Drying Problems

Example 1: Evaporation from a wet surface (convection heat transfer only)

Clothes drying on a line are exposed to air at 20°C and 60% relative humidity. The convective heat transfer coefficient from the air to the clothes is 20 W/m^{2}K and radiation can be ignored.

(a) Determine the rate of water removal (assuming the surface to be fully wet) from one m^2 of surface area of clothes. What will the surface temperature of the clothes be?

(b) How long will it take to dry the clothes from a moisture content of 2.5 to a moisture content of 1.0 assuming that the material is 2mm thick with a dry density of 300 kg/m^3

Example 2: Evaporation from a wet surface (convection and radiation heat transfer)

A 10cm by 20cm steak is placed under a grilling element to cook. The wet bulb and dry bulb temperatures of the air above the steak are 43°C and 100°C, respectively, and the element temperature is 500°C. The radiation view factor may be taken to be 1 and conduction from under the steak may be ignored. Saturation humidities at 60°C, 70°C, 80°C and 90°C are 0.15, 0.28, 0.55 and 1.4 kg/kg, respectively.

(a) Calculate the initial rate of evaporation from the surface of the steak assuming the surface is wet and the heat transfer coefficient to the steak is 8 W/m^{2}K. . What will the surface temperature of the steak be?

(b) How long will it take to reduce the moisture content of the steak from 2.0 to 1.5, assuming that the steak is 5mm thick with a dry density of 600 kg/m^3?

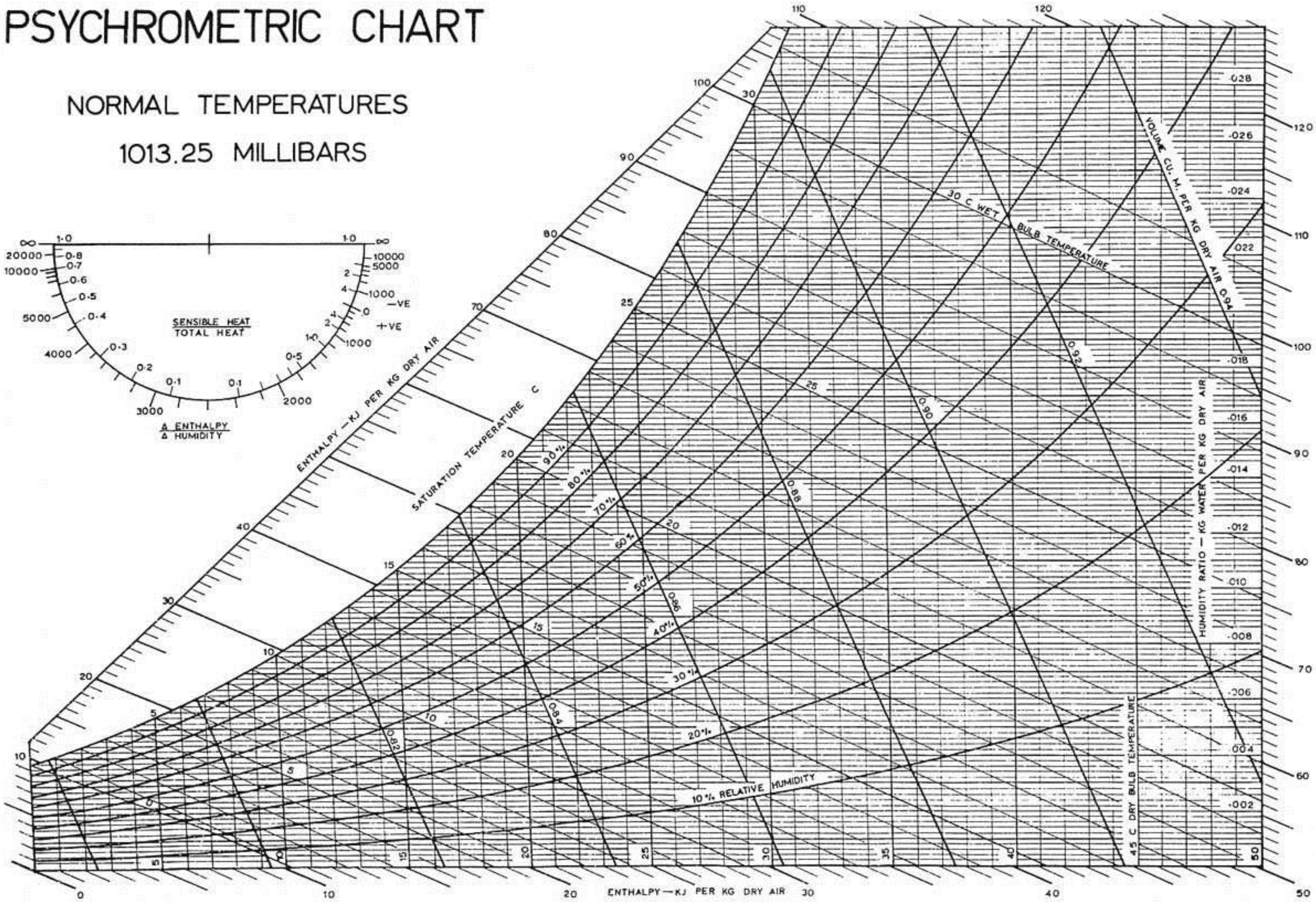
<u>Generic Solution Procedure</u>

1. Calculate the mass transfer coefficient from the analogy
2. Assume a surface temperature
3. Determine the surface saturation humidity from the psychrometric chart
4. Calculate the rate of evaporation using the mass transfer equation
5. Calculate the rate of evaporation using the heat transfer equation
6. If the rates from steps 4 and 5 are the same, you guessed correctly. Otherwise go back to step 2

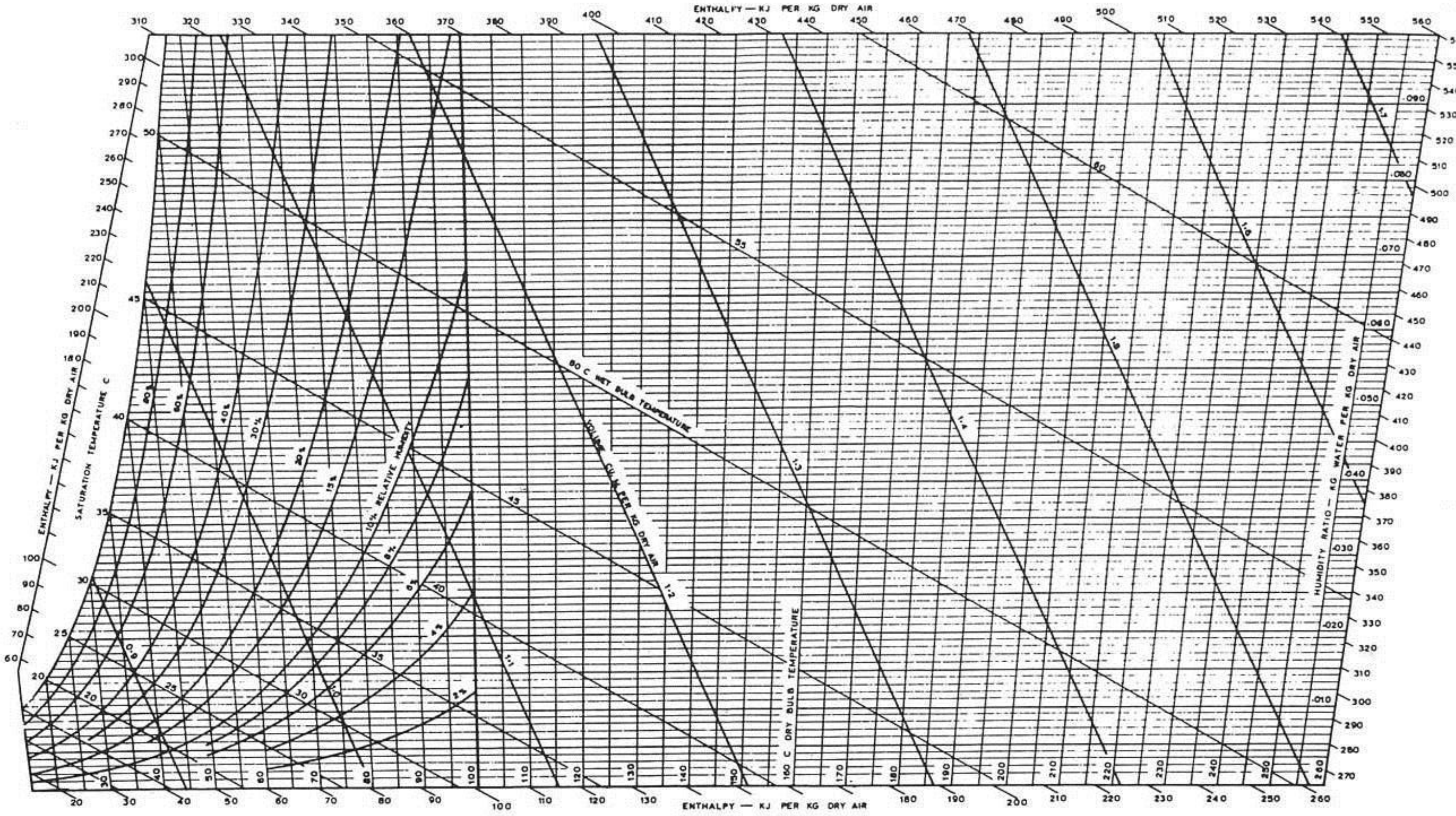
PSYCHROMETRIC CHART

NORMAL TEMPERATURES

1013.25 MILLIBARS



PSYCHROMETRIC CHART HIGH TEMPERATURES 1013.25 MILLIBARS



Example 3: Drying time with spherical particles, in constant and falling rate regimes under capillary action

Calculate the time required to dry 5mm diameter corn kernels with dry density of 200 kg/m^3 and total moisture content of 3 to a moisture content of 0.2. Experimental tests show that the drying rate during the constant rate period is 5×10^{-4} kg/m^{2}s, the critical moisture content is 0.5, and the equilibrium moisture content is 0.025 kg/kg. Assume that drying is dominated by capillary action.

