Title: **THERMAL COMFORT**
Ref Number: **3**
Location: **NATIONAL COLLEGE LABORATORY**
Supervisor: **KIKA YIAKOUMETTI**
Academic: **KIKA YIAKOUMETTI**
Team Size: **~4**
Environment: **INDOORS**

OBJECTIVE

To measure and compare the **air velocity** and **Mean Radiant Temperature** (MRT) under 4 sets of different environmental conditions within the laboratory.

The four conditions are:

1) In the centre of the work room.
2) In the centre of the work room with forced air movement.
3) On a bench near to a radiant heat source, but with a reflective heat shield between the heat source and the thermometers.
4) In the same position as (3) but without the reflective heat shield and the thermometers under the direct influence of the radiant source.

APPARATUS

- Mercury–in-glass thermometer (one with the radiation shield)
- Kata thermometer
- Thermos flask
- Stopwatch
- Globe thermometer
- Electric fire
- Reflective shield
- Fan

THEORY

The Kata thermometer supplied has a cooling range of 54.5 ^{O}C to 51.5 ^{O}C.

The cooling power of the instrument (H) is the kata factor divided by the cooling time of the instrument in seconds. (The kata factor is written on the stem of the instrument)

The relationship between the cooling power, H, the dry bulb air temperature and the air velocity, V, in m/s us given by

$$H = \varepsilon\left(a + b\sqrt{v}\right)$$

where ε is the difference between the mean temperature of the kata, i.e. 53 OC, and the dry bulb temperature of the air, a and b are constants. For the kata supplied, the equation is

$$H = \varepsilon\left(0.1 + 0.37\sqrt{v}\right)$$

If the temperature of the globe thermometer exceeds that of the air, the radiation gain R in W/m^2 is given by

$$\varepsilon\delta\left\{T_{mrt}^4 - T_{\varsigma}^4\right\}$$

where δ is the Steffan Boltzmann Constant

or

$$R = \varepsilon * 5.67 * 10^{-8} * \left\{T_{mrt}^4 - T_{\varsigma}^4\right\}$$

where T_{mrt} and $T\varsigma$ are the absolute mean radiant temperature and the absolute temperature of the globe thermometer respectively, as expressed in ^{O}K. ε is the emissivity of the surface of the globe, take this to be 0.95 in your calculations.

The heat loss in W/m^2 from the globe by convection, C, is given by

$$C = 13.57 * \sqrt{v} * \left\{t_{\varsigma} - t_a\right\}$$

where t_{ς} and t_a are the globe and air temperatures expressed in ^{O}C and v is the air velocity in m/s.

When the globe thermometer is in equilibrium the heat gain by radiation is balanced by the heat loss by convection so that by equating R and C and transposing

$$T_{mrt}^4 * 10^{-8} = T_{\varsigma}^4 * 10^{-8} + 2.52 * \sqrt{v} * \left(t_{\varsigma} - t_a\right)$$

PROCEDURE

Measure the air velocity with the Kata thermometer as follows:

Check that the silver plated bulbs of the Katas are well polished.

Fill the thermos with boiling water.

Measure the air velocity with the Katas as follows:

Immerse the bulb of the Kata in the boiling water and wait until the alcohol reaches halfway up the small upper bulb of the instrument. Dry the bulb thoroughly.

With the stopwatch, measure the cooling time i.e. the time taken fro the alcohol meniscus to fall from the upper to the lower graduation marks.

Repeat the process until consistent readings of cooling time are obtained for 3 successive measurements, then take the average of these three.

Calculate the air velocity from the equation given.

Using the nomogram provided to determine the air velocity in m/s.

Note: the Kata factor is etched on the back of the instrument.

Check global reading every 5 minutes until they reach equilibrium, then determine the Mean Radiant Temperature (MRT) from the globe and dry bulb temperatures and air velocity using the nomograms and the equations provided.

In each location make a sketch showing the position of the "trolley" in relation to the sources of radiant and convective heat loss or gain and air movement e.g. proximity of windows – are the surfaces cold or hot? Or, is the sun out? Are the lights on? Etc.

For measurement with a radiant source:

Read the globe thermometer periodically and plot the results against time in minutes. Continue unitl the instrument reaches equilibrium.

