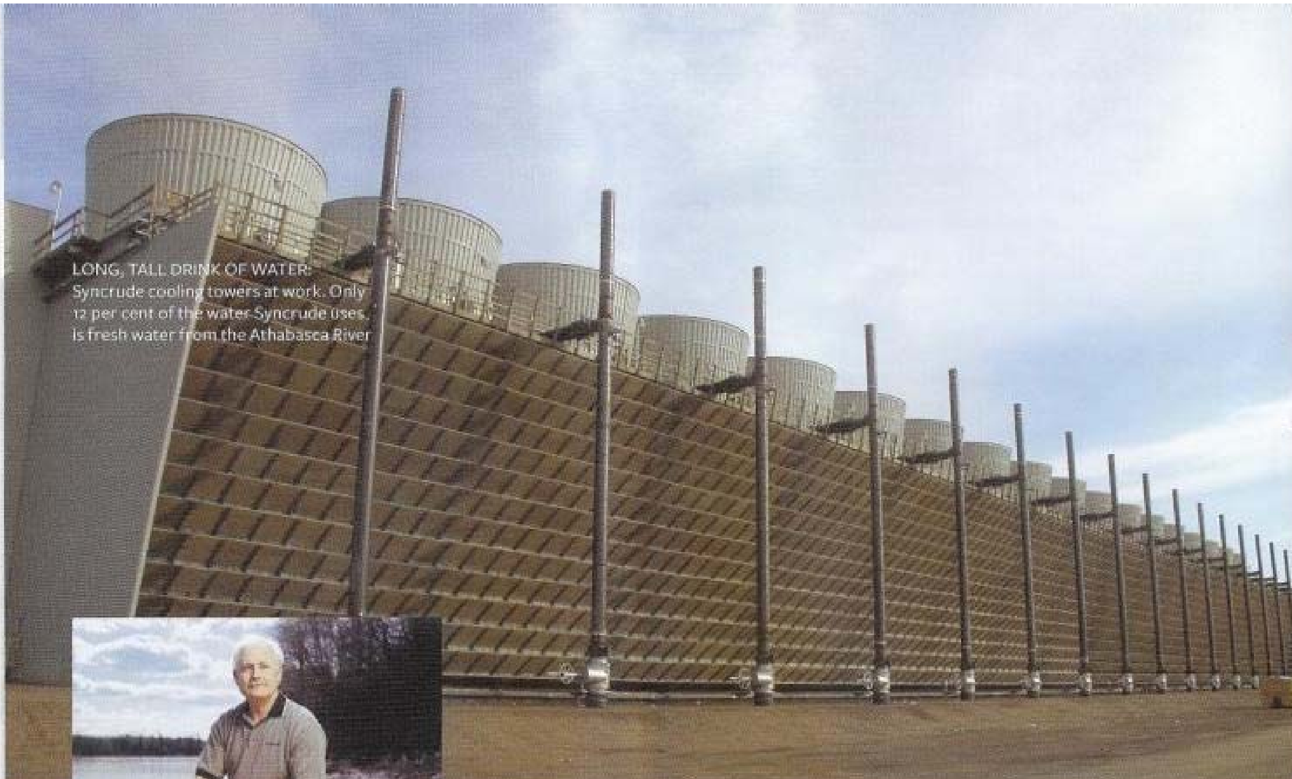
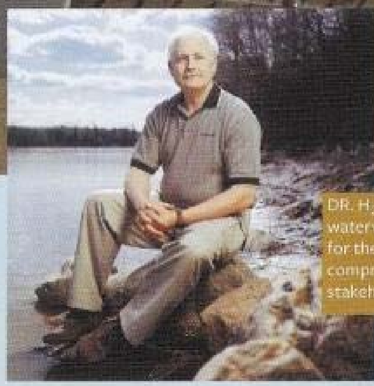
Psychrometric Charts
Animated Guide and Examples

S. Kresta and I. Ayranci
University of Alberta,
Chemical and Materials Engineering

December 2012



LONG, TALL DRINK OF WATER: Syncrude cooling towers at work. Only 12 per cent of the water Syncrude uses is fresh water from the Athabasca River



DR. H_2O: Syncrude scientist Terry Van Meer studies waterways potentially impacted by oil sands development for the Regional Aquatics Monitoring Program (RAMP), comprising members from industry, government and stakeholders. See www.ramp-alberta.org

and stored responsibly. Tailings ponds where the water is stored, for instance, are constructed with groundwater seepage-capture facilities and monitored closely. The independent Regional Aquatic Monitoring Program showed "that there were no detectable regional changes in aquatic resources related to oil sands development" for the Athabasca River and Delta.

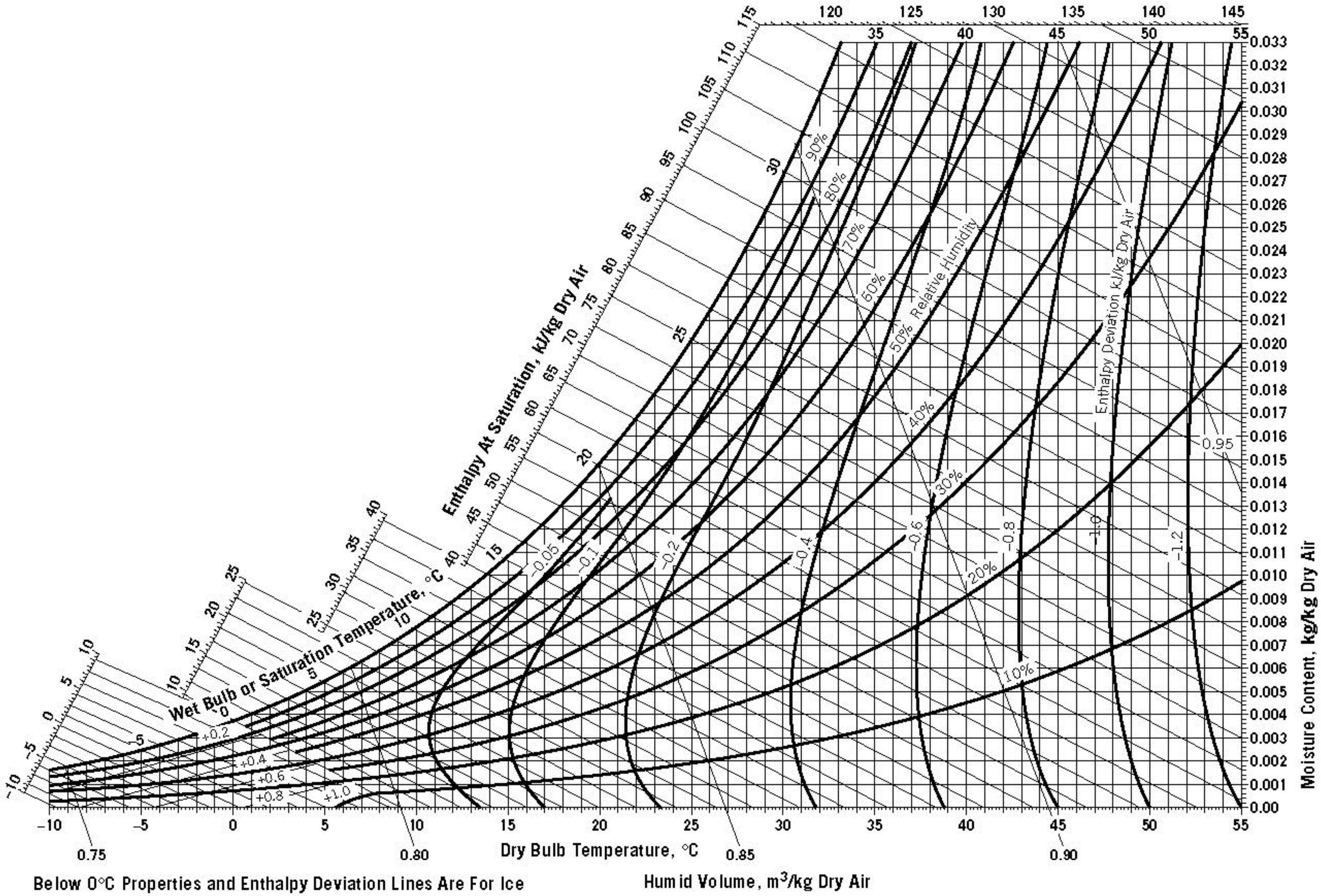
But there are challenges ahead. While many of Syncrude's water management successes are due to reliance on recycled water, there's a limit to how often water can be reused. In Syncrude's case, it's about 18 times.

