T2170(E)(N20)T
NOVEMBER 2003

NON-NATIONAL CERTIFICATE:
ENGINEERING CERTIFICATE OF COMPETENCY

PLANT ENGINEERING: MINES AND WORKS

(8190306)

20 November (X-Paper)
09:00 – 12:00

DEPARTMENT OF EDUCATION

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NON-NATIONAL CERTIFICATE:
ENGINEERING CERTIFICATE OF COMPETENCY
PLANT ENGINEERING: MINES AND WORKS
TIME: 3 HOURS
MARKS: 100

NOTE: If you answer more than the required number of questions, only the required number of questions will be marked. Al work you do not want to be marked, must be clearly crossed out.

INSTRUCTIONS

1. This is NOT an open-book examination. Candidates are NOT allowed to use any notes, textbooks or reference works during the examination.

2. Rule off on completion of each answer.

3. Answers must be clearly and correctly numbered. Answers written in pencil will not be marked. Illegible handwriting will NOT be marked.

4. Examination results will be disqualified if the candidate has not been accepted by the Commission of Examiners prior to the examination.

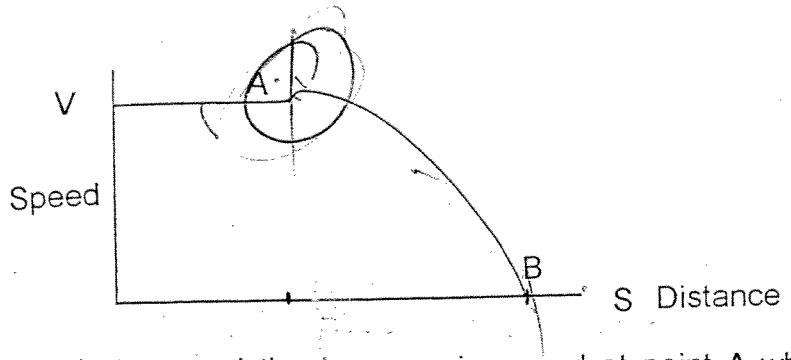
5. Candidates arriving 30 minutes late, will not be allowed to sit for the examination. No candidate writing the examination may leave the examination room before one hour after commencement has elapsed.

6. Show ALL the calculations.

SECTION A (COMPULSORY)

QUESTION 1

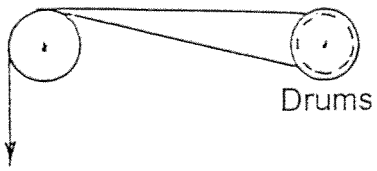
1.1 The following speed-distance curve was drawn during a dynamic test on a winder to ensure that the winder complies with the directive 'Dynamic Tests for Winding Installations' from the Chief Inspector, Department of Minerals and Energy.

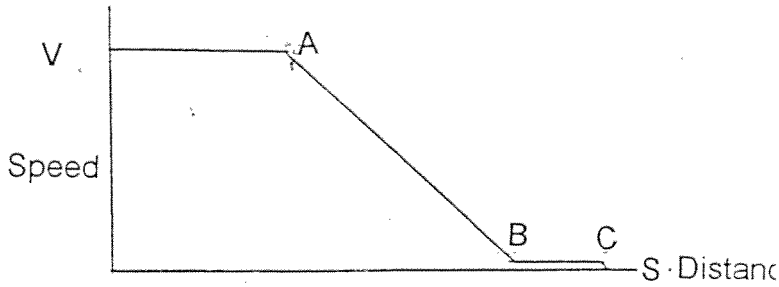


1.1.1 Explain what caused the increase in speed at point A when the winder trips and what should be done to rectify the phenomenon.

1.1.2 What is the importance of the stopping point B in the test? (6)

1.2 The two sheave wheels in a men-material subvertical shaft, equipped with an AC double drum winder, have to be replaced. The appointed engineer specified that the new rim design be heavier for an extended life.





