

PROFESSIONAL ENGINEERS OF ONTARIO

ANNUAL EXAMINATIONS – December 2012

07-Mec-B2 Environmental Control in Buildings

3 hours duration

INSTRUCTIONS:

- 1. If doubt exists as to the interpretation of any of the questions, the candidate is urged to submit a clear statement of the assumption(s) that he/she has had made with the answer.**
- 2. The examination paper is open book and so candidates are permitted to make use of any textbooks, references or notes that they wish.**
- 3. Any non-communicating calculator is permitted. Candidates must indicate the type of calculator(s) that they have used by writing the name and model designation of the calculator(s) on the first inside left hand sheet of the first examination workbook. The usage of computers, internet and smart phones is prohibited.**
- 4. Candidates are expected to have copies of both an environmental control book and steam tables, since it will be necessary to use information presented in the tables and graphs contained in books.**
- 5. Candidates are required to solve five questions.**
- 6. All questions carry the same value. Indicate which five questions are to be graded on the cover of the first examination workbook.**
- 7. Psychrometric charts and the p-h diagram for the refrigerant are attached.**

PROBLEM 1 (20 POINTS).

An air conditioning system is required to cool a theatre capable of accommodating 450 people.

Outside design	85°F dB, 60% RH
Inside design	75°F dB, 66 °F wB
Room sensible-heat gain	60,000 Btu/hr
Ventilation flow	15 cfm /person
Chilling coil by pass factor	0.1

Neglect all friction losses and fan and pump work. Assume sea level conditions.

- Draw a diagram of the system.**
- Draw the operating cycle on the psychrometric chart provided and identify each significant point, on the diagram and psychrometric chart, and note for each of these points its dry bulb and wet bulb temperature.**
- Total system air flow (CFM).**
- System inlet and room supply conditions.**
- Calculate the total refrigeration capacity.**

Briefly discuss the factors which would favour the selection of centrifugal or absorption machinery for this system, in preference to a reciprocating compressor plant.

PROBLEM 2 (20 POINTS).

An air conditioning plant is designed to maintain a room at 20°C, 50% RH with an air supply to the room of 1.8 kg/s at 14°C RH 60%. The design outside air conditions are 27°C 70% RH.

The plant consists of a mixing chamber for recirculated a cooling coil supplied with chilled water, heating coil and supply fan.

The ratio of recirculated air to fresh air is 3; the cooling coil has an apparatus dew point of 5°C and the refrigeration unit supplying the chilled water has an overall coefficient of performance of 2.

Neglect all losses and fan and pump work. Assume sea level conditions

- Draw a diagram of the system.**
- Draw the operating cycle on the psychrometric chart provided. Identify each significant point, on the diagram and psychrometric chart.**
- Determine the total air conditioning load for the room.**
- Calculate the total energy input.**
- the required energy input if the energy to the heating coil is supplied from the refrigeration plant condenser cooling water**