Salts – natural in oil sands ore – are among the solids that sink during extraction, and each fresh batch of ore dissolves more salt into the process water. As anyone who drives a car on winter roads knows, salt is corrosive. At an oil sands plant, the damage it can do to expensive equipment is one of the factors that limits water recyclability. And, though not a hazard to human health, not all plant-based ecosystems can tolerate excessively salty water.

Additional desalination would be a solution, but the process would be prohibitively expensive and energy-intensive, producing more greenhouse gases. Syncrude is currently pursuing other approaches.

One of Syncrude's research partners, Dr. Mohamed Gamel El-Din, Associate Professor, Environmental Engineering Program, University of Alberta, says that Syncrude is making progress in terms of water research. "Syncrude is more proactive than others," he says.

Syncrude continues its efforts to use water more efficiently. Its success is reflected in a more than 10 per cent decrease in water use per barrel of production in 2007 from 2006.



Psychrometric Charts for Humid Air Material and Energy Balances

Psychrometric Charts

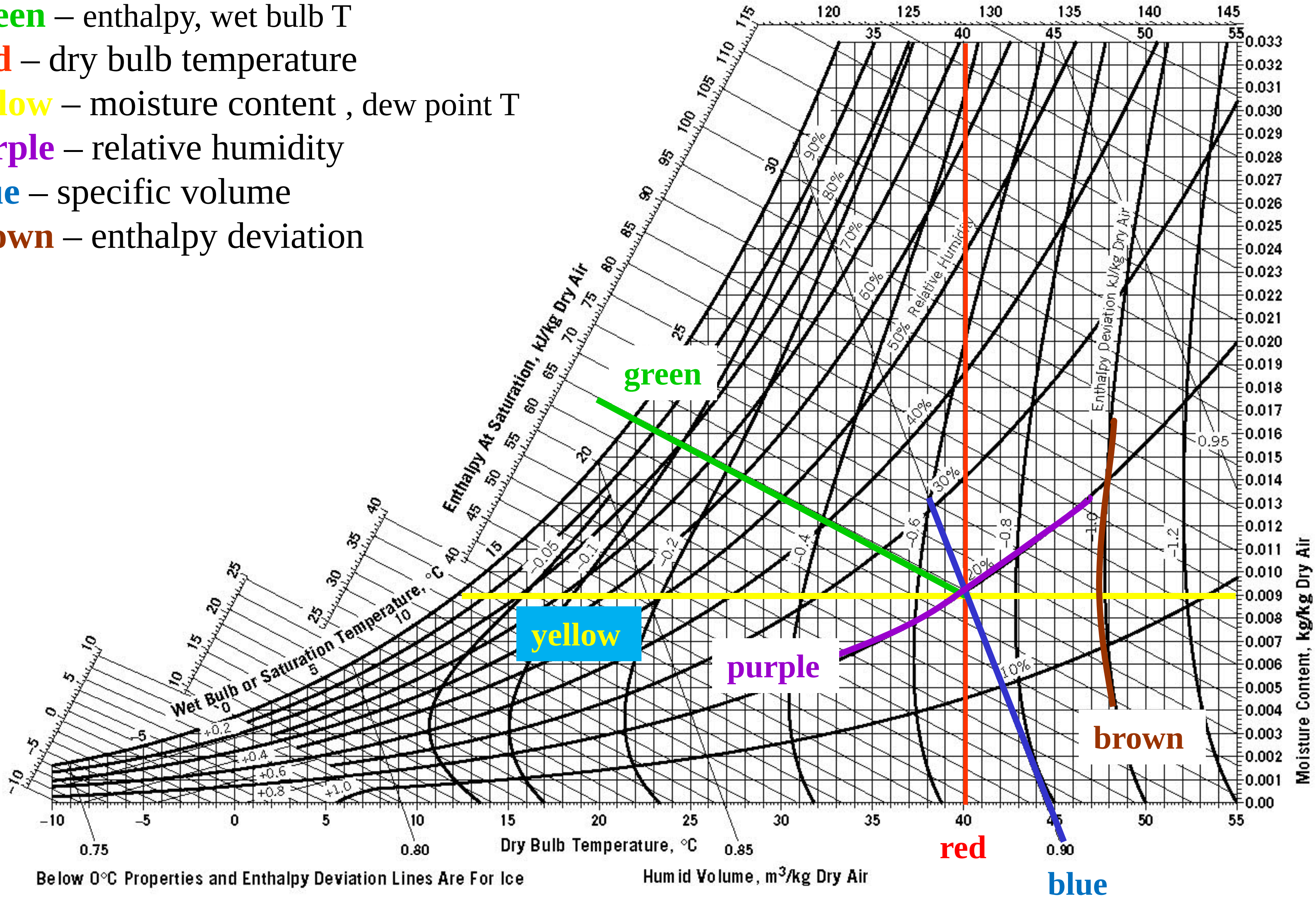
- Humid air
- Useful for drying and humidification or dehumidification (air conditioning) problems
- Much faster than working through full material and energy balance calculations by hand
- Basis is 1 kg of bone dry air

Navigating the Charts

- Open your text to Figure 8.4-1
- Starting at the line “40°C” color the dry bulb temperature red
- Continue with the rest of the lines following the color legend in the next slide.