Setup the ordinary thermometer in such a way as to record the air temperature in the vicinity of the globe thermometer: see that one thermometer is screened from the radiant heat from plate.

Setup the Kata thermometer near the globe thermometer.

Tabulate your results.

Simplified Equation:

$$MRT = t_g + 1.8\ V^{0.5}\ (t_g - t_a)$$

RESULTS

Include one example of each calculation done in the main text. Other calculations may be put in an appendix along with nomograms used etc.

DISCUSSION

Comment on the differences between the readings taken in the different locations and on the effectiveness of

i) the reflective screen
ii) the screened dry thermometer

Comment on the differences in the results from using the supplied nomograms and using the calculations. For the MRT calculations you should use both the full (4^{th} power) calculation given in the notes and also the simplified calculation; comment on any differences.

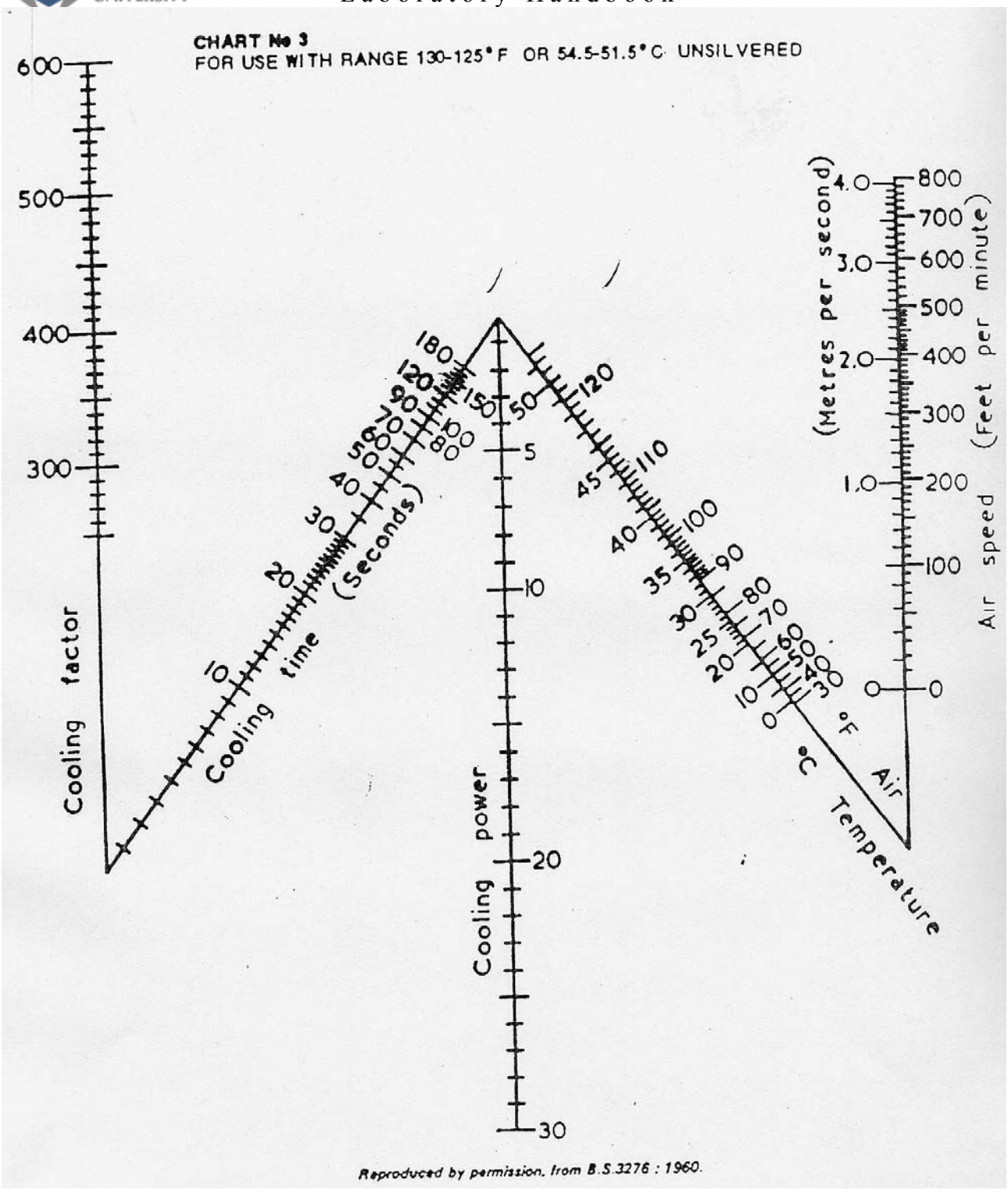


CHART No 3
FOR USE WITH RANGE 130-125°F OR 54.5-51.5°C UNSILVERED
Cooling factor
600
500
400
300
Cooling time (Seconds)
180
120
90
70
60
50
40
30
20
10
Cooling power
5
10
20
30
50
120
45
110
40
100
35
90
30
80
25
70
20
60
10
50
0
40
30
°F
°C
Air Temperature
(Metres per second)
Air speed (Feet per minute)
4.0
3.0
2.0
1.0
0
800
700
600
500
400
300
200
100
0
Reproduced by permission, from B.S.3276 : 1960.

