National Exams December 2016

09-MMP-A2, Underground Mining Methods and Design

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. One only reference sheet, 8.5 x 11 inch, hand written both sides is allowed in the exam. This is not an open book exam, therefore only the approved Sharp or Casio type calculators are permitted.

3. Compulsory Question 1 (Section A) and THREE (3) other questions constitute a complete exam paper.
   Only Section A question 1, the chosen two questions from Section B and the chosen question from Section C, as they appear in the answer book, will be marked. You must select three questions from the "optional" Questions 2 to 6, two from Section B and one from Section C.

4. Compulsory Question 1 is worth 40 marks. Each optional question 2 to 6 is of equal value (20 marks). Three optional questions plus Question 1 constitute a complete exam paper.

5. Many questions require an answer in essay format. Clarity and organization of the answer are important. Use large full page neat sketches and drawings to illustrate your answers when possible.

6. Make sure your diagrams etc. are at least half a page and clearly legible. Thumbnail sketches are not acceptable.

Section A Compulsory General Underground Mining Question 1 (40 marks)

You must answer **all** *of this question, parts 1.1 to 1.6 inclusive*

Question 1.1 (7 marks) ***answer compulsory***

1.1 Mine Backfill

Describe and compare, with examples of usage and mining methods, the following backfill systems. Include size distribution of the fill where appropriate, including any binding agents ;

1.1.1 Cemented waste rock. (2 marks)

1.1.2 Mill tailings. (2 marks)

1.1.3 Paste fill. (3 marks)

Question 1.2 (7 marks) ***answer compulsory***

1.2 Mining Hoists

1.2.1 The following are four typical mine hoist designs in regular use. Draw a neat sketch of each type/application and compare the advantages and disadvantages of each and any practical variations . (1 mark each)

1.2.1.1 Single drum
1.2.1.2 Double drum
1.2.1.3 Friction (Koepe)
1.2.1.4 Blair multi-rope hoist.
1.2.1.5 What do you understand by the term 'creep' as applied to mine hoisting

1.2.2 Discuss the applications of the Blair hoist, and describe situations where it may be used to advantage (2 marks)

Question 1.3 (7 marks) ***answer compulsory***

1.3 Mine Ventilation

1.3.1 What do you understand by the terms latent heat and sensible heat. (3 marks)

Section A Question 1 Compulsory General Underground Mining Question 1.3 Continued

1.3.2 How are wet and dry bulb temperatures determined and how are the values obtained used in maintaining a good working environment for miners. (2 marks)

1.3.3 What are Kirchoff's Laws and how are they applied to series and parallel ventilation circuits. (2 marks)

Question 1.4 (7 marks) ***answer compulsory***

1.4 Costs

In the context of underground mine cost estimating, what do you understand by the following terms, and describe the function and development of these terms.

1.4.1 The Marshall and Swift Mine/Mill cost index (M&S M/M) (2 marks)

1.4.2 The "six tenths rule" (the rule may also be referenced as the 2/3 or 0.7 rule depending on the practitioner) (3 marks)

1.4.3 The "O'Hara Method" from the CIM Bulletin, February 1980. (2 marks)

Question 1.5 (6 marks) ***answer compulsory***

1.5 Mining Methods Room and Pillar Mining

Discuss the geology, geometry and rock strength issues applicable to room and pillar mining. (3 marks)

Provide neat full page sketches showing the development and stopes and show how rock is moved to ore passes (3 marks)

Question 1.6 (6 marks) ***answer compulsory***

1.6 Mining Methods Vertical Crater Retreat (VCR)

Discuss the geology, geometry and rock strength issues applicable to the vertical crater retreat mining method. (3 marks)

Provide neat full page sketches showing the development and stopes and show how rock is moved to ore passes. (3 marks)

Section B 2 of the 3 Questions in this section must be chosen

Maximum Questions to be Answered is Four (including Compulsory Question 1 Section A)

Optional Question 2 Section B (20 marks)

This is one of three optional questions worth 20 marks each. Do not answer this question if it is not one of the 2 questions you have chosen to answer from Section B (questions 2, 3 and 4).

