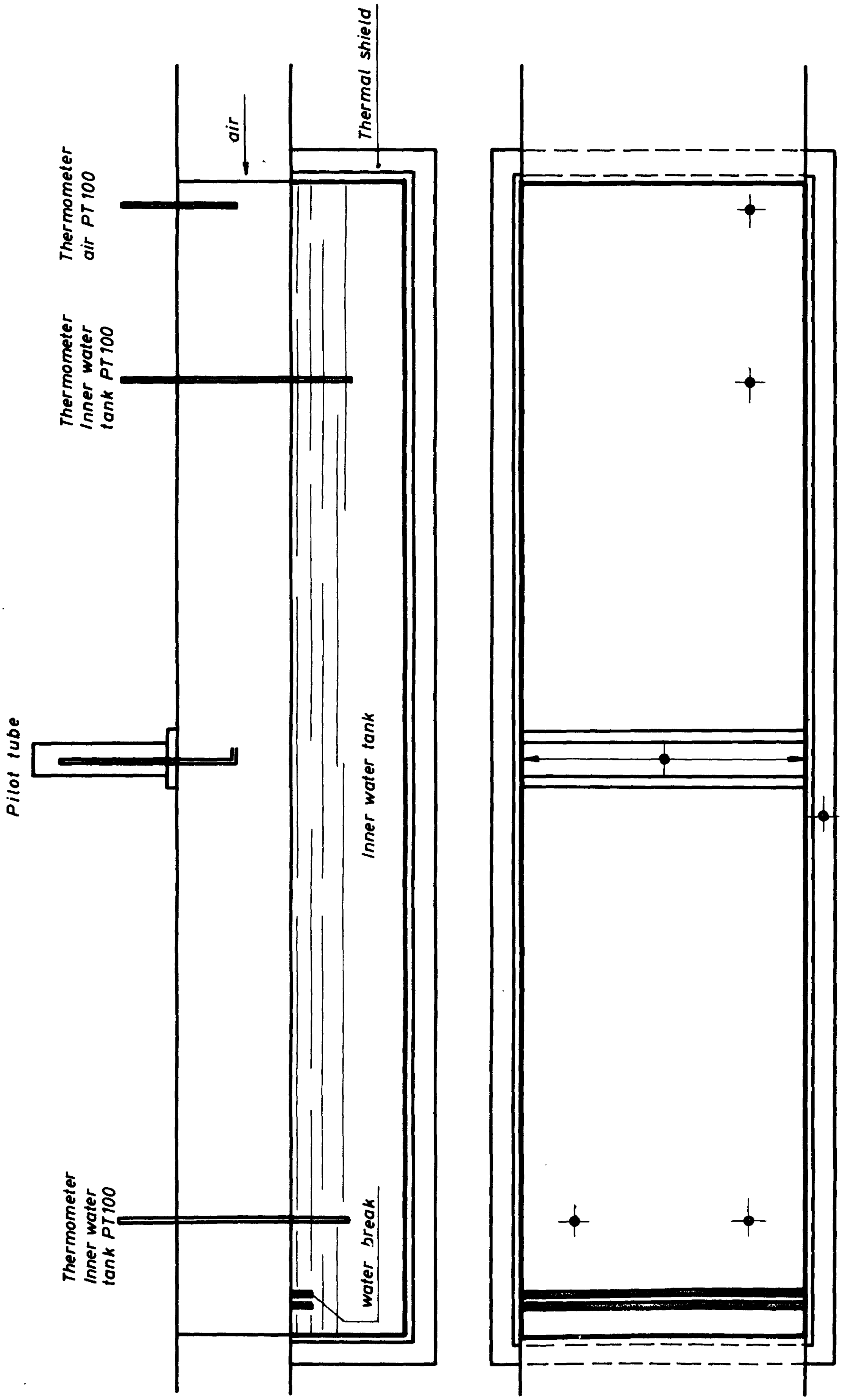
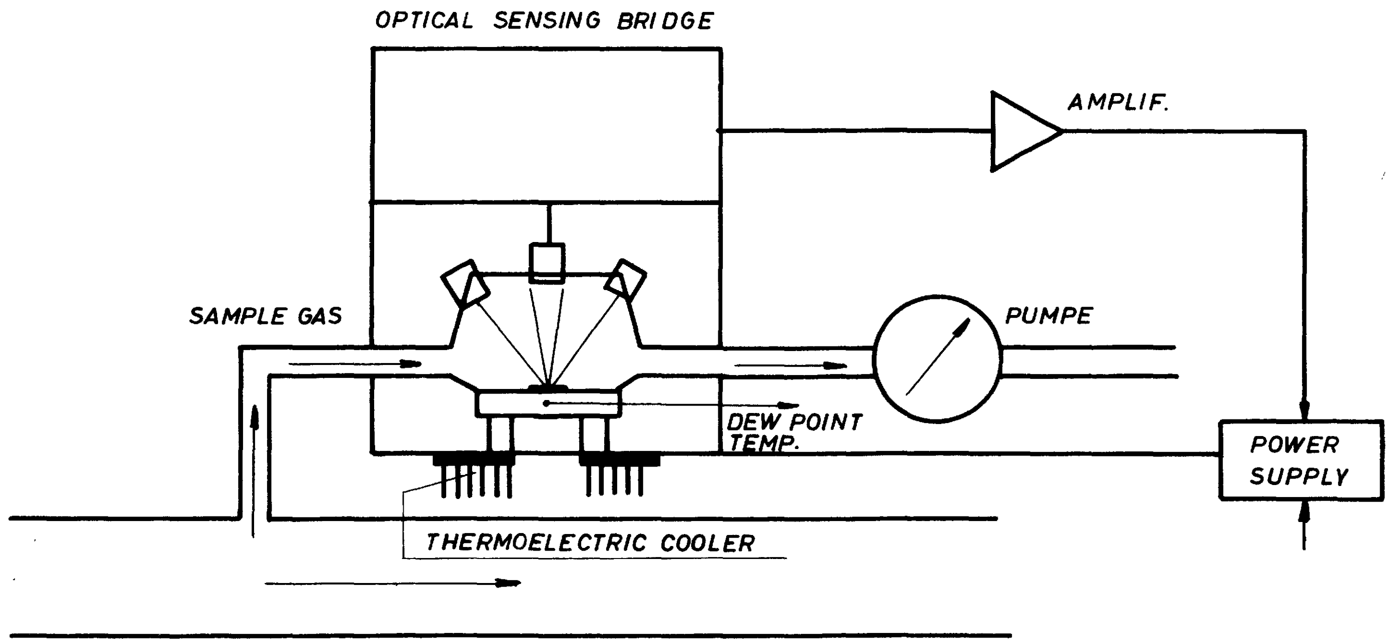

Thermometer air PT100
Thermometer Inner water tank PT100
Pilot tube
Thermometer Inner water tank PT100
air
Thermal shield
Inner water tank
water break

Fig. 9



hymidity instrumentation EG cambridge systems

Fig. 10

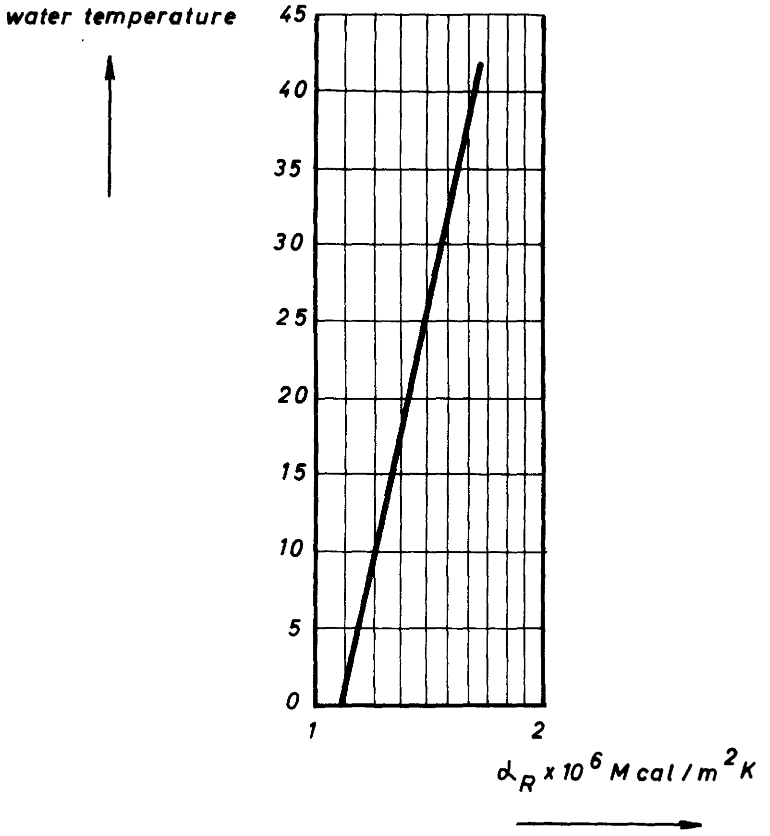


Fig. 11 α_R as a function of water temperature

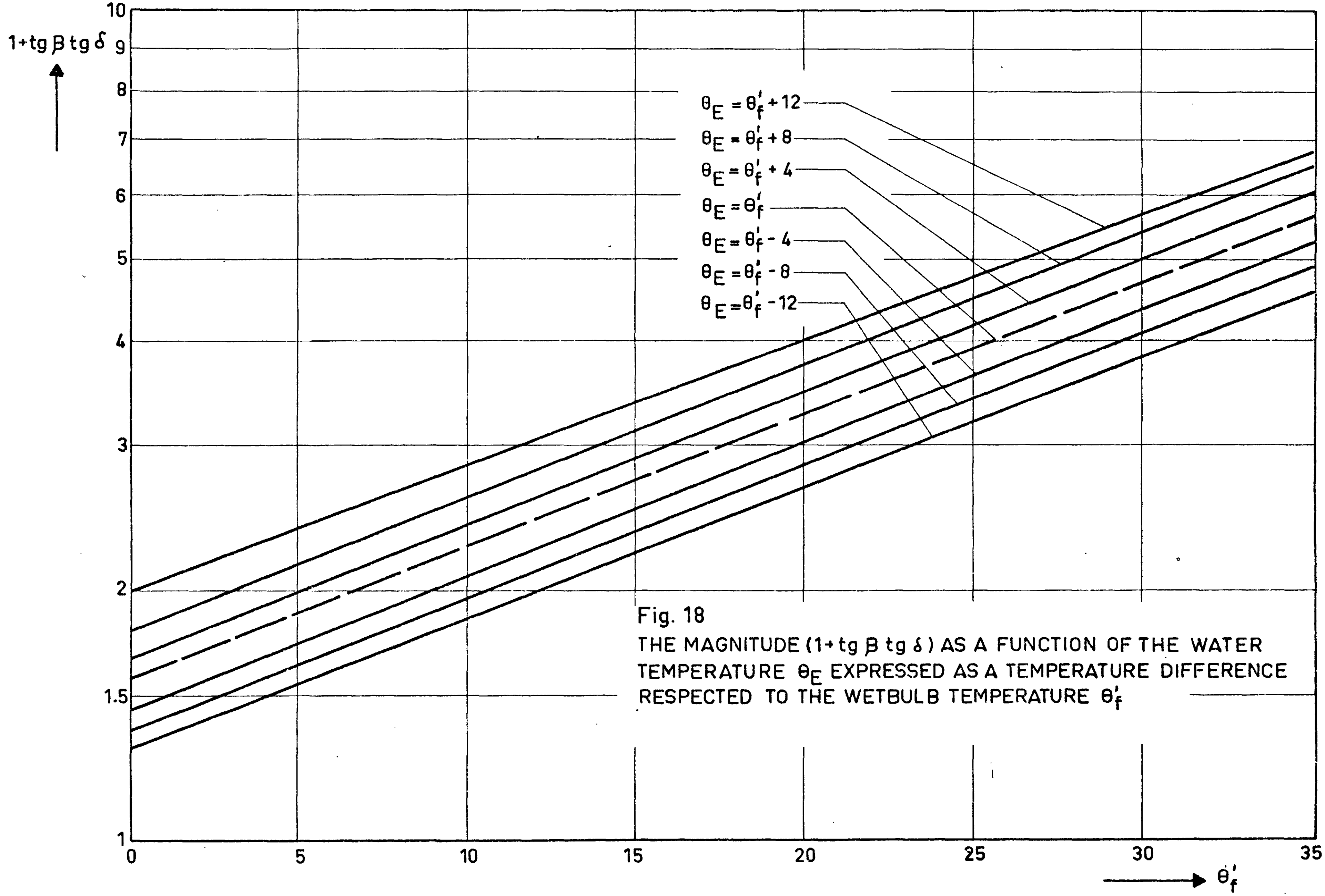


Fig. 18

THE MAGNITUDE $(1 + tg\,\beta\,tg\,\delta)$ AS A FUNCTION OF THE WATER TEMPERATURE θ_E EXPRESSED AS A TEMPERATURE DIFFERENCE RESPECTED TO THE WETBULB TEMPERATURE θ_f'

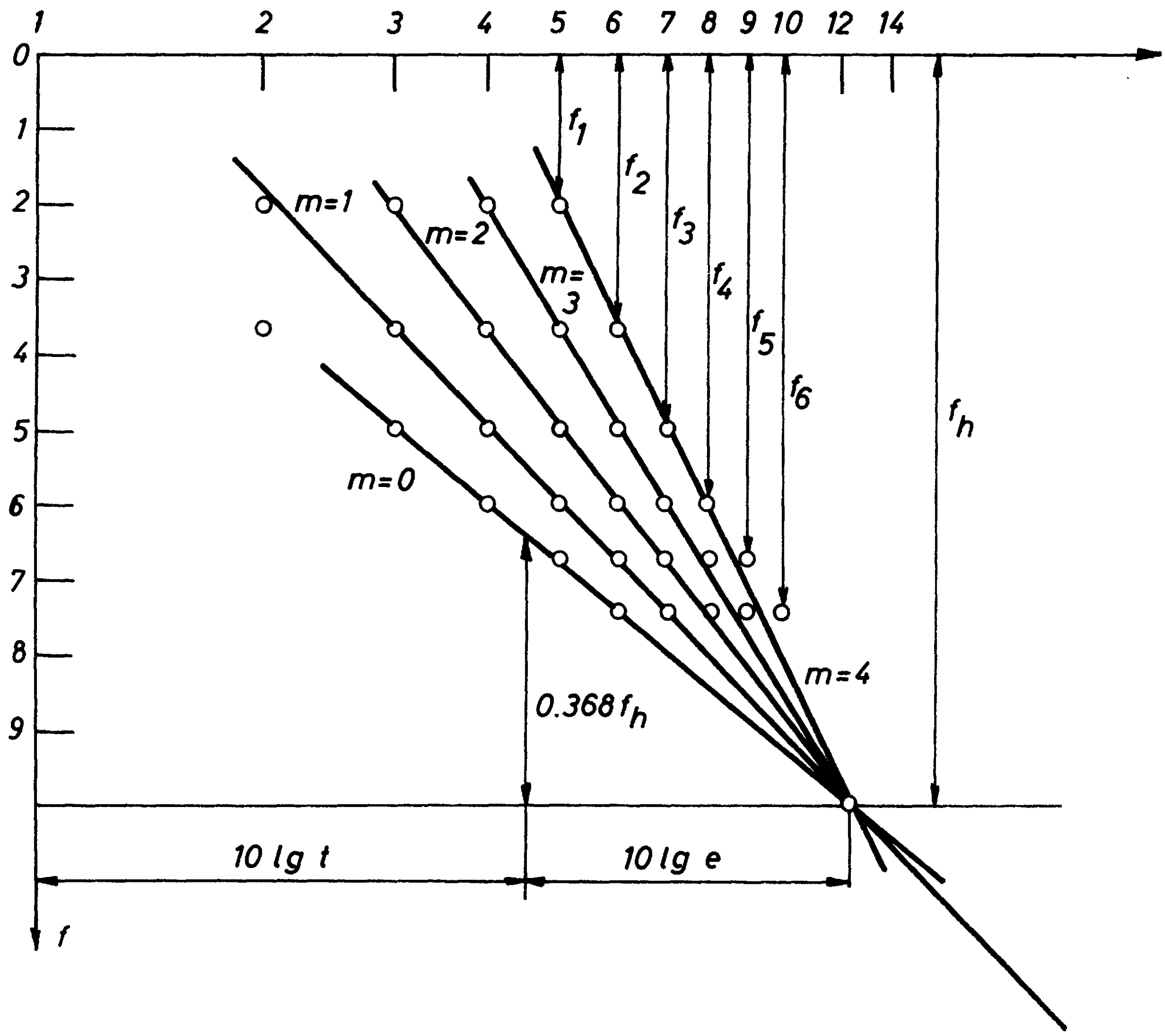
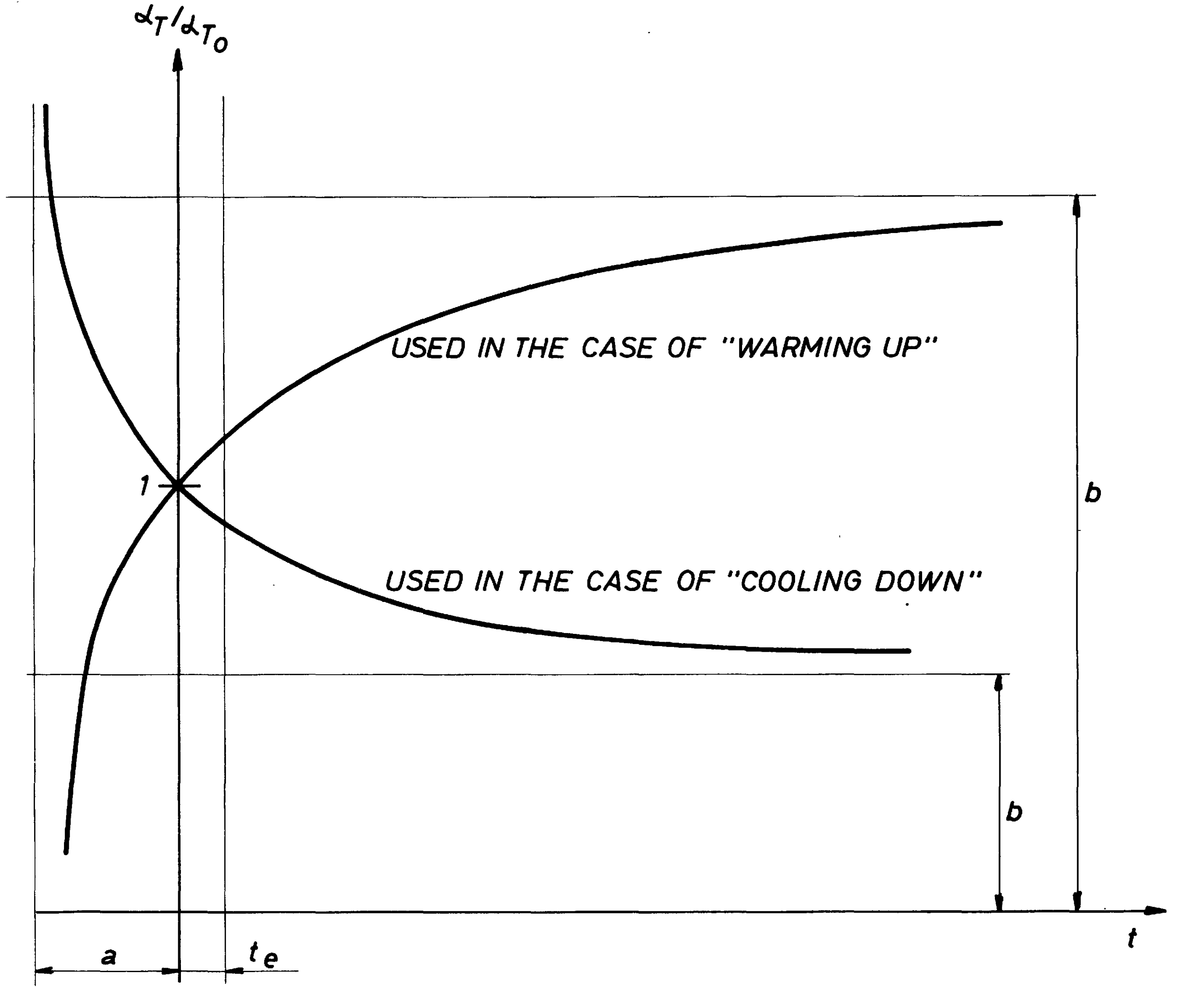


Fig. 20 GRAPHICAL DETERMINATION OF THE EXPONENTIAL DECAY COEFFICIENT β OF THE FUNCTION $f_t = f_h\,(1-e^{-\beta t})$



αT/αTo
USED IN THE CASE OF "WARMING UP"
1
b
USED IN THE CASE OF "COOLING DOWN"
b
a
te
t

Fig. 21

+1.6	+ 3.2	+ 2.4	+ 5.6	+ 2.4	+ 3.2	+ 1.6
+0.8	+ 1.6	+ 1.2	+ 2.8	+ 1.2	+ 1.6	+ 0.8
+3.2	+ 6.4	+ 4.8	+ 11.2	+ 4.8	+ 6.4	+ 3.2
+0.8	+ 1.6	+ 1.2	+ 2.8	+ 1.2	+ 1.6	+ 0.8
+1.6	+ 3.2	+ 2.4	+ 5.6	+ 2.4	+ 3.2	+ 1.6

Fig. 22 DISTRIBUTION SCHEME OF VELOCITY MEASUREMENT COORDINATES WITH INDICATOR OF AREA PERCENTAGES - 35 FIELDS METHOD

$\overline{U} = 2.12\ m/sec$ ⟨35⟩ $\Theta_A = 28.6\,°C$ $\varepsilon = 39.5\ \%$

z →

1.38	1.57	1.65	1.78	2.09	2.22	2.02
1.57	1.81	1.96	1.96	2.22	2.32	2.09
2.09	2.22	2.22	2.22	2.22	2.27	2.09
1.98	2.34	2.45	2.43	2.34	2.45	2.34
1.96	2.32	2.27	2.43	2.34	2.43	2.32

Fig. 23 VELOCITY DISTRIBUTION SCHEME

$\overline{U}_{\langle 35 \rangle} = 2.97\ m/sec$ $\quad \Theta_A = 21.5\ °C$ $\quad \varepsilon = 42\ \%$

z →

2.21	2.52	2.52	2.52	2.64	2.83	2.52
2.19	2.64	2.72	2.72	2.78	2.92	2.66
2.52	3.00	3.05	3.05	3.00	2.77	2.72
2.92	3.35	3.51	3.51	3.51	3.44	3.00
2.92	3.30	3.55	3.65	3.48	3.30	3.00

Fig. 24 VELOCITY DISTRIBUTION SCHEME

$\bar{U}_{\langle 35 \rangle} = 3.82$ m/sec $\quad \Theta_A = 21.6\,°C \quad \varepsilon = 42\%$

2.74	3.20	2.96	3.00	3.27	3.40	3.20
2.74	3.50	3.35	3.35	3.65	3.80	3.84
3.35	3.95	3.95	3.97	3.87	3.84	3.44
3.50	3.74	4.70	4.70	4.40	4.25	3.74
3.50	4.10	4.45	4.80	4.42	4.17	3.80

Fig.25 VELOCITY DISTRIBUTION SCHEME

$\overline{U}_{(35)} = 4.68\ m/sec$ $\Theta_A = 19.5\ °C$ $\varepsilon = 60\%$

3.80	4.00	3.60	3.80	3.95	3.75	3.65
3.80	4.40	4.10	4.40	4.55	4.50	4.50
4.10	4.85	4.80	5.00	5.25	5.10	4.50
4.25	5.26	5.40	5.66	5.65	5.37	4.50
4.20	4.75	5.14	5.40	5.40	5.12	4.50

z

Fig. 26 VELOCITY DISTRIBUTION SCHEME

$\overline{U}_{<35>} = 5.33$ m/sec $\Theta_A = 22.6$ °C $\varepsilon = 41$ %

4.45	4.45	4.45	4.85	4.80	4.56	4.45
4.50	5.10	5.18	5.47	5.50	5.20	4.50
4.70	5.60	5.65	5.90	5.73	5.70	5.00
4.80	5.65	5.82	6.10	6.10	5.79	4.98
4.40	5.07	5.30	5.82	5.79	5.40	4.80

Fig. 27 VELOCITY DISTRIBUTION SCHEME

$\overline{U}_{\langle 35 \rangle} = 6.40\ m/sec$ $\theta_A = 22\,°C$ $\varepsilon = 42\,\%$

5.70	5.73	5.55	5.96	5.70	5.60	5.30
5.50	6.52	6.30	6.70	6.50	6.40	5.30
5.90	7.10	6.90	6.90	6.60	6.33	5.78
5.78	7.00	7.10	7.10	6.70	6.45	5.55
5.73	6.30	6.45	6.70	6.40	6.18	5.36

Z

Fig. 28 VELOCITY DISTRIBUTION SCHEME

CENTER-VELOCITY U_C [m.s^{-1}]	9 FIELDS METHOD $\bar{U}_{\langle 9 \rangle}$	35 FIELDS METHOD $\bar{U}_{\langle 35 \rangle}$	$\frac{\bar{U}_{\langle 35 \rangle} - \bar{U}_{\langle 9 \rangle}}{\bar{U}_{\langle 35 \rangle}}$	$\frac{\bar{U}_{\langle 35 \rangle} - U_C}{\bar{U}_{\langle 35 \rangle}}$ 100%	$\frac{\bar{U}_{\langle 9 \rangle} - U_C}{\bar{U}_{\langle 9 \rangle}}$
5	4.871	4.684	-3.99	-6.32	-2.65
3.05	3.048	2.968	-2.70	-2.69	-0.066
6.90	6.558	6.397	-2.51	-7.29	-5.22
5.90	5.506	5.327	-3.36	-9.71	-7.16
3.97	3.862	3.832	-0.78	-3.53	-2.80
2.22	2.205	2.117	-4.16	-4.64	-0.68
6.70	6.337				-5.73
6.78	6.491				-4.45
6.78	6.437				-5.33
2.15	2.170				+0.92
6.96	6.698				-3.91
4	3.971				-0.73
2.02	2.007				-0.65
6.08	6.514				-5.62
5.80	5.379				-7.83
3.10	3.677				-4.73
2.92	2.614				-11.71
4.87	4.685				-3.95
4.93	4.701				-4.87
5.01	4.822				-4.89
5.14	4.855				-5.87
5	4.870				-2.67
4.95	4.812				-2.87
1	1.035				
1	1.036				
0.46	0.480				
0.34	0.420				

Fig. 29

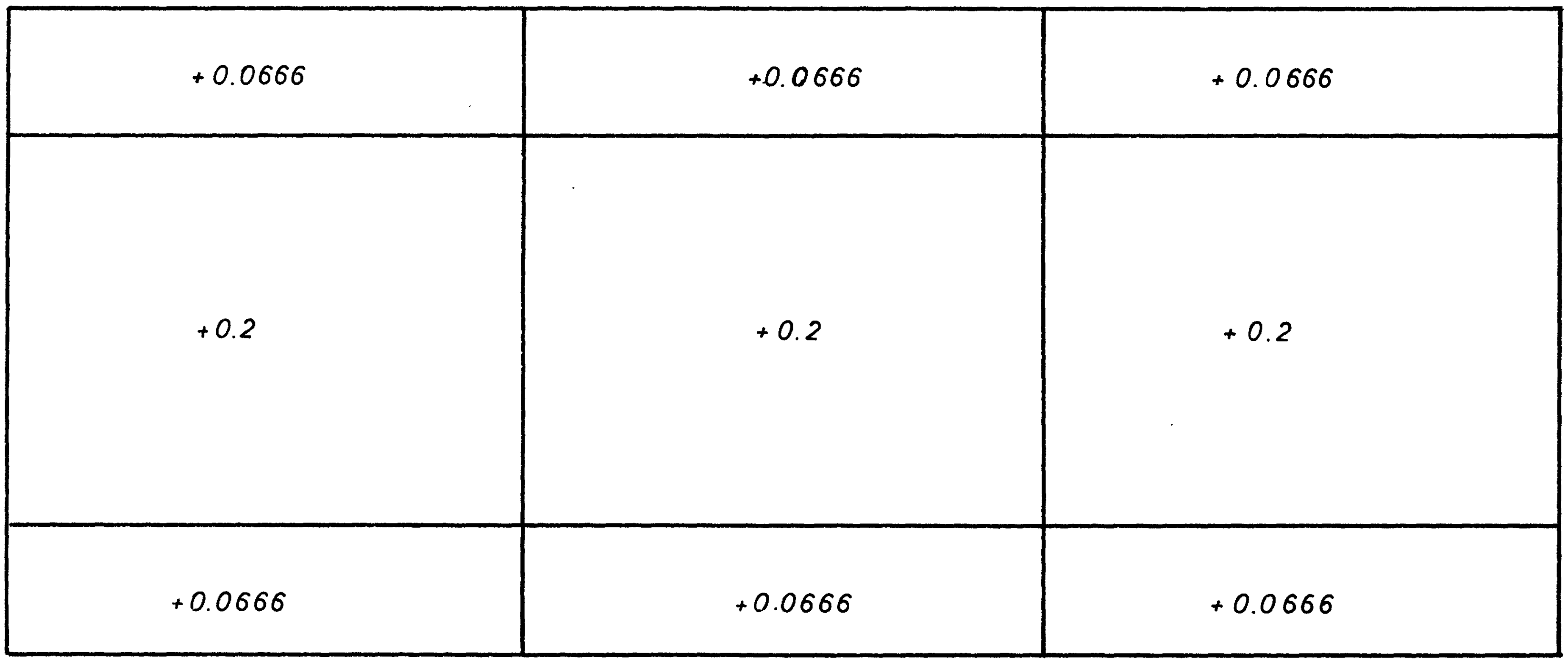


Fig. 30 DISTRIBUTION SCHEME OF VELOCITY MEASUREMENT COORDINATES WITH INDICATION OF AREA FRACTION – 9 FIELDS METHOD

Wind velocity profiles
of humid air over a water surface
as a function of the average channel velocity

Air temperature ± 20°C
Water depth 0.20 m
Length of fetch 2 m

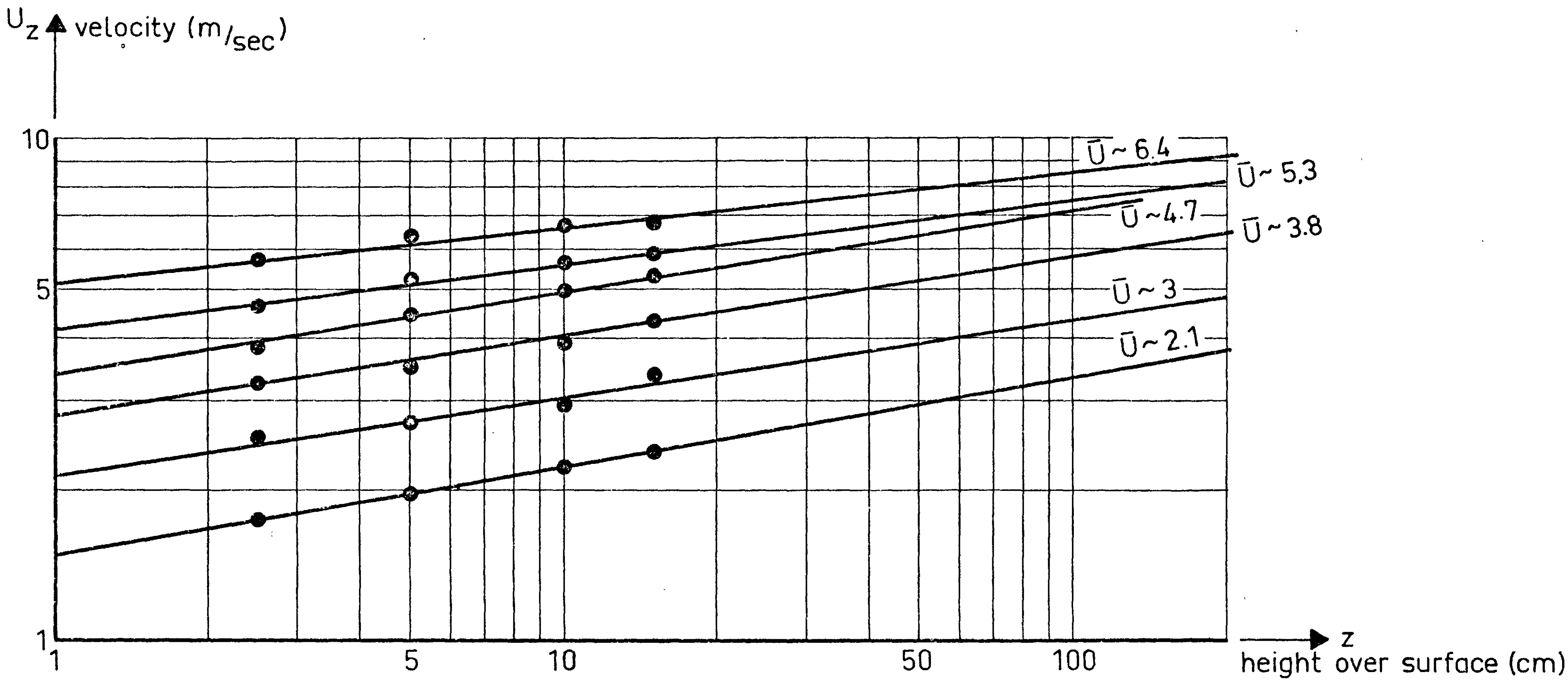


Fig. 31

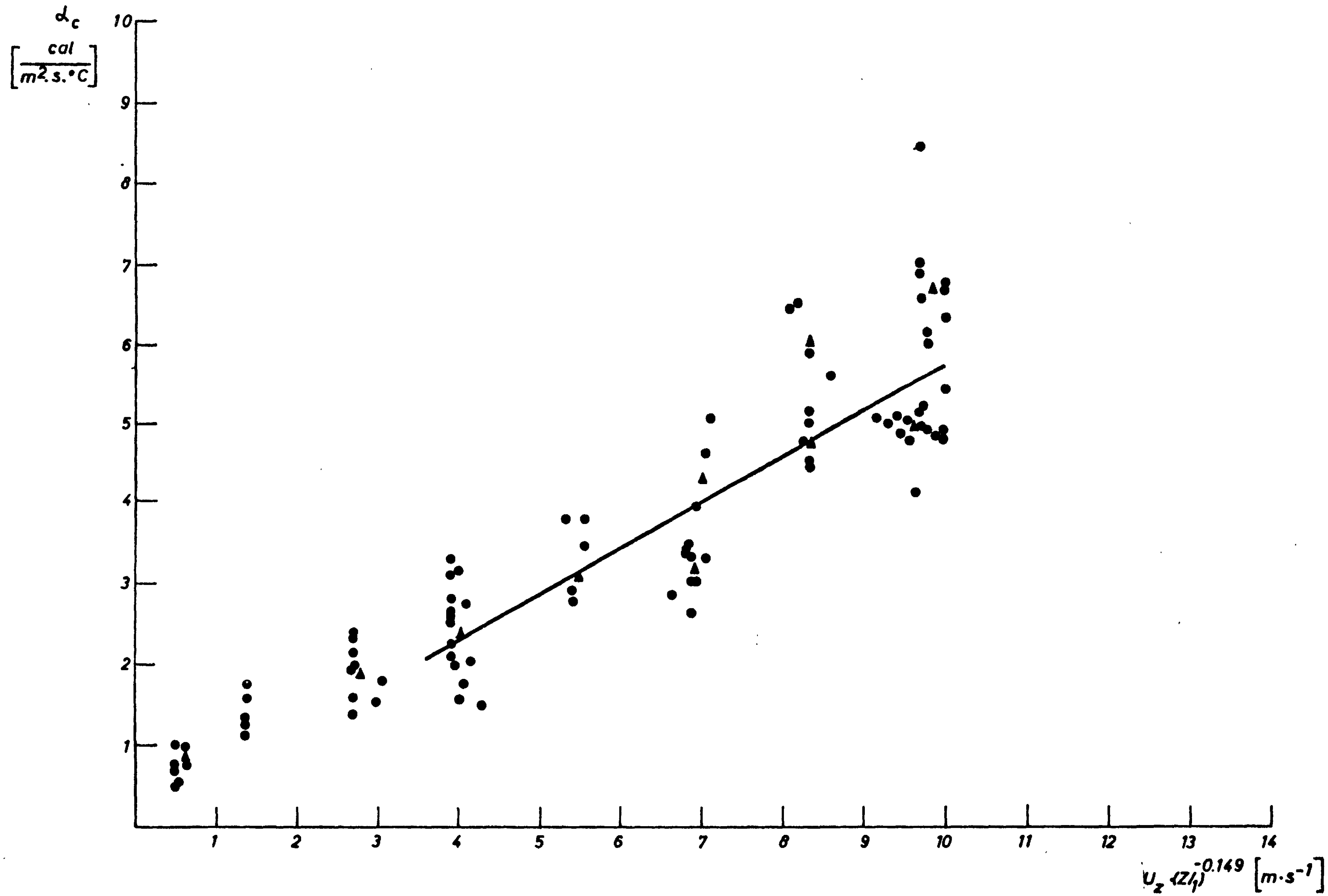
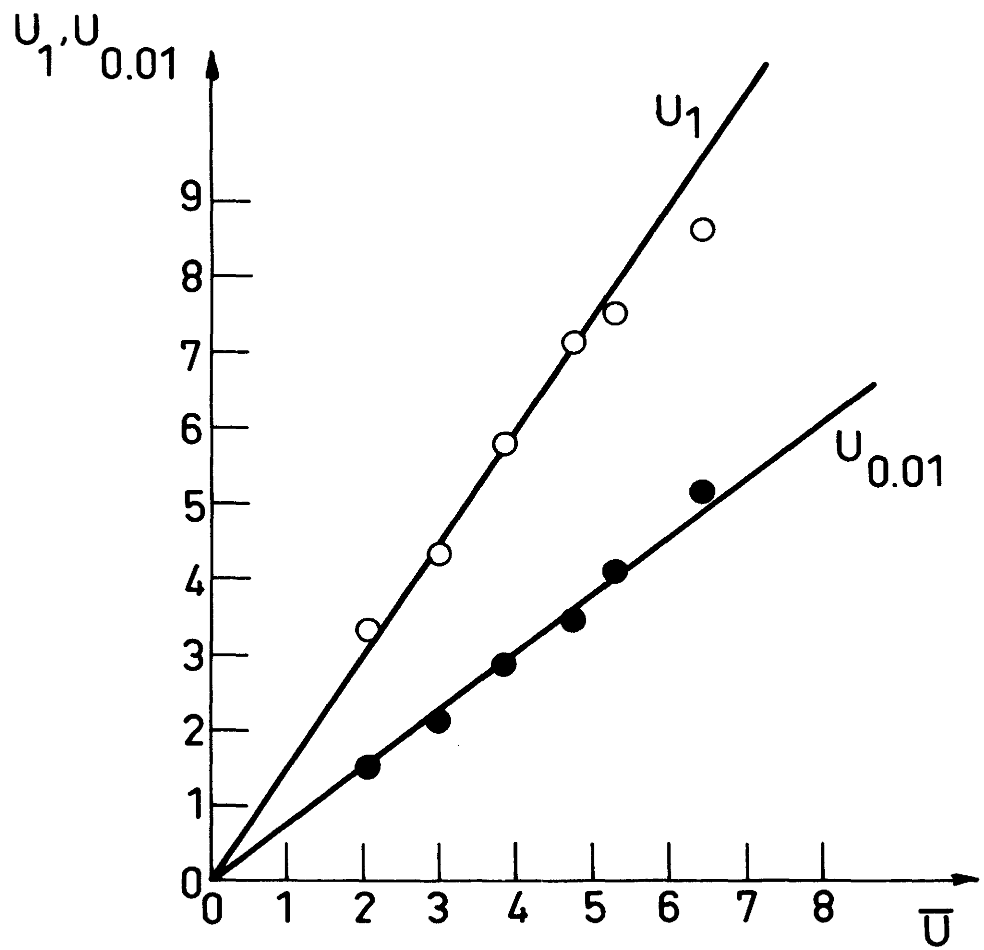


Fig. 32 Plot of α_c versus windvelocity extrapolated at a height of 1 m



WIND - VELOCITIES AT 0.01 m AND AT 1m AS A FUNCTION OF THE AVERAGE WIND VELOCITY

Fig. 33

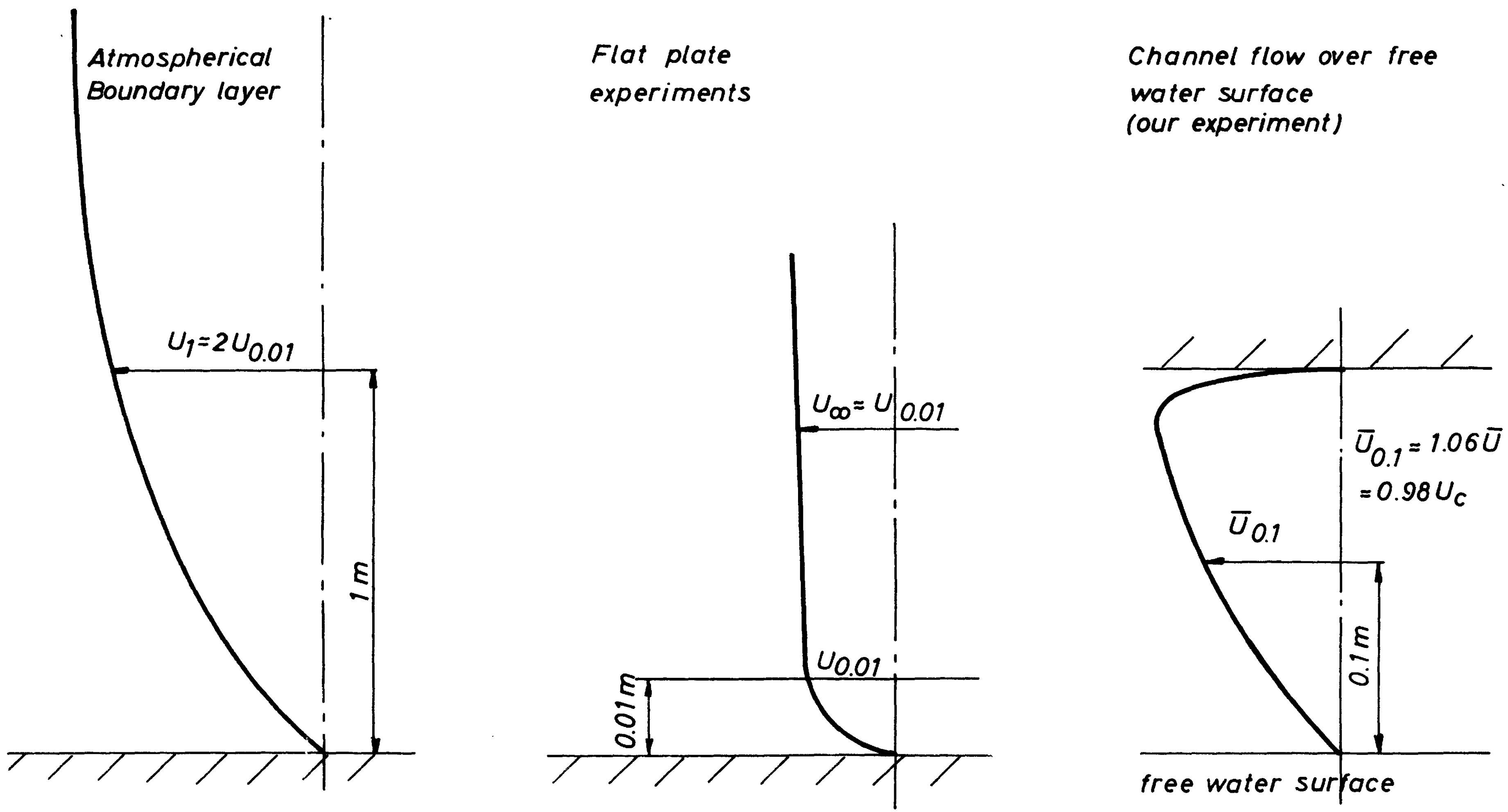


Fig. 34 SOME HYPOTHESIS FOR COMPARISON OF RESULTS FROM DIFFERENT ORIGIN

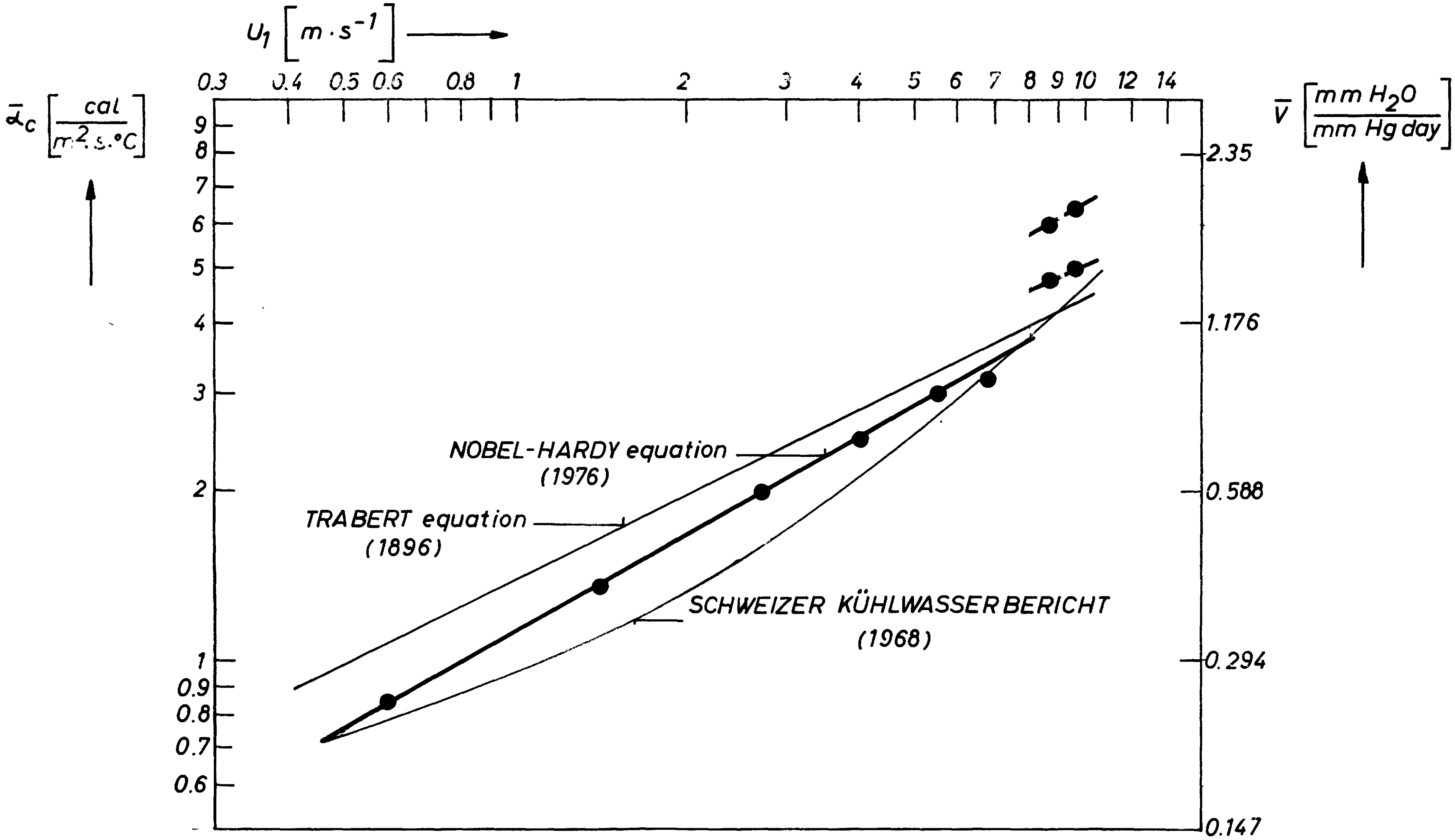


Fig. 35 THE AVERAGE HEAT TRANSFER COEFFICIENT $\bar{\alpha}_c$ AS A FUNCTION OF WINDVELOCITY U_1 AND COMPARISON WITH THE EVAPORATION $\bar{V}$