Example 4: Drying time with slab geometry, in constant and falling rate regimes under capillary action, free moisture

A 25 mm thick slab of soap has a free moisture content of 2 kg/kg prior to drying. The top of the soap is exposed to 90°C air with absolute humidity of 0.03 kg/kg and the bottom of the soap sits on an insulated surface. The heat transfer coefficient to the surface of the soap, the critical moisture content of the soap and the dry density of the soap are estimated to be 50 W/m^{2}K, 0.5 kg/kg and 900 kg/m^3 respectively. Calculate the time required to dry the soap to free moisture contents of (i) 0.6 kg/kg and (ii) 0.1 kg/kg.

Example 5: Drying time with slab geometry, in falling rate regimes under diffusion.

Calculate the time required to dry a 20 mm thick slab of meat from an initial moisture content of 0.51 kg/kg (below critical) to a final average moisture content of 0.033 kg/kg. The equilibrium moisture content of the meat in the air is 0.018 kg/kg. The meat is at 45°C and the effective diffusivity of water through the meat is 3.5×10^{-9} m^2/s at 25°C. Determine the final moisture content in the centre of the meat assuming the meat is exposed on both sides.

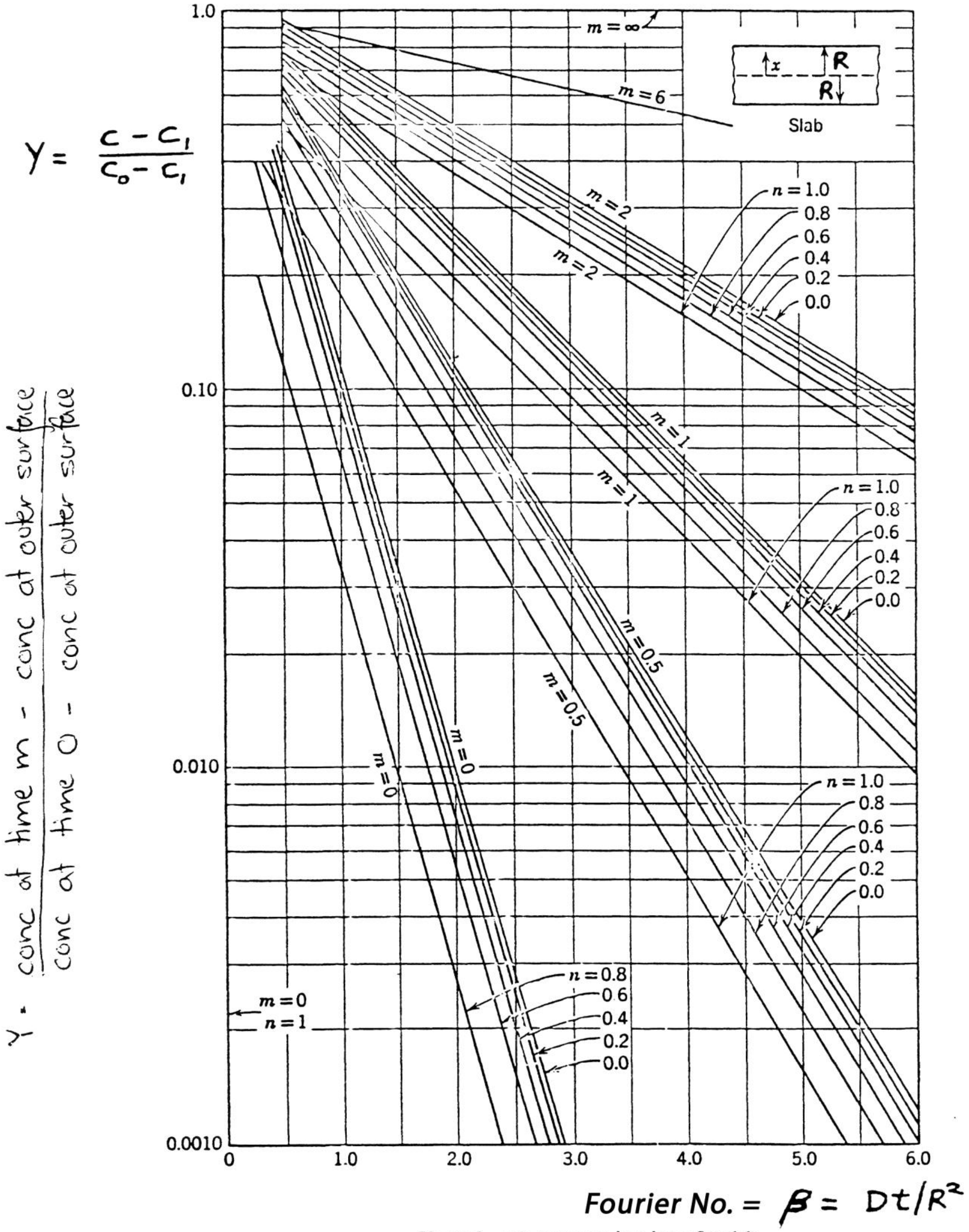
Example 6: Drying time with particle geometry, in constant and falling rate regimes under diffusion.

10mm diameter solid desiccant particles are to be dried in a hot air stream from an initial free moisture content of 0.8 kg/kg to 0.1 kg/kg. The critical free moisture content of the desiccant is 0.6 kg/kg and the effective diffusivity of moisture in the particles is 50×10^{-9} m^2/s. The rate of drying in the constant rate period is 8.5×10^{-3} kg/m^{2}s and the dry solid density is 1100 kg/m^3. Calculate the time required to dry the particles.

Figure 1

POINT LOCATION IN A SLAB

$$Y = \frac{c - c_1}{c_o - c_1}$$



Unsteady-state transport in a large flat slab.

$$n = \frac{x}{R}$$

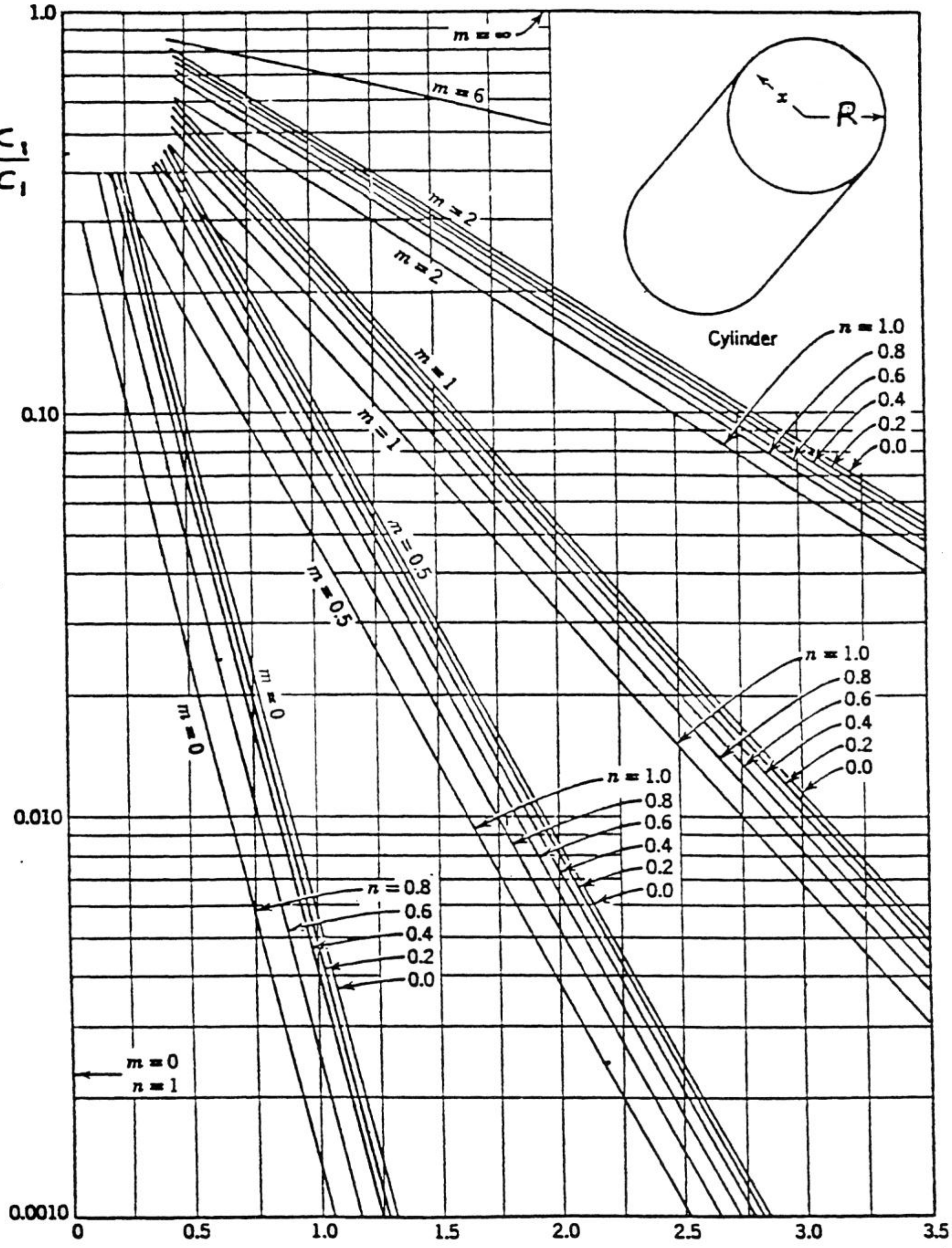
$$m = 1/Bi$$

Figure 2

POINT LOCATION IN A CYLINDER

$$Y = \frac{c - c_1}{c_0 - c_1}$$

$$Y = \frac{\text{conc at time } m - \text{conc at outer surface}}{\text{conc at time } 0 - \text{conc at outer surface}}$$