Mine Hoisting

A 500 tonne/hr shaft is 425 m deep (550 ST short tons/hr, 1395ft). It is equipped with a skip of 12 tonnes (empty plus attachments) which carries a 10 tonne load (13ST, 11ST)

You may assume the drum/rope diameter ratio is 108. Wire ropes are available in 47.6, 50.8, 54.0, and 63.5 mm diameters (nominal 1.875, 2.0, 2.125 and 2.25 inch).

Assume a locked coil rope with a breaking load (tonnes) of 0.07625 times rope diameter squared in mm's. (50xdxd long tons, where rope diameter d is in inches) , and length (shaft + head-frame) = 450m. (1475 ft)

The weight of rope (kg/m) is 0.00577 times rope diameter squared in mm. (2.5xdxd lbs/ft where d is rope diameter in inches).

The shaft winds rock for 10 hours per day and there is another skip on another drum returning as the skip referred to in the question is hoisting. Assume that the returning skip has no influence on the HP required for the hoisting skip.

Use 10 seconds decking (loading plus dumping), and 12 seconds acceleration and 12 seconds deceleration time.

Assume linear acceleration and deceleration.

Assume the electrical driving motor has 8 pairs of poles and is attached to the hoist via a gear box. Answer the following (1.5 marks each unless noted)

2.01 what is the rope diameter (1 mark)

2.02 what is the weight of the rope (1 mark)

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Section B Question 2 Mine Hoisting Continued

2.03 what is the drum diameter

2.04 how many winds/hr and what is the cycle time

2.05 neatly draw the velocity (y) versus time (x) diagram (neatly on at least a ½ page) (1 mark)

2.06 find the "steady state" hoisting velocity. For this calculation assume linear acceleration and deceleration, and that the hoisting velocity is constant.

2.07 what are the maximum revs/min of the hoist drum.

2.08 what is the average linear acceleration

2.09 what is the average angular acceleration of the drum

2.10 what is the motor speed at "steady state" (1 mark)

2.11 what is the gear box ratio required at "steady state"

2.12 what is the maximum static load on the rope (1 mark)

2.13 what is the estimated horse power required at "steady state" (often described as $HP(M)_3$) where (M) refers to metric (1 imperial HP is 1.014 metric HP)

2.14 what is the horse power required to accelerate the maximum static load assuming linear acceleration (often described as $HP(M)_1$)

2.15 what is the estimated maximum horsepower HP(M) required

(2.01, 2.02, 2.05, 2.10, 2.12, 1 mark each, remainder 1.5 marks each)

Total 20 marks

Section B 2 of the 3 Questions in this section must be chosen

Maximum Questions to be Answered is Four (including Compulsory Question 1 Section A)

Optional Question 3 Section B (20 marks)

This is one of three optional questions worth 20 marks each. Do not answer this question if it is not one of the 2 questions you have chosen to answer from Section B (questions 2, 3 and 4).

Mine Ventilation

3.1 Two methods of cooling-dehumidification of mine air are,

3.1.1 Refrigeration

3.1.2 Cooling Towers

In each case, describe a typical application and components, and emphasize the physical process of how the heat is removed from the cooling units. (10 marks)

3.2 What do you understand by 'enthalpy' and the 'psychrometric chart'. Sketch a graph of dry bulb temperature versus water content of dry air (grains/lb) showing a typical 'start point' and how the processes of such as cooling, evaporation and drying (thermodynamics) affect the original start point. (3 marks)

3.3 A fan pulls air across a cooling coil at sea level. The air is cooled and dehumidified from 32.2 ^{0}C (90 ^{0}F) dry bulb (DB) and 26.7 ^{0}C (80 ^{0}F) wet bulb to 21.1 ^{0}C (70 ^{0}F) saturated.