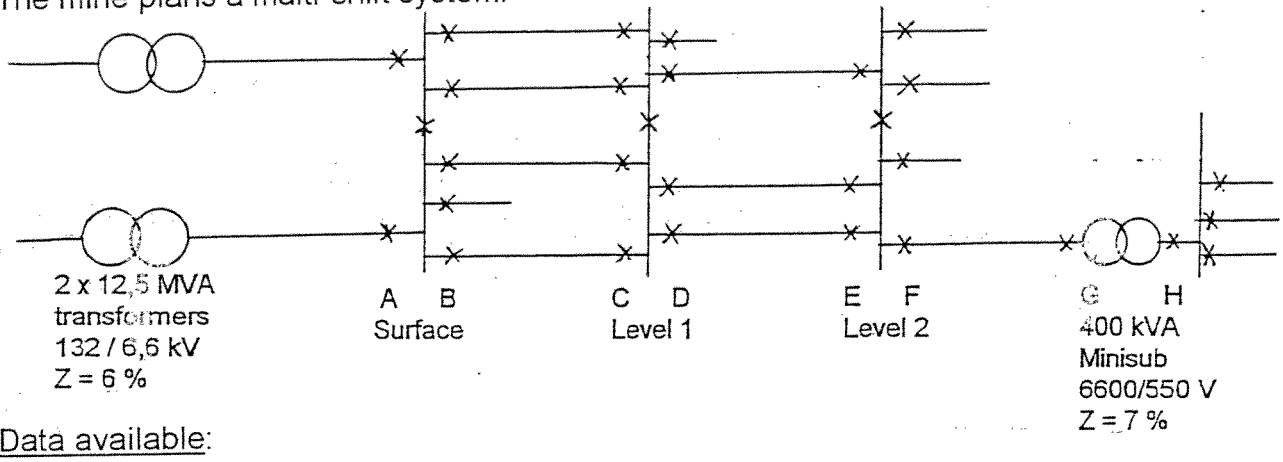
Winding parameters

Full speed	10 m/s
Winding distance	400 m
Mass of empty cage	5 t
Pay load	3,5 t
Rope mass	5,823 kg/m
Rope diameter	37 mm
Average deceleration	1,5 m/s^2
Creep speed	0,5 m/s
Distance BC	1,2 m
Diameter of new sheave wheel	3 m
Mass of new sheave wheel	1 800 kg
Inertia of new sheave wheel	20 000 kg/m^2
Friction factor between rope and sheave wheel	0,25
Distance between highest stopping point and the sheave wheel	7 m
Smallest contact angle	100°

What is the influence of the change of velocity at points A and B on the curve with an empty cage coming up, on the life of the ropes? The calculated deceleration rates at these points are 2,5 m/s^2 for 0,5 m. Do you have any suggestions for improvements?
Base the conclusions on calculations. (14)
[20]

QUESTION 2

Newly developed workings of a mine are to be equipped with electric power from the surface substation at the shaft head as shown in the diagram. The surface substation is equipped with two 12,5 MVA transformers and the high voltage side could be regarded as an infinite bus. All the bus couplers between the transformers usually remain open. The working of the mine consists of two levels, 150 m and 300 m below the surface and are accessible via an incline shaft at an angle of 12°, designed for rubber tyre vehicles.
The mine plans a multi-shift system.



Data available:

Horizontal distances of substations:

Transformers to surface substation	30 m
Surface substation to shaft head	60 m
Level 1 substation to station	40 m
Level 2 substation to station	50 m
Minisubstation to level 2 substation	200 m

Average currents at the incoming breakers of the substations:

	Load	Load factor
Surface, breaker A	850 A	0,90
Level 1, breaker C	210 A	0,60
Level 2, breaker E	70 A	0,80
Minisubstation, breaker G	24 A	0,75

Calculate:

2.1 The lengths and sizes of the cables to be installed on a cable rack from the transformer to the minisubstation. Oversize cables will be penalised. (8)

2.2 The 3-phase symmetrical fault currents for:

The surface breaker B with a fault at the shaft head
The breaker F with a fault in the HT fuses of the minisubstation
The breaker H with a fault in the busbars at the low voltage side of the minisubstation (12)
[20]

QUESTION 3

3.1 Your mine purchased a load haul dumper (LHD) for use in a coal mine. You are tasked to ensure that the requirements for the environment and the potential hazards, while using such a machine, are properly identified and rated in terms of the probability of it happening and the consequence of such an accident. Also recommend how the risks associated with the hazards, will be managed.
A structured approach with TWO or THREE examples will suffice. (12)

3.2 You have been appointed on an old mine where the operational cost is kept under strict control. The main exhaust fan, which is 1,5 km away from the shaft head is supplied with a 33 kV overhead line. The ventilation in the mine comes to a standstill when the fan stops. A flock of ducks, which breeds in a nearby swamp tends to cause intermittent faults on the transmission line close to the fan.

Develop a set of lockout procedures for the supply substation to handle call outs at daybreak when it becomes urgent to restore power before the shift can go down.
(8)
[20]

TOTAL SECTION A 60

SECTION B

Answer any TWO of the following five questions.

QUESTION 4

4.1 A 33 kV overhead transmission line with steel core aluminium conductors spans a non-electrified railway line and a main road owned by the mine, 80 m wide. One end is 5 m above the other end and 10 m above the lowest point. The mass of the line is 5 kN/m over the whole span.

4.1.1 Calculate the maximum tension in a conductor.
4.1.2 State the safety requirements of the transmission line crossing the railway line and the road. (8)

4.2 With reference to the directive 'Caplamps in explosive atmospheres' dated 1 January 1993, discuss the measures introduced by the Chief Inspector to control the introduction of approved caplamps and portable lamps in terms of the Minerals Act regulations 15.5.1, 15.5.2 and 15.6.1. (6)

4.3 Develop lockout procedures for a hydraulically operated cutting boom of a coal cutter to be used for the inspection of the cutters. (6)
[20]

QUESTION 5

A chairlift installation must convey 450 persons per hour up a 34° incline shaft through a vertical height of 185 m by means of chairs suspended from chain driven carriers running on a rail circuit. Both landings are level and 22 m long. The velocity of the traction chain is 1,3 m/s and its mass is 7,38 kg/m and the mass of the safety rope is 1,5 kg/m. The mass of each carrier is 5 kg while that of a chair is 12 kg.