Fourier No. = $\beta = Dt/R^2$

Unsteady-state transport in a long cylinder.

$$n = \frac{x}{R}$$

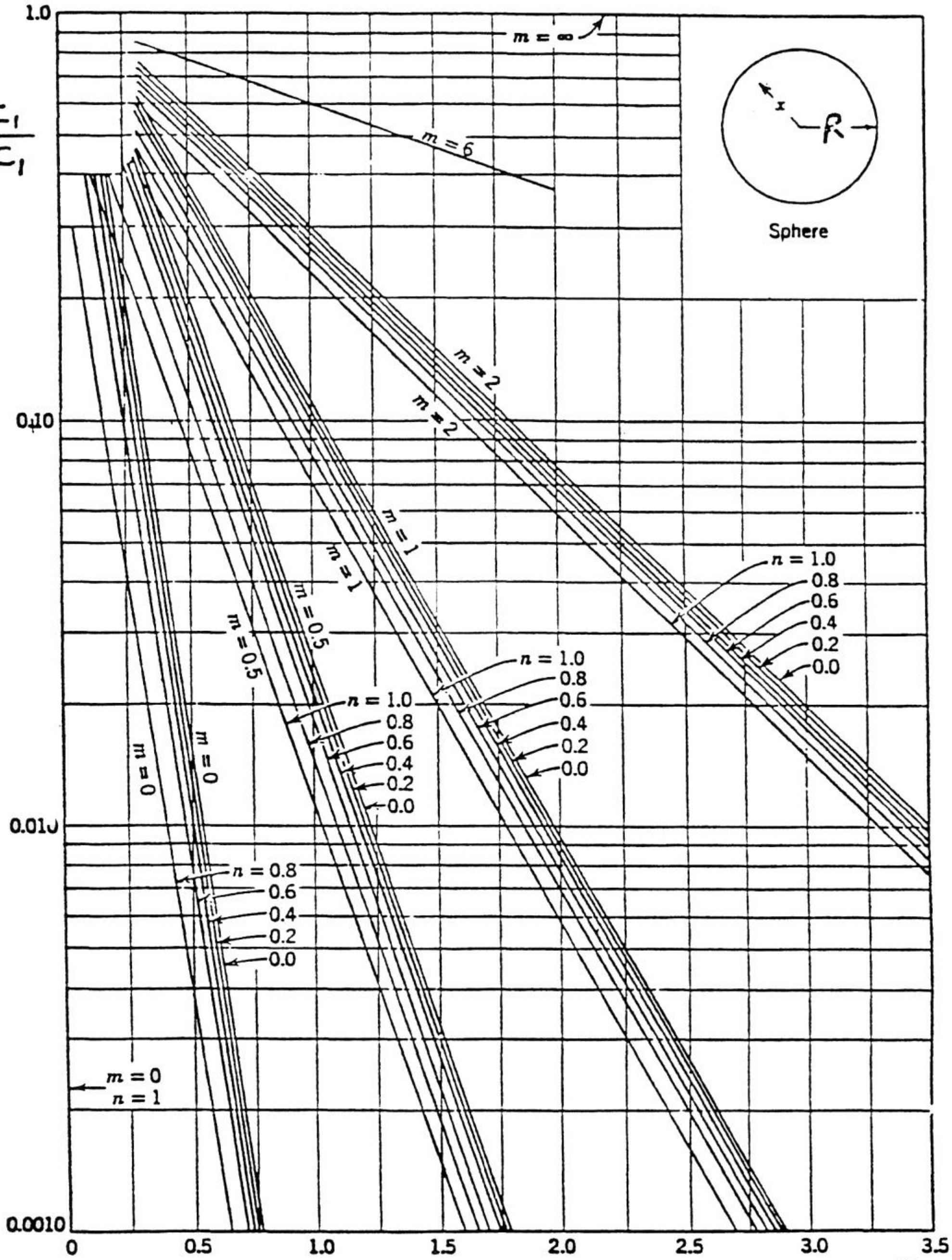
$$m = 1/Bi$$

Figure 3

POINT LOCATION IN A SPHERE

$$Y = \frac{c - c_1}{c_o - c_1}$$

$$Y = \frac{\text{conc at time } m - \text{conc at outer surface}}{\text{conc at time } 0 - \text{conc at outer surface}}$$



Fourier No. = $\beta = Dt/R^2$

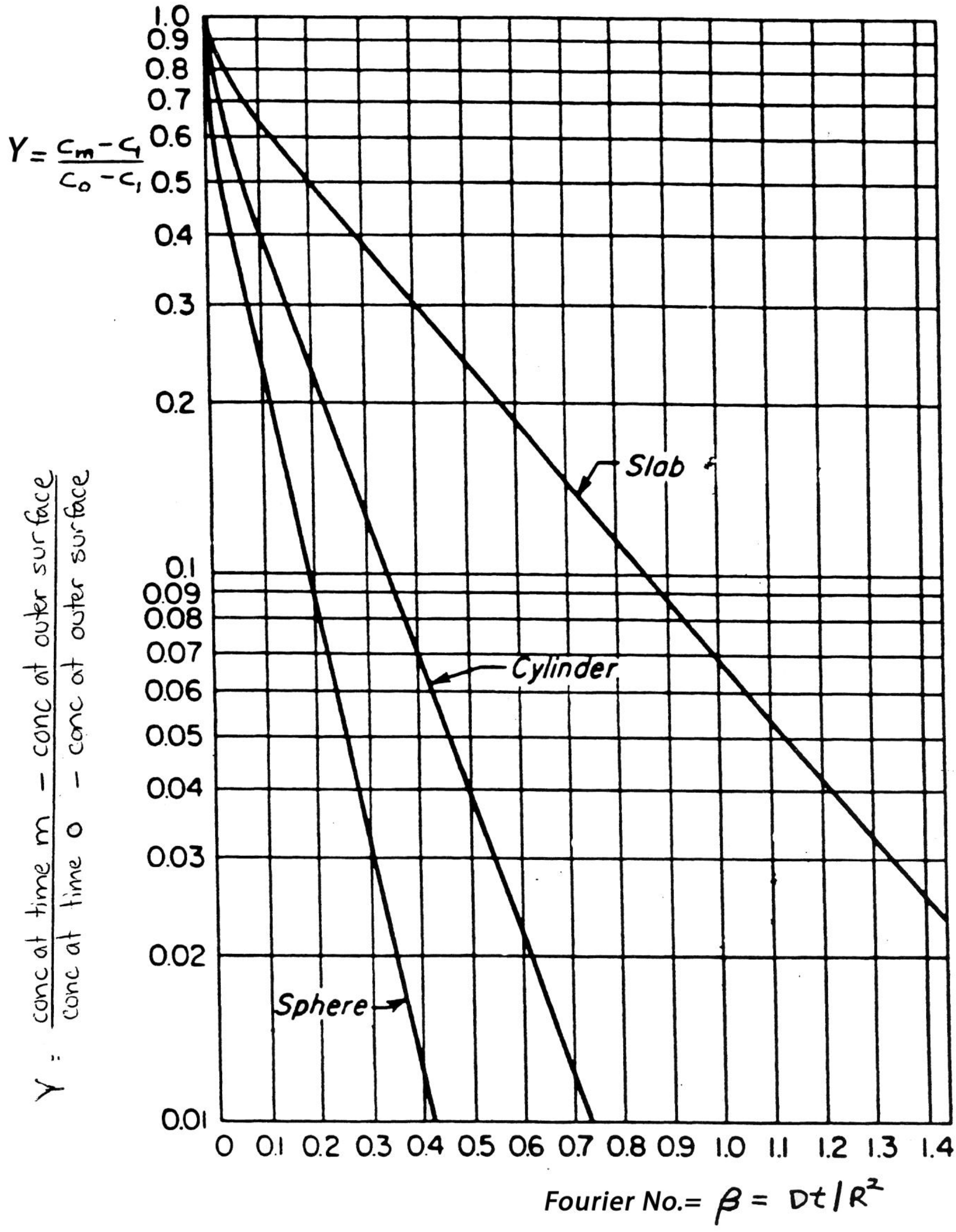
Unsteady-state transport in a sphere.

$$n = \frac{x}{R}$$

$$m = 1/Bi$$

Figure 4

AVERAGE



Plot of Y versus β to find mean concentrations indiffusion processes where all resistance to diffusion is within the solid (Bi = ∞)

Example 7: Dryer mass and energy balances (with recycle)

A dryer is used to dry 690 kg/hr of wet solid with a moisture content 2.7 kg/kg to a final moisture content of 0.3 kg/kg. Air is to be fed to the dryer at 80°C with a humidity of 0.035 kg/kg. An air flow in the dryer of 14 kg/s can be maintained. Make up air is available at 25°C with a humidity of 0.0016 kg/kg.

