higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NON-NATIONAL CERTIFICATE: ENGINEERING CERTIFICATE OF COMPETENCY

PLANT ENGINEERING: FACTORIES

(8190316)

9 November 2020 (X-paper)
09:00–12:00

CLOSED-BOOK EXAMINATION

Nonprogrammable calculators may be used.

This question paper consists of 6 pages and an information sheet of 3 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA
NON-NATIONAL CERTIFICATE: ENGINEERING CERTIFICATE OF COMPETENCY
PLANT ENGINEERING: FACTORIES
TIME: 3 HOURS
MARKS: 100

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

INSTRUCTIONS AND INFORMATION

1. Answer all the questions in SECTION A.

2. Answer any TWO questions in SECTION B.

3. Read all the questions carefully.

4. Number the answers according to the numbering system used in this question paper.

5. Show all calculations.

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

7. Make reasonable assumptions where necessary and clearly state these, together with any formulae used.

8. Rule off across the page on completion of each question.

9. No notes, textbooks, references books or cellphones are allowed in the examination venue.

10. Candidates who were not accepted by the Commission will be disqualified.

11. No candidate may enter the examination room more than 15 minutes after the start of the examination and no candidate may leave the examination room before ONE hour has elapsed.

12. Write neatly and legibly.

Please turn over

SECTION A (COMPULSORY)

QUESTION 1

1.1 A steam pipe is lagged with 75 mm thick insulation material and a thermal conductivity of 0,069 W/m.K. It is covered with a thin layer of material with a transfer coefficient of 6,8 W/m²K. The pipe thickness is thin compared to its radius and has a temperature of 180 °C throughout its wall thickness. The diameter of the pipe is 100 mm and the ambient temperature is 19 °C.

Calculate each of the following:

1.1.1 Temperature on outside surface (5)

1.1.2 Rate of surface heat transfer per metre length pipe (2)

1.1.3 Condition of steam at delivery end if pipe is 120 m long, 500 kg/h steam is transmitted, and initial dryness fraction of the steam is 0,9

Ignore pressure drop due to friction. (8)

1.2 Name FIVE accessories that must be installed on an evaporator for a steam generator. (5)

[20]

QUESTION 2

2.1 Name THREE advantages and THREE disadvantages of oil circuit breakers. (6)

2.2 A single-phase transformer of 10 kVA has 400 W iron losses and 600 W copper losses.

Determine the maximum efficiency of the transformer at 0,8 lagging power factor. Also calculate the load at which maximum efficiency occurs. (5)

2.3 Star/delta starting is used on a 45 kW, 3-phase, 525 V, 1 440 r/min motor with a power factor of 0,85 and an efficiency of 92%.

2.3.1 The motor draws six times its full-load running current and produces 2,2 times its full-load running torque with direct-on-line start.

Determine the current drawn and starting torque when it is started by means of the star/delta starter. (5)

2.3.2 Determine the full-load line and phase currents when running in delta. (4)

[20]

QUESTION 3

3.1   SANS/ISO 45001: 2018: Occupational Health and Safety Management Systems – Requirements with Guidance for Use (previous known as OHSAS 18001) addresses the identification of hazards, how they are communicated, and the analysis and mitigation of known hazards.

    3.1.1   Give FIVE examples of opportunities to improve occupational health and safety performances.   (5)

    3.1.2   Name FIVE hazard identification processes that should be considered.   (5)

3.2   A gantry crane installed above a printing machine in operation has to be shut down for maintenance.

    State 10 points that must be kept in mind before working on the crane.   (10)
                              [20]

TOTAL SECTION A: **60**

SECTION B

Answer any TWO questions in SECTION B.

QUESTION 4

4.1   Give FOUR requirements for the height of a distribution board in an electrical installation.

4.2   State FOUR requirements for the installation of a manually operated disconnector for an electrical motor in an electrical installation.