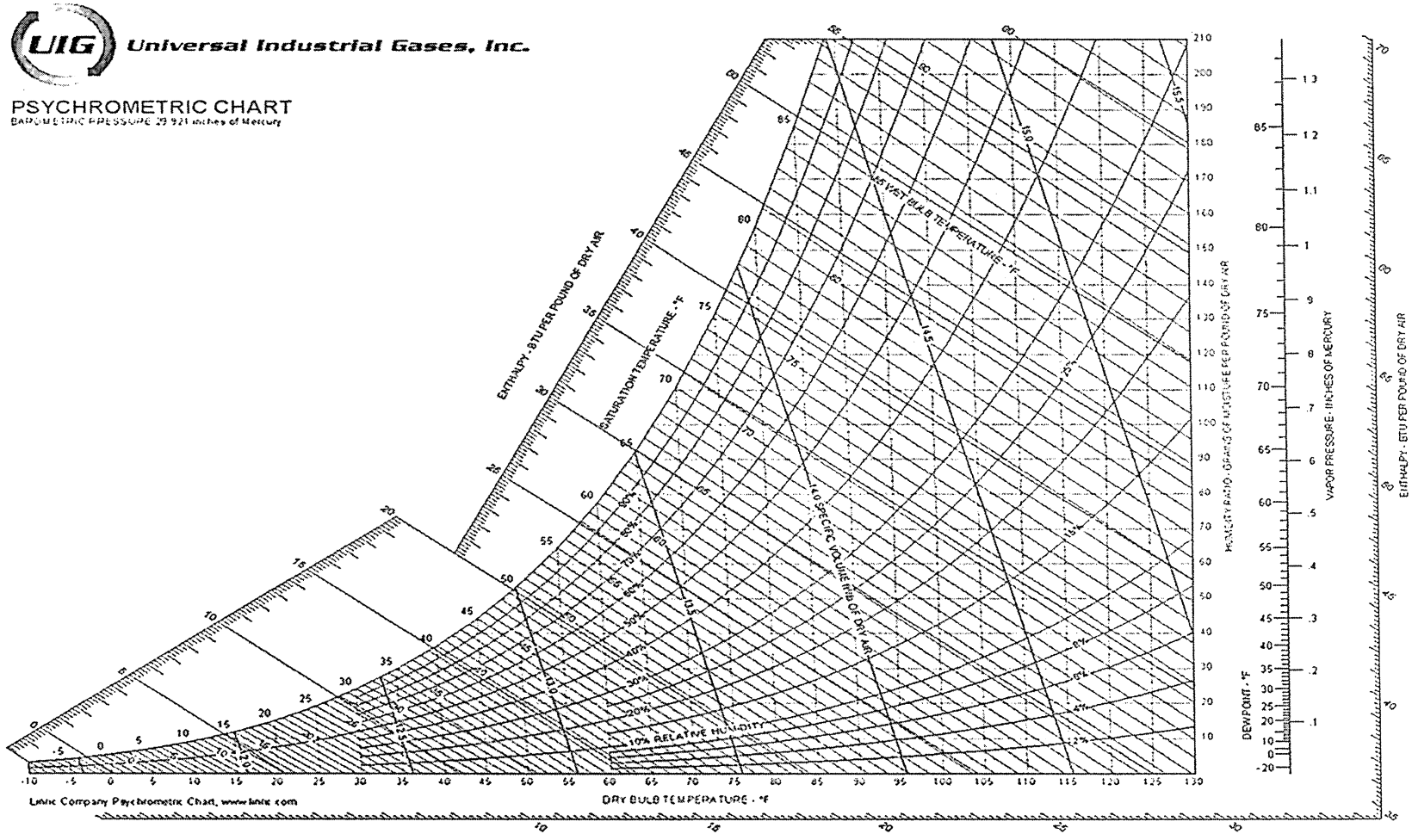
3.3.1 Sketch the process on a psychrometric chart drawn by you for the purpose of understanding what is happening to the air. (3 marks)

