INSTRUCTIONS:

All calculations are to be shown.

No credit will be given for calculations in which the steps cannot be clearly followed.

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

Answer QUESTION 1 and QUESTION 2 and any THREE other questions.

QUESTION 1

As the appointed engineer you have to conduct a dynamic test on an AC double drum men winder operating in a vertical shaft 1 700 m deep. The caliper type brakes are spring applied - hydraulically released.

Describe how you will conduct the dynamic test and obtain the following information:

(i) Brake shoe clearances
(ii) Quick drop travel of the brake rod
(iii) Quick drop period
(iv) The distance travelled in wrong direction if full power is applied and the brakes are released
(v) The static current to test the brakes statically
(vi) The average deceleration of the rope from full speed during a tripout in the end-of-wind zone
(vii) The degree of protection
(viii) The brake rod travel at the instant when the brakes start slipping
(ix) The hydraulic pressure of the brake engine at the point where the brakes start slipping

Substantiate your answers with probable dimensions or values where possible.
EXAMINATION FOR THE ENGINEER'S CERTIFICATE OF COMPETENCY

PLANT ENGINEERING: MINING
(081905606)

11 June (X-Paper) 09:00 - 13:00

Afrikaans op keersy

REPUBLIEK VAN SUID-AFRIKA
REPUBLIC OF SOUTH AFRICA

DEPARTEMENT VAN ONDERWYS EN
KULTUUR

DEPARTMENT OF EDUCATION AND CULTURE

ADMINISTRASIE: VOLKSRaad
ADMINISTRATION: HOUSE OF ASSEMBLY

NASIONALE EKSAMENS
NATIONAL EXAMINATIONS

EXAMINER:
Commission of Examiners

MODERATOR:
Commission of Examiners

Total marks : 100
To pass : 50

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(iv) The distance travelled in wrong direction if full power is applied and the brakes are released
(v) The stator current to test the brakes statically
(vi) The average deceleration of the rope from full speed during a tripout in the end-of-wind zone
(vii) The degree of protection
(viii) The brake rod travel at the instant when the brakes start slipping
(ix) The hydraulic pressure of the brake engine at the point where the brakes start slipping

Substantiate your answers with probable dimensions or values where possible.
QUESTION 2

(a) Using diagrams where necessary, explain the mechanism by which 
 transient voltages are produced when a short-line fault is 
 cleared by a transmission line circuit breaker. 

(b) A three-phase motor, having the following particulars, operates on 
 a 5 % slip:

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stator resistance/phase</td>
<td>0.9 ohm</td>
</tr>
<tr>
<td>Stator leakage reactance/phase</td>
<td>3 Ohms</td>
</tr>
<tr>
<td>Rotor resistance/phase</td>
<td>1.15 ohms</td>
</tr>
<tr>
<td>Rotor standstill reactance/phase</td>
<td>2.2 ohms</td>
</tr>
<tr>
<td>No-load shunt resistance/phase</td>
<td>12 ohms</td>
</tr>
<tr>
<td>No-load shunt reactance/phase</td>
<td>50 ohms</td>
</tr>
<tr>
<td>Potential between phases</td>
<td>500 volts</td>
</tr>
</tbody>
</table>

Determine the:

(i) stator current
(ii) equivalent rotor current
(iii) efficiency of the motor
(iv) the input power factor

QUESTION 3

(a) An uncooled rotary compressor is required for a refrigeration 
 plant using dichlorodifluoromethane (R22) and is to handle 2.5 
 t/min of refrigerant with a pressure ratio of 4.06. The satu-
 rated refrigerant vapour enters the compressor at -15 °C. The 
 mean specific heat at constant pressure of the vapour is 
 0.648 kJ/kg.K and the mean specific heat ratio is 1.148 units.

Calculate the compressor brake power if the isentropic efficiency 
 is 0.8.

