Minerals Council South Africa

EXAMINATION MEMORANDUM

SUBJECT: CHAMBER OF MINES OF SOUTH AFRICA – INTERMEDIATE CERTIFICATE IN MINE ENVIRONMENTAL CONTROL PAPER 2 **SUBJECT CODE:** COMIMEC2 **EXAMINATION DATE:** MAY 2021 **TIME**: 14:30 – 17:30	**EXAMINER:** JJ PIENAAR **MODERATOR:** N. KRUGER **TOTAL MARKS:** 100 **PASS MARK:** 60

NUMBER OF PAGES: 12

SPECIAL REQUIREMENTS:
THIS IS **NOT** AN OPEN BOOK EXAMINATION. THERE IS **NO** FORMULA HANDOUT

INSTRUCTIONS TO CANDIDATES:

1. Answer all questions **legibly** in English.

Write your **ID number** on the outside cover of each book used and on any graph paper or other loose sheets handed in. **Psychrometric chart at 110.0 kPa and 112.5 kPa is provided for Question 3.**

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

2. Show all calculations **and check calculations on which the answers are based.**
3. Hand-held electronic calculators may be used for calculations.
4. Write **legibly** in ink on the **right hand page** only – **left hand pages will not be marked**.
5. Illustrate your answers by means of sketches or diagrams wherever possible.
6. Answers must be given to an accuracy which is typical of practical conditions.
   NB Ensure that the correct unit of measure (SI unit) are recorded as marks will be deducted from answers if the incorrect unit is used. (Even if the calculated value is correct).
7. In answering the questions, full advantage should be taken of your practical experience as well as data given.
8. Please note that you are not allowed to contact your examiner or moderator regarding this examination.
9. Cell phones are **NOT** allowed in the examination room.

QUESTION 1 **(Definitions)**

1.1. Define Heat stress (4)

Heat stress can be defined as environment measurements (½) of air temperature (½), air flow rate (½), the level of radiant heat exchange (½) (where applicable) and evaluation (½) of a person's metabolic (½) heat production rate (½) from exercise and / or work (½).

1.2. Define Charles' Law and give the formula including all SI units (4)

This law states, that at constant pressure (½), the volume (½) of a given mass of a gas (½) is directly proportional (½) to the absolute temperature (½).

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad (½)$$

Where V = Volume (m^3, m^3/s, m^3/kg) (½)

T = Absolute temperature (K) (½)

1.3. Define Dust (4)

Dust is a finely divided (½) solid matter (½) generated during the handling (½), grinding, crushing, rapid impact, blasting etc. (½). of organic (½) and inorganic substances (½) such as rock (½), ore, metal, wood etc. (½)

1.4. Define Inhalable dust (3)

Dust particles less than 50 microns (½) which can be inhaled (½), but will precipitate (½) on the mucous membranes (½) of the nose (½), throat and windpipe (½)

1.5. Define Respirable dust (3)

Dust particles smaller than 7 microns (½) which can be inhaled (½), but will penetrate (½) into the deepest recesses (½) of the lungs (½) and end up in the alveoli. (½)

1.6. Define Fumes (2)

Fumes are solid particles (½) generated by condensation (½) from a gaseous state (½) generally after evaporation from molten metals (½).

1.7. Define Smoke (RCD-Respirable Combustible Dust) (2)

Carbon or soot particles (½) less than 1 micron in size (½) and results from incomplete combustion (½) of carbonaceous material (½) such as coal, oil or diesel.