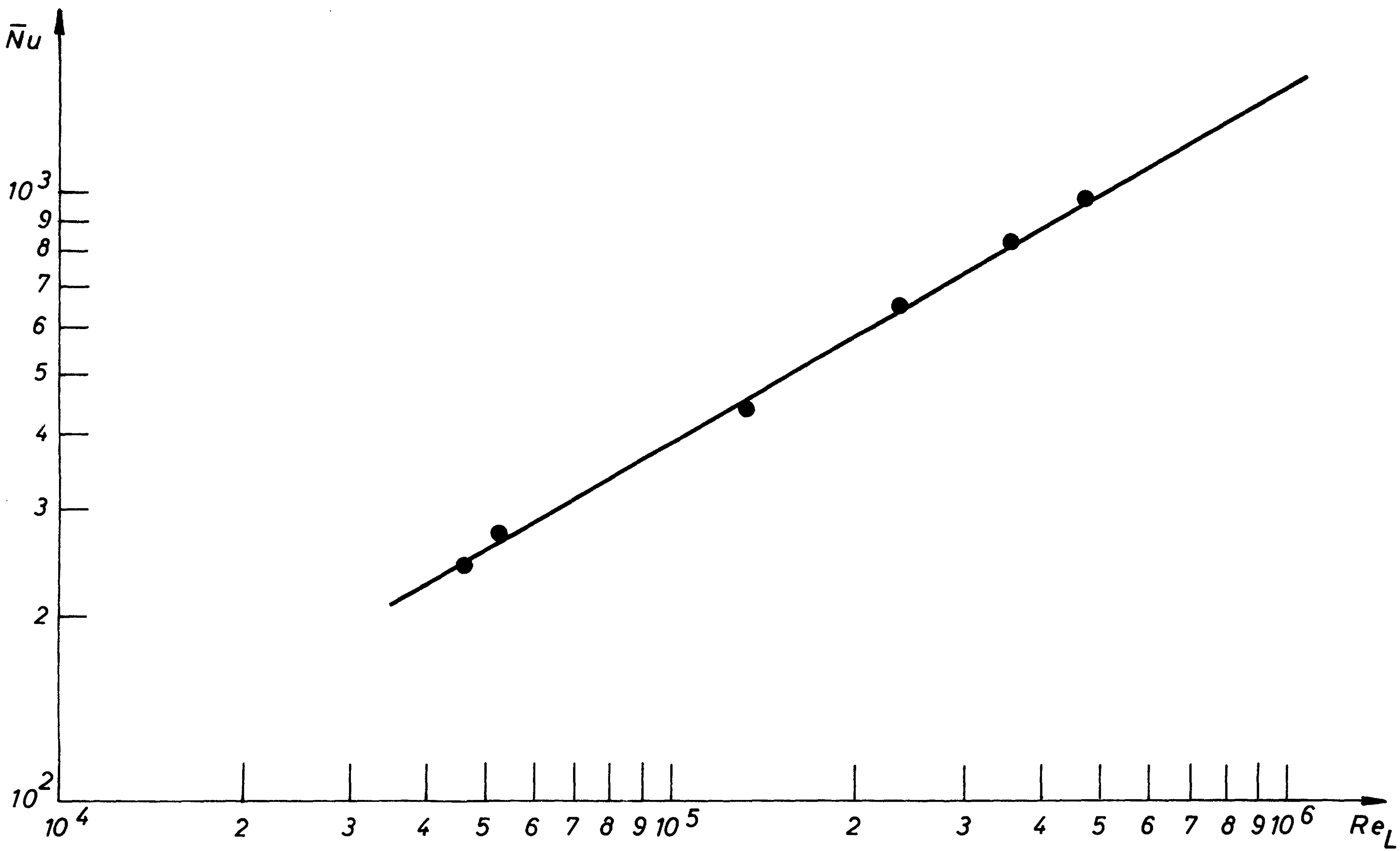


Fig. 36 NUSSELT NUMBER AS A FUNCTION OF FETCH REYNOLDS NUMBER

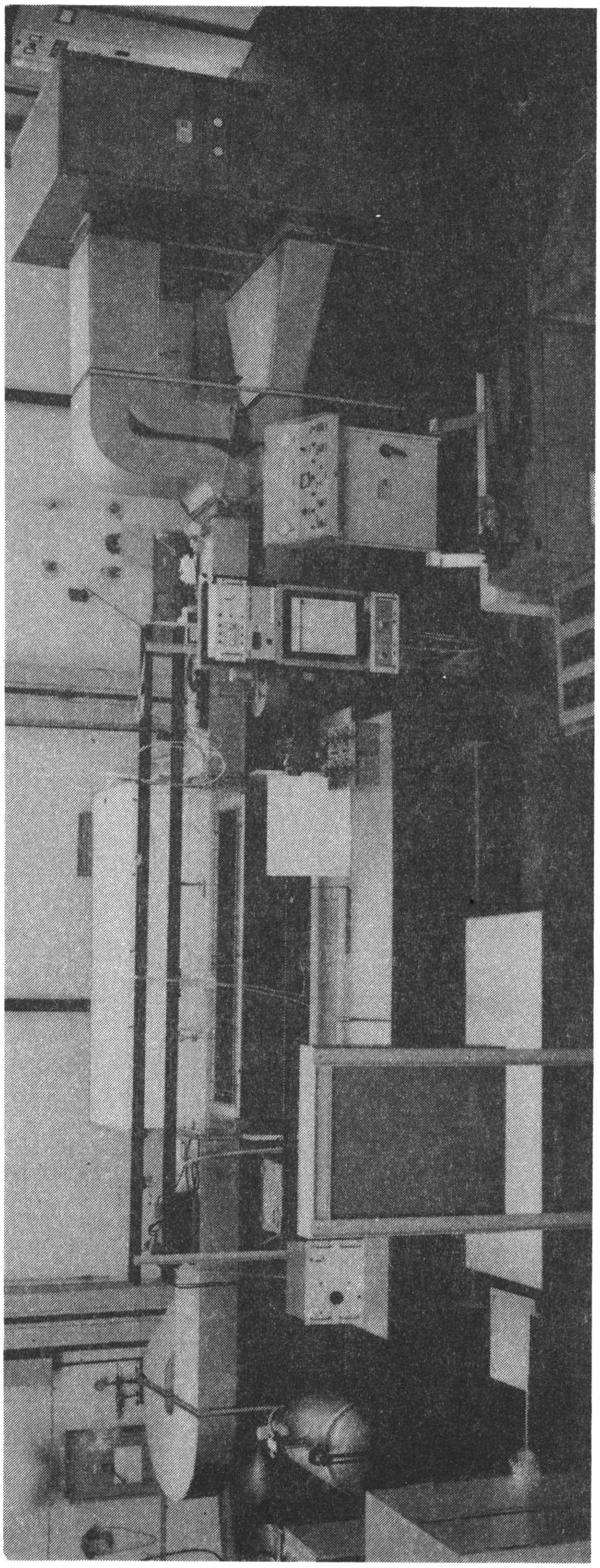


PHOTO 1

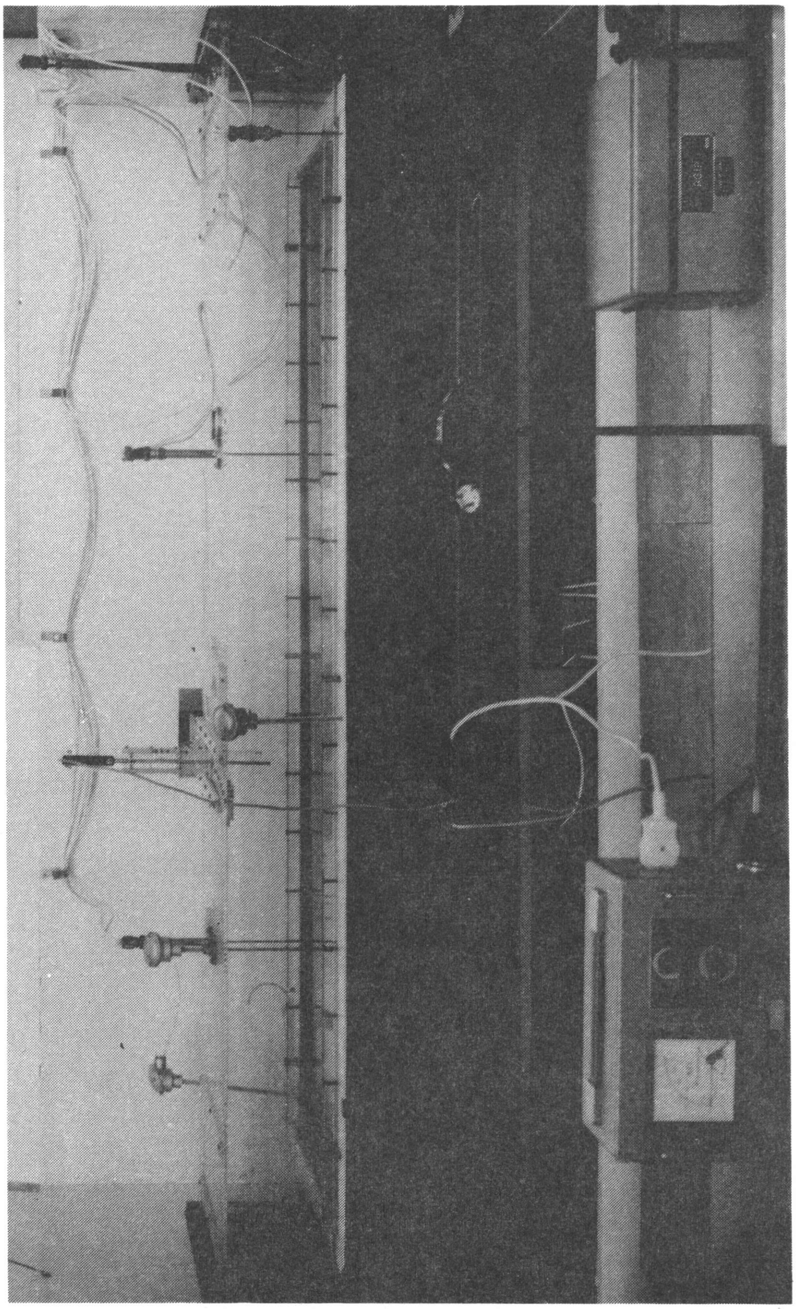


PHOTO 2

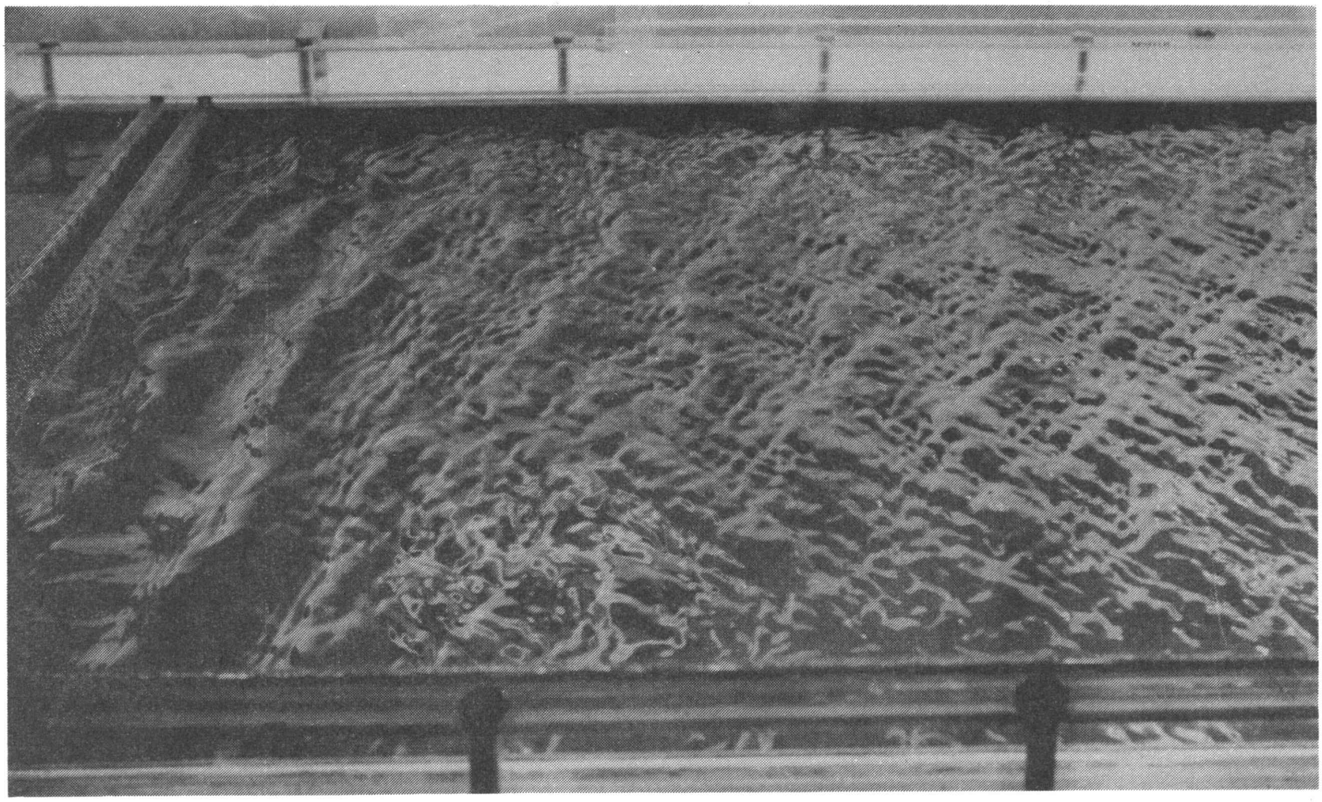


PHOTO 3

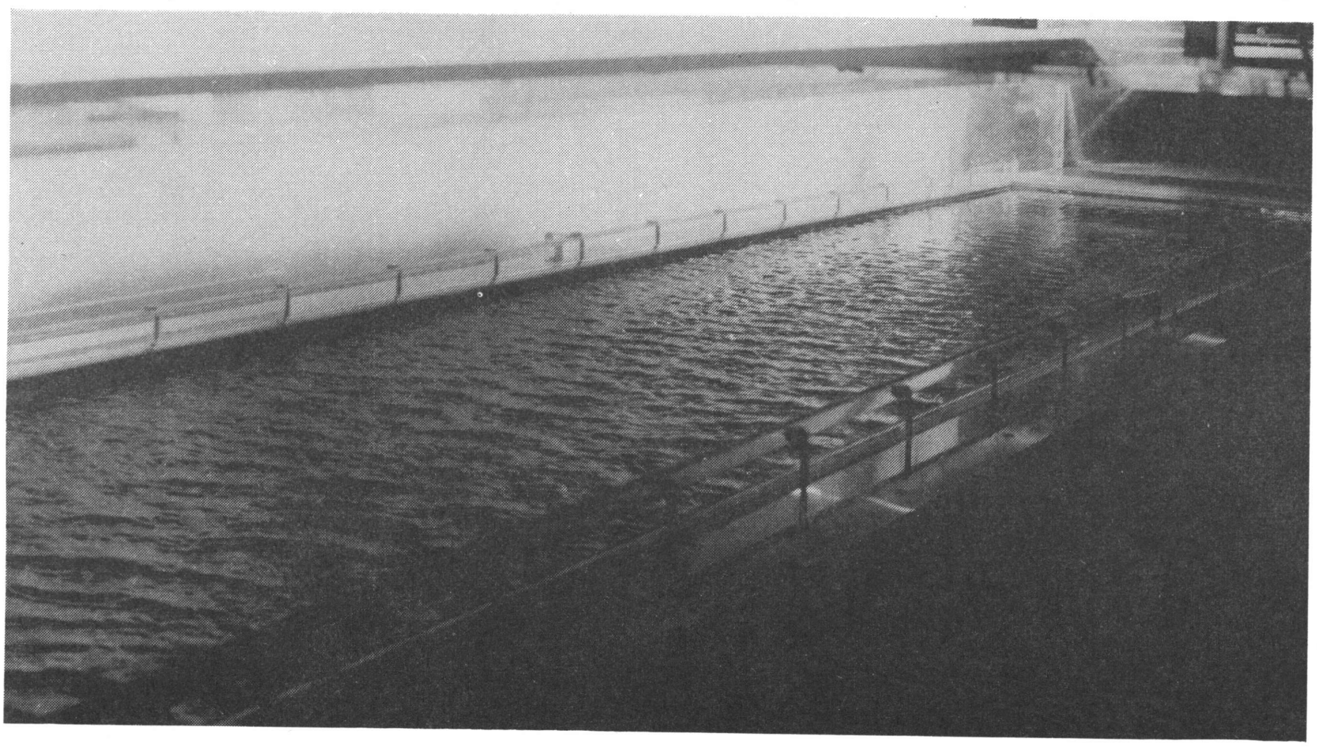


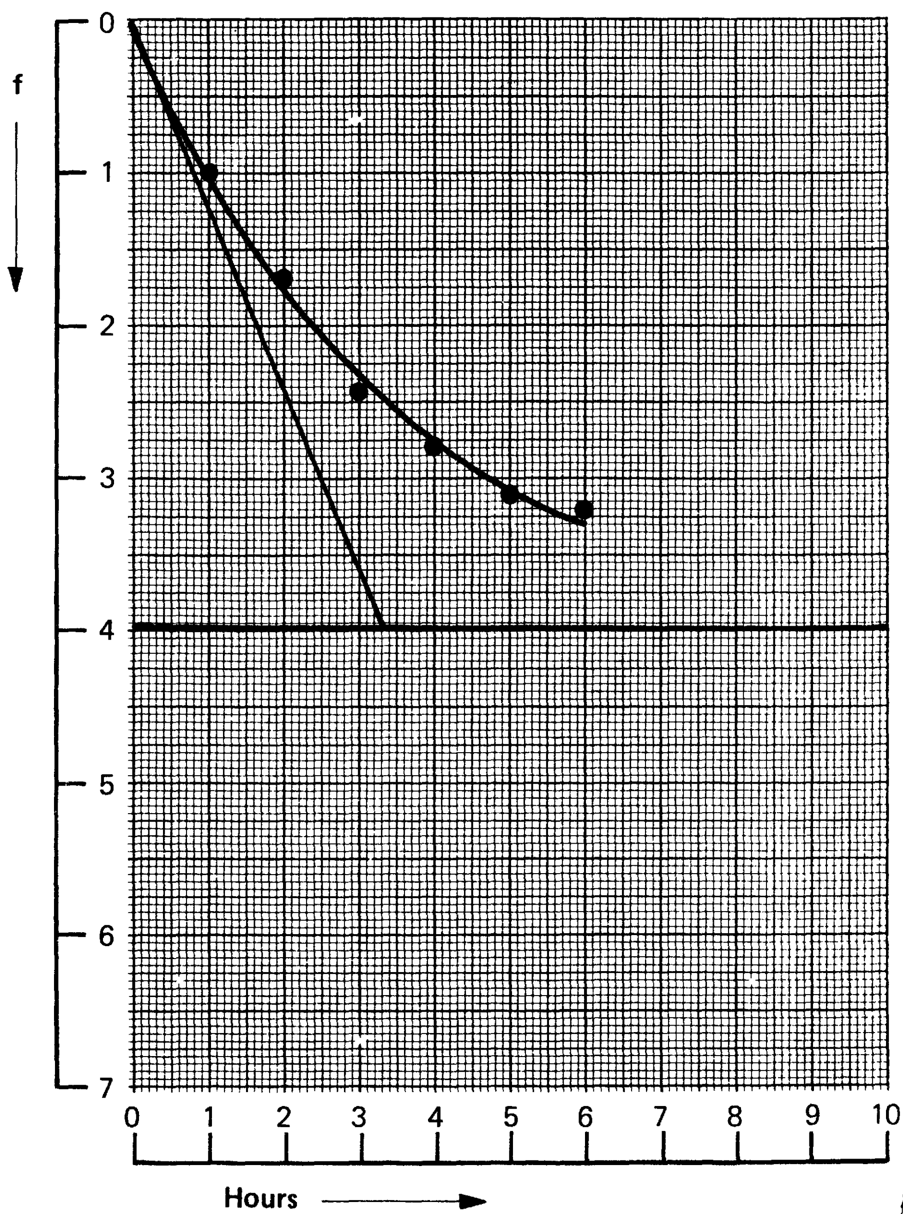
PHOTO 4

Curve Number : 25-11				Result Number : 1								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	6.87		0	6.75	14.72	14.67	0	0	α_T		16.20
ϵ	45	40.5	40	1	7.15	15.59	15.68	0.87	1.01	α_R		1.30
θ_A	27.50	27.50		2	7.50	16.35	16.43	1.63	1.76	$\Delta\alpha$		14.90
$\overline{\theta}_E$		16.30	16.31	3	7.85	17.11	16.99	2.39	2.32	$1 + t_g \beta t_g \delta$		2.95
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.48	4	8.00	17.44	17.41	2.72	2.74	α_c		5.05
$(\theta_E - \theta_{E_c})_0$			+0.05	5	8.15	17.77	17.73	3.05	3.06	σ	0.021156	
θ_F			17.88	6	8.20	17.88	17.96	3.16	3.29			
θ'_F			18.65	∞			18.65		3.98	f_∞	4.20	3.52

Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$

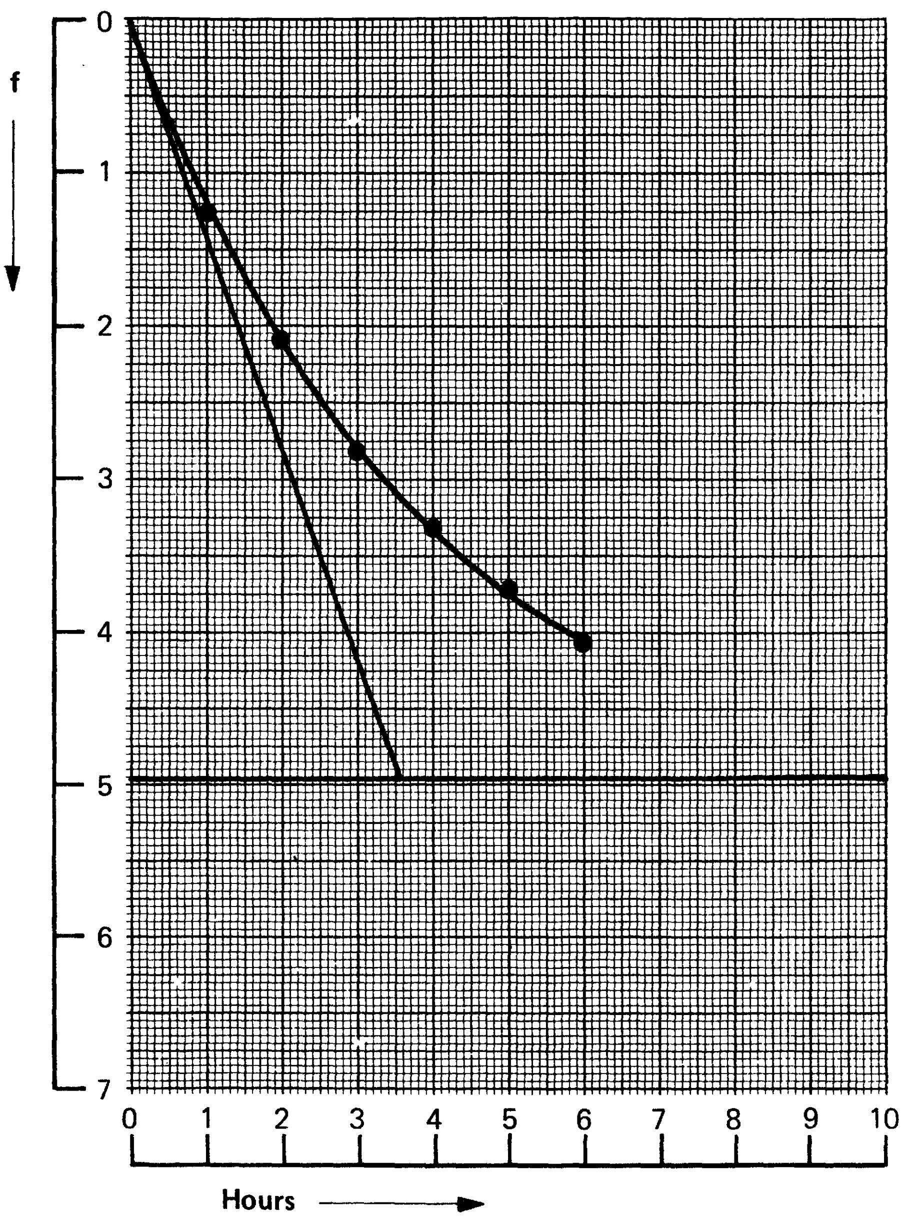


Curve Number : 38 - 67				Result Number : 2								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	6.97		0	8.73	19.03	19.00	0	0	α_T		15.62
ϵ	65	63	72	1	8.12	17.70	17.78	1.33	1.22	α_R		1.32
θ_A	18	17.3		2	7.75	16.90	16.86	2.13	2.13	$\Delta \alpha$		14.30
$\overline{\theta}_E$		16.98	16.98	3	7.42	16.18	16.17	2.85	2.83	$1 + t_g \beta t_g \delta$		2.75
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			15.52	4	7.19	15.67	15.65	3.36	3.35	α_c		5.21
$(\theta_E - \theta_{E_c})_0$			÷ 0.03	5	7.00	15.26	15.25	3.77	3.74	σ	0.02214	
θ_F			13.74	6	6.85	14.93	14.96	4.10	4.04			
θ'_F			14.04	∞			14.04		4.96	f_∞		5.07

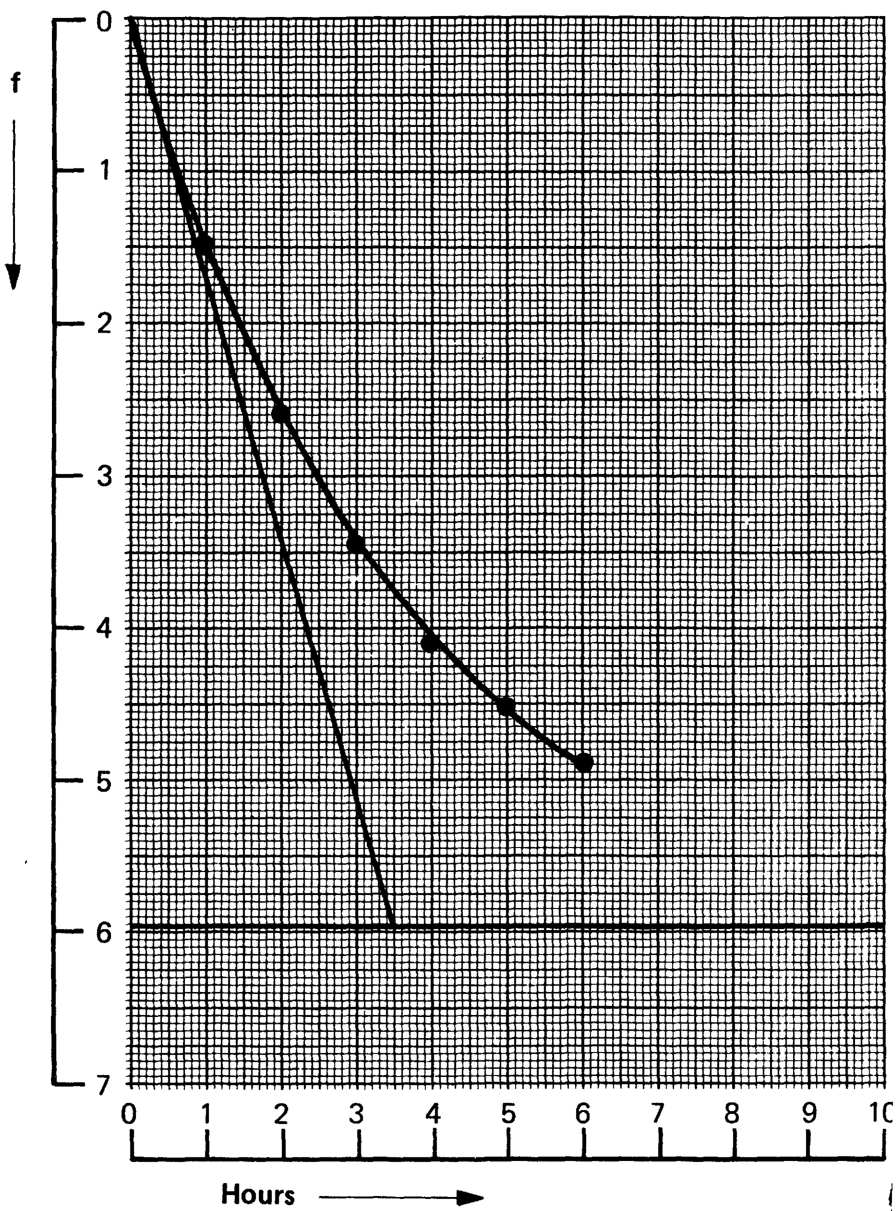
Remarks :

$\overline{\alpha}_c$ = 5

$\overline{\sigma}$ = 0.0208



Curve Number : 39-18				**Result Number :** 3								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	6.8		0	6.32	13.78	13.77	0	0	α_T	16.84	15.96
ϵ	65	65.50	70.00	1	7.00	15.26	15.26	1.48	1.49	α_R	1.30	1.30
θ_A	24	23.30		2	7.50	16.35	16.38	2.57	2.60	$\Delta\alpha$	15.54	14.66
$\overline{\theta}_E$		16.22		3	7.90	17.22	17.21	3.44	3.44	$1 + t_g \beta t_g \delta$		3.00
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.97	4	8.20	17.88	17.84	4.10	4.07	α_c	5.18	4.88
$(\theta_E - \theta_{E_c})_0$			+ 0.01	5	8.39	18.29	18.31	4.51	4.54	σ	0.01938	
θ_F			19.40	6	8.56	18.66	18.66	4.88	4.89			
θ'_F			19.73	∞					5.96	f_∞	5.83	5.92



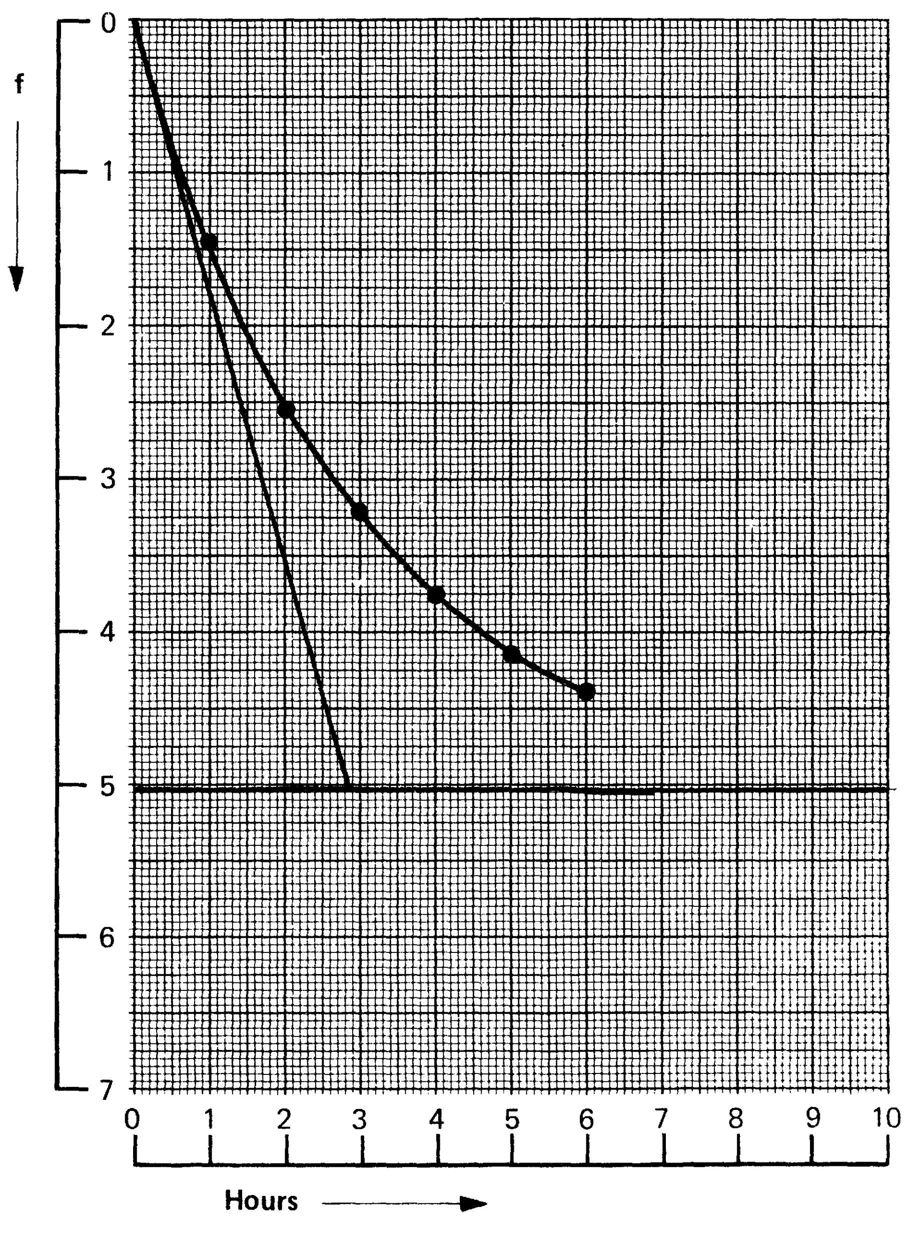
Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$

Curve Number : 40.19 **Result Number :** 4

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	6.78		0	8.60	18.75	18.74	0	0	α_T		19.30
ϵ	65	67	67	1	9.26	20.19	20.21	1.44	1.47	α_R		1.36
θ_A	29	28.40		2	9.76	21.28	21.25	2.53	2.51	$\Delta\alpha$		17.94
$\overline{\theta}_E$		20.93		3	10.07	21.95	21.99	3.20	3.25	$1 + t_g \beta t_g \delta$		3.53
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			22.34	4	10.34	22.54	22.51	3.79	3.77	α_c		5.09
$(\theta_E - \theta_{E_c})_0$			0.01	5	10.50	22.89	22.87	4.14	4.13	σ	0.02131	
θ_F			23.41	6	10.60	23.11	23.13	4.36	4.39			
θ'_F			23.76	∞					5.02	f_∞		5.02



Remarks :

$\overline{\alpha}_c$ = 5

$\overline{\sigma}$ = 0.0208

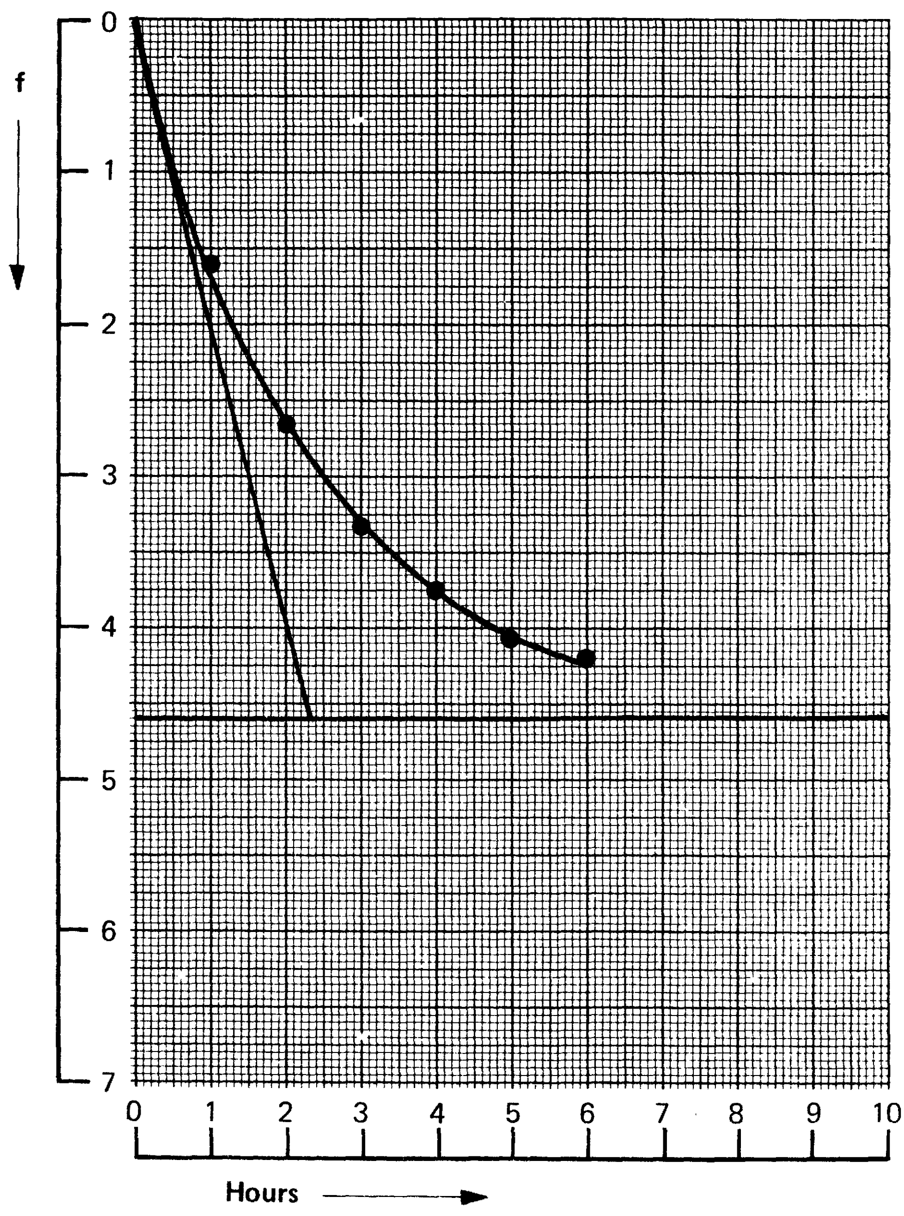
Curve Number : 41-20 **Result Number :** 5

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	6.70		0	11.58	25.24	25.23	0	0	α_T		23.71
ϵ	65	68.50	65	1	12.30	26.81	26.83	1.57	1.60	α_R		1.44
θ_A	35	35.35		2	12.78	27.86	27.87	2.62	2.64	$\Delta\alpha$		22.27
$\overline{\theta}_E$		27.33		3	13.10	28.56	28.55	3.32	3.32	$1 + t_g \beta t_g \delta$		4.43
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			28.57	4	13.30	28.99	28.99	3.75	3.76	α_c		5.03
$(\theta_E - \theta_{E_c})_0$			-0.01	5	13.45	29.32	29.28	4.08	4.05	σ	0.02098	
θ_F			29.46	6	13.50	29.43	29.47	4.19	4.24			
θ'_F			29.82	∞					4.59	f_∞		4.50

Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$

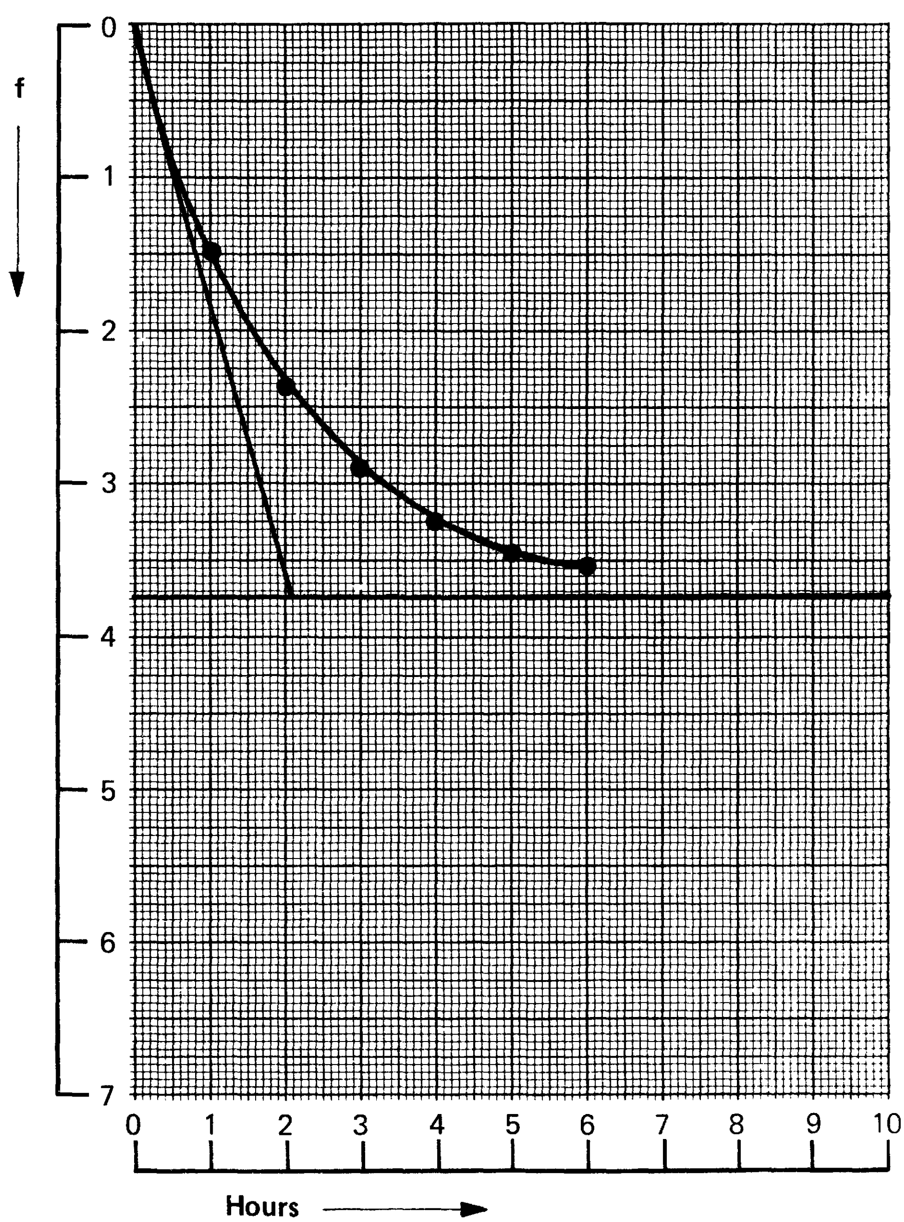


Curve Number : 42				**Result Number :** 6								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	6.6		0	12.68	27.64	27.64	0	0	α_T	20.23	
ϵ	65	67	67	1	12.01	26.18	26.18	1.46	1.46	α_R	1.41	
θ_A	29	28.5		2	11.60	25.29	25.29	2.35	2.35	$\Delta\alpha$	18.82	
$\overline{\theta}_E$		25.86		3	11.35	24.73	24.71	2.91	2.89	$1 + t_g \beta \, t_g \delta$		3.75
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			24.89	4	11.20	24.42	24.42	3.22	3.22	α_c	5.07	
$(\theta_E - \theta_{E_c})_0$			0	5	11.10	24.20	24.18	3.44	3.42	σ	0.02094	
θ_F			23.66	6	11.05	24.09	24.08	3.55	3.54			
θ'_F			23.91	∞					3.73	f_∞	3.73	

Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$

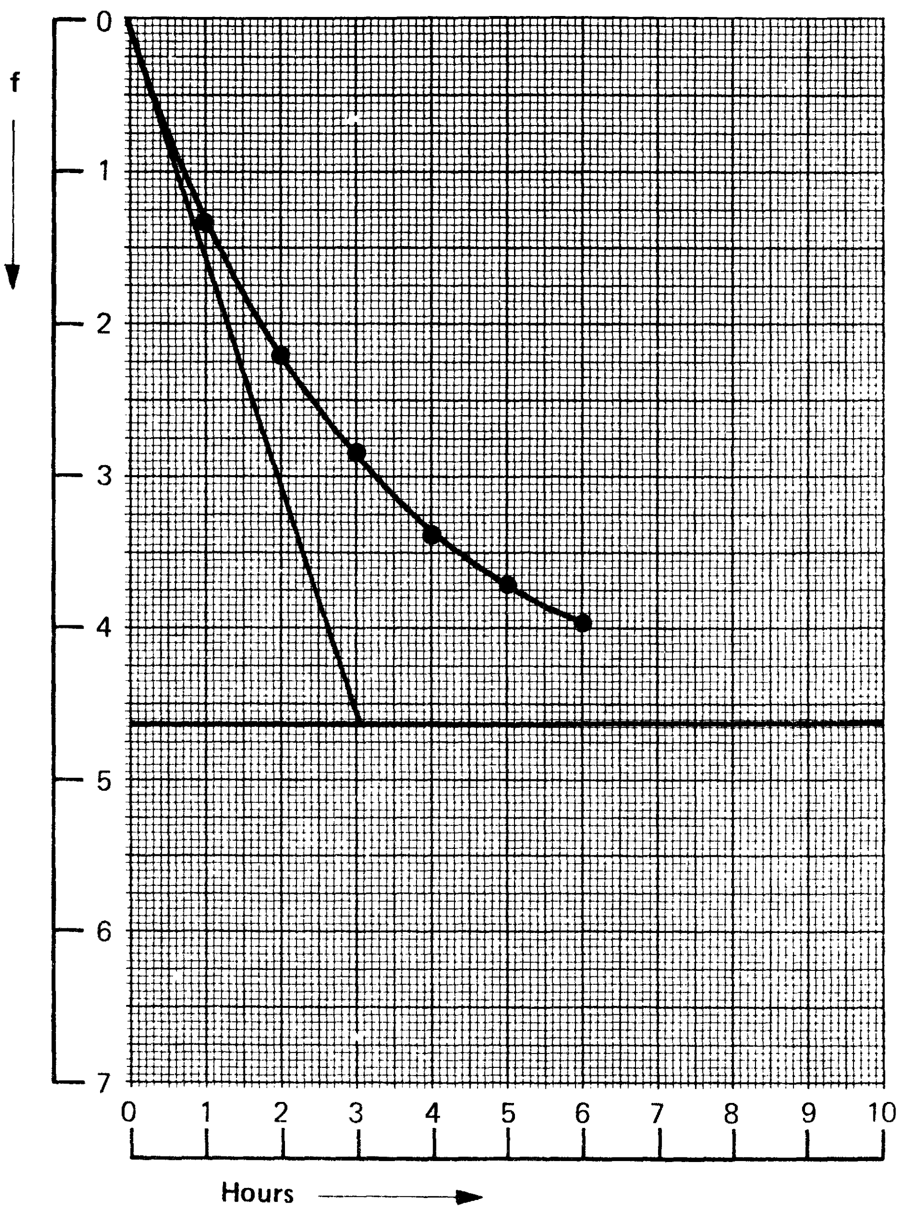


Curve Number : 43 - 68				Result Number : 7								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	6.87		0	10.75	23.44	23.43	0	0	α_T		17.91
ϵ	65	68.6	63.5	1	10.15	22.13	22.16	1.31	1.27	α_R		1.37
θ_A	24.0	23.50		2	9.74	21.23	21.23	2.21	2.20	$\Delta\alpha$		16.54
$\overline{\theta}_E$		21.45		3	9.45	20.60	20.56	2.84	2.87	$1 + t_g\beta\, t_g\delta$		3.25
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			20.13	4	9.20	20.06	20.08	3.38	3.35	α_c		5.09
$(\theta_E - \theta_{E_c})_0$			+ 0.01	5	9.05	19.73	19.73	3.71	3.70	σ	0.02137	
θ_F			18.41	6	8.93	19.47	19.47	3.97	3.96			
θ'_F			18.81	∞			18.81		4.63	f_∞	4.72	4.75

Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.00208$

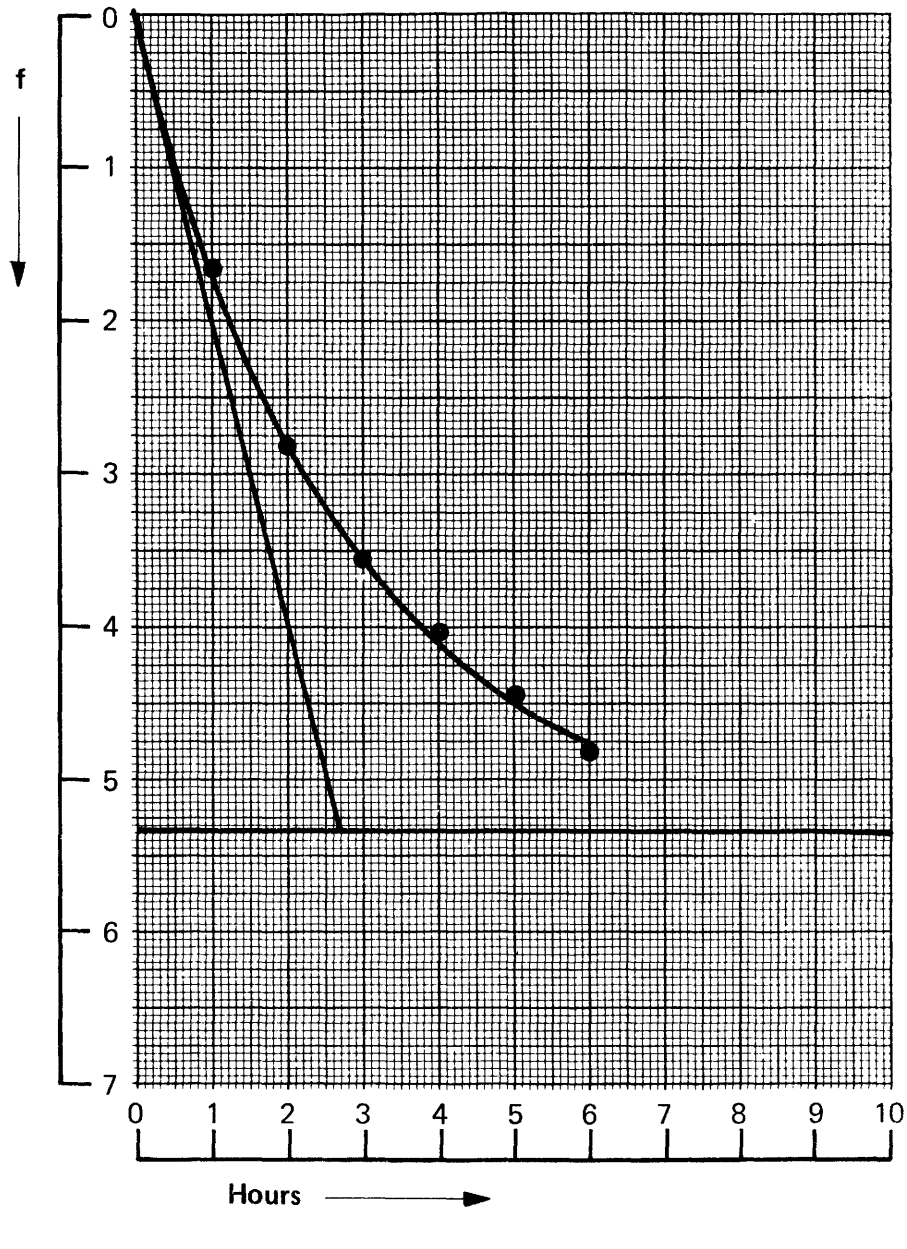


Curve Number : 44 - 69				Result Number : 8								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7.00	7.00		0	12.98	28.30	28.27	0	0	α_T		20.29
ϵ	90	91	86	1	12.20	26.60	26.64	1.70	1.66	α_R		1.423
θ_A	25.5	24.7		2	11.67	25.44	25.51	2.86	2.79	$\Delta\alpha$		18.87
$\overline{\theta}_E$		25.87		3	11.36	24.76	24.72	3.54	3.58	$1 + t_g \beta t_g \delta$		3.80
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			24.40	4	11.13	24.26	24.18	4.04	4.13	α_c		4.96
$(\theta_E - \theta_{E_c})_0$			- 0.03	5	10.94	23.85	23.80	4.45	4.48	σ	0.02064	
θ_F			22.81	6	10.75	23.44	23.54	4.86	4.76			
θ'_F			22.94	∞			22.94		5.33	f_∞		5.64

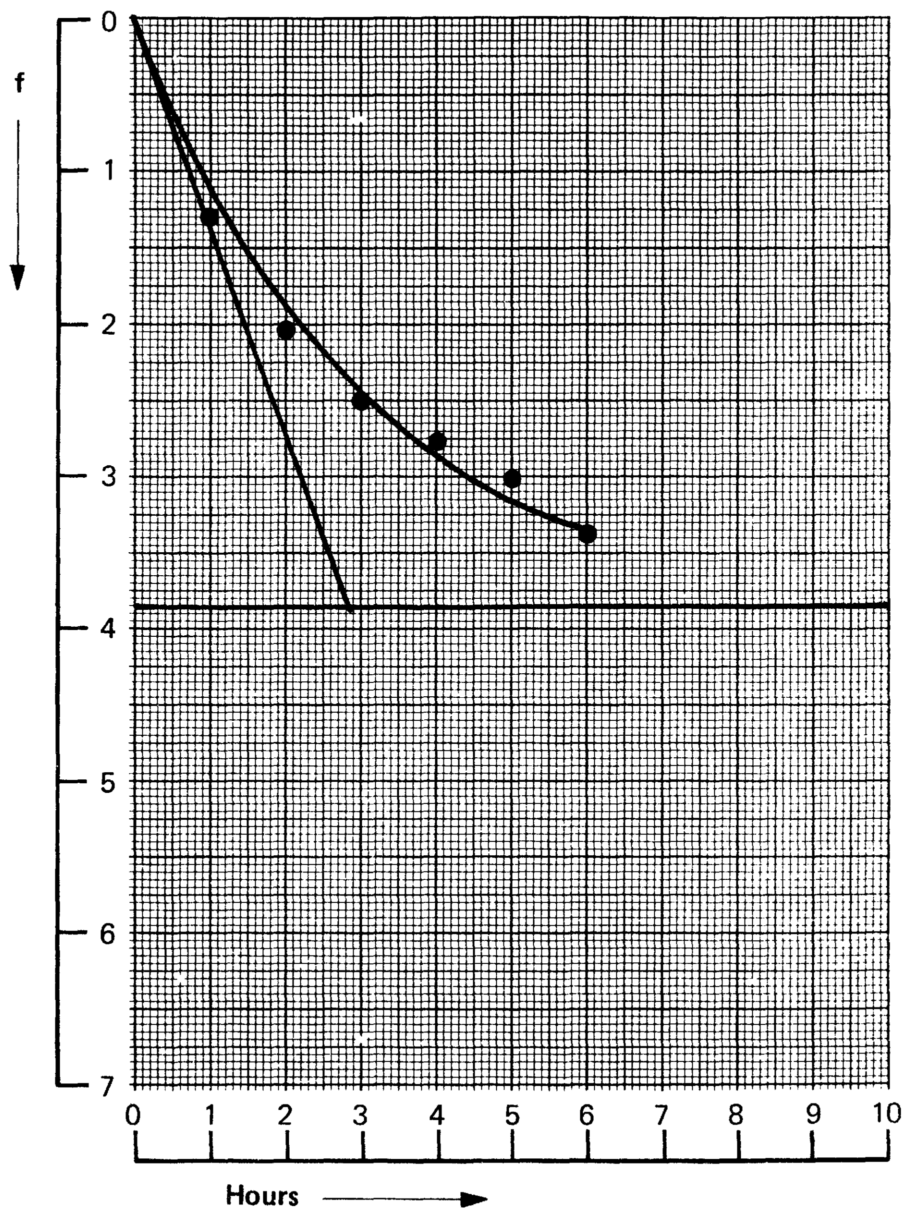
Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$



Curve Number : 45				**Result Number :** 9								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7.2		0	10.40	22.67	22.67	0	0	α_T		18.95
ϵ	90	86	87	1	9.80	21.36	21.56	1.31	1.11	α_R		1.35
θ_A	20	20.25		2	9.47	20.64	20.77	2.03	1.90	$\Delta\alpha$		17.60
$\overline{\theta}_E$		20.98		3	9.25	20.17	20.20	2.50	2.47	$1 + t_g \beta\, t_g \delta$		3.25
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			19.90	4	9.13	19.90	19.80	2.77	2.87	α_c		5.42
$(\theta_E - \theta_{E_c})_0$			0	5	9.02	19.66		3.01		σ	0.02333	
θ_F			18.71	6	8.85	19.29		3.38				
θ'_F			18.82	∞						f_∞		3.85

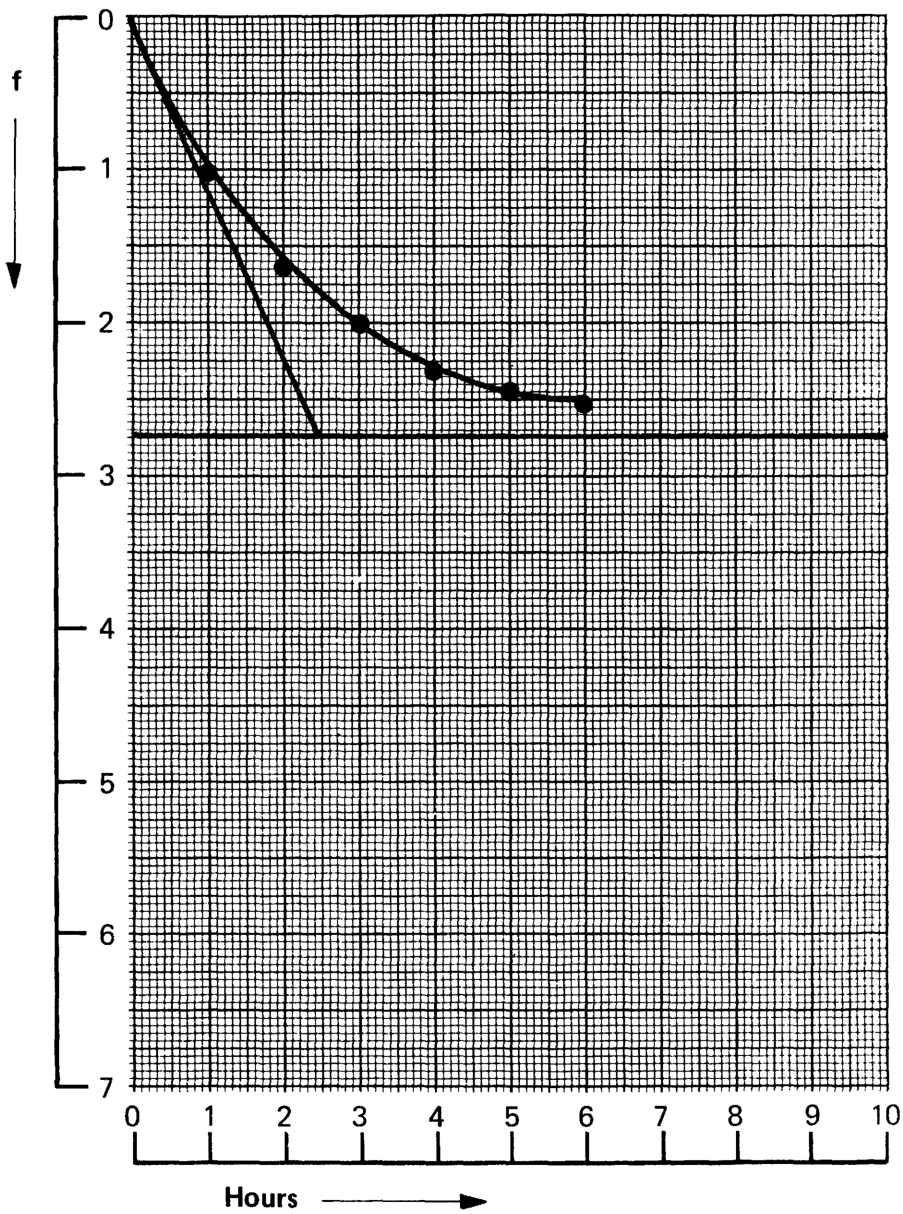


Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$

Curve Number : 48				**Result Number :** 10								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7.22		0	9.38	20.45	20.44	0	0	α_T		24.20
ϵ	90	86.5	87	1	9.85	21.47	21.40	1.02	0.96	α_R		1.35
θ_A	25	25		2	10.14	22.11	22.03	1.66	1.59	$\Delta\alpha$		22.85
$\overline{\theta}_E$		21.71		3	10.30	22.45	22.43	2.00	1.99	$1 + t_g \beta t_g \delta$		3.6
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			22.44	4	10.45	22.78	22.69	2.33	2.25	α_c		6.35
$(\theta_E - \theta_{E_c})_0$			0.01	5	10.51	22.91	22.86	2.46	2.42	σ	0.02611	
θ_F			23.06	6	10.54	22.98	22.97	2.53	2.53			
θ'_F			23.17	∞					2.73	f_∞		2.72



Remarks :

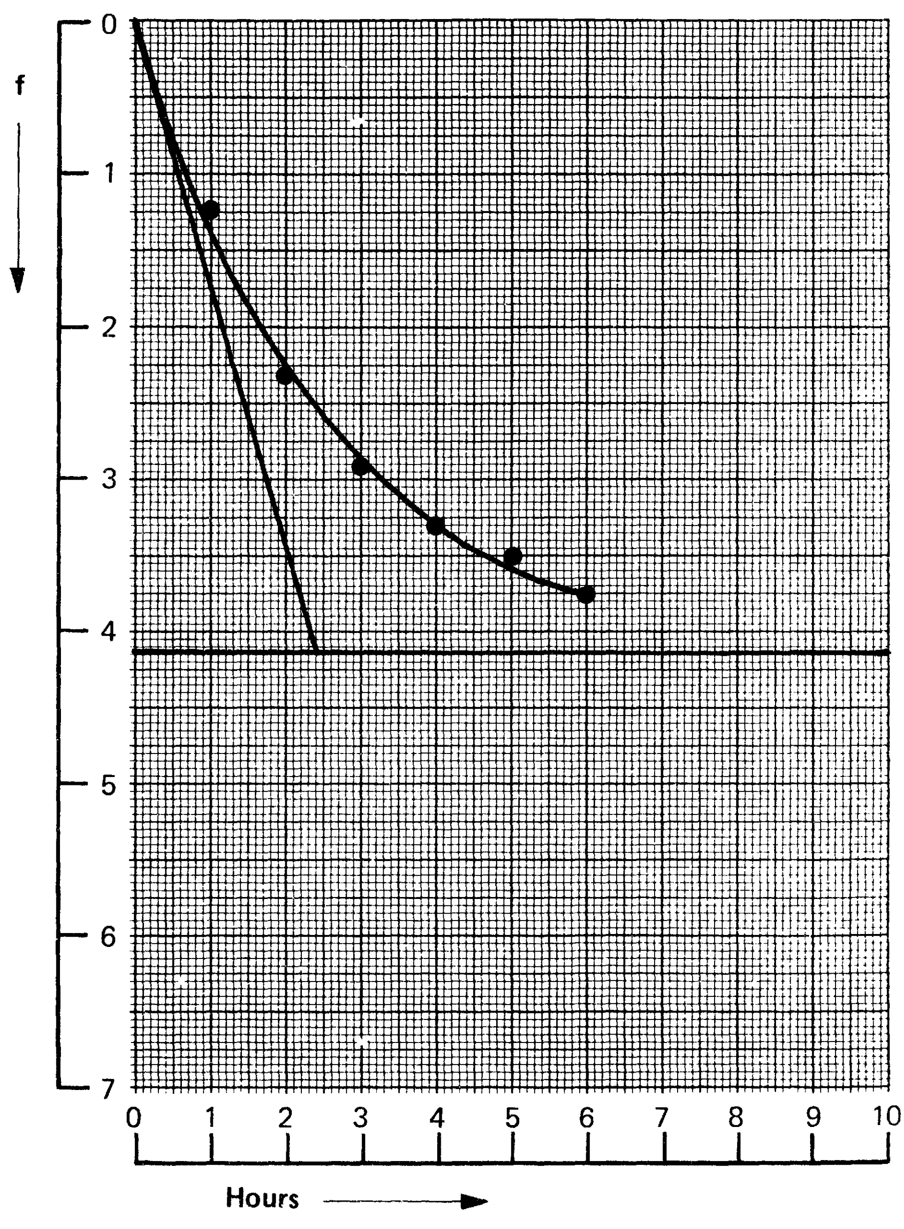
$\overline{\alpha}_c$ = 6.75

$\overline{\sigma}$ = 0.02857

Curve Number : 49.-21

Result Number : 11

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7.12		0	11.45	24.96	24.92	0	0	α_T		22.32
ϵ	90	88	90	1	12.00	26.16	25.28	1.20	1.36	α_R		1.44
θ_A	30.5	30.5		2	12.50	27.25	27.19	2.29	2.27	$\Delta\alpha$		20.88
$\overline{\theta}_E$		26.82		3	12.78	27.86	27.30	2.90	2.89	$1 + t_g\beta\, t_g\delta$		4.33
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			27.93	4	12.95	28.23	·28.21	3.27	3.29	α_c		4.83
$(\theta_E - \theta_{E_c})_0$			+0.04	5	13.04	28.43	28.49	3.47	3.57	σ	0.01987	
θ_F			28.94	6	13.15	28.67	28.67	3.71	3.75			
θ'_F			29.04	∞			29.04		4.12	f_∞		4.02



Remarks :

$\overline{\alpha}_c = 5$

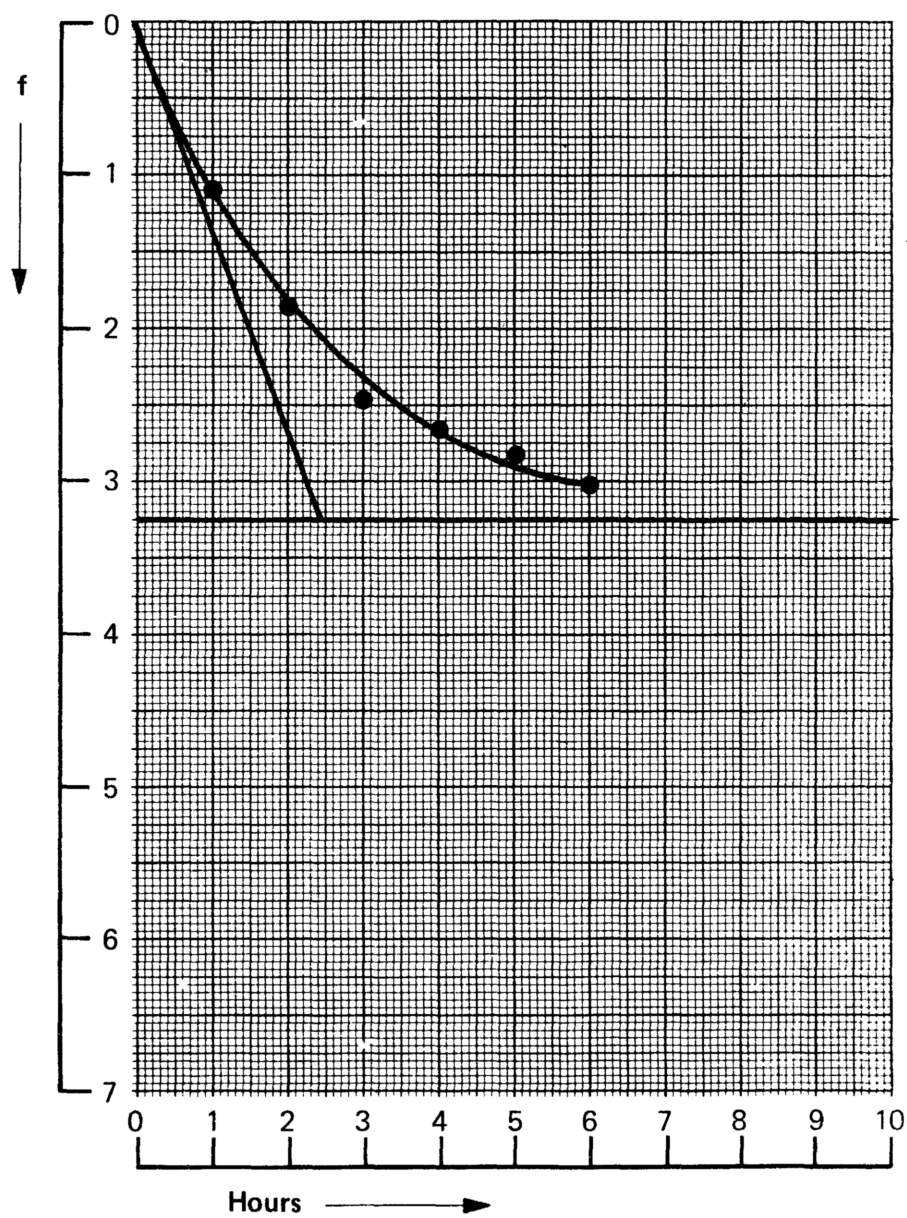
$\overline{\sigma} = 0.0208$

Curve Number : 51				Result Number : 12								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7		0	10.29	22.43	22.43	0	0	α_T		23.75
ϵ	90	90	92.5	1	9.78	21.32	21.30	1.11	1.13	α_R		1.33
θ_A		20		2	9.43	20.56	20.56	1.87	1.87	$\Delta \alpha$		22.42
$\overline{\theta}_E$		20.91		3	9.15	19.95	20.08	2.48	2.35	$1 + t_g \beta t_g \delta$		3.25
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			20.05	4	9.08	19.79	19.77	2.64	2.66	α_c		6.90
$(\theta_E - \theta_{E_c})_0$			0	5	9.00	19.62	19.56	2.81	2.87	σ	0.02937	
θ_F			19.08	6	8.90	19.40	19.43	3.03	3.00			
θ'_F			19.18	∞						f_∞		3.25