Data at a point

Green – enthalpy, wet bulb T
Red – dry bulb temperature
Yellow – moisture content , dew point T
Purple – relative humidity
Blue – specific volume
Brown – enthalpy deviation



Psychrometric Charts for Humid Air Material and Energy Balances

Data at a point

Green – enthalpy, wet bulb T

Red – dry bulb temperature

Yellow – moisture content , dew point T

Purple – relative humidity

Blue – specific volume

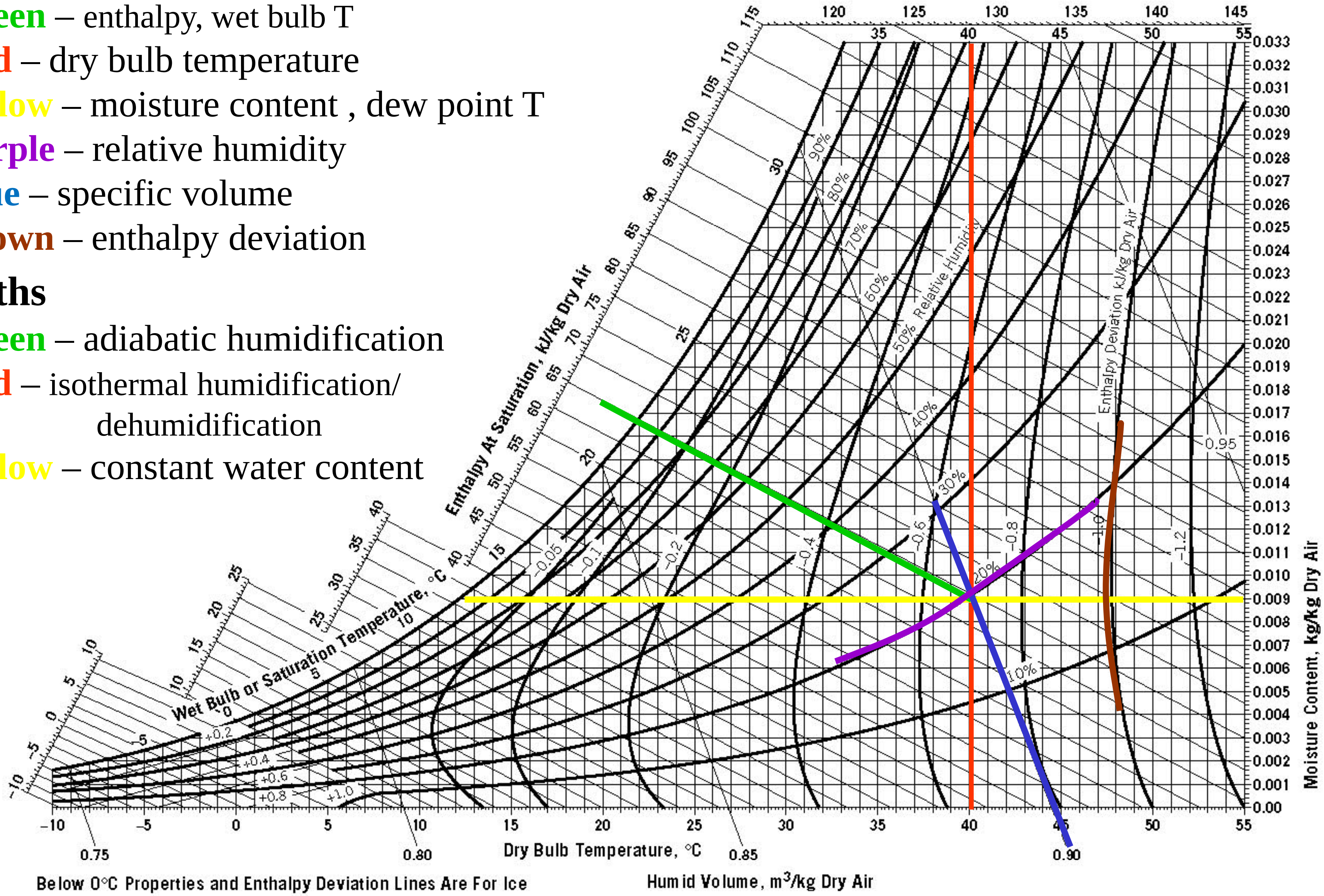
Brown – enthalpy deviation

Paths

Green – adiabatic humidification

Red – isothermal humidification/
dehumidification

Yellow – constant water content



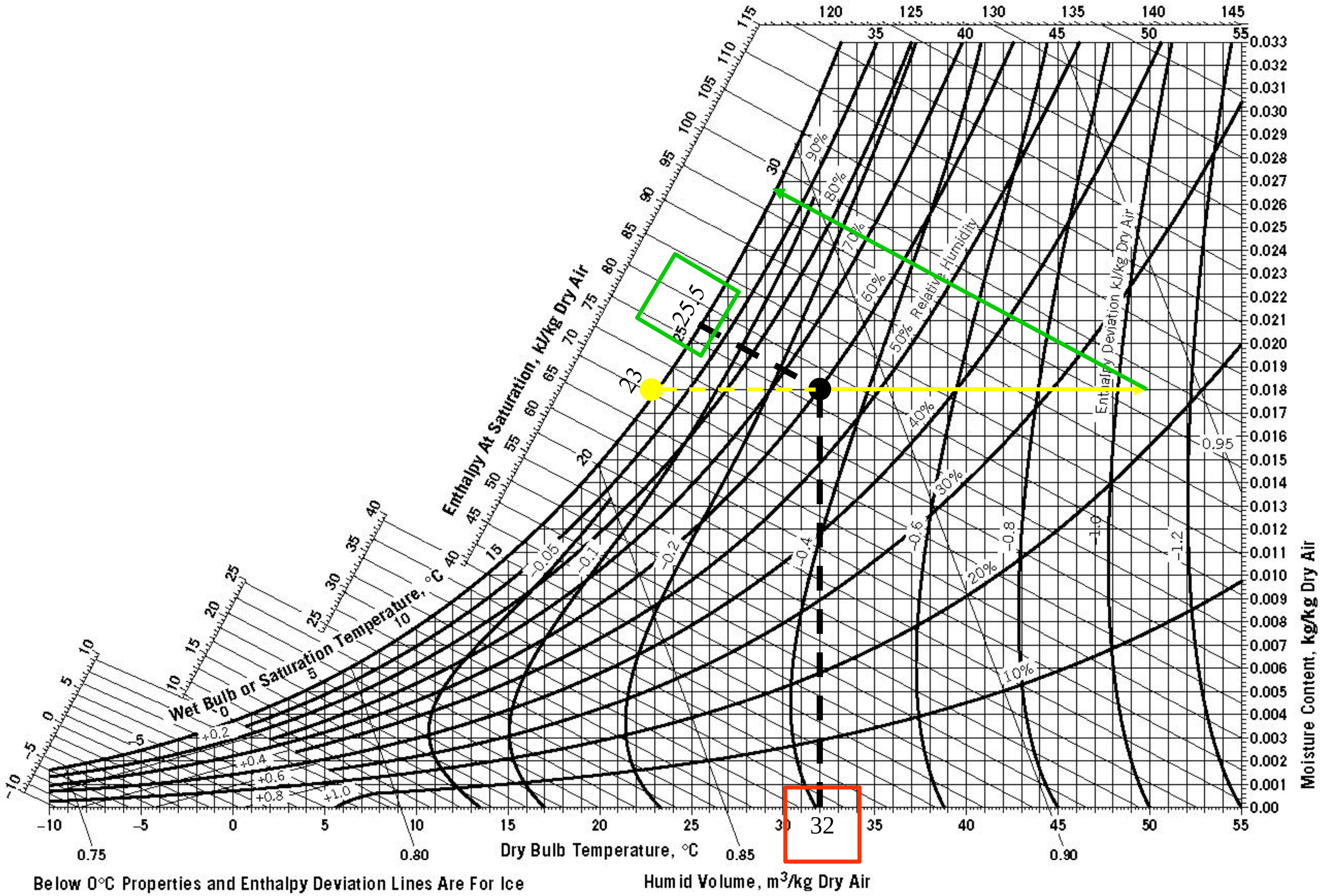
Psychrometric Charts for Humid Air Material and Energy Balances

Psychrometric Charts

1. The air supply for a grain dryer has a dry-bulb temperature of 32°C and a wet-bulb temperature of 25.5°C. It is heated to 50°C and blown into the dryer. In the dryer, it cools along an adiabatic cooling line as it picks up moisture from the grain and leaves the dryer fully saturated.
   a) What is the dew point of the initial air?
   b) What is its absolute humidity?
   c) What is its percent relative humidity?
   d) How much heat is needed to heat 100 m^3 to 50°C?
   e) How much water will be evaporated per 100 m^3 of air entering the dryer?
   f) At what temperature does the air leave the dryer?

2. *Himmelblau 29.31* Air, dry bulb 38°C, wet bulb 27°C, is scrubbed with water to remove dust. The water is maintained at 24°C. Assume that complete equilibrium exists between the water and the gases at the exit. The clean, wet air is then heated to 53°C by passing it over steam coils, and used in an adiabatic rotary dryer, from which it exits at 49°C. The material to be dried enters and leaves at 46°C. The material loses 0.05 kg H_2O per kilogram of product. The total product is 1000 kg/hr.
   a) What is the absolute humidity of the air (i) initially, (ii) leaving the spray tower, (iii) leaving the reheater, (iv) leaving the dryer?
   b) What is the relative humidity at each of the points in part a?
   c) What is the total mass of dry air used per hour?
   d) What is the total volume of air leaving the dryer?
   e) What is the total amount of heat supplied to the cycle in J/hr?

