Minerals Council South Africa

EXAMINATION PAPER

SUBJECT: **CHAMBER OF MINES OF SOUTH AFRICA – CERTIFICATE IN MINE ENVIRONMENTAL CONTROL**	EXAMINER**: JOHAN PIENAAR**
PAPER 2 – THERMAL ENGINEERING	MODERATOR: **MARTHINUS VD BANK**
SUBJECT CODE: **COMMEC2**	
EXAMINATION DATE: **09 OCTOBER 2024**	TOTAL MARKS: **[100]**
TIME: **14:30 – 17:30 (3 HOURS)**	PASS MARK: **(60%)**
NUMBER OF PAGES: **09**	

SPECIAL REQUIREMENTS:

THIS IS **NOT** AN **OPEN BOOK EXAMINATION**.

FORMULA HANDOUTS MUST BE MADE AVAILABLE TO CANDIDATES

1. Answer all 4 questions **legibly** in English.
2. Write your **ID number** on the outside cover of each book used and on any graph paper or other loose sheets handed in.

NB: Your name **must not** appear on any answer book or loose sheets.

3. Show all calculations and **check calculations on which the answers are based**.
4. Hand-held electronic calculators may be used for calculations.
5. Write **legibly** in ink on the **right hand page** only – **left hand pages will not be marked**.
6. Illustrate your answers by means of sketches or diagrams wherever possible.
7. Answers must be given to an accuracy which is typical of practical conditions.

NB: Ensure that the correct unit of measure (SI unit) is recorded as marks will be deducted from answers if the incorrect or no SI unit is used. (Even if the calculated value is correct).

8. Please note that you are not allowed to contact your examiner or moderator regarding this examination.
9. Cell phones and any other electronic devices are **NOT** allowed in the examination room. **Only Calculator**
10. **The following chart is included: Psychrometric chart: 85.0kPa, 100.0kPa and 102.5kPa**
11. You are encouraged to make use of the CoMCert Tip-off Hotline whenever you witness or suspect any wrongdoing related to the CoMCert Examinations on landline 0800 118 998 or alternatively you can use email COMCert@tip-offs.com. This tip-off hotline and tip-off email is managed anonymously and confidentially through an independent service provider.

QUESTION 1

1.1. Define the following terminology:

1.1.1 Overall coefficient of heat transfer. (3)

1.1.2 Hypothermia and give the temperature at which this condition can occur. (2)

1.1.3. Enthalpy. (2)

1.1.4. Microbiological fouling. (2)

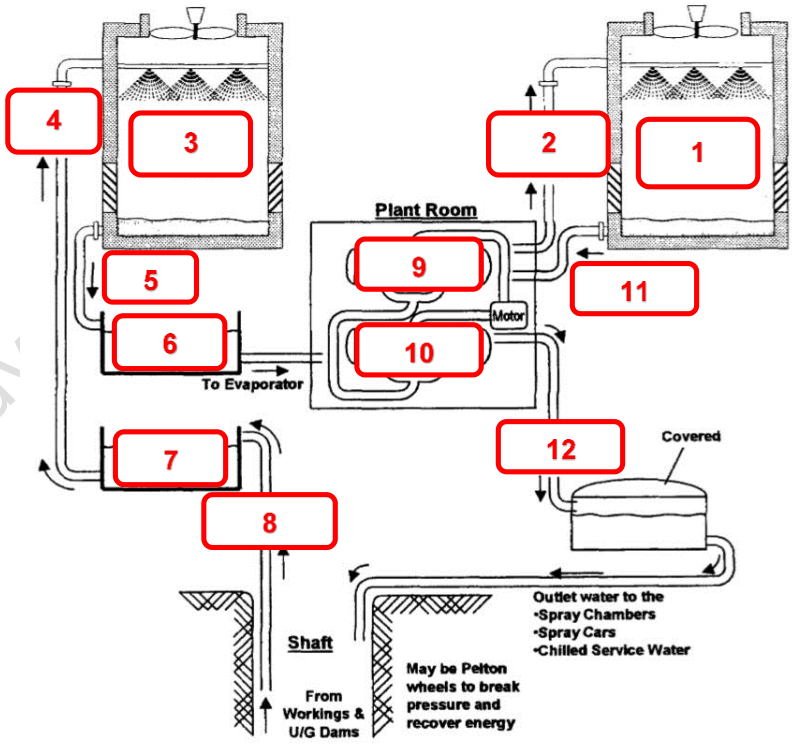
1.1.5. Sigma heat / energy. (3)