1.8. Define Health Threatening Occurrence (2)

Means any occurrence (½) that has or may have the potential to cause serious illness (½) or damage (½) to health. (½)

1.9. Define Risk (1)

Means the likelihood (½) that occupational injury or harm to a person will occur. (½)

Total Marks: (25)

QUESTION 2 **(Theory)**

2.1. Why is it important to electrically interconnect the force fan with the exhaust fan and why must other electrical appliances also be included? (2)

a) If the exhaust fan fails, the force fan will also stop automatically, in order to prevent re-circulation of the force fan. (1)

b) Other appliances in mechanically ventilated areas must also be interconnected with the fans to prevent accidental start-up in unventilated ends (1)

2.2. Name and describe the three routes of entry how toxic substances can enter the human body. (6)

Inhalation (1)

The respiratory route is the most common and probably the most important route of absorption in the workplace, because the worker inhales the air for the duration of his entire shift. (1)

Ingestion (1)

This route of entry is mostly the result of accidental swallowing a hazardous substance and being regarded as being of minor importance (1)

Skin Absorption (1)

Some hazardous substances, upon contact with the skin, are absorbed into the skin or bloodstream and transported to other parts of the body (1)

2.3. List and describe 2 kinds of latent heat. (4)

Latent Heat of Fusion (1)

That which causes a change of state of a substance from a liquid to a solid. e.g. Water that changes to ice. (1)

Latent Heat of Evaporation (1)

That which causes a change of state of a substance from a liquid to a vapour. e.g. water that changes into water vapour (1)

2.4. List three objectives of a detailed noise survey? (3)

Any three of the following: (3)

To obtain specific information on noise levels existing at each employees' work station.

To define areas where hearing protection will be required.

To develop guidelines for establishing engineering and / or administrative controls.

To develop engineering control policies and procedures.

To determine whether legal requirements have been complied with.

To adhere to a hearing conservation program.

2.5. Training is an essential feature of heat stress management, list four topics that should be covered in such training. (2)

Introduction to Heat Stress (½)

Recognition and Treatment of Heat Related Disorders (½)

Heat Stress Hygiene Practices (½)

Overview of Heat Stress Policy and Guidelines (½)

2.6. List the common causes of oxygen deficiency in underground workings (3)

Inadequate supply of ventilation or unventilated places (1)

Oxidation of certain substances which uses up oxygen (1)

Absorption of oxygen by or through chemical reactions (1)

2.7. List the control measures that can be implemented to prevent high dust exposures (5)

Removal of personnel (1)

Prevention of dust at source (1)

Dilution by ventilation (1)

Filtration (1)

Respirators (1)