Remarks :

$\overline{\alpha}_c = 6.75$

$\overline{\sigma} = 0.02857$



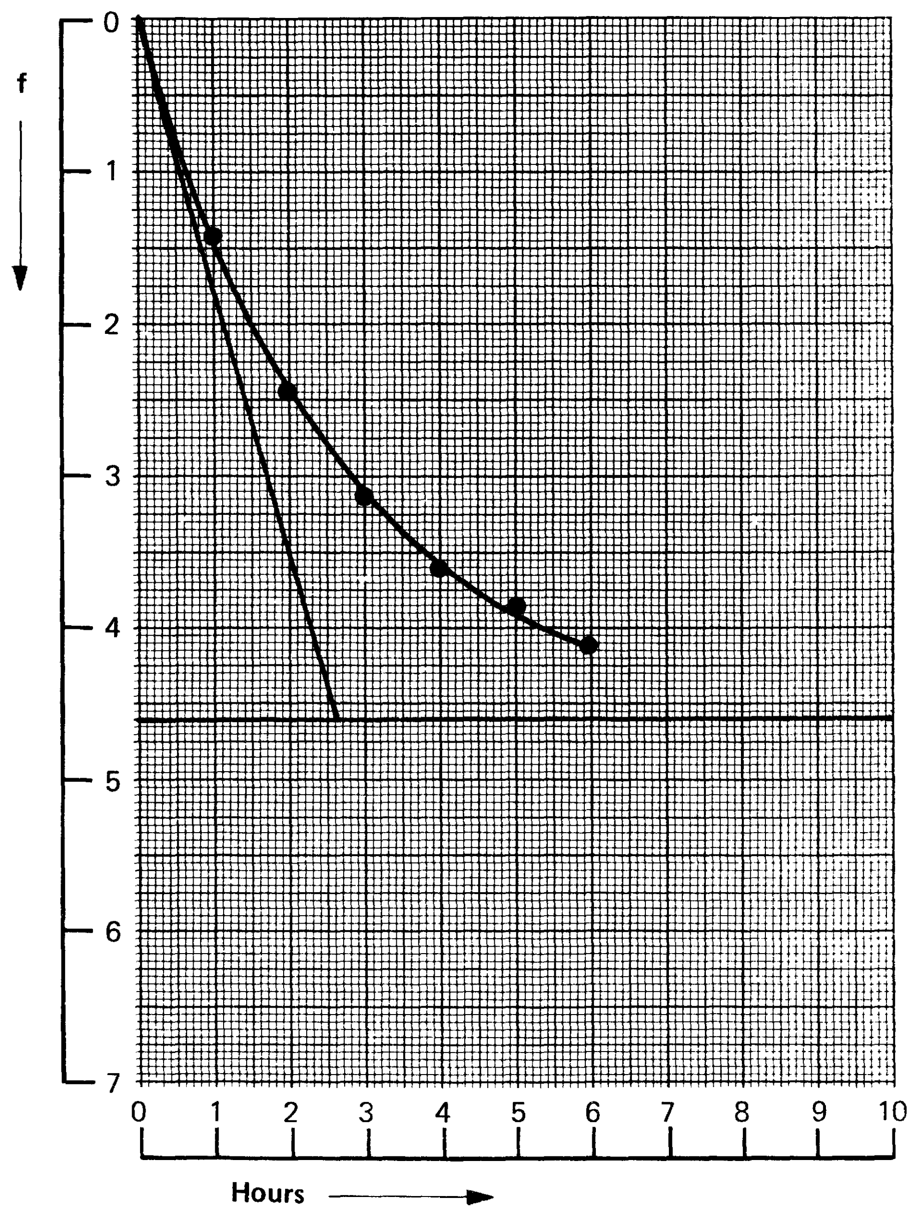
Curve Number : 52-22 **Result Number :** 13

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7.2		0	6.50	14.17	14.16	0	0	α_T		20.99
ϵ	65	61	62	1	7.15	15.59	15.61	1.42	1.45	α_R		1.31
θ_A	23.70	23.75		2	7.62	16.61	16.60	2.44	2.44	$\Delta\alpha$		19.68
$\overline{\theta}_E$		16.23		3	7.93	17.29	17.28	3.12	3.12	$1 + t_g \beta t_g \delta$		2.96
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.5	4	8.15	17.77	17.75	3.60	3.59	α_c		6.67
$(\theta_E - \theta_{E_c})_0$			+0.01	5	8.27	18.03	18.07	3.86	3.90	σ	0.02789	
θ_F			18.43	6	8.39	18.30	18.29	4.13	4.12			
θ'_F			18 77	∞			18.77		4.60	f_∞		4.61

Remarks :

$\overline{\alpha}_c$ = 6.75

$\overline{\sigma}$ = 0.02857

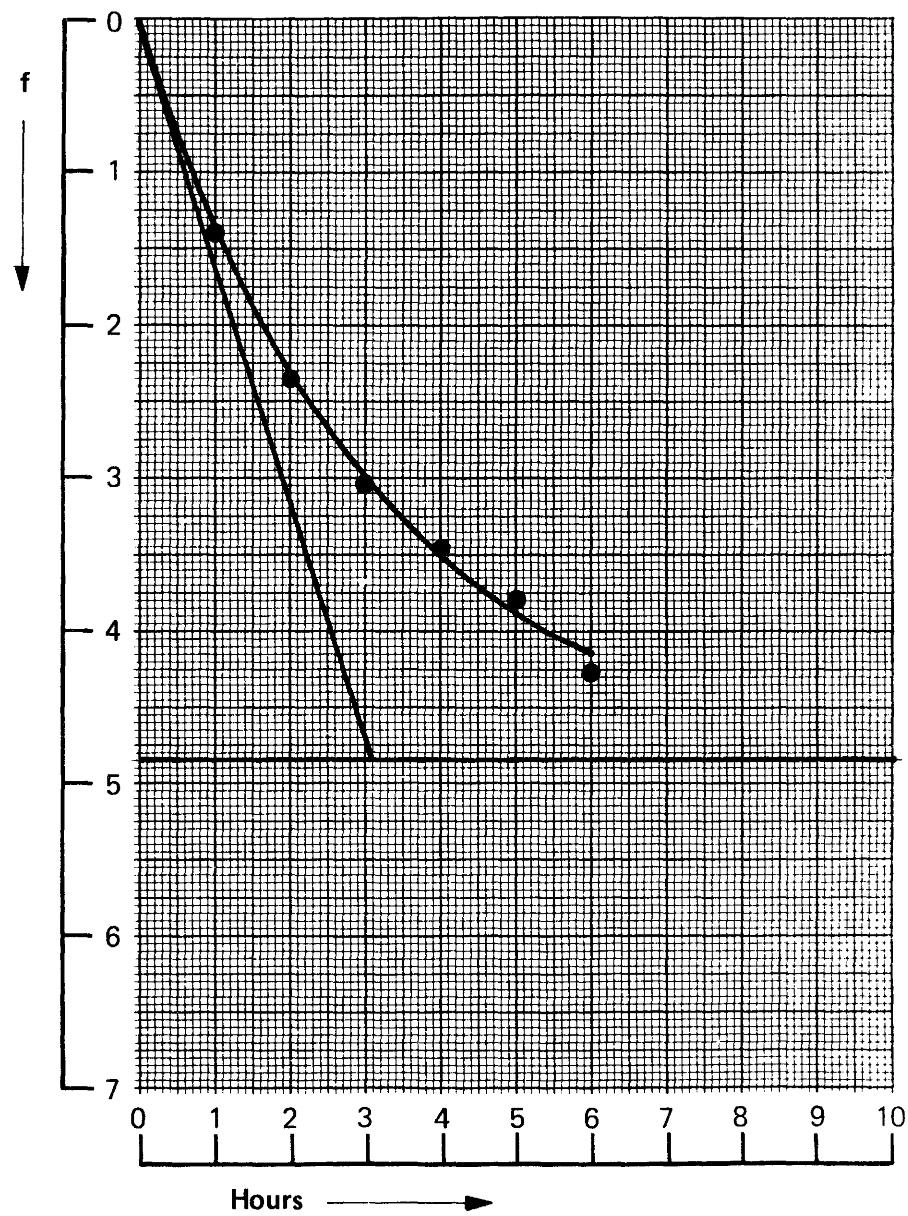


Curve Number : 54 - 23				Result Number : 14								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7.00	7.20		0	8.40	18.31	18.34	0	0	α_T		17.95
ϵ	65	61	65	1	9.05	19.73	19.68	1.42	1.34	α_R		1.36
θ_A	29.5	28		2	9.49	20.69	20.65	2.38	2.31	$\Delta \alpha$		16.59
$\overline{\theta}_E$		20.46		3	9.80	21.36	21.35	3.05	3.01	$1 + t_g \beta t_g \delta$		3.46
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			21.82	4	9.99	21.78	21.86	3.47	3.52	α_c		4.80
$(\theta_E - \theta_{E_c})_0$			- 0.03	5	10.15	22.13	22.23	3.82	3.88	σ	0.01971	
θ_F			22.80	6	10.37	22.61	22.49	4.30	4.15			
θ'_F			23.19	∞			23.19		4.85	f_∞		5.17

Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$

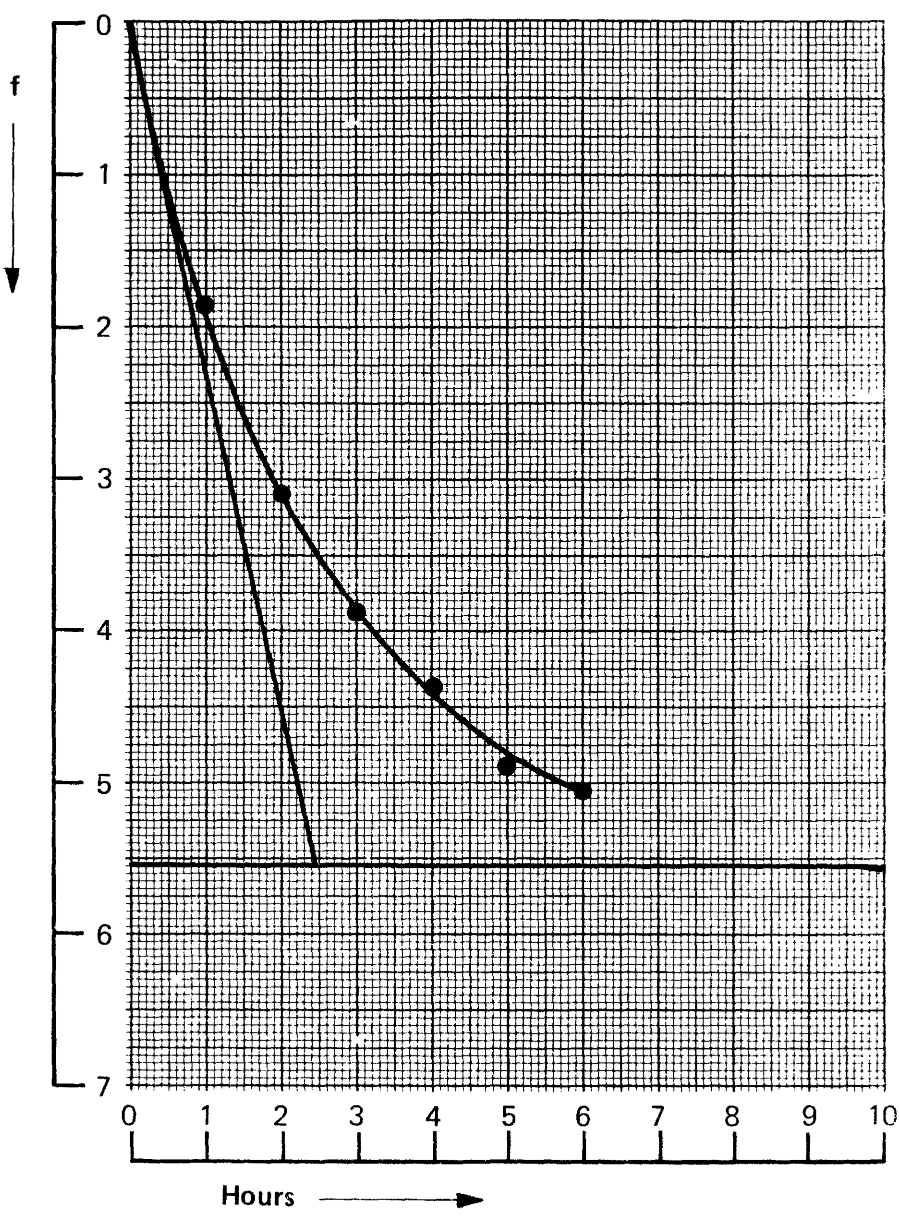


Curve Number : 55 - 24				Result Number : 15								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7.05		0	10.65	23.22	23.22	0	0	α_T	22.22	22.30
ϵ	65	66	66	1	11.50	25.07	25.06	1.85	1.84	α_R	1.40	1.40
θ_A		34.3		2	12.10	26.38	26.28	3.16	3.06	$\Delta\alpha$	20.82	20.90
$\overline{\theta}_E$		25.75		3	12.43	27.10	27.11	3.88	3.89	$1 + t_g \beta t_g \delta$		4.25
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			27.26	4	12.66	27.60	27.66	4.38	4.44	α_c	4.90	4.92
$(\theta_E - \theta_{E_c})_0$			0	5	12.90	28.12	28.02	4.90	4.80	σ	0.02038	
θ_F			28.40	6	12.97	28.27	28.27	5.05	5.05			
θ'_F			28.77	∞			28.77		5.53	f_∞	5.45	5.55

Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$

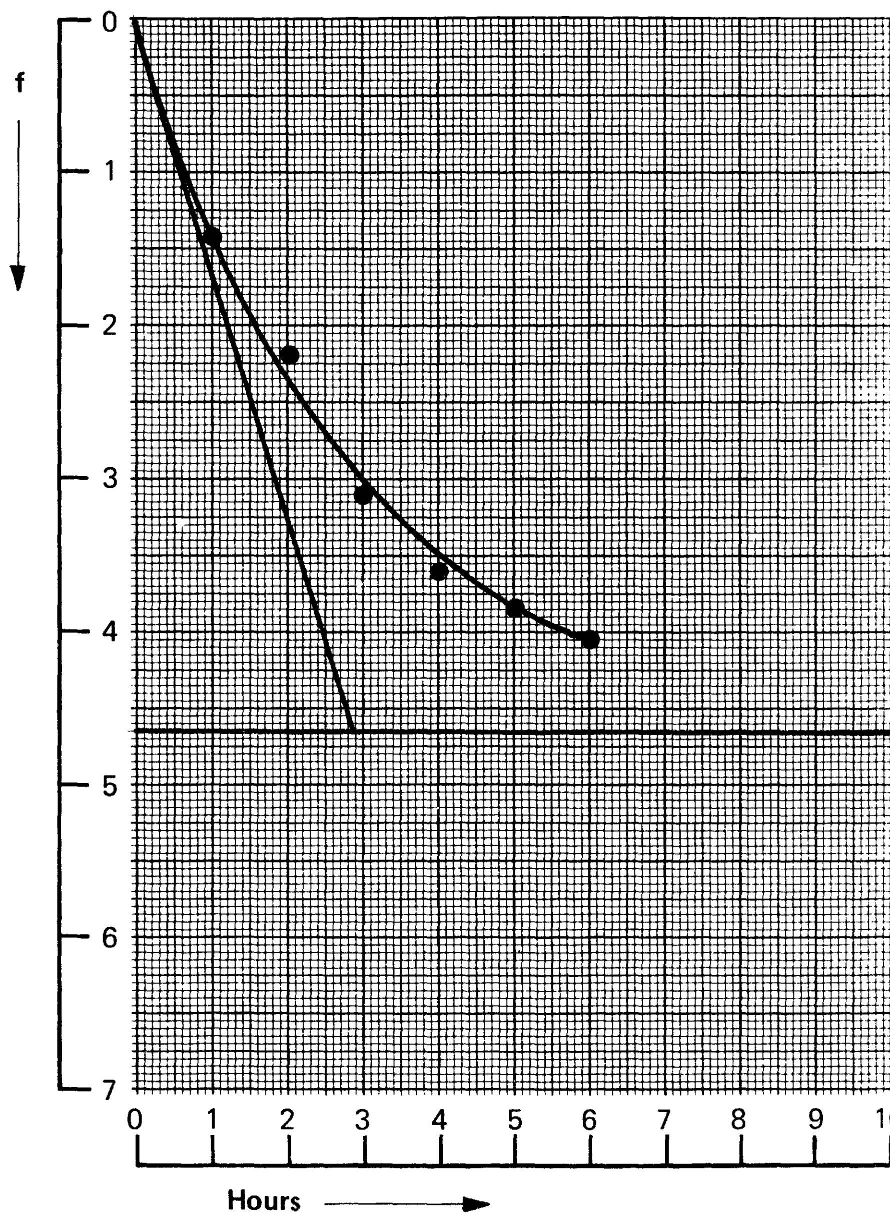


Curve Number : 56 - 70				Result Number : 16								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7.20		0		26.45	26.48	0	0	α_T		19.24
ϵ	65	64	64	1		25.07	25.11	1.40	1.36	α_R		1.41
θ_A	29	26.7		2		24.31	24.15	2.16	2.33	$\Delta\alpha$		17.83
$\overline{\theta}_E$		24.45		3		23.39	23.47	3.08	3.01	$1 + t_g \beta t_g \delta$		3.63
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			23.14	4		22.89	22.99	3.58	3.49	α_c		4.91
$(\theta_E - \theta_{E_c})_0$			-0.03	5		22.67	22.65	3.80	3.83	σ	0.02033	
θ_F			21.44	6		22.45	22.41	4.02	4.07			
θ'_F			21.83	∞			21.83		4.65	f_∞		4.43

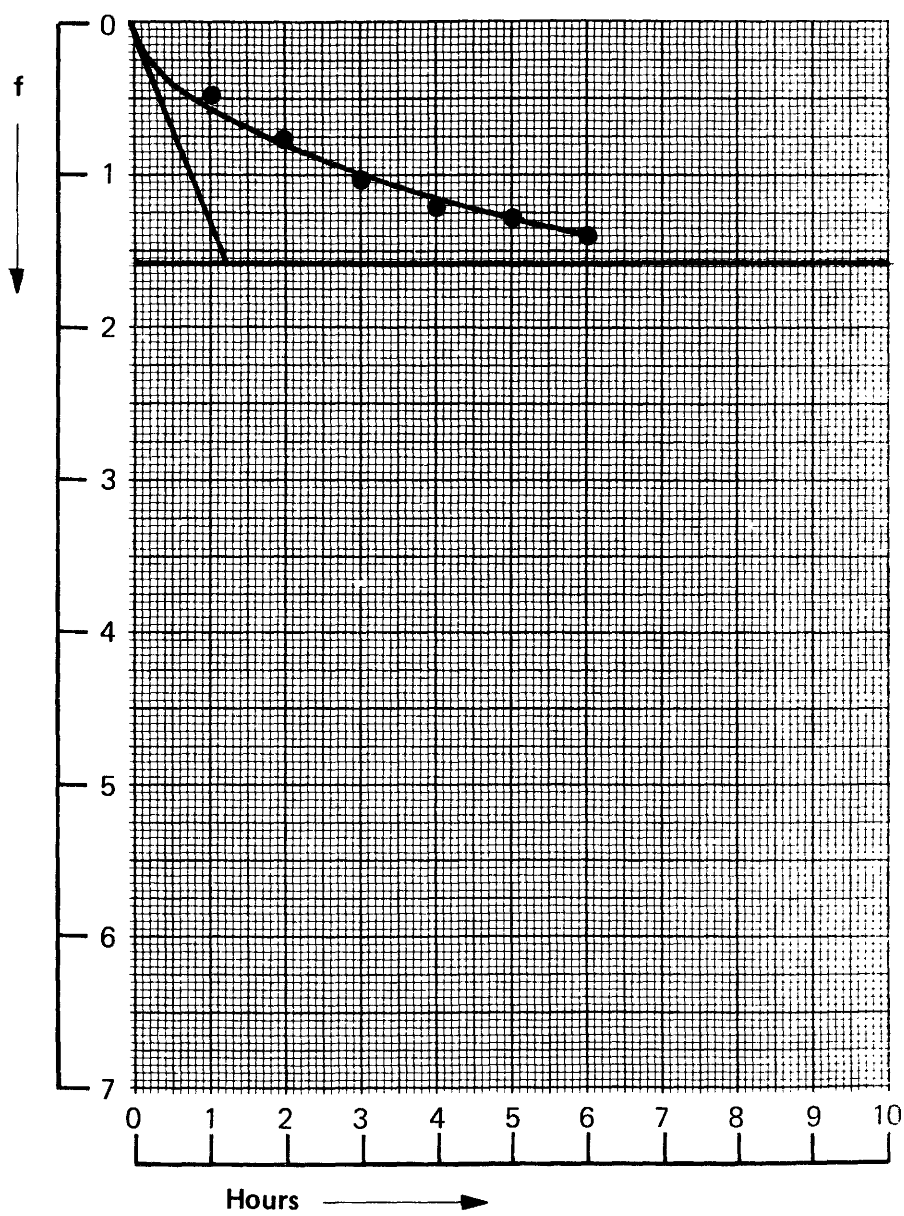
Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$



Curve Number : 58				**Result Number :** 17								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7.1		0	7.36	16.04		0	0	α_T		19.56
ϵ	65	62.5	67	1	7.16	15.61		0.41	0.47	α_R		1.28
θ_A	18.5	18.3		2	7.00	15.26		0.78	0.79	$\Delta\alpha$		18.28
$\overline{\theta}_E$		15.35		3	6.89	15.02		1.02	1.02	$1 + t_g \beta t_g \delta$		2.7
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			14.91	4	6.79	14.80		1.24	1.19	α_c		6.77
$(\theta_E - \theta_{E_c})_0$			0	5	6.76	14.74		1.30	1.30	σ	0.02873	
θ_F			14.20	6	6.73	14.67		1.37	1.38			
θ'_F			14.47	∞						f_∞		1.57

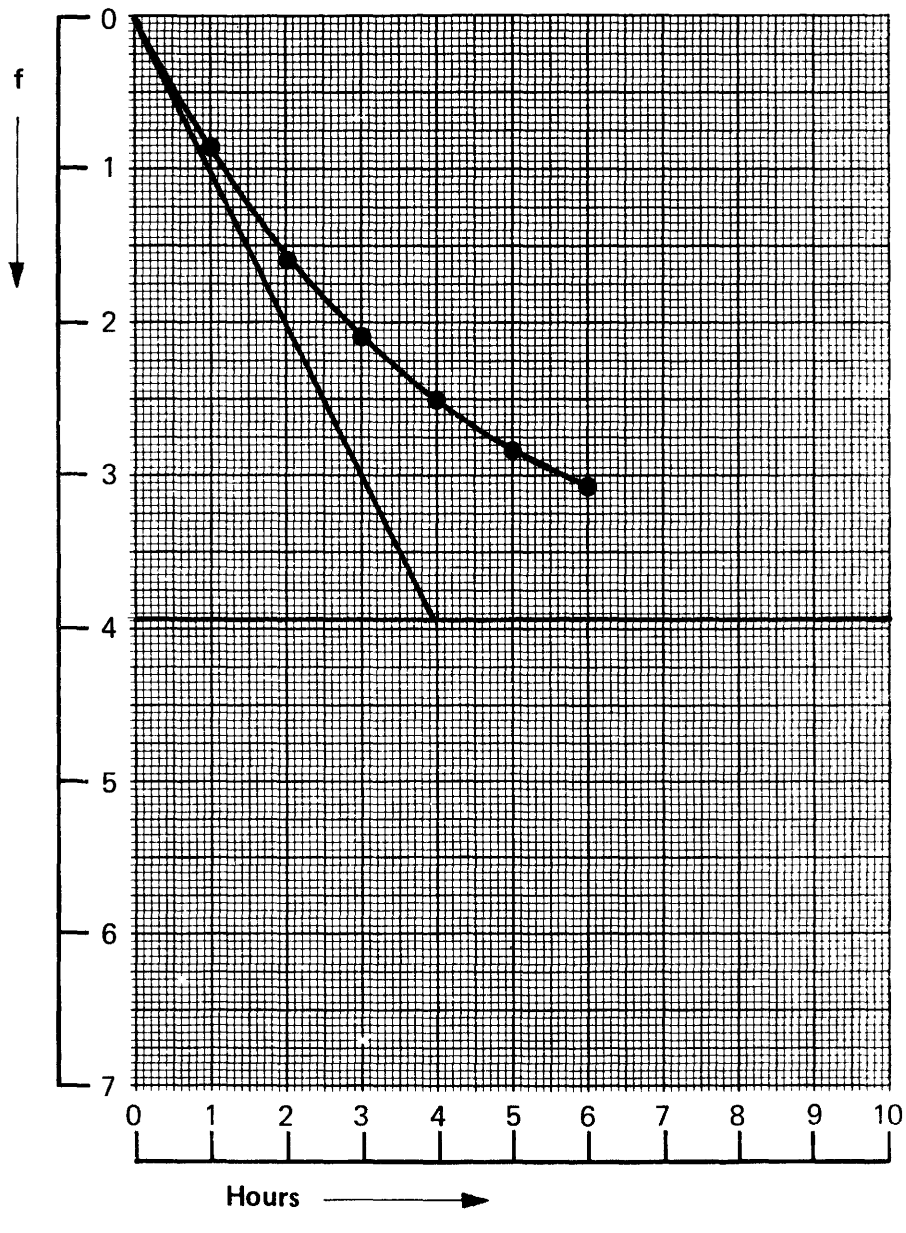


Remarks :

$\overline{\alpha}_c$ = 6.75

$\overline{\sigma}$ = 0.02857

Curve Number : *60 - 25*				**Result Number :** *18*								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7.05	7		0		10.36	10.37	0	0	α_T		14.15
ϵ	45	47	46	1		11.25	11.25	0.89	0.88	α_R		1.25
θ_A	22	21.25		2		11.97	11.93	1.61	1.56	$\Delta\alpha$		12.90
$\overline{\theta_E}$		11.90		3		12.43	12.46	2.07	2.09	$1 + t_g\beta t_g\delta$		2.51
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			13.10	4		12.86	12.87	2.50	2.51	α_c		5.13
$(\theta_E - \theta_{E_c})_0$			- 0.01	5		13.19	13.19	2.83	2.82	σ	0.02180	
θ_F			13.62	6		13.45	13.44	3.09	3.07			
θ'_F			14.29	∞			14.29		3.92	f_∞		4.08



Remarks :

$\overline{\alpha_c}$ = 5

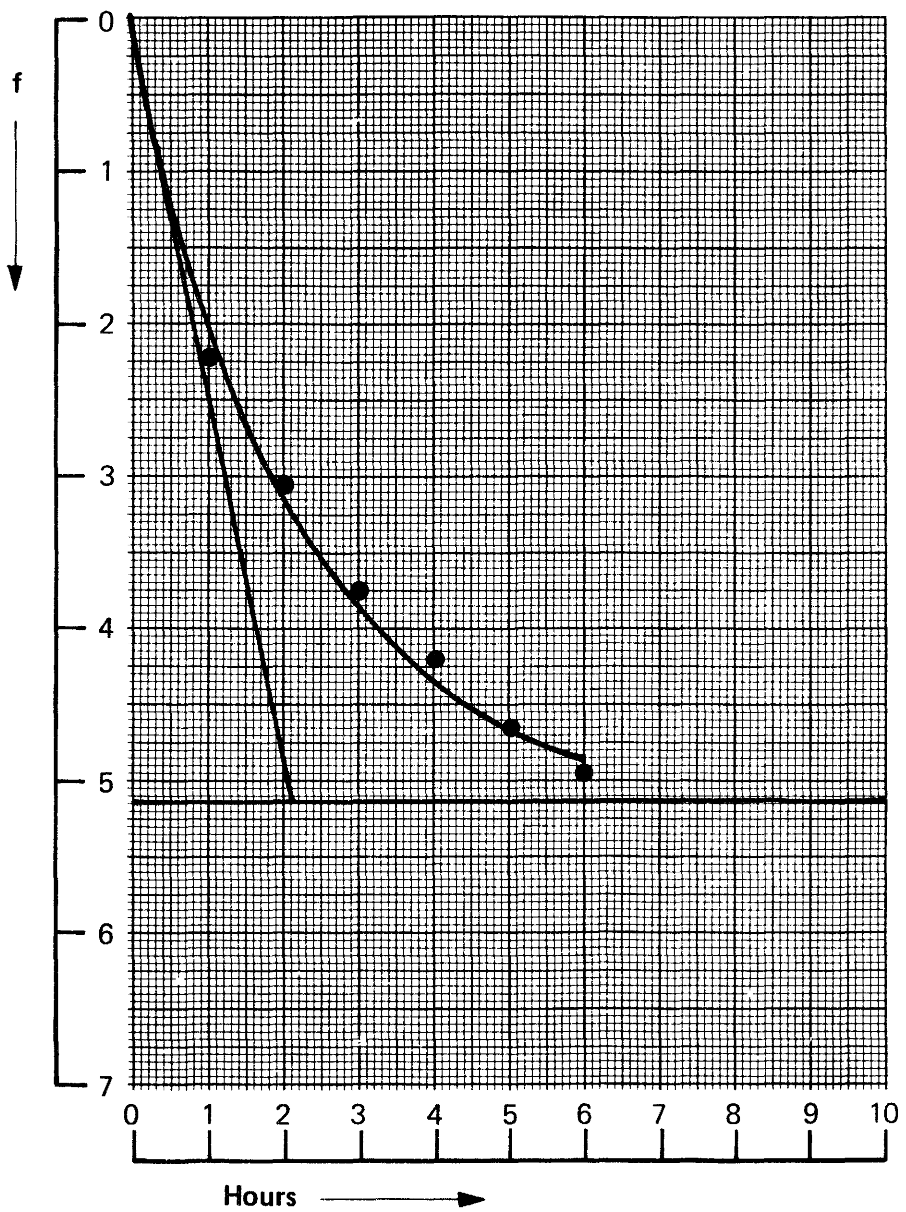
$\overline{\sigma}$ = 0.0208

Curve Number : 61-26				Result Number : 19								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7		0	6.22	13.56	13.67	0	0	α_T		26.30
ϵ	45	48.5	43	1	7.29	15.89	15.60	2.33	1.93	α_R		1.30
θ_A	27.5	27.5		2	7.67	16.72	16.80	3.16	3.13	$\Delta\alpha$		25
$\overline{\theta}_E$		16.11		3	7.99	17.42	17.55	3.86	3.88	$1 + t_g \beta t_g \delta$		2.95
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.45	4	8.20	17.88	18.01	4.32	4.35	α_c		8.48
$(\theta_E - \theta_{E_c})_0$			-0.11	5	8.39	18.29	18.31	4.73	4.64	σ	0.038996	
θ_F			18.33	6	8.56	18.66	18.49	5.10	4.82			
θ'_F			18.79	∞					5.12	f_∞		5.69

Remarks :

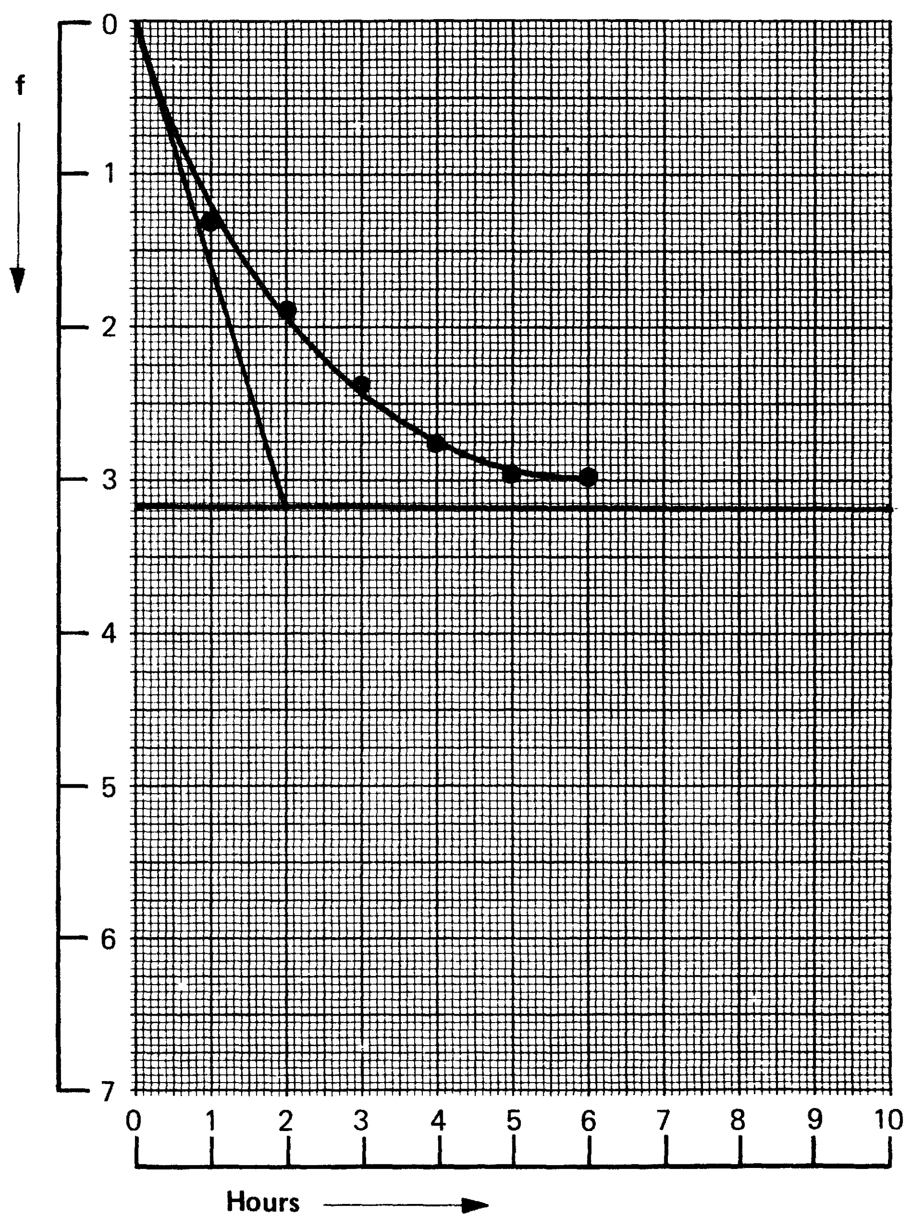
$\overline{\alpha}_c$ = 6.75

$\overline{\sigma}$ = 0.02857



Curve Number : *62 - 27* **Result Number :** *20*

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7		0	9.52	20.75	20.78	0	0	α_T		26.85
ϵ	45	45	40	1	10.14	22.11	22.00	1.36	1.22	α_R		1.38
θ_A	34	34.5		2	10.40	22.67	22.75	1.92	1.97	$\Delta\alpha$		25.47
$\overline{\theta}_E$		22.25		3	10.62	23.15	23.21	2.40	2.43	$1 + t_g \beta t_g \delta$		3.65
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			23.10	4	10.80	23.54	23.50	2.79	2.72	α_c		7.03
$(\theta_E - \theta_{E_c})_0$			-0.03	5	10.88	23.72	23.67	2.97	2.89	σ	0.02973	
θ_F			23.39	6	10.90	23.76	23.78	3.01	3.00			
θ'_F			23.96	∞			23.96		3.18	f_∞		3.22

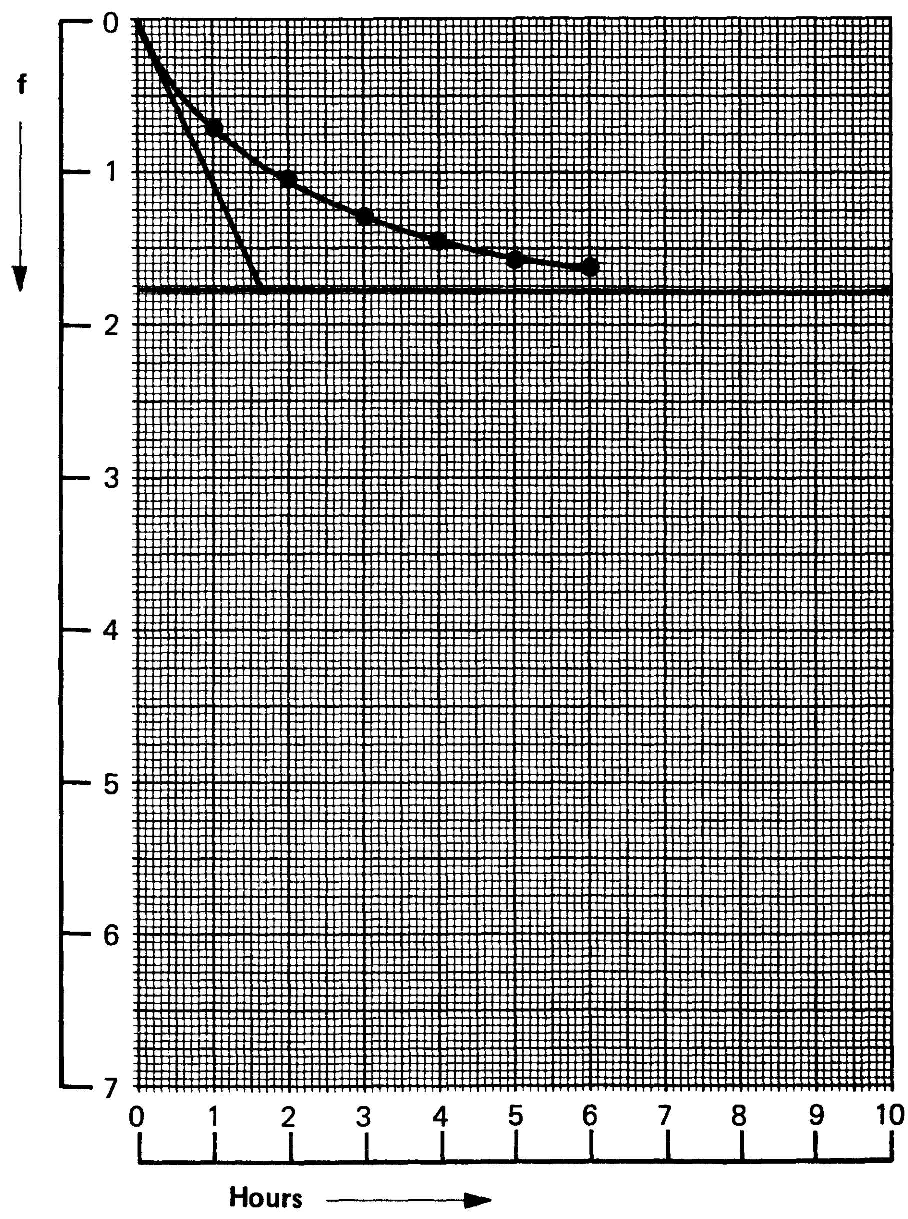


Remarks :

$\overline{\alpha}_c$ = 6.75

$\overline{\sigma}$ = 0.02857

Curve Number : 63				Result Number : 21								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7.05		0	10.18	22.19		0		α_T		25.53
ϵ	45	44.5	43.5	1	9.87	21.52		0.67		α_R		1.35
θ_A	27.5	29.2		2	9.70	21.15		1.04		$\Delta\alpha$		24.18
$\overline{\theta}_E$		21.45		3	9.57	20.86		1.33		$1 + t_g \beta t_g \delta$		3.40
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			20.91	4	9.50	20.71		1.48		α_c		6.15
$(\theta_E - \theta_{E_c})_0$				5	9.45	20.61		1.58		σ	0.03059	
θ_F			19.88	6	9.39	20.48		1.65				
θ'_F			20.37	∞						f_∞		1.76



Remarks :

$\overline{\alpha}_c$ = 6.75

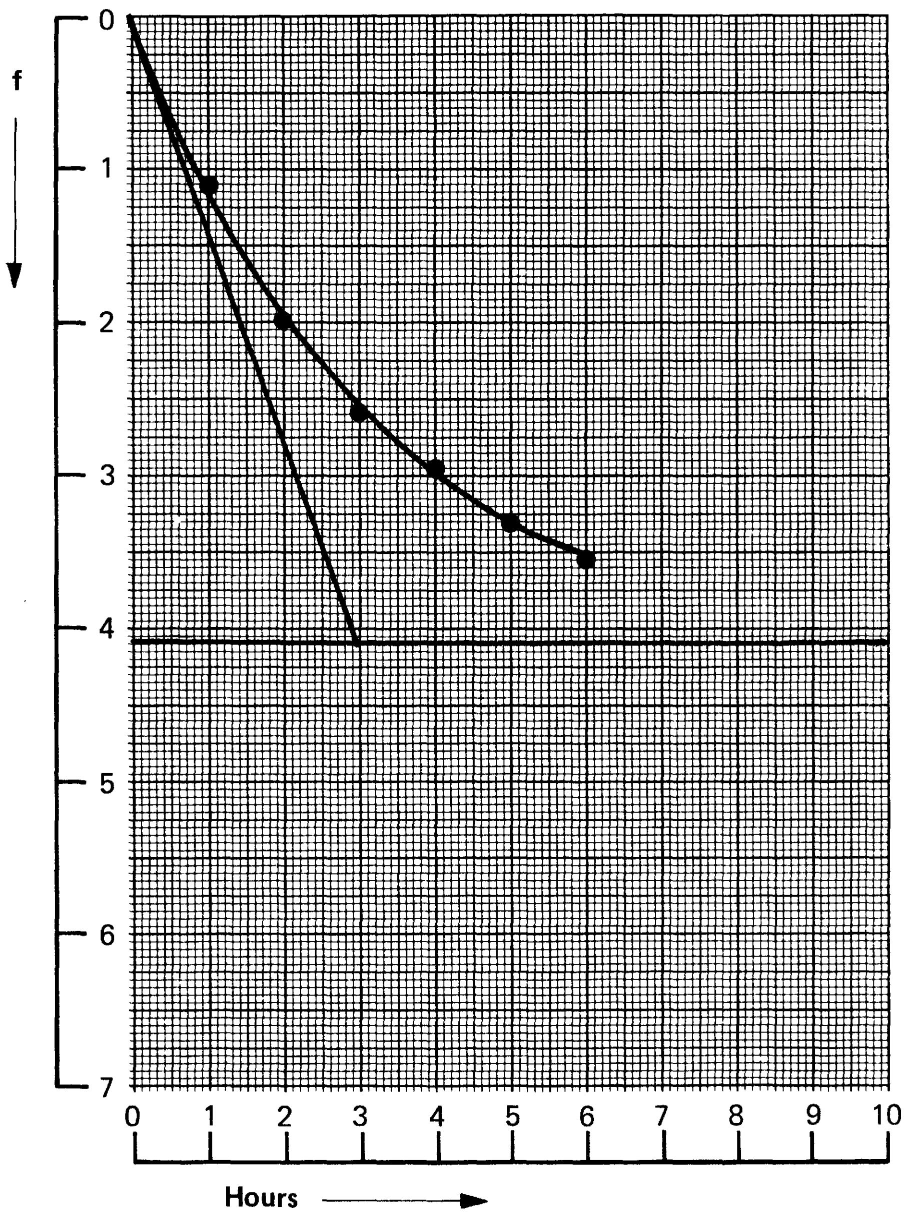
$\overline{\sigma}$ = 0.02857

Curve Number : 65 – 71				Result Number : 22								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7.05		0	7.93	17.29	17.29	0	0	α_T		18.64
ϵ	45	45	46	1	7.40	16.13	16.12	1.16	1.16	α_R		1.28
θ_A	21	19.75		2	7.00	15.26	15.29	2.03	1.99	$\Delta\alpha$		17.35
$\overline{\theta}_E$		15.51		3	6.74	14.69	14.70	2.60	2.58	$1 + t_g \beta t_g \delta$		2.63
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			14.36	4	6.58	14.34	14.28	2.95	3.01	α_c		6.59
$(\theta_E - \theta_{E_c})_0$			0.0	5	6.41	13.97	13.97	3.32	3.31	σ	0.02758	
θ_F			12.72	6	6.30	13.73	13.76	3.56	3.53			
θ'_F			13.21	∞					4.07	f_∞		4.12

Remarks :

$\overline{\alpha}_c$ = 6.75

$\overline{\sigma}$ = 0.02857

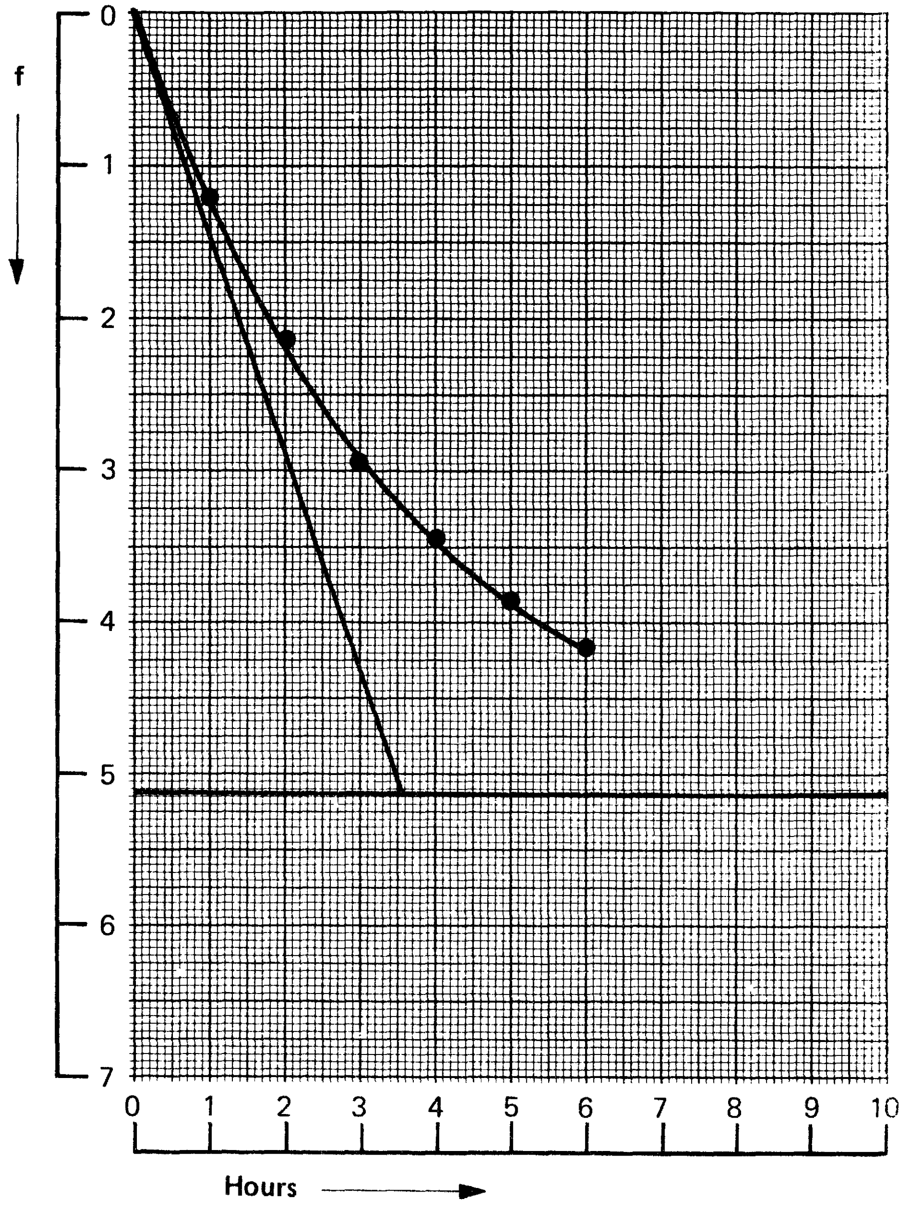


Curve Number : 66-28				Result Number : 23								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	6.9		0	6.69	14.58	14.56	0	0	α_T		15.77
ϵ	45	46	44	1	7.24	15.78	15.82	1.20	1.26	α_R		1.31
θ_A	27.7	27.75		2	7.70	16.78	16.77	2.20	2.21	$\Delta\alpha$		14.46
$\overline{\theta}_E$		16.66		3	8.04	17.53	17.49	2.95	2.93	$1 + t_g \beta t_g \delta$		3.03
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			18.16	4	8.26	18.01	18.03	3.43	3.47	α_c		4.78
$(\theta_E - \theta_{E_c})_0$			+0.02	5	8.46	18.44	18.43	3.86	3.87	σ	0.01942	
θ_F			18.94	6	8.59	18.73	18.74	4.15	4.18			
θ'_F			19.67	∞			19.67		5.11	f_∞		4.97

Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$

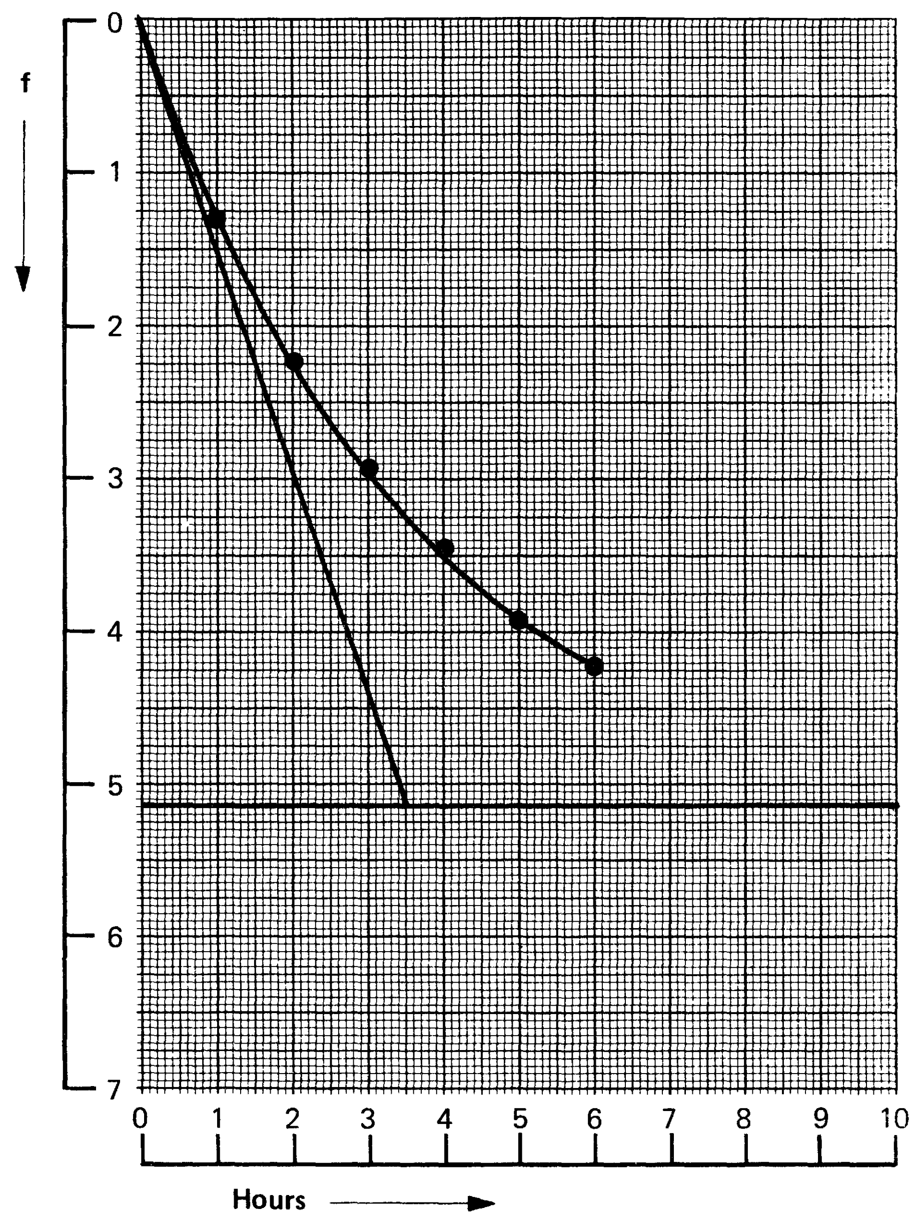


Curve Number : 67 – 72				Result Number : 24								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	7.05		0	7.19	15.67	15.65	0	0	α_T		15.86
ϵ	45	44	43	1	6.58	14.34	14.38	1.33	1.27	α_R		1.27
θ_A	15	16.50		2	6.15	13.41	13.42	2.26	2.23	$\Delta \alpha$		14.59
$\overline{\theta}_E$		13.55		3	5.83	12.71	12.70	2.96	2.95	$1 + t_g \beta t_g \delta$		2.42
$\frac{1}{2} (\overline{\theta}_E + \theta'_F)$			12.03	4	5.59	12.19	12.16	3.48	3.49	α_c		6.04
$(\theta_E - \theta_{E_c})_0$			+0.02	5	5.39	11.75	11.75	3.92	3.90	σ	0.02356	
θ_F			10	6	5.24	11.42	11.44	4.25	4.21			
θ'_F			10.52	∞			10.52		5.13	f_∞		5.25

Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$



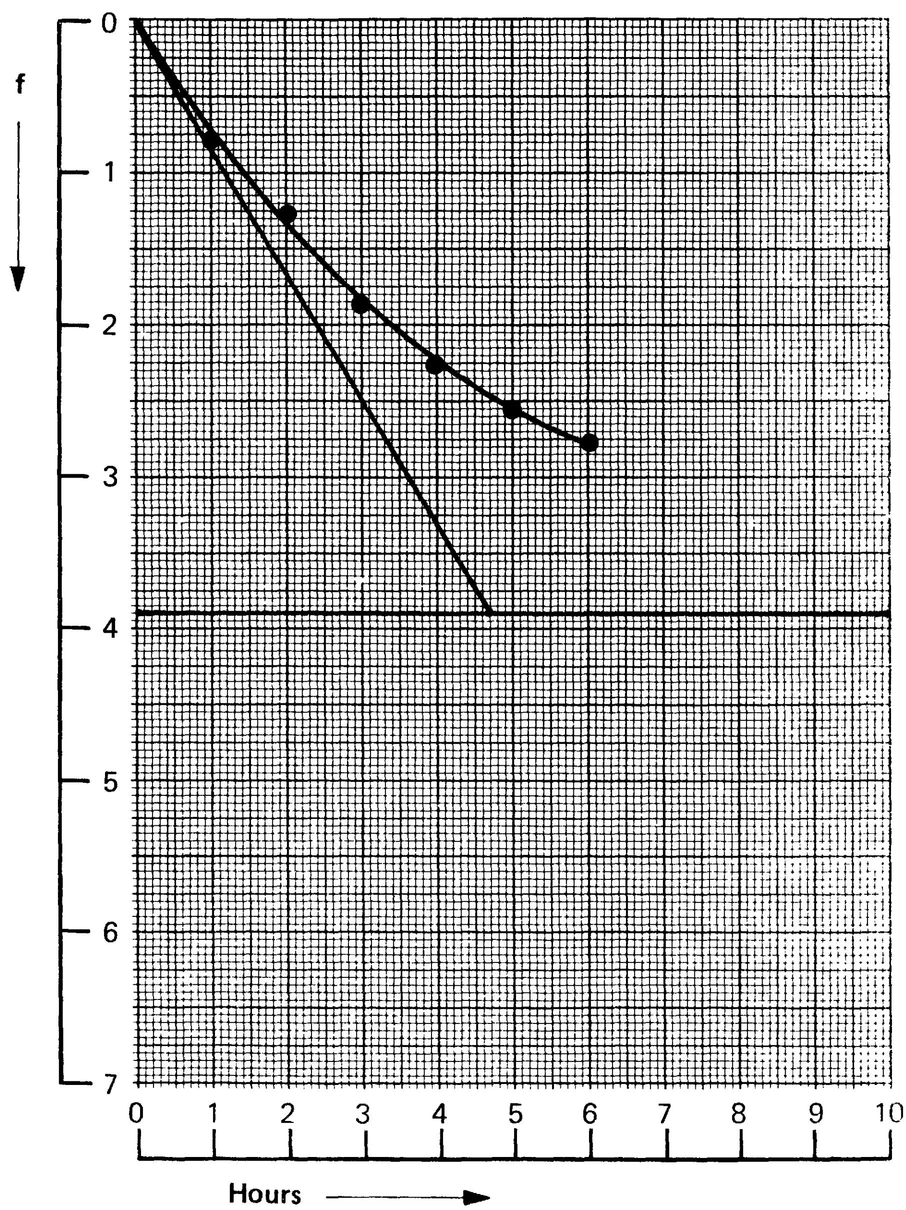
Curve Number : 68 - 29 | **Result Number :** 25

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	7	6.95		0	4.93	10.75	10.75	0	0	α_T		11.76
ϵ	45	44	43	1	5.29	11.53	11.49	0.78	0.74	α_R		1.25
θ_A	21.7	21.25		2	5.51	12.01	12.09	1.26	1.34	$\Delta\alpha$		10.51
$\overline{\theta}_E$		12.13		3	5.78	12.60	12.58	1.85	1.83	$1 + t_g \beta t_g \delta$		2.54
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			13.39	4	5.97	13.01	12.97	2.26	2.22	α_c		4.14
$(\theta_E - \theta_{E_c})_0$			0.00	5	6.10	13.30	13.29	2.55	2.54	σ	0.01723	
θ_F			13.85	6	6.20	13.52	13.55	2.77	2.79			
θ'_F			14.64	∞					3.88	f_∞		3.68