4.3   Give FOUR reasons why an impregnant is used in an electric motor.

4.4   Name FOUR benefits of using thermography as part of a predictive maintenance programme on electrical machinery.

4.5   Name FOUR lamp types used in an industrial environment.

                                                   (5 × 4)   **[20]**

AND/OR

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QUESTION 5

5.1 A new stainless-steel heat exchanger has developed severe cracks around the outlet.

Name SIX possible causes of the cracks and explain each cause. (6 × 2) (12)

5.2 A new flanged-shaft coupling has to be designed. The shaft needs to transmit 45 kW at 140 r/min. 18 mm diameter bolts are used on a 180 mm diameter pitch circle. The maximum torque is 1,3 times the mean and the shear stress in the bolts is limited to 30 mPa.

Calculate each of the following:

5.2.1 Maximum torque that will be transmitted

5.2.2 Number of bolts required

(2 × 4) (8)
[20]

AND/OR

QUESTION 6

6.1 A three-phase, 50 Hz overhead line is 100 km long. The phase values of the resistance, inductance and capacitance per km are 0,15 Ω, 1,2 mH and 0,0087 µF respectively.

Using the nominal T method, calculate the send-end voltage, current and power factor when the 132 kV line supplies a load of 70 MW at 0,8 power-factor lagging. (15)

6.2 What legislation has been promulgated and what else can be done to reduce the theft of transformers, distribution and transmission equipment of overhead power lines? (5)
[20]

AND/OR

QUESTION 7

7.1 Name and discuss THREE items that have to be checked on a steel-wire rope of a gantry crane when carrying out a periodic inspection. (6)

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7.2 The electrically driven crab of an overhead crane can lift a mass-load of 5 000 kg. Its traversing speed is 0,375 m/s and its own mass is 2 500 kg. The traversing drive has no mechanical brake and depends solely on electrical braking assisted by the resistance of the wheels on the track which can be taken as 1 350 N when the crab is fully loaded.

Calculate the maximum distance the crab will travel when fully loaded if there is no electrical braking because of a power failure. The features of the traversing drive are as follows:

Moment of inertia of motor armature: 0,04 kg m^2
Speed of motor: 950 r/min
Diameter of wheel: 250 mm

The wheels are driven by double reduction gears with ratios of 18 to 110 and 15 to 82 and the efficiency of gearing is 85%.

(14)

[20]

AND/OR

QUESTION 8

8.1 The power supplied to a three-phase induction motor for a refrigeration plant is 50 kW and the corresponding stator losses are 1,5 kW.

Calculate each of the following:

8.1.1 Total mechanical power developed and rotor I^2R loss when the slip is 0,04 per unit (4)

8.1.2 Output power of motor if friction and winding losses are 0,8 kW (2)

8.1.3 Efficiency of motor (2)

NOTE: Ignore the rotor iron loss.

8.2 What document must be available when using an induction motor in a hazardous location? (2)

8.3 As horizontal-shaft wind turbines (HAWTs) increase in size, they become more disturbing in certain ways. The development of a range of vertical-axis wind turbines (VAWTs) has addressed some of these negative effects.

Name FIVE advantages of VAWTs over HAWTs. (5)

8.4 Discuss the different stages of the use of concentrated solar plants for the generation of electricity in South Africa. (5)

[20]

TOTAL SECTION B: 40
GRAND TOTAL: 100

PLANT ENGINEERING: FACTORIES

INFORMATION SHEET

$P = \sqrt{3}\, VI \cos\theta$	$t = \dfrac{2A}{C_d\, a\, \sqrt{2g}}\left(H_1^{0.5} - H_2^{0.5}\right)$
$Q = mC\Delta t$	$C = \dfrac{\sigma_c}{2}\, bn$
$P = (T_1 - T_2)\, v$	$T = \sigma_s A_s$
$pv = mRT$	$\dfrac{n}{d-n} = m\, \dfrac{\sigma_c}{\sigma_s}$
$\dfrac{T_1 - T_c}{T_2 - T_c} = e^{\mu\theta}$	$\Delta P = \dfrac{32\,\mu\, L\, v}{D^2}$
$t_m = \dfrac{\Delta t_{in} - \Delta t_{out}}{\ln\dfrac{\Delta t_{in}}{\Delta t_{out}}}$	$z = \dfrac{\pi\,(D^4 - d^4)}{32\, D}$
$\dfrac{M}{I} = \dfrac{\sigma}{y} = \dfrac{E}{R}$	$I = \dfrac{\pi\,(D^4 - d^4)}{64}$
$x = \sqrt{\dfrac{P_i}{P_c}}$	$Q = \dfrac{K \times 2 \times \pi \times L \times (t_1 - t_2)}{\ln\dfrac{r_2}{r_1}}$

