EXAMINATION FOR THE ENGINEER'S CERTIFICATE OF COMPETENCY

PLANT ENGINEERING:
MINES AND WORKS
(8190306)

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

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

1. Full marks: 100
   Full marks: 50

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

3. All calculations are to be shown.

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

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

6. Rule off after each answer.

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

8. Illegible answers will not be marked.

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

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

(a) Sketch and describe a cage holding device used in deep vertical shafts to hold the cage steady while being loaded or unloaded.

(b) A man winder conveys shift in a deep vertical shaft between the bank and the lowest level. The cage is equipped with a holding device which holds the cage stationary while persons embark or disembark from the cage.

(i) Calculate the length of rope to be pulled in before the holding device may be released in order for the cage to maintain its position when the empty cage is loaded with persons at the lowest station.

(ii) Calculate the static factor of safety for the rope at the sheave when the cage is fully loaded.

Nominal diameter of rope 50 mm
Type of rope - triangular strand 6 x 32
Class of steel of rope 1 800 MPa
Breaking strength of rope 1 784 kN
Modulus of elasticity 103 GPa
Mass of rope 10.49 kg/m
Metallic area of rope 0.45 d^2
Length of rope from sheave to cage at lowest station 2 330 m
Number of persons permitted to travel 150
Average mass of person 75 kg
Mass of cage and attachments 6 t

QUESTION 2 (COMPULSORY)

(a) High frequency transients are a major problem with electrical distribution systems on mines. Describe the causes of high-voltage surges in a distribution system.

(b) Describe a practical method to reduce the magnitude of a voltage surge where an overhead line terminates at a transformer.

(c) What effects do lightning have underground in a coal mine? List the risks associated with such an occurrence.

(d) Describe what protective measures are to be taken in a coal mine to minimise the effects of stray electrical potentials.
QUESTION 3 (COMPULSORY)

(a) List the procedure you will follow to assess the integrity of a pressure vessel (condenser) for a 1 000 kW ammonia refrigeration plant.

(b) The mine workshop, for which you are responsible, has been identified as having a high disabling accident frequency rate.

The following accidents have been reported during a period of 12 months.

<table>
<thead>
<tr>
<th>Accident Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laceration of fingers and hands</td>
<td>7</td>
</tr>
<tr>
<td>Material falling</td>
<td>11</td>
</tr>
<tr>
<td>Dust or metal in eye</td>
<td>3</td>
</tr>
<tr>
<td>Back strained</td>
<td>5</td>
</tr>
<tr>
<td>Burning and scalding</td>
<td>2</td>
</tr>
</tbody>
</table>

(i) Determine possible latent causes of the accidents and recommend remedial action.

(ii) If the total workforce in the workshop is 350, calculate the accident frequency rate per year.

Answer any TWO of the following four questions.

QUESTION 4

(a) A tripod, consisting of three 150 mm outside diameter steel pipes, is to be used to lift a transformer having a mass of 1.8 t. The wall thickness of the pipe is 6 mm. The footings of the tripod are spaced equidistant and are 17.32 m apart. The pipe, for the purpose of this calculation, may be considered to be a straight pin-jointed strut.

Using a factor of safety of 5 and Young’s modulus of 200 GPa, determine the maximum safe load that may be raised without the pipes buckling and hence whether it is safe to raise the transformer.

\[ P = \frac{\pi^2 EI}{4L^2} \]

(b) The impeller of a fan is mounted on the end of the shaft and the V-belt driven pulley on the other end. The bearings are 200 mm from the ends and the shaft is 700 mm long. Determine the load on the bearings if the horizontal pull of the V-belt drive is 9 kN and if the impeller has a mass of 350 kg. Ignore the mass of the shaft and consider the shaft to be simply supported for the purpose of this calculation.
QUESTION 5

(a) Calculate the coal consumption per hour of a boiler with the following operating conditions:

- Feed-water inlet temperature: 150°C
- Final steam temperature: 400°C
- Steam pressure at superheater outlet: 4 MPa abs.
- Steam drum operating pressure: 4.5 MPa abs.
- Calorific value of coal (air-dried basis): 27,5 MJ/kg
- Moisture content of coal as fired: 10%
- Overall efficiency: 65%
- Feed-water flow rate: 108 tons/h
- Steam delivery flow rate: 100 tons/h

The following information is extracted from steam tables:

<table>
<thead>
<tr>
<th>Absolute pressure kPa</th>
<th>Temperature °C</th>
<th>$h_f$ kJ/kg</th>
<th>$h_f$ kJ/kg</th>
<th>$h_g$ kJ/kg</th>
<th>$V_g$ m³/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>101.3</td>
<td>100.00</td>
<td>419.04</td>
<td>2257.0</td>
<td>2676.0</td>
<td>1.673</td>
</tr>
<tr>
<td>481.3</td>
<td>150.44</td>
<td>634.0</td>
<td>2112.9</td>
<td>2746.9</td>
<td>0.389</td>
</tr>
<tr>
<td>4001.3</td>
<td>250.42</td>
<td>1087.4</td>
<td>1714.1</td>
<td>2801.5</td>
<td>0.0498</td>
</tr>
<tr>
<td>4501.3</td>
<td>257.50</td>
<td>1122.1</td>
<td>1676.2</td>
<td>2798.2</td>
<td>0.0441</td>
</tr>
</tbody>
</table>

Additional information required must be interpolated or assumed.

(b) The air supplied to a working place is to be 17°C and has a relative humidity of 60%. If the barometric pressure is 1,013,250 kPa, calculate the specific humidity.

At 17°C the saturation pressure is 1,936 kPa.

\[
\omega = 0.622 \times \left( \frac{P_s}{P - P_s} \right)\]
QUESTION 6

(a)

The diagram shows the hydraulic circuit to operate a radial door. At some stage a condition arose when the piston starts hitting its forward (extended) end and stops violently after reciprocating between its limit positions satisfactorily. List the possible causes for this condition and the tests to be carried out for each fault you listed.

(b) It is necessary to calculate the pull on the bearings of a V-belt driven fan. The belt is required to transmit 130 kw at a belt velocity of 1 150 m/min. The coefficient of friction is 0.25, the arc of contact is 170° and the included angle for the V-belt groove is 40°.

QUESTION 7

(a) Explain the arc extinction process in an alternating current circuit breaker and the techniques used in current breakers to extinguish the arc rapidly.

(b) Describe, by means of a sketch, the operation of a 'low oil content' circuit breaker suitable for 12 kV. List the advantages of such a circuit breaker in contrast with tank type circuit breakers.

(c) Why are high-voltage tests necessary for high-voltage circuit breakers?

(d) Describe the process of identifying contaminated dielectric oil and the standard test to assess its condition.
QUESTION 8

A conveyor belt is used in a 17° inclined shaft to convey coal. The capacity of the belt has been increased to convey 1 000 tons/h and resulted in belt-slip at the head pulley and the belt reversing after an unplanned stop.

The conveyor belt is 320 m long between head and tail pulleys, a contact angle of 200°, a velocity of 2 m/s and a mass of 20 kg/m. The additional tension of the loaded belt, due to friction, is 48 kN and the coefficient of friction between the belt and the head pulley is 0.3.

Calculate:

(i) The tight side and slack side tensions in the belt
(ii) The power required to drive the belt

Devise means:

(iii) To stop the belt from slipping
(iv) To prevent it from reversing when stopped fully loaded

[20]

TOTAL: 100