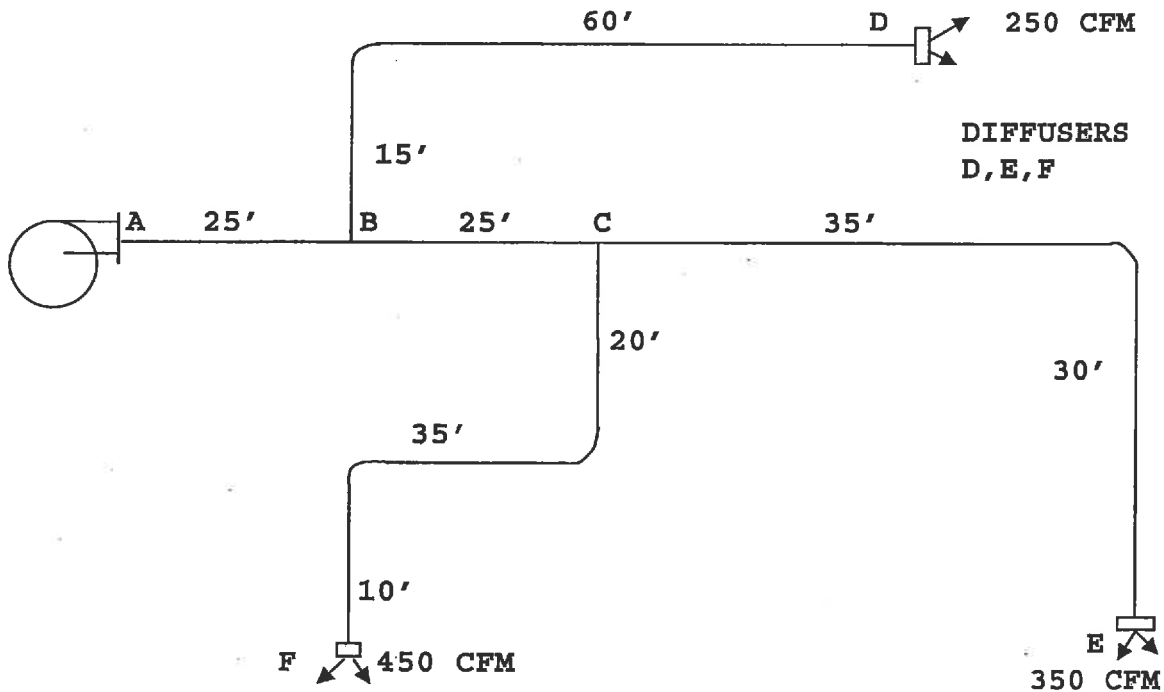
PROBLEM 3 (20 POINTS).

Use equal friction method to select duct sizes for the small duct system shown below.

Data:

- the velocity in section AB is limited to 1000 FPM.
- total pressure loss across each diffuser is 0.02 in. w.g. at the given flow rates.

Calculate the total pressure loss that the fan must supply at A. Give duct sizes in diameter as well as equivalent rectangular dimensions.



PROBLEM 4. (20 POINTS)

Estimate the cost of heating a building for the month of January, using a two stage ammonia heat pump, given the following information:

Heat pump cycle: evaporating 25 psia (dry saturated at evaporator outlet), condensing 180 psia. A flash intercooler gives dry saturated vapour at HP stage inlet. Compression is isentropic. Efficiency of the electric drive is 80%.

Building design heating load is 200,000 Btu/hr
Room temperature 68°F, outside temperature -5°F.
Degree days for January for that location are 1,800.

Take the cost of electricity as 10cents per kilowatt-hour.
Compare the above with the cost of using resistance electric heating.

PROBLEM 5. (20 POINTS)

a. 10 points

A wall is constructed of: 4 in. face brick,
pressed fiber board sheathing ($k = 0.44 \text{ Btu-in./ft}^2\text{-hr-}^\circ\text{F}$),
3.0 in. air space,
0.5 in. lightweight gypsum plaster on 0.5 in plaster board.

When the inside air temperature is 72°F and the outside temperature is -12°F , how thick must be the sheathing in order to prevent water pipes from freezing?

Comment on moisture flow through wall structures and proper installation of vapour barriers.

b. 10 points

The exterior wall of a room in an office building has a solid wood door 3.5 ft. by 6 ft. 10 inches, thick 1.75 inches and three 40 inches by 36 inches glass windows with no sash and double insulating glass with 0.5 inches air space.

The wall is 9ft. high by 20 ft. long. The wall construction is such that it has a U (overall heat transfer) factor of $0.19 \text{ Btu/hr. ft}^2 \text{ }^\circ\text{F}$.

Assume parallel heat flow through the wall, windows and door, and calculate the overall thermal resistance and the overall U factor for the combined wall, windows and door.

PROBLEM 6. (20 POINTS)

a.) 10 points

A room in a single-story building has two 3 x 5-ft wood, double-hung windows of average fit that are not weather stripped. The wind is 3 mph (miles per hour) and normal to the wall with negligible pressurization of the room. Find the infiltration rate assuming that the entire crack is admitting air.

b.) 5 points.

Give an expression for the sensible and latent heat load due to infiltration.

c.) 5 points

Explain the term "stack effect".

PROBLEM 7. (20 POINTS)

You are involved in selecting the heating and cooling system for a campus of a big university in a downtown location.