Determine the outlet air conditions, the amount of air recycled and the thermal efficiency

Example 8: Dryer mass and energy balances (with recycle)

0.5 kg/s of a heat sensitive protein product with an initial moisture content of 1.5 kg water/kg solid is to be dried to a final moisture content of 0.7 kg water/kg solid. Drying air is fed to the dryer at 80°C and 0.015 kg/kg humidity. Moist air is to be purged at a rate sufficient to give an exit humidity of 0.032 kg/kg and make-up air is supplied at 25°C and 60% relative humidity.

Calculate the required flowrate of make-up air, the flowrate of air through the dryer and the thermal efficiency of the dryer.

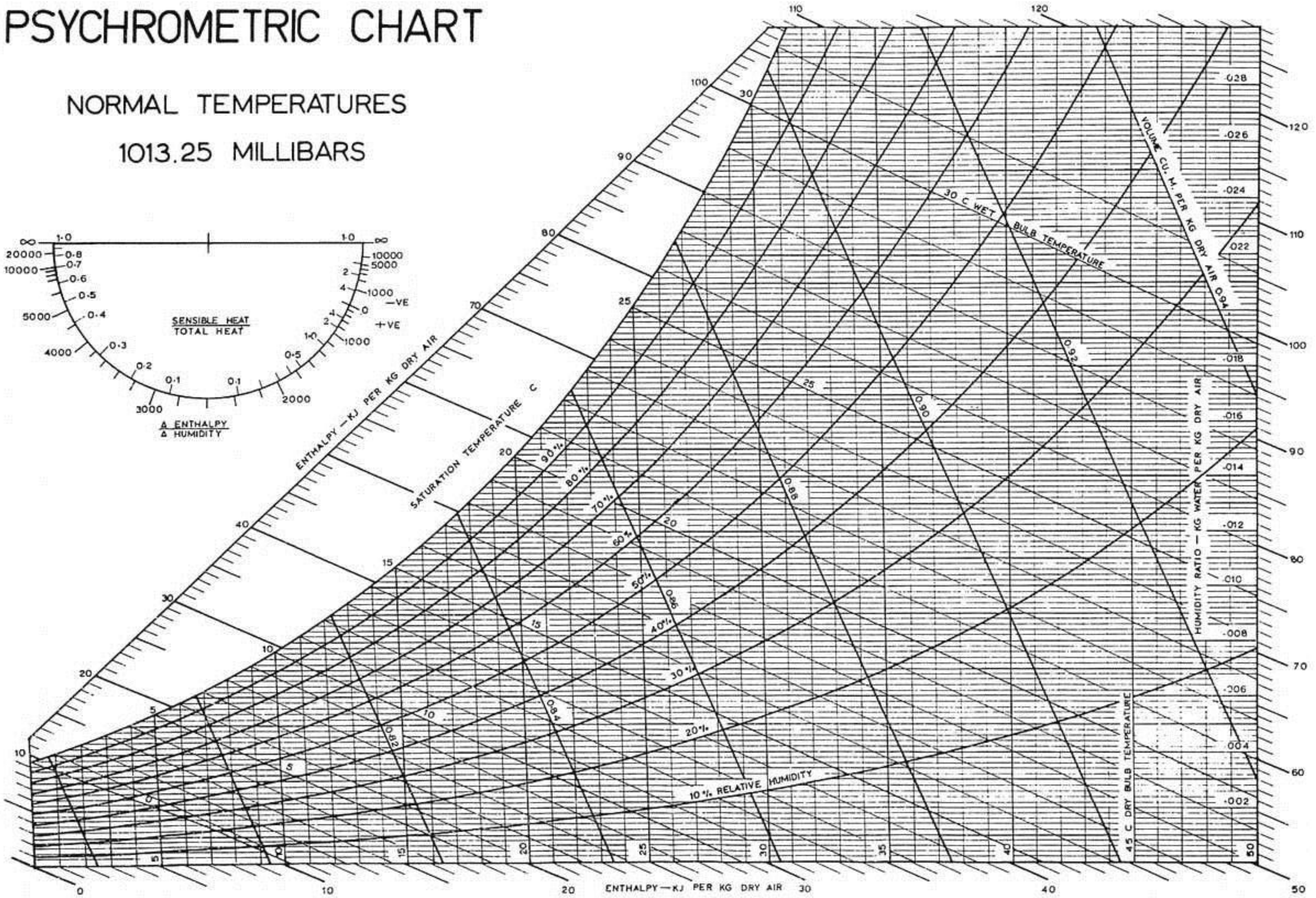
Typical Solution Procedure

1 Use the overall solid balance to determine the missing flowrate M_i or M_o.
2. Use the overall water balance and dryer water balance equations to determine two other missing air variables, probably a flow-rate and a humidity value.
3. Use the psychrometric chart to obtain air enthalpies.
4. Use the energy balance to calculate the required heat to the heater.
5. Calculate the ideal heat required to evaporate the water that was evaporated and hence the efficiency.

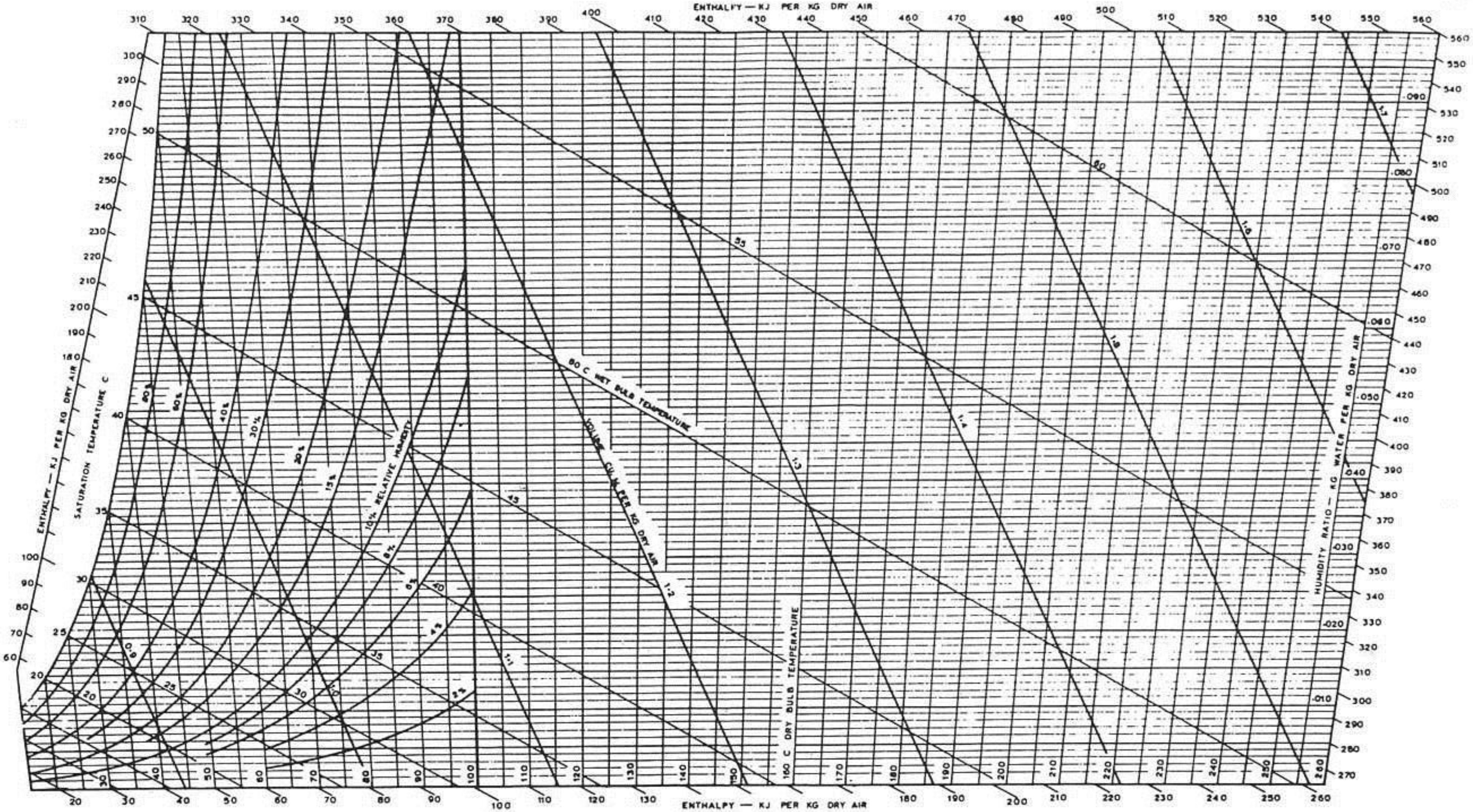
PSYCHROMETRIC CHART

NORMAL TEMPERATURES

1013.25 MILLIBARS



PSYCHROMETRIC CHART HIGH TEMPERATURES 1013.25 MILLIBARS



Example 9: Dryer selection.

Select an appropriate dryer for the following applications and justify your choice:

(a) drying pulverised coal particles prior to injection into a furnace
(b) potato slurry for manufacture of dried potato flakes
(c) cooking/ drying cracker biscuits
(d) drying wheat starch filter cake to give a granular product.
(e) drying a protein solution to a powder product.