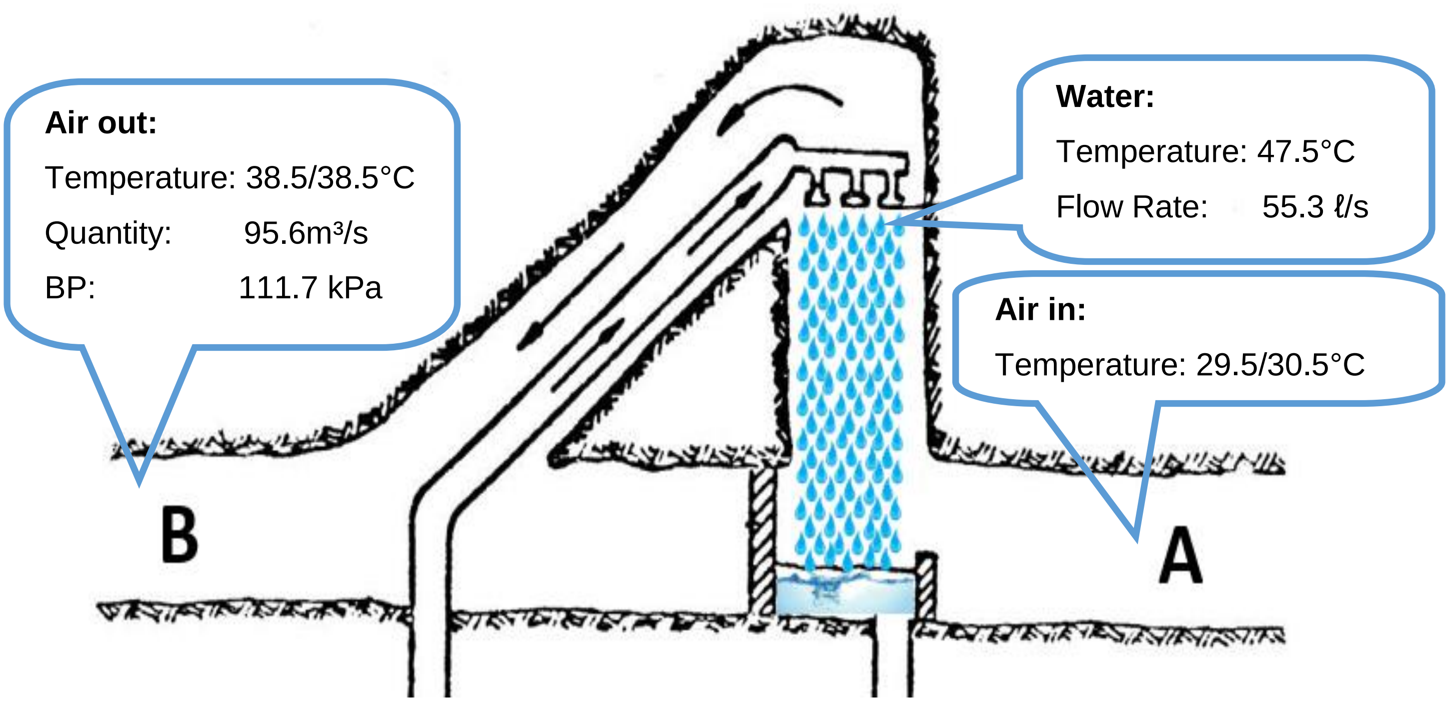
Total Marks: **(25)**

QUESTION 3 **(Psychrometry)**

NOTE! - Ensure that the correct units of measure **(SI unit)** are recorded as answers will be marked wrong if the incorrect unit is used, even if the value calculated is correct.
If psychrometric charts are not used with these questions, it will **NOT** be marked.

An air quantity of 95.6 m³/s flows through an underground condenser cooling tower, at point (B), at a temperature of 38.5/38.5°C and a barometric pressure of 111.7 kPa. The air is entering the condenser cooling at a temperature of 29.5/30.5°C, point (A). The water flow from the condenser is 55.3 l/s at a temperature of 47.5°C.

Using the attached Psychrometric Charts calculate the following:



3.1 State all values read of the chart and show all **interpolations** done. (10)

110.0 to 111.7 kPa		or	112.5 to 111.7 kPa	
111.7 – 110.0 = 1.7			112.5 – 111.7 = 0.8	
112.5 – 110.0 = 2.5			112.5 – 110.0 = 2.5	
1.7 / 2.5 = 0.68	(1)	or	0.8 / 2.5 = 0.32	(1)

Info from 110.0 kPa Chart, temperature 38.5/38.5°C
Sigma Heat (∑H) = 138.2 kJ/kg (½)
Apparent Specific Volume = 0.867 m³/kg (½)
Apparent Specific Humidity = 41.21 g/kg (½)

Info from 112.5 kPa Chart, temperature 38.5/38.5°C
Sigma Heat (∑H) = 135.8 kJ/kg (½)
Apparent Specific Volume = 0.846 m³/kg (½)
Apparent Specific Humidity = 40.23 g/kg (½)

Interpolation to 111.7 kPa for Point (B) at 38.5/38.5°C

110.0 to 111.7 kPa		Or	112.5 to 111.7 kPa	
Sigma heat				
138.0 – 135.6 = 2.4		Or	138.0 – 135.6 = 2.4	
2.4 x 0.68 = 1.63			2.4 x 0.32 = 0.77	
138.0 – 1.63 = 136.37 kJ/kg	(½)	Or	135.6 + 0.77 = 136.37 kJ/kg	(½)
Apparent Specific Volume				
0.867 -0.846 = 0.021		Or	0.867 -0.846 = 0.021	
0.021 x 0.68 = 0.014			0.021 x 0.32= 0.007	
0.867 - 0.014 = 0.853 m^3/kg	(½)	Or	0.846 + 0.007 = 0.853 m^3/kg	(½)
Apparent Specific Humidity (Moisture Content)				
41.21 – 40.23 = 0.98		Or	41.21 – 40.23 = 0.98	
0.98 x 0.68 = 0.67			0.98 x 0.32 = 0.31	
41.21 – 0.67 = 40.54 g/kg	(½)	Or	40.23 + 0.31 = 40.54 g/kg	(½)