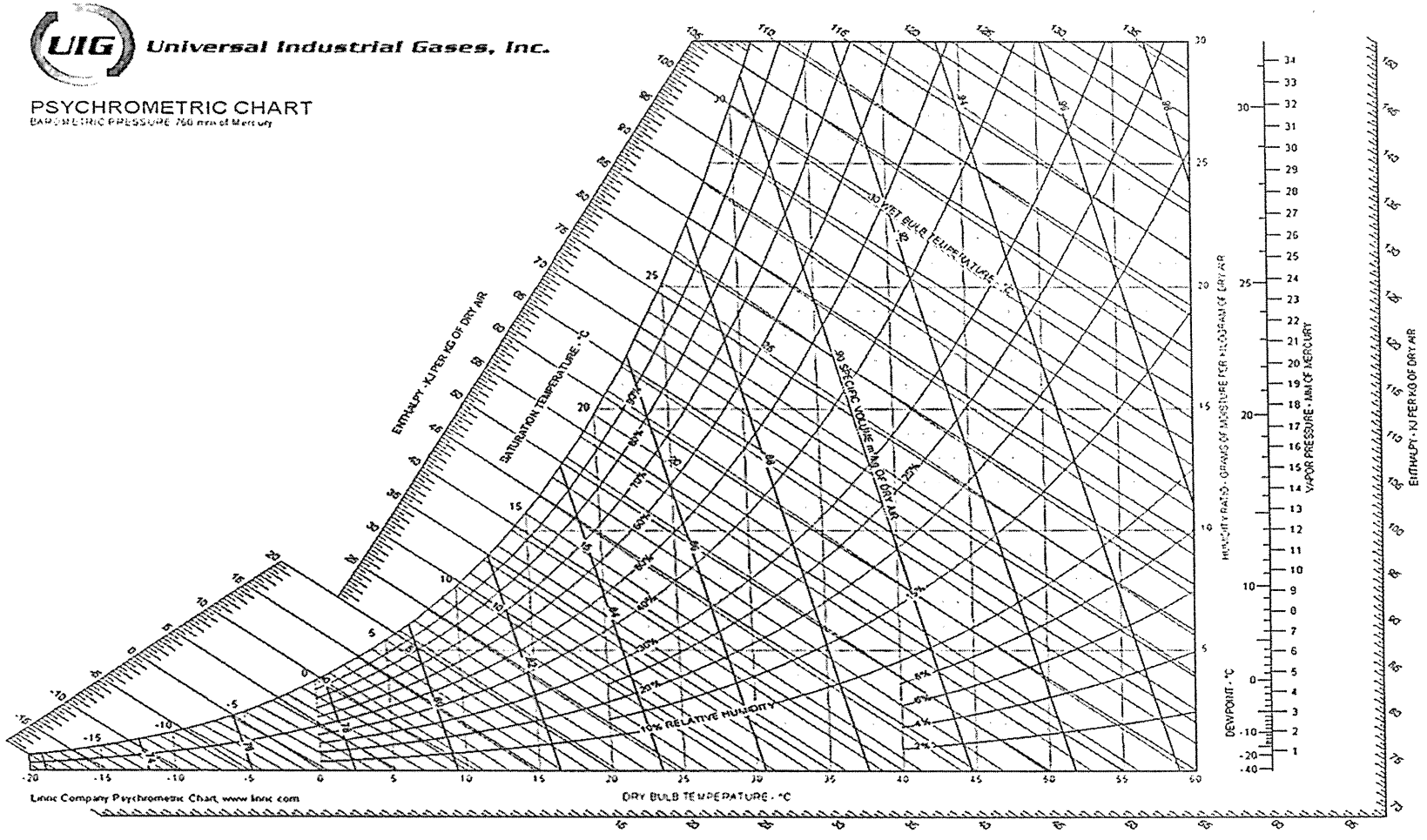
3.3.2 Determine the change in heat (W or Btu/hr) (2 marks)
(1 Btu/hr = 0.293 Watts) (1 lb/hr = 1.26×10^{-4} kg/s) (7000 grains = 1lb) (1 BTU = 1.055 kJ)

