T40(E)(J5)T
JUNE 2006

NON-NATIONAL CERTIFICATE:
ENGINEERING CERTIFICATE OF COMPETENCY

PLANT ENGINEERING: MINES AND WORKS
(8190306)
5 June (X-Paper)
09:00 – 12:00

Alpha-numerical or programmable calculators may NOT be used.

Only non-programmable calculators may be used.

CLOSED-BOOK EXAMINATION

This question paper consists of 7 pages, a 2-page information sheet and 1 diagram sheet.
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 AND INFORMATION

1. This is NOT an open-book examination. Candidates are NOT allowed to use any notes, textbooks, references 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.

7. Candidates may make reasonable assumptions where necessary.

8. Programmable calculators are NOT allowed.

PTO
SECTION A (COMPULSORY)

QUESTION 1

1.1 Distinguish between THREE classes of fires and the type of fire extinguisher that should be used in each case.

1.2 Explain the difference between inspections and audits.

1.3 What are the TWO main sources of disastrous explosions in fiery coal mines?

1.4 What basic precautions are taken to prevent explosions due to the causes in QUESTION 1.3?

QUESTION 2

2.1 A double shoe brake system of a small hoist is shown in FIGURE 1, DIAGRAM 1.

The brake drum rotates clockwise at 100 revolutions per minute. If the coefficient of friction is 0.3, determine the braking capacity. Determine also the forces acting at EACH of the pins A, B, C, D and E. The brake shoe contact angle is 110°.

2.2 State THREE advantages and THREE disadvantages of using Koepé winders.

QUESTION 3

3.1 The maximum efficiency of a 500 kVA transformer occurs at 83% of full load. It has a full-load efficiency of 97.3% at unity power factor. The 24 hour load cycle is as follows:

No load 9 hours
0.6 full load at 0.9 power factor 5 hours
0.75 full load at 0.85 power factor 3 hours
Full load at 0.8 power factor 7 hours

Calculate for the 24 hour period:

3.1.1 The total losses in kWh
3.1.2 The energy efficiency

3.2 Explain why the operation of a plant at a low power factor results in power being 'wasted'.

PTO
3.3 What economic criteria apply when considering the extent to which the power factor of electrical plant may be raised? [20]

TOTAL SECTION A: 60

SECTION B

Answer any TWO of the following six questions.

QUESTION 4

4.1 The following information was obtained for an underground mining area that is to be cooled by chilled service water and air heat exchangers:

<table>
<thead>
<tr>
<th>Mass of rock mined</th>
<th>85 000 t/month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass ratio of service water to mined rock</td>
<td>2.5:1</td>
</tr>
<tr>
<td>Temperature difference of the chilled water across the refrigeration plant</td>
<td>19 °C</td>
</tr>
<tr>
<td>Temperature difference of the chilled water across the heat exchangers</td>
<td>17 °C</td>
</tr>
<tr>
<td>Quantity of refrigeration to cool the air</td>
<td>12 200 kW</td>
</tr>
<tr>
<td>Quantity of refrigeration to cool the mined rock</td>
<td>6 280 kW</td>
</tr>
</tbody>
</table>

Determine:

4.1.1 The quantity of chilled service water (3)
4.1.2 The quantity of chilled water to cool the air (3)
4.1.3 The total quantity of chilled water to be provided (3)
4.1.4 The capacity of the refrigeration plant (3)

4.2 The data below was taken from a pressure switch mounted on a feeder breaker operation in a hazardous location underground in a coalmine.

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IEC 60079-11

4.2.1 Explain the meaning of the above data. (6)

4.2.2 Motivate whether or not the pressure switch is suitable for use on the feeder breaker. (2)
QUESTION 5

5.1 A three-phase load of 3 000 kVA, 0,8 power factor, is supplied at 11 kV from a step-down transformer having a ratio of 3:1. The primary side of the transformer is connected to a transmission line, the constants of which are resistance per conductor, 2 ohms; reactance per conductor 3 ohms.

The resistance and reactance per phase of the primary windings of the transformer (which are star-connected) are 5 ohms and 10 ohms respectively and the corresponding values for the secondary windings (which are delta-connected) are 1,5 ohms and 3 ohms respectively.

Determine the voltage and power factor at the sending end of the transmission line. (10)

5.2 During the monthly inspection of a 500 kVA, 6 600/550 V oil cooled transformer underground it was discovered that water had entered through the breather pipe into the transformer and mixed with the oil.

Describe the procedure you would follow to remove the water from the oil. (5)

5.3 A system operating at its maximum current capacity supplies power to four identical machines at a power factor of 0,75.