Remarks :

$\overline{\alpha}_c = 5$

$\overline{\sigma} = 0.0208$

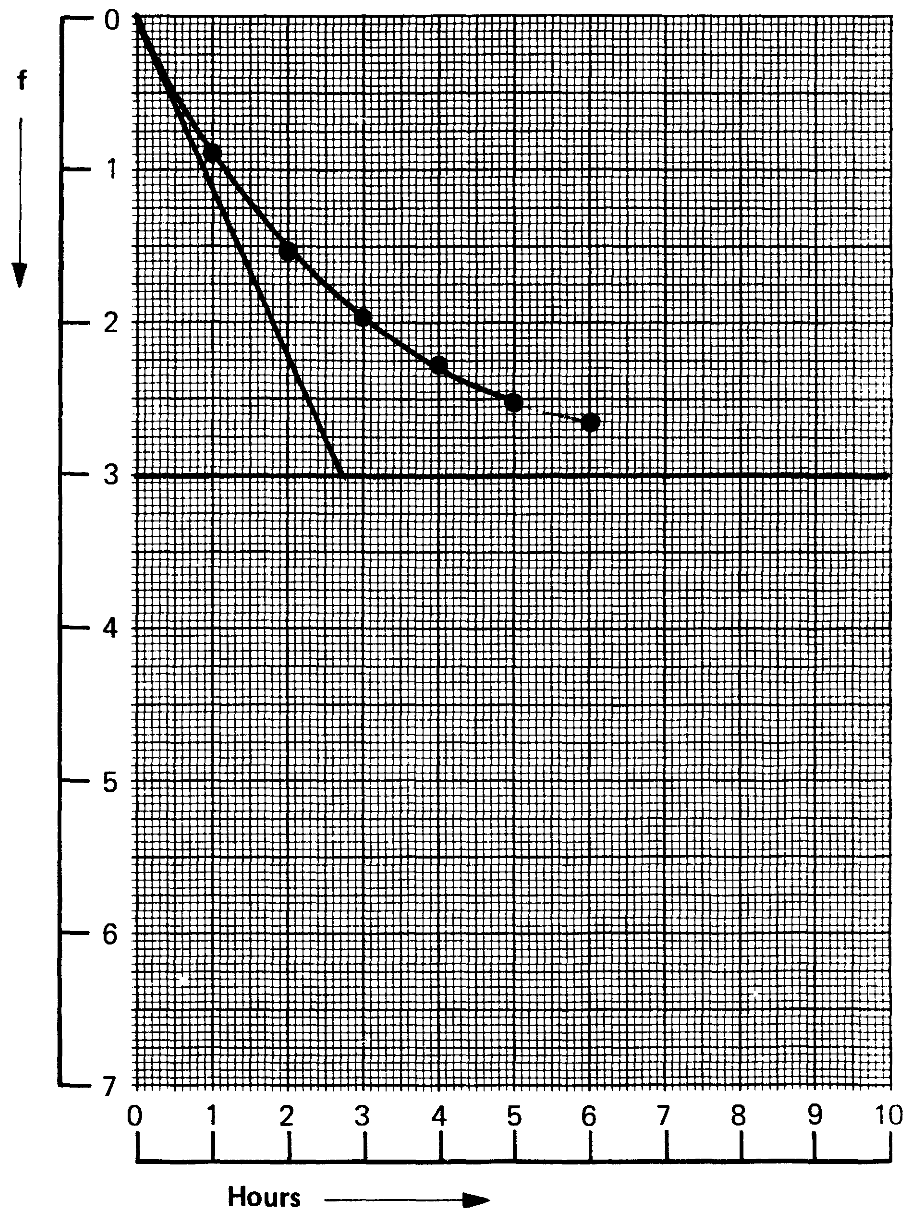


Curve Number : 27 – 12				Result Number : 26								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	6	5.82		0	6.80	14.82	14.81	0	0	α_T		19.99
ϵ	45	40	38	1	7.20	15.70	15.72	0.88	0.91	α_R		1.30
θ_A	26	27.20		2	7.50	16.35	16.35	1.53	1.54	$\Delta\alpha$		18.69
$\overline{\theta}_E$		16.13		3	7.70	16.79	16.79	1.97	1.98	$1 + t_g \beta t_g \delta$		2.89
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			16.97	4	7.85	17.11	17.10	2.29	2.29	α_c		6.45
$(\theta_E - \theta_{E_c})_0$			+0.01	5	7.95	17.33	17.31	2.51	2.50	σ	0.0277	
θ_F			17.15	6	8.00	17.44	17.46	2.62	2.65			
θ'_F			17.80	∞					2.996	f_∞		2.94

Remarks :

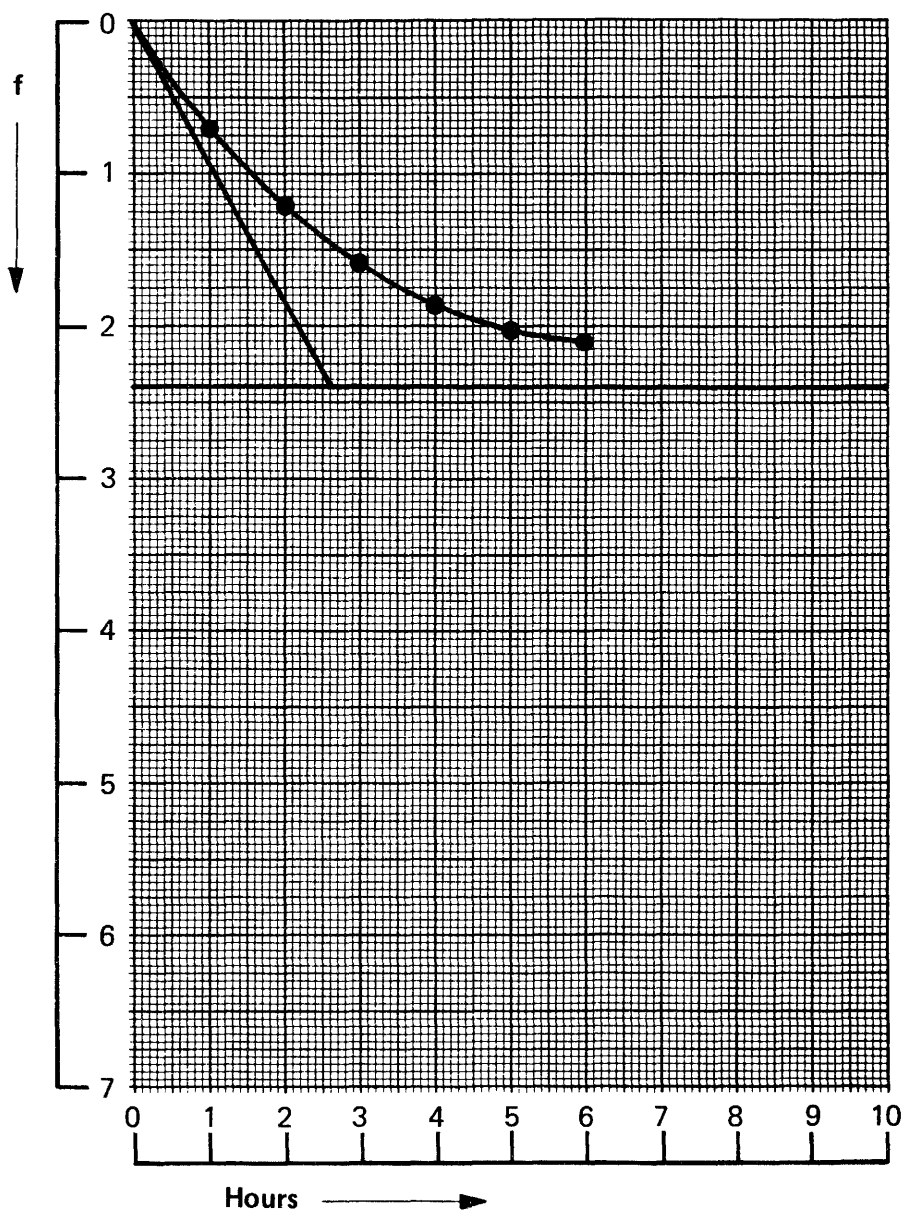
$\overline{\alpha}_c$ = 6.12

$\overline{\sigma}$ = 0.0256



Curve Number : 28 | **Result Number : 27**

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	6	5.9		0	7.85	17.11			0	α_T		19.25
ϵ	45	40	47	1	7.50	16.35			0.75	α_R		1.30
θ_A	22	21.75		2	7.30	15.91			1.25	$\Delta\alpha$		17.95
$\overline{\theta}_E$		16.68		3	7.15	15.59			1.60	$1 + t_g \beta t_g \delta$		2.75
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			15.40	4	7.00	15.26			1.85	α_c		6.53
$(\theta_E - \theta_{E_c})_0$				5	6.95	15.15			2.00	σ	0.0282	
θ_F			14.20	6	6.90	15.04			2.10			
θ'_F			14.71	∞		14.71				f_∞		2.40



Remarks :

$\overline{\alpha}_c = 6.12$

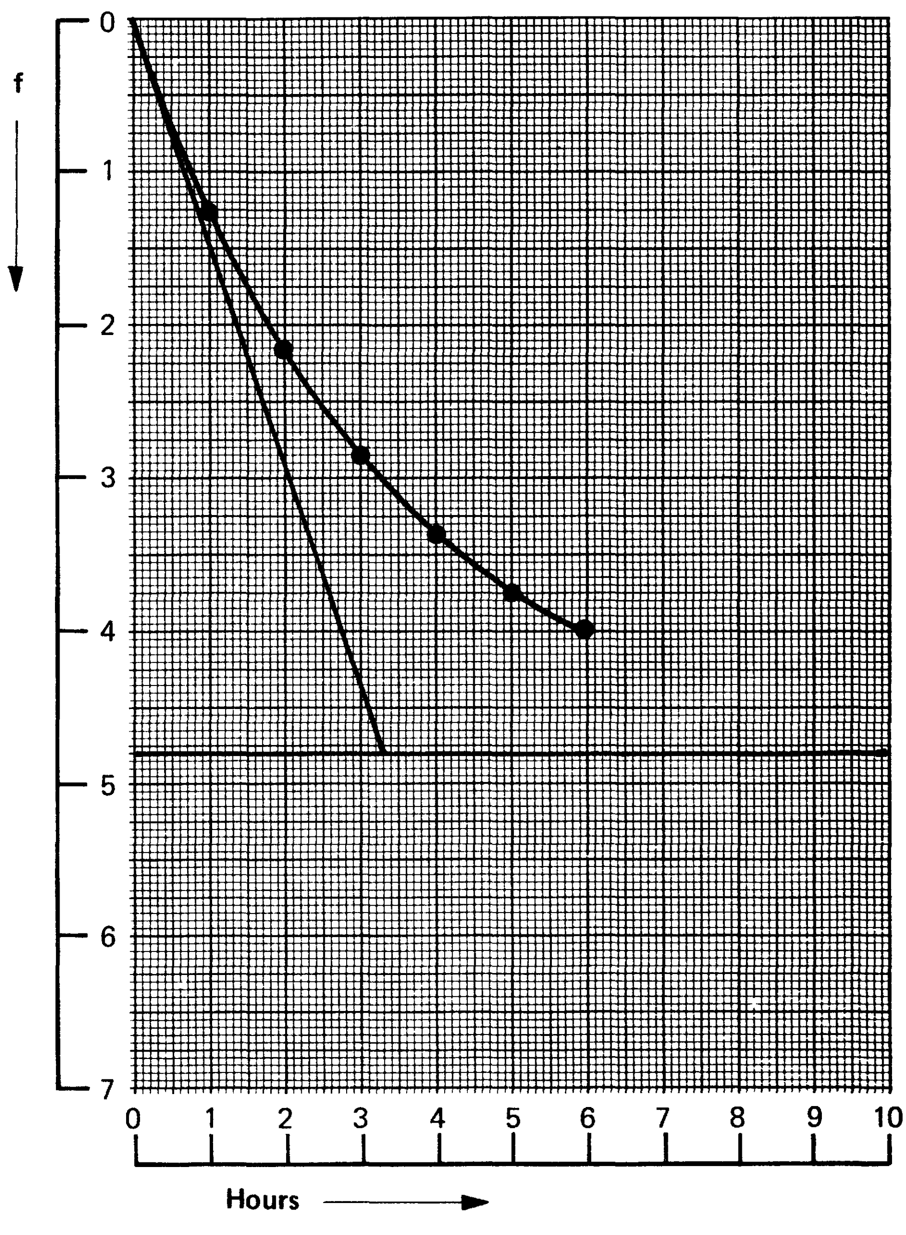
$\overline{\sigma} = 0.0256$

Curve Number : 98 - 105				Result Number : 28								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	6	6		0	115.5	25.16	25.16	0	0	α_T		16.756
ϵ	65	72	75	1	109.7	23.90	23.91	1.26	1.25	α_R		1.389
θ_A	24	24		2	105.6	23.01	22.99	2.15	2.17	$\Delta\alpha$		15.37
$\overline{\theta}_E$		23.16		3	102.4	22.31	22.31	2.85	2.85	$1 + t_g \beta t_g \delta$		3.45
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			21.765	4	100	21.79	21.81	3.37	3.35	α_c		4.45
$(\theta_E - \theta_{E_c})_0$			0.00	5	98.4	21.44	21.43	3.72	3.72	σ	0.0180	
θ_F			20.04	6	97.1	21.16	21.16	4	4			
θ'_F			20.37	∞					4.79	f_∞		4.78

Remarks :

$\overline{\alpha}_c$ = 4.78

$\overline{\sigma}$ = 0.0199

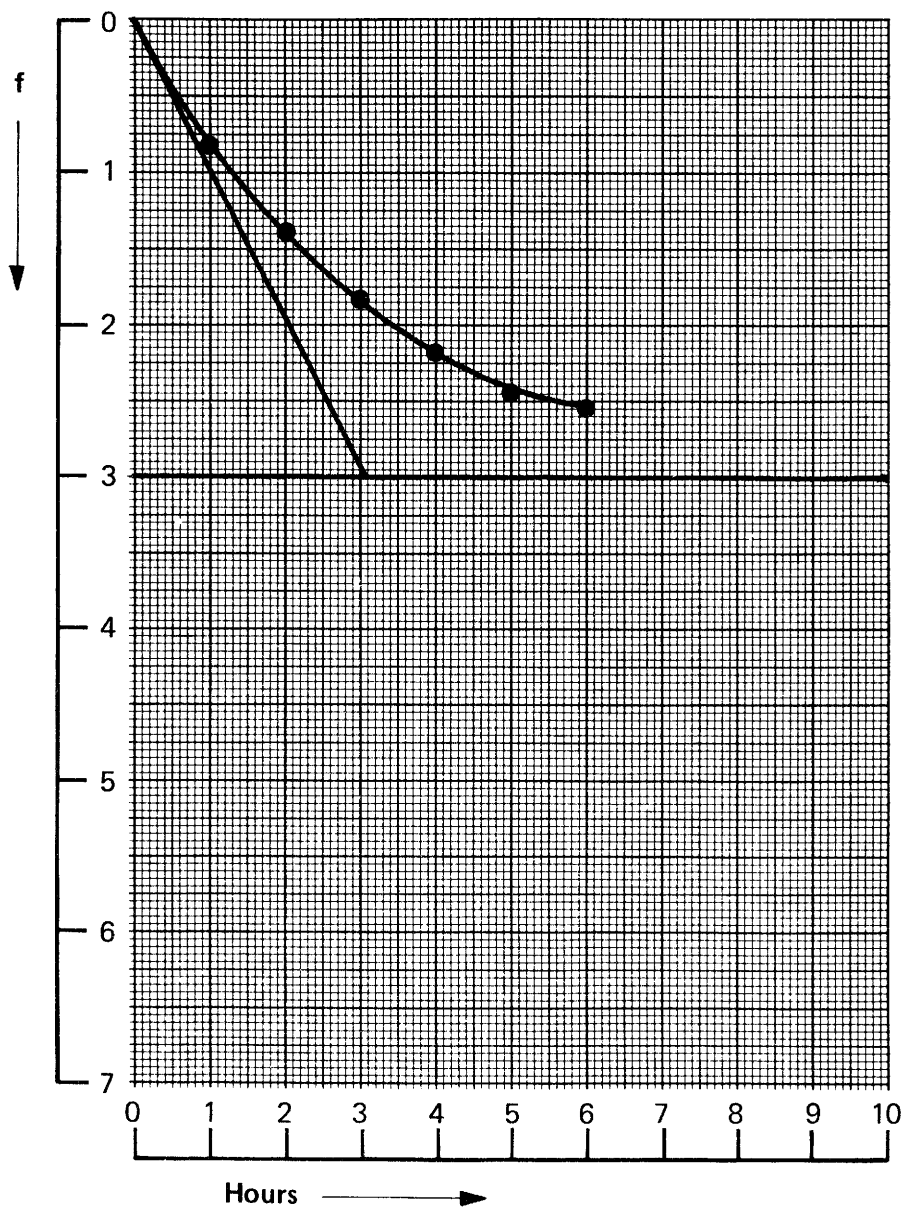


Curve Number : 99				**Result Number :** 29								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	6	6.2		0	86	18.74		0		α_T		17.57
ϵ	65	68	68.5	1	82.3	17.93		0.81		α_R		1.30
θ_A	18.3	19.2		2	79.6	17.34		1.40		$\Delta\alpha$		16.27
$\overline{\theta}_E$		17.47		3	77.5	16.89		1.85		$1 + t_g \beta t_g \delta$		2.90
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			16.61	4	76.1	16.58		2.15		α_c		5.60
$(\theta_E - \theta_{E_c})_0$				5	75.0	16.34		2.40		σ	0.0223	
θ_F			15.47	6	74.4	16.21		2.55				
θ'_F			15.75	∞						f_∞		3

Remarks :

$\overline{\alpha}_c$ = 6.12

$\overline{\sigma}$ = 0.0256

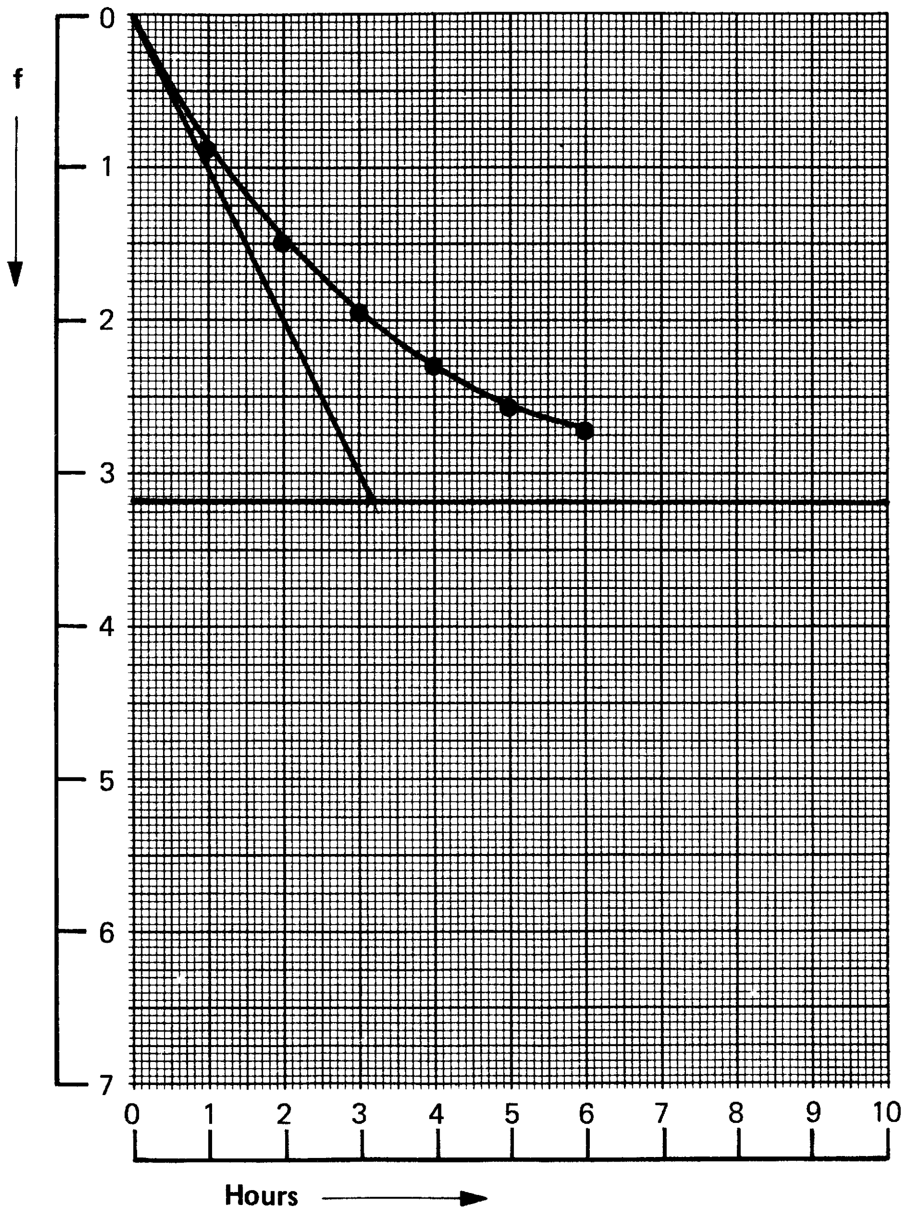


Curve Number : 100 – 106				Result Number : 30								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	6	6		0	77.2	16.82	16.82	0	0	α_T		17.44
ϵ	65	69	66	1	81.2	17.69	17.68	0.87	0.86	α_R		1.33
θ_A	23.7	24.3		2	84	18.30	18.31	1.48	1.49	$\Delta \alpha$		16.11
$\overline{\theta}_E$		18.16		3	86.1	18.76	18.77	1.94	1.94	$1 + t_g \beta t_g \delta$		3.13
$\frac{1}{2} (\overline{\theta}_E + \theta'_F)$			19.08	4	87.6	19.09	19.10	2.27	2.28	α_c		5.15
$(\theta_E - \theta_{E_c})_0$			0.00	5	89	19.39	19.35	2.57	2.52	σ	0.0222	
θ_F			19.65	6	89.5	19.50	19.52	2.68	2.70			
θ'_F			20.01	∞					3.188	f_∞		3.19

Remarks :

$\overline{\alpha}_c = 4.78$

$\overline{\sigma} = 0.0199$

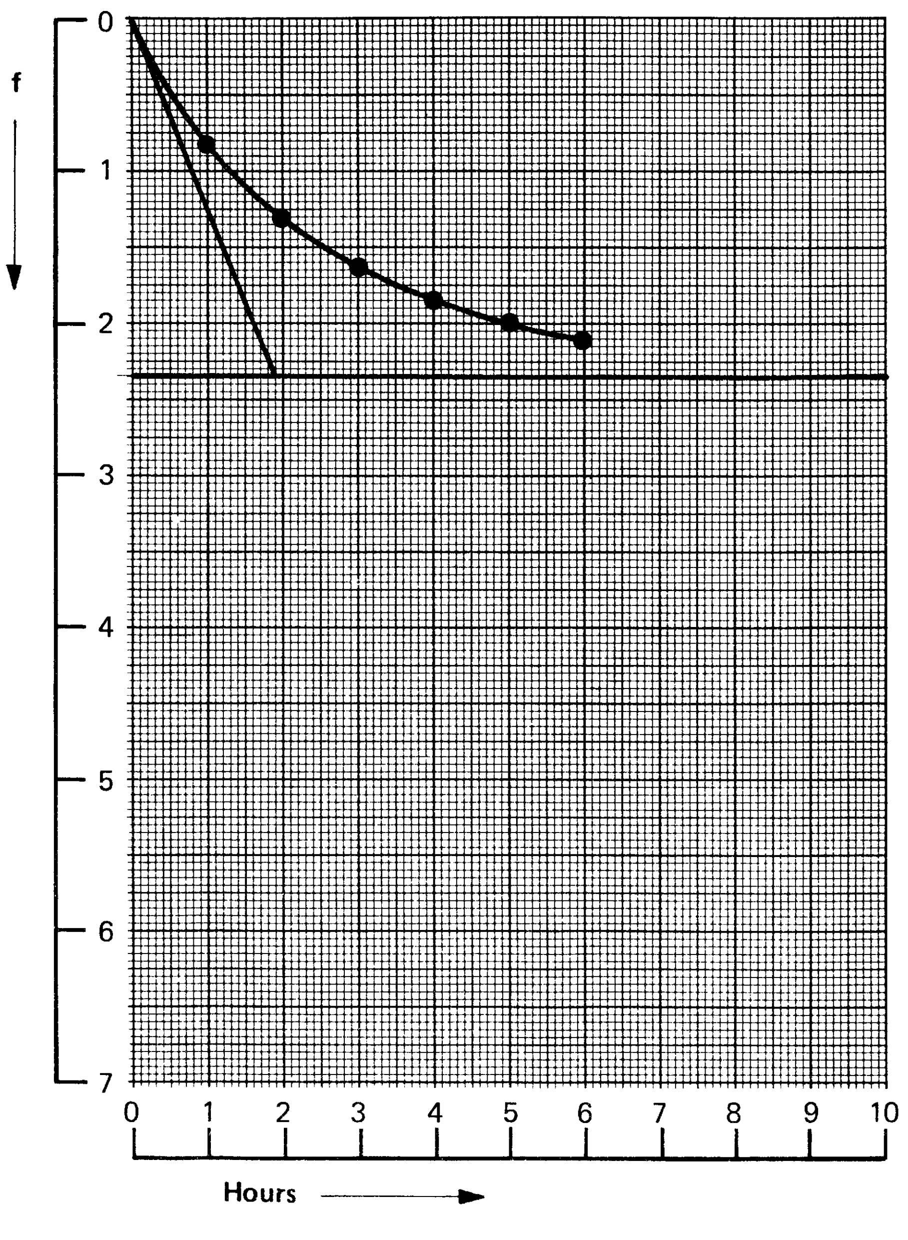


Curve Number : *101* **Result Number :** *31*

	nominal	measured	calcul.
W	6	6	
ϵ	65	72	65
θ_A	29	29	
$\overline{\theta}_E$		22.83	
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			23.48
$(\theta_E - \theta_{E_c})_0$			
θ_F			23.79
θ'_F			24.12

time	reading	θ_E	θ_{E_c}	f	f_c
0	10	21.79		0	
1	10.36	22.57		0.80	
2	10.6	23.09		1.30	
3	10.76	23.44		1.65	
4	10.86	23.66		1.85	
5	10.91	23.77		2	
6	10.95	23.86		2.10	
∞					

	GRAPH	COMPUT
α_T	21.36	22.61
α_R	1.36	1.36
$\Delta\alpha$	20	21.25
$1 + t_g\beta\, t_g\delta$		3.60
α_c	5.56	5.90
σ	0.0243	
f_∞	2.35	2.30



Remarks :

$\overline{\alpha}_c = 6.12$

$\overline{\sigma} = 0.0256$

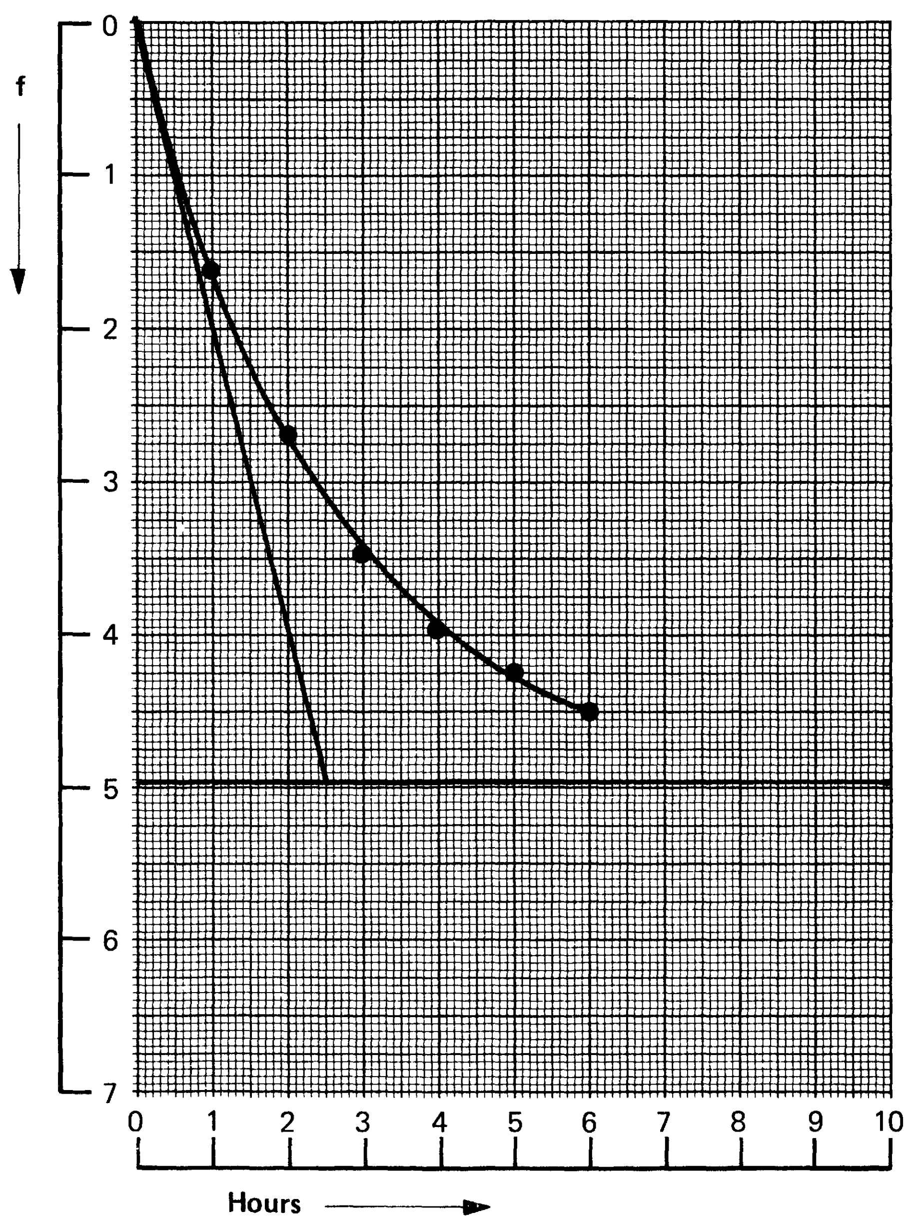
Curve Number : 102 – 107 **Result Number :** 32

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	6	5.95		0	112.3	24.47	24.46	0	0	α_T		22.167
ϵ	65	74	67	1	119.7	26.08	26.09	1.61	1.63	α_R		1.433
θ_A	35	34.6		2	124.6	27.15	27.18	2.68	2.72	$\Delta\alpha$		20.734
$\overline{\theta}_E$		26.71		3	128.3	27.95	27.92	3.48	3.46	$1 + t_g\beta\, t_g\delta$		4.35
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			28.06	4	130.6	28.45	28.41	3.98	3.95	α_c		4.77
$(\theta_E - \theta_{E_c})_0$			+0.01	5	131.8	28.72	28.74	4.25	4.28	σ	0.01984	
θ_F			29.06	6	132.9	28.95	28.96	4.48	4.50			
θ'_F			29.41	∞					4.955	f_∞		4.88

Remarks :

$\overline{\alpha}_c$ = 4.78

$\overline{\sigma}$ = 0.0199

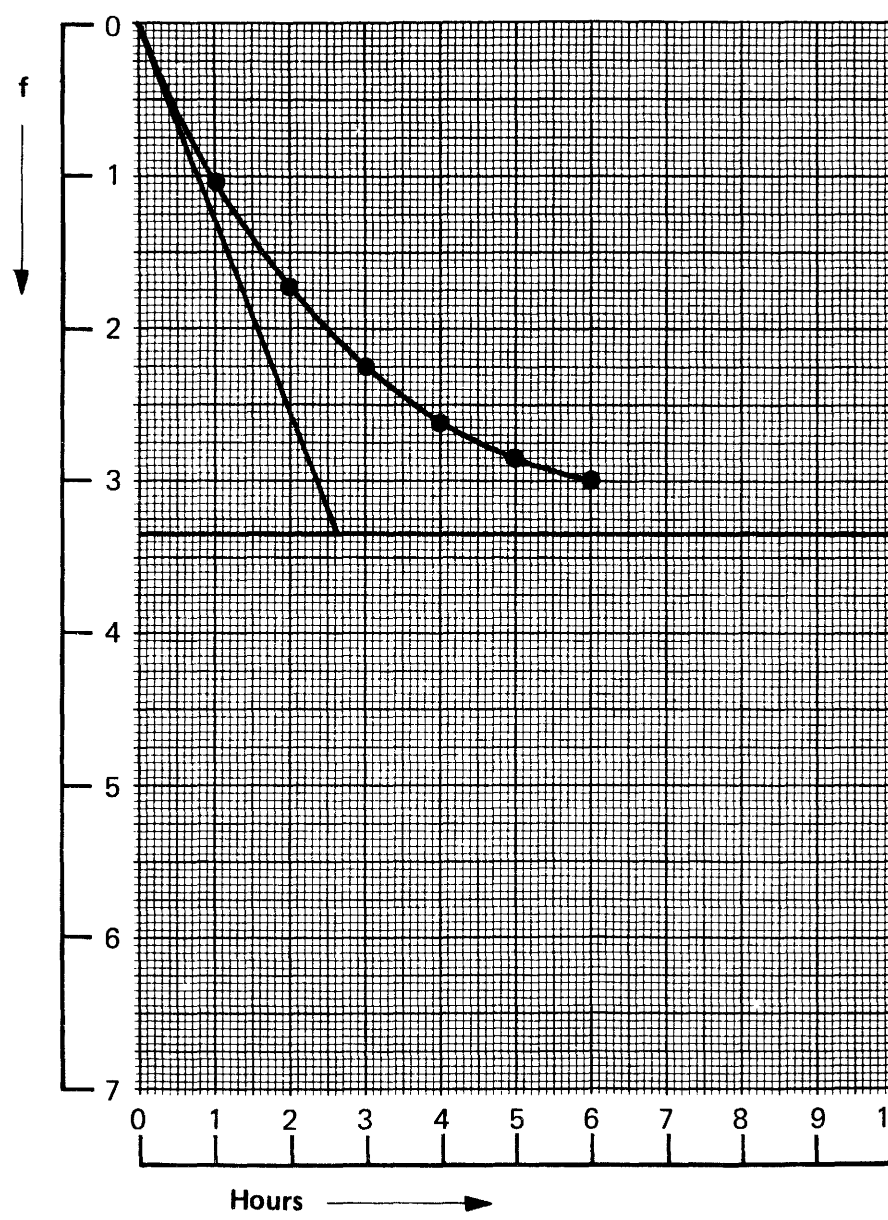


Curve Number : 103				Result Number : 33								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	6	6		0	12.73	27.73		0		α_T		21.41
ϵ	65	72	67	1	12.25	26.69		1.04		α_R		1.41
θ_A	29.50	29		2	11.91	25.95		1.78		$\Delta\alpha$		20
$\overline{\theta}_E$		26.25		3	11.68	25.45		2.28		$1 + t_g \beta t_g \delta$		4
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			25.32	4	11.55	25.16		2.57		α_c		5
$(\theta_E - \theta_{E_c})_0$				5	11.44	24.93		2.80		σ	0.021	
θ_F			24.10	6	11.37	24.77		3				
θ'_F			24.40	∞						f_∞		3.33

Remarks :

$\overline{\alpha}_c = 4.78$

$\overline{\sigma} = 0.0199$



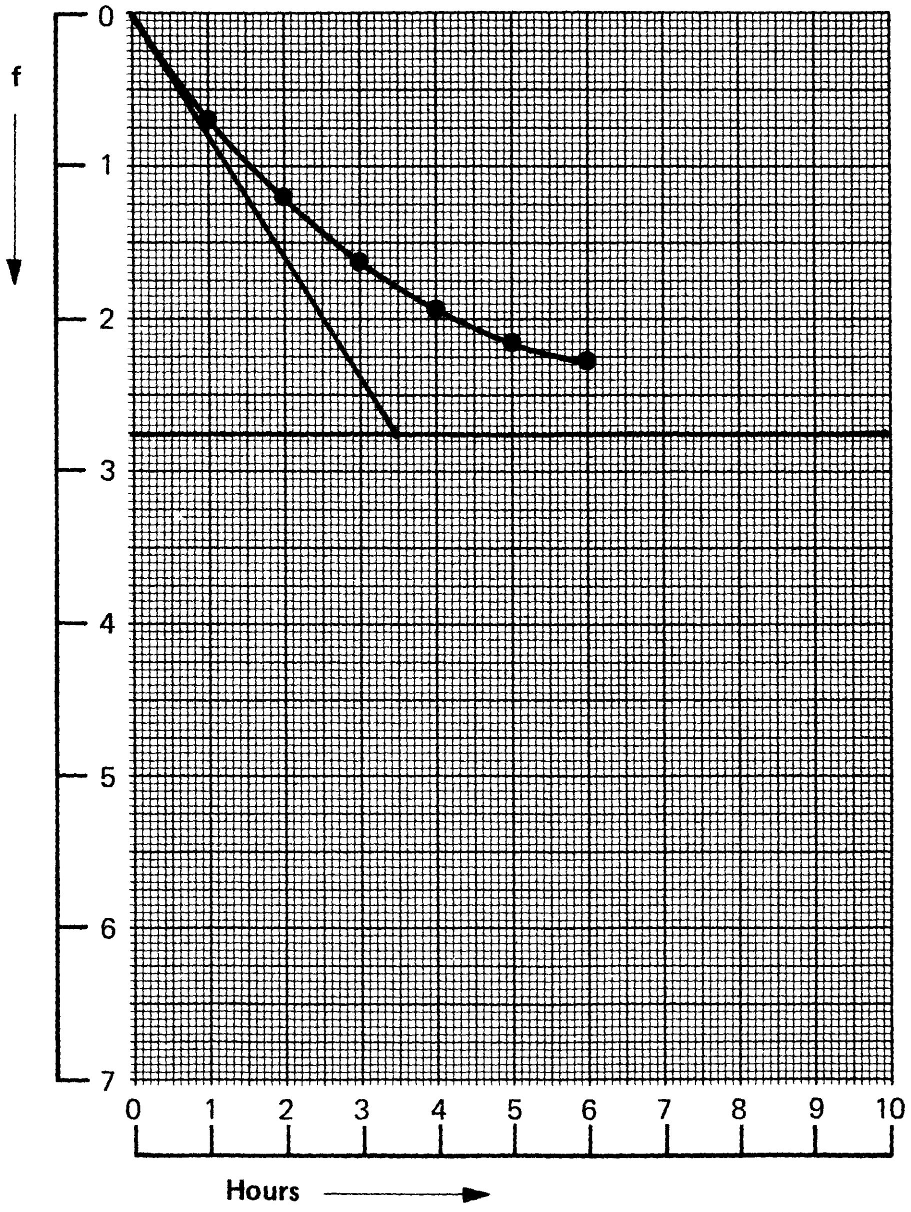
Curve Number : 104 | **Result Number :** 34

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	6	6		0	10	21.79		0		α_T		15.82
ϵ	65	70	69	1	9.7	21.13		0.66		α_R		1.32
θ_A	23.7	22.8		2	9.48	20.65		1.14		$\Delta\alpha$		14·50
$\overline{\theta}_E$		20.64		3	9.26	20.17		1.62		$1 + t_g \beta t_g \delta$		3.20
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			18.83	4	9.12	19.87		1.92		α_c		4.53
$(\theta_E - \theta_{E_c})_0$				5	9.02	19.65		2.14		σ	0.01841	
θ_F			18.69	6	8.95	19.50		2.29				
θ'_F			19.03	∞						f_∞		2.76

Remarks :

$\overline{\alpha}_c = 4.78$

$\overline{\sigma} = 0.0199$

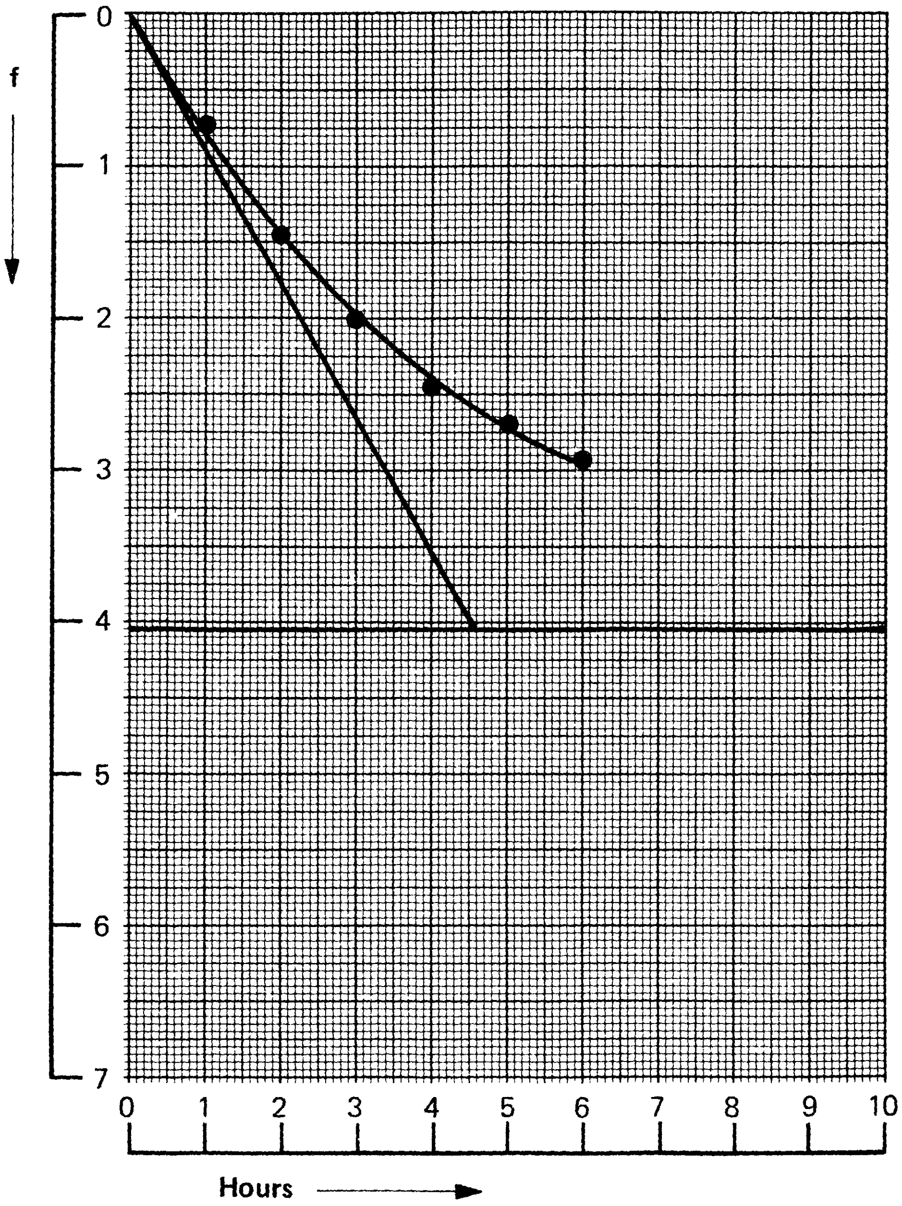


Curve Number : 1-55				Result Number : 35								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	5.10		0	6.60	14.39	14.43	0	0	α_T		12.28
ϵ	65	55	65	1	6.28	13.69	13.63	0.70	0.80	α_R		1.26
θ_A	14	13.50		2	5.98	13.04	12.99	1.35	1.44	$\Delta \alpha$		11.02
$\overline{\theta}_E$		12.95		3	5.70	12.43	12.47	1.96	1.96	$1 + t_g \beta t_g \delta$		2.38
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			11.67	4	5.50	11.99	12.06	2.40	2.37	α_c		4.62
$(\theta_E - \theta_{E_c})_0$			-0.04	5	5.38	11.73	11.73	2.66	2.70	σ	0.0202	
θ_F			10.04	6	5.28	11.51	11.47	2.88	2.97			
θ'_F			10.394	∞					4.037	f_∞		3.70

Remarks :

$\bar{\alpha}_c = 4.34$

$\bar{\sigma} = 0.0183$

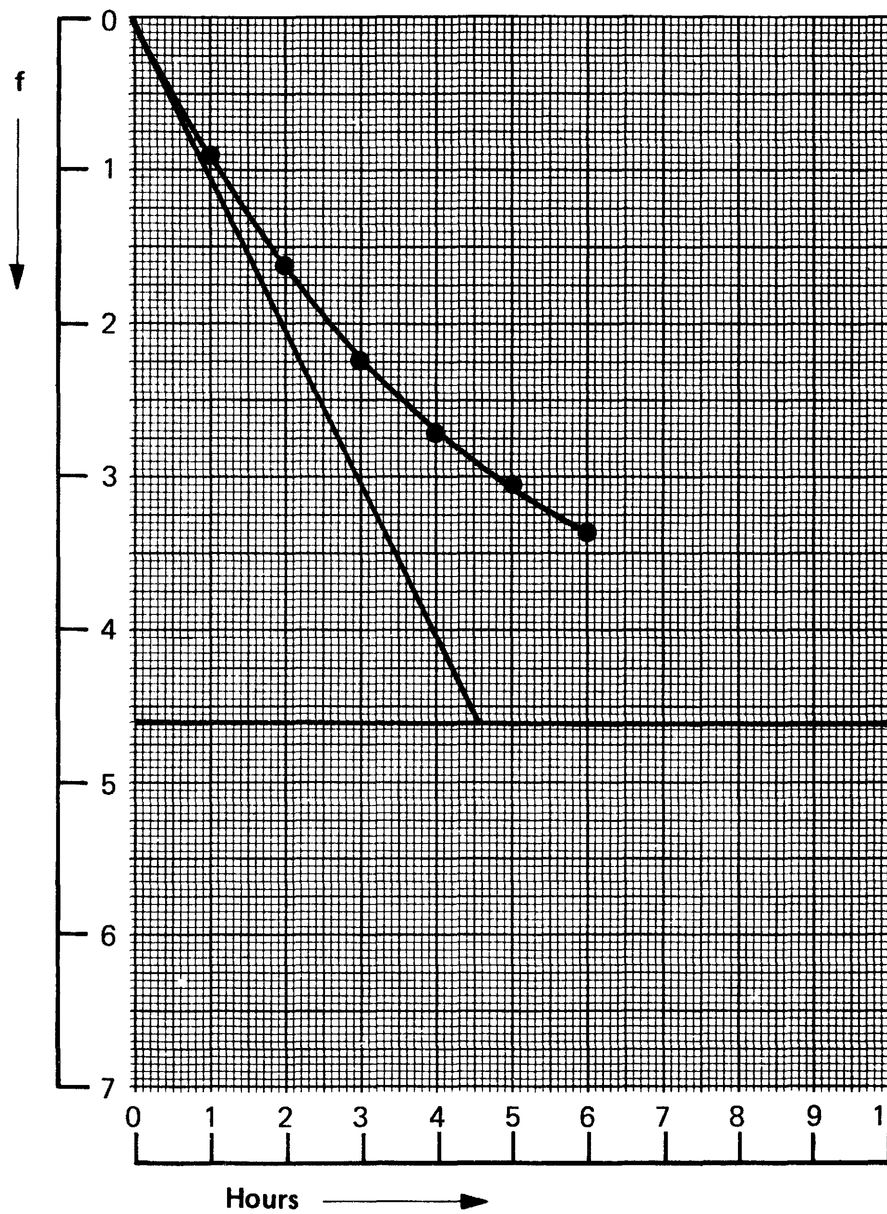


Curve Number : 3 - 2				Result Number : 36								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	4.95		0	8.65	18.86	18.86	0	0	α_T		12.20
ϵ	65	61	59	1	9.07	19.77	19.77	0.91	0.91	α_R		1.36
θ_A	30	29		2	9.40	20.49	20.50	1.63	1.64	$\Delta\alpha$		10.84
$\overline{\theta}_E$		20.55		3	9.67	21.08	21.08	2.22	2.22	$1 + t_g \beta t_g \delta$		3.48
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			22.01	4	9.90	21.58	21.55	2.72	2.70	α_c		3.11
$(\theta_E - \theta_{E_c})_0$			0.00	5	10.05	21.91	21.93	3.05	3.07	σ	0.01277	
θ_F			22.77	6	10.20	22.24	22.23	3.38	3.38			
θ'_F			23.469	∞					4.609	f_∞		4.65

Remarks :

$\overline{\alpha}_c = 3.24$

$\overline{\sigma} = 0.0135$

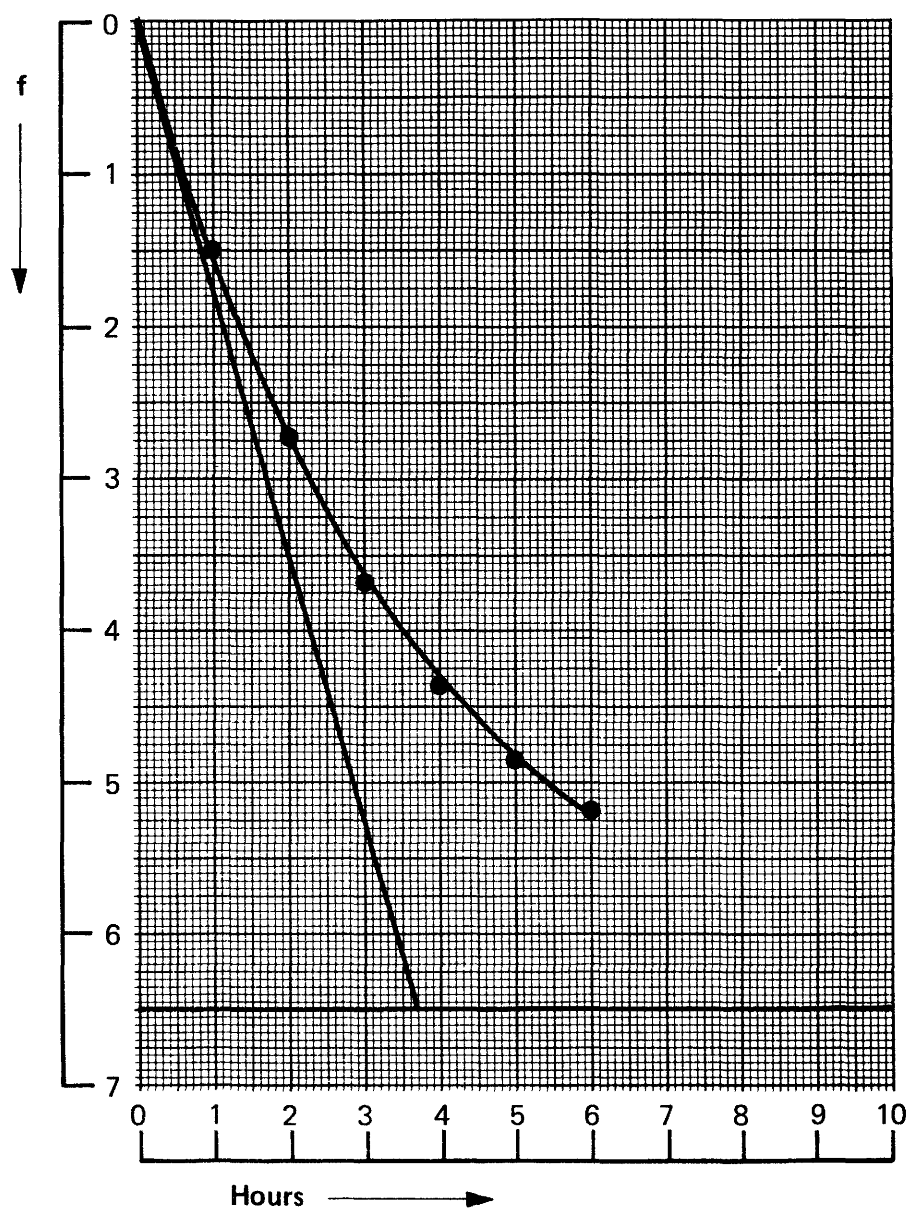


Curve Number : 6 - 3				Result Number : 37								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	4.9		0	10.00	21.80	21.75	0	0	α_T		15.16
ϵ	65	54.5	52	1	10.65	23.22	23.30	1.42	1.55	α_R		1.40
θ_A	35	36.25		2	11.22	24.46	24.48	2.66	2.73	$\Delta\alpha$		13.76
$\overline{\theta}_E$		24.36		3	11.66	25.42	25.38	3.62	3.62	$1 + t_g \beta t_g \delta$		4.07
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			26.30	4	11.98	26.12	26.06	4.32	4.31	α_c		3.37
$(\theta_E - \theta_{E_c})_0$			+0.05	5	12.20	26.60	26.58	4.80	4.83	σ	0.0143	
θ_F			27.42	6	12.35	26.92	26.98	5.12	5.22			
θ'_F			28.24	∞					6.48	f_∞		6.18

Remarks :

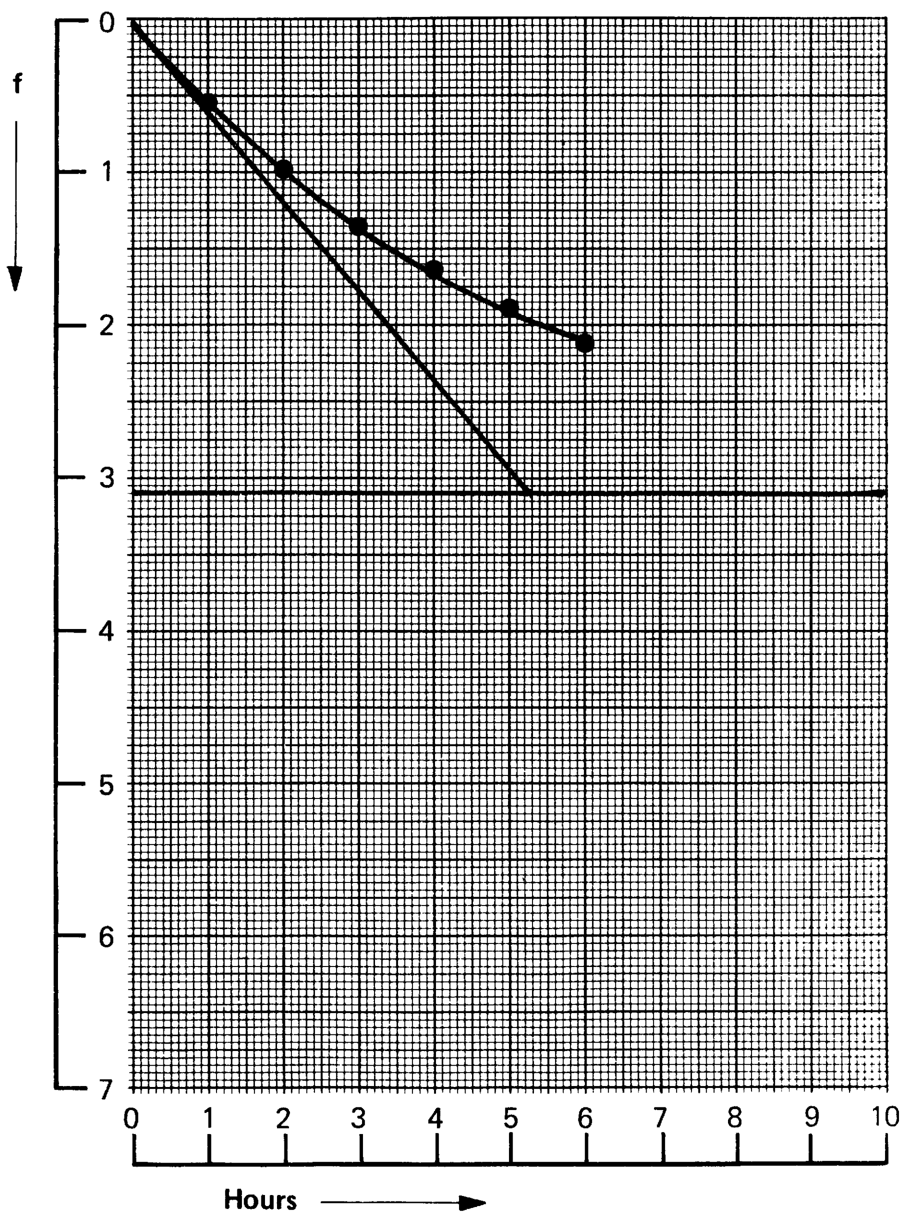
$\overline{\alpha}_c = 3.24$

$\overline{\sigma} = 0.0135$



Curve Number : 9 - 56 | **Result Number :** 38

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	5.07		0	8.30	18.09	18.08	0	0	α_T		10.52
ϵ	65	62	67	1	8.04	17.53	17.54	0.56	0.53	α_R		1.31
θ_A	18.5	18.30		2	7.84	17.09	17.10	1	0.97	$\Delta \alpha$		9.21
$\overline{\theta}_E$		17.02		3	7.68	16.74	16.74	1.35	1.34	$1 + t_g \beta t_g \delta$		2.795
$\frac{1}{2} (\overline{\theta}_E + \theta'_F)$			16	4	7.55	16.46	16.44	1.63	1.64	α_c		3.29
$(\theta_E - \theta_{E_c})_0$			+ 0.01	5	7.43	16.20	16.19	1.89	1.89	σ	0.0139	
θ_F			14.51	6	7.32	15.96	15.98	2.13	2.10			
θ'_F			14.989	∞					3.09	f_∞		3.20