3.3.3 Determine the moisture content of the expelled air (kg/s or lbs/hr) (2 marks)

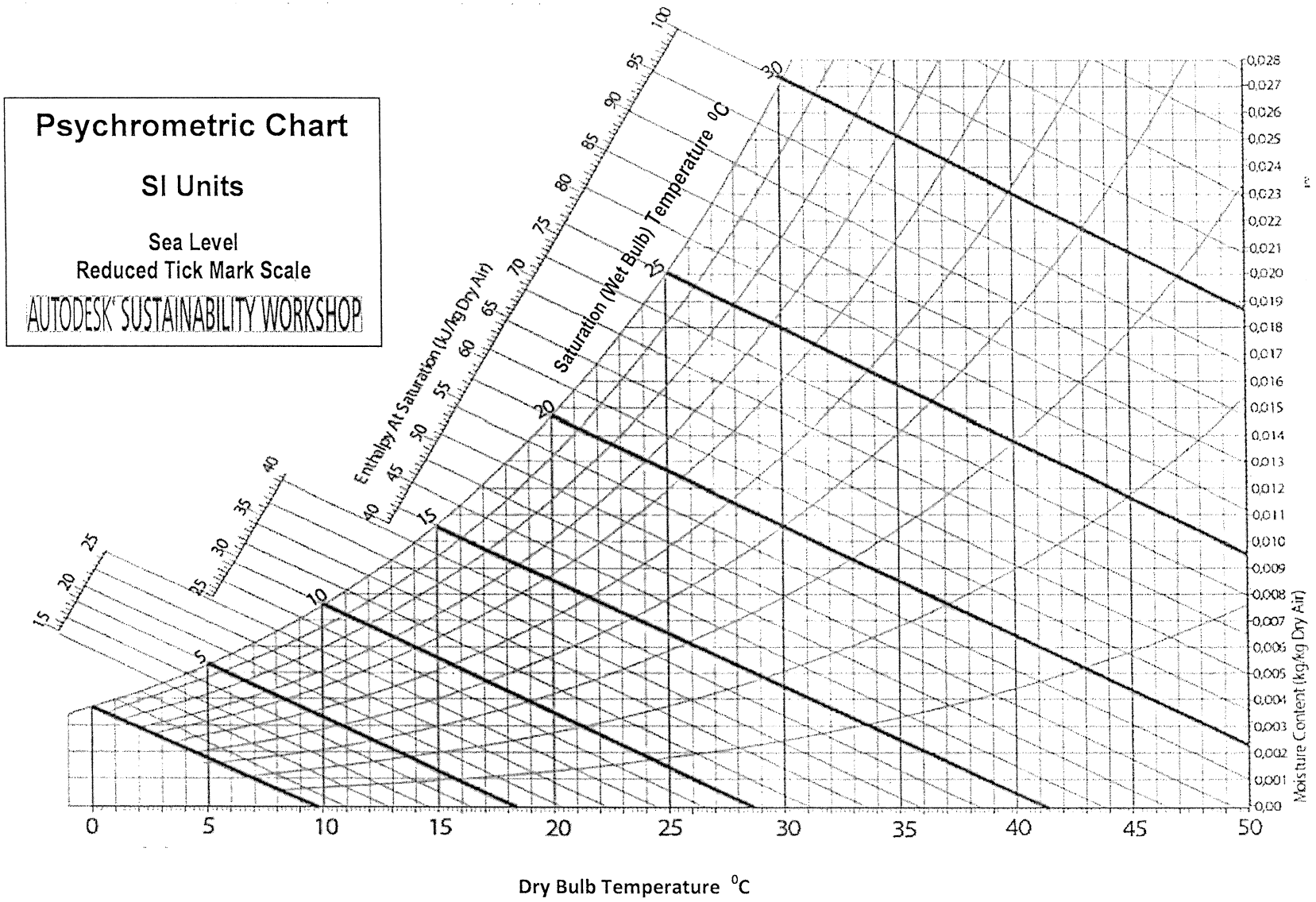
Psychrometric charts are attached, both metric and US imperial on Pages 8, 9 and 10. Page 10 is included in order to better see, understand and read the scales.