Comment on economical and environmental implication of the following heating or cooling systems (your comments must be short and dealing with the issue):

- **vapour compression air conditioning system using different refrigerants: comment on refrigerants recommended.**
- **absorption chiller air conditioning system using steam from district heating.**
- **absorption chiller air conditioning system using natural gas.**
- **Heating and cooling from a central station that provides cold water and hot water for heating and cooling.**

Limit your comments to a maximum of 2 pages.

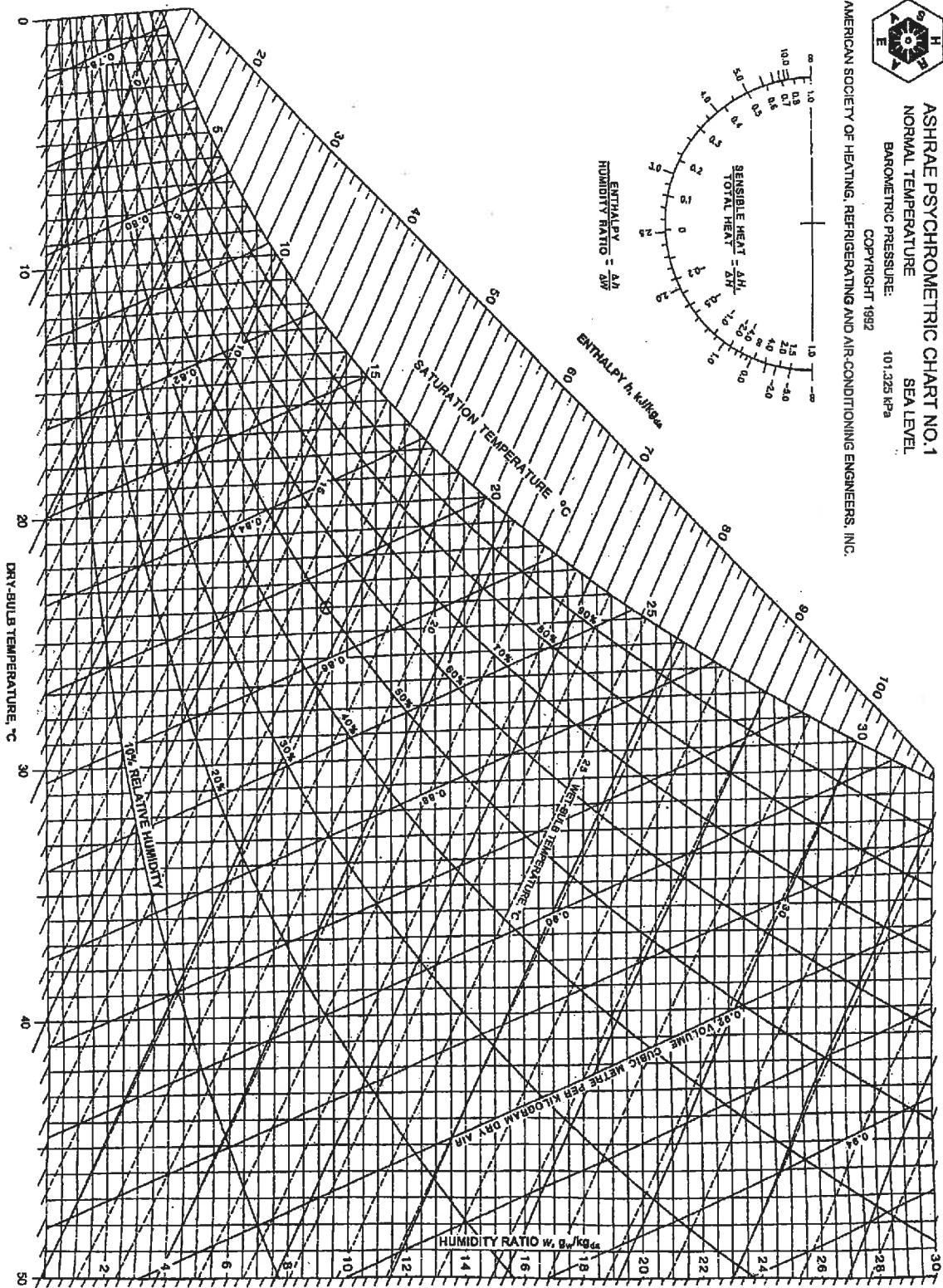


Fig. 1 ASHRAE Psychrometric Chart No. 1

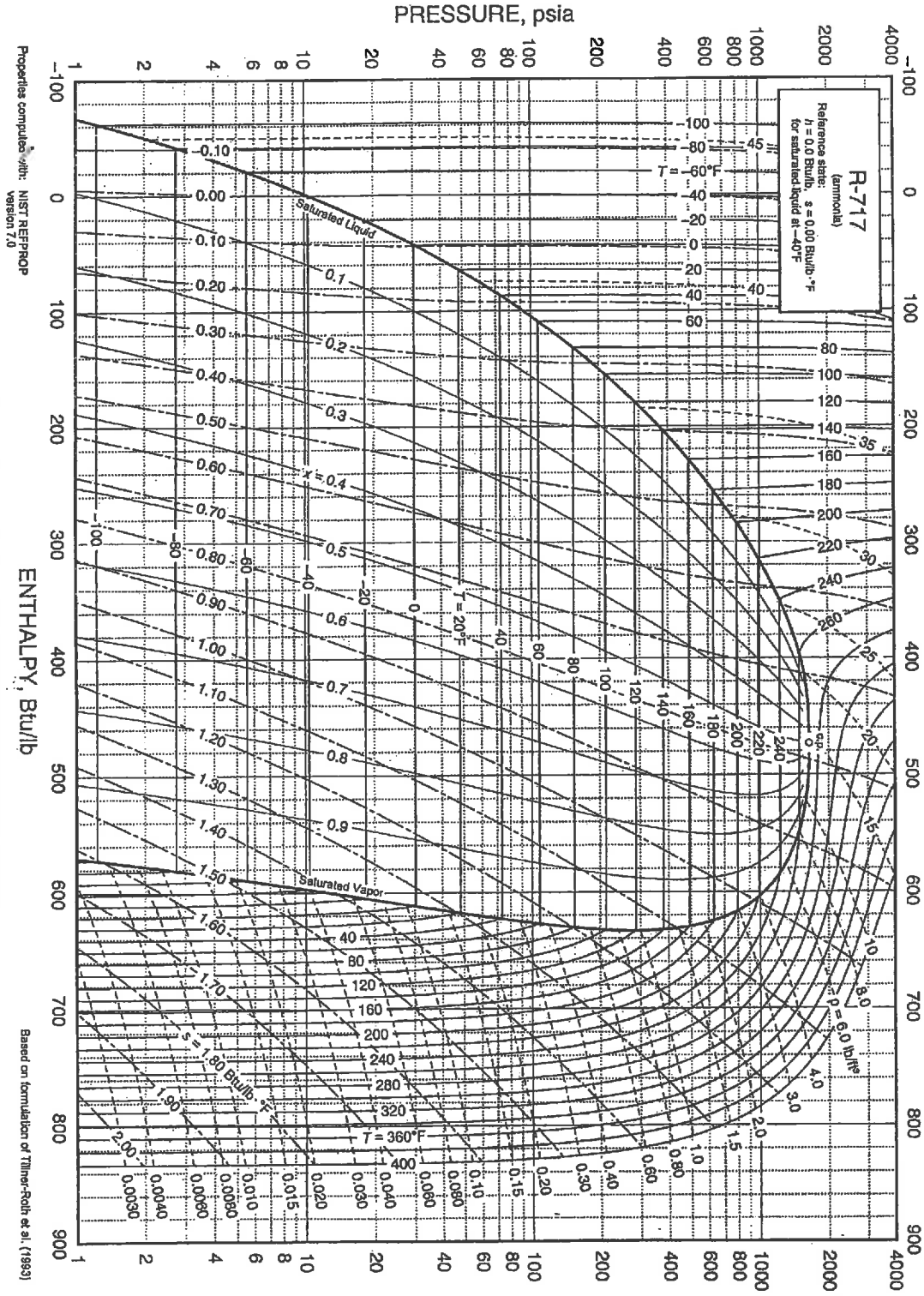


Fig. 16 Pressure-Enthalpy Diagram for Refrigerant 717 (Ammonia)