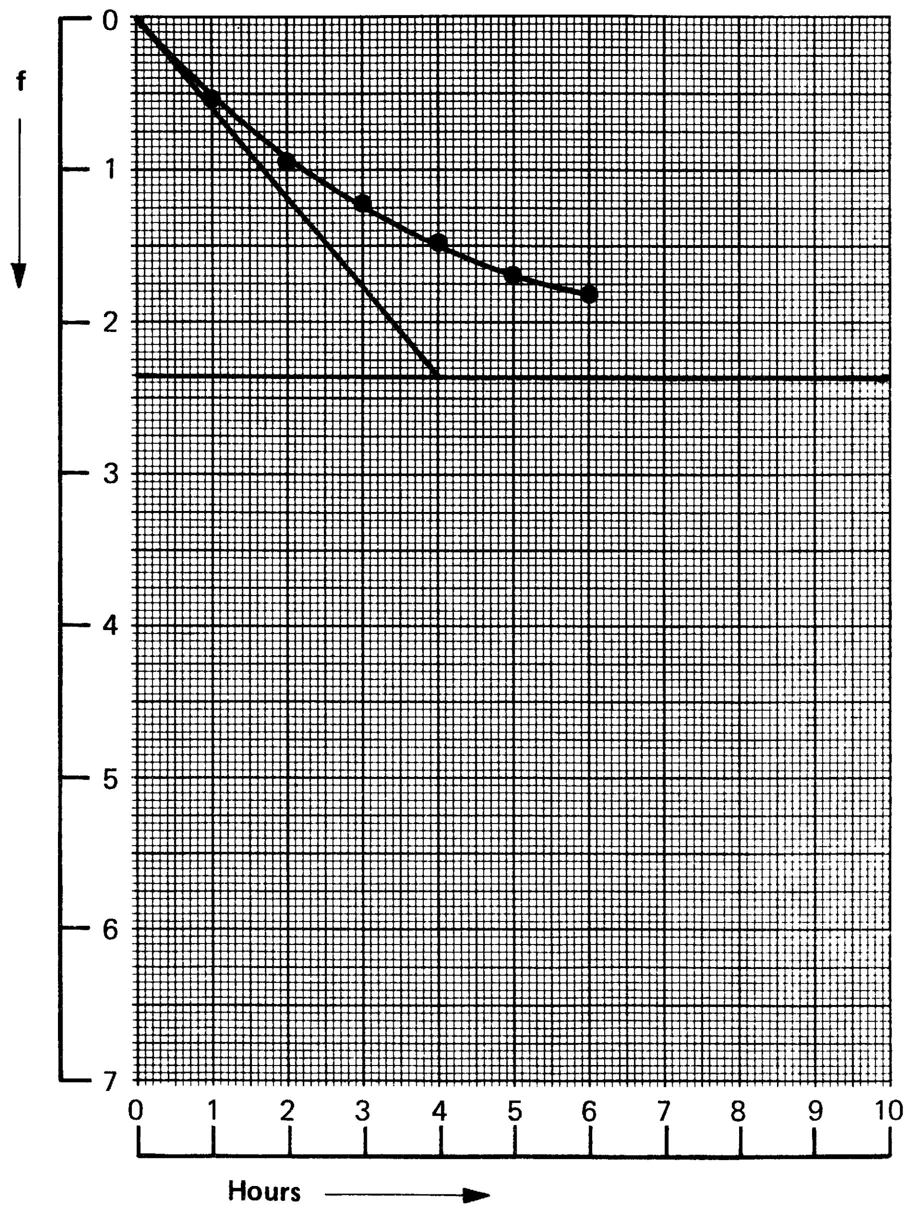


Remarks :

$\overline{\alpha}_c$ = 3.24

$\overline{\sigma}$ = 0.0135

Curve Number : 10 - 57				Result Number : 39								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	5.14		0	6.33	13.80	13.80	0	0	α_T		13.83
ϵ	45	45.5	54	1	6.10	13.30	13.28	0.50	0.52	α_R		1.26
θ_A	15	16.1		2	5.90	12.86	12.88	0.94	0.93	$\Delta \alpha$		12.57
$\overline{\theta}_E$		12.89		3	5.77	12.58	12.56	1.22	1.24	$1 + t_g \beta t_g \delta$		2.43
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			12.16	4	5.65	12.32	12.32	1.48	1.49	α_c		5.17
$(\theta_E - \theta_{E_c})_0$			0.00	5	5.55	12.10	12.12	1.70	1.68	σ	0.02398	
θ_F			10.98	6	5.50	11.99	11.98	1.81	1.83			
θ'_F			11.44	∞					2.36	f_∞		2.36

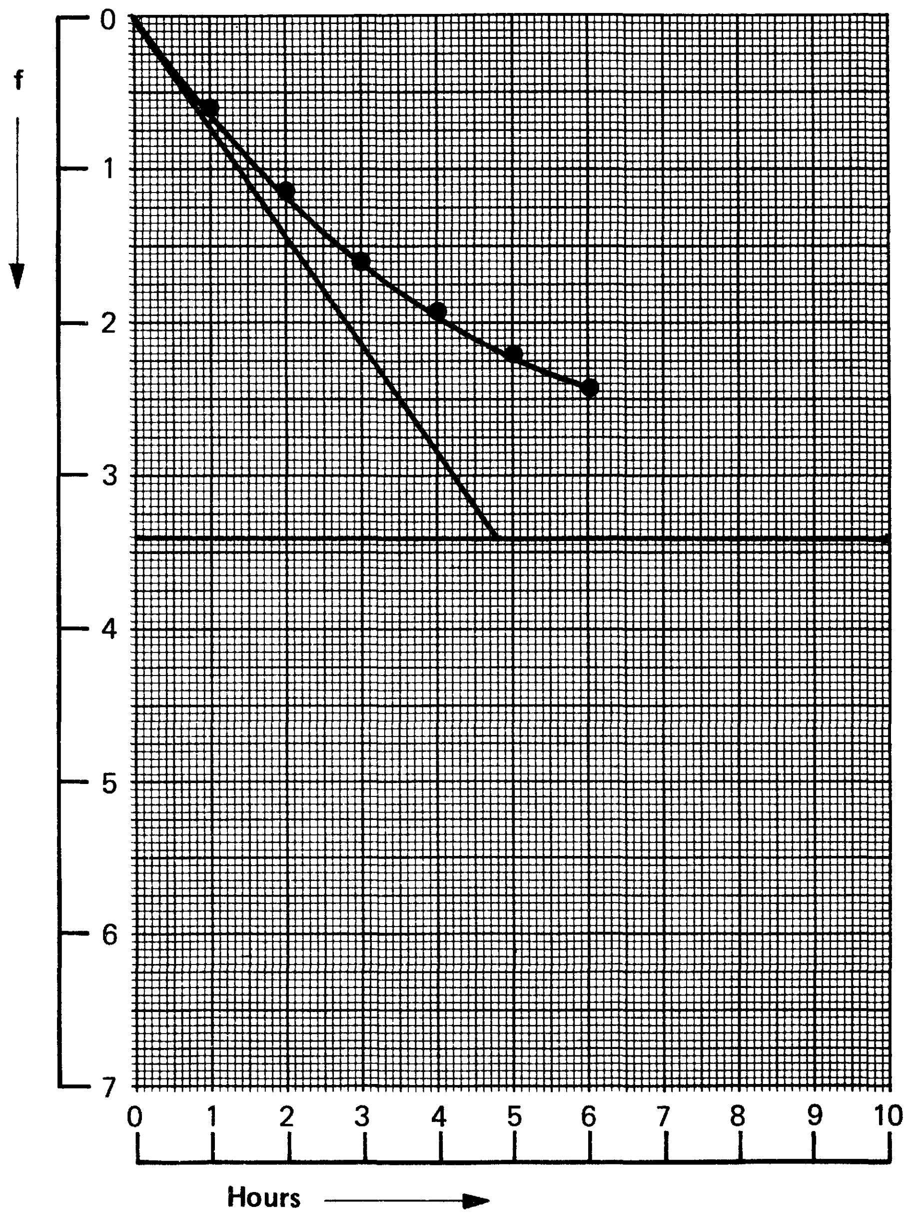


Remarks :

$\overline{\alpha}_c$ = 4.34
$\overline{\sigma}$ = 0.0183

Curve Number : 11-4 | **Result Number :** 40

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	5		0	5.40	11.77	11.75	0	0	α_T		11.54
ϵ	45	44	45	1	5.67	12.36	12.39	0.59	0.64	α_R		1.26
θ_A	22	22		2	5.90	12.86	12.91	1.09	1.16	$\Delta\alpha$		10.28
$\overline{\theta}_E$		12.97		3	6.15	13.41	13.33	1.64	1.58	$1 + t_g\beta t_g\delta$		2.60
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			14.06	4	6.27	13.67	13.68	1.90	1.93	α_c		3.95
$(\theta_E - \theta_{E_c})_0$			+0.02	5	6.40	13.95	13.95	2.18	2.21	σ	0.01547	
θ_F			14.32	6	6.50	14.17	14.18	2.40	2.43			
θ'_F			15.16	∞					3.41	f_∞		3.06

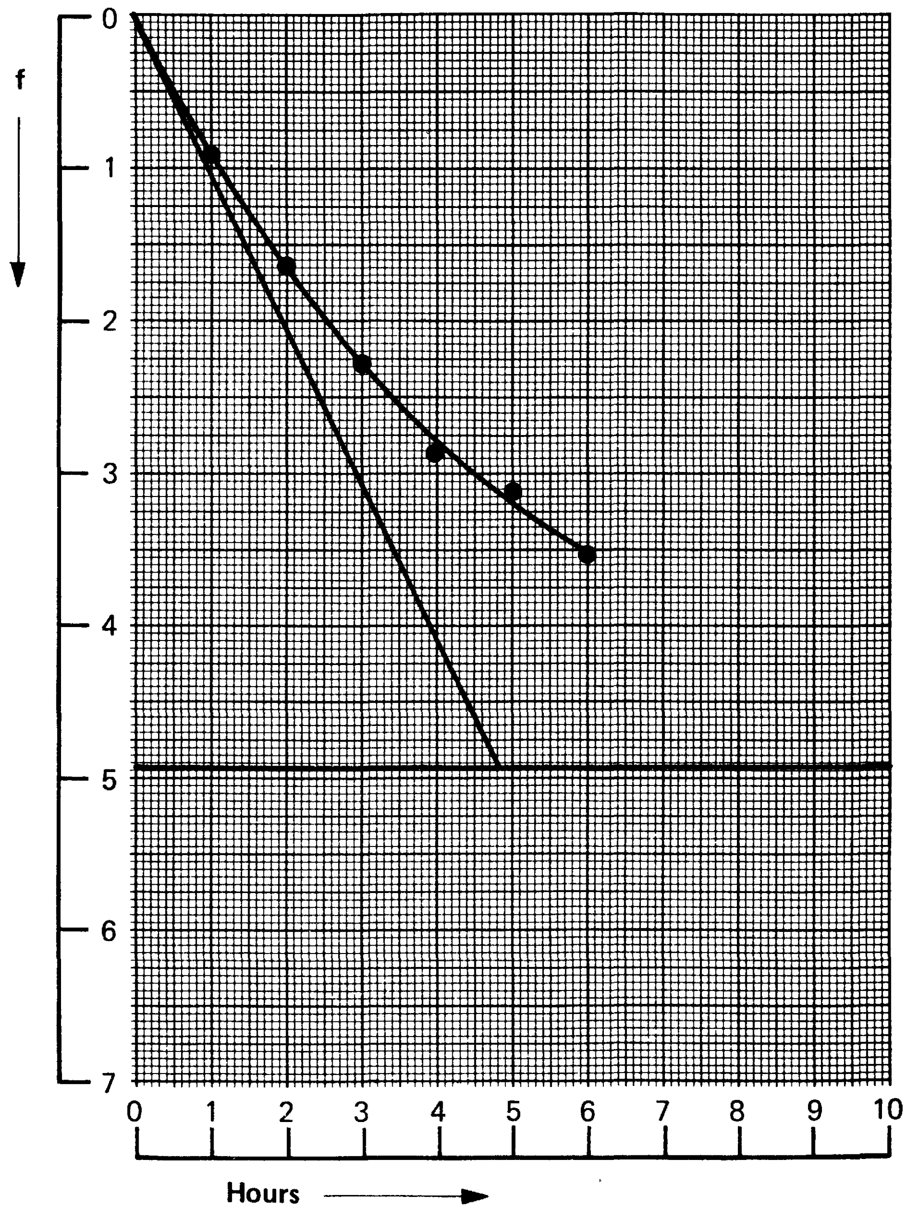


Remarks :

$\overline{\alpha}_c = 4.34$

$\overline{\sigma} = 0.0183$

Curve Number : 12-5				**Result Number :** 41								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	4.90		0	6.65	14.50	14.48	0	0	α_T		11.55
ϵ	45	44	44	1	7.06	15.39	15.41	0.89	0.93	α_R		1.30
θ_A	27.5	27.20		2	7.40	16.13	16.16	1.63	1.68	$\Delta\alpha$		10.25
$\overline{\theta}_E$		16.25		3	7.70	16.79	16.77	2.29	2.29	$1 + t_g \beta t_g \delta$		2.99
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.84	4	7.96	17.35	17.27	2.85	2.79	α_c		3.43
$(\theta_E - \theta_{E_c})_0$			+0.02	5	8.08	17.61	17.67	3.11	3.19	σ	0.01468	
θ_F			18.43	6	8.26	18.01	18.00	3.51	3.52			
θ'_F			19.42	∞					4.93	f_∞		4.90



Remarks :

$\overline{\alpha}_c = 3.24$

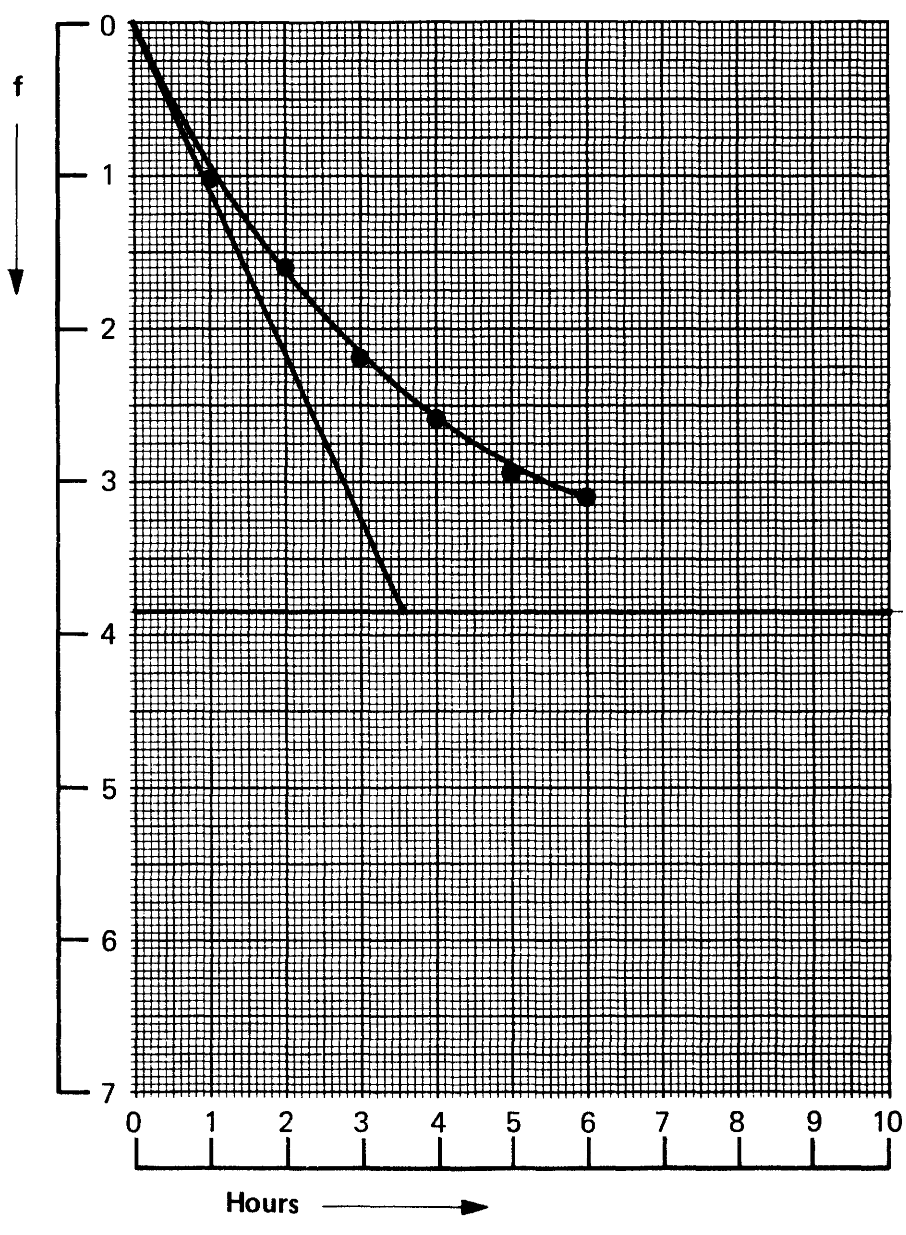
$\overline{\sigma} = 0.0135$

Curve Number : 13-6				Result Number : 42								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	4.95		0	9.20	20.06	20.08	0	0	α_T		15.65
ϵ	45	46	42	1	9.67	21.08	21.02	1.02	0.94	α_R		1.37
θ_A	34	33.8		2	9.94	21.67	21.72	1.61	1.64	$\Delta\alpha$		14.28
$\overline{\theta}_E$		21.61		3	10.2	22.24	22.26	2.18	2.18	$1 + t_g \beta t_g \delta$		3.58
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			22.76	4	10.4	22.67	22.66	2.61	2.58	α_c		3.99
$(\theta_E - \theta_{E_c})_0$			-0.02	5	10.55	23	22.96	2.94	2.88	σ	0.0161	
θ_F			22.95	6	10.63	23.17	23.19	3.11	3.11			
θ'_F			23.90	∞					3.82	f_∞		3.80

Remarks :

$\overline{\alpha}_c = 4.34$

$\overline{\sigma} = 0.0183$



Curve Number : 14 - 58 | **Result Number :** 43

	nominal	measured	calcul.
W	5	4.95	
ϵ	45	43	41.5
θ_A	27.5	27.3	
$\overline{\theta}_E$		21.67	
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			20.31
$(\theta_E - \theta_{E_c})_0$			- 0.01
θ_F			18.09
θ'_F			18.96

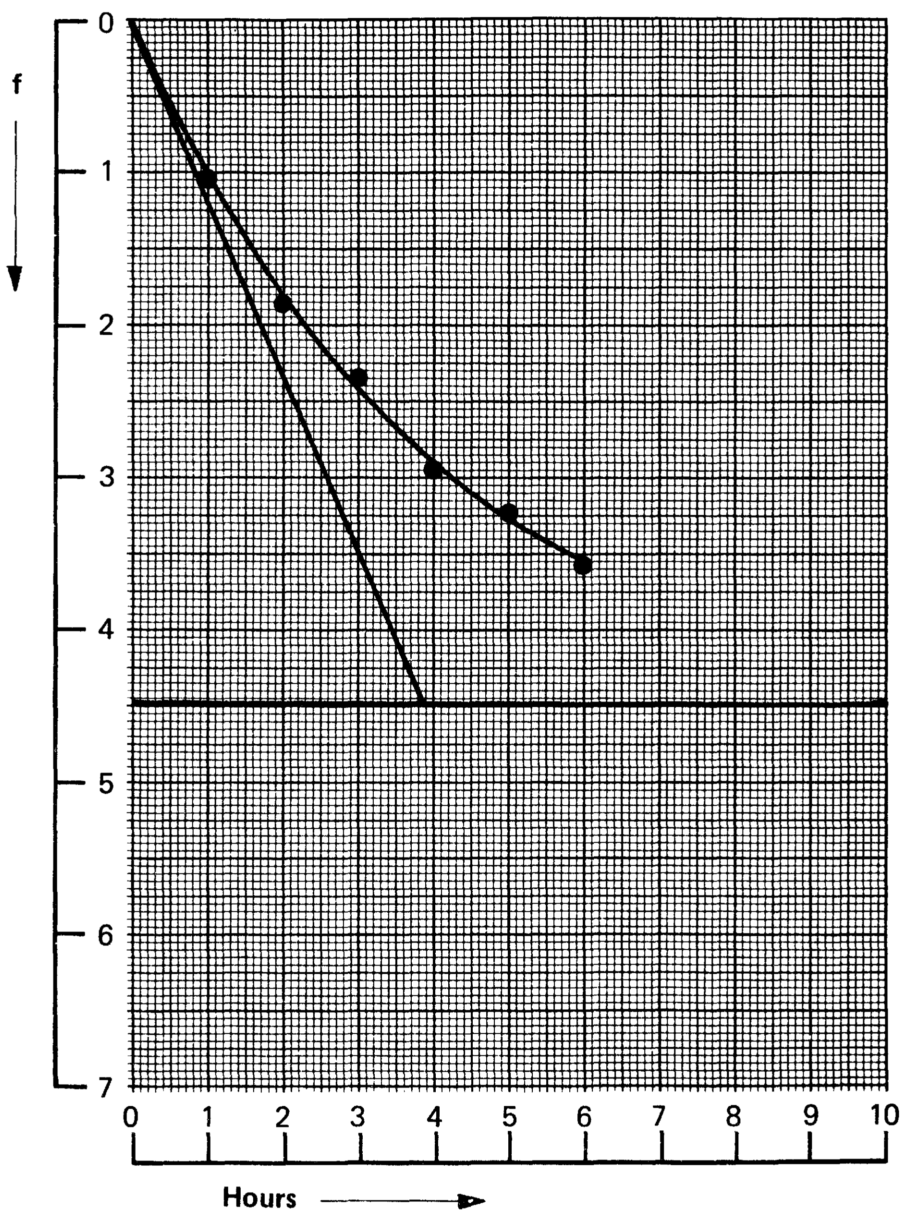
time	reading	θ_E	θ_{E_c}	f	f_c
0	10.76	23.46	23.45	0	0
1	10.28	22.41	22.42	1.05	1.03
2	9.90	21.58	21.63	1.88	1.82
3	9.68	21.10	21.02	2.36	2.43
4	9.40	20.50	20.55	2.96	2.90
5	9.28	20.23	20.19	3.23	3.26
6	9.12	19.88	19.91	3.58	3.54
∞					4.481

	GRAPH	COMPUT
α_T		14.46
α_R		1.37
$\Delta\alpha$		13.09
$1 + t_g \beta t_g \delta$		3.27
α_c		3.99
σ	0.0161	
f_∞		4.89

Remarks :

$\overline{\alpha}_c = 4.34$

$\overline{\sigma} = 0.0183$

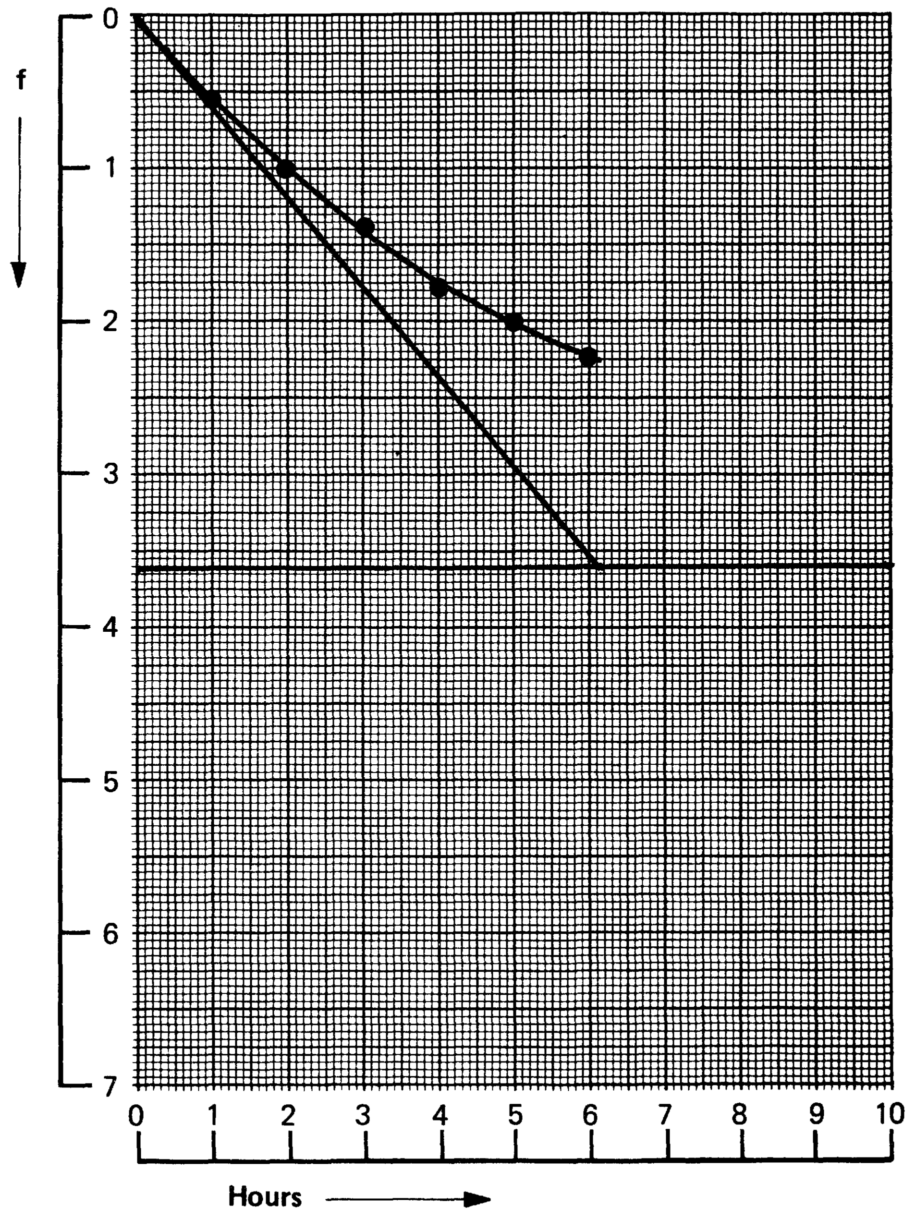


Curve Number : 17 - 7				Result Number : 44								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	4.95		0	5.22	11.38	11.38	0	0	α_T		9.05
ϵ	45	3.85	43	1	5.47	11.93	11.92	0.55	0.54	α_R		1.25
θ_A	22	22		2	5.68	12.38	12.38	1	1	$\Delta\alpha$		7.80
$\overline{\theta}_E$		12.50		3	5.85	12.75	12.78	1.37	1.40	$1 + t_g \beta t_g \delta$		2.57
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			13.25	4	6.03	13.15	13.11	1.77	1.73	α_c		3.02
$(\theta_E - \theta_{E_c})_0$			0,00	5	6.14	13.38	13.39	2	2.01	σ	0.0121	
θ_F			13.26	6	6.25	13.63	13.63	2.25	2.25			
θ'_F			14.99	∞					3.61	f_∞		3.83

Remarks :

$\overline{\alpha}_c = 3.24$

$\overline{\sigma} = 0.0135$



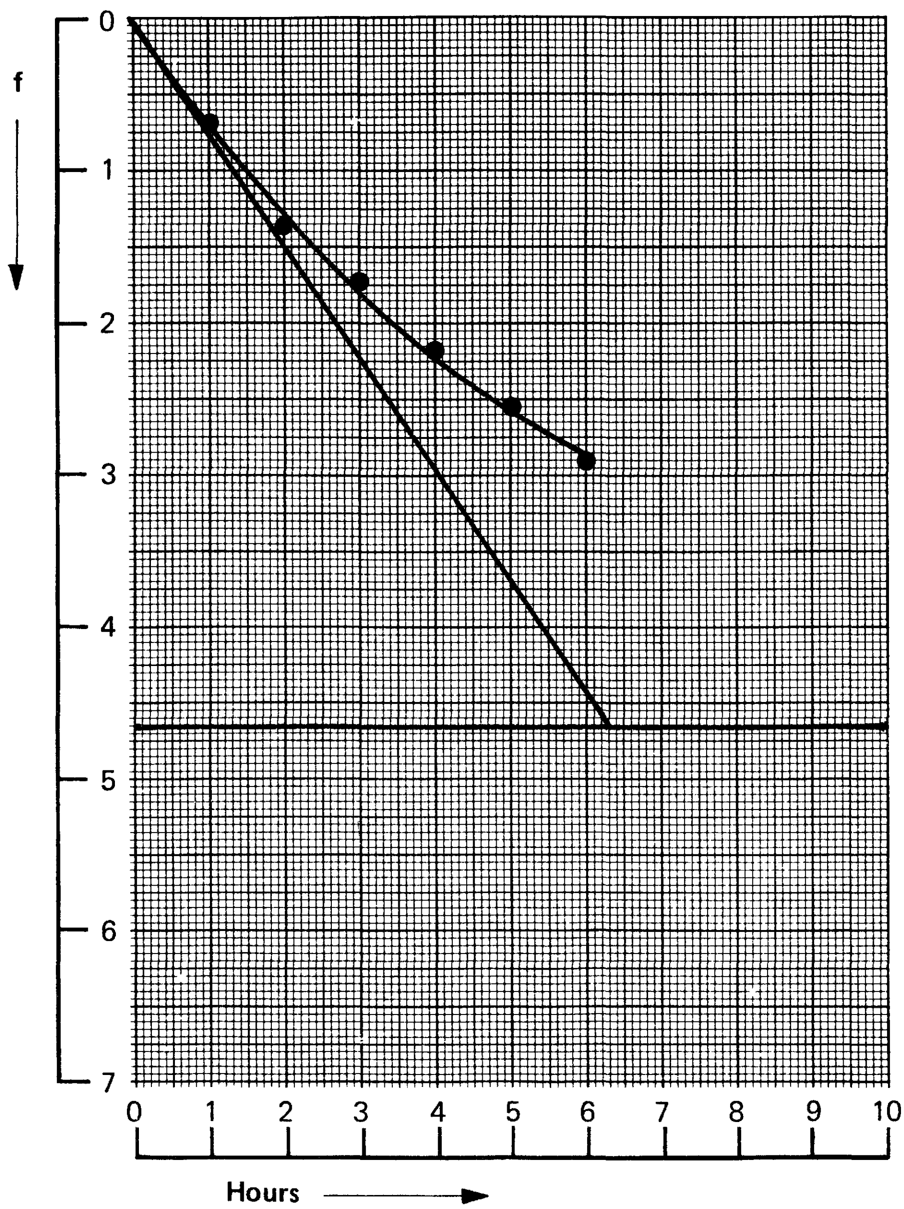
Curve Number : *18 – 60* **Result Number :** *45*

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	4.95		0	6.25	13.63	13.62	0	0	α_T		8.85
ϵ	45	40.5	55	1	5.94	12.95	12.93	0.68	0.69	α_R		1.25
θ_A	15	12.50		2	5.63	12.27	12.35	1.36	1.27	$\Delta\alpha$		7.60
$\overline{\theta}_E$		12.18		3	5.46	11.90	11.85	1.73	1.77	$1 + t_g \beta t_g \delta$		2.29
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			10.56	4	5.25	11.44	11.42	2.19	2.20	α_c		3.32
$(\theta_E - \theta_{E_c})_0$			+0.01	5	5.08	11.07	11.06	2.56	2.56	σ	0.0141	
θ_F			8.37	6	4.92	10.73	10.75	2.90	2.87			
θ'_F			8.95	∞					4.66	f_∞		5.34

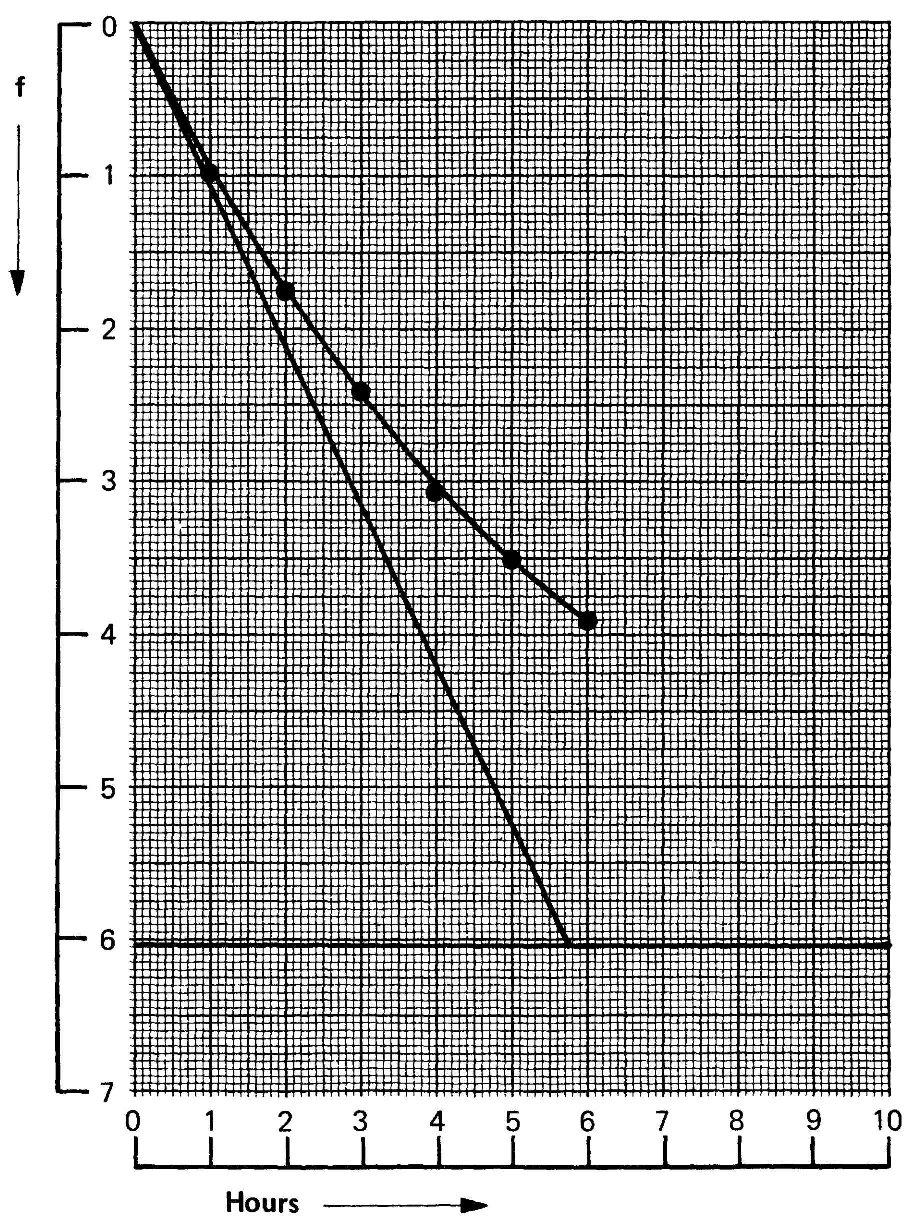
Remarks :

$\overline{\alpha}_c = 3.24$

$\overline{\sigma} = 0.0135$



Curve Number : 19 - 8				Result Number : 46								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	4.76		0	6.05	13.19	13.18	0	0	α_T		9.65
ϵ	90	76.4	86	1	6.49	14.15	14.15	0.96	0.96	α_R		1.29
θ_A	20	20.8		2	6.85	14.93	14.95	1.74	1.77	$\Delta\alpha$		8.36
$\overline{\theta}_E$		15.13		3	7.16	15.61	15.63	2.42	2.45	$1 + t_g \beta t_g \delta$		2.91
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.17	4	7.46	16.26	16.20	3.07	3.02	α_c		2.86
$(\theta_E - \theta_{E_c})_0$			+0.01	5	7.65	16.68	16.68	3.49	3.50	σ	0.0112	
θ_F			18.97	6	7.83	17.07	17.09	3.88	3.90			
θ'_F			19.21	∞					6.03	f_∞		6.1



Remarks :

$\overline{\alpha}_c = 3.24$

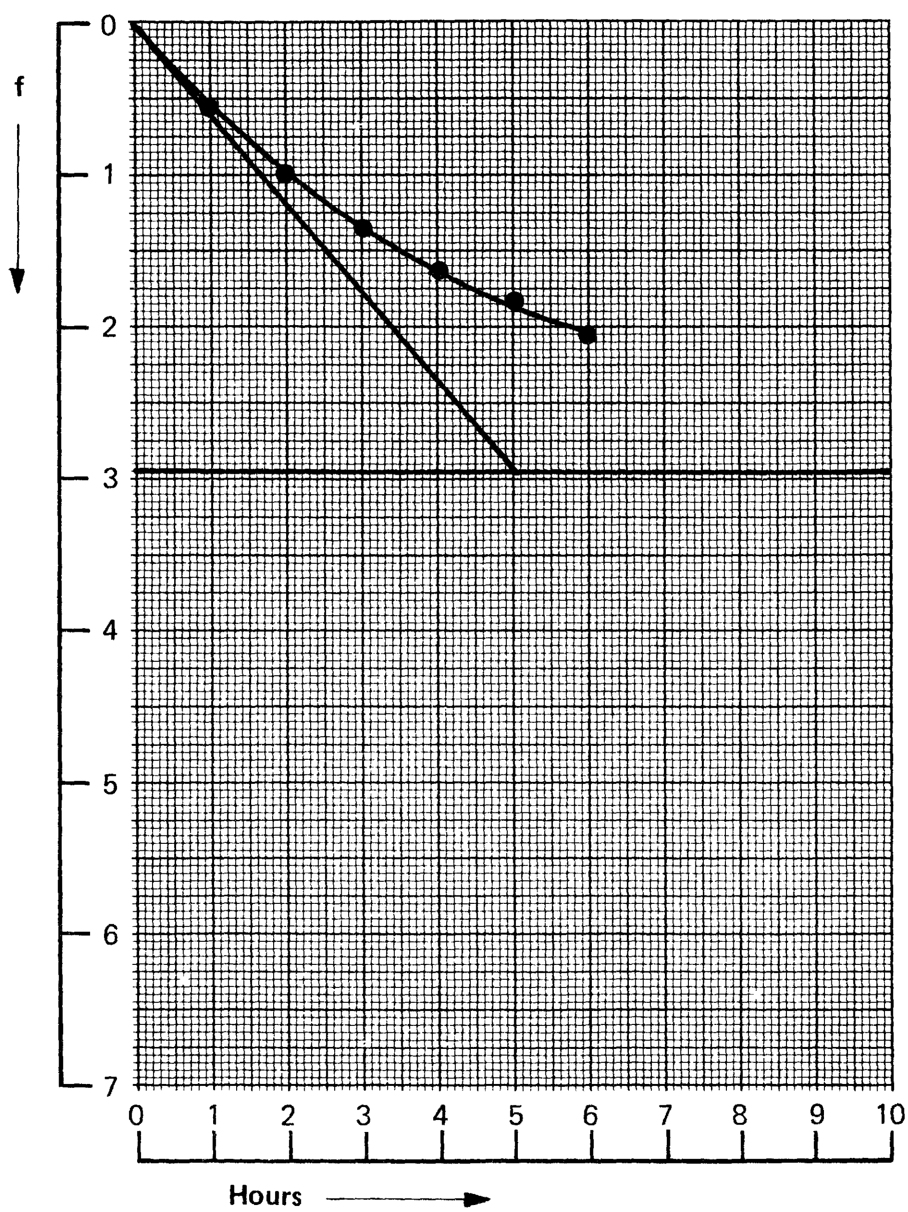
$\overline{\sigma} = 0.0135$

Curve Number : 20 - 61				**Result Number :** 47								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	5	4.92		0	8.09	17.64	17.63	0	0	α_T		10.96
ϵ	90	85.6	80	1	7.84	17.09	17.11	0.55	0.53	α_R		1.30
θ_A	15	15		2	7.65	16.68	16.67	0.96	0.96	$\Delta\alpha$		9.66
$\overline{\theta}_E$		16.60		3	7.48	16.31	16.32	1.33	1.32	$1 + t_g \beta t_g \delta$		2.75
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			15.64	4	7.35	16.02	16.02	1.62	1.61	α_c		3.50
$(\theta_E - \theta_{E_c})_0$			+ 0.01	5	7.25	15.81	15.78	1.83	1.85	σ	0.0153	
θ_F			14.64	6	7.14	15.57	15.59	2.07	2.05			
θ'_F			14.68	∞					2.95	f_∞		3

Remarks :

$\overline{\alpha}_c$ = 3.24

$\overline{\sigma}$ = 0.0135

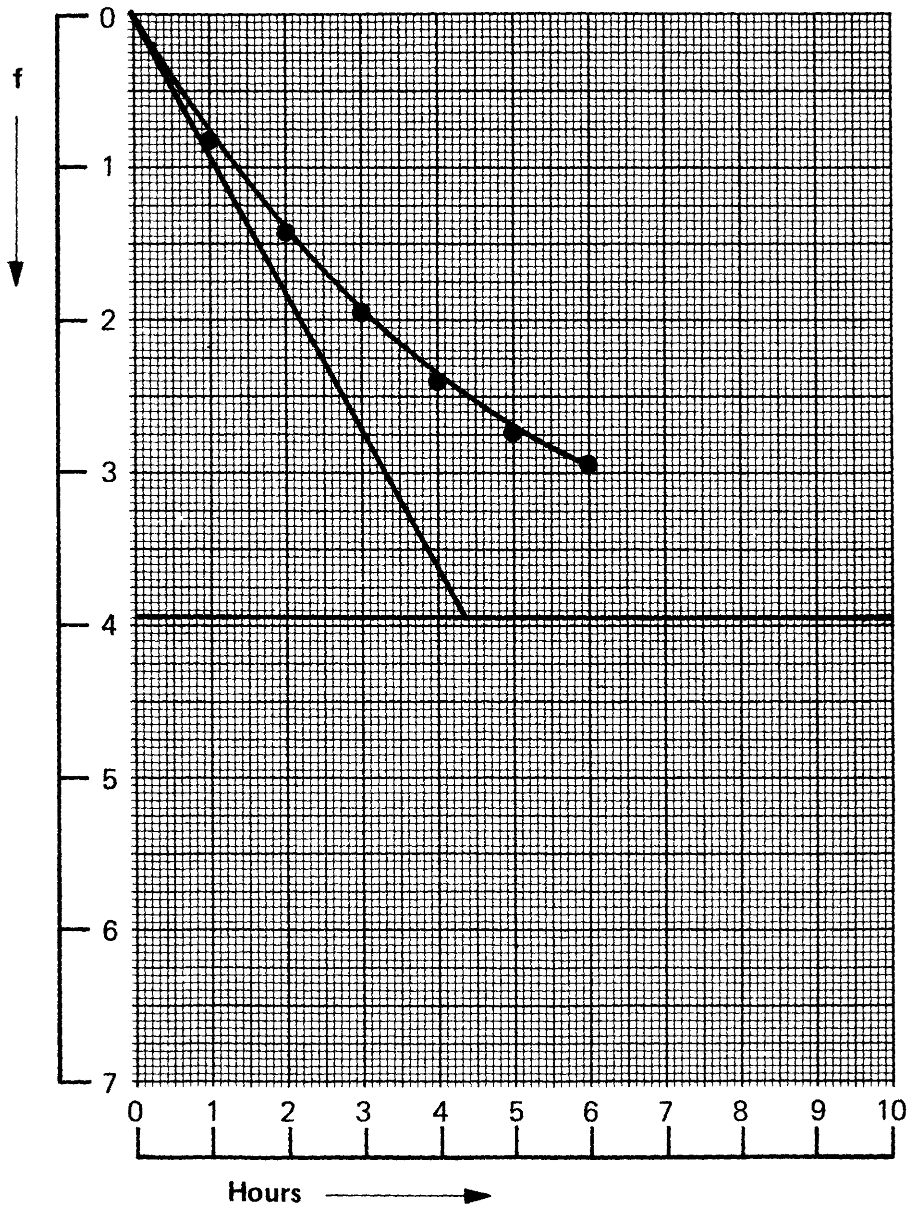


Curve Number : 29-13				**Result Number :** 48								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	4	4		0	7	15.26	15.27	0	0	α_T		12.76
ϵ	45	40	35	1	7.40	16.13	16.08	0.87	0.81	α_R		1.30
θ_A	28	29		2	7.65	16.68	16.72	1.42	1.45	$\Delta\alpha$		11.46
$\overline{\theta}_E$		16.73		3	7.90	17.22	17.24	1.96	1.96	$1 + t_g \beta t_g \delta$		3
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			23.38	4	8.10	17.66	17.64	2.40	2.37	α_c		3.81
$(\theta_E - \theta_{E_c})0$			-0.01	5	8.25	17.99	17.96	2.73	2.69	σ	0.01731	
θ_F			18.09	6	8.35	18.20	18.22	2.94	2.95			
θ'_F			19.21	∞					3.94	f_∞		3.92

Remarks :

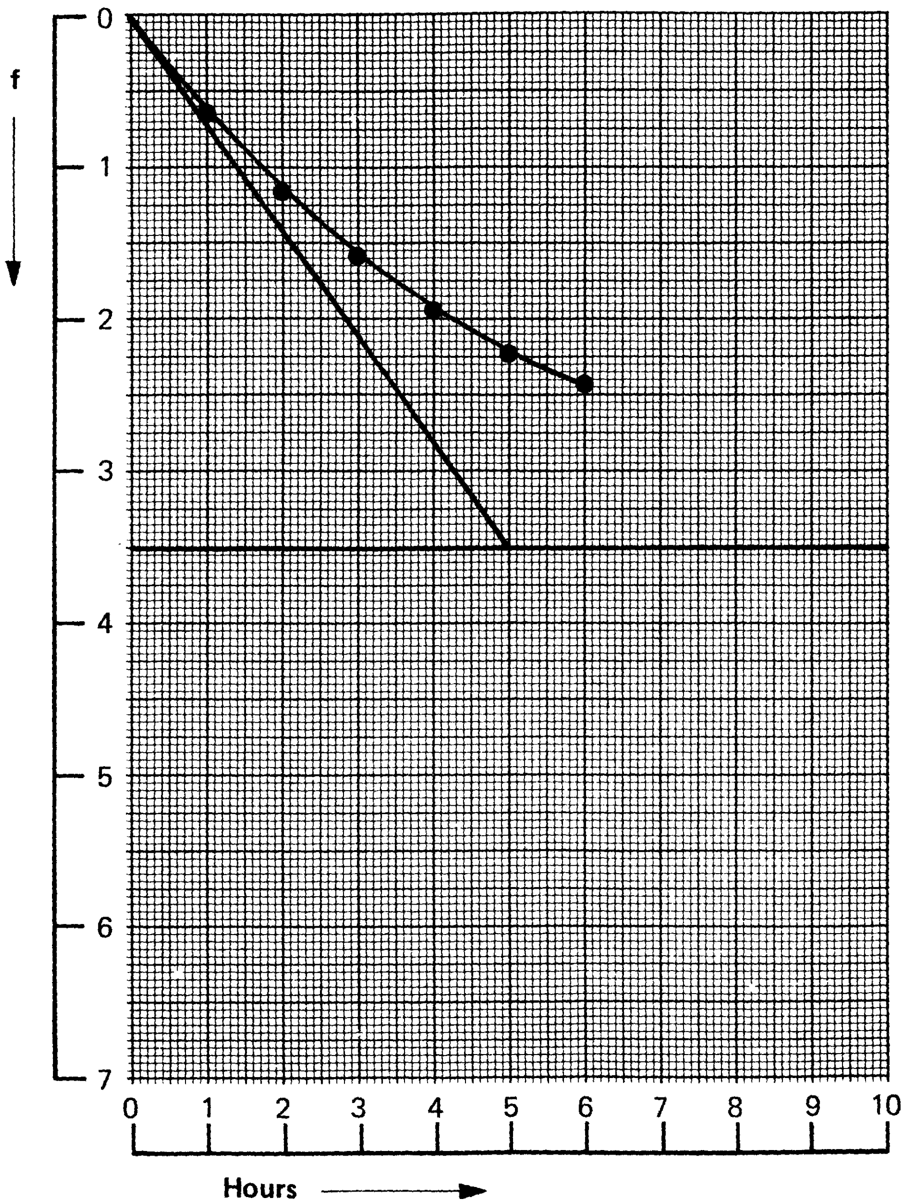
$\overline{\alpha}_c = 3.15$

$\overline{\sigma} = 0.0134$



Curve Number : *105-82* | **Result Number :** *49*

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	4	4		0	86	18.74	18.74	0	0	α_T		11.16
ϵ	65	67	72	1	83	18.08	18.10	0.66	0.64	α_R		1.32
θ_A	18.3	18.10		2	80.8	17.60	17.58	1.14	1.16	$\Delta\alpha$		9.84
$\overline{\theta}_E$		17.52		3	78.8	17.17	17.15	1.57	1.58	$1 + t_g \beta t_g \delta$		2.83
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			16.38	4	77	16.78	16.80	1.96	1.93	α_c		3.47
$(\theta_E - \theta_{E_c})_0$			0.00	5	75.8	16.51	16.52	2.23	2.22	σ	0.01523	
θ_F			14.85	6		16.30	16.29	2.44	2.45			
θ'_F			15.24	∞					3.50	f_∞		3.52



Remarks :

$\overline{\alpha}_c = 3.15$

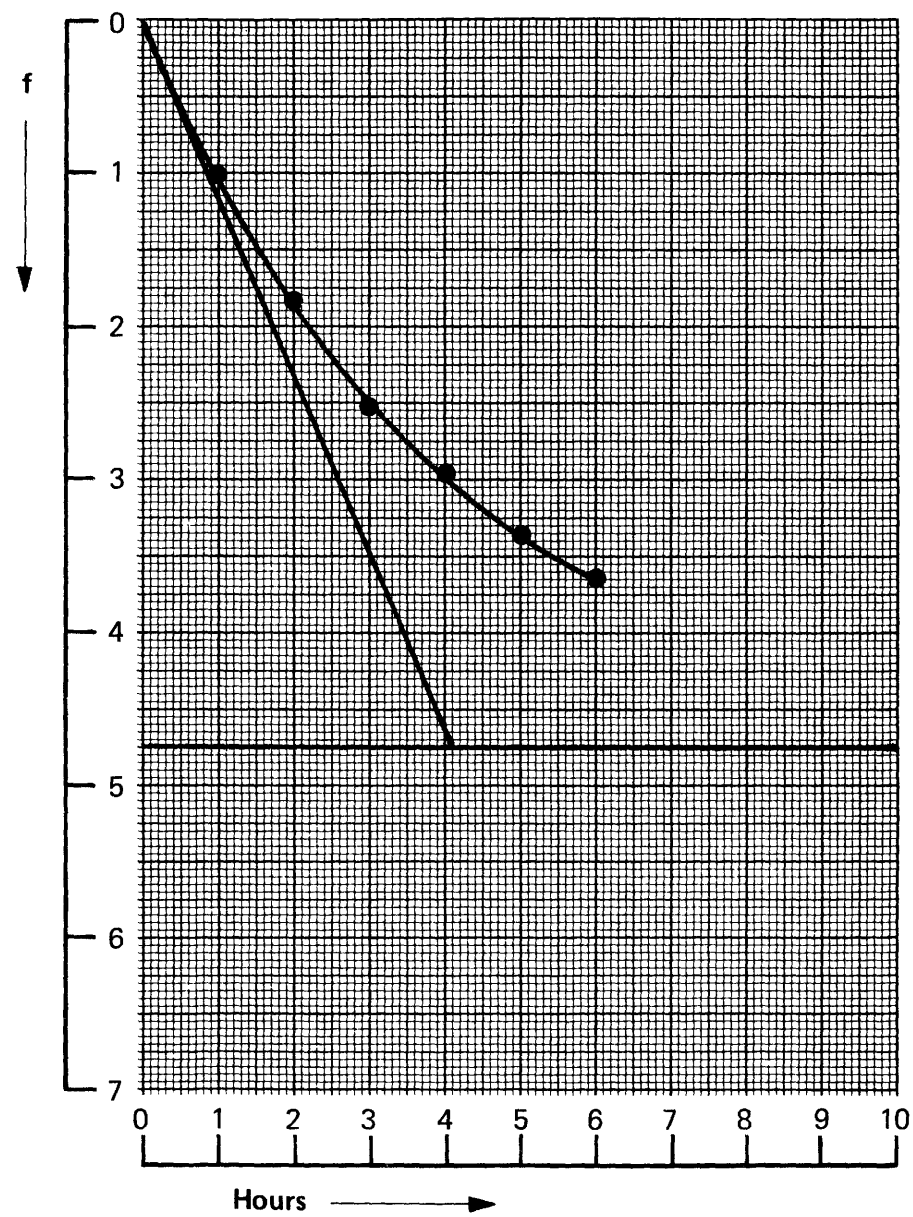
$\overline{\sigma} = 0.0134$

Curve Number : 108 – 41				Result Number : 50								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	4	3.85		0	114.5	24.95	24.94	0	0	α_T		13.63
ϵ	65	73	65	1	119.1	25.95	25.97	1	1.03	α_R		1.43
θ_A	35	35.1		2	122.8	26.75	26.77	1.80	1.84	$\Delta\alpha$		12.20
$\overline{\theta}_E$		26.76		3	126	27.45	27.40	2.50	2.47	$1 + t_g \beta t_g \delta$		4.37
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			28.22	4	128	27.89	27.90	2.94	2.96	α_c		2.79
$(\theta_E - \theta_{E_c})_0$			+0.01	5	129.8	28.28	28.28	3.33	3.34	σ	0.01119	
θ_F			29.03	6	131.2	28.58	28.59	3.63	3.65			
θ'_F			29.67	∞					4.73	f_∞		4.56

Remarks :

$\overline{\alpha}_c = 3.15$

$\overline{\sigma} = 0.0134$

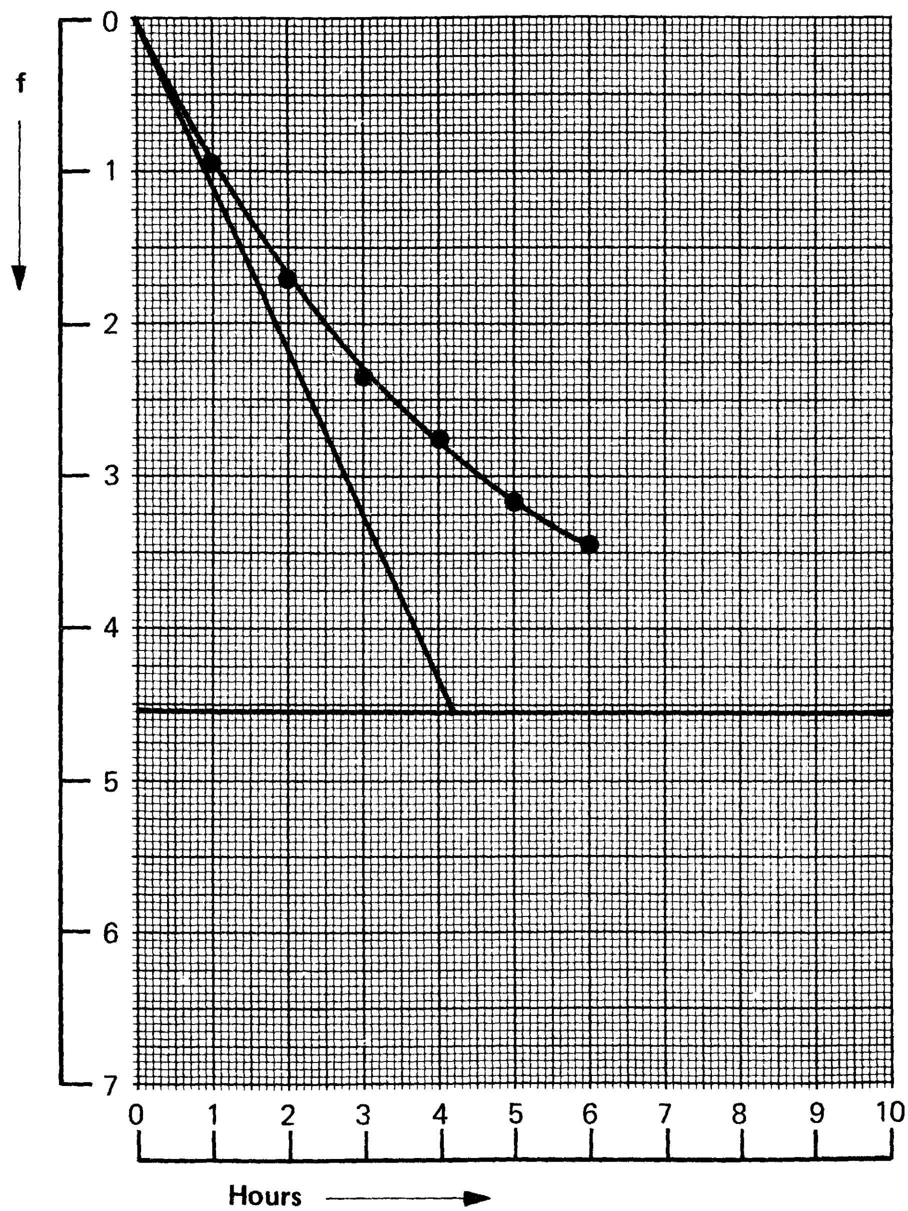


Curve Number : 109-83				Result Number : 51								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	4	3.9		0	132.8	28.93	28.94	0	0	α_T		13.15
ϵ	65	69	61	1	128.6	28.02	27.99	0.91	0.96	α_R		1.44
θ_A	29.4	29.80		2	125	27.23	27.23	1.70	1.71	$\Delta\alpha$		11.71
$\overline{\theta}_E$		27.21		3	122	26.58	26.63	2.35	2.31	$1 + t_g \beta\, t_g \delta$		4
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			25.80	4	120.2	26.19	26.16	2.74	2.78	α_c		2.93
$(\theta_E - \theta_{E_c})_0$			-0.01	5	118.4	25.80	25.79	3.13	3.15	σ	0.01169	
θ_F			23.73	6	117	25.49	25.50	3.44	3.45			
θ'_F			24.40	∞					4.54	f_∞		4.38

Remarks :