1.2. State the three factors affecting the rate of transfer of heat by radiation? (3)

1.3. Give three effects of condenser tube fouling. (3)

1.4. The diagram below indicates the typical layout of a surface refrigeration plant.

1.4.1 List the typical components of a surface cooling plant as indicated in the diagram below which are numbered from 1 to 12. (12)



[30]

QUESTION 2

2.1. 25kg/s of ice is manufactured by a surface ice plant.

Assuming that:

The water fed to the ice maker is pre-chilled to 5.0ºC.
The temperature of the manufactured ice is a constant 0ºC.
The ice mass fraction (IMF) of the manufactured ice is 0.93.
The overall COP of the ice plant is 3.75.
The ice "free-falls" down a 300mm plastic pipe to an underground dam located 2 730m below surface.

Determine the following:

2.1.1. The surface duty of the ice plant. (2)

2.1.2. The input power required to the ice plant. (2)

2.1.3. The IMF of the ice as it arrives at the dam. (9)

2.1.4. The expected cooling duty of the underground dam (assuming dam outlet temperature = 5.0ºC and return temperature to dam = 19.0ºC). (2)

2.2. You are the Ventilation Engineer on a shaft and you have to make an estimate of the heat load potential of a new kind of explosive to be tested on your shaft. The following technical details of the explosive are available.

ANFO Explosives heat release	3 700kJ/kg of explosives
The charge density of ANFO explosives	0,8kg/ton of rock blasted

It is known that the heat generated by the explosives will be removed in two stages, namely with the blasting fumes and some will be retained in the rock as heat. With high fragmentation it is assumed that 45% of the heat will be removed with the fumes. It is also estimated that 20% of the heat will be removed within the first hour after blasting. The amount of rock to be blasted is 2 000tons and assume the Cp of rock as 950J/kgºC.

Determine the following:

2.2.1. The total amount of heat produced by the explosives (kJ) (1)

2.2.2. How much of the total heat produced remains in the rock and is not removed with the fumes (kJ) (1)

2.2.3. The rate at which heat energy is removed with the fumes within the first hour after blasting (2)

2.2.4. The rise in temperature of the rock blasted within the first hour (2)

2.2.5. What would be the rise in temperature in the rock be (within the first hour) if the explosives used were a nitro glycerine-based explosive with a heat release rate of 5 800kJ/kg explosive used assume same charge density. (4)