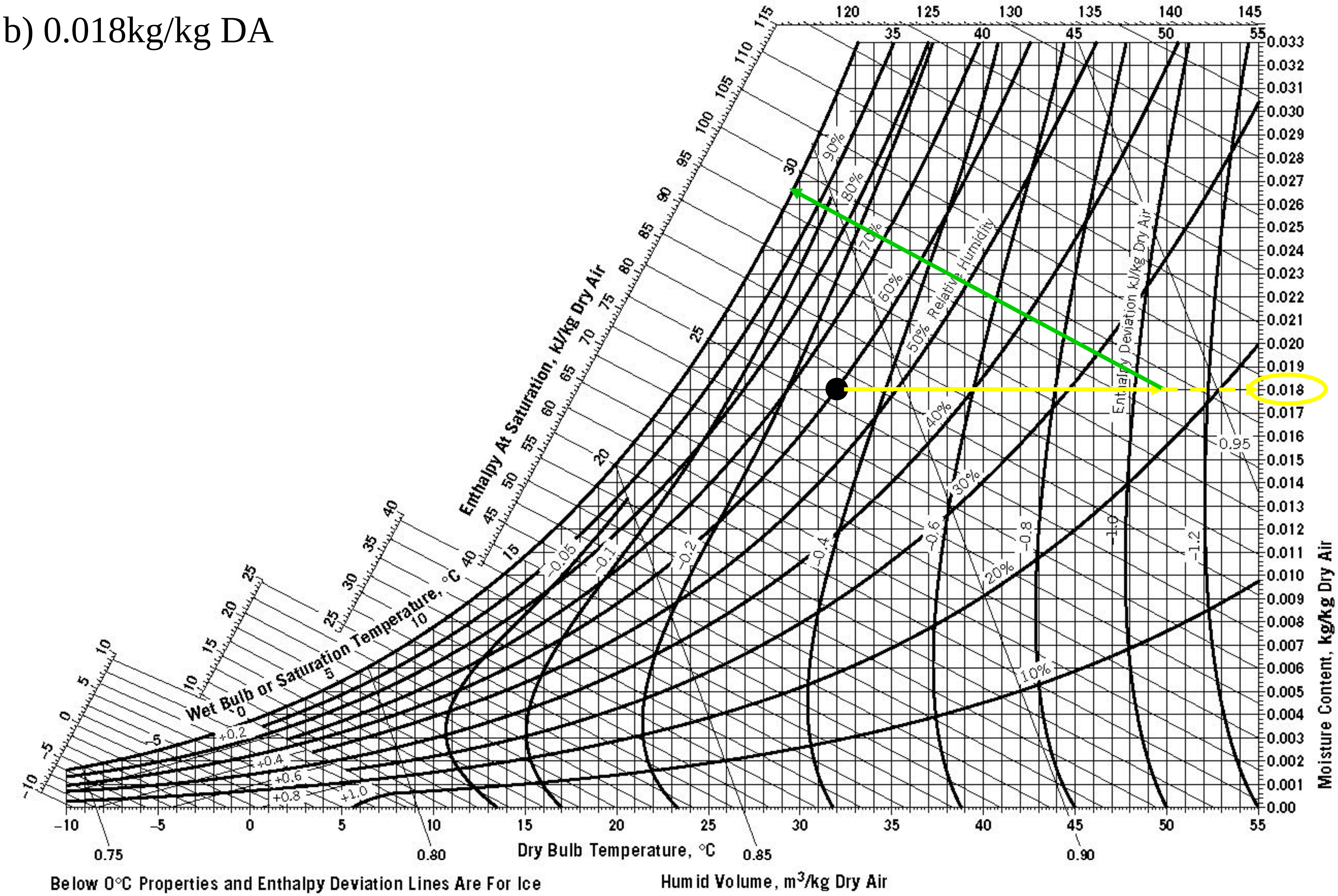
1a) 23°C



Problem 1: Grain Dryer

1a) 23°C

b) 0.018kg/kg DA

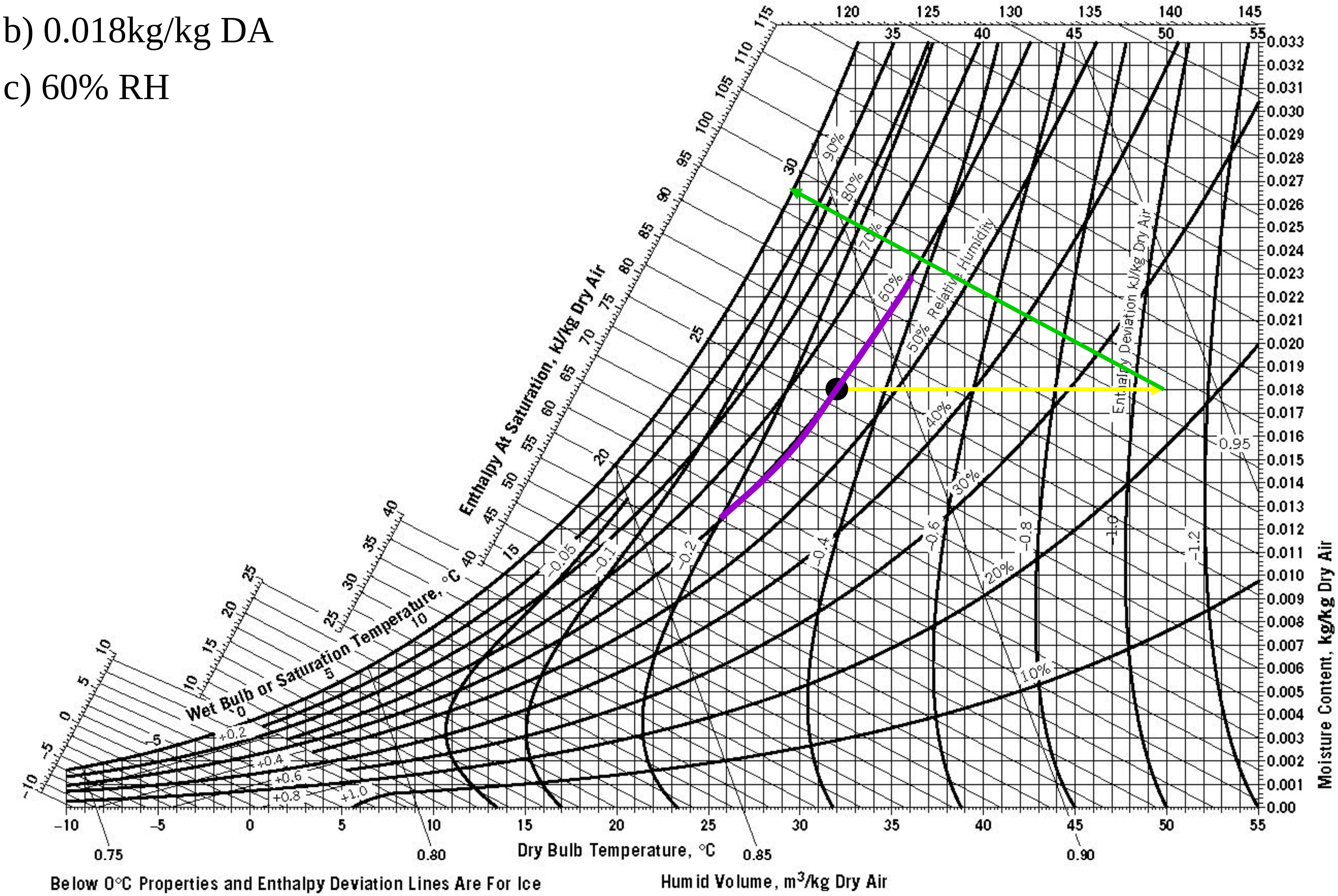


Problem 1: Grain Dryer

1a) 23°C

b) 0.018kg/kg DA

c) 60% RH



Problem 1: Grain Dryer