p	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g
kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg. K	kJ/kg. K
75	91,8	2,217	385	2 279	2 664	1,213	7,457
80	93,5	2,087	392	2 274	2 666	1,233	7,435
85	95,2	1,972	399	2 270	2 669	1,252	7,415
90	96,7	1,869	405	2 266	2 671	1,270	7,395
95	98,2	1,777	412	2 262	2 674	1,287	7,377
100	99,6	1,694	418	2 258	2 676	1,303	7,360
110	102,3	1,549	429	2 251	2 680	1,333	7,328
120	104,8	1,428	439	2 244	2 683	1,361	7,300
130	107,1	1,325	449	2 238	2 687	1,387	7,272
140	109,3	1,236	458	2 232	2 690	1,411	7,247
150	111,4	1,159	467	2 226	2 693	1,434	7,223
160	113,3	1,091	475	2 221	2 696	1,455	7,202
170	115,2	1,031	483	2 216	2 699	1,475	7,181
180	116,9	0,977 2	491	2 211	2 702	1,494	7,162
190	118,6	0,929 0	498	2 206	2 704	1,513	7,144
200	120,2	0,885 4	505	2 202	2 707	1,530	7,127
210	121,8	0,845 9	511	2 197	2 708	1,547	7,111
220	123,3	0,809 8	518	2 193	2 711	1,563	7,095
230	124,7	0,776 8	524	2 189	2 713	1,578	7,080
240	126,1	0,746 5	530	2 185	2 715	1,593	7,066
250	127,4	0,718 4	535	2 181	2 716	1,607	7,052
260	128,7	0,692 5	541	2 177	2 718	1,621	7,039
270	130,0	0,668 4	546	2 174	2 720	1,634	7,026
280	131,2	0,646 0	551	2 170	2 721	1,647	7,014
290	132,4	0,625 1	557	2 167	2 724	1,660	7,002
300	133,5	0,605 6	561	2 163	2 724	1,672	6,991
310	134,7	0,587 2	566	2 160	2 726	1,683	6,980
320	135,8	0,570 0	571	2 157	2 728	1,695	6,969
330	136,8	0,553 8	576	2 154	2 730	1,706	6,959
340	137,9	0,538 5	580	2 150	2 730	1,717	6,949
350	138,9	0,524 0	584	2 147	2 731	1,727	6,939
360	139,9	0,510 3	589	2 144	2 733	1,738	6,930
370	140,8	0,497 4	593	2 141	2 734	1,748	6,921
380	141,8	0,485 1	597	2 139	2 736	1,757	6,912
390	142,7	0,473 4	601	2 136	2 737	1,767	6,903
400	143,6	0,462 2	605	2 133	2 738	1,776	6,894
410	144,5	0,451 6	609	2 130	2 739	1,786	6,886
420	145,4	0,441 5	612	2 128	2 740	1,795	6,878
430	146,3	0,431 8	616	2 125	2 741	1,803	6,870
440	147,1	0,422 6	620	2 122	2 742	1,812	6,862
450	147,9	0,413 8	624	2 120	2 744	1,820	6,855
460	148,7	0,405 3	627	2 117	2 744	1,829	6,847
470	149,5	0,397 2	630	2 115	2 745	1,837	6,840
480	150,3	0,389 4	634	2 112	2 746	1,845	6,833
490	151,1	0,381 9	637	2 110	2 747	1,853	6,826
500	151,8	0,374 7	640	2 107	2 747	1,860	6,819
520	153,3	0,361 1	647	2 103	2 750	1,875	6,806
540	154,8	0,348 5	653	2 098	2 751	1,890	6,793
560	156,2	0,336 7	659	2 094	2 753	1,904	6,781
580	157,5	0,325 7	665	2 089	2 754	1,918	6,769