Info from 110.0 kPa Chart, temperature 29.5/30.5°C
Sigma Heat (∑H) = 88.79 kJ/kg (½)
Apparent Specific Volume = 0.822 m^3/kg (½)
Apparent Specific Humidity = 23.90 g/kg (½)

Info from 112.5 kPa Chart, temperature 29.5/30.5°C
Sigma Heat (∑H) = 87.43 kJ/kg (½)
Apparent Specific Volume = 0.803 m^3/kg (½)
Apparent Specific Humidity = 23.34 g/kg (½)

Interpolation to 111.7 kPa for Point (A) at 29.5/30.5°C

110.0 to 111.7 kPa		Or	112.5 to 111.7 kPa	
Sigma heat				
88.79 – 87.43 = 1.36		Or	88.79 – 87.43 = 1.36	
1.36 x 0.68 = 0.92			1.36 x 0.32 = 0.44	
88.79 – 0.92 = 87.87 kJ/kg	(½)	Or	87.43 + 0.44 = 87.87 kJ/kg	(½)
Apparent Specific Volume				
0.822 – 0.803 = 0.019		Or	0.822 – 0.803 = 0.019	
0.019 x 0.68 = 0.013			0.019 x 0.32 = 0.006	
0.822 – 0.013 = 0.809 m^3/kg	(½)	Or	0.803 + 0.006 = 0.809 m^3/kg	(½)
Apparent Specific Humidity (Moisture Content)				
23.90 – 23.34 = 0.56		Or	23.90 – 23.34 = 0.56	
0.56 x 0.68 = 0.38			0.56 x 0.32 = 0.18	
23.90 – 0.38 = 23.52 g/kg	(½)	Or	23.34 + 0.18 = 23.52 g/kg	(½)

3.2. Calculate he amount of heat added to the air at point (B). (5)

Mass flow of air at point (B) (2)
M = Q / ASV
= 95.6 / 0.853
= 112.1 kg/s

$\Delta\sum H = \sum_o - \sum_i$
= 136.37 – 87.87
= 48.5 KJ/Kg (1)

Total heat (T) = Mass flow x $\Delta\sum H$
T = M x $\Delta\sum H$
= 112.1 x 48.5
= 5437 kW (2)

3.3. Calculate the air quantity at Point (A). (3)

Mass flow of air at point (B) = Mass flow of air at point (A) (1)

M = Q / ASV
Q = M x ASV (1)
= 112.1 x 0.809
= 90.7m³/s (1)

3.4. Calculate the temperature of the water returning from the condenser cooling tower (state any assumptions made). (5)

Heat added to the air = heat removed from the water = 5437 kW (1)

$q = M \times C_p \times \Delta t$ (1)
$\Delta t = q / (M \times C_p)$
= 5437 / (55.3 x 4.187)
= 23.5°C (1)

$\Delta t = (t_i – t_o)$ (1)
$t_o = t_i – \Delta t$
= 47.5 – 23.5
= 24.0°C (1)

3.5. Calculate the amount of water condensed out or evaporated into the air at point (B) in ℓ/h. (5)

Moisture content of air entering cooling tower = 23.52 g/kg
Moisture content of air leaving cooling tower = 40.54 g/kg

$\Delta mc = mc_o - mc_i$
= 40.54 – 23.52
= 17.02 g/kg (1)

Amount of water condensed = (M x Δmc) / 1000 (1)
= (112.1 x 17.02) / 1000
= 1.91 ℓ/s (1)

Amount of water condensed in litres per hour (ℓ/h)
= 1.91 x 60 x 60 (1)
= 6868 ℓ/h (1)

3.6. State whether water is condensed out of or evaporated into the air at point (B) and give your reason. (2)

Water evaporated into the air (1)
There is an increase in moisture content or the air temperature has increased. (1)