Note these formulae **may** be of use $q=G(h_1 - h_2)$ and $G_w=(1) * (W_1 - W_2)$


Universal Industrial Gases, Inc.
PSYCHROMETRIC CHART
BAROMETRIC PRESSURE 29.921 inches of Mercury
DRY BULB TEMPERATURE - °F
DEWPOINT - °F
VAPOR PRESSURE - INCHES OF MERCURY
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE - °F
WET BULB TEMPERATURE - °F
10% RELATIVE HUMIDITY
Linric Company Psychrometric Chart, www.linric.com



Section B Question 3 Psychrometric Chart SI Units


Psychrometric Chart
SI Units
Sea Level
Reduced Tick Mark Scale
AUTODESK SUSTAINABILITY WORKSHOP
Enthalpy At Saturation (kJ/kg Dry Air)
Saturation (Wet Bulb) Temperature °C
Moisture Content (kg/kg Dry Air)
Dry Bulb Temperature °C

Section B 2 of the 3 Question in this section must be chosen

Maximum Questions to be Answered is Four (including Compulsory Question 1 Section A)

Optional Question 4 Section B (20 marks)

This is one of three optional questions worth 20 marks each. Do not answer this question if it is not one of the 2 questions you have chosen to answer from Section B (questions 2, 3 and 4).

Mine Cost Estimation

This question refers to data from the United States (Camm, T.W. (USBM),1989) and the units are US Imperial and US dollars as of 1989. Answers are expected in US dollars for 1989 in 4.1 and 4.2, and escalated to 2008 US $ in 4.3 for a pre-feasibility study of a 20,000 short ton per day (st/d) block caving mining operation.

4.1 Table 4.1 refers to the capital and operating costs of a shaft to be sunk to a nominal 2000 foot level. What are the shaft capital and operating costs for 1989 based on the Table 4.1 for the 20,000 short ton/day operation. Comment on each of the component values found and the adequacy of the models in each case. (7 marks)

Table 4.1. Underground mine model depth factors for year 1989 (Capacity range 100 - 40,000 st/d)		
Category	Capital cost, $	Operating cost, $/st
Labor	$+75(D)(X)^{0.399}$	$+2{,}010/(X)$
Equipment	$+350(X)+65(D)(X)^{0.386}$	$+0.325(D)/(X)$
Steel	$+25(D)(X)^{0.373}$	$+0.00014(D)$
Lumber	Nap	Nap
Fuel	Nap	Nap
Lube	$+6(D)(X)^{0.342}$	$+0.090(D)/(X)$
Explosives	$+5(D)(X)^{0.389}$	Nap
Tires	Nap	Nap
Construction material	$+9(D)(X)^{0.522}$	$+200/(X)$
Electricity	$+4(D)(X)^{0.230}$	$+0.0014(D)$
Total	$+371(X)+180(D)(X)^{0.404}$	
D = Depth of shaft to bottom of ore body in feet		
NAp = Not Applicable		
X = Capacity of mine in short tons per day		

Section B Question 4 Mine Cost Estimation Continued

4.2 The mine will use the block caving method for the material between 1000 and 2000 feet and hoist the rock from the nominal 2000 foot deep shaft described in part 4.1 above. What are the mining (excluding shaft related costs found in 4.1) capital and operating costs for 1989 based on the Table 4.2 for the 20,000 st/d operation. Comment on each of the values found and the adequacy of the models in each case. (8 marks)