$\overline{\alpha}_c$ = 3.15

$\overline{\sigma}$ = 0.0134



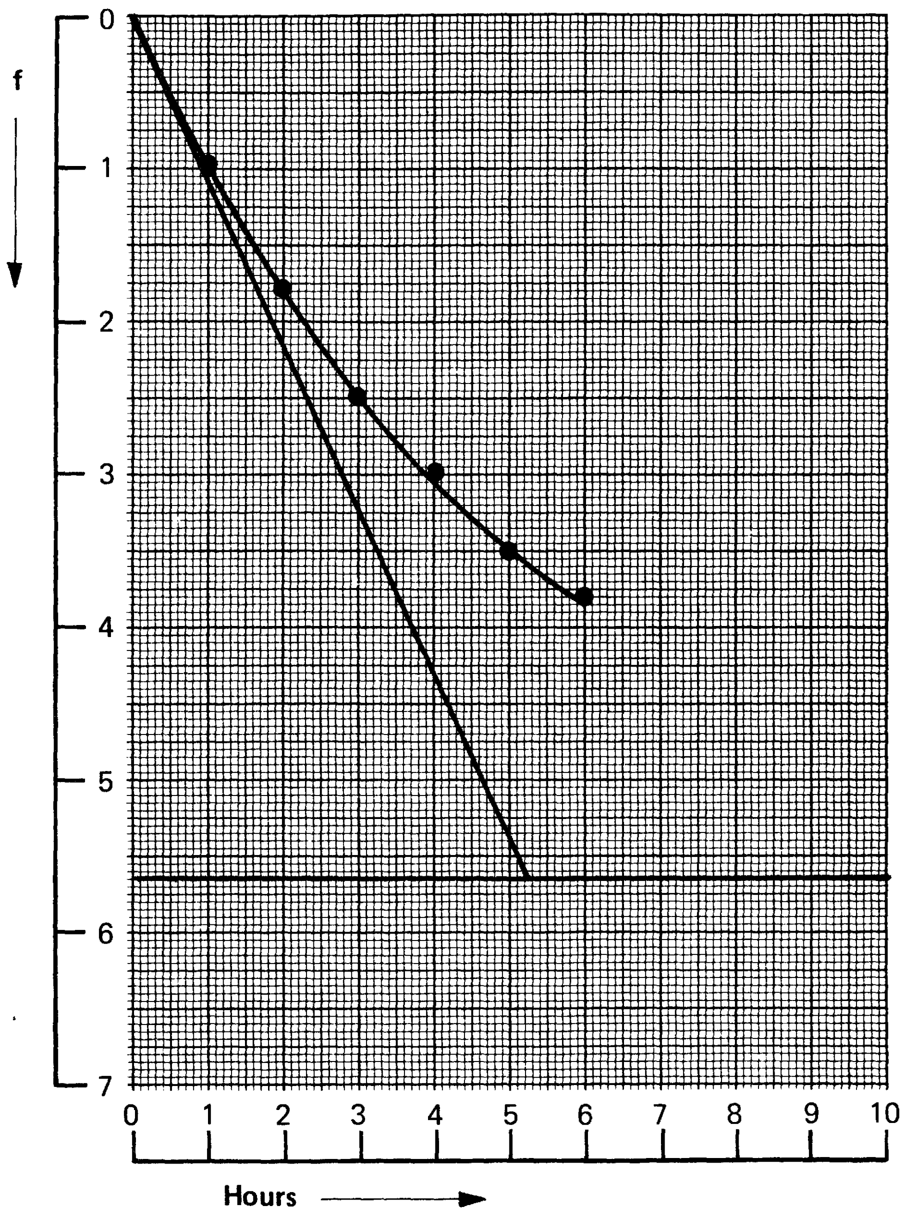
Curve Number : 110 - 84 **Result Number :** 52

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	4	3.9		0	112.3	24.47	24.48	0	0	α_T		10.60
ϵ	65	67	60	1	107.9	23.51	23.50	0.96	0.98	α_R		1.38
θ_A	23.7	23.7		2	104.2	22.70	22.69	1.77	1.79	$\Delta\alpha$		9.22
$\overline{\theta}_E$		22.56		3	101	22	22.02	2.47	2.46	$1 + t_g \beta t_g \delta$		3.2
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			20.7	4	98.6	21.48	21.47	2.99	3.01	α_c		2.77
$(\theta_E - \theta_{E_c})_0$			-0.01	5	96.3	20.98	21.01	3.49	3.47	σ	0.0115	
θ_F			18.10	6	94.8	20.65	20.63	3.82	3.85			
θ'_F			18.83	∞					5.64	f_∞		5.55

Remarks :

$\overline{\alpha}_c = 3.15$

$\overline{\sigma} = 0.0134$

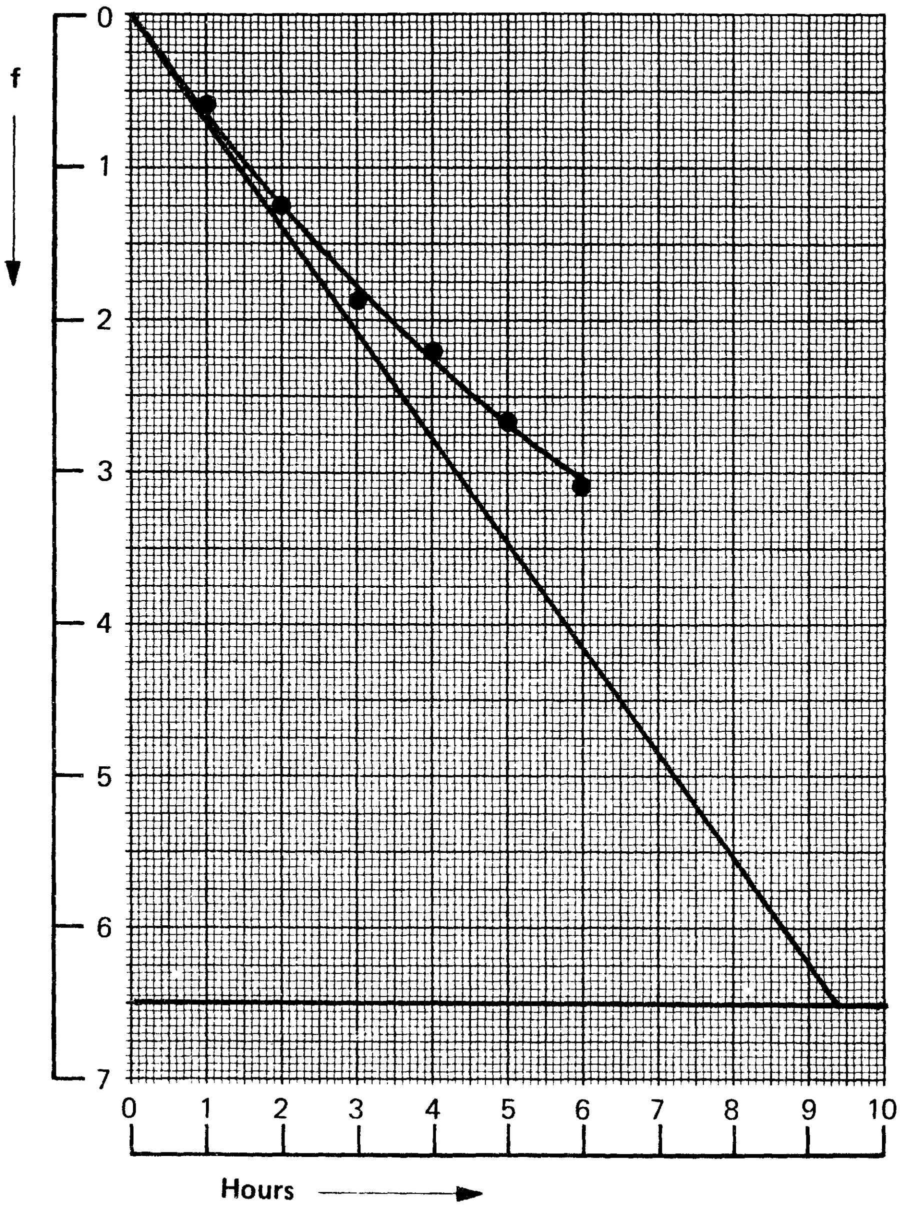


Curve Number : 21 - 9				**Result Number :** 53								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	3.1		0	6.70	14.61	14.57	0	0	α_T		5.90
ϵ	45	45	45	1	6.95	15.15	15.23	0.54	0.66	α_R		1.3
θ_A	27.5	27.7		2	7.25	15.81	15.82	1.20	1.25	$\Delta\alpha$		4.6
$\overline{\theta}_E$		16.13		3	7.55	16.46	16.35	1.85	1.78	$1 + t_g \beta t_g \delta$		3.07
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			18.60	4	7.70	16.79	16.83	2.18	2.25	α_c		1.50
$(\theta_E - \theta_{E_c})_0$			+0.04	5	7.90	17.22	17.26	2.61	2.68	σ	0.00442	
θ_F			19.20	6	8.10	17.66	17.64	3.05	3.07			
θ'_F			21.08	∞					6.50	f_∞		5.27

Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$



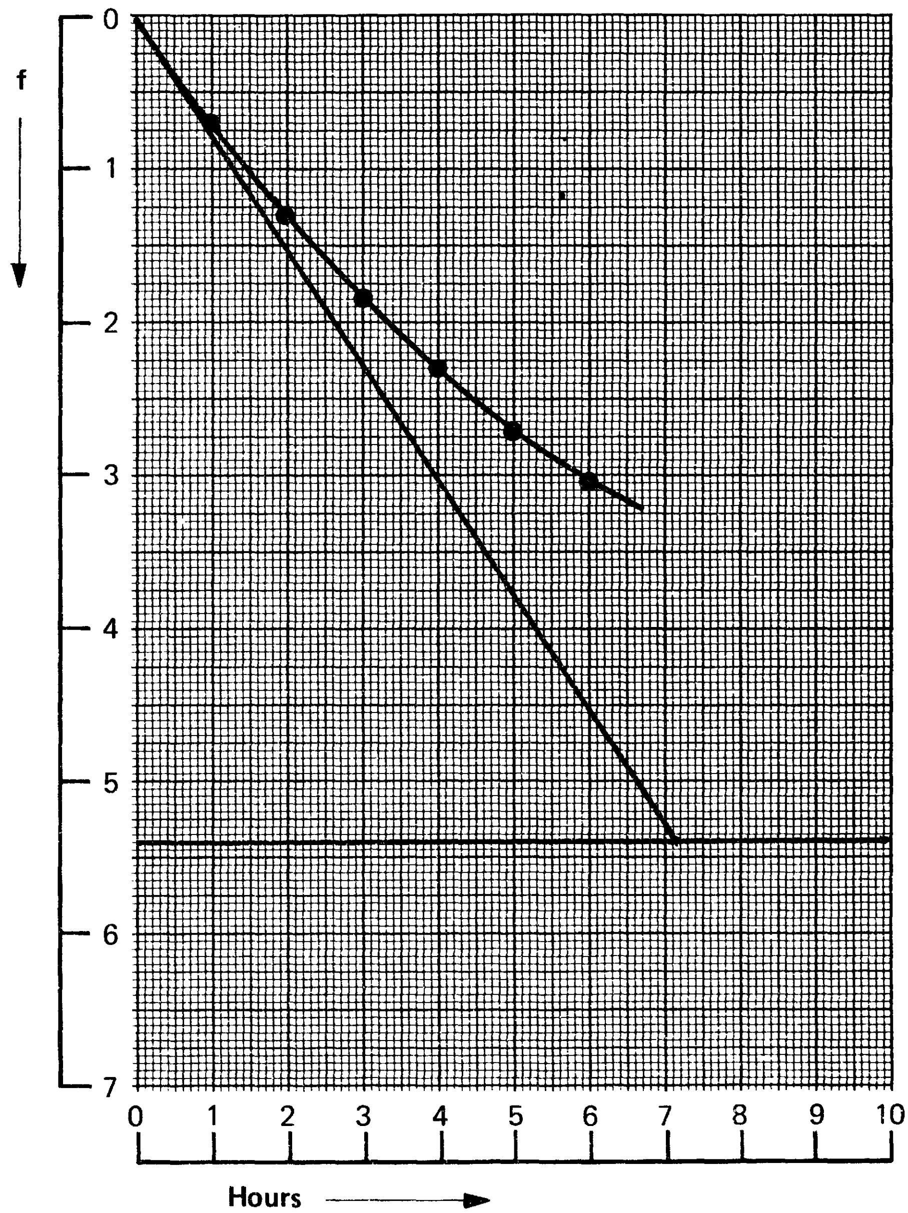
Curve Number : 22.10 **Result Number :** 54

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.92		0	9.05	19.73	19.73	0	0	α_T		7.75
ϵ	45	44.5	43	1	9.37	20.43	20.43	0.70	0.70	α_R		1.36
θ_A	34	34.6		2	9.65	21.04	21.04	1.31	1.31	$\Delta\alpha$		6.39
$\overline{\theta}_E$		21.25		3	9.90	21.58	21.57	1.85	1.84	$1 + t_g \beta t_g \delta$		3.63
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			23.18	4	10.10	22.02	22.03	2.29	2.31	α_c		1.76
$(\theta_E - \theta_{E_c})_0$			0.00	5	10.30	22.45	22.44	2.72	2.71	σ	0.00632	
θ_F			23.09	6	10.45	22.78	22.79	3.05	3.06			
θ'_F			25.11	∞					5.38	f_∞		5.27

Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$

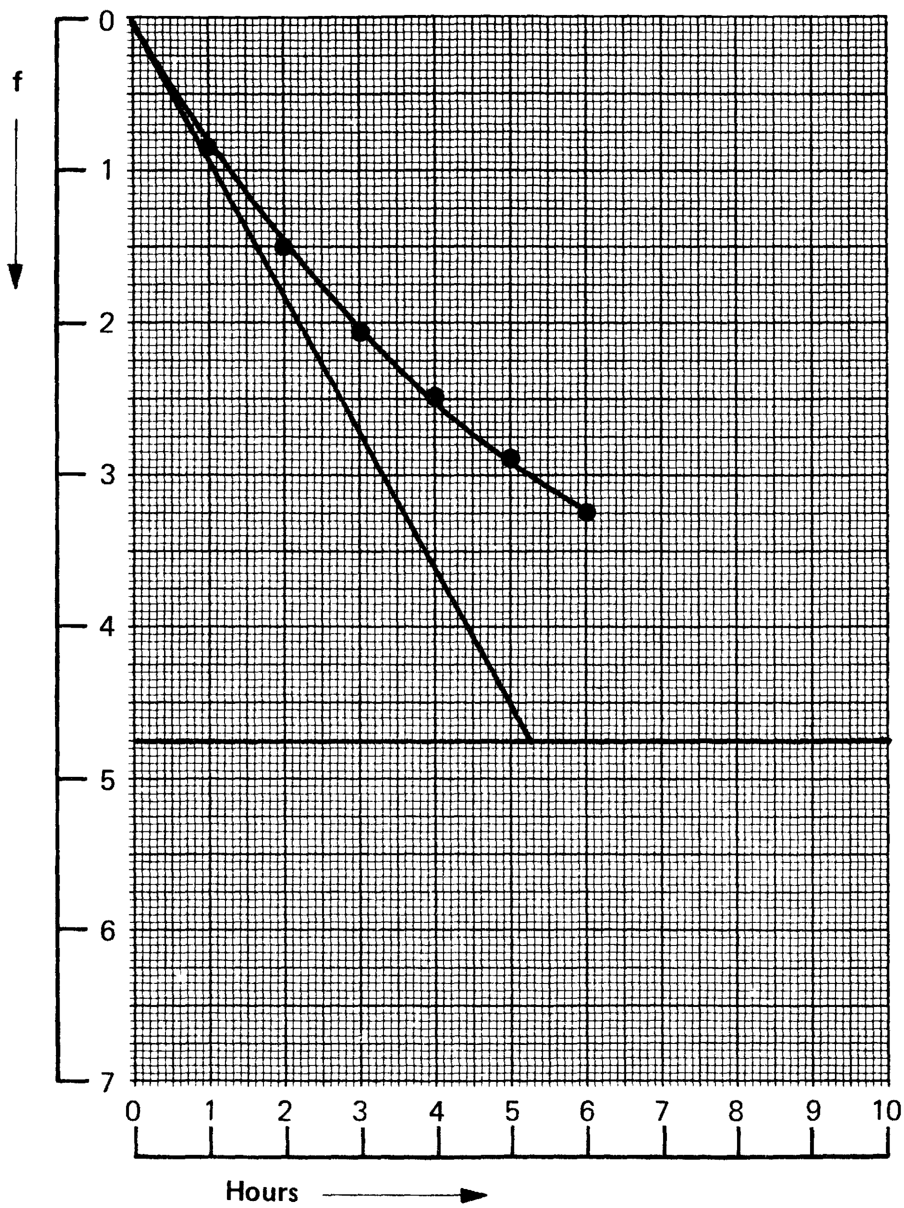


Curve Number : 23·62				Result Number : 55								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.97		0	11	23.98	23.96	0	0	α_T		10.52
ϵ	45	42.2	39	1	10.6	23.11	23.14	0.87	0.82	α_R		1.38
θ_A	27.5	27.8		2	10.3	22.45	22.46	1.53	1.49	$\Delta\alpha$		9.14
$\overline{\theta}_E$		22.34		3	10.05	21.91	21.90	2.07	2.05	$1 + t_g \beta t_g \delta$		3.32
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			20.78	4	9.85	21.47	21.44	2.51	2.52	α_c		2.74
$(\theta_E - \theta_{E_c})_0$			+0.02	5	9.67	21.08	21.06	2.90	2.90	σ	0.0121	
θ_F			17.92	6	9.50	20.71	20.74	3.27	3.22			
θ'_F			19.22	∞					4.74	f_∞		4.93

Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$



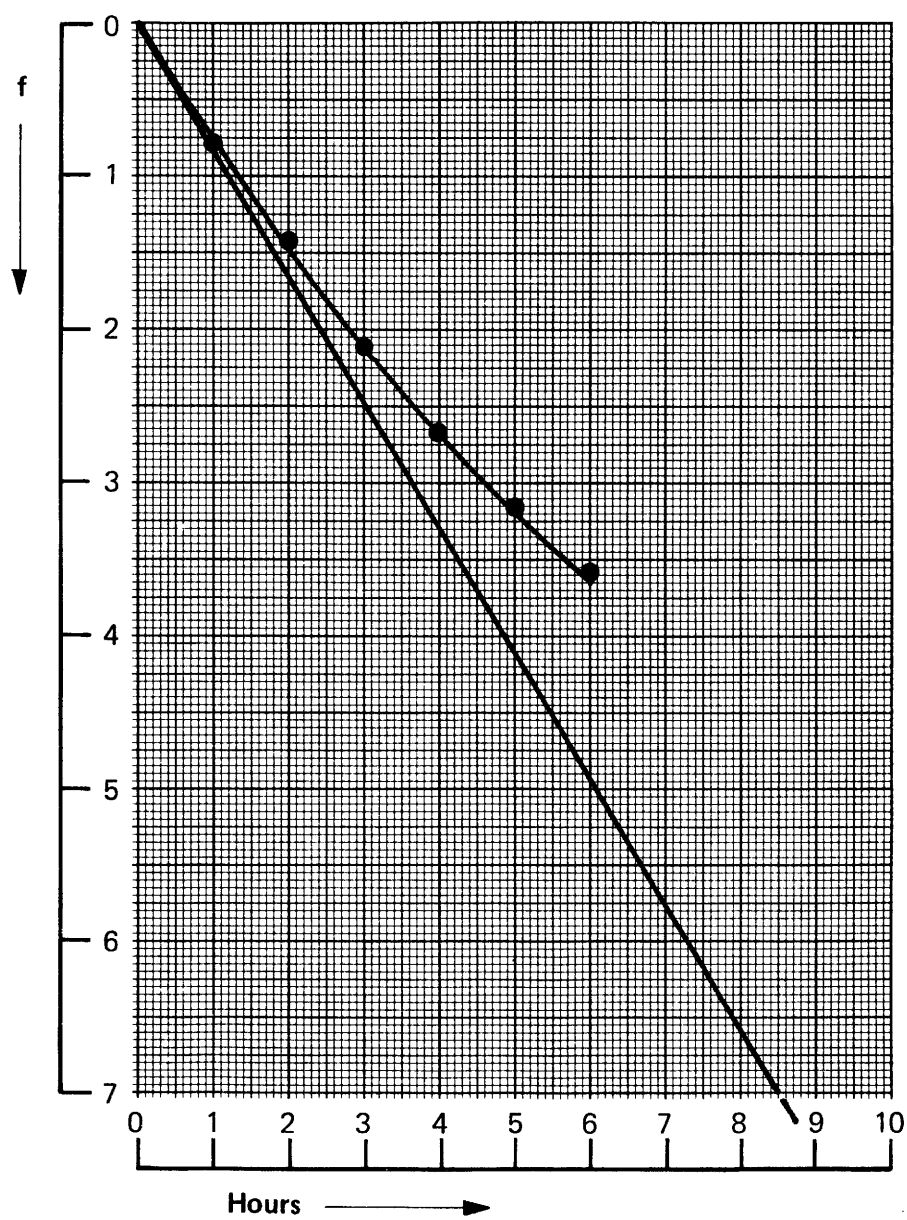
Curve Number : 69- 30 **Result Number :** 56

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.9		0	6.35	13.84	13.83	0	0	α_T		6.1
ϵ	45	47	48	1	6.70	14.61	14.61	0.77	0.78	α_R		1.29
θ_A	27.5	27.7		2	7	15.26	15.30	1.42	1.48	$\Delta \alpha$		4.81
$\overline{\theta}_E$		15.63		3	7.31	15.94	15.93	2.10	2.10	$1 + t_g \beta t_g \delta$		3.06
$\frac{1}{2} (\overline{\theta}_E + \theta'_F)$			18.47	4	7.58	16.52	16.49	2.68	2.66	α_c		1.57
$(\theta_E - \theta_{E_c})_0$			+0.01	5	7.80	17	16.99	3.16	3.16	σ	0.00487	
θ_F			19.59	6	7.99	17.42	17.44	3.58	3.61			
θ'_F			21.31	∞					7.48	f_∞		7.11

Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$

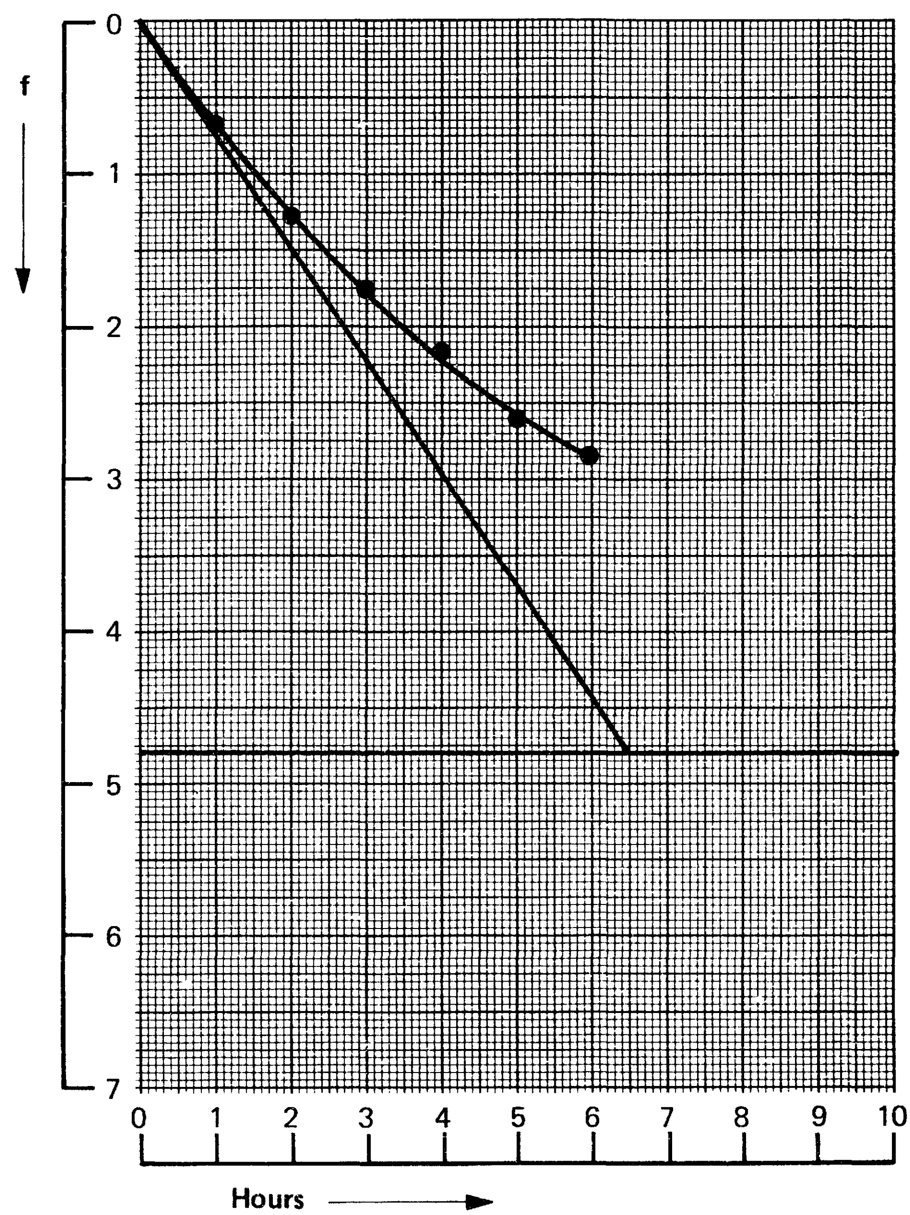


Curve Number : 70-31				Result Number : 57								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.85		0	8.98	19.58	19.58	0	0	α_T		8.57
ϵ	45	48	41	1	9.30	20.27	20.27	0.69	0.68	α_R		1.36
θ_A	34	33.3		2	9.57	20.86	20.85	1.28	1.27	$\Delta\alpha$		7.21
$\overline{\theta}_E$		21.01		3	9.79	21.34	21.35	1.76	1.77	$1 + t_g\beta\, t_g\delta$		3.57
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			22.69	4	9.98	21.76	21.78	2.18	2.20	α_c		2.02
$(\theta_E - \theta_{E_c})_0$			0.00	5	10.18	22.19	22.15	2.61	2.57	σ	0.00779	
θ_F			22.66	6	10.30	22.45	22.47	2.87	2.88			
θ'_F			24.36	∞					4.77	f_∞		4.77

Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$



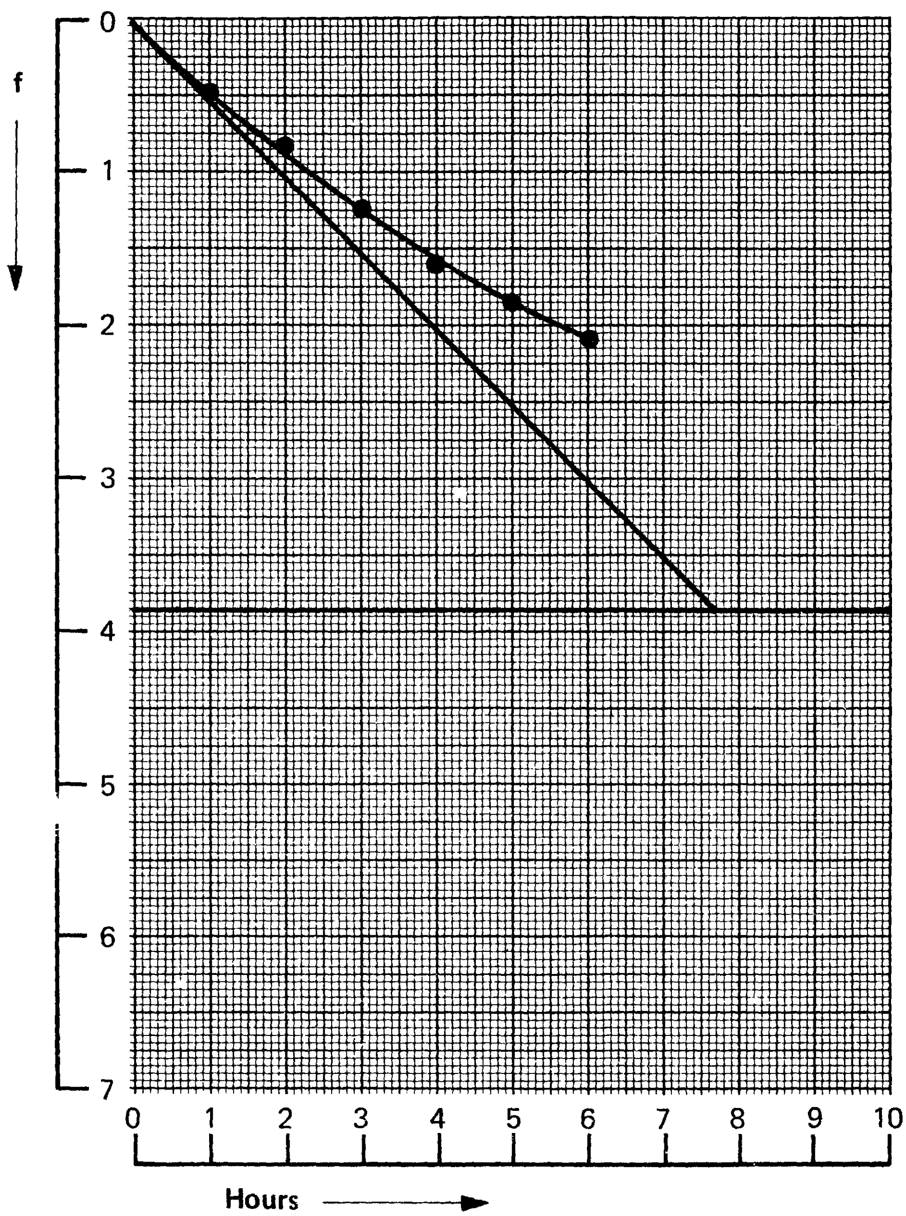
Curve Number : 74 - 32 **Result Number :** 58

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.82		0	5.44	11.86	11.87	0	0	α_T		7.21
ϵ	44	46	45	1	5.68	12.38	12.34	0.52	0.47	α_R		1.26
θ_A	22	22		2	5.83	12.71	12.75	0.85	0.88	$\Delta\alpha$		5.95
$\overline{\theta}_E$		12.90		3	6.01	13.10	13.11	1.24	1.24	$1 + t_g \beta t_g \delta$		2.62
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			14.31	4	6.18	13.47	13.43	1.61	1.56	α_c		2.26
$(\theta_E - \theta_{E_c})_0$			-0.01	5	6.29	13.71	13.71	1.85	1.84	σ	0.00913	
θ_F			14.40	6	6.40	13.95	13.96	2.09	2.09			
θ'_F			15.73	∞					3.86	f_∞		3.86

Remarks :

$\overline{\alpha}_c = 2.4$

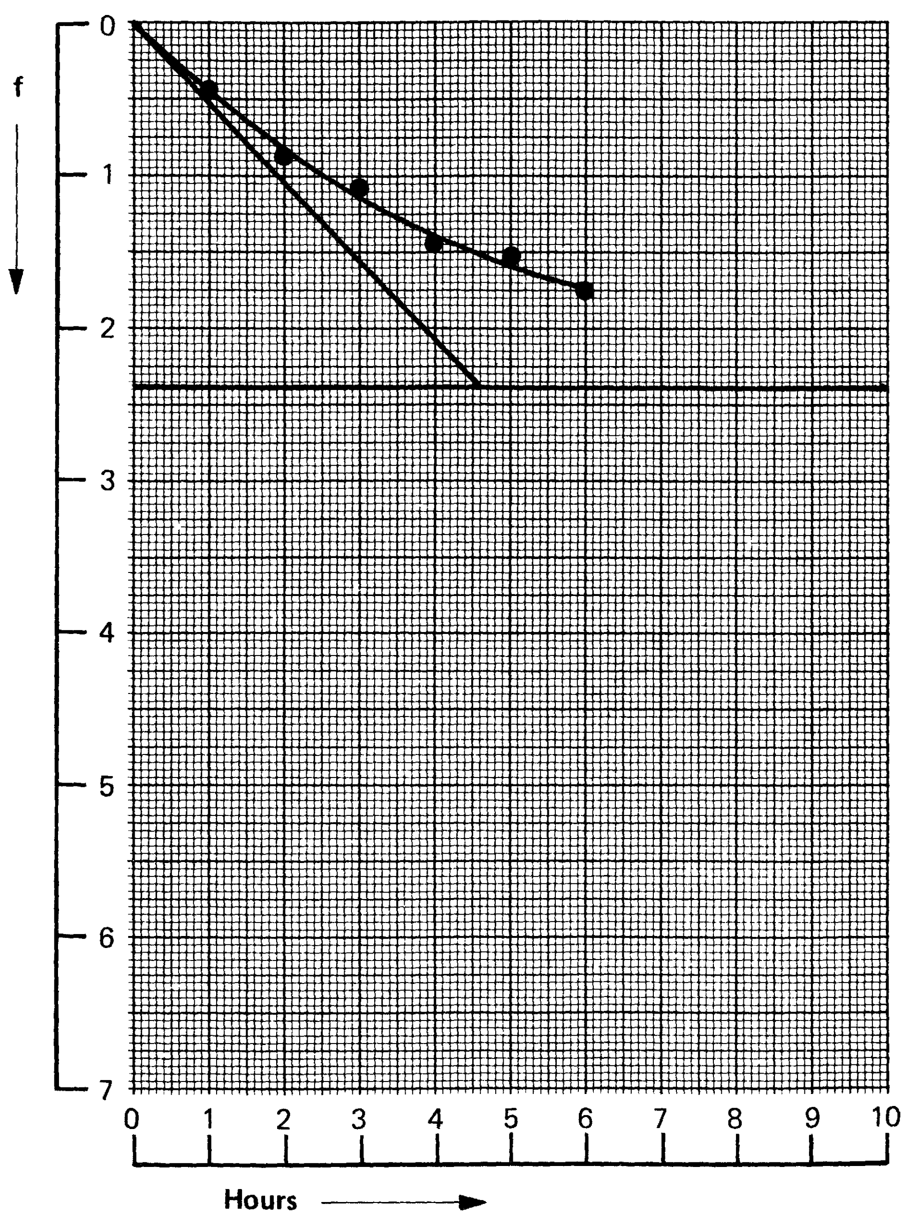
$\overline{\sigma} = 0.01$



Curve Number : 76-33				Result Number : 59								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.82		0	9.30	20.27	20.27	0	0	α_T		12.16
ϵ	65	69	63	1	9.51	20.73	20.74	0.46	0.46	α_R		1.36
θ_A	29	27.50		2	9.70	21.15	21.11	0.88	0.84	$\Delta \alpha$		10.80
$\overline{\theta}_E$		21.14		3	9.80	21.36	21.41	1.09	1.14	$1 + t_g \beta t_g \delta$		3.46
$\frac{1}{2} (\overline{\theta}_E + \theta'_F)$			21.88	4	9.95	21.69	21.65	1.42	1.38	α_c		3.11
$(\theta_E - \theta_{E_c})_0$			0.00	5	10	21.80	21.84	1.53	1.57	σ	0.0142	
θ_F			22.01	6	10.10	22.02	22	1.75	1.73			
θ'_F			22.63	∞					2.36	f_∞		2.76

Remarks :

$\overline{\alpha}_c = 2.4$
$\overline{\sigma} = 0.01$

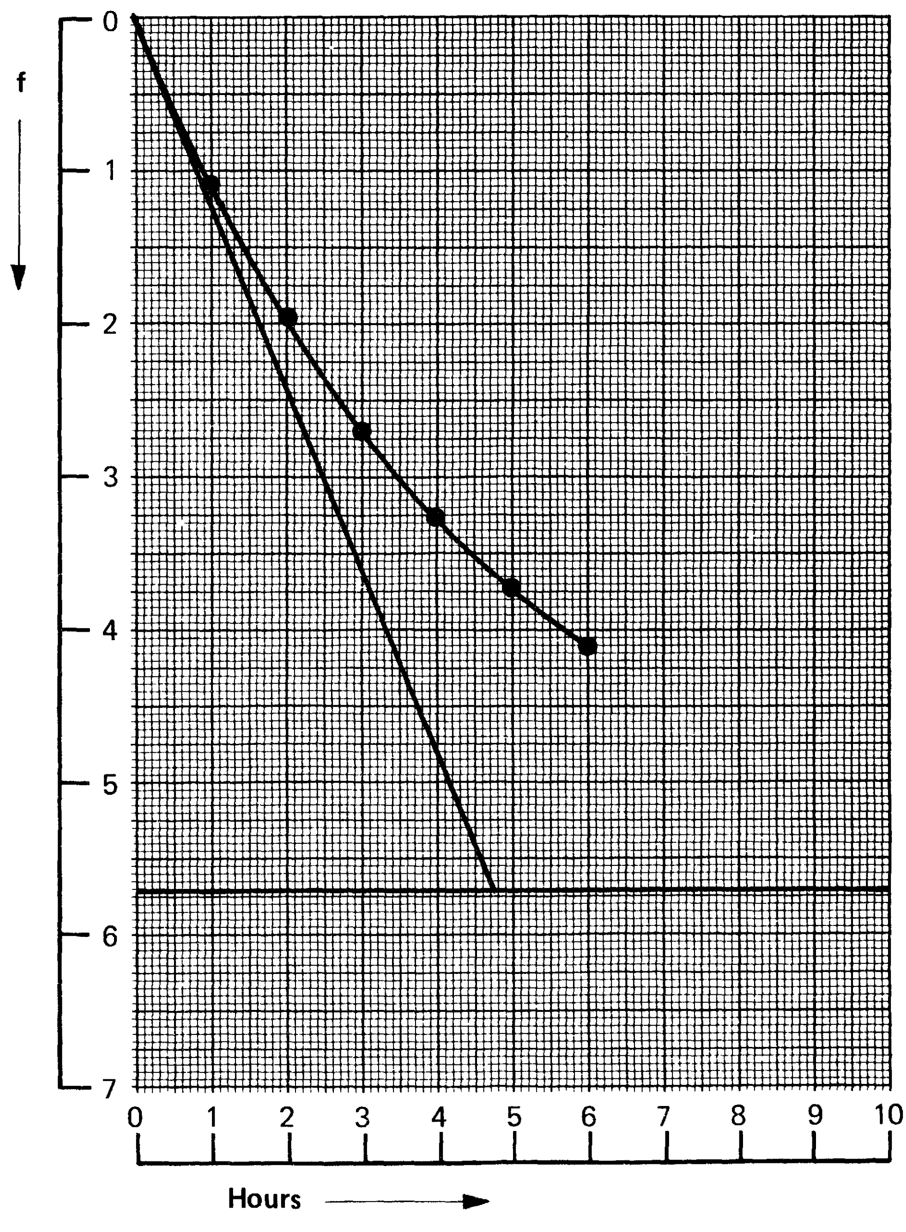


Curve Number : 77 - 34				Result Number : 60								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.82		0	10.40	22.67	22.67	0	0	α_T		11.73
ϵ	65	73	63	1	10.90	23.76	23.76	1.09	1.09	α_R		1.41
θ_A	35	34		2	11.30	24.63	24.64	1.96	1.97	$\Delta\alpha$		10.32
$\overline{\theta}_E$		24.72		3	11.63	25.35	25.35	2.68	2.68	$1 + t_g \beta t_g \delta$		4.11
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			26.55	4	11.90	25.94	25.93	3.27	3.24	α_c		2.51
$(\theta_E - \theta_{E_c})_0$			0.00	5	12.11	26.40	26.40	3.73	3.73	σ	0.01061	
θ_F			27.6	6	12.28	26.77	26.78	4.10	4.11			
θ'_F			28.38	∞					5.71	f_∞		5.70

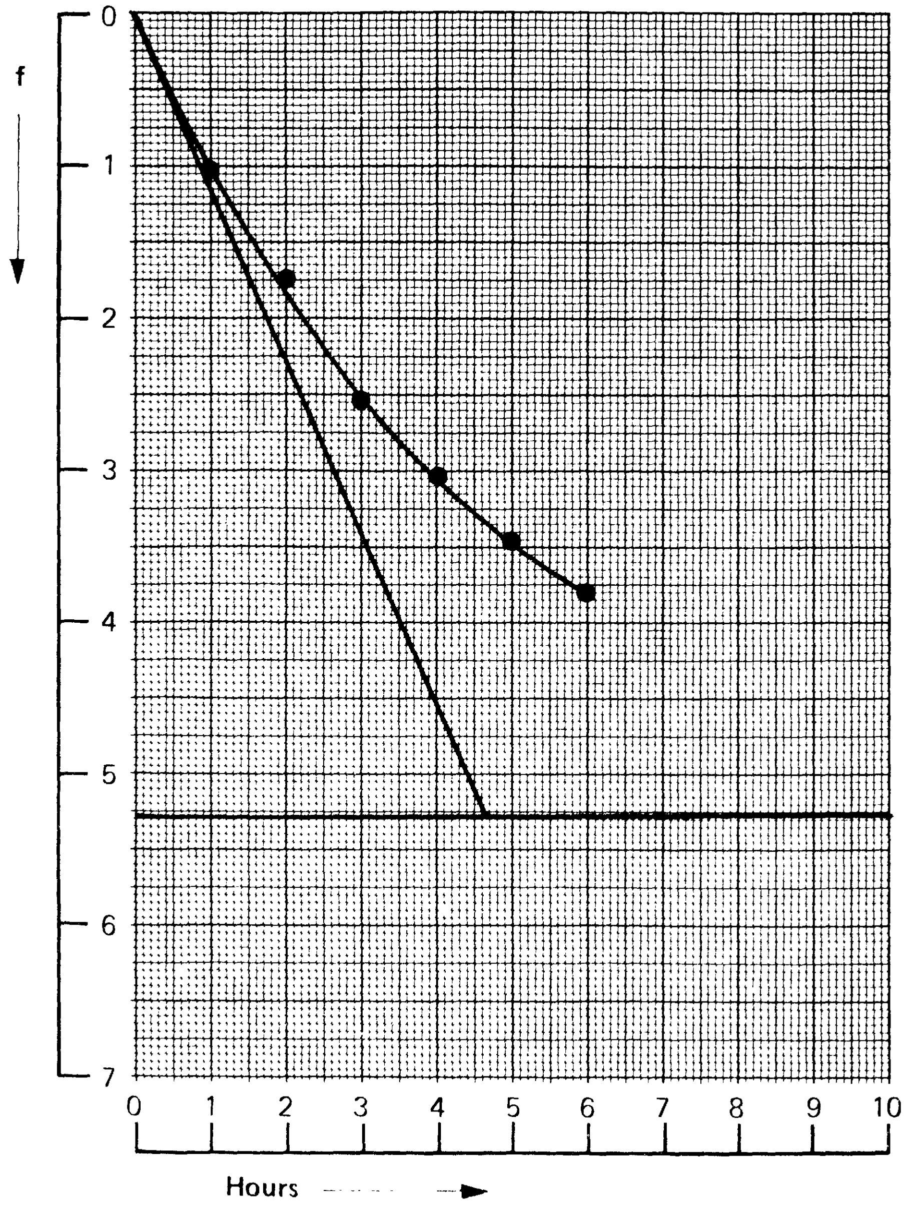
Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$



Curve Number : 79-76				Result Number : 61								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.62		0	13.8	30.08	30.07	0	0	α_T		11.94
ϵ	65	69	64	1	13.3	28.99	29.05	1.09	1.02	α_R		1.45
θ_A	29	29 6		2	12.95	28.33	28.23	1.75	1.84	$\Delta\alpha$		10.49
$\overline{\theta}_E$		28.17		3	12.63	27.53	27.57	2.55	2.50	$1 + t_g\beta t_g\delta$		4.10
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			26.49	4	12.39	27.01	27.03	3.07	3.04	α_c		2.55
$(\theta_E - \theta_{E_c})_0$			+0.01	5	12.20	26.60	26.60	3.48	3.47	σ	0.01087	
θ_F			24.14	6	12.05	26.27	26.26	3.81	3.81			
θ'_F			24.80	∞					5.26	f_∞		5.04

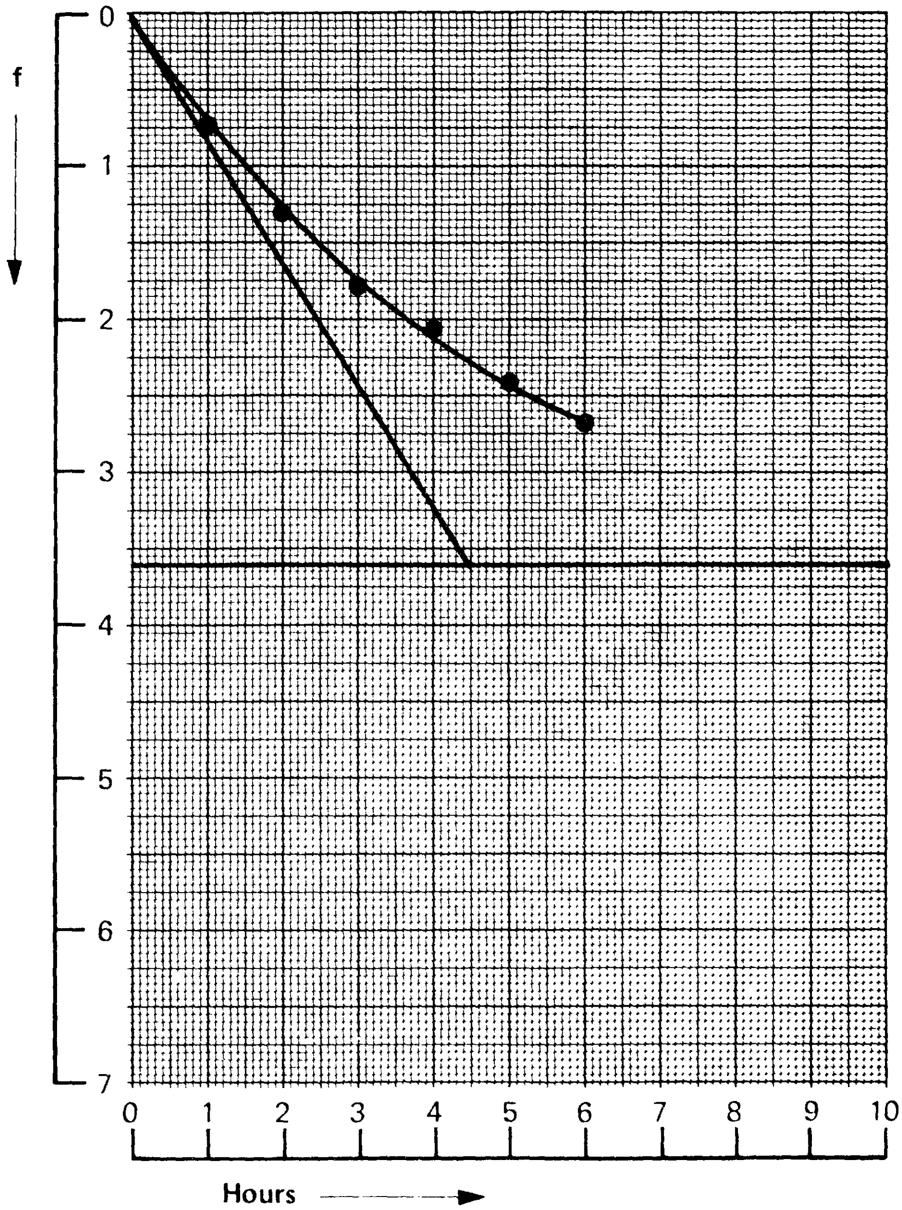


Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$

Curve Number : 82-78				Result Number : 62								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.9		0	11.24	24.50	24.49	0	0	α_T		12.41
ϵ	65	66	72	1	10.89	23.74	23.77	0.76	0.72	α_R		1.39
θ_A	24	24		2	10.64	23.20	23.19	1.30	1.30	$\Delta\alpha$		11.02
$\overline{\theta}_E$		23.15		3	10.41	22.69	22.73	1.81	1.76	$1 + t_g \beta t_g \delta$		3.48
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			22.01	4	10.28	22.41	22.36	2.09	2.13	α_c		3.16
$(\theta_E - \theta_{E_c})_0$			+ 0.01	5	10.13	22.08	22.06	2.42	2.42	σ	0.01448	
θ_F			20.49	6	10	21.80	21.83	2.70	2.66			
θ'_F			20.88	∞					3.60	f_∞		3.56



Remarks :

$\overline{\alpha}_c = 2.4$

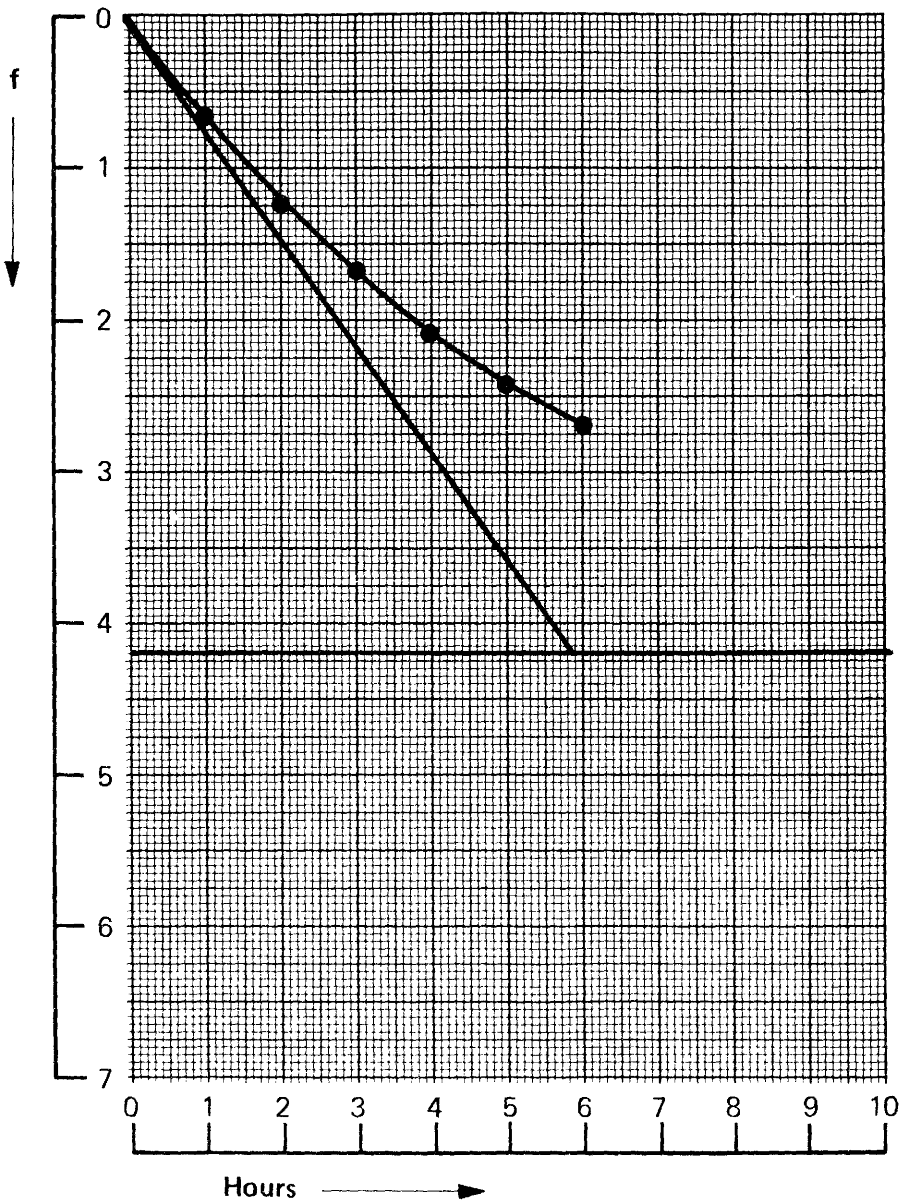
$\overline{\sigma} = 0.01$

Curve Number : 83-79				Result Number : 63								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.82		0	9.10	19.84	19.84	0	0	α_T		9.50
ϵ	65	62.5	72	1	8.80	19.18	19.18	0.66	0.66	α_R		1.33
θ_A	18	18.50		2	8.54	18.62	18.63	1.22	1.21	$\Delta\alpha$		8.17
$\overline{\theta}_E$		18.50		3	8.34	18.18	18.16	1.66	1.68	$1 + t_g \beta \, t_g \delta$		2.90
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.07	4	8.14	17.75	17.76	2.09	2.08	α_c		2.81
$(\theta_E - \theta_{E_c})_0$			0.00	5	7.99	17.42	17.43	2.42	2.41	σ	0.01265	
θ_F			15.18	6	7.87	17.16	17.15	2.68	2.69			
θ'_F			15.65	∞					4.19	f_∞		4.31

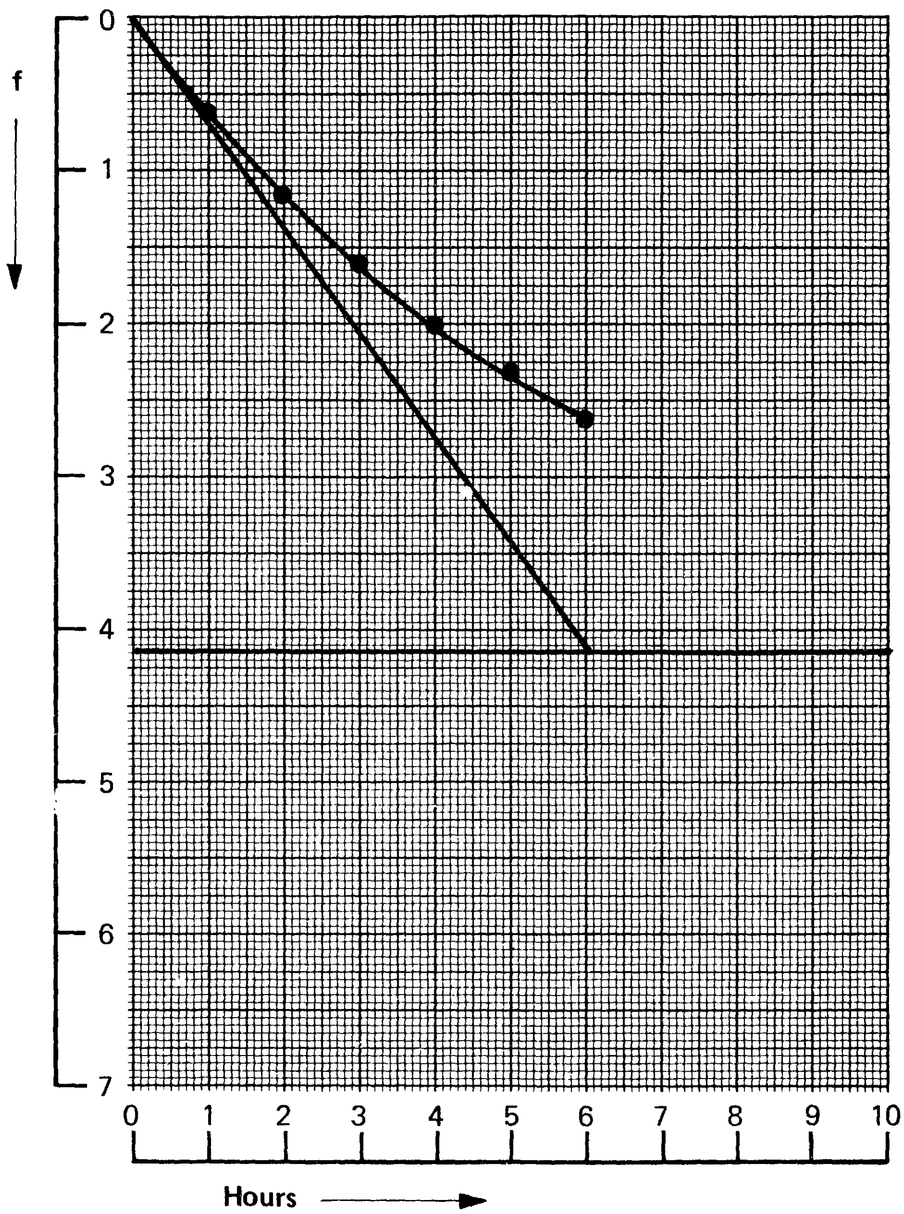
Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$



Curve Number : 84-35				Result Number : 64								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.82		0	6.94	15.13	15.13	0	0	α_T		9.21
ϵ	90	87.5	93	1	7.22	15.74	15.76	0.61	0.63	α_R		1.30
θ_A	20	20		2	7.49	16.33	16.30	1.20	1.17	$\Delta\alpha$		7.91
$\overline{\theta}_E$		16.44		3	7.68	16.74	16.75	1.61	1.62	$1 + t_g \beta \, t_g \delta$		2.99
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.85	4	7.86	17.13	17.13	2	2.01	α_c		2.64
$(\theta_E - \theta_{E_c})_0$			0.00	5	8	17.44	17.46	2.31	2.33	σ	0.01153	
θ_F			19.14	6	8.14	17.75	17.74	2.62	2.61			
θ'_F			19.26	∞					4.13	f_∞		4.32



Remarks :

$\overline{\alpha}_c = 2.4$

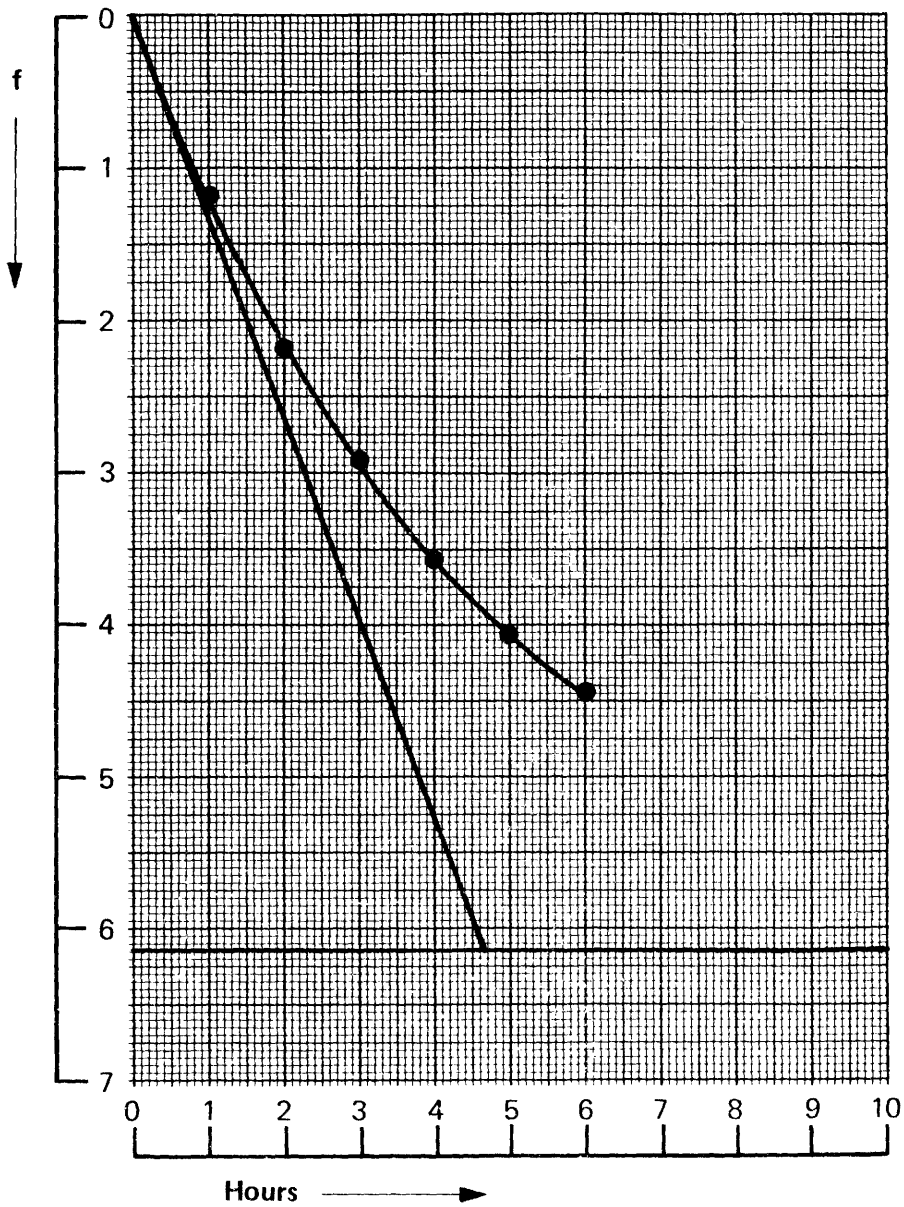
$\overline{\sigma} = 0.01$

Curve Number : 87.37				**Result Number :** 65								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	3		0	13.07	28.49	28.48	0	0	α_T		12.04
ϵ	90	93	92	1	13.60	29.65	29.67	1.16	1.19	α_R		1.48
θ_A	35	35.5		2	14.06	30.65	30.63	2.16	2.16	$\Delta\alpha$		10.56
$\overline{\theta}_E$		30.7		3	14.4	31.39	31.41	2.9	2.93	$1 + t_g \beta\, t_g \delta$		5.14
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			32.65	4	14.70	32.05	32.03	3.56	3.55	α_c		2.05
$(\theta_E - \theta_{E_c})_0$			+0.01	5	14.93	32.55	32.53	4.06	4.05	σ	0.008212	
θ_F			34.48	6	15.1	32.92	32.94	4.43	4.46			
θ'_F			34.6	∞					6.13	f_∞		6.14

Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$

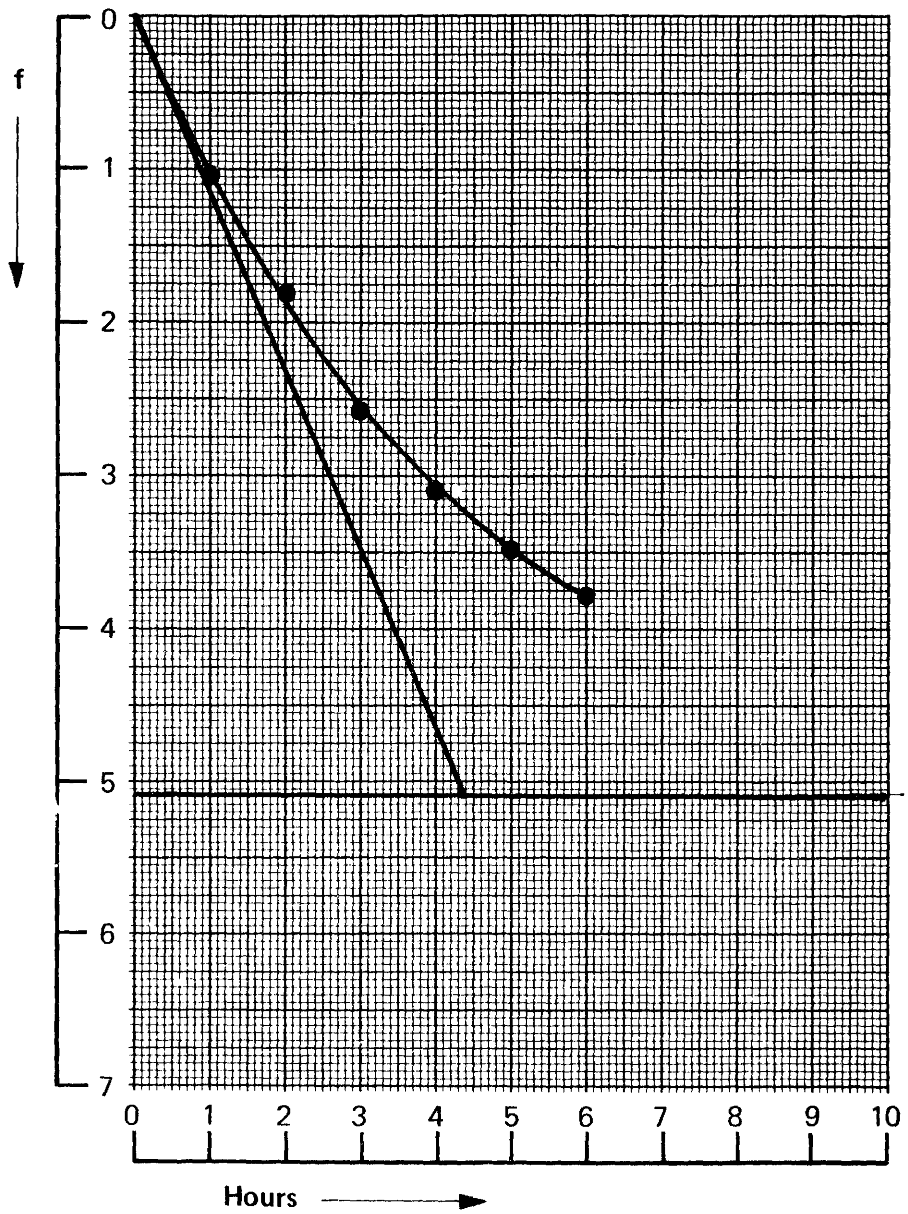


Curve Number : 91 - 38				**Result Number :** 66								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.82		0	8.42	18.36	18.34	0	0	α_T		12.8
ϵ	90	89	88	1	8.88	19.36	19.38	1	1.04	α_R		1.35
θ_A	25	25		2	9.24	20.14	20.21	1.78	1.87	$\Delta\alpha$		11.45
$\overline{\theta}_E$		20.23		3	9.6	20.93	20.87	2.57	2.53	$1 + t_g \beta t_g \delta$		3. 45
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			21.82	4	9.83	21.43	21.39	3.07	3.05	α_c		3.31
$(\theta_E - \theta_{E_c})_0$			+ 0.02	5	10	21.8	21.81	3.44	3.47	σ	0.01539	
θ_F			23.22	6	10.14	22.11	22.14	3.75	3.80			
θ'_F			23.41	∞					5.07	f_∞		4.75

Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$

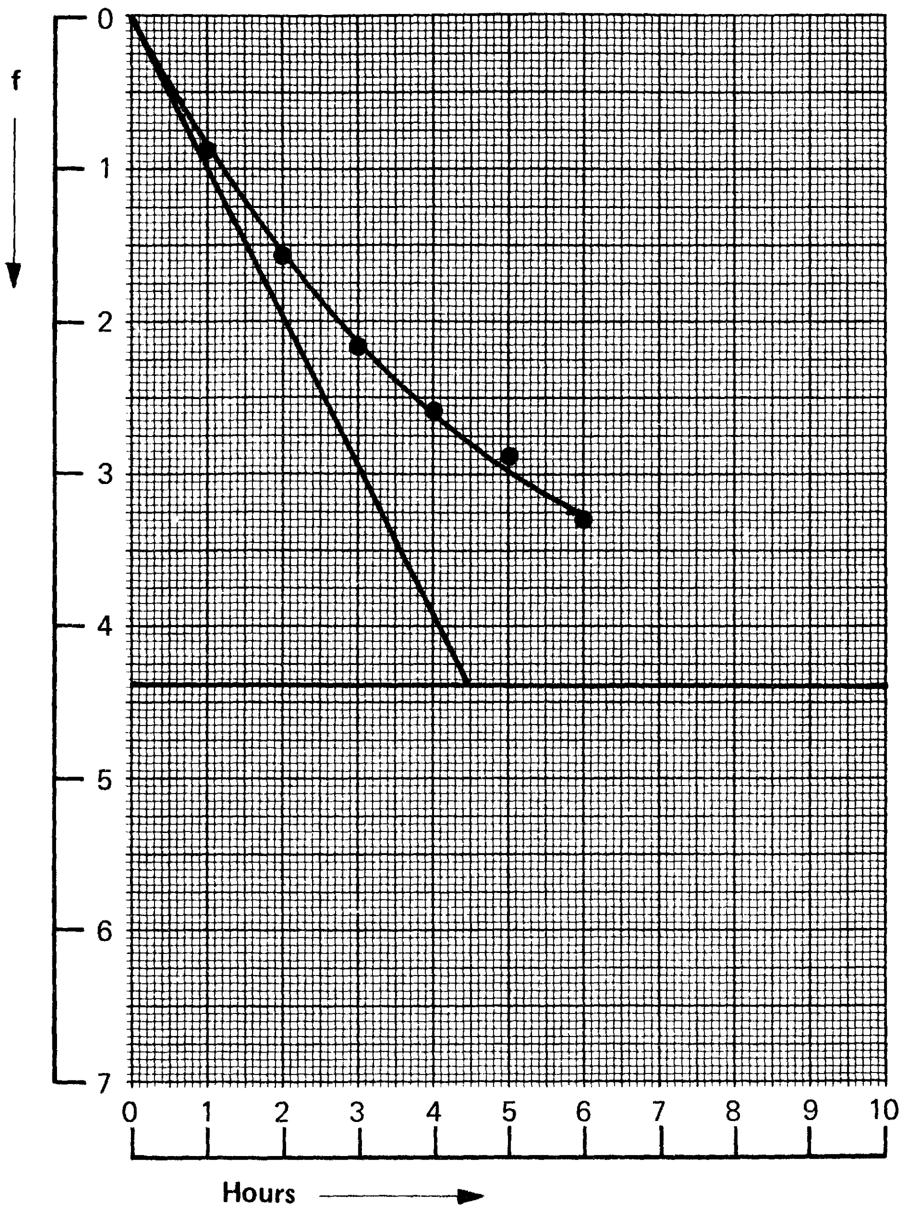


Curve Number : 93-99				Result Number : 67								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	3	2.82		0	13.78	30.04	30.05	0	0	α_T		12.51
ϵ	90	95	90	1	14.20	30.96	30.94	0.92	0.88	α_R		1.49
θ_A	35.5	35.75		2	14.51	31.63	31.64	1.59	1.59	$\Delta\alpha$		11.02
$\overline{\theta}_E$		31.69		3	14.78	32.22	32.20	2.18	2.15	$1 + t_g \beta t_g \delta$		5.22
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			33.05	4	14.98	32.66	32.65	2.62	2.6	α_c		2.11
$(\theta_E - \theta_{E_c})_0$			-0.01	5	15.1	32.92	33.01	2.88	2.95	σ	0.008511	
θ_F			34.24	6	15.3	33.35	33.29	3.31	3.24			
θ'_F			34.42	∞					4.37	f_∞		4.53

Remarks :

$\overline{\alpha}_c = 2.4$

$\overline{\sigma} = 0.01$

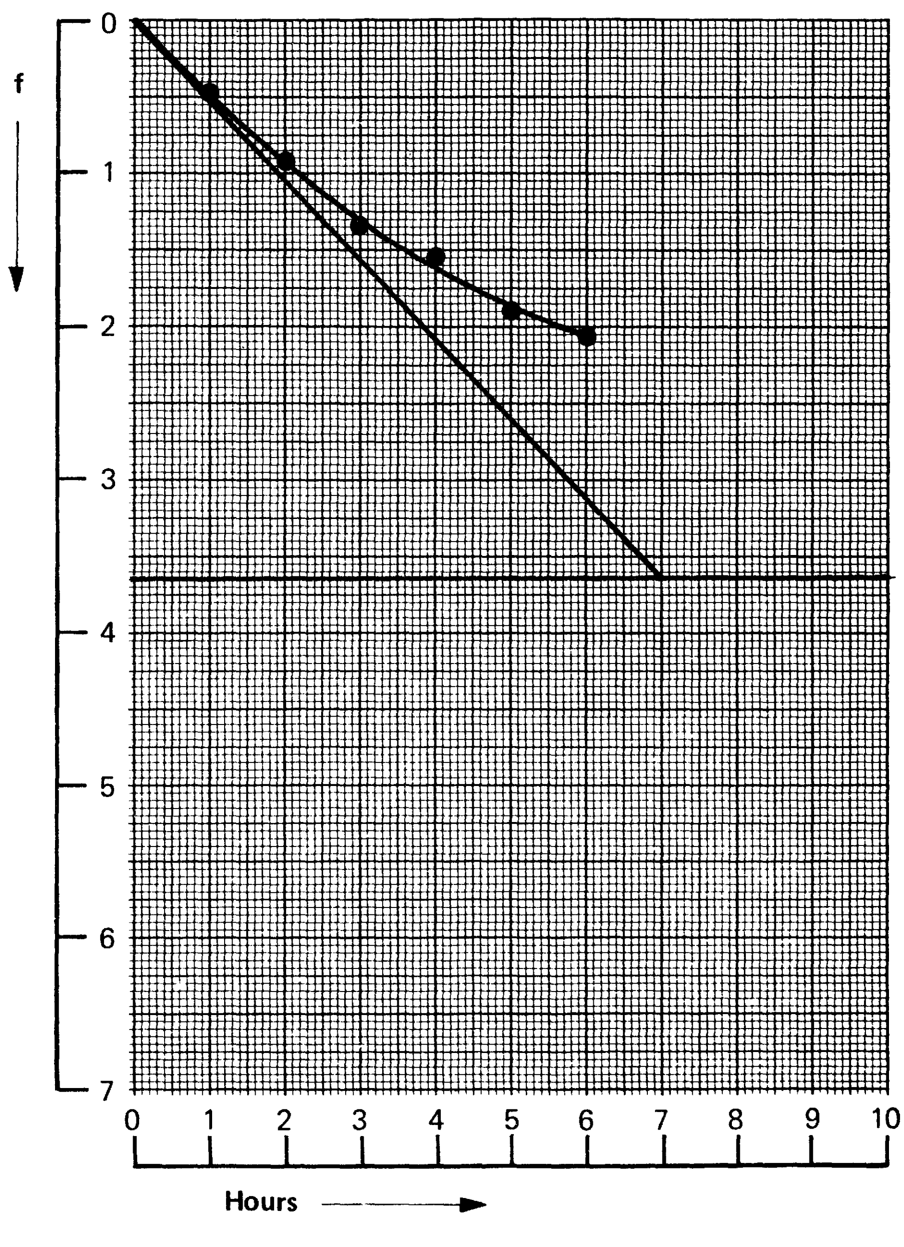


Curve Number : 32 - 64 | **Result Number :** 68

	nominal	measured	calcul.
W	2	1.95	
ϵ	45	38.5	45
θ_A	22	21.7	
$\overline{\theta}_E$		17.71	
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			16.42
$(\theta_E - \theta_{E_c})_0$			-0.02
θ_F			13.82
θ'_F			15.13

time	reading	θ_E	θ_{E_c}	f	f_c
0	8.6	18.75	18.77	0	0
1	8.4	18.31	18.28	0.44	0.48
2	8.2	17.88	17.86	0.87	0.9
3	8	17.44	17.5	1.31	1.27
4	7.9	17.22	17.18	1.53	1.58
5	7.75	16.90	16.91	1.85	1.85
6	7.65	16.68	16.67	2.07	2.09
∞					3.63

	GRAPH	COMPUT
α_T		7.94
α_R		1.32
$\Delta\alpha$		6.62
$1 + t_g \beta t_g \delta$		2.83
α_c		2.33
σ	0.01072	
f_∞		3.12

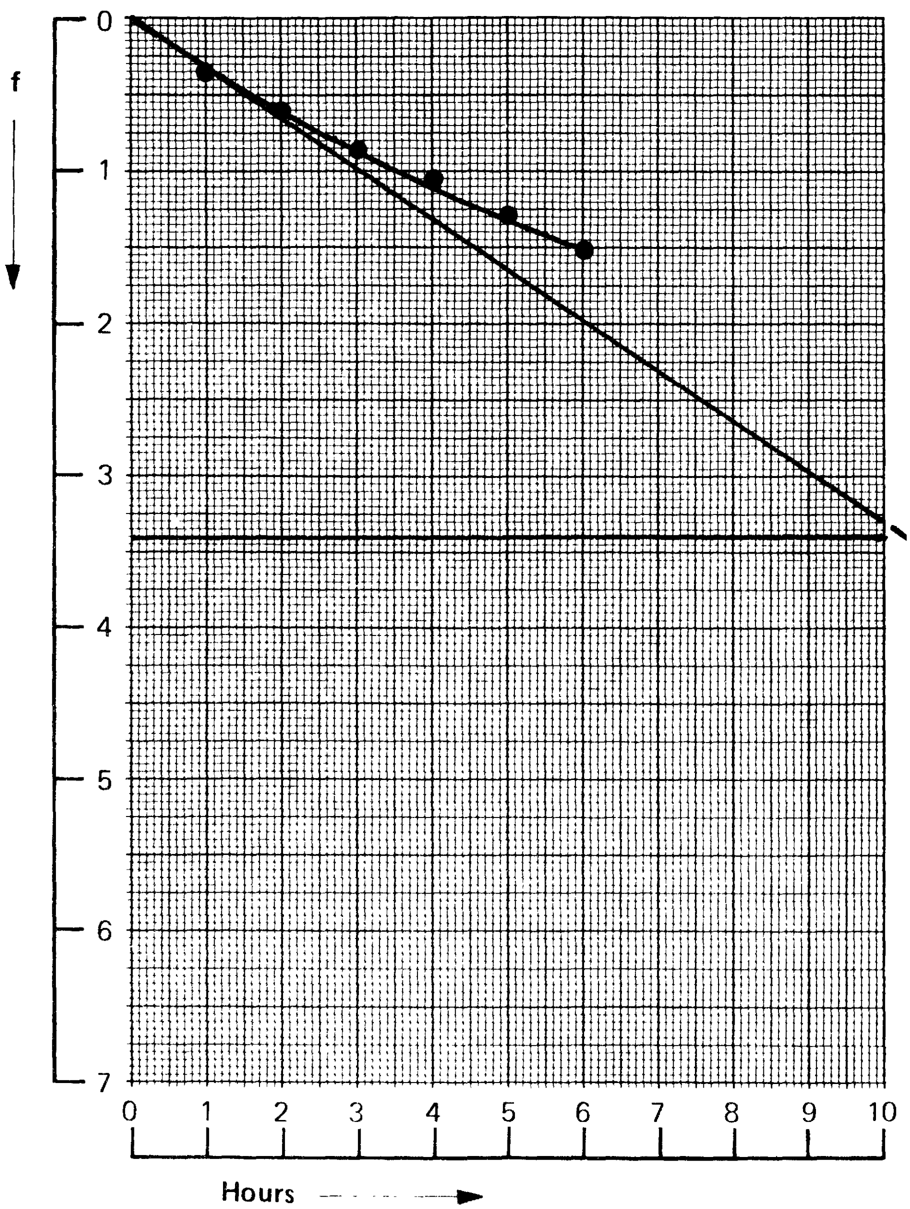


Remarks :

$\overline{\alpha}_c = 1.91$

$\overline{\sigma} = 0.008$

Curve Number : 34 - 65				Result Number : 69								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	2	2.15		0	7.74	16.87	16.85	0	0	α_T		5.37
ϵ	90	77.5	76	1	7.57	16.5	16.53	0.37	0.31	α_R		1.3
θ_A	15	15.3		2	7.45	16.24	16.25	0.63	0.6	$\Delta \alpha$		4.07
$\overline{\theta}_E$		16.1		3	7.33	15.98	15.99	0.89	0.86	$1 + t_g \beta t_g \delta$		2.67
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			14.77	4	7.25	15.8	15.75	1.07	1.09	α_c		1.52
$(\theta_E - \theta_{E_c})_0$			+0.02	5	7.13	15.54	15.54	1.33	1.31	σ	0.00539	
θ_F			12.84	6	7.03	15.33	15.35	1.54	1.50			
θ'_F			13.44	∞					3.40	f_∞		3.30



Remarks :

$\overline{\alpha}_c$ = 1.91

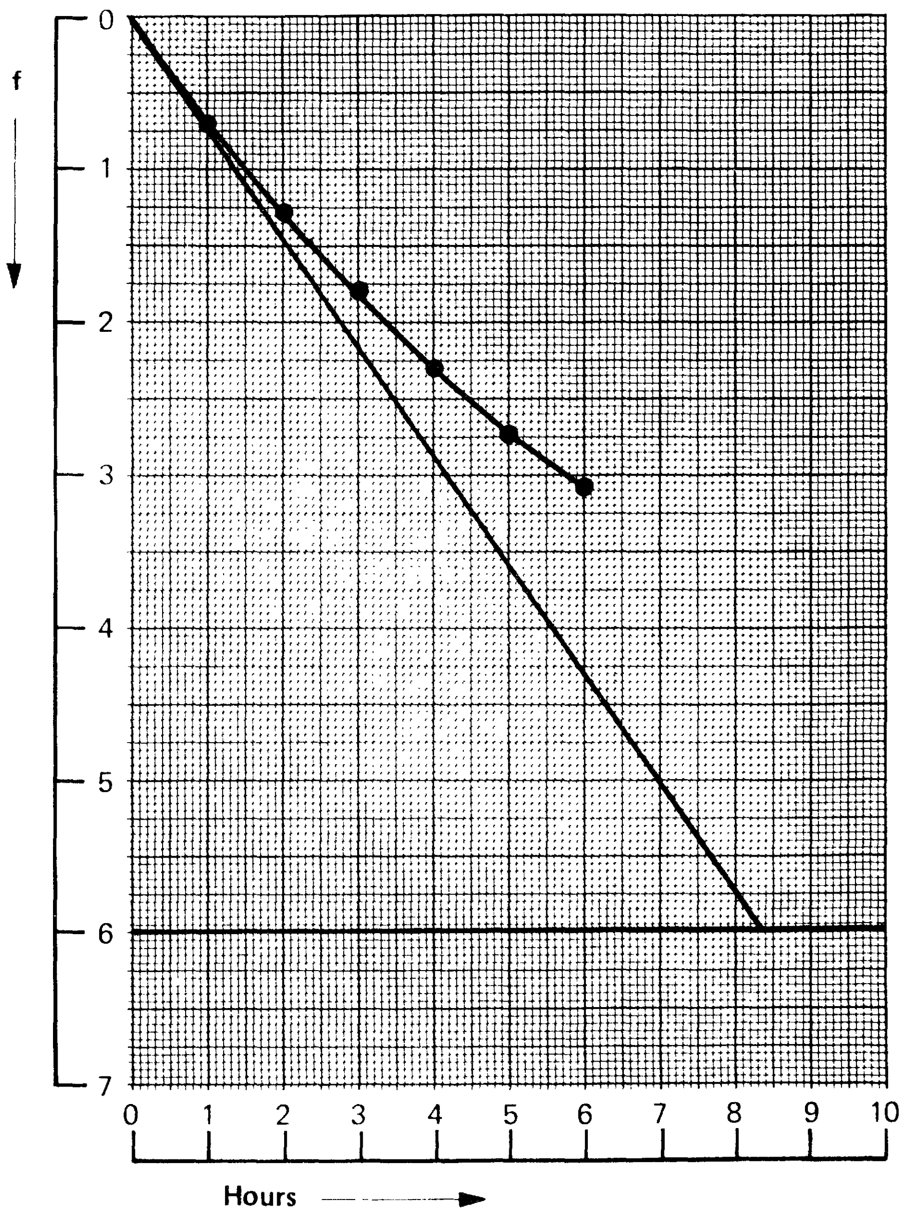
$\overline{\sigma}$ = 0.008

Curve Number : 35 - 16				Result Number : 70								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	2	2.2		0	6.53	14.24	14.24	0	0	α_T		6.68
ϵ	65	59.5	65	1	6.84	14.91	14.91	0.67	0.68	α_R		1.29
θ_A	24	24		2	7.12	15.52	15.52	1.28	1.28	$\Delta\alpha$		5.39
$\overline{\theta}_E$		15.77		3	7.35	16.02	16.05	1.78	1.81	$1 + t_g \beta t_g \delta$		3
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.99	4	7.59	16.55	16.52	2.31	2.29	α_c		1.79
$(\theta_E - \theta_{E_c})_0$			0.00	5	7.77	16.95	16.94	2.71	2.71	σ	0.00725	
θ_F			19.31	6	7.93	17.3	17.31	3.06	3.08			
θ'_F			20.22	∞					5.98	f_∞		6.34

Remarks :

$\overline{\alpha}_c = 1.91$

$\sigma = 0.008$



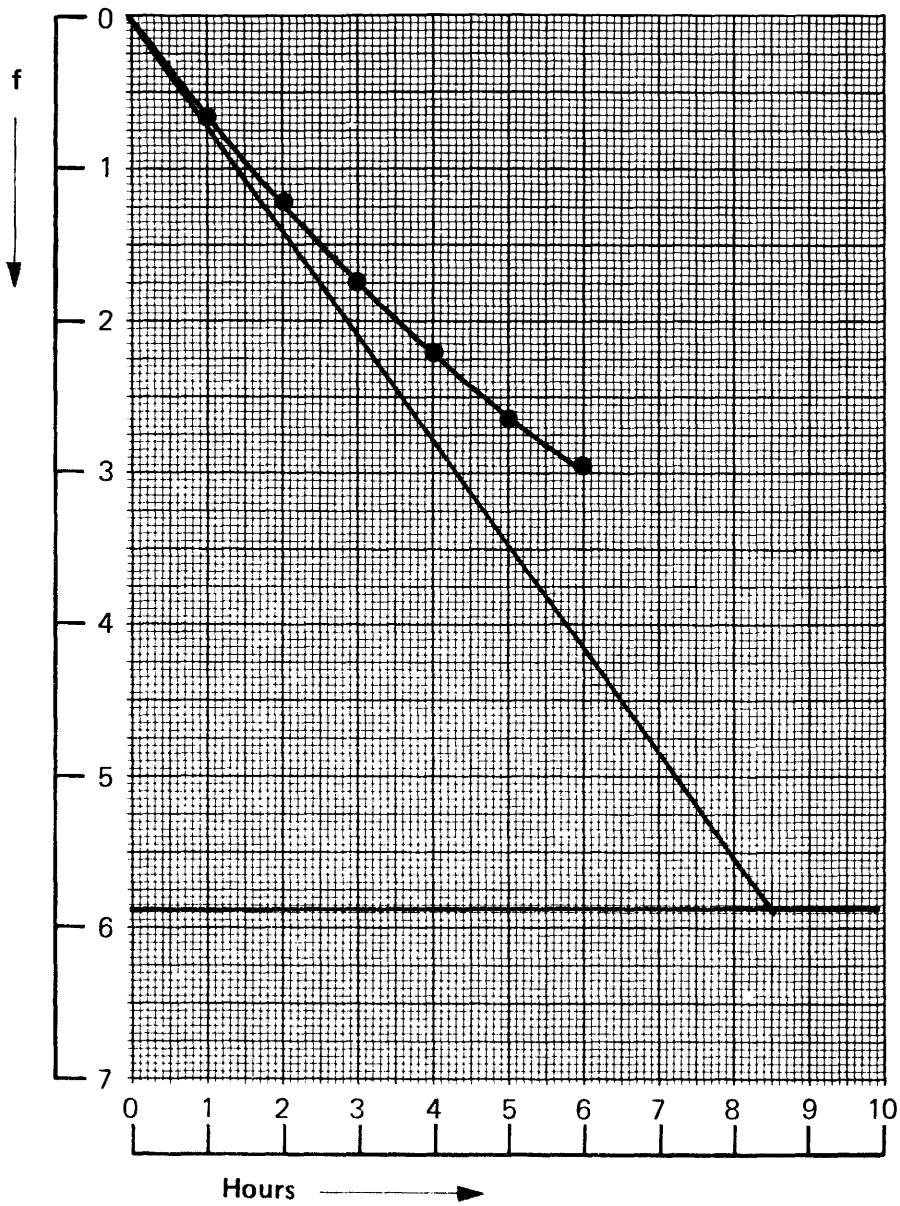
Curve Number : *113-43* | **Result Number :** *71*

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	2	1.95		0	93.5	20.37	20.36	0	0	α_T		6.52
ϵ	65	70	69	1	96.5	21.02	21.02	0.65	0.65	α_R		1.37
θ_A	29.4	30.2		2	99	21.57	21.59	1.20	1.23	$\Delta\alpha$		5.15
$\overline{\theta}_E$		21.84		3	101.5	22.11	22.11	1.74	1.74	$1 + t_g \beta t_g \delta$		3.75
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			24.03	4	103.6	22.57	22.57	2.20	2.20	α_c		1.37
$(\theta_E - \theta_{E_c})_0$			+0.01	5	105.6	23.01	22.97	2.64	2.61	σ	0.00491	
θ_F			25.18	6	107.2	23.31	23.34	2.94	2.97			
θ'_F			26.23	∞					5.87	f_∞		5.61

Remarks :

$\overline{\alpha}_c = 1.91$

$\overline{\sigma} = 0.008$

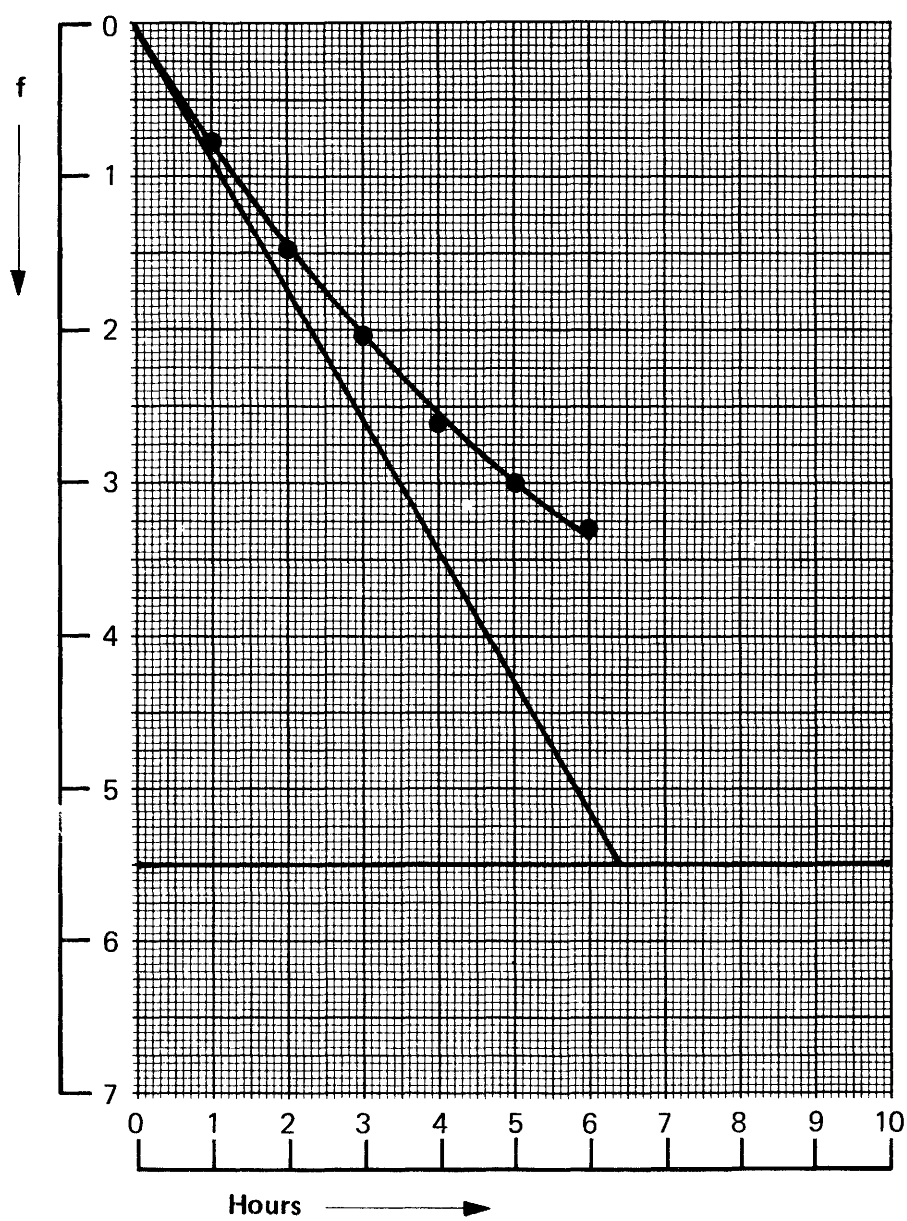


Curve Number : 114 - 44				Result Number : 72								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	2	1.95		0	118	25.76	25.73	0	0	α_T		8.67
ϵ	65	73	65	1	121.3	26.49	26.53	0.73	0.79	α_R		1.44
θ_A	35	36.1		2	124.6	27.21	27.21	1.45	1.47	$\Delta \alpha$		7.23
$\overline{\theta}_E$		27.4		3	127.1	27.75	27.79	1.99	2.06	$1 + t_g \beta t_g \delta$		4.55
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			29.36	4	129.9	28.36	28.29	2.60	2.55	α_c		1.59
$(\theta_E - \theta_{E_c})_0$			+0.03	5	131.6	28.73	28.71	2.97	2.98	σ	0.00624	
θ_F			30.25	6	133	29.04	29.08	3.28	3.34			
θ'_F			31.23	∞					5.49	f_∞		5.66

Remarks :

$\overline{\alpha}_c = 1.91$

$\overline{\sigma} = 0.008$

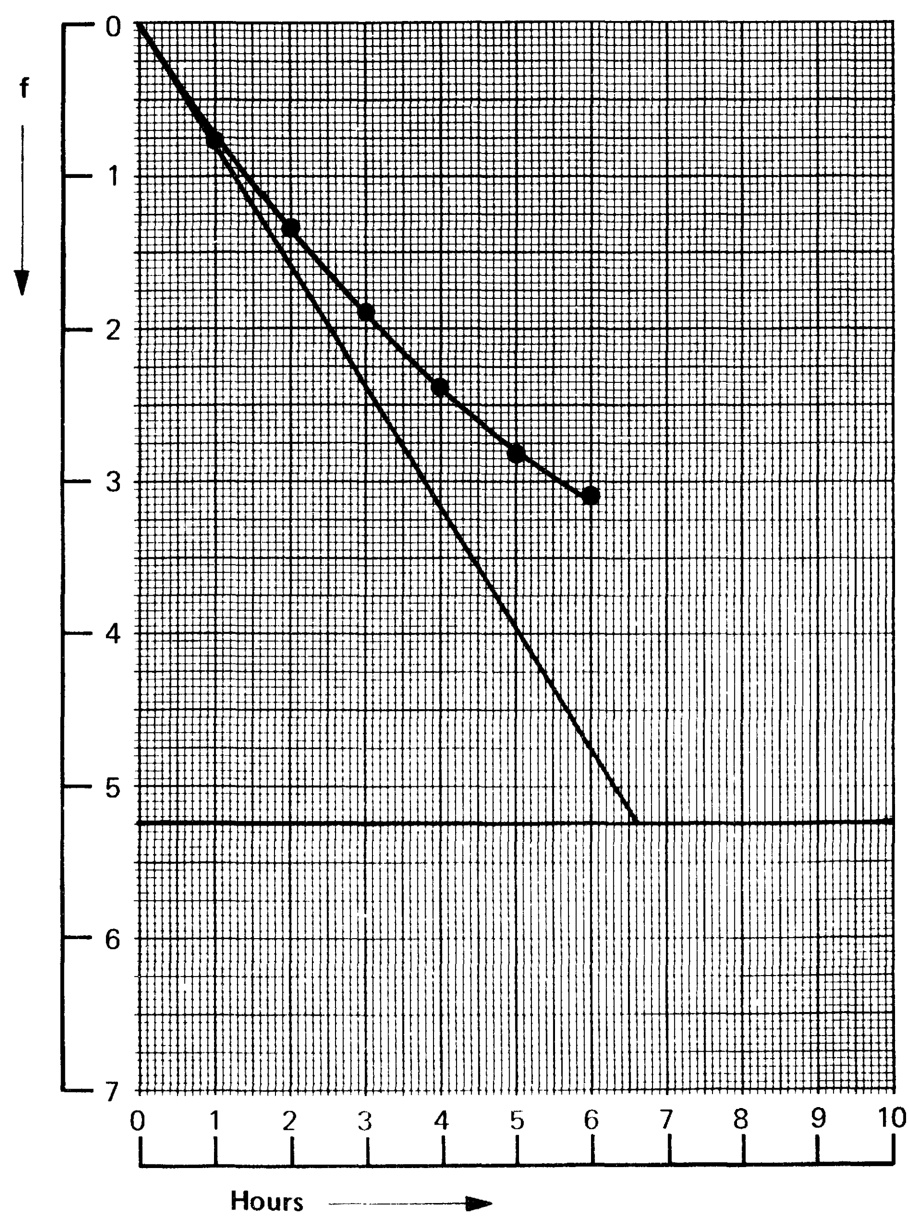


Curve Number : 116-86				Result Number : 73								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	2	1.95		0	116	25.33	25.32	0	0	α_T		8.4
ϵ	65	68	65	1	112.4	24.54	24.58	0.79	0.74	α_R		1.39
θ_A	23.4	23.9		2	109.8	23.97	23.95	1.36	1.37	$\Delta\alpha$		7.01
$\overline{\theta}_E$		23.77		3	107.3	23.43	23.4	1.9	1.91	$1 + t_g\beta t_g\delta$		3.47
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			21.92	4	105	22.93	22.93	2.40	2.38	α_c		2.01
$(\theta_E - \theta_{E_c})_0$			+0.01	5	103	22.49	22.53	2.84	2.78	σ	0.00860	
θ_F			19.30	6	101.7	22.21	22.19	3.12	3.13			
θ'_F			20.07	∞					5.24	f_∞		5.31

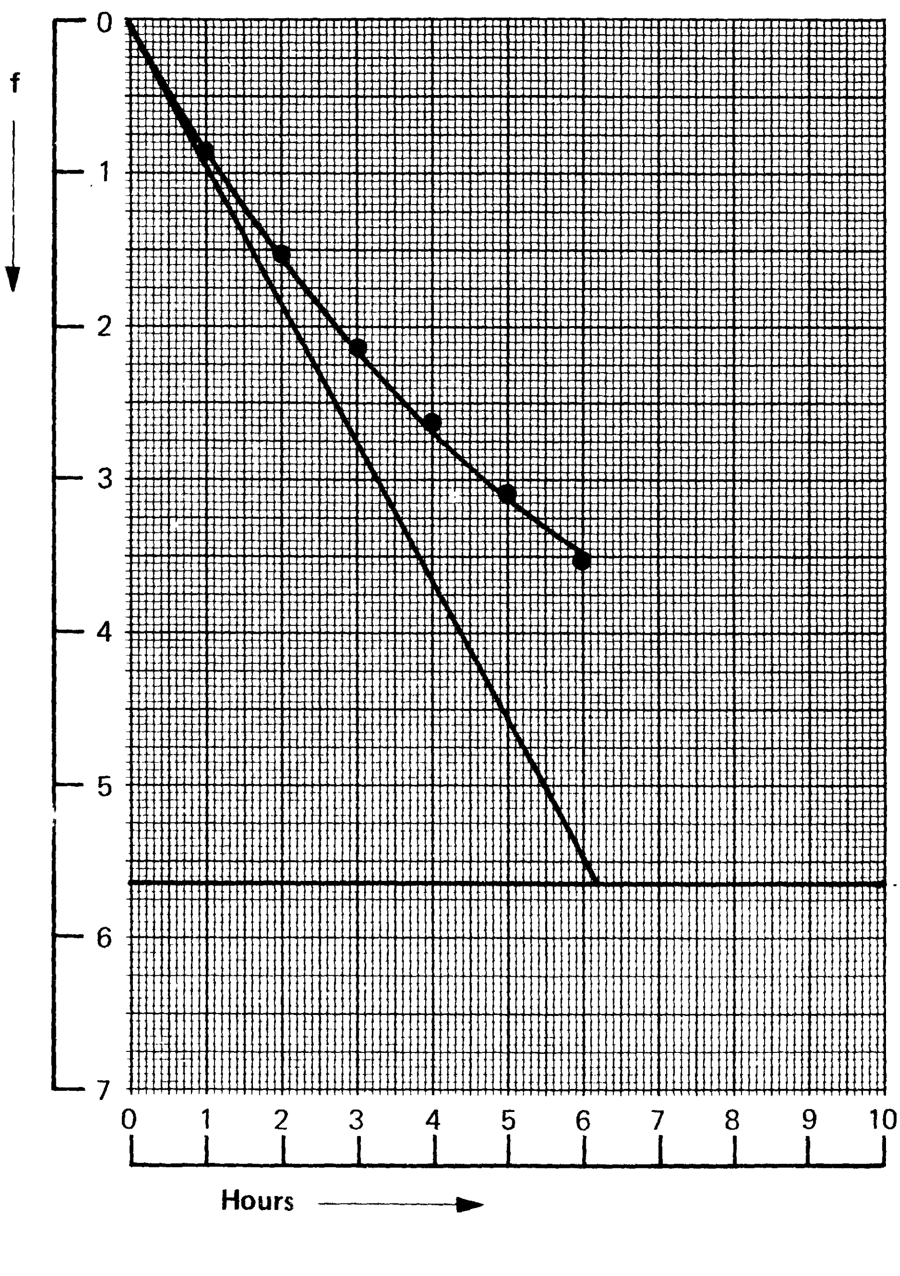
Remarks :

$\overline{\alpha}_c$ = 1.91

$\overline{\sigma}$ = 0.008



Curve Number : 119 - 87				**Result Number :** 74								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	2	1.95		0	118.5	25.87	25.85	0	0	α_T		8.92
ϵ	65	68	70	1	114.4	24.98	25.01	0.89	0.84	α_R		1.4
θ_A	23.7	23.6		2	111.3	24.3	24.3	1.57	1.55	$\Delta\alpha$		7.52
$\overline{\theta}_E$		24.1		3	108.7	23.73	23.69	2.14	2.16	$1 + t_g \beta \, t_g \delta$		3.5
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			22.15	4	106	23.14	23.18	2.73	2.68	α_c		2.14
$(\theta_E - \theta_{E_c})_0$			+0.02	5	104.3	22.77	22.73	3.1	3.12	σ	0.00935	
θ_F			19.57	6	102.3	22.34	22.36	3.53	3.49			
θ'_F			20.2	∞					5.65	f_∞		6.11



Remarks :

$\overline{\alpha}_c$ = 1.91

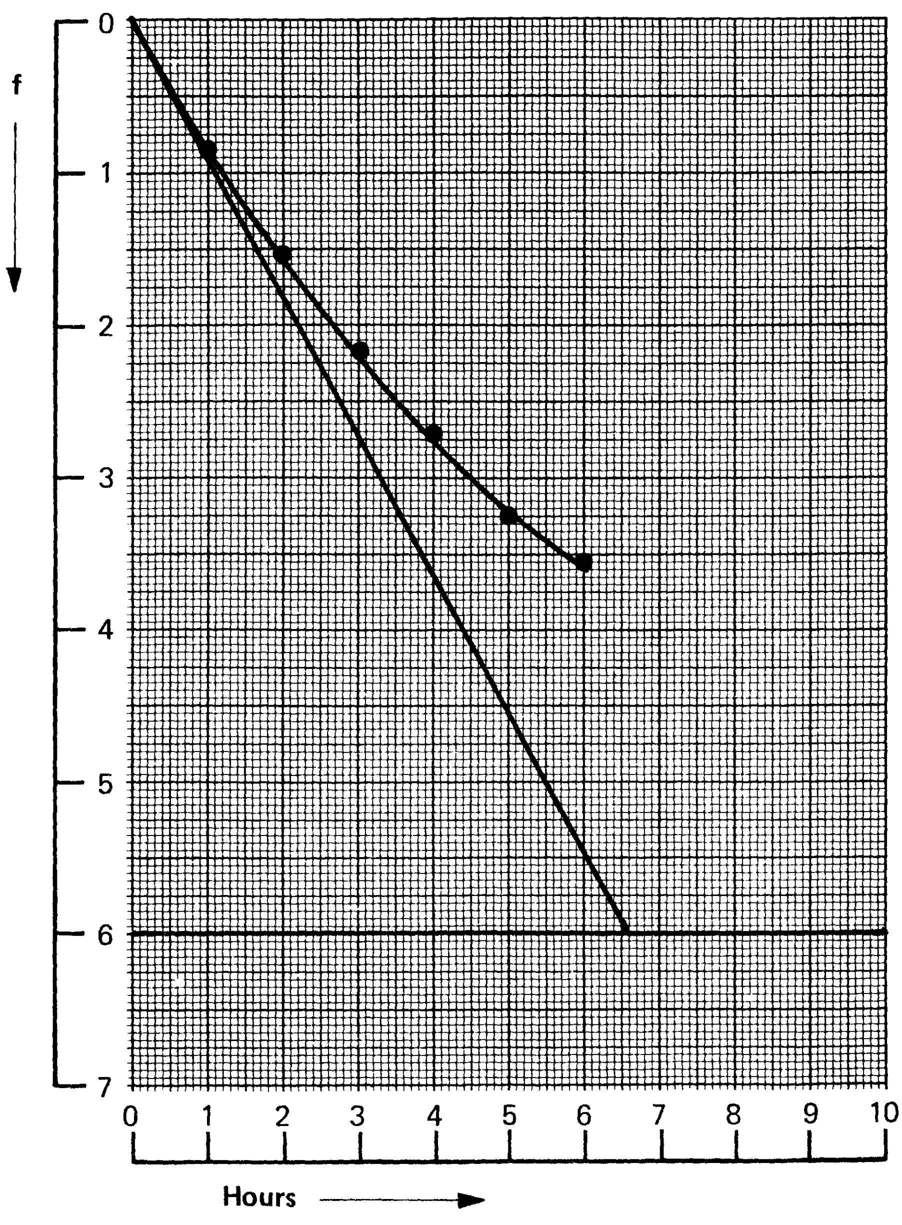
$\overline{\sigma}$ = 0.008

Curve Number : 122-89				Result Number : 75								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	2	1.95		0	121.8	26.59	26.6	0	0	α_T		8.42
ϵ	65	69	68	1	118	25.76	25.76	0.83	0.84	α_R		1.41
θ_A	23.7	24.3		2	114.8	25.07	25.03	1.52	1.57	$\Delta\alpha$		7.01
$\overline{\theta}_E$		24.82		3	111.9	24.4	24.41	2.19	2.19	$1 + t_g\beta t_g\delta$		3.57
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			22.71	4	109.3	23.87	23.87	2.72	2.73	α_c		1.96
$(\theta_E - \theta_{E_c})_0$			-0.01	5	107	23.36	23.41	3.23	3.19	σ	0.00827	
θ_F			19.86	6	105.6	23.06	23.02	3.53	3.58			
θ'_F			20.6	∞					5.99	f_∞		5.64

Remarks :

$\overline{\alpha}_c$ = 1.91

$\overline{\sigma}$ = 0.008

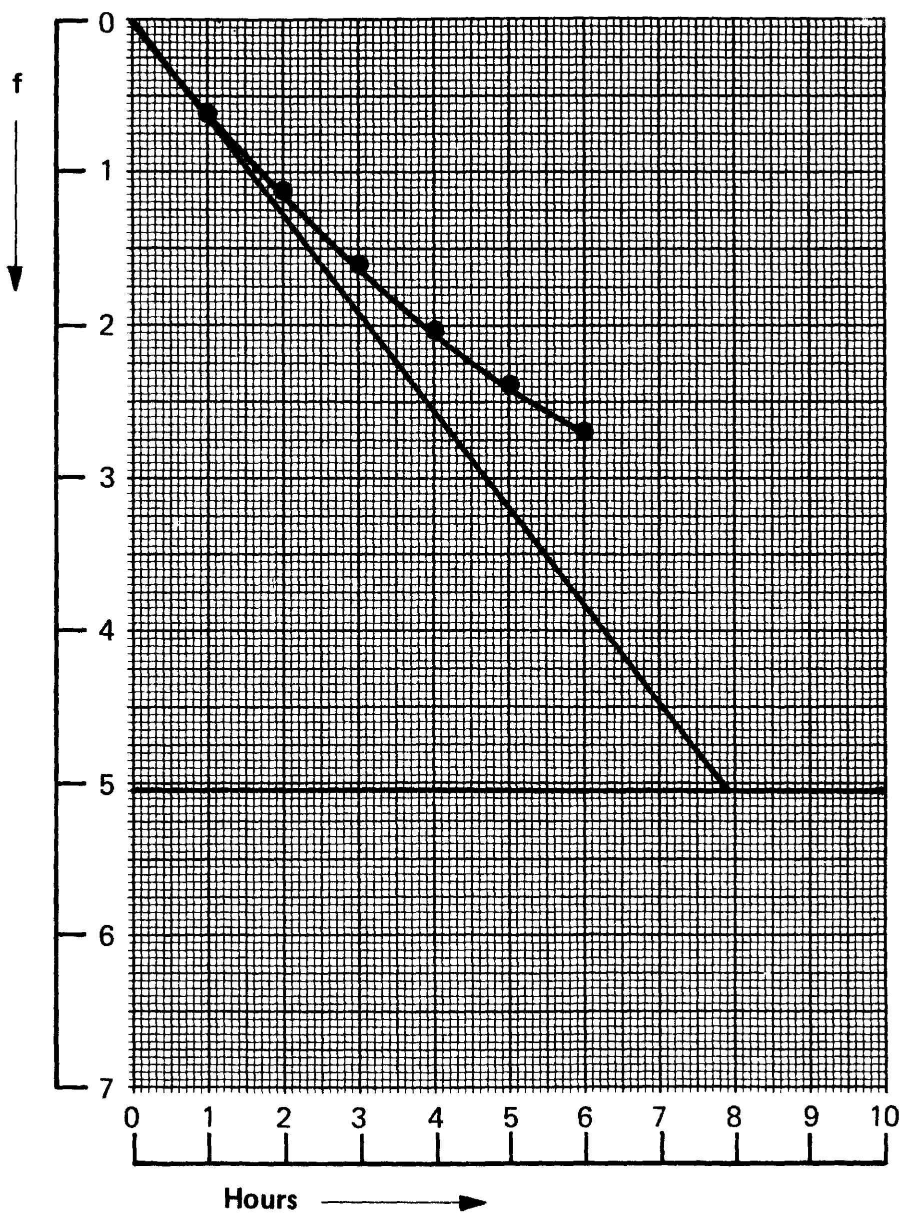


Curve Number : 123 - 90				**Result Number :** 76								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	2	1.95		0	92.3	20.15	20.16	0	0	α_T		7.03
ϵ	65	65	67	1	89.6	19.56	19.56	0.59	0.6	α_R		1.33
θ_A	18.3	18		2	87.2	19.04	19.03	1.11	1.13	$\Delta\alpha$		5.7
$\overline{\theta}_E$		18.81		3	85	18.56	18.56	1.59	1.6	$1 + t_g \beta t_g \delta$		2.89
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			16.95	4	83	18.12	18.15	2.03	2.01	α_c		1.96
$(\theta_E - \theta_{E_c})_0$			- 0.01	5	81.5	17.8	17.79	2.35	2.37	σ	0.00836	
θ_F			14.42	6	80	17.47	17.47	2.68	2.69			
θ'_F			15.1	∞					5.05	f_∞		5.06

Remarks :

$\overline{\alpha}_c$ = 1.91

$\overline{\sigma}$ = 0.008



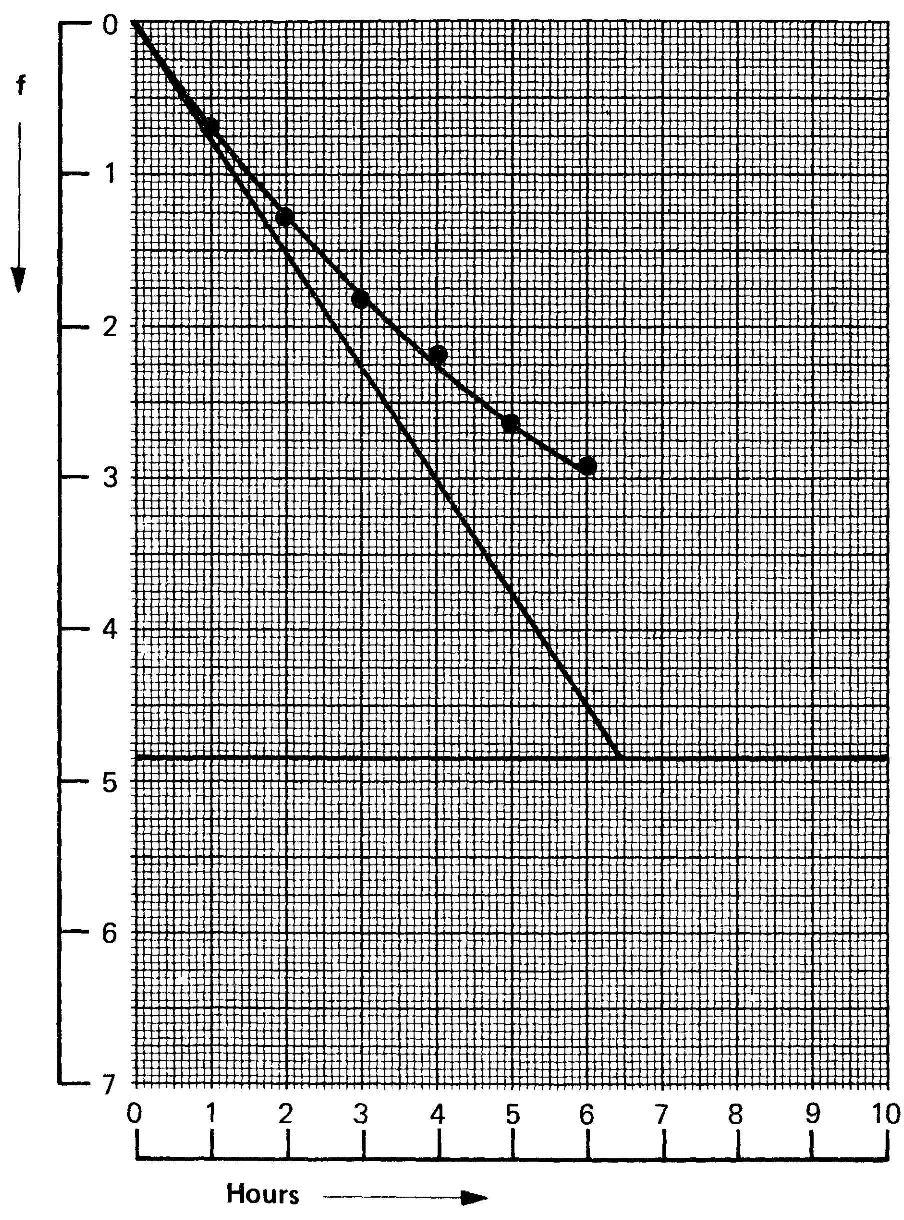
Curve Number : 124 - 45 | **Result Number :** 77

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	2	1.95		0	71.6	15.63	15.63	0	0	α_T		8.68
ϵ	65	67	68	1	74.8	16.33	16.33	0.7	0.7	α_R		1.31
θ_A	23.7	24.3		2	77.5	16.92	16.93	1.29	1.29	$\Delta\alpha$		7.37
$\overline{\theta}_E$		17.09		3	80	17.47	17.44	1.84	1.81	$1 + t_g \beta t_g \delta$		3.09
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			18.77	4	81.6	17.82	17.87	2.19	2.24	α_c		2.38
$(\theta_E - \theta_{E_c})0$			0.00	5	83.7	18.28	18.25	2.65	2.62	σ	0.01089	
θ_F			19.77	6	85	18.56	18.57	2.93	2.94			
θ'_F			20.45	∞					4.82	f_∞		4.51

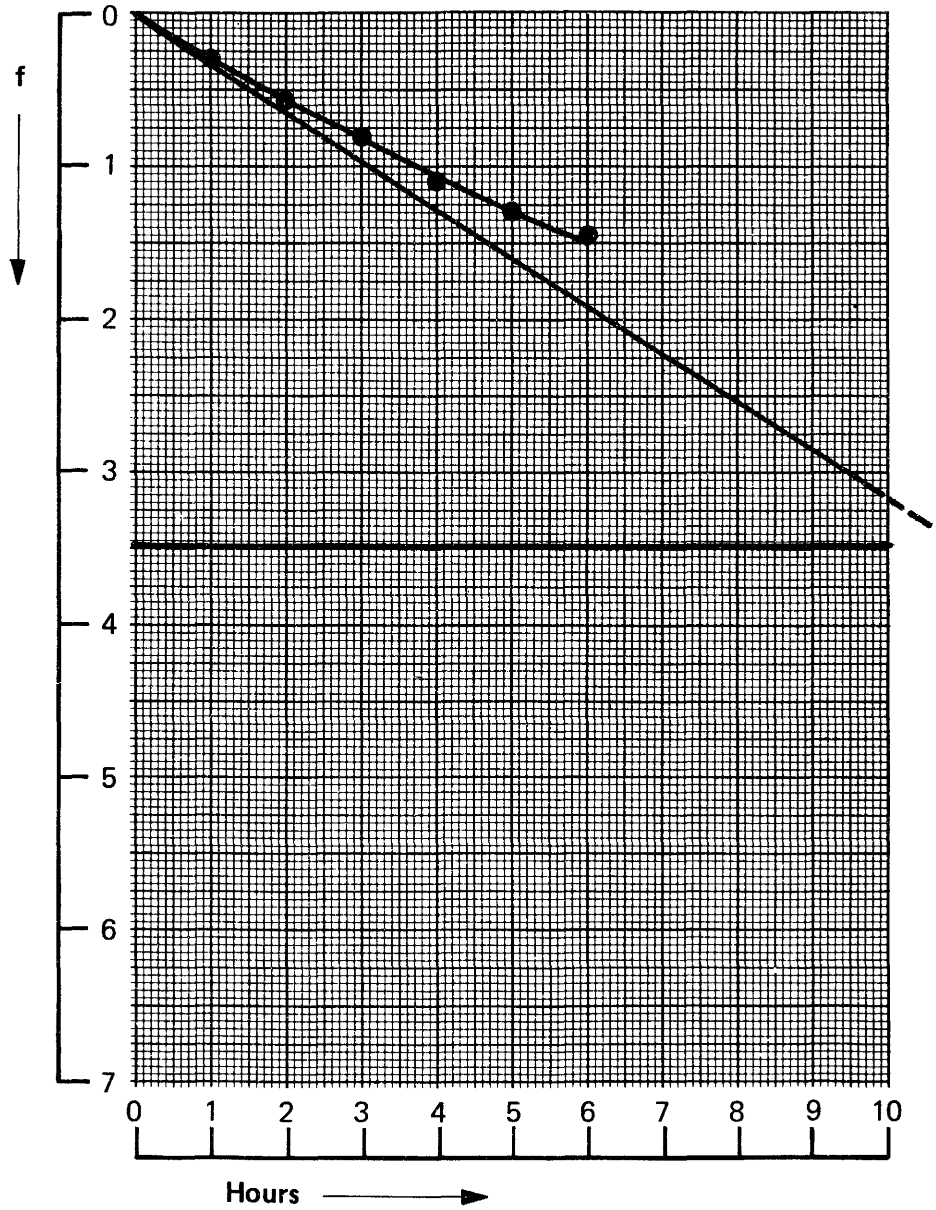
Remarks :