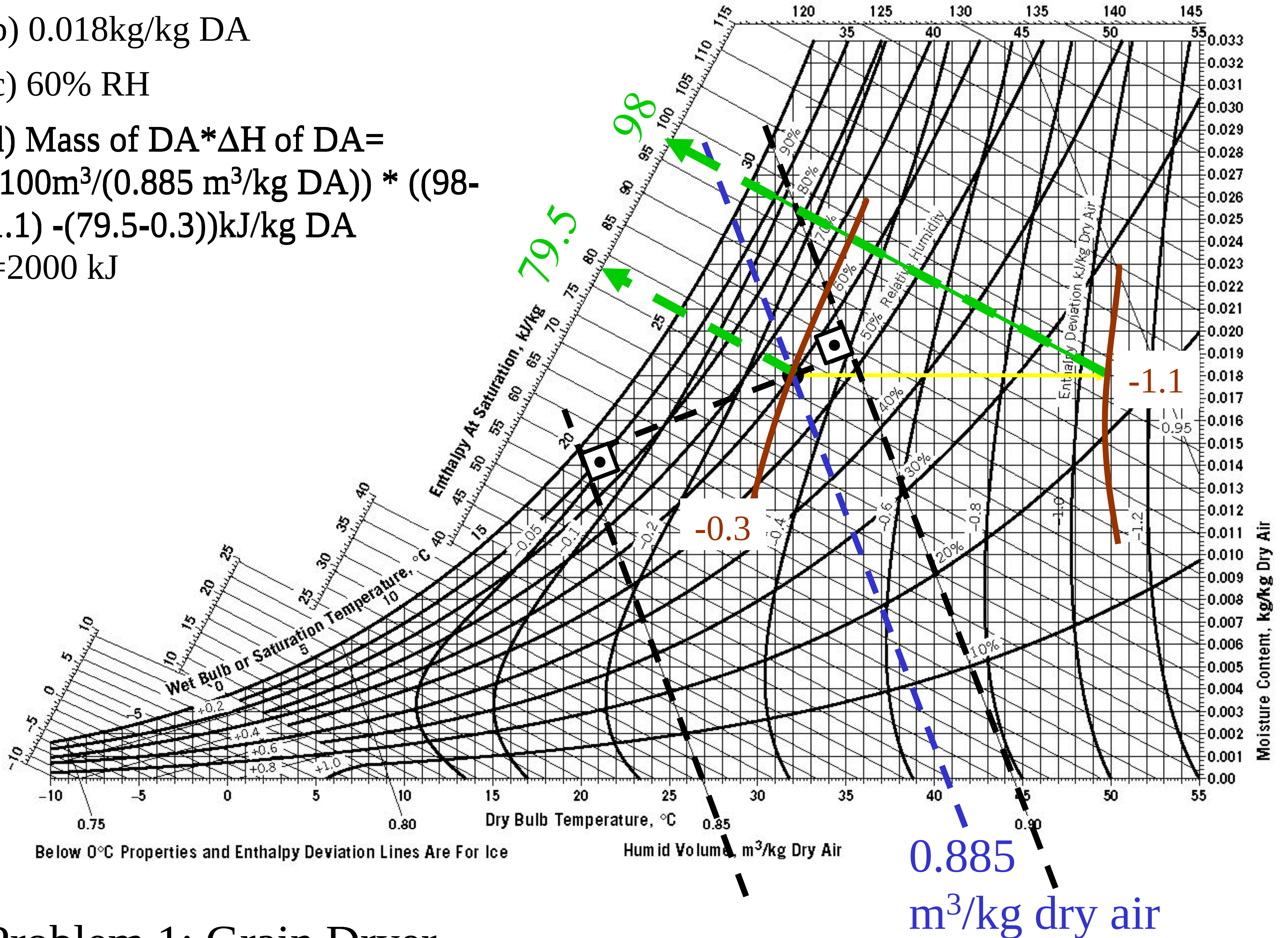
1a) 23°C

b) 0.018kg/kg DA

c) 60% RH

d) Mass of DA*ΔH of DA= $(100m^3/(0.885\ m^3/kg\ DA)) * ((98-1.1) -(79.5-0.3))kJ/kg\ DA$

=2000 kJ



Problem 1: Grain Dryer

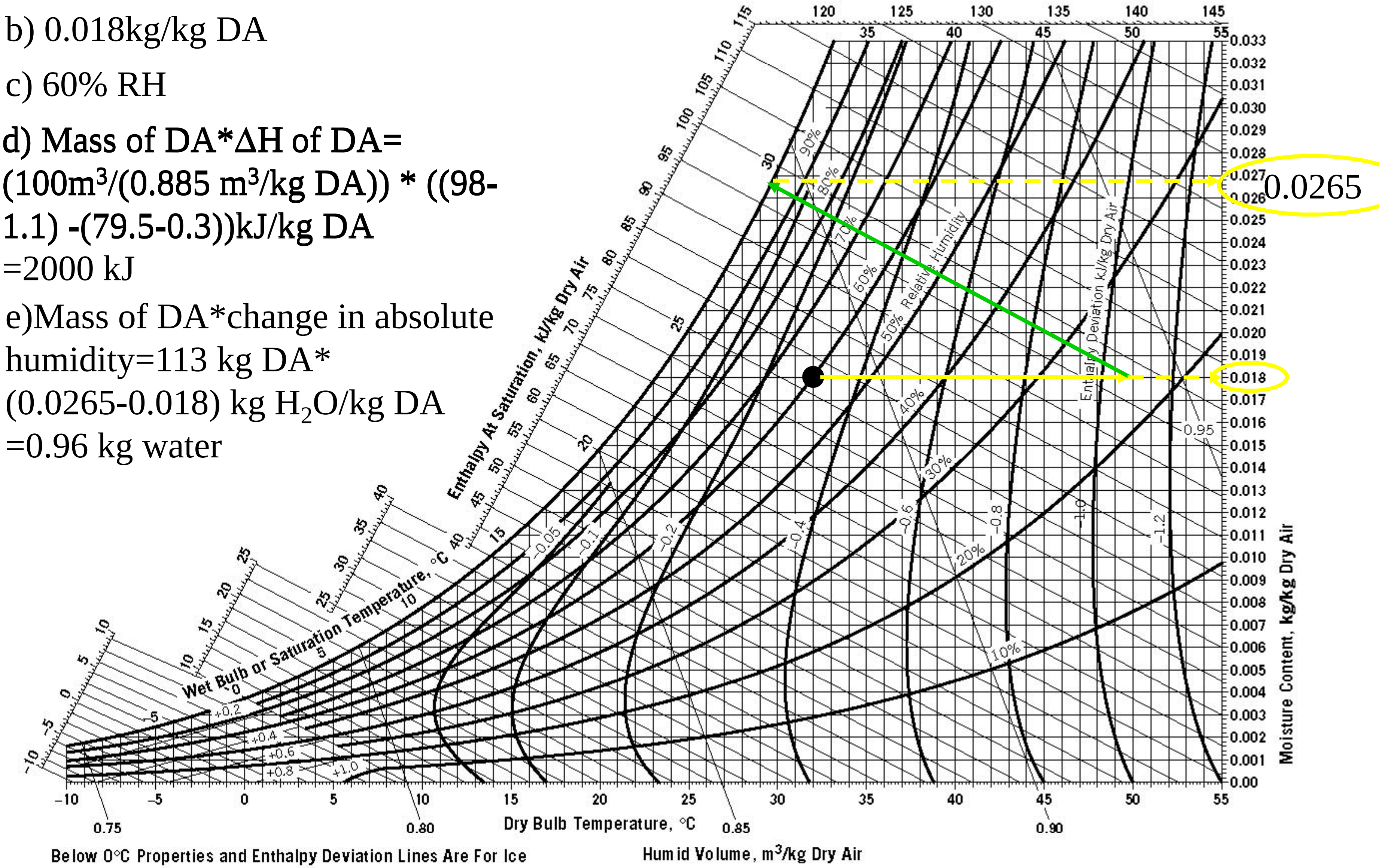
1a) 23°C

b) 0.018kg/kg DA

c) 60% RH

d) Mass of DA*ΔH of DA= $(100m^3/(0.885\ m^3/kg\ DA)) * ((98-1.1) -(79.5-0.3))$kJ/kg DA
=2000 kJ

e)Mass of DA*change in absolute humidity=113 kg DA* (0.0265-0.018) kg H_2O/kg DA
=0.96 kg water



