higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NONNATIONAL CERTIFICATE

PLANT ENGINEERING: FACTORIES

(8190316)

11 November 2019 (X-Paper)
09:00–12:00

CLOSED-BOOK EXAMINATION

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

Copyright reserved

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. All work you do not want to be marked must be clearly crossed out.

INSTRUCTIONS AND INFORMATION

1. SECTION A is compulsory. Answer any TWO questions in SECTION B.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Show all the calculations.
5. No marks will be given for calculations which are unclear or for work in pencil.
6. Candidates must make reasonable assumptions where necessary and these, together with any formulae used, must be clearly stated.
7. Rule off on completion of each question before starting a new question.
8. No candidates may enter the examination room more than half an hour after the start of the examination and no candidate may leave the examination room before one hour has elapsed.
9. Cellphones are not allowed in the examination room.
10. Candidates who were not accepted by the commission will be disqualified.
11. Write neatly and legibly.

Copyright reserved

SECTION A (COMPULSORY)

QUESTION 1

1.1 A steam pipe is lagged with 75 mm thick insulation material having a thermal conductivity of 0,069 W/m.K and covered with a thin layer of material which has a transfer coefficient of 6,8 W/m^{2}K. 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 the outside surface (5)

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

1.1.3 Condition of steam at the delivery end if the pipe is 120 m long, 500 kg/h steam is transmitted, and the initial dryness fraction of the steam is 0,9. Ignore the pressure drop due to friction. (8)

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

[20]

QUESTION 2

2.1 Oil circuit breakers are not manufactured on a large scale mainly due to the major disadvantages outweighing the advantages.

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

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

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

2.3 Star/delta starting is used on a 45 kW, three-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 when it is started directly on line.

Establish 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]

Copyright reserved

QUESTION 3

3.1 SANS/ISO 45001: 2018: Occupational health and safety management systems – Requirements with guidance for use (previously known as OHSAS 18001) is a health and safety management system. Occupational health and safety opportunities address the identification of hazards, how they are communicated, and the analysis and mitigation of known hazards. Other opportunities address system improvement strategies.

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

3.1.2 Name FIVE of the organisation's hazard identification processes that should be considered. (5)

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

Draw up a procedure with TEN critical points for the artisans before they may work on the crane. (10)
[20]

TOTAL SECTION A: 60

SECTION B

Answer any TWO of the FIVE questions.

QUESTION 4

4.1 Give FOUR requirements for the heights of distribution boards in an electrical installation.

4.2 Give 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 different lamp types used in an industrial environment.

(5 × 4) **[20]**

AND/OR

QUESTION 5

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

Name SIX possible causes for these cracks and discuss each cause. (12)

5.2 A new flanged shaft coupling has to be designed after the previous coupling has disintegrated. 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 the following:

5.2.1 Maximum torque that will be transmitted (4)

5.2.2 Number of bolts required (4)

[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 can be done to reduce the theft of transformers, distribution and transmission equipment of overhead power lines? (5)

[20]

Copyright reserved

QUESTION 7

7.1 Name and discuss THREE items to check on a steel-wire rope used on a gantry crane when carrying out a periodic inspection. (6)

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; 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 travels when fully loaded if, because of a power failure, there is no electrical braking. The relevant 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 gearing efficiency 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 the rotor I^2R loss when the slip is 0,04 per unit (4)

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

8.1.3 Efficiency of the motor (2)

NOTE: Ignore the rotor iron loss.

8.2 What document must be available for 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 (VAWT) has addressed some of these negative effects.

Name FIVE advantages of VAWTs over HAWTs. (5)

8.4 Discuss the different stages of concentrated solar plants used in South Africa for the generation of electricity. (5)
[20]

TOTAL SECTION B: 40
GRAND TOTAL: 100

Copyright reserved

INFORMATION SHEET

$P = \sqrt{3}\ VI \cos\theta$	$t = \frac{2A}{C_d\ a\sqrt{2g}} (H_1^{0,5} - H_2^{0,5})$
$Q = mC\Delta t$	$C = \frac{\sigma_c}{2}\ bn$
$P = (T_1 - T_2)\ v$	$T = \sigma_s A_s$
$pv = mRT$	$\frac{n}{d-n} = m\ \frac{\sigma_c}{\sigma_s}$
$\frac{T_1 - T_c}{T_2 - T_c} = e^{\mu\theta}$	$\Delta P = \frac{32\ \mu\ L\ v}{D^2}$
$t_m = \frac{\Delta t_{in} - \Delta t_{out}}{\ln \frac{\Delta t_{in}}{\Delta t_{out}}}$	$z = \frac{\pi\ (D^4 - d^4)}{32.D}$
$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$	$I = \frac{\pi\ (D^4 - d^4)}{64}$
$x = \sqrt{\frac{P_i}{P_c}}$	$Q = \frac{K \times 2 \times \pi \times L \times (t_1 - t_2)}{\ln \frac{r_2}{r_1}}$

Copyright reserved

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

Copyright reserved

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	2,121	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	6,534
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	1 964	2 787	2,268	6,478
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	2,344	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

Copyright reserved