T40(E)(J7)T
JUNE 2004

NON-NATIONAL CERTIFICATE:
ENGINEERING CERTIFICATE OF COMPETENCY

PLANT ENGINEERING: MINES AND WORKS

(8190306)

7 June (X-Paper).
09:00 – 12:00

Alphanumeric or programmable calculators must NOT be used.

Only non-programmable calculators may be used.

Graph paper will be supplied.

CLOSED-BOOK EXAMINATION
DEPARTMENT OF EDUCATION
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. All 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, reference works or cell phones 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 had 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.

An information sheet is included in this question paper.
SECTION A (COMPULSORY)

QUESTION 1

A DC driven double drum men/material winder is equipped with 32 spring applied hydraulic release disk brake units on a drum. The brake units are arranged in pairs of eight on a brake support post, one in the front and a second one at the rear of the drum which is regarded as a brake on one drum.

1.1 Calculate the total suspended mass (conveyance and load) that could be supported by one brake at the bottom of the wind. Compare the answer with the legal requirements for the ropes and select the value that satisfies all the requirements.

1.2 Fully describe the brake test required by the regulation to confirm the above calculation.

Data:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from sheave wheel to lowest landing</td>
<td>1800 m</td>
</tr>
<tr>
<td>Distance from sheave wheel to drum</td>
<td>80 m</td>
</tr>
<tr>
<td>Diameter of rope</td>
<td>50 mm</td>
</tr>
<tr>
<td>Mass of rope</td>
<td>9.7 kg/m</td>
</tr>
<tr>
<td>Breaking strength of rope</td>
<td>1575 kN</td>
</tr>
<tr>
<td>Diameter of a sheave wheel</td>
<td>4.85 m</td>
</tr>
<tr>
<td>Mass of sheave wheel</td>
<td>380 kg</td>
</tr>
<tr>
<td>Diameter of a drum</td>
<td>4.00 m</td>
</tr>
<tr>
<td>Inertia of rotating parts</td>
<td>250 000 kg/m²</td>
</tr>
<tr>
<td>Mean diameter of disk brake</td>
<td>4.75 m</td>
</tr>
<tr>
<td>Area of one brake pad</td>
<td>0.09 m²</td>
</tr>
<tr>
<td>Dynamic coefficient of friction of brake lining</td>
<td>0.27</td>
</tr>
<tr>
<td>Static coefficient of friction of brake lining</td>
<td>0.30</td>
</tr>
<tr>
<td>Free length of brake spring coil</td>
<td>200 mm</td>
</tr>
<tr>
<td>Coil length with brake fully on</td>
<td>100 mm</td>
</tr>
<tr>
<td>Active turns per coil</td>
<td>8</td>
</tr>
<tr>
<td>Wire diameter of a coil</td>
<td>20 mm</td>
</tr>
<tr>
<td>Mean coil diameter</td>
<td>90 mm</td>
</tr>
</tbody>
</table>
QUESTION 2

2.1 The power supply in a mine was extended from an existing underground 6.6 kV substation to two mini-substations, 400 kVA each and a number of gate end boxes in two different working areas. Each mini-substation is supplied separately from a joint box at the split in the haulage and the joint box is supplied with a single feeder cable from 6,6 kV substation. The mining process consists of drilling, blasting, scraping into stope chutes and transport by train.

2.1.1 Describe the tests required before switch-on to ensure the safety of operating personnel when an earth fault occurs on a machine and to ensure the dependability of the power supply.

2.1.2 Briefly describe what is needed and how you would determine the diversity and load factors for this installation.

2.2 A 6 600/550 V, 250 kVA, three-phase transformer has a core loss of 1,8 kW and a full-load copper loss of 2,5 kW.

Determine:

2.2.1 The kVA load for maximum efficiency and calculate the maximum efficiency with a power factor of 0,9 lagging for this condition

2.2.2 The efficiencies at:

<table>
<thead>
<tr>
<th>0,5</th>
<th>0,75</th>
<th>1,10</th>
<th>0,9</th>
</tr>
</thead>
</table>

of full-load power factor lagging

(6) [20]

QUESTION 3

3.1 A fully equipped BASEEFA certified underground flameproof enclosure has been imported for use in a hazardous location in a fiery mine.

What is the procedure to be followed by the engineer before such enclosure may be installed and operated in a mine?

(4)
3.2 Two-way radios with the following specifications/particulars are to be used in a coal mine. Will they be safe for this application? Substantiate the answer clearly by considering the information below:

SABS certification for propane gas:

- Ignition temperature: 465°C
- Higher explosion limit: 9.5%
- Lower explosion limit: 2.0%

Marking on name plate of radio:

- Output power: 1 watt radiated power
  - Ex ia II A T4
  - SABS M/V805 X

3.3 What is the purpose of the pilot circuit of a trailing cable? Briefly discuss the safety features of the design to support the purpose.

SECTION B: CHOICE QUESTIONS

Answer TWO of the five questions.

**QUESTION 4**

4.1 Will you ever recommend that the stator voltage on a three-phase fan motor be reduced to reduce the speed in order to save power? Support the answer with formulae.

4.2 A belt driven centrifugal ventilation fan for underground workings of a mine runs at 450 r/min and the volume of air circulated is 140 m³/s. The pressure developed by the fan being 0.75 kPa. The natural ventilation pressure of the mine is 0.375 kPa in assistance to the fan. It is required to increase the quantity of air circulated to 180 m³/s by increasing the speed of the fan. The natural ventilation pressure and the efficiency of the fan at 75%, remain constant.