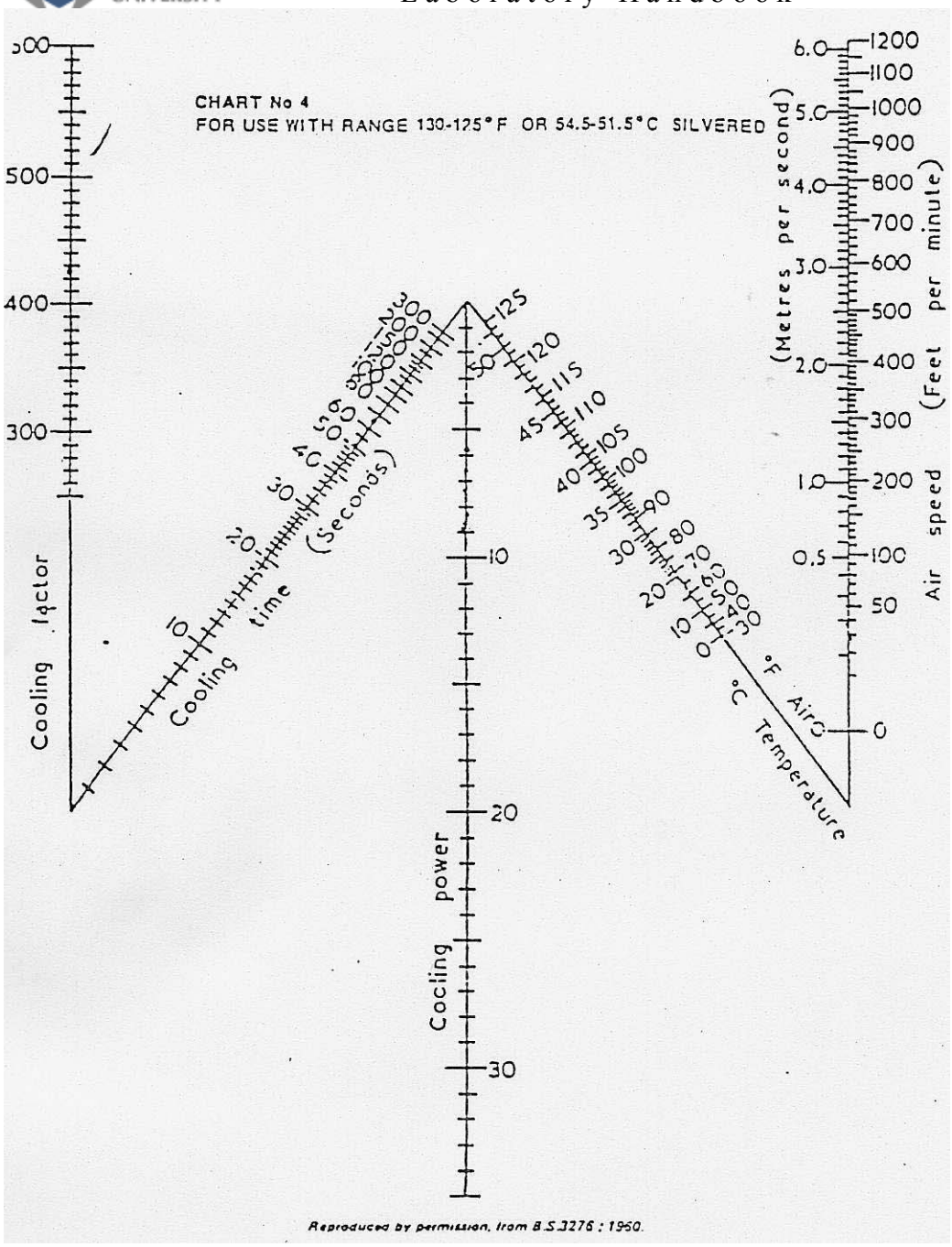
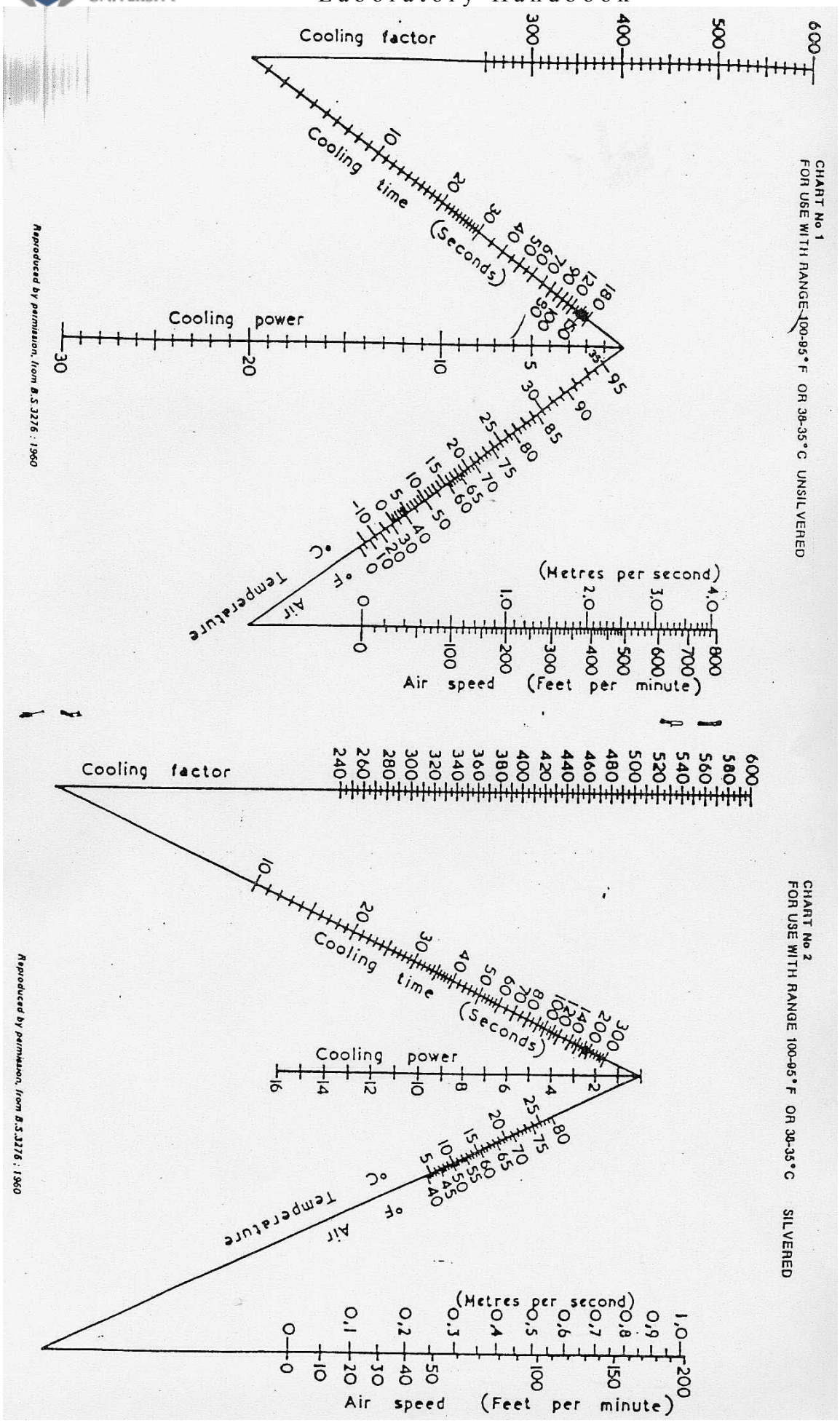


CHART No 4
FOR USE WITH RANGE 130-125°F OR 54.5-51.5°C SILVERED
Cooling factor
Cooling time (Seconds)
Cooling power
°F Air
°C Temperature
Air speed (Metres per second)
(Feet per minute)
Reproduced by permission, from B.S.3276 : 1960.