Table 4.2 Block caving mine model, base case for year 1989 (Capacity range 4,000 - 40,000 st/d)		
Category	Capital cost, $	Operating cost, $/st
Labor	$27{,}900(X)^{0.646}$	$60.0(X)^{-0.305}$
Equipment	$25{,}600(X)^{0.812}$	$4.40(X)^{-0.230}$
Steel	$4{,}410(X)^{0.685}$	$0.217(X)^{0.0}$
Lumber	$149(X)^{0.902}$	$0.310(X)^{0.0}$
Fuel	$10.6(X)^{0.897}$	$0.894(X)^{-0.239}$
Lube	$4.54(X)^{0.897}$	$0.545(X)^{-0.253}$
Explosives	$1{,}040(X)^{0.737}$	$0.183(X)^{-0.0}$
Tires	$1.87(X)^{0.946}$	$0.412(X)^{-0.151}$
Construction material	$31{,}100(X)^{0.591}$	$2.83(X)^{-0.182}$
Electricity	$50.4(X)^{0.748}$	$1.36(X)^{-0.060}$
Total	$64{,}800(X)^{0.759}$	$48.4(X)^{-0.217}$
X = Capacity of mine in short tons per day		

4.3 Typical cost escalation factors for the period 1989 to 2008 are given in Table 4.3. What are the total shaft and total mining capital and operating costs for 2008 for the 2000 ft deep project at the 20,000 st/d capacity. Comment on the adequacy of the cost estimates for 2008. (5 marks)

Table 4.3 Underground Mine

Year	Capital Cost Index	Operating Cost Index
1989	56.9	91.1
2008	98.7	141.9

Section C One Question in this section may be chosen

Maximum Questions to be Answered is Four (including Compulsory Question 1 Section A)

Optional Question 5 Section C (20 marks)

This is one of three optional questions worth 20 marks each. Do not answer this question if it is not the question you have chosen to answer from Section C (questions 5 and 6)

Cut & Fill and Longhole Mining Methods

Compare and contrast the cut & fill and longhole mining methods with special emphasis on the following;

- Geology, orebody shape, size and orientation
- Host and ore rock properties
- Development size, amount, cost and time taken to start extraction
- Ground support
- Mining sequence and mill feed rate
- Number and skills of mining personnel
- Types and numbers of mechanized equipment
- Cost of mining
- Mine life
- Mining rate
- Dilution and recovery
- Methods and costs of any pillar recovery
- Post mining stabilization

Your answer may be in table format if you feel this makes your answers more understandable.

(1.5 marks each plus 0.5 for clarity)

Section C One Question in this section may be chosen

Maximum Questions to be Answered is Four (including Compulsory Question 1 Section A)

Optional Question 6 Section C (20 marks)

This is one of three optional questions worth 20 marks each. Do not answer this question if it is not the question you have chosen to answer from Section C (questions 5 and 6)

Shrinkage and Sub-Level Caving Mining Methods

Compare and contrast the shrinkage and sub-level caving mining methods with special emphasis on the following;

- Geology, orebody shape, size and orientation
- Host and ore rock properties
- Development size, amount, cost and time taken to start extraction
- Ground support
- Mining sequence and mill feed rate
- Number and skills of mining personnel
- Types and numbers of mechanized equipment
- Cost of mining
- Mine life
- Mining rate
- Dilution and recovery
- Methods and costs of any pillar recovery
- Post mining stabilization

Your answer may be in table format if you feel this makes your answers more understandable.

(1.5 marks each plus 0.5 for clarity)

Be sure you have Answered Only

Section A, Question 1

Your choice of 2 questions from the three in Section B

Your choice of 1 question from the two in Section C

End of Exam