Calculate the power factor improvement required to run a fifth identical machine off the same system at a power factor of 0,8. (5) (20)

QUESTION 6

6.1 The following are particulars of a three-throw single-acting belt-driven plunger pump used to elevate the settled slime up a vertical shaft:

<table>
<thead>
<tr>
<th>Particular</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of plunger</td>
<td>120 mm</td>
</tr>
<tr>
<td>Length of stroke</td>
<td>270 mm</td>
</tr>
<tr>
<td>Speed of pump</td>
<td>1,66 r/s</td>
</tr>
<tr>
<td>Relative density of the solids</td>
<td>2,7</td>
</tr>
<tr>
<td>Relative density of the slime</td>
<td>1,12</td>
</tr>
<tr>
<td>Diameter of pipe line</td>
<td>150 mm</td>
</tr>
<tr>
<td>Depth of shaft</td>
<td>1 000 m</td>
</tr>
<tr>
<td>Volumetric efficiency</td>
<td>95%</td>
</tr>
<tr>
<td>Pump efficiency</td>
<td>48%</td>
</tr>
</tbody>
</table>

Determine:

6.1.1 The mass of dry solids pumped in kg/s (8)
6.1.2 The power rating of the electrical driving motor (2)
6.2 A pipe carrying wet steam with a pressure of 1,35 MPa at 193 °C has an external radius of 100 mm. It is lagged to a radius of 150 mm with insulation with a thermal conductivity of 0,04 W/m°C.

The temperature of the surrounding air is 24 °C and the loss from the surface of the insulation is 8,3 W/m²°C. Neglecting the effect of the conductivity of the pipe itself, calculate the heat loss in kJ/h per 10 m of lagged pipe.

QUESTION 7

7.1 A conveyor belt runs at 1,5 m/s for 26 days per month, 20 hours per day, to convey 100 000 tons over a horizontal distance of 120 m and a vertical distance of 20 m. The bulk density of the product conveyed is 1,6 t/m³. The angle of wrap on the drive pulley is 250° with a coefficient of friction of 0,35, and a coefficient of friction of the idlers of 0,04. The drive gearbox has an efficiency of 90%.

Determine:

7.1.1 The width of the conveyor belt
7.1.2 The power of the driving motor required
7.1.3 The mass of the counterweight required

7.2 A two-stage reciprocating compressor compresses 6 kg of air per second from a barometric pressure of 85 kPa abs. to a delivery pressure of 650 kPa gauge. The temperature of air at inlet is 27° and that of the air leaving the high pressure cylinder is 130 °C.

The following readings have been obtained:

<table>
<thead>
<tr>
<th></th>
<th>Quantity</th>
<th>Inlet temperature °C</th>
<th>Outlet temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water jacket of low pressure cylinder</td>
<td>350</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>Water jacket of high pressure cylinder</td>
<td>300</td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td>Cooling water to intercooler</td>
<td>1 200</td>
<td>20</td>
<td>35</td>
</tr>
</tbody>
</table>

Determine the isothermal efficiency of the compressor.
QUESTION 8

8.1 The manufacturer claims that a refrigeration plant using Freon 22 has a coefficient of 2.5:1. The user monitors the plant and records the following:

- Suction pressure: 400 kPa
- Condenser pressure: 300 kPa
- Temperature after compression: 70 °C

The refrigerant vapour is dry at the compressor inlet with no under-cooling of condensate.

Determine from the attached Freon 22 chart the actual coefficient of performance and the compressor efficiency. (12)

8.2 A solenoid-operated hydraulic valve fails to operate. State FOUR possible causes with appropriate correction actions. (8) [20]

QUESTION 9

9.1 A production mineshaft with a labour force of 200 people is to be established remote from any services or town areas. List and describe briefly the services, plant and amenities that must be provided on surface to operate the production shaft. (12)

9.2 Describe how the following heat treatments of steel are carried out and why they are required:

- 9.2.1 Normalising (2)
- 9.2.2 Hardening (2)
- 9.2.3 Tempering (2)
- 9.2.4 Nitriding (2) [20]

TOTAL SECTION B: 40

GRAND TOTAL: 100
FIGURE 1
PLANT ENGINEERING: MINES AND WORKS

FORMULAE AND CONSTANTS

\[ P = \sqrt{3} V I \cos \theta \]

\[ M = \sigma Z \]

\[ Q = m C \Delta t \]

\[ Z = \frac{I}{Y} \]

\[ P = (T_1 - T_2)^\nu \]

\[ I_{xx} = \frac{bd^3}{12} \]

\[ P = m g L \sin \theta \]

\[ h = \frac{4 \sin \theta / 2}{\theta + \sin \theta} \times R \]

\[ M = f z \]

\[ T / h = C W^2 \rho v \]

\[ h_f = \frac{4 f L v^2}{2 g d} \]

\[ Q = \frac{U A (\theta_1 - \theta_2)}{\ln(\phi_2 / \phi_1)} \]

\[ h = \frac{k v^2}{2 g} \]

\[ W = \frac{n}{n - 1} \cdot P V_1 ((P_2 / P_1) \exp[(n - 1)/n - 1]) \]

\[ p v = m R T \]

\[ \frac{M}{I} = \sigma = \frac{E}{y} = \frac{R}{R} \]

\[ M = \frac{W L^2}{8} \]

\[ M = \frac{W L}{4} \]