Total Marks: (30)

QUESTION 4 **(General Calculations)**

4.1. An underground tip has an open area of 0.8m x 5.4m.
a) Using the downcast velocity of 1.0 m/s for the tip calculate the amount of air that is required to effectively filtrate the air by means of a fabric filter. (2)

Area of tip = length x width
= 0.8 x 5.4
= 4.3 m^2 (1)

Air quantity down tip = Area x velocity
= 4.3 x 1.0
= 4.3 m^3/s (1)

b) If the area of one filter bag is 1.288 m^2 how many bags will be required to effectively filtrate the air at a typical filter velocity of 0.1 m/s. (2)

Air quantity through one bag = area x velocity
= 1.288 x 0.1
= 0.1288 m^3/s (1)

Number of bags = Qty down tip / Qty through one bag
= 4.3 / 0.1288
= 33 bags (1)

4.2. 50m^3/s of air enters a bulk air cooler at 29.0/31.0°C. Calculate the temperature of the air leaving the bulk air cooler assuming that the pressure remains constant, the air leaving is saturated and 3.0m^3/s re-circulates through the bulk air cooler fans. (4)

$V1/T1 = V2/T2$ (1)
T1 = 273 + 29.0 = 302K
And V2 = 50 – 3 = 47m^3/s (1)
Then T2 = (V2T1) / V1 (1)
= (47 x 302) / 50
= 284K
= 284 - 273°C
= 11°C (1)

4.3. The following information was obtained from a gravimetric dust sample taken underground: (9)

Pump flow rate:	2.2ℓ/min
Pump Running time:	Start Time 05:00, Stop Time 13:50
Pre weighed filter mass:	20.88mg
Post weighed filter mass:	21.14mg
Control filter pre weighed filter mass:	20.00mg
Control filter post weighed filter mass:	20.09mg
Silica content of sample:	20.0%

Determine the following:

4.3.1. Average Flow rate and sample time.

Flowrate	= 2.2ℓ/min	
Sample time	= Convert hours to minutes	
Minutes	= (hours x 60) + minutes	
	= (8 x 60) + 50	
	= 530 minutes	(1)

4.3.2. Sample volume.

Volume of air sampled	= (2.2ℓ/min x 530) / 1000	
	= 1166ℓ / 1000	
	= 1.166m^3 (of air)	(1)

4.3.3. Correction filter mass (Correction factor)

Corrected mass	= Post filter mass – Pre filter mass	
	= 20.09 – 20.00	
	= 0.09mg	(1)

4.3.4. Sample Mass.

Sample mass	= Post weight – Pre weight	
	= 21.14 – 20.88	
	= 0.26mg	(1)

4.3.5. Corrected sample mass.

Corrected mass	= Sample mass – Correction factor	
	= 0.26 – 0.09	
	= 0.17mg	(1)

4.3.6. Sample concentration.

Sample concentration	= Corrected sample mass / Sample volume	
	= 0.17 / 1.166	
	= 0.146mg/m^3	(1)

4.3.7. TWA sample concentration.

TWA	= sample concentration x (total sampling time (min) / 480)	
	= 0.146 x (530 / 480)	
	= 0.161mg/m^3	(1)

4.3.8. Pollutant Concentration.

Pollutant Concentration	= TWA sample concentration x (% pollutant / 100)	
	= 0.0.161 x (20.0 / 100)	
	= 0.032mg/m^3	(1)