Example 10: Drying mass and energy balances (no recycle) and rotary dryer sizing.

Flue gas at 180°C and humidity of 0.03 kg water/kg dry flue gas is used to dry 1.5 kg/s of 5mm diameter wet ore particles from a moisture content of 0.7 kg water/kg dry solid to 0.1 kg water/kg dry solid. Calculate the required flowrate of flue gas if the exit humidity is 0.08 kg/kg.

(a) Calculate the thermal efficiency of the drying operation assuming that 150 kJ/kg of heat was expended in heating the flue gas from ambient temperature to 180°C.

(b) Drying could be performed in a rotary dryer with a gas flowrate of 1 kg/m^{2}s. At this flowrate, what would the diameter and the length of the dryer need to be to ensure that sufficient heat is transferred to evaporate the water ? Hence calculate the residence time of the solid in the dryer assuming a 10% solids volume fraction and solid density of 1100 kg/m^3. How does this compare with the residence time required for a single particle with heat transfer coefficient of 50 W/m^{2}K ? Assume drying is in the constant rate regime only.

(c) What other dryer would you suggest for this task ?

Example 11: Dryer mass and energy balances with recycle and tray dryer capacity

Apricot slab (10mm thick) with an initial moisture content of 0.8 kg water/kg solid is to be dried in a batch tray dryer with hot air recirculation to a final moisture content of 0.2 kg/kg. The dryer contains 15 shelves and is 5m wide by 1m deep. Drying of the apricot slab is from both top and bottom faces presenting a total heat transfer area of 150 m^2 from all 15 shelves. Drying air (ρ = 1 kg/m^3) is fed to the dryer at 80°C and 0.02 kg/kg humidity and exits at 60°C. The heat transfer coefficient is estimated to be 30 W/m^{2}K.

(a) Calculate the heat transferred from the drying air, assuming that drying is in the constant rate regime only. Hence determine the flowrate of the drying air through the dryer, the exit moisture content of the air and the rate of evaporation of water from the apricot slab.

(b) Make-up air is supplied at 25°C and 60% relative humidity. Calculate the required flowrate of make-up air and the thermal efficiency of the dryer

(c) Determine the time that the slab will take to dry and hence the amount of apricot slab that can be produced in an eight hour day, allowing 30 minutes between each batch for loading/unloading. The density of the apricot slab is 1000 kg/m^3.

Example 12: Dryer mass and energy balances (no-recycle)

Milk powder produced at a mass flow rate of 0.3kg/s, by drying concentrated milk with free moisture content of 2.33 (30 wt% solids) to a final free moisture content of zero. Drying is done with air at 200°C and 0.08 kg/kg humidity. Air exits the dryer at 93°C (line of constant enthalpy gives exit humidity of 0.1246 kg/kg).

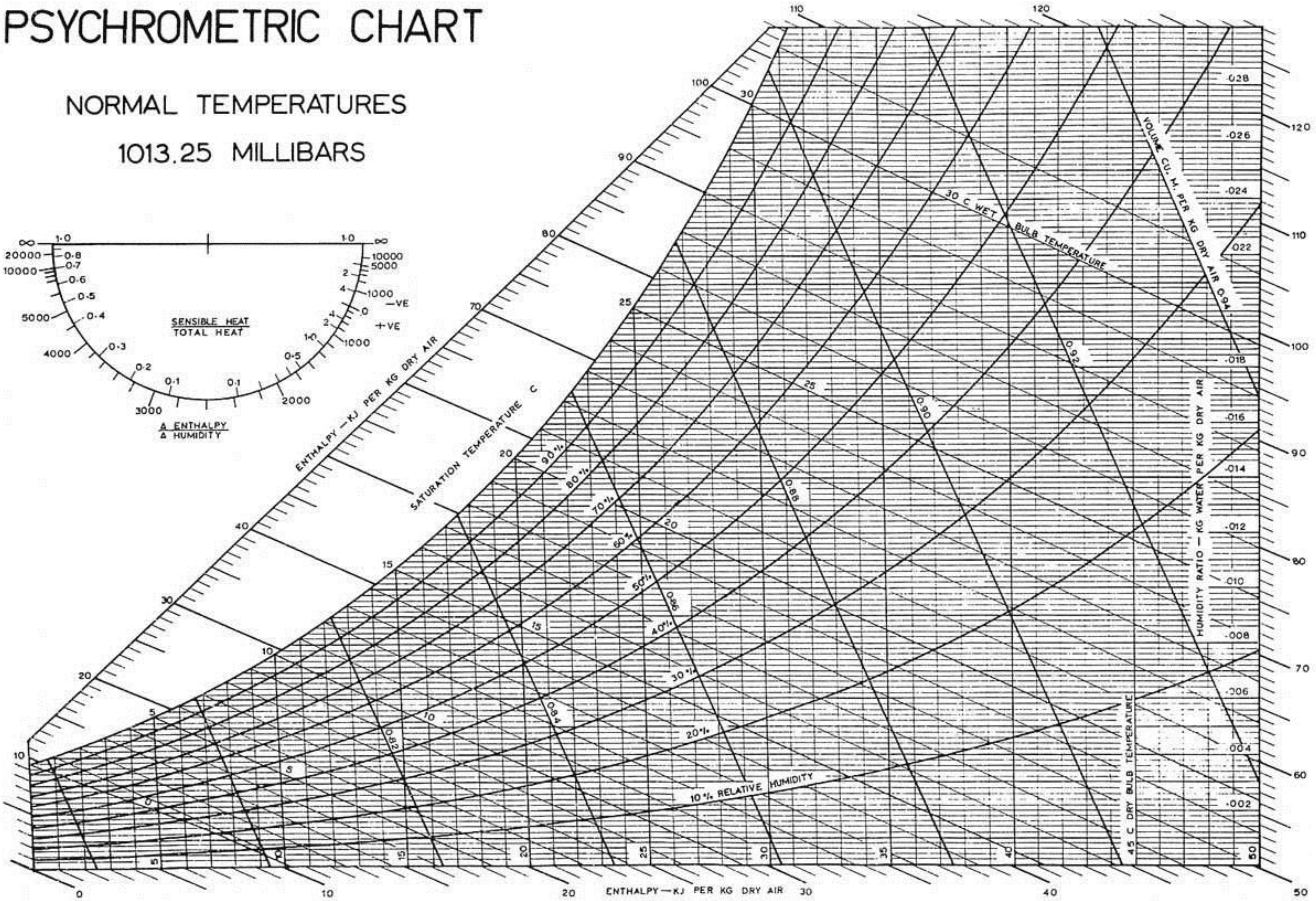
(a) Calculate the volume of air required to dry the milk powder.

(b) If the residence time in the spray dryer is 20 s, is this time likely to be sufficient if the heat transfer coefficient to the 100 μm diameter droplets is 50 W/m^2K and the dry solid density is 300 kg/m^3 ?

