EXAMINATION FOR THE ENGINEER'S CERTIFICATE OF COMPETENCY

PLANT ENGINEERING: MINING

11 June (X-Paper)
09:00 - 12:00

Alphanumerically or programmable calculators may NOT be used.
Non-programmable calculators may be used.

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

INSTRUCTIONS

Full marks: 100
Pass mark: 50

Answer QUESTIONS 1, 2 and 3 and any TWO other questions.

ALL the calculations are to be shown.

No credit will be given for calculations in which the steps cannot be clearly followed, or for work completed in pencil.

Candidates are expected to make reasonable assumptions where necessary and these, together with any formulae used, must be clearly stated.

Rule off after each question.

Answers must be clearly and correctly numbered, neat and legible.

Illegible answers will not be marked.

Candidates are NOT allowed to use any notes, text or reference books during the examination.

Candidates who are not accepted by the Commission will be disqualified.
QUESTION 1 (COMPULSORY)

(a) Describe a simple test to test the effective brake holding power of a double drum Ward Leonard mine winder. (5)

(b) During a test of the spring-applied hydraulic-release brake engine of a mine winder, it was found that the hydraulic pressure required to lift the brakes is 60% of the pressure it is supposed to be. Describe how this condition will manifest itself and how you will rectify it. (5)

(c) A false bank was created 50 m below the bank of a vertical mine shaft for the purpose of testing the overwind prevention device of a mine winder.

The winder was allowed to run freely into the false bank and the following velocity/displacement graph was recorded:

Determine:

(i) The safety status of the winder

(ii) The period from trip to brake contact

(iii) The average deceleration

(iv) How the deceleration rate can be obtained at any point on the curve (10) [20]
QUESTION 2 (COMPULSORY)

(a) A transformer was ordered to cater for a maximum demand of 10 MW, a load factor of 0.5 and a diversity factor of 1.5. After installation it was found to overheat when connected to the load.

Determine whether the transformer is faulty or whether the specified factors are exceeded if it feeds two sections of the plant having the following typical loading during the day:

<table>
<thead>
<tr>
<th>Time</th>
<th>Load A (MW)</th>
<th>Load B (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00 - 04:00</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>04:00 - 08:00</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>08:00 - 12:00</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>12:00 - 16:00</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>16:00 - 20:00</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>20:00 - 24:00</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

(b) A used 6 pole, 50 Hz motor was salvaged and is to be considered for a specified duty.

The following information is available:

- Full-load slip: \(3\%\)
- Rotor resistance: \(0.0011 \, \Omega/\text{phase}\)
- Standstill reactance: \(0.0052 \, \Omega/\text{phase}\)

Find the ratio of the maximum to the full-load torque and the speed at which maximum torque occurs.

\[
T_f = 2T_m \cdot \frac{s \alpha}{(\alpha^2 + s^2)}
\]

where \(\alpha = \) the ratio of rotor resistance to standstill reactance per phase, that is \(R_2/X_2\) at full load

\[
s = \text{slip at full load}
\]

QUESTION 3 (COMPULSORY)

(a) Describe the four-step method to conduct a safety audit for an accident prone mine section.

(b) What hazards will you be looking for during a safety audit of an underground pump chamber situated near the shaft where maintenance workers suffer hand and foot injuries?
(c) How will you:

(i) Assess the probability of a detaching hook on a man-winder conveyance detaching accidentally

(ii) Reduce the risk of such a detaching hook opening accidentally

QUESTION 4

(a) The following results were obtained during a test on a steam boiler to ascertain the reason for its high fuel consumption:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam pressure</td>
<td>1 400 kPa</td>
</tr>
<tr>
<td>Dryness fraction of steam</td>
<td>0.95</td>
</tr>
<tr>
<td>Calorific value of coal</td>
<td>30 MJ/kg</td>
</tr>
<tr>
<td>Feedwater evaporated/kg coal</td>
<td>9.1 kg</td>
</tr>
<tr>
<td>Temperature of feedwater to economiser</td>
<td>22°C</td>
</tr>
<tr>
<td>Temperature of feedwater to boiler</td>
<td>56°C</td>
</tr>
<tr>
<td>Temperature of flue gas entering economiser</td>
<td>369°C</td>
</tr>
<tr>
<td>Temperature of flue gas leaving economiser</td>
<td>233°C</td>
</tr>
<tr>
<td>Mass of flue gas/kg coal</td>
<td>18.2 kg</td>
</tr>
<tr>
<td>Mean specific heat of flue gas</td>
<td>1.05 kJ/kg.K</td>
</tr>
</tbody>
</table>