(b) A vapour compressor refrigeration plant using ammonia operates 
 on the reverse Rankine cycle between condensation and evaporation 
 temperatures 30 °C and -9 °C. At the end of the isentropic 
 compression in the compressor, the temperature of the ammonia is 
 40 °C. The refrigerant leaves the evaporator 0.95 dry.

Sketch the pressure enthalpy diagram and calculate:

(i) the heat transfer per kg from the ammonia in the evaporator
(ii) the work transfer in compressing one kg of ammonia
QUESTION 4

(a) Briefly describe the possible causes of brake judder or brake squeal on mine winders. In each case describe possible relief measures.

(b) A cage of which the total mass is 16 tons is suspended by a 45 mm diameter rope (8.701 kg/m). While the cage was lowered, it got stuck in the shaft and caused 2 m of slack rope to be paid out before the drum stopped. The total length of rope between the cage and the drum at the time was 140 m. Before the slack rope could be taken up, the cage became dislodged and caused the rope to be pulled taut.

If the relative density of the steel for the rope is 7.84 t/m³ and the elasticity modulus 210 GPa, calculate the maximum stress induced in the rope.

QUESTION 5

(a) Select a safety valve from the table below for a 24 kW sealed cooking pot which is electrically heated. The atmospheric pressure is 87.5 kPa and the safe working gauge pressure is 300 kPa. The valve must prevent the pressure from rising 10% above the safe working pressure.

<table>
<thead>
<tr>
<th>SATURATED STEAM – kg/h 10% ACCUMULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauge pressure kPa</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>600</td>
</tr>
<tr>
<td>800</td>
</tr>
<tr>
<td>1000</td>
</tr>
</tbody>
</table>

PTO
(b) A positive-displacement pump operating in a part of a mine raises water 30 m through a 50 mm diameter pipe 1 km long. The pump is capable of operating against a maximum discharge pressure of 450 kPa with a capacity of 8 m³/h. The friction factor (Darcy-Weisbach) for the pipes is 0.01. It is planned to extend the pipe range backwards horizontally by 800 m. The existing pump will remain in place and will pump into the extended range by means of a tee-junction. A new pump will be installed at the beginning of the extended range with the same capacity as the original pump, but will be capable of pumping against a maximum discharge pressure of 900 kPa.

(i) Show by calculation that this arrangement will not be satisfactory.

(ii) What are the alternatives so that the water can be pumped from this part of the mine?

The total quantity of water to be pumped at a constant rate by the two pumps is 224 m³ per day.

QUESTION 6

(a) Briefly describe considerations that should be taken into account before installing a booster fan in a mine which is subject to spontaneous combustion.

(b) Discuss the alternatives to a booster fan installation that may be used in any mine, paying particular attention to the cost and benefits.

(c) One longwall district of a mine consists of an intake airway 2 km long, a face and 2 km return airway. The face has a resistance of 2 N s²/m⁸ and the intake and return airways have resistances of 0.1 N s²/m⁸ and 0.15 N s²/m⁸ per kilometre respectively. The mid-points of the intake and return airways are to be connected by a pump chamber having a resistance of 10 N s²/m⁸. A booster fan is to be placed in the return airway between the face and the return pump crosscut junction to ensure that the airflow through the chamber and the face is to be 5 m³/s and 15 m³/s respectively.

Ignore other leakage effects and calculate:

(i) the pressure of the booster fan

(ii) the differential pressure required between the inlet and outlet of the district
(b) A positive-displacement pump operating in a part of a mine raises water 30 m through a 50 mm diameter pipe 1 km long. The pump is capable of operating against a maximum discharge pressure of 450 kPa with a capacity of 8 m$^3$/h. The friction factor (Darcy-Weisbach) for the pipes is 0.01. It is planned to extend the pipe range backwards horizontally by 800 m. The existing pump will remain in place and will pump into the extended range by means of a tee-junction. A new pump will be installed at the beginning of the extended range with the same capacity as the original pump, but will be capable of pumping against a maximum discharge pressure of 900 kPa.

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The total quantity of water to be pumped at a constant rate by the two pumps is 224 m$^3$ per day.