Cooling factor
300
400
500
600
Cooling time (Seconds)
10
20
30
40
50
60
80
120
180
300
Cooling power
30
20
10
5
Temperature
Air
°C
°F
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-10
(Metres per second)
0
1.0
2.0
3.0
4.0
Air speed (Feet per minute)
0
100
200
300
400
500
600
700
800
CHART No 1
FOR USE WITH RANGE 100-95°F OR 38-35°C UNSILVERED
Reproduced by permission, from B.S.3276 : 1960
Cooling factor
240
260
280
300
320
340
360
380
400
420
440
460
480
500
520
540
560
580
600
Cooling time (Seconds)
10
20
30
40
50
60
80
120
200
300
Cooling power
16
14
12
10
8
6
4
2
Temperature
Air
°C
°F
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
(Metres per second)
0
0,1
0,2
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1,0
Air speed (Feet per minute)
0
10
20
30
40
50
100
150
200
CHART No 2
FOR USE WITH RANGE 100-95°F OR 38-35°C SILVERED
Reproduced by permission, from B.S.3276 : 1960

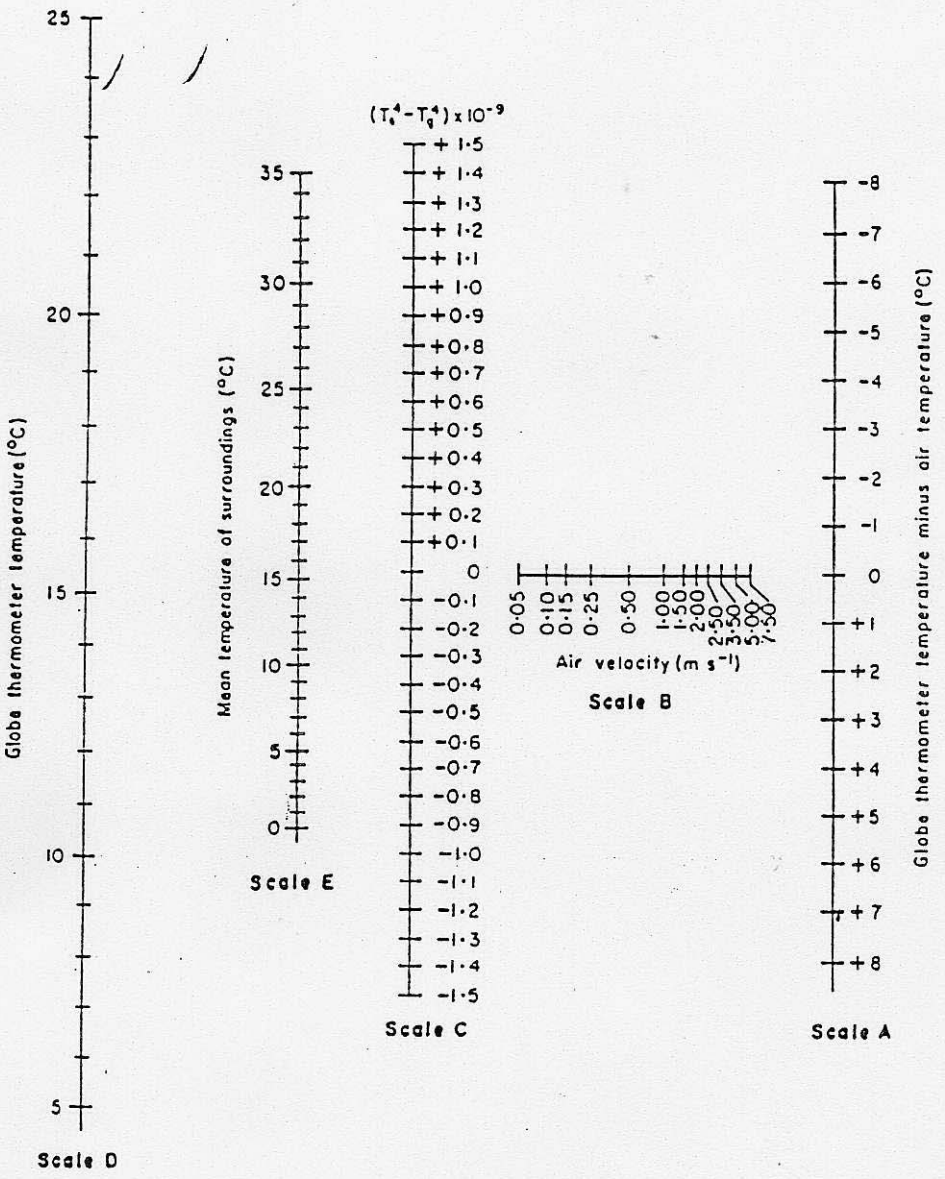


Figure 4 ; Nomogram for the estimation of mean radiant temperature

Range : 5-25°C

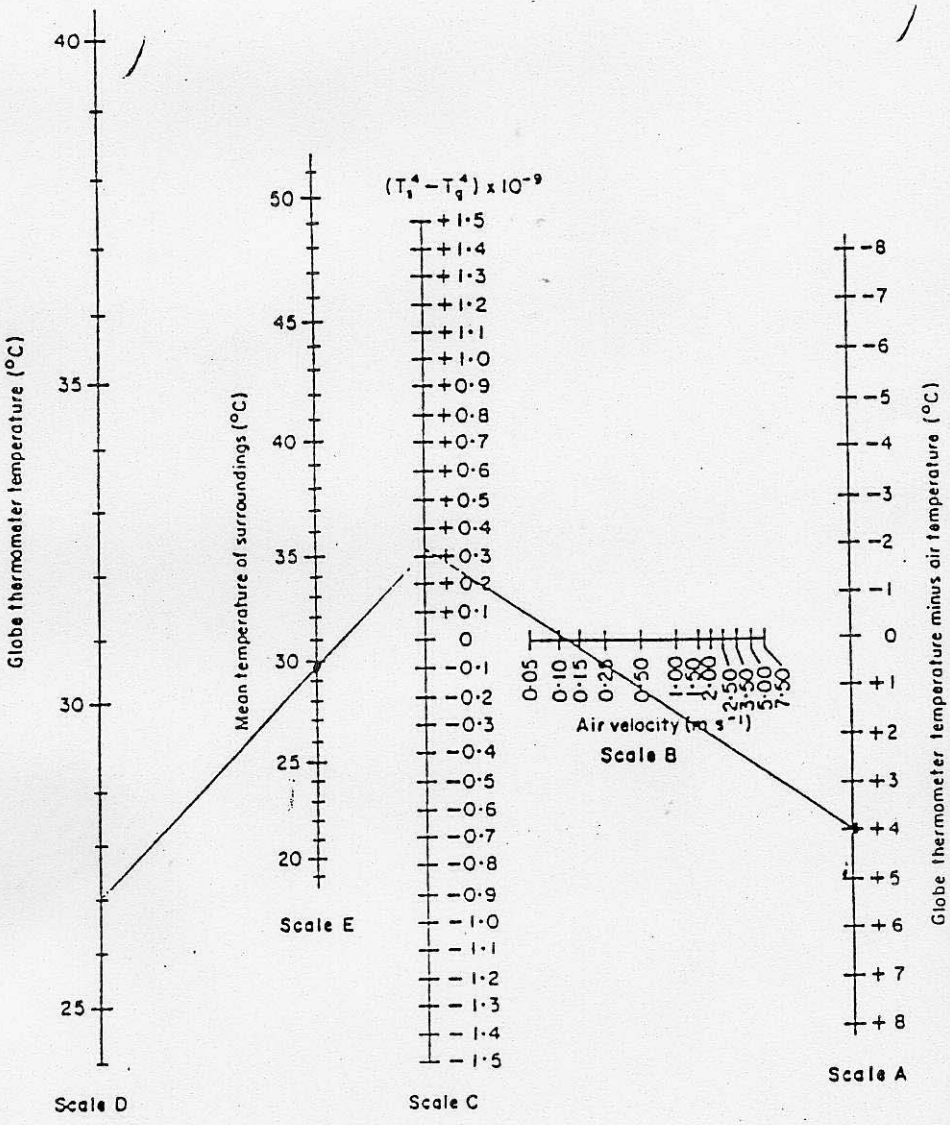


Figure 5 ; Nomogram of the estimation of mean radiant temperature .