4.3.9. Air Quality Index.

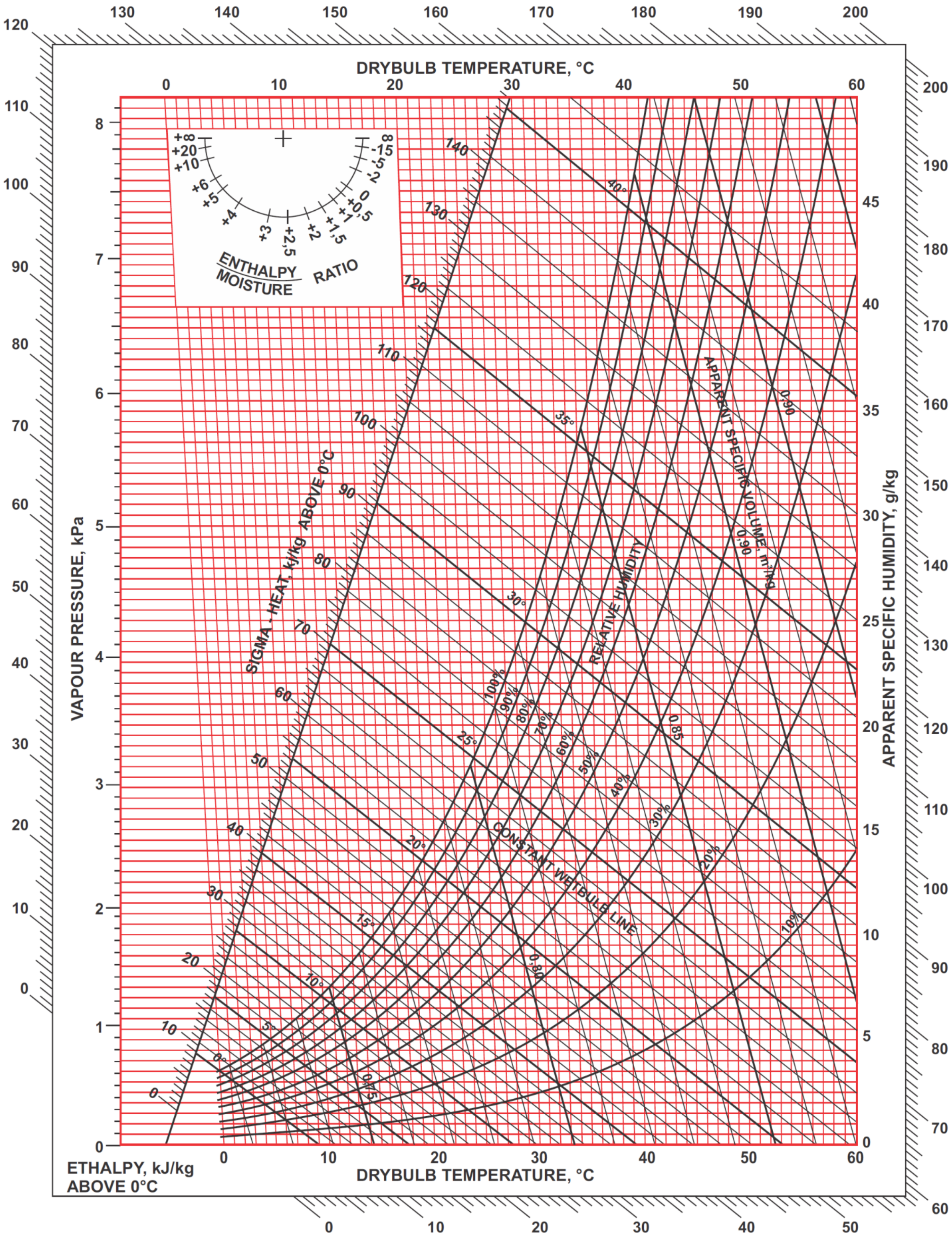
AQI = Pollutant concentration / OEL
= 0.032 / 0.1
= 0.322mg/m³ (1)

4.4. Determine the wind chill factor for a surface downcast shaft at an average velocity of 13.9 m/s and a temperature of 0.0 / 5.0°C. (3)

$WCET = 33 - (10.45 + 10\sqrt{V} – V) x (33 – T) / 22.04$ (1)
$= 33 - (10.45 + 10\sqrt{13.9} – 13.9) x (33 – 5) / 22.04$ (1)
= 33 - (33.8 x 28.0) / 22.04
= 33 – 42.9
= -9.9°C (1)

Total Marks: (20)