4.3 Discuss the purpose of ventilation in underground workings and the factors supporting this purpose.
QUESTION 5

5.1 Which aspects are to be addressed under 'Design and specifications: Railbound equipment and Maintenance' in the Guideline for the Compilation of a Mandatory Code of Practice for underground Railbound Transport Equipment, effective date 1 February 2004.

5.2 A haulage in a mine with a 0.5% gradient to the tips is equipped with railway tracks. A battery locomotive, pulling four hoppers, is equipped with two brake shoes on every wheel and is applied with a hand wheel on a long screw. The tracks are wet in some places which is difficult to keep dry.

5.2.1 What is the maximum speed of a fully loaded train to the tips if the safety braking distance was found to be 25 m and the brake only binds after 1½ seconds and travels for another 10 seconds after the driver has seen an obstacle? Assume practical brake conditions.

5.2.2 Will a fifth hopper be allowed under the above-mentioned Guideline for a Mandatory Code of Practice even if the speed is being reduced?

Train data:

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass of locomotive with batteries</td>
<td>5 t</td>
</tr>
<tr>
<td>Mass of empty hopper</td>
<td>2.5 t</td>
</tr>
<tr>
<td>Mass of payload</td>
<td>5 t</td>
</tr>
<tr>
<td>Rolling resistance of the train</td>
<td>300 N/m</td>
</tr>
<tr>
<td>Coefficient of friction between dry track and wheels</td>
<td>0.23</td>
</tr>
<tr>
<td>Coefficient of friction between wet track and wheels</td>
<td>0.18</td>
</tr>
<tr>
<td>Coefficient of friction between brake shoe and wheels</td>
<td>0.25</td>
</tr>
</tbody>
</table>

QUESTION 6

6.1 A 600 mm troughed belt conveyor with main pulley centres 60 m apart delivers 150 t/h of crushed rock into a storage bin, the height of lift being 12 m. The belt speed is 1.5 m/s, the coefficient of friction between driving pulley and belt is 0.23 and the snub pulley provides 220° of contact between belt and drive pulley.

If the power required to overcome friction is 40% of the power required to lift the load against gravity and the efficiency of the drive is 70% and that of the motor is 95%, determine:

6.1.1 The number of plies the belt must have if the stress is not to exceed 7 kN/m width/ply

6.1.2 The size of the driving motor
6.2 Briefly describe the procedures to hot splice a four-m-ply belt with a gravity take-up and a single drive pulley. (6)

6.3 Describe the safety features that would be installed on a belt conveyor to protect the operational and maintenance staff. (6) [20]

QUESTION 7

7.1 Application 1: A 12-pole, three-phase slip-ring induction motor absorbs 250 kW from a 50 Hz supply and runs at 490 r/min. The total stator is 12 kW and the efficiency is 92%.

Application 2: The speed is to be reduced to 350 r/min by adding resistances to the rotor circuit.

Determine:

7.1.1 The mechanical loss of the motor for application 1
7.1.2 The overall efficiency and the power available at the shaft for application 2 neglecting the changes in power factor and mechanical losses
7.1.3 The difference in torque between the two applications (15)

7.2 Briefly describe the tests that you will call for to ensure that a 55 kW, 550 V-, three-phase induction motor in the mine motor pool is healthy and fit for installation.

Quote some typical values which you would look at. (5) [20]

QUESTION 8

8.1 A shaft column, 200 mm diameter, delivers clean water 1 000 m high at a rate of 80 l/s. The pump station, equipped with two pumps, is 30 m away from the ducks-foot bend and each pump is equipped with a non-return and manually operated gate valve.

Calculate the total pressure at the non-return valve if the pumps trip out and the closing of the non-return valve flaps is delayed for one second due to corrosion in the valves. It takes another 0.20 seconds for the flaps to close. Ignore the inertia of the pump and the friction loss in the pipe. (10)

PTO
8.2 One 10 m length of a 200 mm diameter, flanged, pump column, which is situated between two men-cages of the same winder, is due to be replaced midway between the highest station and surface. An expansion joint has been installed just below the sub-bank. The only safe way to work on the column is from a platform, built on top of both conveyances.

Develop a procedure for this job.

TOTAL SECTION B: 40
GRAND TOTAL: 100
For high quality steel:
Modulus of elasticity = 200 GPa
Modulus of rigidity = 85 GPa

\[ T = \frac{\pi D^3 r_{\text{max}}}{16} \quad J = \frac{\pi D^4}{32} \quad y = \frac{8 FD^3 n}{d^4 G} \quad k = \frac{G d^4}{8 D^3 n} \]

Properties of water:

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>0</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure kPa</td>
<td>0.611</td>
<td>0.706</td>
<td>0.872</td>
<td>1.228</td>
<td>1.705</td>
<td>2.338</td>
<td>3.169</td>
<td>4.246</td>
</tr>
<tr>
<td>Bulk modulus GPa</td>
<td>2.02</td>
<td>2.10</td>
<td>2.18</td>
<td>2.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ h_f = \frac{f l v^2}{2 g d} \quad c = \sqrt{\frac{\text{bulk modulus of water}}{\text{density of water}}} \quad \Delta p = \rho c (V_2 - V_1) \]