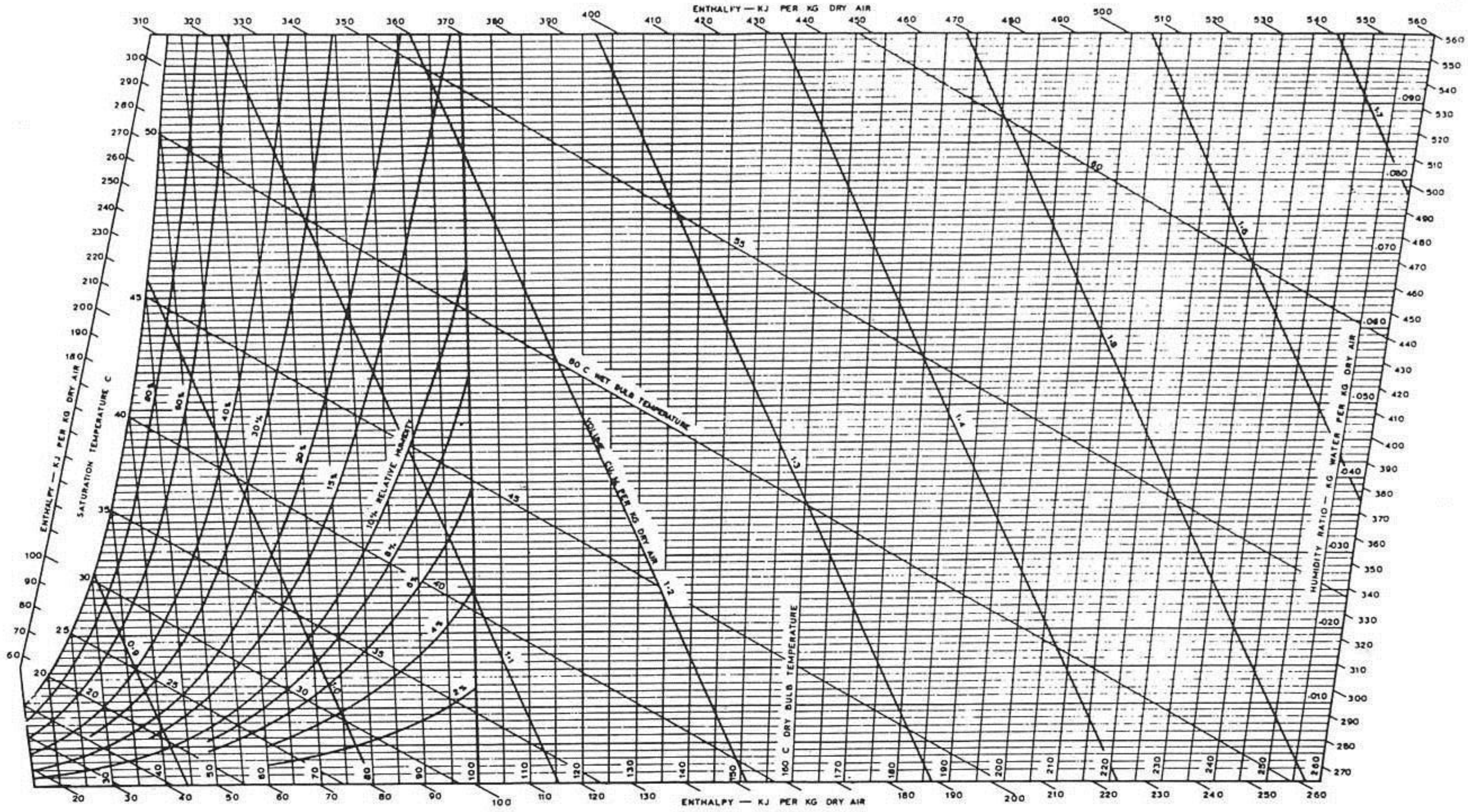
PSYCHROMETRIC CHART

NORMAL TEMPERATURES

1013.25 MILLIBARS



PSYCHROMETRIC CHART HIGH TEMPERATURES 1013.25 MILLIBARS



Example 13: Freezing weight loss.

Peas are being frozen in a fluidized bed freezer. The peas are present for 110 seconds in an air temperature of -38°C and with a surface heat transfer coefficient of 150 W/m^2K. The air relative humidity is approximately 90%. Each pea is 8mm in diameter and the density of the peas is approximately 1000 kg/m^3. Estimate the % weight loss in freezing if the measured surface temperature/ time data is as follows. $C_p$air ˜ 1000 J/kgK @-38°C

Time (s)	Surface Temperature (°C)
0	20
10	8
20	0
30	-2
40	-4
50	-6
60	-8
70	-11
80	-14
90	-18
100	-21
110	-26

Example 14: Weight loss from stored product

(a) Calculate the weight loss from stored unwrapped lettuce (diameter = 20cm) over 2 days in a domestic fridge when the lettuce temperature is 4°C and the evaporator plate temperature is -5°C. The heat transfer coefficients to the lettuce and to the evaporator plate are estimated to be 15 W/m^2K and 20 W/m^2K, respectively. The evaporator plate is 20 cm high and 20 cm wide.

(b) What temperature do you expect the air around the lettuce to be at? Will the air in the fridge be saturated with moisture?

Example 15: Weight loss from stored product

A half peeled 8cm diameter apple was found beside the body in the shed. Mr. Holmes the detective carefully cut the apple in half to find that the unpeeled half weighed 0.2% more than the peeled half. Consulting the weather bureau he determined that the 50 m^2 of shed cladding surrounding the body would have been at approximately 10°C while the air inside the shed (and the apple) was at 12°C. He estimates that the heat transfer coefficient from the air to the cladding (and the apple) is approximately 5 W/m2K and the density of the apple is 1000 kg/m^3. Taking out his trusty weight loss calculations he determines the time of the murder. How long ago was it ?