QUESTION 6

(a) Briefly describe considerations that should be taken into account before installing a booster fan in a mine which is subject to spontaneous combustion.

(b) Discuss the alternatives to a booster fan installation that may be used in any mine, paying particular attention to the cost and benefits.

(c) One longwall district of a mine consists of an intake airway 2 km long, a face and 2 km return airway. The face has a resistance of 2 N s$^2$/m$^8$ and the intake and return airways have resistances of 0.1 N s$^2$/m$^8$ and 0.15 N s$^2$/m$^8$ per kilometre respectively. The mid-points of the intake and return airways are to be connected by a pump chamber having a resistance of 10 N s$^2$/m$^8$. A booster fan is to be placed in the return airway between the face and the return pump crosscut junction to ensure that the airflow through the chamber and the face is to be 5 m$^3$/s and 15 m$^3$/s respectively.

Ignore other leakage effects and calculate:

(i) the pressure of the booster fan

(ii) the differential pressure required between the inlet and outlet of the district
QUESTION 7

(a) Briefly describe the advantages and disadvantages of a high impedance earthed protection system on a mine.

(b) Determine the value of the resistance to be provided for an earth fault protection of a transformer if the line voltage is 525 V, the impedance of the resistances between each phase is 3 kΩ and the pick-up current of the relay is 25 mA to ensure positive operation of the relay during a zero impedance earth fault. Take the current permitted to flow to be twice the pick-up value of the relay.

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QUESTION 8

(a) An overhead transmission line is supported over rising ground in still air from two pylons differing in height by 19 m. The horizontal distance between the pylons is 151 m. The conductors make an angle of 18° with the horizontal at the attachment point at the higher pylon. The maximum tension in each conductor is found to be 8 kN.

If the mass of each conductor is 2 kg/m, calculate:

(i) the sag below the attachment point of the lower pylon
(ii) the length of the conductor between the pylons

(b) If the underground trackless mining section for which you are responsible, shows that the accident frequency involving brake failures, is on the increase, describe the steps you will take to:

(i) change the operations to be more safe
(ii) improve the maintenance and regular testing of the brakes
(iii) install a safer braking system
QUESTION 1

PROCEDURE FOR DYNAMIC TESTING OF WINDERS

1. GENERAL GUIDELINES

1.1 The responsible engineer must be present when dynamic tests are carried out.

1.2 The correct load necessary for properly conducting the test must be readily available to avoid delays.

1.3 The winding engine driver must be fully informed regarding the tests to be carried out and all relative information must be entered in the log book.

1.4 Only one person must be responsible for giving instructions during the test period.

1.5 The person responsible for conducting the tests must be fully conversant with the design and commissioning details relating to the specific winder being tested. In the interests of safety and possible damage to equipment, no tests must be conducted without the personnel being fully aware of the dynamic testing procedures. Should there be any uncertainty regarding the above, assistance must be obtained from a suitably qualified engineer or technician.

1.6 Suitable recorders (Lintott) may be provided and installed to record the following:

1.6.1 Speed of conveyance
1.6.2 Distance travelled by conveyance
1.6.3 Safety contactor trip out
1.6.4 Brake engine movement

Note: Where recorders are not available acceptable results can be obtained with a stop watch.

2. BRAKE SETTINGS

2.1 Ensure that a balance pipe from one brake to the other is installed with no valves interfering. (only on double drum winders).

2.2 Recommended brake settings must, as far as possible, be determined for each and every winder by carrying out brake tests using a cage mounted decelerometer if available.

2.3 The 100% and 90% brake strokes, the quick drop and the fast and slow braking times must be checked, recorded and adjusted if necessary to the recommended settings. (If there is no Escort control). This must be done with the drums in a marked position if there is any ovality or distortion present in the brake path.

2.4 The brake engine operating times along the end-of-wind fast braking cams must be checked every drum turn, recorded and compared with the recommended settings. These mechanical cams are often incorrectly adjusted.