Properties of steam at 1 400 kPa

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>t_s</td>
<td>195°C</td>
</tr>
<tr>
<td>h_f</td>
<td>830 kJ/kg</td>
</tr>
<tr>
<td>h_fg</td>
<td>1 958 kJ/kg</td>
</tr>
<tr>
<td>h_g</td>
<td>2 788 kJ/kg</td>
</tr>
</tbody>
</table>

(i) Determine the current efficiency of the plant.

(ii) Determine the efficiency of the economiser.

(iii) Give the reason(s) for the low efficiencies.

(iv) Give remedial steps to restore it to the original condition.

(b) Briefly describe a method of balancing (not trial and error) a large fan impeller in a single plane.
QUESTION 5

A salvage yard is equipped with an overhead crane running on two parallel reinforced concrete beams 7 m apart and simply supported on vertical columns. The crawl beam runs on the concrete beams. Calculate the actual factor of safety for the beams if the total mass of the load (suspended from the middle of the crawl beam) and the crawl beam itself is 40 t and decide whether it is safe or not. The crawl beam is also in the middle between two columns 6 metres apart supporting the beam.

Width of beam 600 mm
Depth of beam 800 mm
Number of 25 mm diameter reinforcing rods 7
situated 30 mm from the bottom
Allowable compressive stress for concrete 7 MPa
Allowable tensile stress in steel rods 180 MPa
Modular ratio 15
Density of concrete 2 400 kg/m³

\[ \frac{c_{\text{steel}}}{c_{\text{concrete}}} = \frac{m(d - h)}{h} \]

Resisting moment = \( F(d - h/3) \) [20]
QUESTION 6

A water supply system was designed to deliver 440 m³/h clean water through a 200 mm diameter pipe 1.6 km long and a static head of 145 m. Due to unforeseen circumstances the demand increased considerably. Determine whether the identical standby pump should be connected in series or parallel with the other for maximum capacity. The friction factor is 0.006.

\[ h_f = 4fL_v^2/2gd \]

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QUESTION 7

(a) Sketch and describe the pilot wire system for a trailing cable used in a hazardous area.

(b) Draw a simple sketch to show the essential components of an AC, 2,2 kV, 400 A air-break contactor with magnetic blow-out. It is not necessary to include mechanical operating gear.

(c) An underground feeder cable is 450 m long and trips out on earth leakage with a fault to earth on one phase.

Find the location of the fault from the feeder end of the cable if the followig measurements were recorded at that end:

- Conductor resistance
  - 8.2 Ω/km
- Distant end of faulty core solidly earthed
  - 3.16 Ω
- Distant end of faulty core insulated
  - 7.52 Ω
QUESTION 8

A 100 t truck is to be used to convey 50 t of rock from a quarry up a steady incline of 1 in 50. The truck is designed to apply emergency brakes to the front wheels within 10 seconds in case of the service brake failure. The engine develops 250 kW, the transmission efficiency is 85% and the rolling resistance is 200 N/t. The wheel base of the truck is 7 m and the centre of gravity of the loaded truck is 3 m in front of the rear axle and 1.75 m above the road surface. The coefficient of friction between the road surface and the wheels is 0.25.

(a) Calculate:

(i) The maximum steady speed of the truck up the incline

(ii) The speed of the truck, 15 seconds after an engine failure and a loss of service brakes have occurred and if the truck travelled at full speed

(iii) The braking effort of the emergency brakes when the truck is running backwards (that is only the front wheels are braked)

(b) Briefly comment on the degree of safety of this arrangement.

TOTAL: 100

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