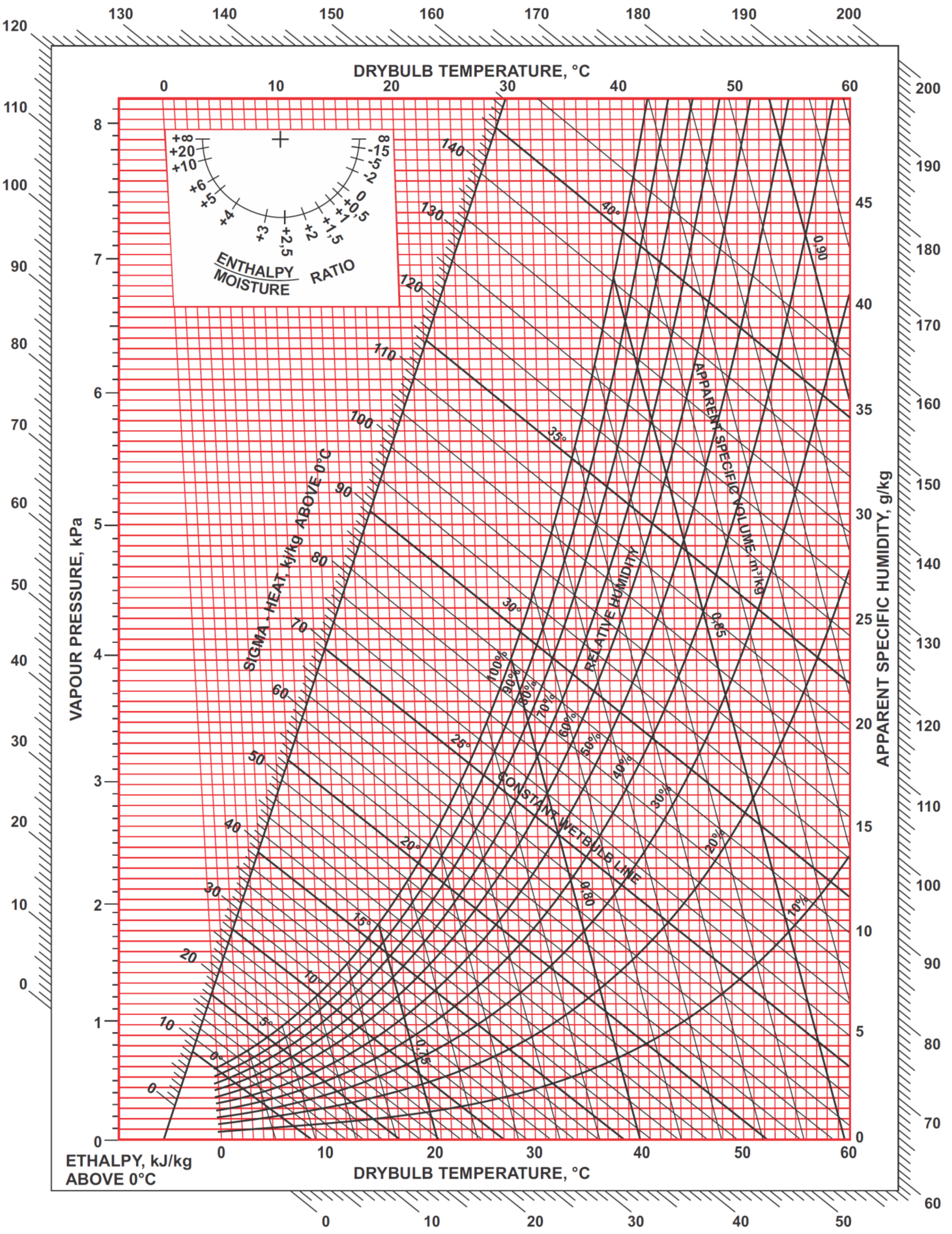
PSYCHROMETRIC CHART
110,0 kPa



A.W.T.B.

CHART NO 14
110,0 kPa

PSYCHROMETRIC CHART
112,5 kPa



A.W.T.B.

CHART NO 15
112,5 kPa