5.1 Assume an appropriate friction factor and calculate the total pull in the chains at the driving sheave and the bottom sheave when the up-going chairs are loaded. (15)

5.2 Describe how the brakes are statically and dynamically tested. (5)
[20]

QUESTION 6

A three-stage reciprocating air compressor compresses 2,1 m^3/s of air at a pressure of 85 kPa and a temperature of 40°C to a pressure of 1,2 MPa. The same quantity of work is done in each stage and the air is cooled down to 40°C between stages and in the aftercooler.
The mechanical efficiency is 92% and assume that all the waste heat is removed by the cooling water.
n = 1,35.

6.1 How much cooling water is required if the water inlet temperature is 26°C and the maximum allowable water outlet temperature is 33°C? (12)

6.2 How would you ensure that the cooling system protects the compressor at all times and remains efficient for many months? (8)
[20]

QUESTION 7

7.1 Referring to the Guideline for the Compilation of a mandatory Code of Practice on Mine Residue Deposits, dated 31 May 2001, state the aspects to be addressed in the COP to ensure the management of significant risks. (10)

7.2 A slimes pump and motor has an efficiency of 48% and must pump slime against a static head of 25 m. The density of the dry solids is 2,4 t/m^3 and the solid to water ratio is 1,1 to 1 by mass. The pump column is 750 m long and has a diameter of 150 mm. The pump is driven by a 30 kW motor.
Assume a friction factor of 0,009 and a pipe velocity of 2,45 m/s.

Calculate the tons of dry slime that can be pumped in 24 hours. (10)
[20]

QUESTION 8

8.1 A shaft column, 250 mm in diameter, delivers clean water 800 m high at a rate of 100 ℓ/s. The pump station, equipped with two pumps, is 20 m from the duck's-foot bend and each pump is equipped with a non-return and a manually operated gate valve.

Calculate the total pressure at the non-return valve if the pump trips out and the non-return valve only commences to close after a second due to corrosion in the valve. The flap of the non-return valve is only fully closed in 0,20 seconds after the flap commenced to move.
Ignore the inertia of the pump and the friction loss in the pipe. (12)

8.2 Ambient air at 25°C, 60% relative humidity and 95 kPa is entering an underground pump chamber and the outlet is directly coupled to the main exhaust shaft. The pump station contains 7 pumps, each driven by a motor with an input of 650 kW. The efficiency of the motors and pumps is 94% and 70% respectively. The heat capacity of the air is 1,043 kJ/kg.K and the density at NTP is 1,29 kg/m^3.

Determine the minimum volume of air to limit the maximum temperature of the pump station to 27°C wet bulb when all 7 pumps are pumping. (8)
[20]

TOTAL SECTION B: 40

GRAND TOTAL: 100

Information for PVC cables, 6,6 kV, 3 core with copper conductors and braiding

Area	Current rating	AC resistance at 80 °C	Impedance at 80 °C	Zero sequence resistance	Zero sequence impedance	Short circuit rating
mm^2	A	Ω/km	Ω/km	Ω/km	Ω/km	kA/s
16	89	1,421	1,425	7,448	7,450	2,2
25	120	0,899	0,904	6,122	6,124	3,5
35	145	0,648	0,655	5,487	5,489	4,9
50	175	0,479	0,486	5,167	5,169	6,6
70	220	0,332	0,341	4,324	4,344	9,6
95	270	0,239	0,250	3,704	3,706	13,3
120	310	0,190	0,203	3,256	3,258	16,8
150	355	0,155	0,169	2,845	2,847	20,7
185	410	0,124	0,141	2,505	2,507	25,9
240	485	0,096	0,116	2,173	2,176	34,1
300	560	0,077	0,100	1,824	1,827	42,8

De-rating factors (2 - 3 cabels)

In ground	0,95
In air	0,98
In water	1,00

Thermodynamic properties of water

Temp	°C	0	2	5	10	15	20	25	30
Press	kPa	0,611	0,706	0,872	1,228	1,705	2,338	3,169	4,246

R = 287 J/kg K. Cp - 1,005 kJ/kg K. Specific heat capacity of water = 4,185 kJ/kgK

$$WD = \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{n}{n-1}} - 1 \right] \quad or \quad WD = \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1} \right)^{\frac{n}{n-1}} - 1 \right] - P_1 V_1 \log_e \frac{P_2}{P_1}$$

$$I_{sh} = Ix \frac{100}{\%X} \bullet \quad \Delta p = \rho c (V_2 - V_1) \bullet \quad c = \sqrt{\frac{bulk\ modulus\ of\ water}{density\ of\ water}} \bullet$$

$$Tan\phi = \frac{2y}{x} \bullet \quad T_0 = \frac{wx^2}{2y} \bullet \quad T_r^2 = w^2 x^2 \left[\left(\frac{x^2}{4y^2} \right) + 1 \right] \bullet \quad h_f = \frac{4flv^2}{2gd} \bullet$$

Mechanical properties of water

Temp °C	0	10	20	30
Bulk modulus GPa	2,02	2,10	2,18	2,25