$\overline{\alpha}_c = 1.91$

$\overline{\sigma} = 0.008$



Curve Number : 125 - 91				**Result Number :** 78								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	1	1		0	91.5	19.93	19.95	0	0	α_T		5.11
ϵ	65	66	70	1	90.3	19.67	19.65	0.26	0.31	α_R		1.34
θ_A	18.3	19		2	89	19.39	19.37	0.54	0.58	$\Delta\alpha$		3.77
$\overline{\theta}_E$		19.22		3	87.8	19.13	19.12	0.8	0.84	$1 + t_g \beta t_g \delta$		2.99
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.85	4	86.5	18.85	18.88	1.08	1.07	α_c		1.26
$(\theta_E - \theta_{E_c})_0$			-0.02	5	85.5	18.63	18.67	1.3	1.28	σ	0.00546	
θ_F			15.59	6	85	18.52	18.48	1.41	1.47			
θ'_F			16.48	∞					3.46	f_∞		3.37



Remarks :

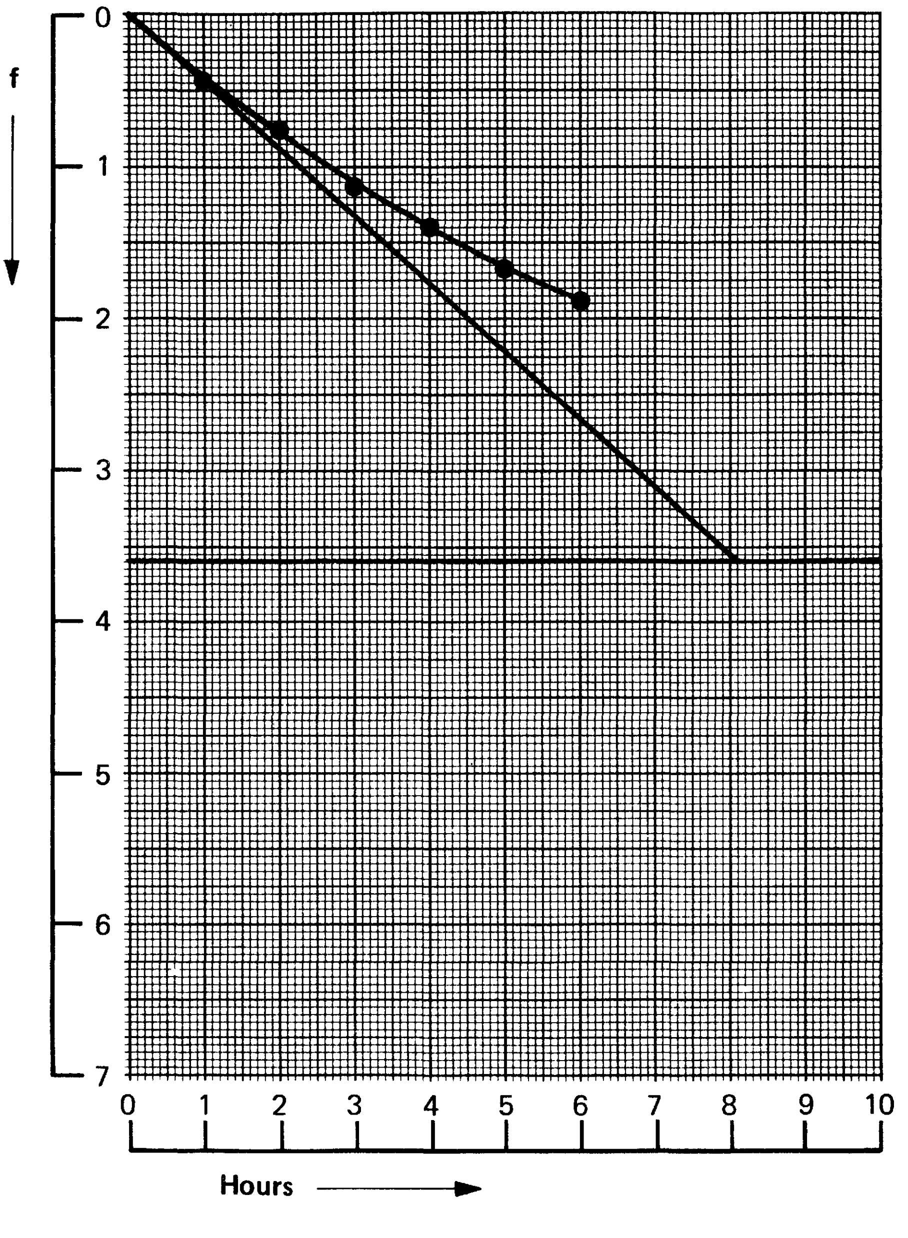
$\overline{\alpha}_c = 1.36$

$\overline{\sigma} = 0.00583$

Curve Number : 126 - 46				Result Number : 79								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	1	1		0	77.8	16.95	16.95	0	0	α_T		6.86
ϵ	65	70	63	1	79.8	17.39	17.37	0.44	0.42	α_R		1.32
θ_A	23.7	25.1		2	81.3	17.71	17.74	0.76	0.79	$\Delta\alpha$		5.54
$\overline{\theta}_E$		17.88		3	83	18.06	18.06	1.13	1.11	$1 + t_g \beta t_g \delta$		3.14
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			19.21	4	84.2	18.34	18.35	1.39	1.4	α_c		1.76
$(\theta_E - \theta_{E_c})_0$			0.00	5	85.5	18.63	18.61	1.68	1.65	σ	0.00814	
θ_F			19.45	6	86.4	18.82	18.83	1.87	1.88			
θ'_F			20.54	∞					3.58	f_∞		3.27

Remarks :

$\overline{\alpha}_c$ = 1.36
$\overline{\sigma}$ = 0.00583

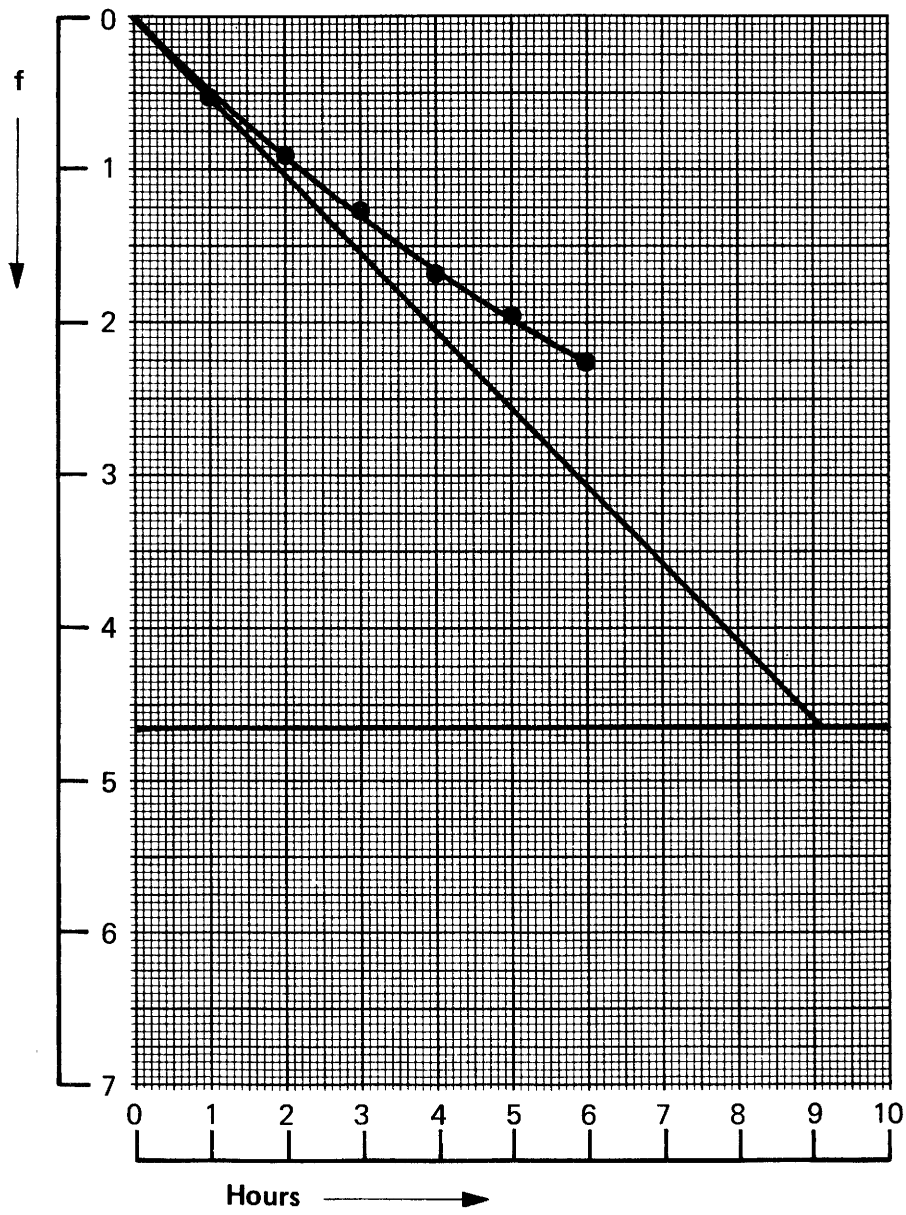


Curve Number : 129 - 92				**Result Number :** 80								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	1	1		0	139	30.28	30.26	0	0	α_T		6.12
ϵ	65	74	63	1	136.5	29.74	29.78	0.54	0.48	α_R		1.46
θ_A	29.4	30.1		2	134.7	29.35	29.34	0.93	0.92	$\Delta \alpha$		4.66
$\overline{\theta}_E$		29.14		3	132	28.98	28.95	1.3	1.31	$1 + t_g \beta\, t_g \delta$		4.23
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			27.37	4	131.2	28.58	28.61	1.70	1.66	α_c		1.10
$(\theta_E - \theta_{E_c})_0$			+0.02	5	130	28.32	28.29	1.96	1.97	σ	0.00426	
θ_F			24.2	6	128.5	28	28.01	2.28	2.25			
θ'_F			25.61	∞		·			4.65	f_∞		5.28

Remarks :

$\overline{\alpha}_c = 1.36$

$\overline{\sigma} = 0.00583$



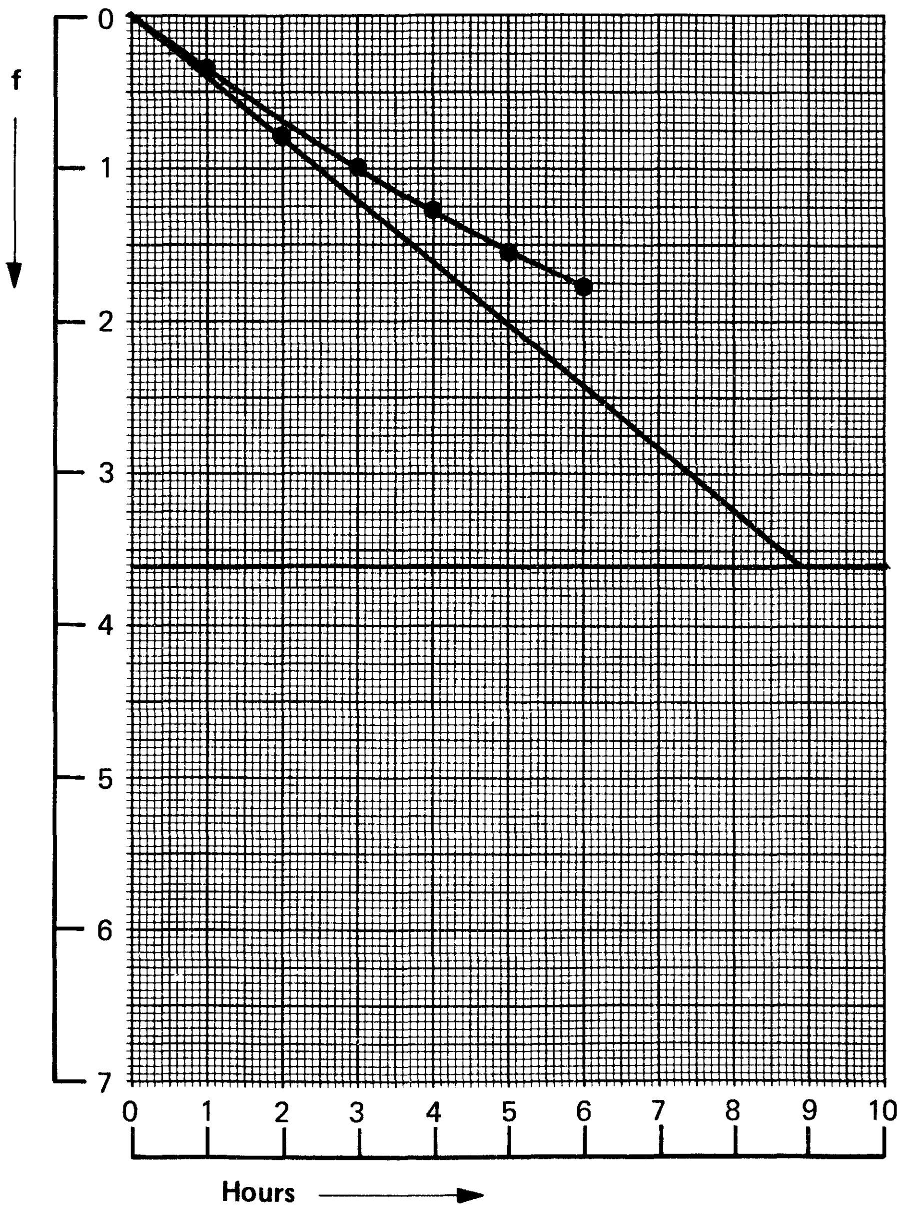
Curve Number : 131-93 | **Result Number :** 81

	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	1	1		0	95.6	20.83	20.83	0	0	α_T		6.17
ϵ	65	62	82	1	94	20.48	20.45	0.35	0.38	α_R		1.34
θ_A	18.3	19		2	92	20.04	20.11	0.79	0.72	$\Delta\alpha$		4.83
$\overline{\theta}_E$		19.94		3	91	19.83	19.8	1	1.03	$1 + t_g \beta \, t_g \delta$		3.07
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			18.57	4	89.8	19.56	19.53	1.27	1.3	α_c		1.57
$(\theta_E - \theta_{E_c})_0$			0.00	5	88.5	19.28	19.29	1.55	1.54	σ	0.00698	
θ_F			16.71	6	87.5	19.06	19.07	1.77	1.76			
θ'_F			17.21	∞					3.61	f_∞		4.35

Remarks :

$\overline{\alpha}_c = 1.36$

$\overline{\sigma} = 0.00583$

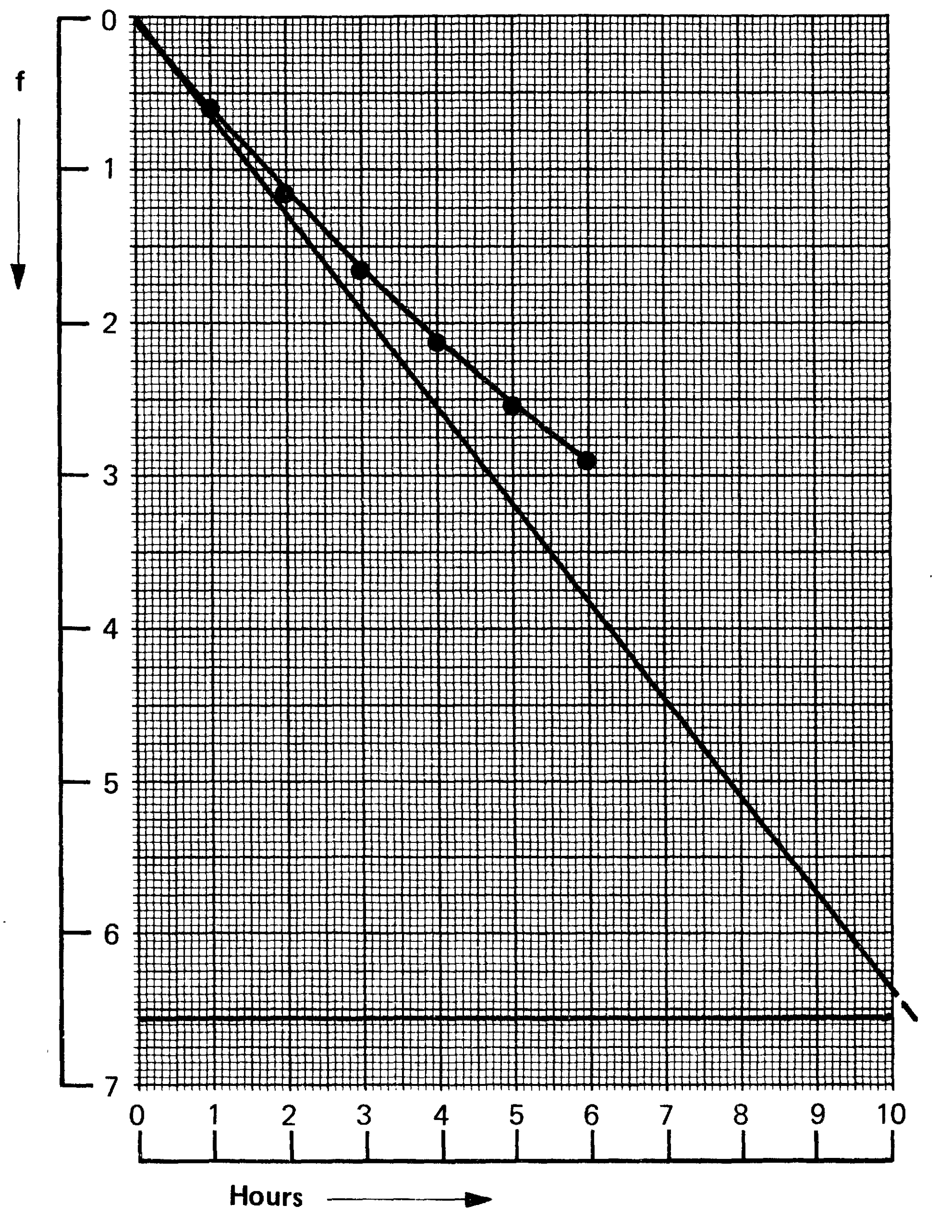


Curve Number : 132-49				Result Number : 82								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	1	1		0	86.6	18.91	18.92	0	0	α_T		5.39
ϵ	65	67	58	1	89.5	19.54	19.53	0.63	0.61	α_R		1.35
θ_A	29.4	30.5		2	92	20.09	20.08	1.18	1.16	$\Delta \alpha$		4.04
$\overline{\theta}_E$		20.37		3	94.2	20.57	20.58	1.66	1.66	$1 + t_g \beta t_g \delta$		3.6
$\frac{1}{2} (\overline{\theta}_E + \theta'_F)$			22.92	4	96.3	21.03	21.03	2.12	2.12	α_c		1.12
$(\theta_E - \theta_{E_c})_0$			-0.01	5	98.2	21.44	21.45	2.53	2.53	σ	0.00429	
θ_F			23.8	6	100	21.83	21.82	2.92	2.9			
θ'_F			25.48	∞					6.56	f_∞		6.89

Remarks :

$\overline{\alpha}_c = 1.36$

$\overline{\sigma} = 0.00583$

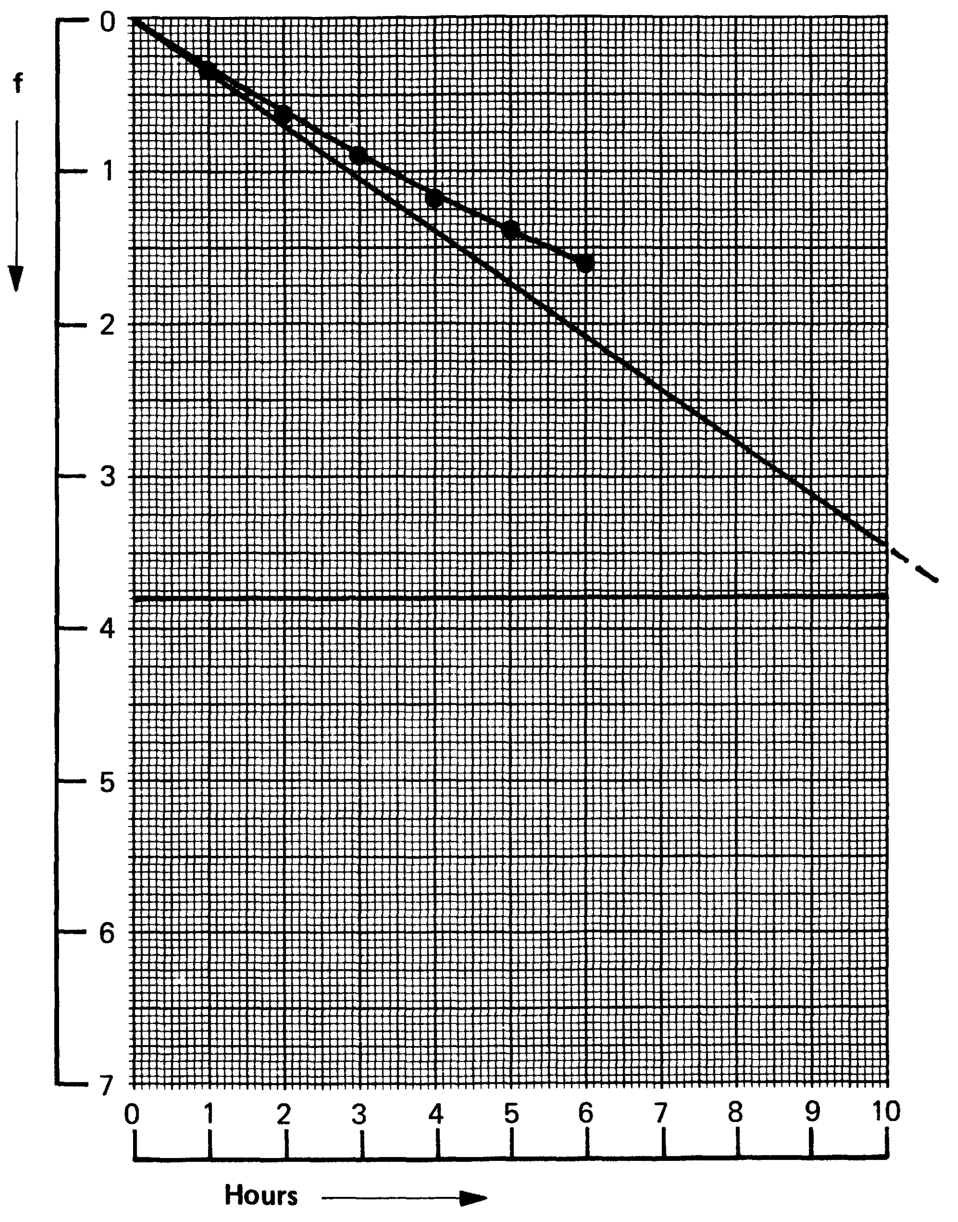


Curve Number : 136 - 50				Result Number : 83								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	0.5	0.46		0	99.6	21.70	21.70	0	0	α_T		5.09
ϵ	65	72	57.5	1	101.2	22.05	22.04	0.35	0.33	α_R		1.38
θ_A	29.4	30.5		2	102.5	22.33	22.34	0.63	0.63	$\Delta\alpha$		3.71
$\overline{\theta}_E$		22.5		3	103.8	22.61	22.62	0.91	0.91	$1 + t_g \beta t_g \delta$		3.75
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			23.99	4	105	22.88	22.87	1.18	1.16	α_c		0.99
$(\theta_E - \theta_{E_c})_0$			0.00	5	106	23.09	23.1	1.39	1.39	σ	0.00425	
θ_F			23.63	6	107	23.31	23.31	1.61	1.60			
θ'_F			25.49	∞					3.79	f_∞		3.94

Remarks :

$\overline{\alpha}_c \doteq 0.905$

$\overline{\sigma} = 0.00377$

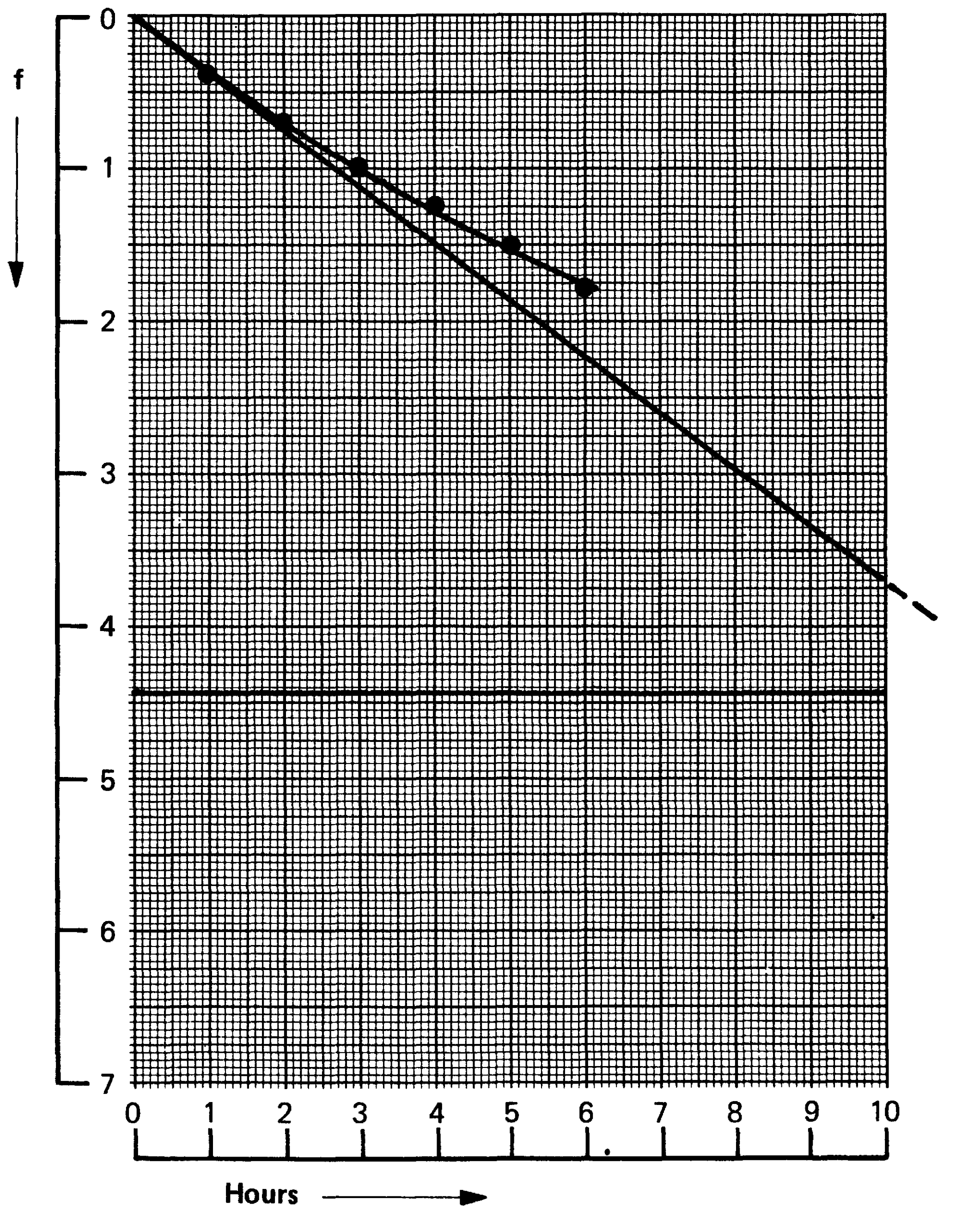


Curve Number : 138 - 95				Result Number : 84								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	0.5	0.46		0	136	29.63	29.61	0	0	α_T		4.66
ϵ	65	69	55	1	134.2	29.24	29.26	0.39	0.36	α_R		1.46
θ_A	29.4	30.4		2	132.7	28.91	28.93	0.72	0.69	$\Delta\alpha$		3.2
$\overline{\theta}_E$		28.73		3	131.4	28.63	28.63	1	0.99	$1 + t_g \beta t_g \delta$		4.17
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			26.95	4	130.2	28.37	28.35	1.26	1.26	α_c		0.767
$(\theta_E - \theta_{E_c})_0$			+0.02	5	129	28.11	28.09	1.52	1.52	σ	0.00302	
θ_F			22.8	6	127.8	27.84	27.86	1.79	1.75			
θ'_F			25.18	∞					4.43	f_∞		4.76

Remarks :

$\overline{\alpha}_c$ = 0.905

$\overline{\sigma}$ = 0.00377

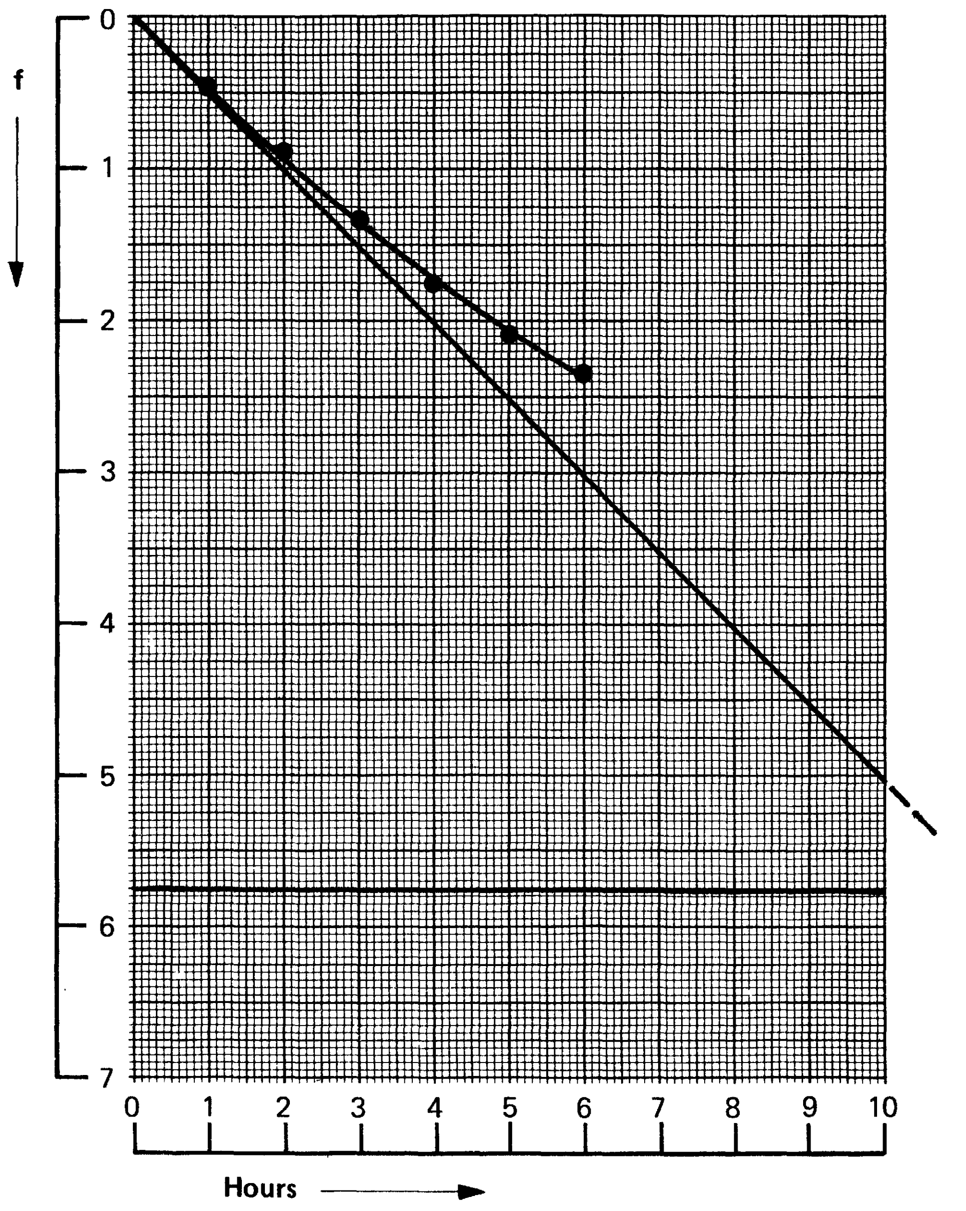


Curve Number : 141-96 | **Result Number :** 85

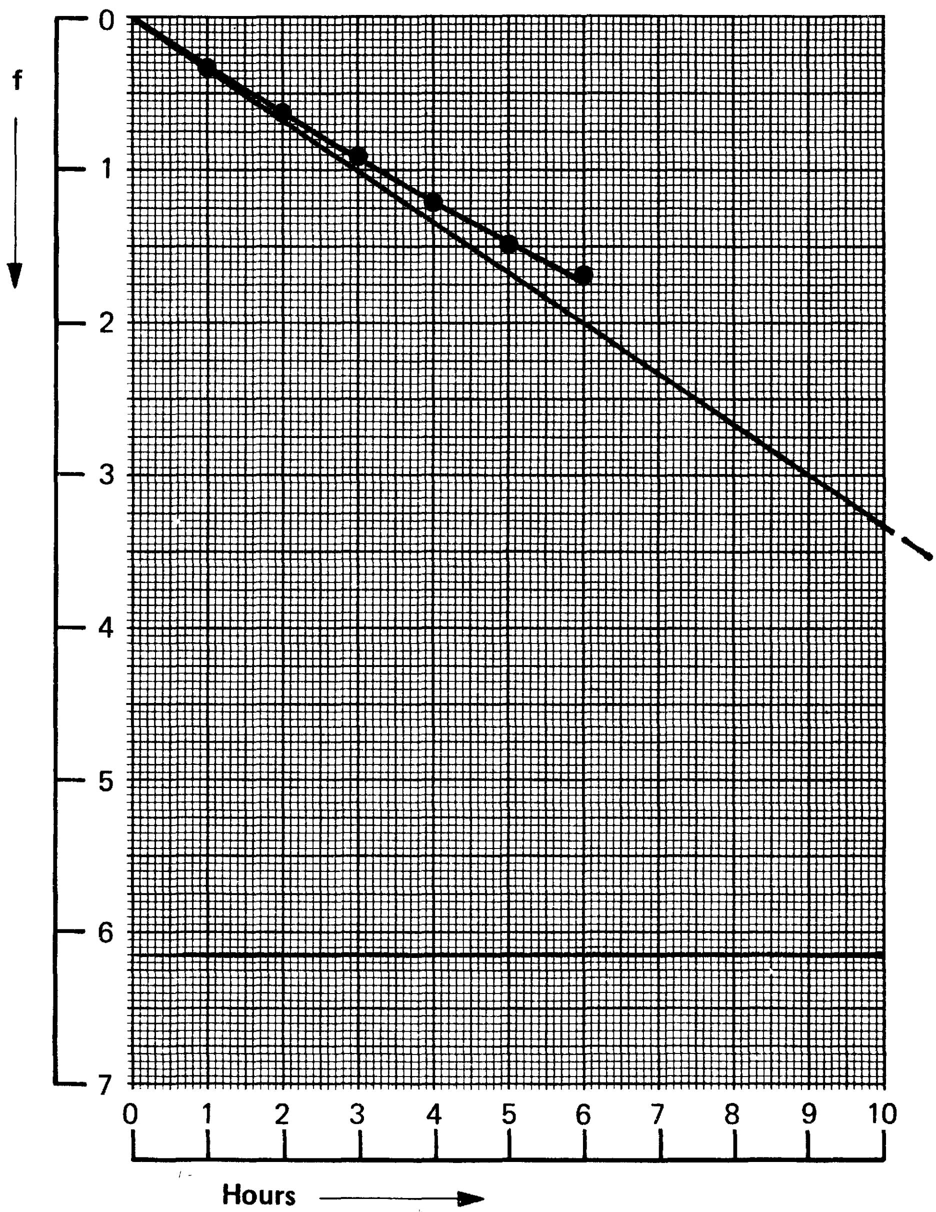
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	0.5	0.45		0	122	26.58	26.6	0	0	α_T		4.89
ϵ	65	60	62	1	120	26.14	26.12	0.44	0.49	α_R		1.41
θ_A	23.7	24.5		2	118	25.71	25.67	0.87	0.93	$\Delta\alpha$		3.48
$\overline{\theta}_E$		25.42		3	116	25.27	25.27	1.31	1.34	$1 + t_g \beta t_g \delta$		3.63
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			23.13	4	114	24.84	24.89	1.74	1.71	α_c		0.959
$(\theta_E - \theta_{E_c})_0$			- 0.02	5	112.6	24.53	24.55	2.05	2.05	σ	0.00408	
θ_F			19.35	6	111.4	24.27	24.24	2.31	2.37			
θ'_F			20.84	∞					5.76	f_∞		5.54

Remarks :

$\overline{\alpha}_c$ = 0.905
$\overline{\sigma}$ = 0.00377



Curve Number : 142 - 99				Result Number : 86								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	0.35	0.38		0	97.2	21.18	21.18	0	0	α_T		3.04
ϵ	65	57.5	42	1	95.7	20.85	20.85	0.33	0.33	α_R		1.35
θ_A	18.3	19.2		2	94.3	20.55	20.54	0.63	0.64	$\Delta\alpha$		1.69
$\overline{\theta}_E$		20.33		3	93	20.26	20.25	0.92	0.93	$1 + t_g \beta t_g \delta$		2.97
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			17.68	4	91.7	19.98	19.97	1.20	1.21	α_c		0.56
$(\theta_E - \theta_{E_c})_0$			0.00	5	90.3	19.67	19.71	1.51	1.47	σ	0.00205	
θ_F			11.67	6	89.4	19.48	19.46	1.70	1.72			
θ'_F			15.03	∞					6.15	f_∞		6.05



Remarks :

$\overline{\alpha}_c$ = 0.72

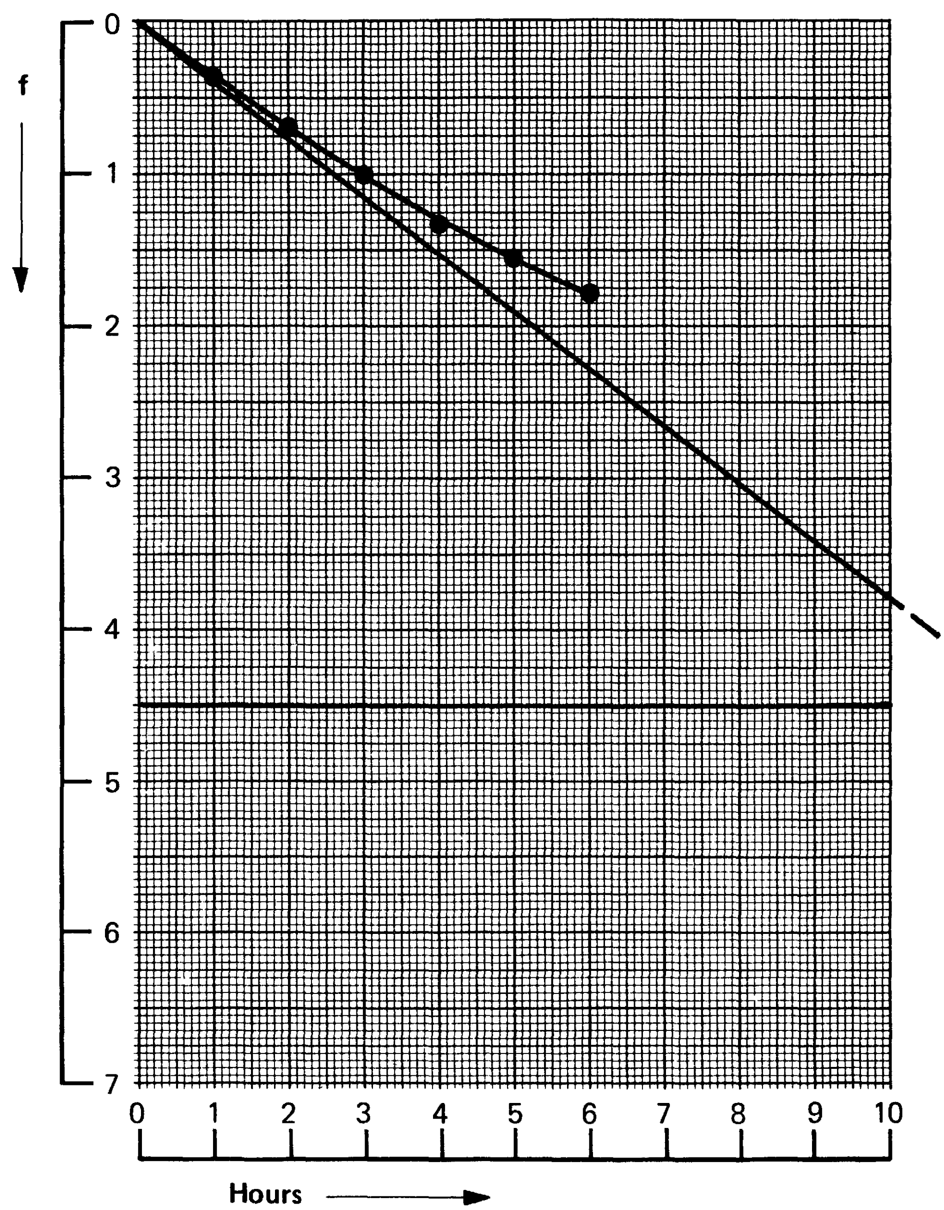
$\overline{\sigma}$ = 0.00303

Curve Number : 152 - 100				Result Number : 07									
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	0.35	0.36		0	133.5	29.15	29.17	0	0	α_T		4.66
ϵ	65	64	60	1	132	28.82	28.8	0.33	0.36	α_R		1.45
θ_A	29.4	28.70		2	130.5	28.49	28.47	0.66	0.70	$\Delta\alpha$		3.21
$\overline{\theta}_E$		28.27		3	129	28.17	28.16	0.98	1	$1 + t_g\beta t_g\delta$		4.1
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			26.46	4	127.5	27.84	27.88	1.31	1.29	α_c		0.78
$(\theta_E - \theta_{E_c})_0$			-0.02	5	126.5	27.62	27.62	1.53	1.54	σ	0.00335	
θ_F			22.82	6	125.5	27.4	27.38	1.75	1.78			
θ'_F			24.66	∞					4.50	f_∞		4.57

Remarks :

$\overline{\alpha}_c = 0.72$

$\overline{\sigma} = 0.00303$

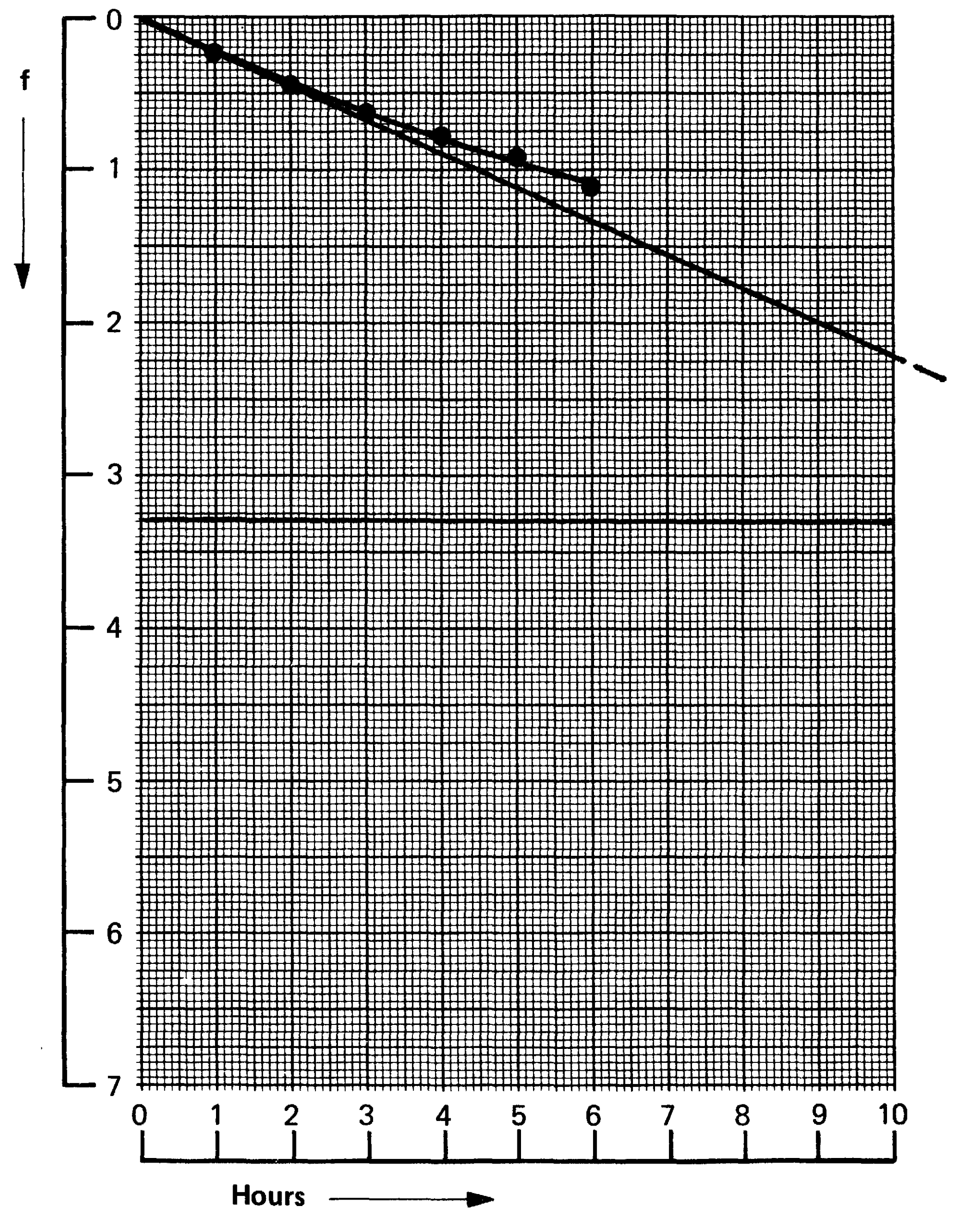


Curve Number : 153 - 54				Result Number : 88								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	0.35	0.36		0	123.8	27.03	27.05	0	0	α_T		3.76
ϵ	65	76	57	1	125	27.29	27.26	0.26	0.22	α_R		1.44
θ_A	35	35		2	125.8	27.47	27.46	0.44	0.42	$\Delta\alpha$		2.32
$\overline{\theta_E}$		27.6		3	126.6	27.64	27.65	0.61	0.6	$1 + t_g\beta t_g\delta$		4.49
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			28.96	4	127.5	27.84	27.83	0.81	0.78	α_c		0.51
$(\theta_E - \theta_{E_c})_0$			-0.02	5	128	27.95	27.99	0.92	0.94	σ	0.00191	
θ_F			27.42	6	129	28.17	28.14	1.14	1.10			
θ'_F			30.33	∞					3.28	f_∞		4.65

Remarks :

$\overline{\alpha}_c = 0.72$

$\overline{\sigma} = 0.00303$

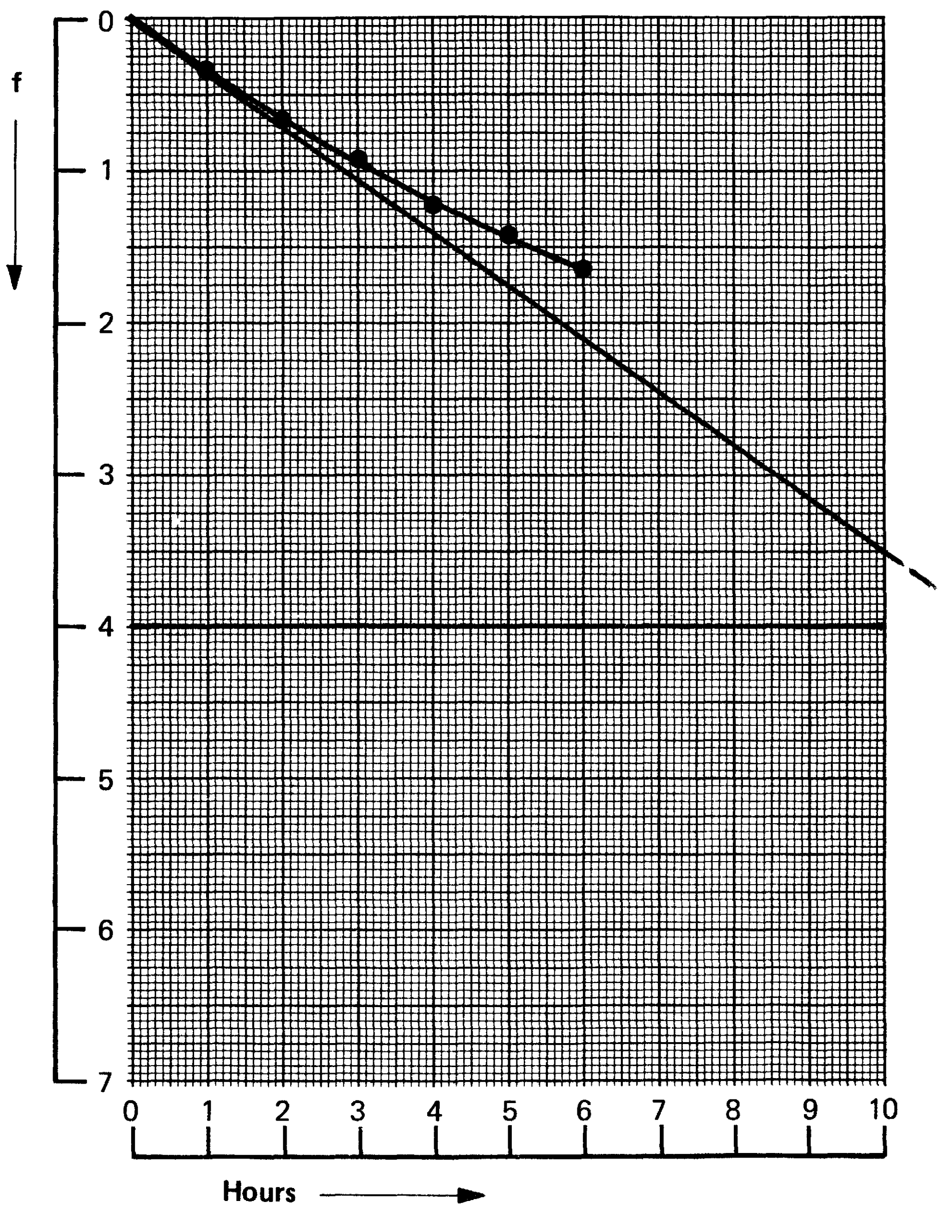


Curve Number : 155 - 101				Result Number : 89								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	0.35	0.36		0	114.2	24.94	24.95	0	0	α_T		4.92
ϵ	65	66	70	1	112.8	24.63	24.61	0.31	0.34	α_R		1.4
θ_A	23.7	23.6		2	111.3	24.3	24.3	0.64	0.65	$\Delta \alpha$		3.52
$\overline{\theta}_E$		24.12		3	110	24.02	24.02	0.92	0.93	$1 + t_g \beta t_g \delta$		3.55
$\frac{1}{2} (\overline{\theta}_E + \theta'_F)$			22.53	4	108.7	23.73	23.76	1.21	1.19	α_c		0.99
$(\theta_E - \theta_{E_c})_0$			-0.01	5	107.8	23.54	23.52	1.40	1.43	σ	0.00458	
θ_F			19.9	6	106.7	23.3	23.3	1.64	1.65			
θ'_F			20.95	∞					3.99	f_∞		4.23

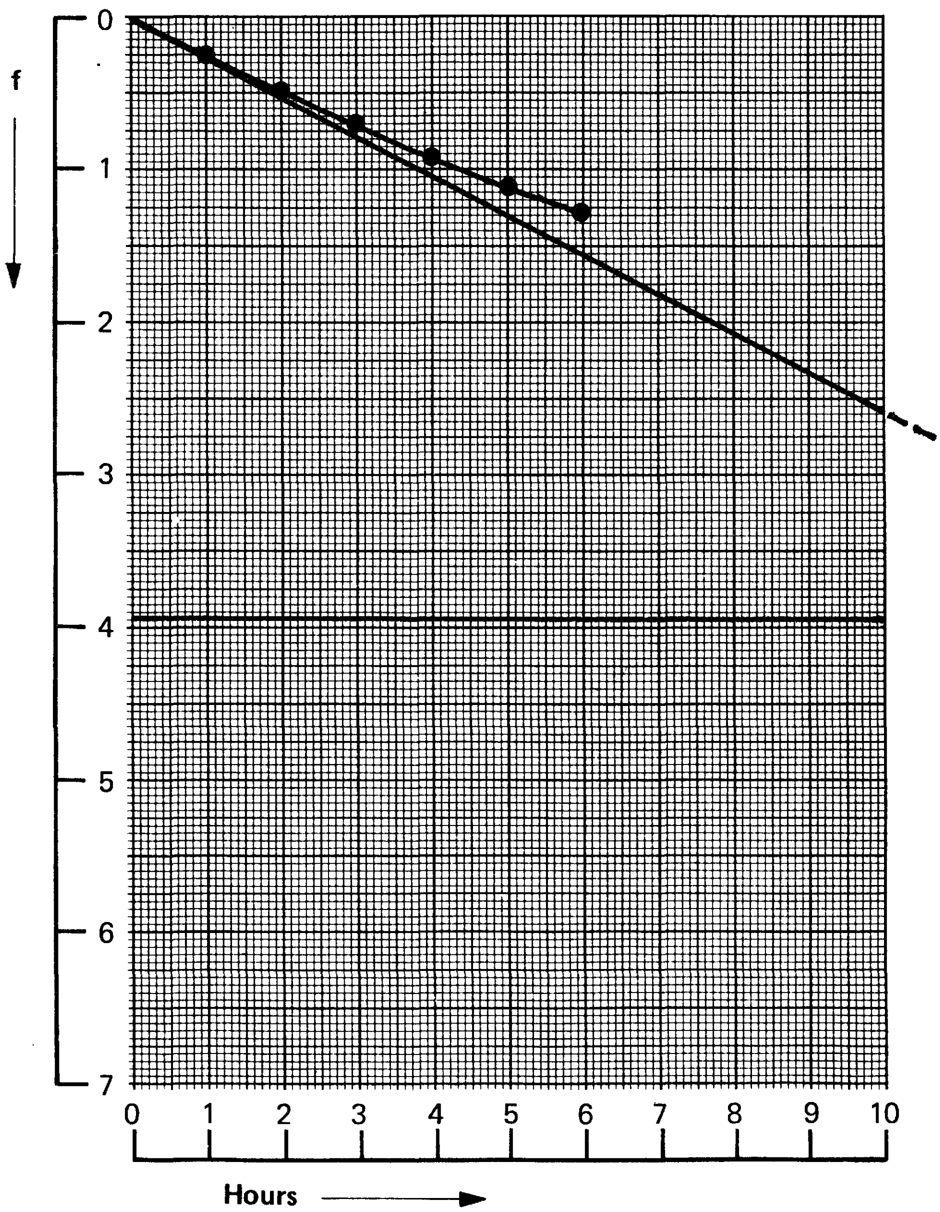
Remarks :

$\overline{\alpha}_c = 0.72$

$\overline{\sigma} = 0.00303$



Curve Number : 158 - 103				**Result Number :** 90								
	nominal	measured	calcul.	time	reading	θ_E	θ_{E_c}	f	f_c		GRAPH	COMPUT
W	0.35	0.36		0	94	20.52	20,51	0	0	α_T		3.65
ϵ	65	61	75	1	92.8	20.26	20.26	0.26	0.25	α_R		1.35
θ_A	18.3	18.5		2	91.5	19.98	20.03	0.54	0.48	$\Delta\alpha$		2.3
$\overline{\theta}_E$		19.86		3	90.8	19.83	19.81	0.69	0.70	$1 + t_g \beta t_g \delta$		3.03
$\frac{1}{2}(\overline{\theta}_E + \theta'_F)$			18.22	4	89.8	19.61	19.60	0.91	0.91	α_c		0.76
$(\theta_E - \theta_{E_c})_0$			+0.01	5	89	19.43	19.41	1.09	1.10	σ	0.00324	
θ_F			15.47	6	88	19.21	19.23	1.31	1.28			
θ'_F			16.59	∞					3.92	f_∞		6,80



Remarks :

$\overline{\alpha}_c$ = 0.72

$\overline{\sigma}$ = 0.00303

European Communities – Commission

The experimental determination of the combined heat and mass transfer coefficient between the free surface of a water body and an air flow

by L. Nobel and M. Hardy,

Joint Research Centre, Ispra Establishment, Italy
(Engineering Division)

Luxembourg : Office for official publications of the
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1977 – 160 p. – 21,0 x 29,7 cm

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From temperature decay-time curves of a water-bath the total heat transfer coefficient of a free water surface in contact with an air stream has been determined.

From this total heat transfer coefficient the convective part was deduced and the interdependence between this convective heat transfer coefficient and the air velocity related to a height of 1 m has been established.

The results are in good agreement with the Trabert equation and the equation of the Schweisser Kühlwasser Bericht.

In the report different methods for the determination of the asymptotic water temperature are given as well as formulas for the calculation of the wetbulb temperature of the air from this asymptotic temperature.