Carrier

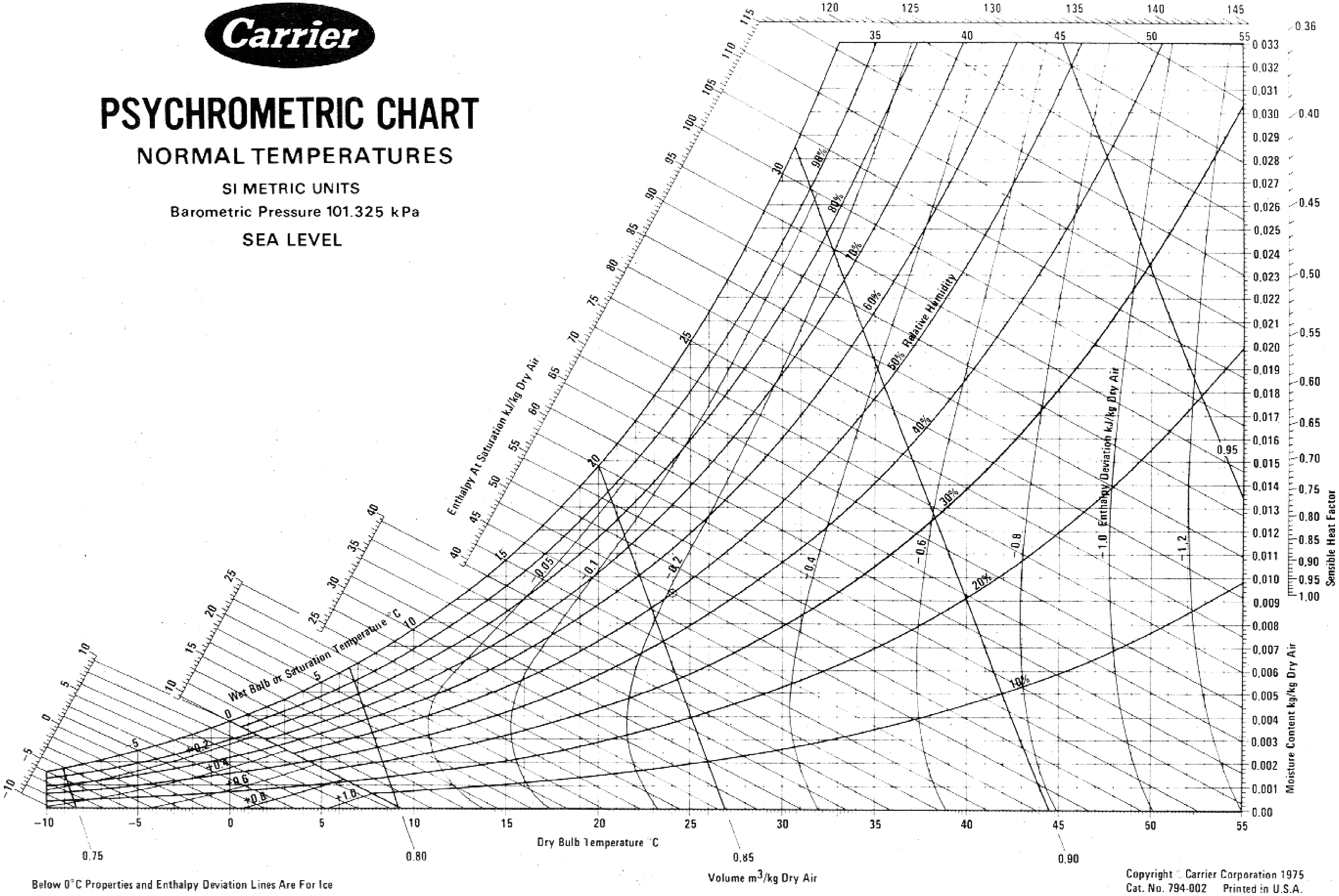
PSYCHROMETRIC CHART

NORMAL TEMPERATURES

SI METRIC UNITS

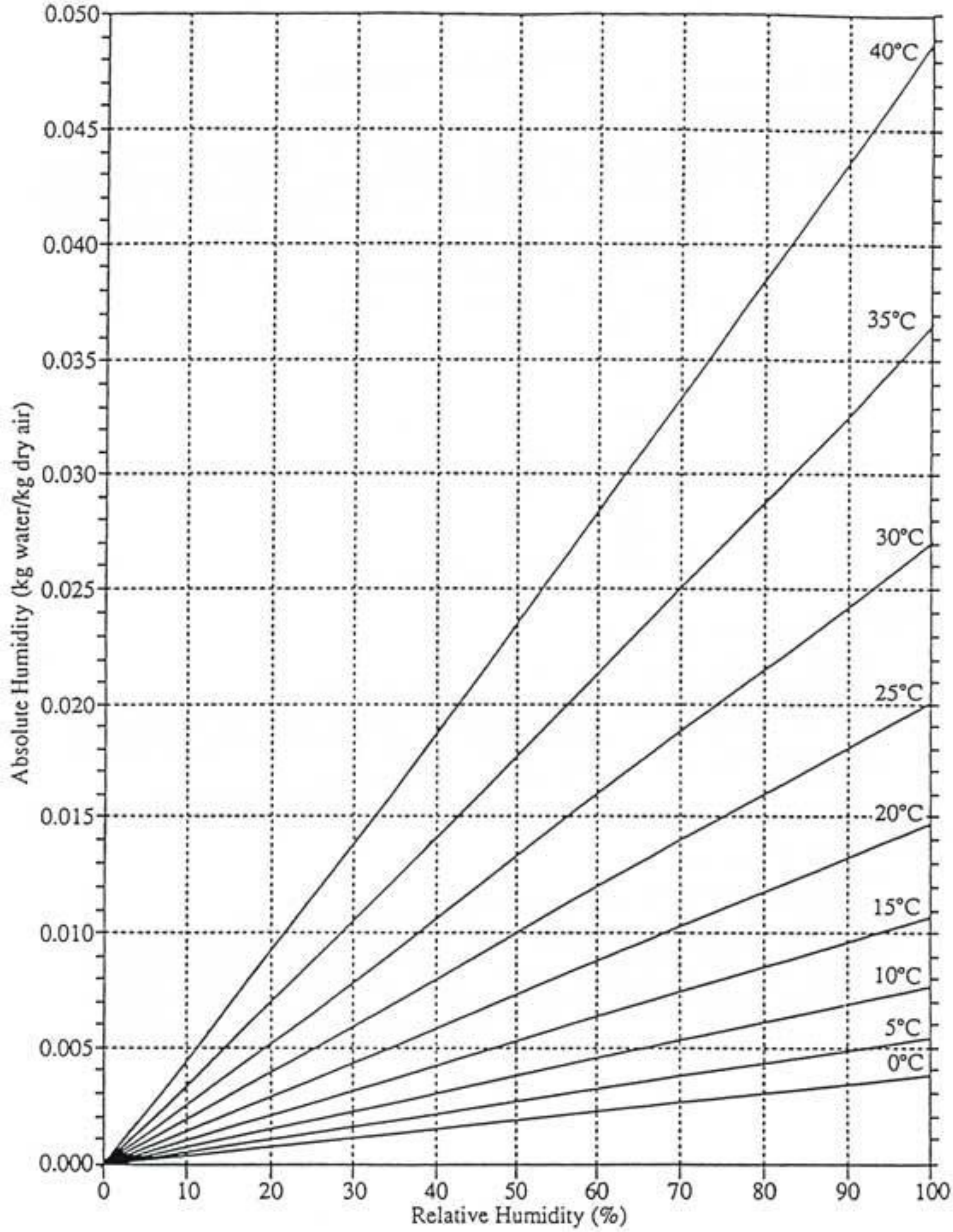
Barometric Pressure 101.325 kPa

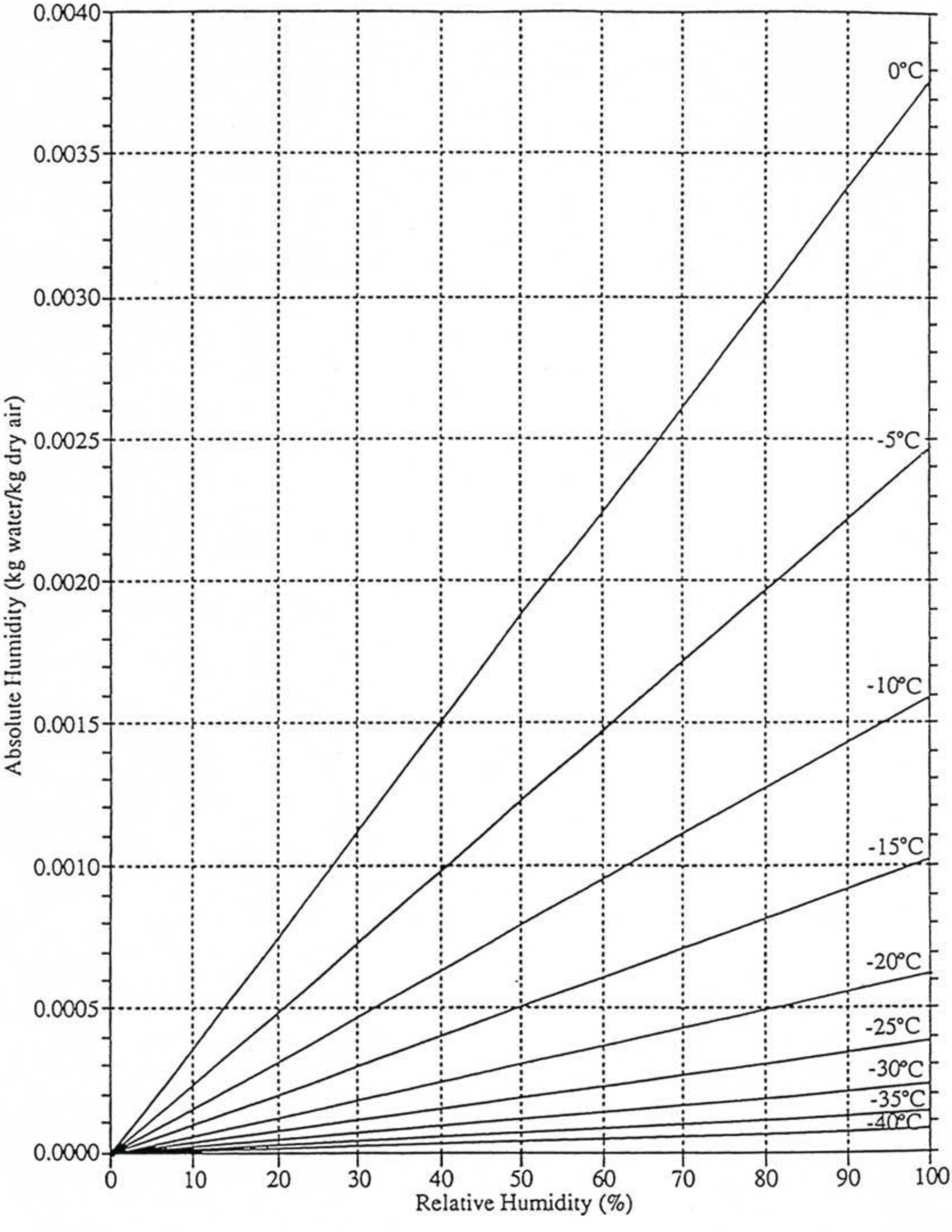
SEA LEVEL



Copyright © Carrier Corporation 1975
Cat. No. 794-002 Printed in U.S.A.

Reproduced courtesy of Carrier Corporation


0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Absolute Humidity (kg water/kg dry air)
0
10
20
30
40
50
60
70
80
90
100
Relative Humidity (%)
40°C
35°C
30°C
25°C
20°C
15°C
10°C
5°C
0°C


0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Absolute Humidity (kg water/kg dry air)
0°C
-5°C
-10°C
-15°C
-20°C
-25°C
-30°C
-35°C
-40°C
0
10
20
30
40
50
60
70
80
90
100
Relative Humidity (%)

Example 16 2006

(a) Sketch a plot of drying rate vs. moisture content and label appropriate points. Briefly discuss how drying the same material in different dryers with different heat and mass transfer conditions can influence the shape of this drying rate curve.

(b) Puffed rice biscuits are baked in a batch forced convection oven. During this process the moisture content is reduced to ensure good storage stability. Heating by conduction can be ignored but radiation from the oven walls should be considered. The biscuits are 100 mm in diameter and 12 mm thick, with a dry bulk
density of 150 $kg.m^{-3}$ and water evaporates from both surfaces. The air temperature is maintained at 160°C and the bulk air absolute humidity is maintained at 0.011 $kg.kg^{-1}$ by introducing make-up air as required. The air flow
ensures a convective heat transfer coefficient of 80 $W.m^{-2}.°C^{-1}$ The view factor
can be regarded as 1.

(i) Determine the approximate surface temperature of the biscuits and the drying rate during the constant rate period by trial and error. Note that the radiative heat transfer coefficient is not a strong function of surface temperature and need only be estimated once.

(ii) Estimate the total cooking (and hence drying) time required if the initial moisture content is 1.2 $kg.kg^{-1}$ the critical moisture content is 0.8 $kg.kg^{-1}$ and the final moisture content is 0.4 $kg.kg^{-1}$. The equilibrium moisture content is estimated from the sorption isotherm to be 0.15 $kg.kg^{-1}$.
Drying in the falling rate period is assumed to be by capillary action only.

Question 17 2006

(a) A granular material is dried in a two-stage continuous belt dryer. The feed stream of 300 $kg.h^{-1}$ wet material enters and exits the first stage with moisture contents (MC) of 60 wt % and 40 wt %, respectively; this material passes to the second stage where it is dried to a final MC of 10 wt %. Ambient air at 20°C and 50% RH is heated to 90°C before it enters the first stage dryer co-currently with the feed. The air exits the first stage at 50°C and is then heated to 70°C before it passes co- currently to the second stage dryer; there is no recycle of air in either stage. Calculate the following:

(i) The inlet and outlet solids concentrations from the first stage expressed on a dry solids basis and the mass flow rate of dry solids.

(ii) The ambient air absolute humidity and the RH and enthalpy of the heated air entering the first stage dryer.

(iii) The absolute humidity of the air leaving the first stage dryer.

(iv) The flowrate of partially-dried material leaving the first stage and the required air flowrate.

(v) The flowrate of dry product, and the absolute humidity, dry bulb temperature and enthalpy of air leaving the second stage drier.

(vi) The required total heat input into the air stream.

(b) Describe the major features of a fluidised-bed dryer. Briefly comment on how different drying conditions could be established in different sections of the dryer and what advantages this might confer. Use one or more diagrams to illustrate your answer.

Example 18 2007

A heat sensitive granular food material has to be dried. The size of the feed stream is 500 kg h^{-1} and the initial moisture content is 2 kg water (kg dry solids)$^{-1}$. The density of the dry solids is 368 kg dry solids m^{-3}. The granular food material consists of spherical 'particles' with a diameter of 0.5 cm. Based on previous experiences, a two-stage belt dryer seems to be a good choice. In the first-stage of the dryer, the material will be dried to a moisture content of 0.5 kg water (kg dry solids)$^{-1}$. This material passes to the second stage where it is dried to a final moisture content of 0.05 kg water (kg dry solids)$^{-1}$. Both stages of the dryer are operated in series and the food material moves through the dryers co-currently with the air. In the first stage of the dryer, the drying process takes place at 'constant rate' and in the second stage at 'falling rate'. For both drying stages ambient air at 20 °C, RH =50% is heated to the required inlet air temperatures of 200 °C and 100 °C for stages 1 and 2, respectively. The outlet air from stage 1 has a RH = 80% and the outlet air from stage 2 has a RH = 5%. None of the air is recycled. The equilibrium moisture content of the food material at RH = 5 % is 0.03 kg water (kg dry solids)$^{-1}$. The external mass transfer coefficient is 0.02 m s^{-1}. The water diffusion coefficient in the food material is 3×10^{-11} m^2 s^{-1}. The mass density of air is 1 kg m^{-3}.