Range : 25-40°C

Example : Using a globe temperature of 27.0°C , a dry bulb temperature of 23.0°C and an air velocity of 0.11m/s , we obtain a mean radiant temperature of 29.5°C .

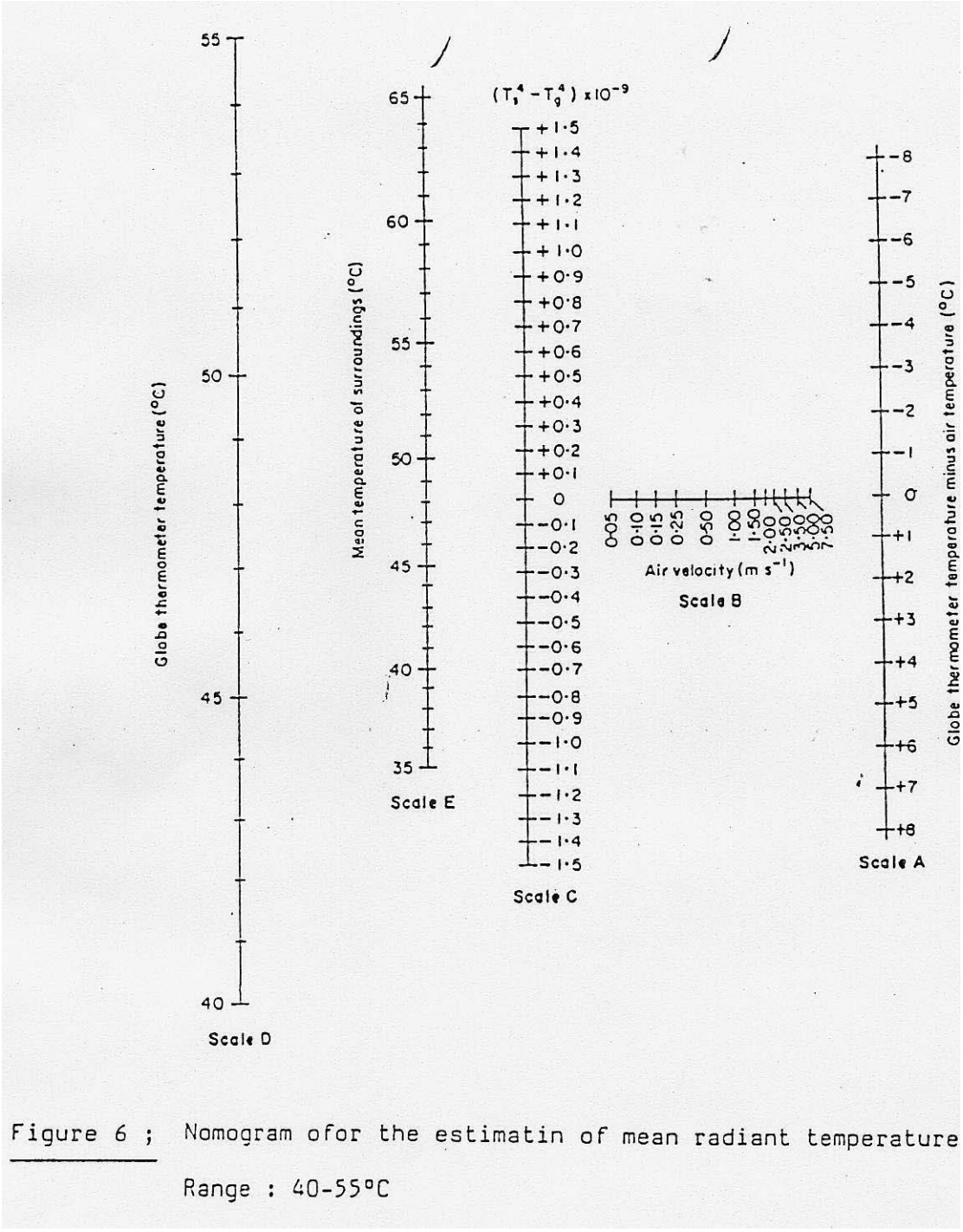


