



C471(E) (J12)G
JUNE 2000

**DEPARTMENT
OF
EDUCATION**

EXAMINATION FOR THE ENGINEER'S
CERTIFICATE OF COMPETENCY

**PLANT ENGINEERING: MINES AND
WORKS**
(8190306)

EXAMINER:
Commission of Examiners
MODERATOR:
Commission of Examiners

12 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 you do not want to be marked, must be clearly crossed out.

INSTRUCTIONS

1. Full marks: 100
Pass mark: 50
2. Answer QUESTION 1, 2 and 3 and any TWO other questions.
3. ALL the 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 on completion of each question before starting the answer to a new question.
7. Answers must be clearly, correctly numbered, neat and legible.
8. Illegible answers will not be marked.
9. Candidates who were not accepted by the Commission, will be disqualified.

QUESTION 1 (COMPULSORY)

- (a) Briefly state the advantages of disc-type brakes and that of caliper-type drum brakes for large mine winders. (5)
- (b) Calculate the peak power in kW in the beginning of the wind and the RMS power of the driving motor for a double-drum mine winder operating in a vertical shaft 1 800 m deep. The maximum speed and acceleration of the conveyance are 17 m/s and $1,1 \text{ m/s}^2$ respectively. The utilisation factor of the winder is 90% and 3 700 tons of ore must be raised per day. Other information available is as follows:

Loading time	15 seconds
Skip to payload ratio	0,8
Mass of rope	10,6 kg/m
Length of suspended portion of each rope in shaft	1 850 m
Equivalent inertia of rotating masses (motors, drums, gears and sheaves)	$470,272 \times 10^3 \text{ kg.m}^2$
Drum diameter	4,2 m
Friction	5% of all travelling masses

RMS torque =

$$\sqrt{[(T_1^2 + T_2^2 + T_3^2) \times 1/3t_1 + (T_4^2 + T_5^2 + T_6^2) \times 1/3t_2 + (T_7^2 + T_8^2 + T_9^2) \times 1/3t_3] / (2/3t_1 + t_2 + 2/3t_3 + 1/3t_4)} \quad (15)$$

[20]

QUESTION 2 (COMPULSORY)

- (a) Describe how to dry the windings of a large transformer. Include estimates of voltage, current settings and time needed. (5)
- (b) Briefly describe, with the aid of diagrammatic sketches the details of a modern thyristor control system for a mine winder. Comment on its efficiency and operating cost in contrast with a Ward-Leonard system. (5)
- (c) A synchronous generator is connected to a synchronous motor. Both machines are rated at 1 250 kVA, 600 V, with reactance $X = X_2 = 10\%$, $X_0 = 4\%$. The neutrals of both machines are solidly earthed. Neglect the reactance of the busbars and the load current to calculate the fault current of a single line to ground fault near the terminals of the motor. (10)

[20]

QUESTION 3 (COMPULSORY)

- (a) An onsetter at an underground shaft station was found to frequently signal wrong signals to the winding engine driver of a man-hoist. It has resulted in two near accidents which might have had serious consequences. You as the engineer in charge, have the responsibility to investigate the probability of a recurrence. Describe the methodology you will follow to go about this and the probable causes that need to be investigated more closely. (15)
- (b) Describe ways and means to reduce derailment and rerailment accidents of trains in the underground transport section for which you are responsible. (5)

[20]

Answer any TWO of the following questions.

QUESTION 4

- (a) With regard to the efficiency of a coal-fired steam boiler, briefly describe the significance of:
- Moisture in the fuel
 - Moisture in the atmosphere
 - Temperature of the air
 - Carbon lost in the ash pit
- (b) The efficiency of the boiler for which you are responsible is suspect and you are requested by the manager to draw up a heat balance sheet and to determine the overall efficiency of the boiler and the overall efficiency of the plant. (5)

The following observations were made:

• Atmospheric pressure	95 kPa
• Boiler gauge pressure	700 kPa
• Hot well temperature	50°C
• Steam condensed per hour	400 kg
• Temperature of boiler house	28°C
• Moisture in fuel	2% per mass