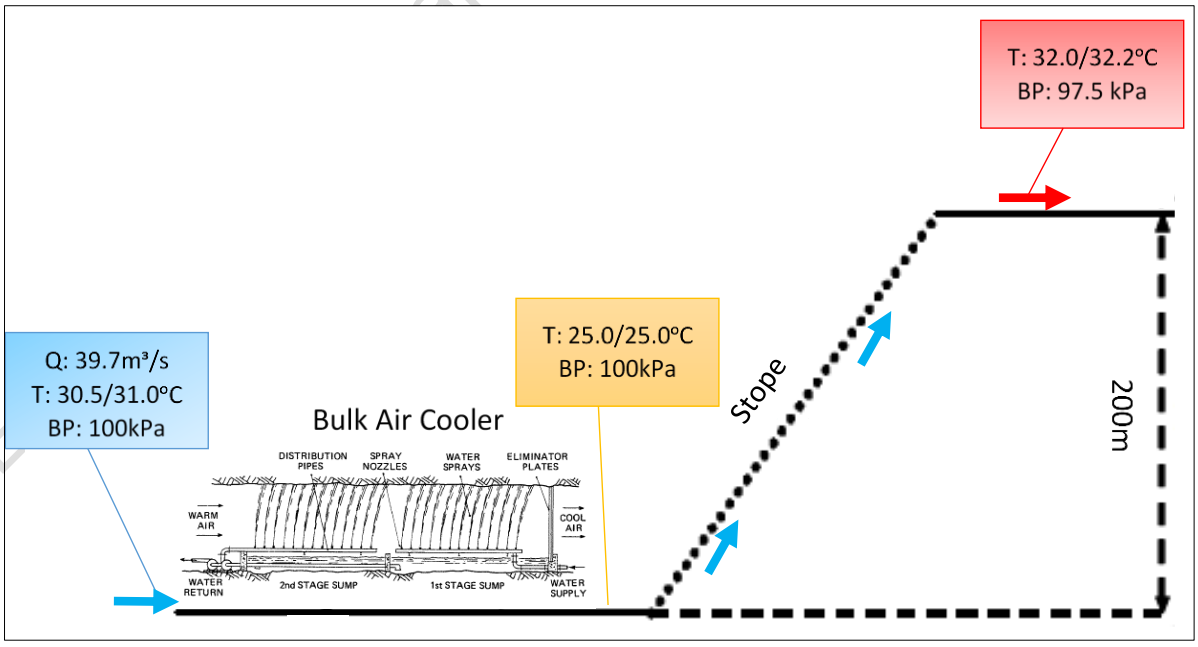
[25]

QUESTION 3

3.1. Use the Psychrometric Charts and the information in the table below to determine and list the answers for 3.1.1 to 3.1.20:

Property	**A**	**B**	**SI Unit**
Barometric Pressure	**85.0**	**102.5**	**kPa**
Temperature (Wet / Dry)	**29.7/31.2**	**33.3/34.1**	**°C**
Sigma heat content Enthalpy	*3.1.1*	*3.1.2*	*3.1.3*
Moisture content	*3.1.4*	*3.1.5*	*3.1.6*
Vapour pressure	*3.1.7*	*3.1.8*	*3.1.9*
Relative humidity	*3.1.10*	*3.1.11*	*3.1.12*
Dew-point temperature	*3.1.13*	*3.1.14*	
Apparent specific volume	*3.1.15*	*3.1.16*	*3.1.17*
Apparent density	*3.1.18*	*3.1.19*	*3.1.20*

3.2. The sketch below shows various environmental measurements made in a section of a mine.



Calculate the following:

3.2.1. The duty of the bulk cooling installation. (3)

3.2.2. The amount of water condensed in the bulk cooling installation. (3)

3.2.3. The heat generated in the stope. (3)

3.2.4. The amount of water evaporated into the air in the stope. (1)

[20]

QUESTION 4

4.1. Briefly list five properties of an ideal refrigerant. (5)

4.2. The following measurements were taken at a surface refrigeration plant operating under full load conditions (type of refrigerant used is R134-a):

Evaporator

Water flow rate	153.0l/s
Inlet water temperature	16.0ºC
Delivery water temperature	5.0ºC
Evaporating temperature	0.4ºC

Condenser

Water flow rate	357.0l/s
Inlet water temperature	19.0ºC
Outlet water temperature	24.7ºC
Condensing temperature	29.3ºC

Compressor

Motor current:	100 A
Voltage:	6 590V
Power factor:	0.95
No. of phases:	3
Motor efficiency:	97%

Calculate the following:

4.2.1. The plant duty. (2)

4.2.2. The input power to the compressor motor. (2)

4.2.3. The heat balance. (5)

4.2.4. The Carnot COP. (2)

4.2.5. The overall (or plant) compressor COP. (2)

4.2.6. Explain the difference between Carnot COP and overall compressor COP. (1)

4.2.7. The actual compressor COP. (2)

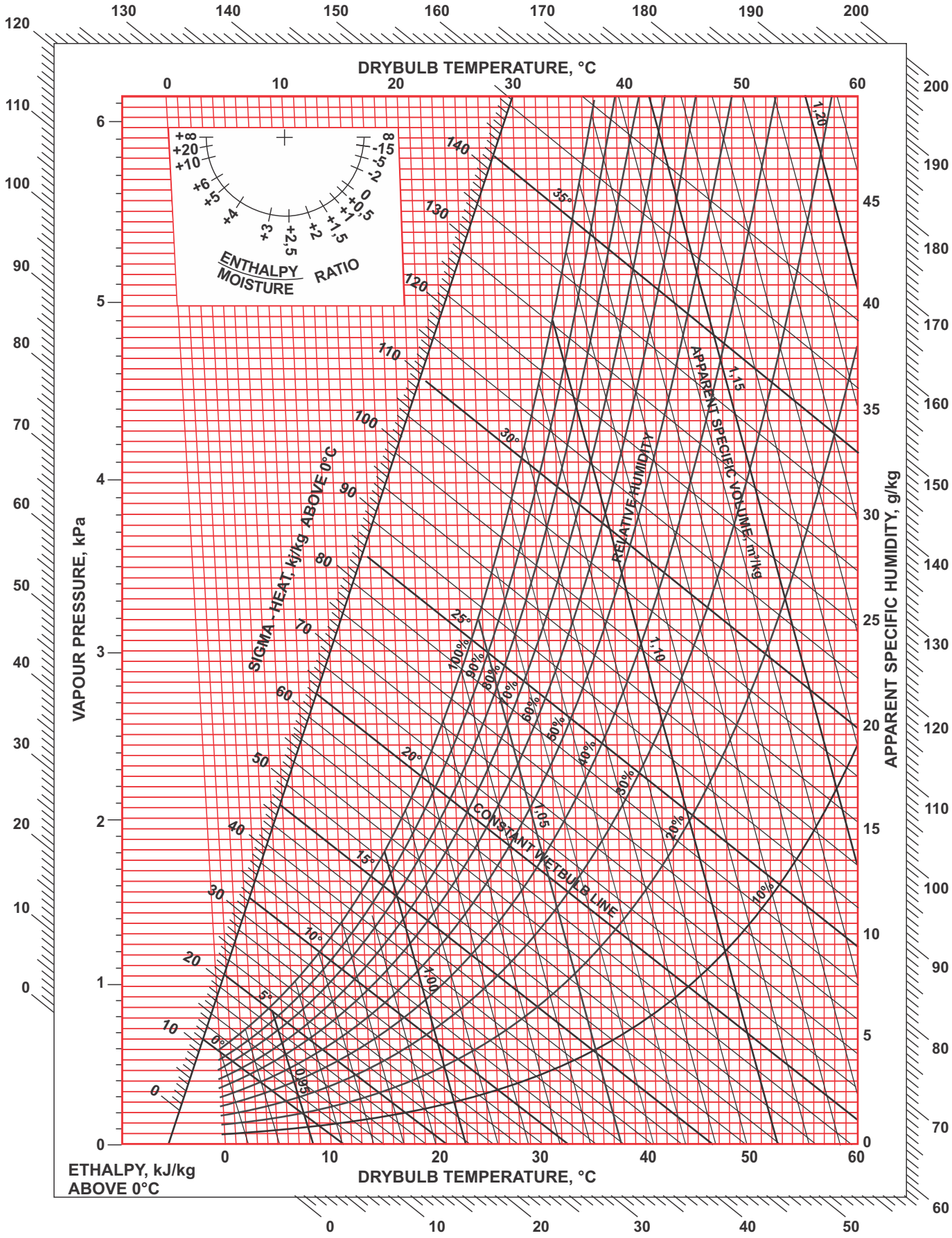
4.2.8. The overall cycle efficiency. (2)

4.2.9. The actual cycle efficiency. (2)

[25]

TOTAL MARKS: [100]