p	t_s	v_g	h_f	h_{fg}	h_g	s_f	s_g
kPa	°C	m³/kg	kJ/kg	kJ/kg	kJ/kg	kJ/kg. K	kJ/kg K
600	158,8	0,315 5	670	2 085	2 755	1,931	6,758
620	160,1	0,305 9	676	2 081	2 757	1,944	6,746
640	161,4	0,296 8	682	2 077	2 759	1,956	6,736
660	162,6	0,288 3	687	2 073	2 760	1,968	6,725
680	163,8	0,280 3	692	2 069	2 761	1,980	6,715
700	165,0	0,272 7	697	2 065	2 762	1,992	6,705
720	166,1	0,265 5	702	2 061	2 763	2,003	6,696
740	167,2	0,258 7	707	2 057	2 764	2,014	6,686
760	168,3	0,252 2	712	2 054	2 766	2,025	6,677
780	169,4	0,246 1	717	2 050	2 767	2,035	6,668
800	170,4	0,240 3	721	2 047	2 768	2,046	6,660
820	171,4	0,234 7	725	2 043	2 768	2,056	6,651
840	172,5	0,229 4	730	2 040	2 770	2,066	6,643
860	173,4	0,224 3	734	2 036	2 770	2,075	6,635
880	174,4	0,219 5	739	2 033	2 772	2,085	6,627
900	175,4	0,214 8	743	2 030	2 773	2,094	6,619
920	176,3	0,210 4	747	2 026	2 773	2,103	6,612
940	177,2	0,206 1	751	2 023	2 774	2,112	6,604
960	178,1	0,202 0	755	2 020	2 775	2,130	6,597
980	179,0	0,198 1	759	2 017	2 776	2,130	6,590
1 000	179,9	0,194 3	763	2 014	2 777	2,138	6,583
1 050	182,0	0,185 5	772	2 006	2 778	2,159	6,566
1 100	184,1	0,177 4	781	1 999	2 780	2,179	6,550
1 150	186,1	0,170 0	790	1 991	2 781	2,198	6,531
1 200	188,0	0,163 2	798	1 984	2 782	2,216	6,519
1 250	189,8	0,156 9	807	1 977	2 784	2,234	6,505
1 300	191,6	0,151 1	815	1 971	2 786	2,251	6,491
1 350	193,4	0,145 7	823	1 961	2 787	2,268	6,178
1 400	195,0	0,140 7	830	1 958	2 788	2,284	6,465
1 450	196,7	0,136 0	838	1 951	2 789	2,299	6,453
1 500	198,3	0,131 7	845	1 945	2 790	2,315	6,441
1 550	199,9	0,127 5	852	1 939	2 791	2,330	6,429
1 600	201,4	0,123 7	859	1 933	2 792	2,341	6,418
1 650	202,9	0,120 1	865	1 927	2 792	2,358	6,407
1 700	204,3	0,116 6	872	1 922	2 794	2,371	6,396
1 750	205,7	0,113 4	878	1 916	2 794	2,385	6,385
1 800	207,1	0,110 3	885	1 910	2 795	2,398	6,375
1 850	208,5	0,107 4	891	1 905	2 796	2,410	6,365
1 900	209,8	0,104 7	897	1 899	2 796	2,423	6,355
1 950	211,1	0,102 0	903	1 894	2 797	2,435	6,346
2 000	212,4	0,099 54	908	1 889	2 797	2,447	6,337
2 050	213,6	0,097 16	914	1 883	2 797	2,459	6,328
2 100	214,9	0,094 89	920	1 878	2 798	2,470	6,319
2 150	216,1	0,092 72	926	1 873	2 799	2,481	6,310
2 200	217,2	0,090 65	931	1 868	2 799	2,492	6,302
2 250	218,4	0,088 67	936	1 863	2 799	2,503	6,293
2 300	219,6	0,086 77	942	1 858	2 800	2,514	6,285
2 350	220,7	0,084 95	947	1 853	2 800	2,524	6,277
2 400	221,8	0,083 20	952	1 849	2 801	2,534	6,269
2 450	222,9	0,081 52	957	1 844	2 801	2,544	6,261