(a) Calculate the amount of energy (kJ h^{-1}) that is needed to heat the air for both dryer stages.

(b) Estimate the required drying time (s) of the granular material in the first stage of the drying process. Assume that the material doesn't shrink during drying and use 'averaged' drying air conditions.

(c) Estimate the required drying time (s) of the granular material in the second stage of the drying process. Assume that the material doesn't shrink during drying.

The surface of a sphere = $4 \pi r^2$, the volume of a sphere = $4/3 \pi r^3$.

Example 19 2008

(i) Fruit slices are being dried in a batch tray dryer prior to packaging. The product slices can be modelled as round discs of 8 mm thickness. Air passes through the mesh trays and drying can be assumed to occur only from the two large faces. The initial moisture content (MC) of the slices is 80 % (w/w) and the final moisture content must be 15 % (w/w). Ambient air at 20°C and 60 % RH is heated to 50°C before entering the dryer and leaves at 40°C. There is no air recycle; assume there is no shrinkage of the slices.

In a separate batch laboratory drying trial with 4 kg of fresh sliced material (MC = 80 % w/w) using the same air conditions with two-sided drying, drying occurred at a constant rate of 2.5 x 10^{-3} $kg.m^{-2}.s^{-1}$ (the adjustment period was negligible). At the end of the constant rate period, the (wet) product weight had decreased to 2 kg. The equilibrium moisture content was estimated to be 5 % (w/w) and the dry solids density was estimated to be 600 $kg.m^{-3}$.

Calculate:

(a) The initial, final, equilibrium and critical moisture contents for the fruit product (X_1, X_2, X^* and X_C).

(b) The drying time to achieve the final moisture content of 15 % (w/w), assuming all drying in the falling rate period occurs by capillary action.

(c) The RH of the air entering the dryer and the fruit slice surface temperature during constant rate drying.

(d) The heat transfer coefficient for drying in the constant rate period.

(ii) It is common practice to 'cure' kiwifruit prior to placing them into cool storage to reduce the subsequent incidence of *Botrytis* rots. Curing is optimally conducted by holding the fruit in bins in a well ventilated area at a temperature of 14°C for 2 or more days.

(a) If the heat transfer coefficient is 20 $W.m^{-2}.°C^{-1}$ and the ambient air has a θ_{wb} of 10°C, what percentage weight loss would you expect if the fruit were held for 3 days at the (constant) optimum temperature? Assume the mass of a fruit is 110 g and the effective exposed surface area of a loosely-packed fruit in a bin is given by:

$$A = 1.5\pi r L$$

where r = radius [= 3 cm] and L = length [= 8 cm]

(b) If the harvest season was unusually warm and the mean ambient temperature was 18°C how would this influence weight loss and why?

APPENDIX

Steam Tables

3 Saturated Data

P	θ_{sat}	v_l	v_v	u_l	u_v	h_l	$\Delta(h_{vap})$	h_v	s_l	s_v
MPa	°C	m^3/Mg		kJ/kg		kJ/kg			kJ/(kgK)	
0.0010	6.970	1.000	129178	29.30	2384	29.30	2484	2514	0.106	8.975
0.0015	13.02	1.001	87959	54.68	2393	54.68	2470	2525	0.196	8.827
0.0020	17.49	1.001	66987	73.43	2399	73.43	2459	2533	0.261	8.723
0.0025	21.08	1.002	54240	88.42	2404	88.42	2451	2539	0.312	8.642
0.0030	24.08	1.003	45653	101.0	2408	101.0	2444	2545	0.354	8.576
0.0035	26.67	1.003	39466	111.8	2411	111.8	2438	2550	0.391	8.521
0.0040	28.96	1.004	34791	121.4	2415	121.4	2432	2554	0.422	8.473
0.0045	31.01	1.005	31131	130.0	2417	130.0	2427	2557	0.451	8.431
0.0050	32.87	1.005	28185	137.7	2420	137.7	2423	2561	0.476	8.394
0.0060	36.16	1.006	23733	151.5	2424	151.5	2415	2567	0.521	8.329
0.0070	39.00	1.008	20524	163.3	2428	163.4	2408	2572	0.559	8.274
0.0080	41.51	1.008	18099	173.8	2431	173.8	2402	2576	0.592	8.227
0.0090	43.76	1.009	16199	183.2	2434	183.3	2397	2580	0.622	8.186
0.010	45.81	1.010	14670	191.8	2437	191.8	2392	2584	0.649	8.149
0.011	47.68	1.011	13412	199.6	2440	199.7	2388	2587	0.674	8.115
0.012	49.42	1.012	12358	206.9	2442	206.9	2383	2590	0.696	8.085
0.013	51.03	1.013	11462	213.7	2444	213.7	2379	2593	0.717	8.057
0.014	52.55	1.013	10691	220.0	2446	220.0	2376	2596	0.737	8.031
0.015	53.97	1.014	10020	225.9	2448	225.9	2372	2598	0.755	8.007
0.016	55.31	1.015	9431	231.5	2450	231.6	2369	2601	0.772	7.985
0.018	57.80	1.016	8443	241.9	2453	242.0	2363	2605	0.804	7.944
0.020	60.06	1.017	7648	251.4	2456	251.4	2358	2609	0.832	7.907
0.022	62.13	1.018	6994	260.1	2459	260.1	2352	2613	0.858	7.874
0.024	64.05	1.019	6445	268.1	2461	268.2	2348	2616	0.882	7.844
0.025	64.96	1.020	6203	271.9	2462	272.0	2345	2617	0.893	7.830
0.030	69.10	1.022	5228	289.2	2468	289.3	2335	2625	0.944	7.767
0.035	72.68	1.024	4525	304.3	2472	304.3	2326	2631	0.988	7.715
0.040	75.86	1.026	3993	317.6	2476	317.6	2318	2636	1.026	7.669
0.045	78.71	1.028	3576	329.6	2480	329.6	2311	2641	1.060	7.629
0.050	81.32	1.030	3240	340.5	2483	340.5	2305	2645	1.091	7.593
0.055	83.71	1.032	2963	350.5	2486	350.6	2299	2649	1.119	7.561
0.060	85.93	1.033	2732	359.8	2489	359.9	2293	2653	1.145	7.531
0.065	87.99	1.035	2535	368.5	2492	368.6	2288	2656	1.170	7.504
0.070	89.93	1.036	2365	376.7	2494	376.8	2283	2659	1.192	7.479
0.075	91.76	1.037	2217	384.4	2496	384.4	2278	2662	1.213	7.456
0.080	93.49	1.039	2087	391.6	2498	391.7	2273	2665	1.233	7.434
0.085	95.13	1.040	1972	398.5	2500	398.6	2269	2668	1.252	7.414
0.090	96.69	1.041	1869	405.1	2502	405.2	2265	2670	1.270	7.394
0.095	98.18	1.042	1777	411.4	2504	411.5	2261	2673	1.287	7.376
0.100	99.61	1.043	1694	417.4	2506	417.5	2257	2675	1.303	7.359
0.120	104.8	1.047	1428	439.2	2512	439.4	2244	2683	1.361	7.298
0.140	109.3	1.051	1237	458.3	2517	458.4	2232	2690	1.411	7.246
0.160	113.3	1.054	1091	475.2	2521	475.4	2221	2696	1.455	7.201
0.180	116.9	1.058	977.5	490.5	2525	490.7	2211	2701	1.494	7.162
0.200	120.2	1.061	885.7	504.5	2529	504.7	2202	2706	1.530	7.127
0.220	123.2	1.063	810.1	517.4	2532	517.6	2193	2711	1.563	7.095
0.240	126.1	1.066	746.7	529.4	2535	529.6	2185	2715	1.593	7.066
0.260	128.7	1.068	692.7	540.6	2538	540.9	2177	2718	1.621	7.039
0.280	131.2	1.071	646.2	551.1	2541	551.4	2170	2722	1.647	7.015
0.300	133.5	1.073	605.8	561.1	2543	561.4	2163	2725	1.672	6.992
0.320	135.7	1.075	570.2	570.6	2545	570.9	2157	2728	1.695	6.970
0.340	137.8	1.078	538.6	579.5	2547	579.9	2151	2731	1.717	6.950
0.360	139.8	1.080	510.5	588.1	2549	588.5	2145	2733	1.738	6.931
0.380	141.8	1.082	485.2	596.3	2551	596.8	2139	2736	1.758	6.913
0.400	143.6	1.084	462.4	604.2	2553	604.7	2133	2738	1.776	6.895
0.420	145.4	1.085	441.7	611.8	2555	612.3	2128	2740	1.795	6.879
0.440	147.1	1.087	422.7	619.1	2556	619.6	2123	2742	1.812	6.864
0.460	148.7	1.089	405.4	626.1	2558	626.6	2118	2744	1.829	6.849
0.480	150.3	1.091	389.5	632.9	2559	633.5	2113	2746	1.845	6.834
0.500	151.8	1.093	374.8	639.5	2561	640.1	2108	2748	1.860	6.821