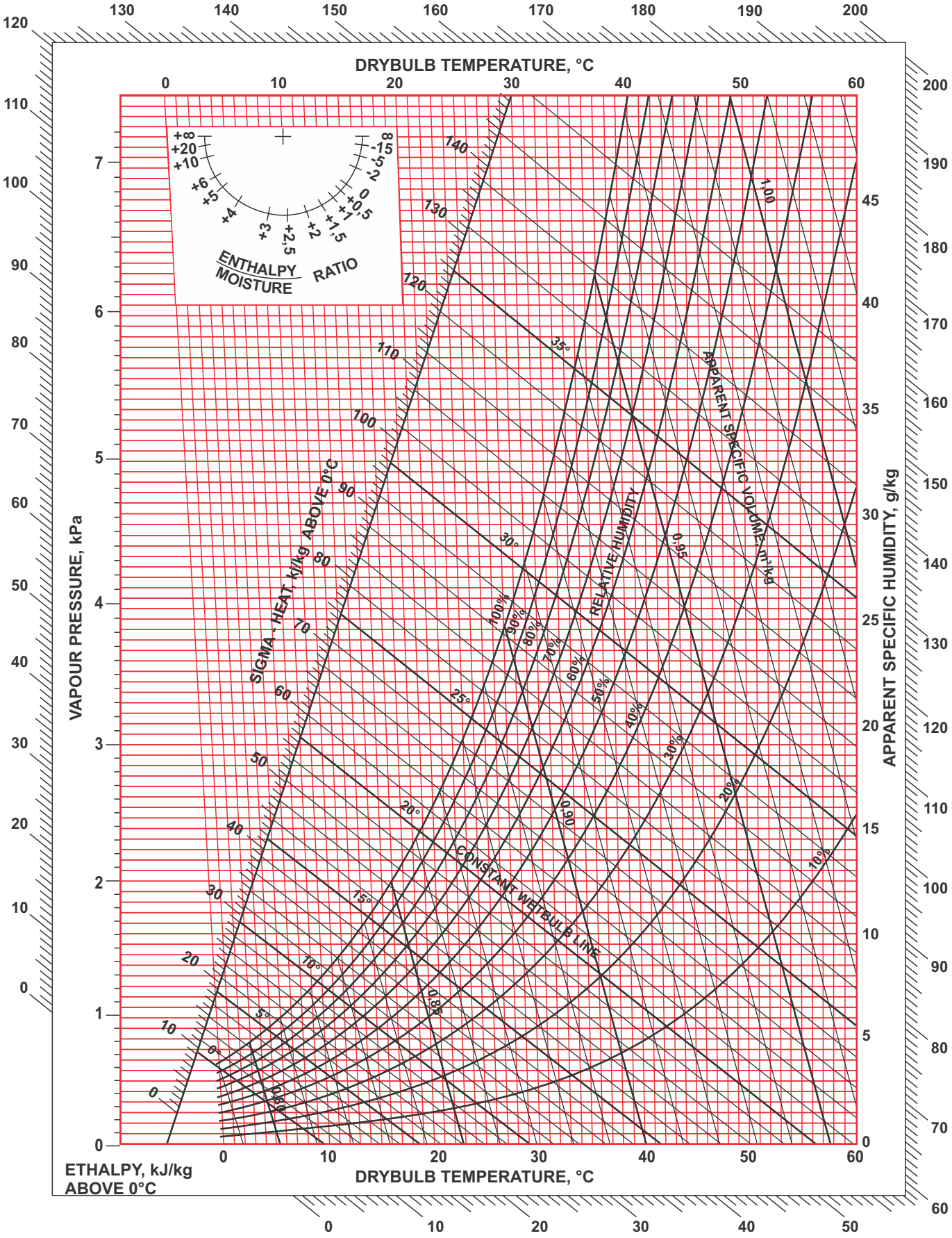
PSYCHROMETRIC CHART
85,0 kPa



A.W.T.B.

CHART NO 4
85,0 kPa

PSYCHROMETRIC CHART
100,0 kPa



A.W.T.B.

CHART NO 10
100,0 kPa

PSYCHROMETRIC CHART
102,5 kPa