• Mass of flue gases per kg of fuel	17,8 kg
• Coal used per hour	60,2 kg
• Lower calorific value of coal	31,8 MJ/kg
• Temperature of flue gas	325°C
• Brake power of engine	39 kW
• Mean specific heat of flue gas	1,045 kJ/kg
• Condition of steam	0,96 dry

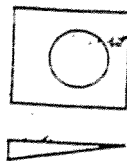
From steam tables:

p (kPa)	t_s (°C)	h_f (kJ/kg)	h_{fg} (kJ/kg)
95	98,2	418	2 262
880	174,4	739	2 033
900	175,4	743	2 030

(15)
[20]

QUESTION 5

- (a) Explain how a tapered washer, as shown below, is used and name the possible results if such washers are not used where they are supposed to be used.



(5)

- (b) Two 220 × 80 channels are held in position, back to back, by two 20 mm thick 200 mm wide steel plates at the top and bottom and constitutes the main beam of a cantilever type hoist. Calculate the maximum distance of the trolley from the support to safely lift a transformer having a mass of 5 tonnes. The safe bending stress is 108 MPa.

Size (mm)	About x-x (10^{-6} m^4)		About y-y (10^{-6} m^4)	
	I	Z_e	I	Z_e
220 x 80	26,91	244,6	1,959	33,45

Neglect the mass of the beam and the lifting tackle.

(15)
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QUESTION 6

- (a) Explain, with the aid of sketches, where losses occur in centrifugal pumps and describe what can be done to minimise such losses. (5)
- (b) A 200 mm diameter water pipe is fitted with a 30° bend. The pressure at both ends of the bend is similar and equal to 200 kPa. If the bend is horizontal, calculate the resultant force to be exerted by the pipe system for the bend to remain in position if the flow is $0,15 \text{ m}^3/\text{s}$. (10)
- (c) The capacity of a centrifugal pump has to be increased from 12 kl/s to 15 kl/s. Calculate the increase in speed required to achieve this and the resultant increase in power consumption. The initial speed of the impeller and the total head is 1 450 r/min and 300 m respectively. (5)

[20]

QUESTION 7

- (a) Briefly discuss the problem of radio frequency interference in respect of computer-aided blasting systems as used in quarries and mines. (5)
- (b) Discuss the principles of the following earthing systems and their application in an electrical distribution system: (5)
 - Ungrounded system
 - Solid grounding or effective grounding
 - Reactance grounding
 - Resonant grounding
- (c) Sketch and describe the arc suppression coil provided with tapings of a transformer to permit selection of reactance dependant on the length of a transmission line and to neutralise the capacitance. (10)

(5)
[20]

QUESTION 8

(a) A steel ring with an external diameter of 80 mm and an internal diameter of 39,9 mm must be shrunk onto a 40 mm diameter steel shaft, the temperature of which is 20°C. If the coefficient of linear expansion of the steel is $1,14 \times 10^{-5}$, determine the temperature to which the ring must be heated to fit over the shaft.

(5)

(b) During the equipment of a new vertical shaft it was found that the 25 mm nominal diameter galvanised bolts and nuts used, fail in tensile when torqued. The torque for ungalvanised bolts was used. Calculate the maximum torque for the galvanised bolts and the axial force exerted, given the following information:

•	Included angle of the V-thread	55°
•	Pitch	2 mm
•	Average diameter of thread	23 mm
•	Root diameter of thread	21 mm
•	Maximum tensile strength	80 MPa
•	Coefficient of friction between nut and bolt	0,12

$$T = (W / \cos \beta) \cdot r \cdot \tan(\alpha + \phi)$$

(5)

(c) The speed of scraper winches used underground in a mine have to be reduced by changing the epicyclical gear ratio of the drive. The planetary system consists of an annulus, planetary gear and sun gear, all in the same plane. If the annulus gear wheel has 300 teeth, calculate the number of teeth of the sun and planetary gears to give a gear ratio of 3 when the annulus is held and the planetary carrier drives the rope drum.

(10)

[20]

TOTAL: 100