Problem 1: Grain Dryer

1a) 23°C

b) 0.018kg/kg DA

c) 60% RH

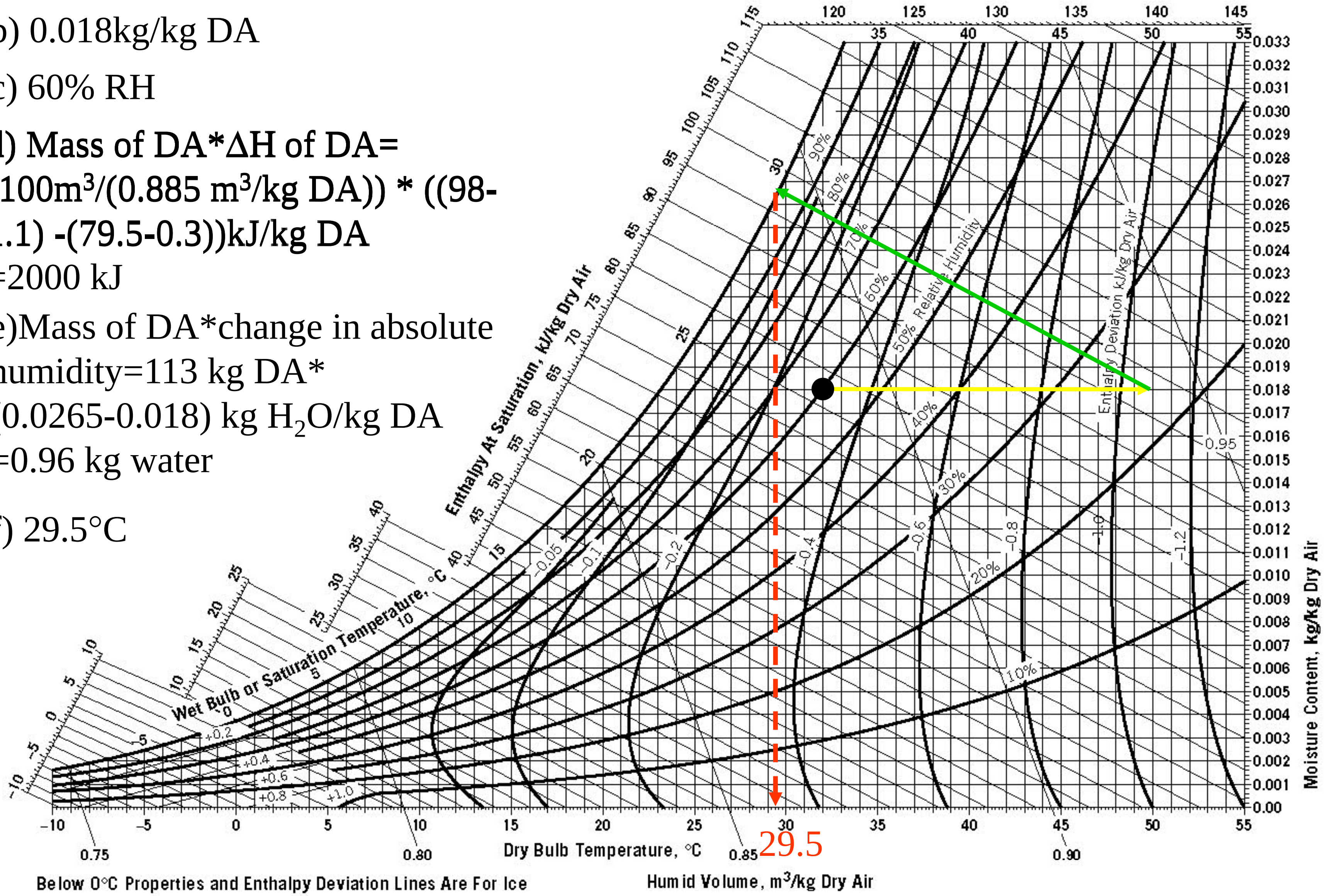
d) Mass of DA*ΔH of DA= $(100m^3/(0.885\ m^3/kg\ DA))$ * ((98-1.1) -(79.5-0.3))kJ/kg DA

=2000 kJ

e)Mass of DA*change in absolute humidity=113 kg DA* (0.0265-0.018) kg H_2O/kg DA

=0.96 kg water

f) 29.5°C



Problem 1: Grain Dryer

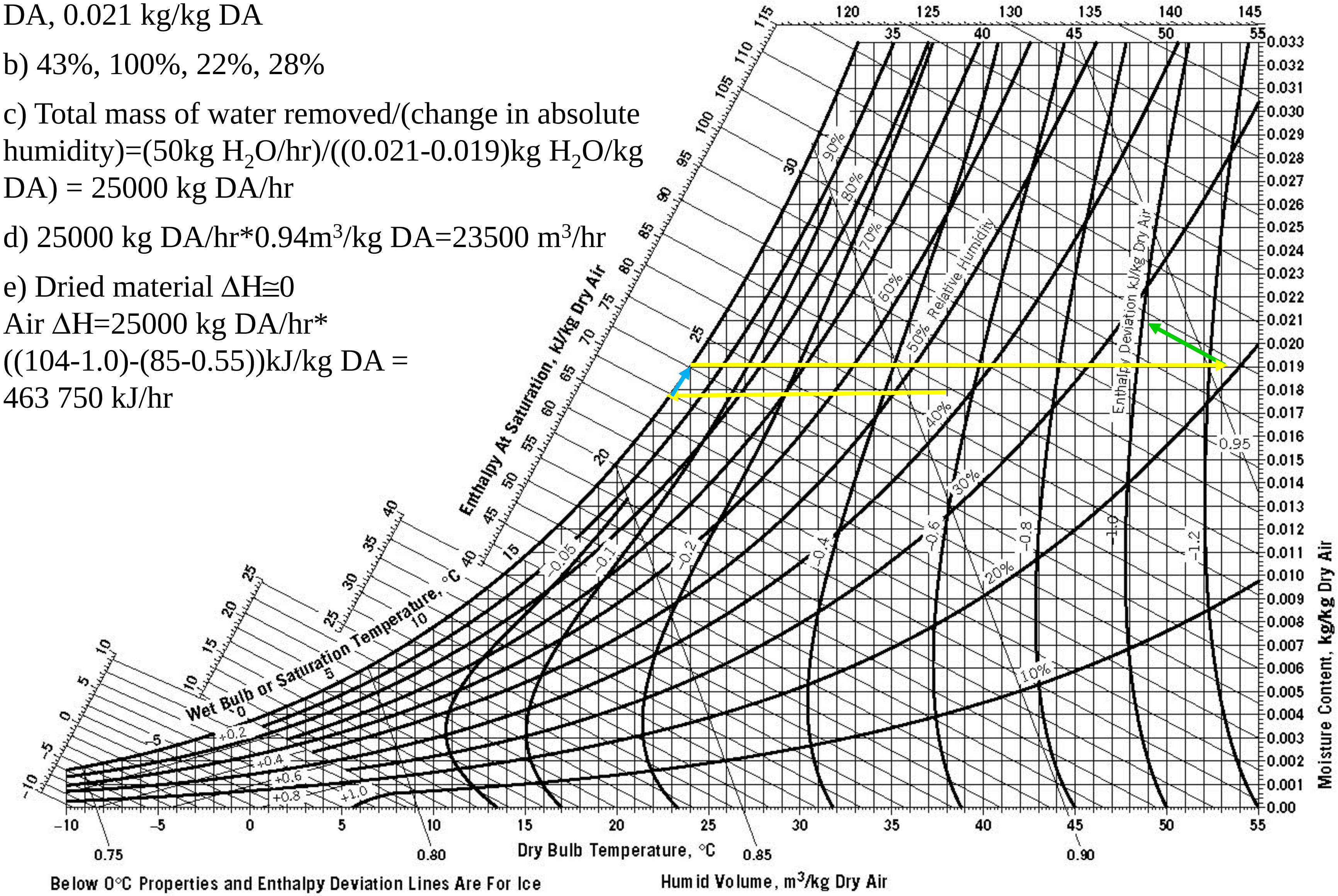
2a) 0.018kg/kg DA, 0.019kg/kg DA, 0.019 kg/kg DA, 0.021 kg/kg DA