Figure 6 ; Nomogram ofor the estimatin of mean radiant temperature

Range : 40-55°C

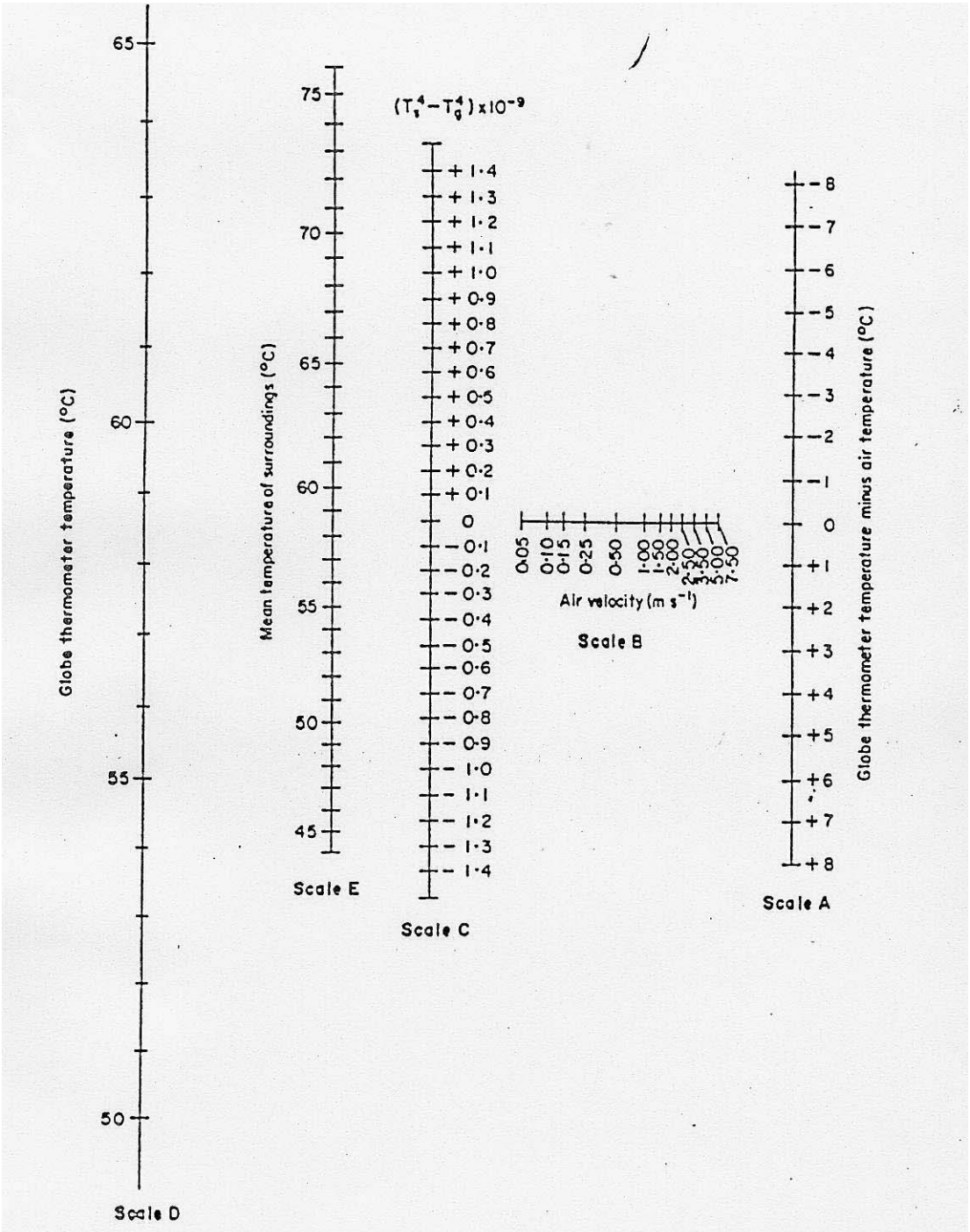


Figure 7 ; Nomogram for the estimation of mean radiant temperature

Range : 50-65°C