b) 43%, 100%, 22%, 28%

c) Total mass of water removed/(change in absolute humidity)=(50kg H_2O/hr)/((0.021-0.019)kg H_2O/kg DA) = 25000 kg DA/hr

d) 25000 kg DA/hr*0.94m^3/kg DA=23500 m^3/hr

e) Dried material ΔH≅0
Air ΔH=25000 kg DA/hr*
((104-1.0)-(85-0.55))kJ/kg DA =
463 750 kJ/hr



Problem 2: Air cleaning for dryer

1a) 23°C

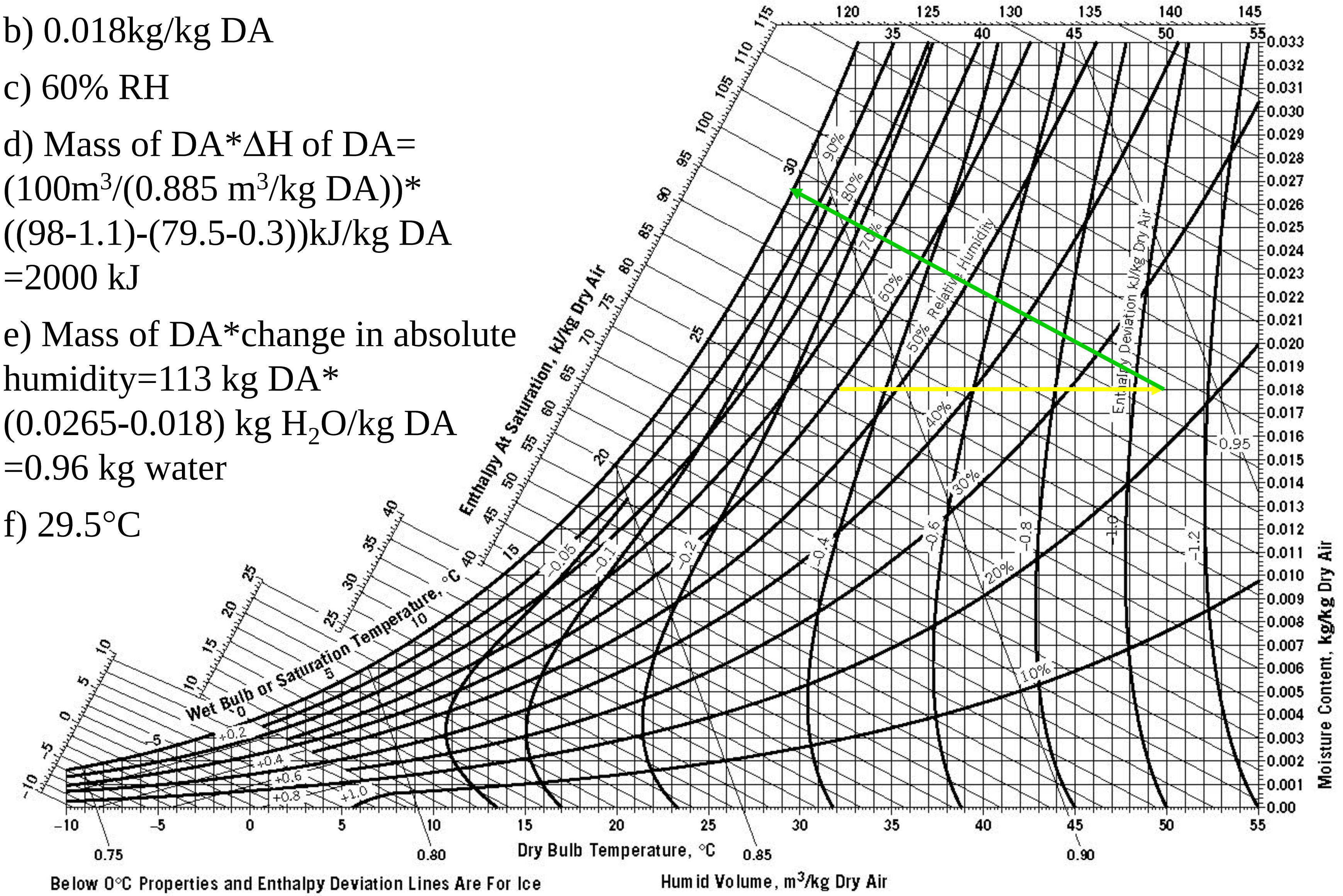
b) 0.018kg/kg DA

c) 60% RH

d) Mass of DA*ΔH of DA=
$(100m^3/(0.885\ m^3/kg\ DA))*$
((98-1.1)-(79.5-0.3))kJ/kg DA
=2000 kJ

e) Mass of DA*change in absolute humidity=113 kg DA*
(0.0265-0.018) kg H_2O/kg DA
=0.96 kg water

f) 29.5°C



Problem 1: Grain Dryer